M.Sc. (Agri) – Genetics and Plant Breeding (GGPB23)

Programme Specific Outcome

To provide

1. The basics of classical to molecular plant breeding including biotechnological, quantitative, and genomic techniques.
2. Skill in self-designing, regional and crop specific plant breeding programs linking conventional and modern techniques; selection strategies for development of new varieties.
3. Competency in collection, investigation and analysis of data sets using statistical software; interpretation of the genetic results to arrive at meaningful conclusions.
4. Insight about various biotechnological tools, tissue culture techniques, principles behind transgenic crops and its ethical implications.
5. Understand the importance of quantitative genetic analysis, identifying the genes and QTL analysis.
6. Proficiency in mapping population, molecular marker assisted selection and its application in crop improvement.
7. Significance of germplasm, biodiversity conservation in relation to Plant Variety Protection and Intellectual Property Rights.
8. Knowledge and expertise in genomics, proteomics, bioinformatics and gene editing technologies.

COURSE OBJECTIVES AND OUTCOMES

GGPB23 611 PRINCIPLES OF GENETICS (2+1)

Learning Objectives

- To make the students understand the basic principles and recent development in genetics
- To motivate the students to develop their analytical, quantitative and problem solving skills from classical to molecular genetics.

Theory

Unit I: Mendelian genetics & chromosomal theory of inheritance

Mendelian genetics, allosomes, linkage and extra chromosomal inheritance Introduction to genetics -Earlier concepts of inheritance – cell and cell organelles- Cell division, Mendel's laws; Discussion on Mendel's paper- Chromosomal theory of inheritance; Multiple alleles, gene interactions, sex determination, differentiation and sex-linkage, sex influenced and sex limited inheritance; Linkage-detection,estimation; recombination and genetic mapping in eukaryotes, somatic cell genetics, Extra chromosomal inheritance.

Unit II: Population genetics, chromosomal aberrations & protein synthesis

Population genetics, variation in chromosomes and protein synthesis Population - Mendelian population – Random mating population -Frequencies of genes and genotypes-Causes of change: Hardy-Weinberg equilibrium; Structural and numerical changes in chromosomes; Nature, structure and replication of the genetic material; Organization of DNA in chromosomes, Genetic code; Protein biosynthesis.

Unit III: Concepts of genes

Concepts of gene, gene repair and gene regulation Genetic fine structure analysis, Allelic complementation, Split genes, Transposable genetic elements, Overlapping genes, Pseudogenes, Oncogenes, Gene families and clusters. 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 IV: Genetic hybridization

Gene cloning, gene amplification and functional genomics 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). Genomics and proteomics; Functional and pharmacogenomics; Metagenomics.

Unit V: Behavioural genetics & biochemical synthesis

Metagenomics, role of environment in genetic characters, Polymorphism, bioethics and Behavioural genetics, Methods of studying polymorphism at biochemical and DNA level; Transgenic bacteria and bioethics; Gene silencing; genetics of mitochondria and chloroplasts; Concepts of Eugenics, Epigenetics, Genetic disorders and Behavioural Genetics.

Practical

Laboratory exercises in probability and chi-square; problems on various genetic principles; 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

Theory schedule

1. Beginning of genetics, heredity, inheritance, Brief history and earlier concepts of genetics.

2. Structure and function of cell and cell organelles – Differences between Prokaryotes and Eukaryotes.
3. Cell division – mitosis, meiosis and their significance, cell cycle.
4. Work of Mendel – Characters studied reasons for Mendel's success, Laws of Mendel, Discussion on Mendel's paper- Rediscovery of Mendel's work.
5. Chromosomal theory of inheritance; Multiple alleles with examples.
6. Gene interactions-i.) Dominant epistasis (12:3:1) ii.) Recessive epistasis(9:3:4) iii.) Duplicate and additive epistasis((9:6:1) iv.) Duplicate dominant epistasis(15:1) v) Duplicate recessive epistasis (9:7) vi.) Dominant and recessive epistasis(13:3); Summary of epistatic ratios (i)to (vi).
7. Sex determination: Autosomes and sex chromosomes - chromosomal theory- Genic balance theory of sex determination - different types.Sex linked inheritance – Criss cross inheritance – reciprocal difference; holandric genes; sex influenced and sex limited inheritance.
8. Linkage – detection and estimation-Strength of linkage and recombination; Two point and three point test cross. Double cross over, recombination and genetic map in eukaryotes.
9. Somatic cell genetics-extra chromosomal inheritance.
10. Population-Hardy-Weinberg law-equilibrium –Random mating population-gene and genotypic frequencies.
11. Chromosomal aberration: Variation in chromosome structure – deletion, duplication, inversion and translocation – genetic and cytological implications.
12. Chromosomal aberration: Variation in chromosome number – euploid, aneuploid, types of aneuploids and their origin-Polyploid - auto and allopolyploids, their characters; meaning of genome; evolution of wheat, Triticale, cotton, tobacco, Brassicas.
13. DNA, the genetic material – Griffith's experiment, experiment of Avery, McCleod and McCarthy – confirmation by Hershey and Chase; RNA as genetic material – Frankel, Conrat and Singer experiment.
14. Structure of DNA – Watson and Crick model – Central dogma of life-Proof for semi conservative method of DNA replication; Models of DNA replication; steps involved in DNA replication.
15. Organization of DNA in chromosomes; Genetic code; Protein biosynthesis – Transcription –translation gene expression.
16. Protein synthesis; Regulation of gene expression – operon model of Jacob and Monad; Structural genes and regulator genes.
17. **Mid-Semester Examination**
18. Fine structure of the gene- Cistron, muton and recon; Complementation test; exons, introns – split genes – plant genome structure; Transposable genetic elements; Overlapping genes, Pseudogenes – Oncogenes.
19. Gene families-origin-actin- Divergence in multigene families-Evolution of members-clusters-Globin-Histone; Regulation of gene expression in prokaryotes – Operon model of Jacob and Monad; Structural genes and regulator genes.
20. Molecular mechanisms of mutation, repair and suppression; Bacterial plasmids, insertion (IS) and Transposable (Tn) elements.
20. Gene regulation in eukaryotes; RNA editing.
21. Gene isolation, synthesis –chemical synthesis-Phosphodiester approach-phosphotriester approach-Enzymatic synthesis of DNA-synthesis of complete gene-
22. Gene cloning-.recombinant DNA-cloning and expression- plasmids-cosmids-integration of DNA into vectors-introduction of vector into host-selection of recombinant clones-multiplication-expression-integration of DNA inserts in host genome.
23. cDNA libraries-preparation of cDNA –problems in c DNA preparation-Isolation of m RNA; Genomic library-construction of Genomic library.
24. PCR based cloning; positional cloning
25. Nucleic acid hybridization and immunochemical detection-DNA sequencing.
26. DNA restriction- restriction enzymes-types-nomenclature-recognition sequences-cleavage patterns-modification of cut ends.
27. Anti-sense RNA and ribozymes; Micro-RNAs (miRNAs).
28. Genomics and proteomics; Functional and pharmacogenomics; Metagenomics.
29. Polymorphism-Methods of studying polymorphism at biochemical and DNA level .
30. Transgenic bacteria and bioethics
31. Gene silencing-Transcriptional silencing-post transcriptional silencing-
32. Genetics of mitochondria-CMS-mt DNA-Yeast mitochondrial genome- chloroplasts-features of organellar genome.
33. Concepts of Eugenics, Epigenetics.
34. Genetic disorders and Behavioural Genetics.

Practical schedule

1. Problems and exercises in probability and chi-square test.
2. Demonstration of genetic principles using laboratory organisms.

3. Problems on two point test cross and three point test cross; Working out interference, coincidence and drawing genetic maps.
4. Chromosome mapping using three point test cross.
5. Tetrad analysis-detection of linkages.
6. Analysis of ordered and unordered tetrads
7. Induction and detection of mutations through genetic tests.
8. Problems on various genetics disorders
9. Problems on autosomal inheritance
10. Problems on allosomal inheritance
11. DNA extraction from crops through various methods-detection of quality and quantity.
12. Basic principles of PCR
13. Amplification and running of PCR
14. Developing marker systems.
15. Detection of transgenes in the exposed plant material.
16. Visit to transgenic glasshouse and learning the practical considerations.
17. **Practical examination**

References

1. Singh, B.D., Fundamentals of genetics 2014, Kalyani Publishers, New Delhi.
2. Gardner, E.J. & Snustad, D.P. 1991. Principles of Genetics. John Wiley & Sons, USA.
3. Russell, P.J. 1998. Genetics. The Benzamin Cummings Publishers, USA.
4. Snustad, D.P. & Simmons, M.J. 2006. Genetics. 4th Ed. John Wiley & Sons, USA.
5. Strickberger, M.W. 2005. Genetics (III Ed). Prentice Hall, New Delhi, India.
6. Uppal S, Yadav R, Subhadra & Saharan R.P. 2005. Practical Manual on Basic and Applied Genetics. Dept. of Genetics, CCS HAU Hisar, India.

Outcome

1. Students will acquire comprehensive understanding of the chemical basis of heredity.
2. The knowledge required to design, execute, and analyze the results of genetic experimentation in Plant Breeding systems
3. Critical understanding on quantification of heritable traits that provides insight into cellular and molecular mechanisms.
4. The ability to evaluate conclusions that are based on genetic data.

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	**1**							
CO2		**2**	**3**					
CO3					**2**			
CO4			**2**					

GGPB23 612 PRINCIPLES OF PLANT BREEDING (2+1)

Learning objectives

- To impart knowledge on application of various genetics principles in crop improvement
- To impart knowledge on emasculation and pollination techniques of various crops
- Various plant breeding methods involved in crop improvement

Theory

Unit I: Reproductive systems in plant breeding

Objectives and role of plant breeding - historical perspective – activities in Plant Breeding. Centres of origin – contribution of Vavilov- law of homologous series. Plant genetic resources – importance – germplasm – types – activities Modes of reproduction – sexual – asexual - self and cross fertilization – significance of pollination. Self incompatibility – classifications – mechanisms – application Sterility – male sterility – introduction – classification – CMS, GMS, CGMS-inheritance and applications. TGMS, PGMS, Gametocides, Transgenic Male sterility and applications. Apomixis – introduction - classification-applications; Parthenocarpy and its types.

Unit II: Breeding methods of self pollinated crops

Basic biometrics-nature and significance of qualitative and quantitative variation-phenotypic, genotypic and environmental-heritability and genetic advance. Plant introduction as a breeding method – types of introduction – objectives – quarantine - acclimatization – achievements - merits and demerits. Genetic basis of self pollinated crops – Vilmorin principle of progeny selection - Breeding methods for self pollinated crops without involving artificial hybridization: - Breeding methods of self pollinated crops involving artificial hybridization: Creating variability in self pollinated crops - steps in hybridization - kinds of emasculation. Pedigree breeding – procedure – mass pedigree – merits – demerits – achievements; Bulk breeding , Single Seed Descent (SSD) method. Backcross breeding– multi lines and multi blends - population improvement approach in self-pollinated crops.

Unit III: Breeding methods of cross pollinated crops and clonally propagated crops

Genetic structure of a population in cross pollinated crop – Hardy Weinberg law – gene frequencies in random mating population – principles in population improvement. Breeding methods of cross pollinated crops without involving artificial hybridization: Mass selection Breeding methods of cross pollinated crops involving artificial hybridization: Recurrent selection ; Heterosis breeding – genetic basis – hybrid vigour – estimation of heterosis – inbreeding depression – development of inbreds; Heterosis breeding – procedure – use of male-sterility systems and manual emasculation in hybrid seed production – maintenance of parental lines -types of hybrids – achievements – merits and demerits; Synthetics and composites - steps in development of synthetics and composites – achievements – merits and demerits. Genetic characters of asexual reproduction – breeding methods – clonal selection – hybridization and clonal selection.

Unit IV: Special breeding methods

Mutation breeding: mutation – types – mutagens – breeding procedure – applications – achievements – limitations. Breeding for biotic and abiotic stresses; Breeding for pest resistance - mechanisms of resistance; Breeding for disease resistance - mechanisms of resistance; Breeding for Abiotic stress – drought and cold. – mechanisms of resistance; Breeding for Abiotic stress – salinity and alkalinity - mechanisms of resistance; Breeding for quality produce; Ideotype breeding,

Unit V: Maintenance breeding

Types of cultivars – procedure for release of new varieties – stages in seed multiplication – seed certification and TC plants certification. Maintenance Breeding: General seed production techniques – steps in nucleus and breeder seed production – varietal rundown and renovation. Current trends in Plant Breeding- Marker assisted breeding -Transgenic crops - Varietal protection and geographical indications –DNA fingerprinting. PPV & FR act, 2001- Plant breeders' right, Farmers right, Biodiversity act, 2002; Germplasm registration.

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; Maintanance

of experimental records; Learning techniques in hybrid seed production using male sterility in field crops.

Theory schedule

1. Objectives and role of plant breeding - historical perspective
2. Activities in Plant Breeding-Centres of origin – contribution of Vavilov- law of homologous series.
3. Plant genetic resources – importance – germplasm – types
4. Modes of reproduction – sexual – asexual - self and cross fertilization – significance of pollination- Self incompatibility – classifications – mechanisms – application
5. Sterility – male sterility CMS,GMS,CGMS-inheritance and applications
6. TGMS,PGMS, Gametocides, Transgenic Male sterility and applications.
7. Apomixis – introduction - classification-applications; Parthenocarpy and its types
8. Basic biometrics-nature and significance of qualitative and quantitative variation-phenotypic, genotypic and environmental-heritability and genetic advance.
9. Plant introduction as a breeding method – types of introduction – objectives – quarantine - acclimatization – achievements - merits and demerits
10. Genetic basis of self pollinated crops – Vilmorin principle of progeny selection
11. Breeding methods for self pollinated crops without involving artificial hybridization - Breeding methods of self pollinated crops involving artificial hybridization
12. Creating variability in self pollinated crops
13. Steps in hybridization - kinds of emasculation. Pedigree breeding – procedure – mass pedigree – merits – demerits – achievements - Bulk breeding , Single Seed Descent (SSD) method
14. Backcross breeding– multi lines and multi blends - population improvement approach in self-pollinated crops.
15. Genetic structure of a population in cross pollinated crop – Hardy Weinberg law – gene frequencies in random mating population
16. Principles in population improvement.
17. **Mid-semester examination**
18. Breeding methods of cross pollinated crops without involving artificial hybridization: Mass selection
19. Breeding methods of cross pollinated crops involving artificial hybridization: Recurrent selection
20. Heterosis breeding – genetic basis – hybrid vigour – estimation of heterosis – inbreeding depression – development of inbreds
21. Heterosis breeding – procedure – use of male-sterility systems and manual emasculation in hybrid seed production
22. Maintenance of parental lines -types of hybrids – achievements – merits and demerits - Bulk breeding, Single Seed Descent (SSD) method
23. Backcross breeding– multi lines and multi blends - population improvement approach in self-pollinated crops.
24. Mutation breeding: mutation – types – mutagens – breeding procedure – applications – achievements – limitations
25. Breeding for biotic and abiotic stresses; Breeding for pest resistance - mechanisms of resistance
26. Breeding for disease resistance - mechanisms of resistance - Breeding for Abiotic stress – drought and cold
27. Mechanisms of resistance - Breeding for Abiotic stress – salinity and alkalinity - mechanisms of resistance
28. Breeding for quality produce; Ideotype breeding - Types of cultivars – procedure for release of new varieties
29. Stages in seed multiplication – seed certification and TC plants certification
30. Maintenance Breeding: General seed production techniques – steps in nucleus and breeder seed production - varietal rundown and renovation. Current trends in Plant Breeding
31. Marker assisted breeding -Transgenic crops
32. Varietal protection and geographical indications – DUS. PPV &FR act, 2001
33. Plant breeders' right, Farmers right
34. Biodiversity act, 2002; Germplasm registration.

Practical schedule

1. Pollination and reproduction in plants
2. Alternation of generation and life cycle, preparation of herbarium
3. Description and drawing different pollination systems - Mechanisms enforcing Self and cross pollination in crops; Pollen morphology - Exine structure of different crops
4. Breeder kit and its components – uses; Basic steps of selfing and crossing techniques.
5. Emasculation and pollination techniques in field crops.
6. Emasculation and pollination techniques in horticultural crops.
7. Studies on segregating generations and maintenance of records.
8. Fertility and sterility in A, B, R and TGMS lines - Maintenance of A, B and R line and TGMS lines

9. Hybrid seed production techniques
10. Estimation of heterosis.
11. Studies on different wild species in crop plants and wide hybridization.
12. Irradiation - dosimetry - half life period - procedure for irradiation of seeds and planting materials. Chemical mutagenesis - molar solution preparation - procedure for chemical mutagenesis of seeds and planting materials.
13. Calculation of PCV, GCV, heritability, genetic advance, genetic divergence
14. Layout of different yield trials - Observing the experimental plots; Visit to nucleus and breeder seed production plots.
15. Screening methods – laboratory and field – for biotic and abiotic stresses.
16. Procedure for marker assisted selection.
17. **Final Practical Examination**.

References

1. Allard, R. W.1981. Principles of Plant Breeding. John Wiley & Sons, London.
2. Chopra, V.L. 2001. Breeding Field Crops. Oxford & IBH, New Delhi.
3. Chopra, V.L. 2004. Plant Breeding. Oxford & IBH, New Delhi.
4. Singh, B.D.2006. Plant Breeding. Kalyani Publishers, New Delhi.
5. Singh, P. 2002. Objective Genetics and Plant Breeding. Kalyani Publishers, New Delhi.
6. Singh, P. 2006. Essentials of Plant Breeding, Kalyani Publishers, New Delhi.

Outcome

- Students will be well versed in practical emasculation and pollination methods of important crops.
- To understand the various components to structure a plant breeding programme.
- Know the requirements in breeding for biotic and abiotic stress tolerant varieties.
- Learn the impact of IPRs including PBR, PVP and PPVFRA
- Students will acquire independent ability to carry out statistical analysis of data and interpretation of results in breeding programs.

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1		**2**						
CO2		**2**						
CO3		**2**						
CO4							**3**	
CO5			**1**					

GGPB23 613 BREEDING FIELD CROPS - I (2+1)

Learning objectives

- To impart knowledge about the floral biology, crossing techniques, objectives of breeding and wild species as donors for resistant traits.
- To provide insight into recent advances in improvement of cereals, pulses, fibres and oil seeds using conventional and modern biotechnological approaches.

Unit I : Major Cereals

Origin, Evolution, and distribution of cultivated species – wild relatives and germplasm: Genetics and cytogenetics and genome relationship – breeding objectives – yield, quality characters, biotic and abiotic stress resistance etc – variety release – seed production in the following crops. Rice, Wheat, Maize, Sorghum, Pearl Millet

Unit II : Minor Cereals

Ragi, Varagu, Samai, Thinai, Panivaragu

Unit III : Pulses

Redgram, Greengram, Blackgram, Cowpea, Bengalgram, Horsegram, Field and garden beans

Unit IV : Oil Seeds

Groundnut, Soybean, Sesame, Sunflower, Safflower,

Unit V : Oil Seeds

Mustrad, Castor, linseed, Coconut, Oil palm,

Practical

Floral morphology – Emasculation techniques – crossing techniques in the following crops. Rice, Maize, Sorghum, Pearl millet, Redgram, Greengram, Blackgram, Cowpea, Bengalgram, Field and garden beans, Groundnut, Soybean, Sesame, Sunflower, Castor and coconut.

Theory schedule

1. Breeding of Rice
2. Breeding of Rice
3. Breeding of Rice
4. Breeding of Wheat
5. Breeding of Wheat
6. Breeding of Maize
7. Breeding of Maize
8. Breeding of Sorghum
9. Breeding of Sorghum
10. Breeding of Pearl Millet
11. Breeding of Pearl Millet
12. Breeding of Ragi
13. Breeding of Varagu,
14. Breeding of Samai,
15. Breeding of Thinai,
16. Breeding of Panivaragu
17. **Mid –semester examination**
18. Breeding of Redgram
19. Breeding of Greengram,
20. Breeding of Blackgram
21. Breeding of Cowpea
22. Breeding of Bengal gram
23. Breeding of Horsegram
24. Breeding of Beans
25. Breeding of Groundnut,
26. Breeding of Soybean
27. Breeding of Sesame
28. Breeding of Sunflower
29. Breeding of Safflower
30. Breeding of Mustard
31. Breeding of Castor

32. Breeding of linseed,
33. Breeding of Coconut
34. Breeding of Oil palm

Practical schedule

1. Emasculation and crossing techniques of Rice
2. Emasculation and crossing techniques of Maize
3. Emasculation and crossing techniques of Sorghum
4. Emasculation and crossing techniques of Pearl Millet
5. Emasculation and crossing techniques of Redgram
6. Emasculation and crossing techniques of Greengram and Blackgram
7. Emasculation and crossing techniques of Cowpea and Bengalgram
8. Emasculation and crossing techniques of Field and garden beans
9. Emasculation and crossing techniques of Groundnut
10. Emasculation and crossing techniques of Soybean
11. Emasculation and crossing techniques of Sesame
12. Emasculation and crossing techniques of Sunflower
13. Emasculation and crossing techniques of Castor
14. Emasculation and crossing techniques of Mustard and linseed
15. Emasculation and crossing techniques of Coconut
16. Emasculation and crossing techniques of Oil palm
17. **Final Practical examination**

References

1. Bahl, P.N., P.N. Salimath and A.K. Mandal, 1998, Genetics, Cytogenetics and Breeding of crop Plants, Oxford and IBH Publishers & Co., New Delhi.
2. Chopra, V.L. 1994 Plant breeding – Theory and Practices. Oxford and IBH Publishers, New Delhi.
3. Hari Har Ram and Hari Govind Singh. 2006. Crop breeding and genetics, Kalyani Publishers, New Delhi.
4. Singh, D.P. 1991. Genetics and Breeding of pulse crops. Kalyani Publishers, New Delhi.

Outcome

- Acquire knowledge on floral biology and selection of proper breeding method.
- Cultivate skill in emasculation and pollination of various crop plants.
- Gain expertise on hybrid seed production techniques.
- Learn to use the descriptors in various crops for selection of superior genotypes.

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	**1**	**2**						
CO2		**2**						
CO3		**3**						
CO4		**2**						

GGPB23 621 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 : Continuous variation

Introduction – Degree of Statistics : First degree, Second degree, third degree statistics – Mendelian traits and 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 : Analysis of variance

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

Unit – III : Plant Breeding Experiments

Designs of plant breeding experiments – principles and applications; Genetic diversity analysis – metroglyph, cluster and D^2 analysis – Association analysis – phenotypic and genotypic correlations ; Path analysis and Parent – progeny regression analysis – Selection indices – selection of parents – Concepts of selection – selection intensity, selection differential and types of selection – selection responses for additive and non-additive traits, heritability and genetic advance.

Unit – IV : Gene Action

Heterosis and inbreeding depression – Mating designs – Diallel, partial diallel, line x tester analysis, NCD's and Triple Test Cross analysis (TTC) - Generation mean analysis: scaling techniques

Unit – V : GxE and QTL

Models for GxE analysis and stability parameters; AMMI analysis – GGE bi plot technique principles and interpretation – 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) – selection based on marker and phenotype – factors influencing MAS.

Practical

Problems on multiple factor inheritance – Partitioning of variance – Estimation of heritability and genetic advance – Covariance analysis – D^2 analysis – 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's and their interpretations – Line x tester analysis and interpretation of results – Estimation of heterosis – estimation of inbreeding depression – Scaling test - Generation mean analysis; analytical part and interpretation – Estimation of different types of gene actins. Partitioning of phenotypic variance – GxE analysis – Construction of saturated linkage maps and QTL mapping – strategies for QTL mapping ; statistical methods in QTL mapping ; Phenotype and Marker linkage studies – Use of software's in statistical analysis

Theory schedule

1. Introduction for biometric Genetics
2. First degree, Second degree, third degree statistics
3. Mendelian traits and polygenic traits
4. Multiple factor hypothesis
5. Analysis of continuous variation
6. Variance and covariance analysis
7. Nature of gene action – additive, dominance, epistatic and linkage effects.
8. Principles of analysis of Variance (ANOVA)
9. Expected variance of components - random and fixed models;
10. MANOVA - biplot analysis
11. Comparison of means and variances for significance.
12. Designs of plant breeding experiments - principles and applications
13. Genetic diversity analysis – metroglyph, cluster
14. D^2 analysis
15. Association analysis – phenotypic and genotypic correlations
16. Path analysis and Parent – progeny regression analysis

17. **Mid semester examination**
18. Selection indices – selection of parents – Concepts of selection – selection intensity, selection differential and types of selection
19. Selection responses for additive and non-additive traits,
20. Heritability and genetic advance.
21. Heterosis and inbreeding depression
22. Mating designs – Diallel, partial diallel,
23. Line x tester analysis
24. NCDs and Triple Test Cross (TTC)
25. Generation mean analysis
26. Scaling techniques
27. Models for GxE analysis
28. Stability parameters
29. AMMI analysis – principles and interpretation
30. QTL mapping ; Strategies for QTL mapping
31. Desired populations for QTL mapping
32. Statistical methods in QTL mapping – QTL mapping in genetic analysis
33. Marker assisted selection (MAS) – selection based on marker and phenotype
34. Factors influencing MAS.

Practical schedule

1. Problems on multiple factor inheritance
2. Estimation of heritability and genetic advance
3. D^2 analysis
4. Correlation analysis
5. Path analysis
6. Parent progeny regression analysis
7. Diallel analysis - Griffing's methods I and II
8. Diallel analysis - Hayman's graphical approach
9. NCD and their interpretations
10. Line x tester analysis
11. Estimation of heterosis and inbreeding depression
12. Scaling test
13. Generation mean analysis Introducing, deriving data for various generations
14. G x E analysis : Stability parameters
15. Construction of saturated linkage maps and QTL mapping – strategies for QTL mapping ; statistical methods in QTL mapping
16. Phenotype and Marker linkage studies
17. Use of software's in statistical analysis

References

1. Bos, I. and Caligari, P. 1995. Selection methods in Plant Breeding. Chapman and Hall, London.
2. Falconer, D.S. and Mackay, J. 1998. Introduction to Quantitative Genetics. Longman, London.
3. Mather, K. and Jinks, J.L. 1971. Biometrical Genetics, Chapman and Hal,. London.
4. Mather, K. and Jinks, J.L. 1983. Introduction to Biometrical Genetics, Chapman and Hall, London.
5. Nadarajan, N., Manivannan. N. and Gunasekaran, M. 2016. Quantitative Genetics and Biometrical Techniques in Plant Breeding, Kalyani Publishers, New Delhi.
6. Singh, RK. and Choudhary, BD. 2012. Biometrical methods in Quantitative Genetics. Kalyani Publishers, New Delhi.
7. Singh, P and Narayanan, S.S. 2017. Biometrical techniques in plant breeding, Kalyani Publishers, New Delhi.

Outcome

Learn principles and methodologies of quantitative genetics so the students are able to:

- Analyze and evaluate literature involving quantitative genetic experiments.
- Design and analyze quantitative genetic experiments.
- Statistically analyze the phenotypic data of plant traits collected taking into account G x E interaction.
- Manage breeding populations to maximize progress from selection for accomplishment of breeding objectives.

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	**1**							
CO2		**2**	**3**					
CO3			**3**					
CO4		**3**						

GGPB23 622 PRINCIPLES OF CYTOGENETICS (2+1)

Objective

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

Theory

Unit I : Chromosome architecture

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, 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- chemical composition of chromosomes and staining properties

Unit II : Chromosomal aberrations

Variation in chromosome structure: Evolutionary significance -Introduction to techniques for karyotyping; Chromosome banding and painting - *in situ* hybridization and various applications; 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 III : Polyploidy

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 –meiotic behavior in apomicts- Evolutionary and genetic problems in crops with apomixis.

Unit IV : Interspecific hybridization

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 V : Wide hybridization

Fertilization barriers in crop plants at pre-and post fertilization 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 Rice, 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.

Theory Schedule

1) Architecture of chromosome in prokaryotes and eukaryotes
2) Artificial chromosome construction and its uses
3) Special types of chromosomes - Chromosomal theory of inheritance.
4) Cell Cycle and cell division – mitosis and meiosis;
5) Recombination models, cytological basis- differences, significance and deviations
6) Cytological basis- chemical composition of chromosomes. Synapsis, structure and function of synaptonemal complex and spindle apparatus, anaphase movement of chromosomes and crossing over.
7) Mechanisms and theories of crossing over- recombination models, cytological basis.
8) Variation in chromosome structure- numerical aberration.
9) Evolutionary significance of chromosomal aberration.
10) Introduction to techniques for karyotyping and dye binding properties of chromosomes.
11) Chromosome banding and painting
12) *In situ* hybridization and various applications.
13) Euploidy -haploids, diploids and polyploids.
14) Utilization of aneuploids in gene location.
15) Variation in chromosome behaviour - somatic segregation and chimeras – endomitosis and somatic reduction. Evolutionary advantages of autopolyploids vs allopolyploids.
16) Balanced lethals and chromosome complexes. Role of aneuploids in basic and applied aspects of crop breeding.
17) **Mid-semester examination**
18) Inter-varietal chromosome substitutions - Polyploidy and role of polyploids in crop breeding. Maintenance and utilization of polyploids in gene mapping.
19) Alien addition and substitution lines – creation and utilization.
20) Apomixis - Evolutionary and genetic problems in crops with apomixes .
21) Reversion of autopolyploids to diploids;
22) Genome mapping in polyploids.
23) Interspecific hybridization and allopolyploids .
24) Synthesis of new crops - wheat, triticale and brassica .
25) Hybrids between species with same chromosome number, alien translocations.
26) Hybrids between species with different chromosome number.
27) Gene transfer using amphidiploids - Bridge species
28) Fertilization barriers in crop plants at pre-and post fertilization levels.
29) *In vitro* techniques to overcome the fertilization barriers in crops.
30) Chromosome manipulations in wide hybridization.
31) Production of doubled haploids.
32) Maintenance of cytogenetics stock.
33) Somaclonal variation.
34) FISH and GISH, Anther culture and ovule culture.

Practical Schedule

1) Learning the cytogenetics laboratory, various chemicals to be used for fixation, dehydration, embedding, staining, cleaning etc.
2) Microscopy: various types of microscopes
3) Observing sections of specimen using Electron microscope; Preparing specimen for observation
4) Fixative preparation and fixing specimen for light microscopy studies in cereals
5) Studies on the course of mitosis in wheat, pearl millet - Studies on the course of mitosis in onion and *Aloe vera*
6) Studies on the course of meiosis in cereals, millets and pulses - Studies on the course of meiosis in oilseeds and forage crops
7) Using micrometers and studying the pollen grain size in various crops
8) Various methods of staining and preparation of temporary and permanent

slides

9) Pollen germination *in vivo* and *in vitro;* Microtomy and steps in microtomy
10) Agents employed for the induction of various ploidy levels
11) Solution preparation and application at seed, seedling level - Identification of polyploids in different crops - Induction and identification of haploids
12) Anther culture and Ovule culture - Morphological observations on synthesized autopolyploids
13) Observations on C-mitosis, learning on the dynamics of spindle fibre assembly - Morphological observations on allopolyploids
14) Morphological observations on aneuploids - Cytogenetic analysis of interspecific and intergeneric crosses
15) Maintenance of Cytogenetic stocks and their importance in crop breeding - Various ploidy levels due to somaclonal variation
16) Polyploidy in ornamental crops. -Fluorescent *in situ* hybridization (FISH)- Genome *in situ* hybridization GISH
17) **Final practical Examination**

References

1) Charles, B. 1993. Discussions in Cytogenetics. Prentice Hall, USA.
2) Georger Allen & Unwin Elgin, S.C.R. 1995. Chromatin Structure and Gene Expression. IRL Press, New York.
3) Becker K & Hardin. 2004. The World of Cell. 5th Ed. Pearson Edu.
4) Khush, G.S. 1973. Cytogenetics of Aneuploids. Academic Press, USA.
5) Sharma, A.K. & Sharma, A. 1988. Chromosome Techniques: Theory and Practice. Butterworth, London.
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10) Singh RJ (2003). Plant Cytogenetics (Second Edition). CRC Press, Taylor & Frances group.
11) Singh RJ and Prem P. Jauhar (Eds.) (2005). Genetic Resources, Chromosome Engineering, and Crop Improvement: Grain Legumes, Volume I. CRC Press, Taylor & Frances group

Outcomes

The students can learn to

- Understand the basics of chromosome structure and occurrence of cytogenetic abnormalities
- Fix and count meiotic and mitotic chromosomes of major crops
- Analyse chromosome abnormalities in inter-specific crosses
- The student will be able to carry out cytological analysis in breeding populations.

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	**1**							
CO2	**1**							
CO3	**2**							
CO4		**2**						

GGPB23 623 BREEDING FIELD CROPS - II (2+1)

Learning objectives

- To impart knowledge about the genetic means of taming, training and improving crop plants
- To provide insight into recent advances in improvement of fibers, sugar crops, vegetables and forage crops using conventional and modern biotechnological approaches.

Unit I : Cash Crops

Origin, Evolution, and distribution of cultivated species – wild relatives and germplasm: Genetics and Cytogenetics and genome relationship – breeding objectives – yield, quality characters, biotic and abiotic stress resistance etc – variety release – seed production in the following crops Cotton, Jute, Mesta and Tobacco

Unit II : Sugar Crops

Sugarcane, Potato, Sweet Potato, Cassava

Unit III : Tropical Vegetable

Brinjal, Tomato, Chillies, Bhendi, Gourds, Onion and Beans

Unit IV : Temperate Vegetable

Cabbage, Knolkhol, Radish, Carrot, Turnip, Beetroot

Unit V : Forage crops

Fodder sorghum, Maize, Cumbu, Napier grass, Cumbu napier hybrid, Forage cowpea, Desmodium, Desmanthus, Lucerne and Pillipesara.

Practical

Floral morphology – Emasculation techniques – crossing techniques in the following crops. Cotton, Jute, Mesta, Sugarcane, Potato, Sweet Potato, Tobacco, Cassva, Brinjal, Tomato, Chillies, Bhendi, Gourds, Onion, and Beans

Theory Schedule

1. Breeding of Cotton
2. Breeding of Cotton
3. Breeding of Jute
4. Breeding of Mesta
5. Breeding of Sugarcane
6. Breeding of Sugarcane
7. Breeding of Sugarcane
8. Breeding of Potato
9. Breeding of Sweet Potato
10. Breeding of Tobacco
11. Breeding of Cassava
12. Breeding of Tomato
13. Breeding of Brinjal
14. Breeding of Chilles
15. Breeding of Bhendi
16. Breeding of Gourds
17. **Mid semester examination**
18. Breeding of Cabbage
19. Breeding of Onion
20. Breeding of Beans
21. Breeding of Knolkhol
22. Breeding of Radish
23. Breeding of Carrot
24. Breeding of Turnip

25. Breeding of Beetroot
26. Breeding of Forage Surghum
27. Breeding of Forage Maize
28. Breeding of Forage Cumbu
29. Breeding of Cumbu X Napier Hybrid
30. Breeding of Forage Cowpea
31. Breeding of Desmodium
32. Breeding of Desmanthus
33. Breeding of Lucerne
34. Breeding of Pillipesara

Practical Schedule

1. Emasculation and crossing techniques of Cotton
2. Emasculation and crossing techniques of Jute and Mesta
3. Emasculation and crossing techniques of Sugarcane
4. Emasculation and crossing techniques of Potato
5. Emasculation and crossing techniques of Sweet Potato
6. Emasculation and crossing techniques of Tobacco
7. Emasculation and crossing techniques of Cassava
8. Emasculation and crossing techniques of Brinjal
9. Emasculation and crossing techniques of Tomato
10. Emasculation and crossing techniques of Chillies
11. Emasculation and crossing techniques of Bhendi
12. Emasculation and crossing techniques of Gourds
13. Emasculation and crossing techniques of Onion
14. Emasculation and crossing techniques of Beans
15. Emasculation and crossing techniques of Forage maize and sorghum.
16. Emasculation and crossing techniques of legume fodder
17. **Final Practical examination**

References

1. Agarwal, R.L. 1996. Identifying characteristics of crop varieties. Oxford & IBH Publishing Co Pvt. Ltd., New Delhi.
2. Ahlren, G.H. 1956. Forage crops. Mc Graw Hill Book Co., New York.
3. Munro, J.M. 1987. Cotton. Longman, New York.
4. Hari Har Ram, 1998. Vegetable Breeding- Principles and Practices. Kalyani Publishers, New Delhi.
5. Chadha, L. and G. Kalloo. (eds). Advances in Horticulture. Vol.5. Vegetable crops. Part1, Malhotra Publishing House , New Delhi.

Outcomes

- Acquire knowledge on floral biology and selection of proper breeding method.
- Cultivate skill in emasculation and pollination of various crop plants.
- Gain expertise on hybrid seed production techniques.
- Learn to use the descriptors in various crops for selection of superior genotypes.
- Students will be able to independently plan and design breeding experiments for crop improvement.
- Will be capable of handling segregating populations in major crops.

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	**1**							
CO2		**2**						
CO3		**2**						
CO4		**2**			**3**			
CO5		**3**						

GGPB23 624 BIOTECHNOLOGY FOR CROP IMPROVEMENT (2+0)

Learning Objectives

- To impart knowledge and practical skills to use biotechnology tools in crop improvement.

Unit I : Introduction to Biotechnology

Biotechnology and its relevance in agriculture; Definition, terminologies and scope in plant breeding. Tissue culture – History, callus, suspension cultures, cloning; Regeneration; Somatic embryogenesis; Anther culture; somatic hybridization techniques; Meristem, ovary and embryo culture; cryopreservation.

Unit II : Various techniques in biotechnology & mapping sequences

Techniques of DNA isolation, quantification and analysis; Genotyping; Sequencing techniques; Vectors, vector preparation and cloning, Biochemical and Molecular markers: RFLP, RAPD, AFLP, SSR, SNPs, ESTs etc.), mapping populations (F_2'S, back crosses, RILs, NILs AND DH), Next generation sequencing, GCMS, DNA fingerprinting.

Unit III : Molecular analysis and genome mapping

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. Genomics and geoinformatics. Integrating functional genomics information in plant breeding; Marker-assisted backcross breeding for rapid introgression.

Unit IV : Transgenic plants & genetic engineering

Recombinant DNA technology, transgenes, method of transformation, selectable markers and clean transformation techniques, vector-mediated gene transfer, direct gene transfer - physical methods of gene transfer. Production of transgenic plants in various field crops: cotton, wheat, maize, rice, soybean, oilseeds, sugarcane etc., Commercial releases – Edible vaccine production through genetic engineering – Blue Rose, Orange Petunia – Insect and disease resistance

Unit V : Biotechnology applications, IPR & Bioinformatics

Biotechnology applications in male sterility/hybrid breeding molecular farming, GMO's- related issues- risks and regulations regulatory procedures in major countries including India, ethical, legal and social issues; intellectual property rights. Bioinformatics ; Nanotechnology and its application in crop improvement programmes.

Theory schedule

1. Biotechnology and its relevance in agriculture definitions and terminologies and history of plant tissue culture
2. Plant tissue culture : general techniques. Tissue culture media – composition and their readymade availability, importance of the nutrients added and their function
3. Culture establishment : cell, callus and organ cultures and special types.
4. Morphogenesis *in vitro* – introduction, influencing factors.
5. Organogenesis and embryogenesis
6. In vitro culture methods and applications meristem culture
7. Anther and pollen culture – applications and achievements
8. *In vitro* pollination and in vitro fertilization techniques, ovary, ovule, embryo and endosperm culture
9. Protoplast isolation and its culture
10. Somatic hybridization
11. Somaclonal variation and applications
12. Tissue culture and germplasm maintenance – cryopreservation
13. Techniques of DNA isolation, quantification and analysis
14. Genotyping, gene sequencing techniques
15. Vectors, vector preparation and cloning
16. Bio-chemical markers
17. **Mid- semester examination**

18. Molecular markers – RFCP, RAPD, AFCP
19. SSR, SNPS ESTS etc.
20. Molecular mapping and tagging of agronomically important traits
21. Statistical tools in marker analysis
22. Robotics
23. Marker assisted selection for qualitative traits
24. QTL analysis
25. Gene pyramiding
26. Genomics and geoinformatics
27. Functional genomics and plant breeding
28. Marker assisted back cross breeding
29. Methods of transformation
30. Vector mediated gene transfer, direct gene transfer
31. Transgenic plants in cotton, maize, wheat, rice, soybean, oilseeds, sugarcane etc.
32. Biotechnology applications in hybrid breeding
33. GMO's related issues and intellectual property rights
34. Bio informatics and nano-technology in crop improvement programme.

References

1. Chopra, V.L & Nasim, A. 1990. Genetic Engineering and Biotechnology: concepts, methods and application, Oxford & IBH, New Delhi.

2. Gupta, P.K. 1997. Elements of Biotechnology, Rastogi Publications. Meerut.

3. Hackett, P.B., Fuchs, J.A, and Messing, J.W. 1988. An Introduction to Recombinant DNA technology – Basic experiments in gene manipulation 2nd Ed. Benjamin Publishers, London.

4. Sambrook, J. and Russel, D. 2001. Molecular cloning – a laboratory Mannal. 3rd Ed. Cold spring Harbor Lab press, USA.

5. Singh, B.D. 2005. Biotechnology, Expanding Horizons, Kalyani Publications, New Delhi.

6. Satyanarayana, U. 2008, Biotechnology, Books & Allied Ltd.,

Outcome

- Ability to apply the concepts and principles of plant tissue culture techniques on research problems pertinent to crop improvement ,
- Dissemination of skills on usage of the acquired knowledge on practical biotechnology tools to augment plant breeding research.
- The knowledge required to execute, analyze and apply molecular marker systems for crop improvement.

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	**1**							
CO2		**2**				**3**		
CO3		**2**						

OPC- GGPB23 621 CONCEPTS OF CROP PHYSIOLOGY (2+1)

Learning objectives

- To impart knowledge in understanding the physiological processes taking place during growth and development of plants.
- To understand source sink relationship in different groups of plants and also hormonal, environmental and stress physiology in crop plants.

Theory

Unit I : Photo physiology

Role of physiology in different branches of agriculture. Physiological processes on productivity – Photosynthesis – Mechanism of light interaction. Physiological processes influenced by radiation. Light and phytochrome mediated processes. – CO_2 reduction – utilization of assimilatory power and carbohydrate synthesis - C_3, C_4 and CAM mechanisms – Major differences.

Unit II : Growth and Development

Growth Vs Development.. Dry Matter Accumulation and Harvest Index – components of Dry Matter Accumulation and Harvest Index and their role in productivity. Growth analysis. Photorespiration and dark respiration.

Unit III : Source sink relationship

LAI and its components –interception of solar energy. Photosynthates partitioning – source – sink relationship – mode of partitioning at different stages in different species. Role of growth regulators in monitoring source and sink.

Unit IV : Environmental physiology

Green house effect and Global warming. Ozone layer depletion - Causes, effects. CO_2 enrichment and plant productivity. Physiology of crops under high altitude and flooding – air pollution and plant growth – effect of effluent on plant growth.

Unit V : Stress physiology

Mechanisms of drought, salt, cold, heat and UV radiation stress tolerance – adaptation of crop plants – crop management practices under unfavourable situations – Importance of selection indices for crop productivity – recent advances in physiological research.

Practical

Leaf Area measurement – measurement of leaf angle and interception of solar radiation – light transmission ratio – measurement of photosynthesis – difference in the photosynthetic rate between the leaves at different position – photosynthetic efficiency of C_3 and C_4 plants – estimation of chlorophyll – RuBP case and PEP case – Measurement of respiration – Growth regulation – response to source and sink relationship – Measurement of water potential and its component. Measurement of leaf temperature, diffusive resistance and transpiration rate – use of antitranspirants – yield component analysis – study of selection indices.

Lecture Schedule

Theory

1. Role of physiology in different branches of agriculture
2. Physiological processes on productivity
3. Photosynthesis – Mechanism of light interaction
4. Photo Physiology
5. Physiological processes influenced by radiation
6. Light and phytochrome mediated processes
7. Utilization of assimilatory power and CH_2O synthesis
8. C_3-C_4 and CAM mechanisms and major differences
9. Photosynthetic measurements
10. Germination, growth and development
11. DMA and HI. Components of DMA and HI.
12. Role of DMA, LAI and HI in crop productivity
13. Growth analysis
14. Photorespiration and dark respiration
15. Oxidative phosphorylation.
16. Release and utilization of energy for various metabolisms.

17. **MID-SEMESTER EXAMINATION**
18. Interception of solar energy
19. Source-sink relationship
20. Photosynthate partitioning
21. Mode of partitioning at different stages and different species
22. Role of growth regulators in monitoring source-sink relationship
23. Growth regulators – auxins, gibberellins and cytokinins, biosynthesis, functions and agricultural role.
24. Abscisic acid and ethylene. Biosynthesis, functions and agricultural role.
25. Growth retardants. Role in agricultural and horticultural crops
26. Green house effect and plant productivity.
27. CO_2 enrichment and plant productivity.
28. Physiology of crops under high altitude flooding, air and water pollution
29. Water stress, effect of water stress on various physiological processes
30. Mechanisms of adaptation to stress condition.
31. Salt stress, classifications and its effects on physiological processes of plant
32. Temperature stress – cold tolerance – adaptation
33. Heat stress – Heat shock proteins – heat tolerance – adaptation.
34. Recent advances in physiological research

Practical Schedule

1. Leaf area index measurement. Measurement of leaf angle and interception of solar radiation
2. Measurement of photosynthesis
3. Determination of Photosynthetic efficiency of various crop plants
4. Estimation of soluble protein content
5. Estimation of chlorophyll contents
6. Estimation of water potential
7. Determination of chlorophyll stability index
8. Estimation of relative water content
9. Estimation of leaf proline content
10. Measurement of leaf temperature, diffusive resistance and transpiration
11. Growth analysis of field crops
12. Determination of nitrate reductase activity
13. Determination of IAA oxidase activity
14. Estimation of total phenolics
15. Estimation of peroxidase activity
16. Estimation of catalase activity
17. **FINAL PRACTICAL EXAMINATION**

References

1. Devlin, B. 1983. Plant Physiology. Narosa Publishing House, New Delhi.
2. Franklin P. Gardner, R. Brent Pearce and Roger L. Mitchell,1988. Physiology of crop plants. Scientific Publishers, Jodhpur.
3. Gupta, U.S. 1988. Progress in Crop Physiology. Oxford IBH Publishing Co. Pvt., Ltd., New Delhi.
4. Kumar, A. and S.S. Purohit. 1996. Plant Physiology. Agro Botanical Publishers, Bikaner.
5. Lincoln Taiz, Eduardo Zeiger. 2002. Plant Physiology 2nd Edition. Replica press Pvt. Ltd., Delhi.
6. Noggle, G.R. and G.J. Fritz. 1986. Introductory Plant Physiology. Prentice Hall of India Ltd., New Delhi.
7. Panday, S.N. and B.K.Sinha. 1972. Plant Physiology. Vikas Publishing House Pvt. Ltd., New Delhi.
8. Price, C.A. 1974. Molecular approaches to plant physiology. Tata MCGraw Hill Publishing Co. Ltd., New Delhi.
9. Purohit, S.S. 2005, Plant Physiology. Student Edition Agrobios, Jodhpur.
10. Purohit, S.S., Q.J. Shammi, and A.K. Agrawal, 2005. A Text book of Environmental sciences, Student Edition, Agrobios, Jodhpur.
11. Salisbury, F.B. and C.M.Ross. 2004. Plant Physiology. Thomson and Wadsworth publications, Belmont, California.

Outcome

- Will be able to identify the crop mineral nutrient deficiencies and their symptoms
- In addition, hands on exposure to preparation of solutions, analysis of pigment composition, estimation of growth analytical parameters,
- Will be able to diagnose and correct nutrient deficiencies,
- Will be competent in enzyme assays and application of plant growth regulators.

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	**1**							
CO2				**1**				
CO3		**1**		**2**				
CO4	**2**							

OPC- GGPB23 711 GERMPLASM COLLECTION, EXCHANGE AND QUARANTINE (2+1)

Learning Objectives

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

Theory

UNIT I : INTRODUCTION

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 : MATING SYSTEMS

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 : GERMPLASM COLLECTION

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 : STRATEGIES IN COLLECTION OF GERMPLASM

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 : PLANT QUARANTINE

History, principles, objectives and importance of plant introduction; Prerequisites, conventions, national and international legislations and policies on germplasm collection and exchange; Documentation and information management; Plant quarantine-introduction, history, principles, objectives and relevance; Regulations and plant quarantine set up in India. Post-entry quarantine operation, seed treatment and other prophylactic treatments and facilities; Domestic quarantine; seed certification; International linkages in plant quarantine; weaknesses and future thrust.

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. Use of visual, qualitative, quantitative, microscopic, molecular and plant growth related techniques(controlled green houses/growth chambers, etc); Study of post-entry quarantine operation, seed treatment and other prophylactic treatments.

THEORY SCHEDULE

1. History and importance of germplasm exploration.
2. Distribution and extent of prevalent genetic diversity
3. Phyto-geographical regions/ecological zones and associated diversity
4. Mapping eco-geographic distribution of diversity.
5. Plant exploration and collection;
6. Concept of population and gene pool .
7. Coarse and fine grid surveys.
8. Gene pool sampling in self and cross pollinated and vegetatively propagated species.
9. Non-selective, random and selective sampling strategies.
10. Strategies and logistics of plant exploration and collection.
11. Practical problems in plant exploration.
12. .*In vitro* methods in germplasm collection.
13. Ethno botanical aspects of PGR.
14. Identification of wild relatives of crop plants.
15. Collection, cataloguing and preservation of specimens.
16. Post-exploration handling of germplasm collections.
17. **Mid-semester examination**
18. Present status and future strategies in collection of major crops of Indian origin such as rice, maize, sorghum.

19. Present status and future strategies in collection of crops sesame, *Brassica*, okra, eggplant, cotton, mango.
20. History, principles, objectives and importance of plant introduction.
21. Documentation and information management
22. Importance and use of herbaria.
23. Preparation of herbarium specimens.
24. Sampling techniques of plant materials;
25. Plant quarantine- introduction, history, principles, objectives and relevance.
26. Regulations and plant quarantine set up in India.
27. Quarantine regulations.
28. Visual, qualitative, quantitative, microscopic, molecular and plant growth related techniques.
29. Study of post-entry quarantine operation.
30. Seed treatment and other prophylactic treatments.
31. Domestic quarantine.
32. Seed certification.
33. International linkages in plant quarantine.
34. Weaknesses and future thrust in plant quarantine

PRACTICAL SCHEDULE

1. Plant exploration and collection.
2. Handling of germplasm collections.
3. Preparation of herbarium specimens.
4. Identification of wild relatives of crop plants.
5. Techniques of coarse and fine grid surveys.
6. Identification of wild relatives of crop plants.
7. Example of collection.
8. Cataloguing of collection.
9. Preservation of specimens.
10. Sampling techniques of plant materials.
11. Visiting ports, airports to study the quarantine regulations.
12. Use of visual, microscopic, molecular and plant growth related techniques(controlled green houses/growth chambers, etc);
13. Qualitative and quantitative related techniques.
14. Study of post-entry quarantine operation.
15. Seed treatment and other prophylactic treatments.
16. Seed certification.
17. **Practical examination**

Suggested Readings

1. Briggs D. 1997. *Plant Variation and Evolution*. Science Publ.
2. Cronquist AJ. 1981. *An Integrated System of Classification of Flowering Plants*. Columbia Univ. Press.
3. Dhillon BS, Varaprasad KS, Kalyani S, Singh M, Archak S, Srivastava U & Sharma GD. 2001. *Germplasm Conservation A Compendium of Achievements*. NBPGR, New Delhi.
4. Di Castri F & Younes T. 1996. *Biodiversity Science and Development: Towards New Partnership*. CABI & International Union for Biol. Sci. France.
5. Gurcharan Singh. 2004. *Plant Systematics: An Integrated Approach*. Science Publ.
6. Lawrence GMH. (Ed.). 1951. *Taxonomy of Vascular Plants*. London.
7. Paroda RS & Arora RK. 1991. *Plant Genetic Resources Conservation and Management Concepts and Approaches*. IPGRI Regional office for South and South Asia, New Delhi.
8. Pearson LC. 1995. *The Diversity and Evolution of Plants*. CRC Press.
9. Singh BP. 1993. *Principles and Procedures of Exchange of Plant Genetic Resources Conservation and Management*. Indo-US PGR Project Management.
10. Sivarajan VV. 1991. *Introduction of Principles of Plant Taxonomy*. Science Publ.
11. Stace CA. Plant Taxonomy and Biosystematics 2nd Ed. Cambridge Univ. Press.
12. Takhrajan A. 1997. *Diversity and Classification of Flowering Plants*. Columbia Univ. Press.
13. Wiersema JH. 1999. *World Economic Plants: A Standard Reference*. Blanca Leon.

Outcome

- Students will have knowledge on the conservation of biodiversity
- They will be able to identify the various *insitu* and *exsitu* conservation techniques
- They will acquire knowledge on various organizations involved in conservation and their policies
- The students will have knowledge on plant quarantine regulations.

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	**1**						**3**	

CO2							**3**	
CO3							**2**	
CO4	**1**							

OPC- GGPB23 712 FUNDAMENDALS OF GENETICS (2+1)

Learning objectives

- The course imparts knowledge to the students about the structure organization, function and transmission of chromosomes and genes and variation among them,
- It explains the parallelism between the behaviour of chromosomes and genes.
- Principles involved in construction of linkage map and location of genes.
- Molecular genetics of gene organization and function: the effects of mutagens on biological system and evolution of crop plants.

THEORY

Unit I: Cytology

Earlier concepts of heredity – cell and cell organelles – Prokaryotes – Eukaryotes – study of mitosis and meiosis – cell cycle – Sporogenesis – Gametogenesis – Fertilization.

Unit II: Mendelian Genetics

Mendel's work – laws of heredity – Multiple alleles – gene interaction – penetrance – Expressivity – Pleiotropy – Modifying genes – Phenocopy – lethal genes – Multiple Factor hypothesis.

Unit III: Linkages

Linkage and Crossing over – Estimation of strength of linkage and crossing over value – two and three point test cross – genetic map – sex determination – genic balance theory – Sex linked – sex influenced and sex limited inheritance – cytoplasmic inheritance.

Unit IV: Cytogenetics

Chromosomal theory of inheritance – chromosome structure – chemical composition and nucleosome – Types of chromosomes – special chromosomes – Mutation – point mutation – Transition and Transversion – Variation in chromosome number and structure – Aneuploidy and Euploidy – Its genetic and cytological implications.

Unit V: Genetic at Molecular Level

Experiments showing DNA as genetic material – DNA Structure and function – DNA replication – Genetic code – central dogma of life – gene expression – protein synthesis and gene regulation – Operon concept – modern concept of gene.

PRACTICAL

Study of genetic ratios of – Monohybrid, Dihybrid, Polyhybrid, inheritance – co-dominance – incomplete dominance, gene interactions. Multiple alleles and Multiple factors. Study of linkage, estimation of strength of linkage and crossing over in two point and three point test cross – Drawing of genetic map – interference and coincidence. Preparation of fixatives and stains – Pretreatment of materials for mitosis and meiosis – Study of mitosis and meiosis.

THEORY SCHEDULE

1. Concept of heredity – Vapour and fluid theory, Magnetic power theory, Preformation theory – Lamarck's theory, Darwin's theory, Germplasm theory and Mutation theory.
2. Definition of genetics, heredity and inheritance
3. Definition and Brief history of cytogenetics; structure and functions of cell and organelles – Difference between prokaryotes and Eukaryotes. Physical basis of heredity: Structure and function of cell and cell organelles – Differences between Prokaryotes and Eukaryotes.
4. Chromosome structure, chemical composition, nucleosome, centromere, telomere, euchromatin, NOR, satellite chromosome - karyotype, ideogram – types of chromosomes based on position of centromere.
5. Study of mitosis and meiosis – Cell cycle.

6. Work of Mendel – Characters studies, his observations and interpretation s-reasons for his success – Law of dominance. Law of segregation and Law of independent assortment.
7. Rediscovery of Mendel's work, chromosomal theory of inheritance
8. Definitions of gene, alleles, homozygous, heterozygous, genome, phenotype, genotype, monohybrid, dihybrid, polyhybrid, backcross and test cross.
9. Lethal genes, Pleiotrophy with examples; phenocopy, penetrance and expressivity, Allelic interaction – Types – Complete dominance, incomplete dominance, Co-dominance and Over dominance with examples.
10. Non allelic interaction – epistatic and hypostatic genes, types of epistasis – Non – allelic interaction without modifications in Mendelian ratio – Bateson and Punnet's experiment on fowl comb shape.
11. Epistasis with modification of Mendelian ratio – 1) Dominant epistasts, ii) Recessive epistasis, iii) Duplicate and additive epistasis
12. Iv) Duplicate dominant epistasis, v) Duplicate recessive epistasts vi) Dominant and recessive epistasis.
13. Multiple alleles – characteristic features, study of blood group, coat colour in rabbits and self incompatibility in plants.
14. Multiple factor hypothesis – Nilson – Ehle – Wheat kernel colour experiment – polygenes – Transgressive segregation – Quantitative vs Qualitative characters and modifiers.
15. Linkage - coupling and repulsion - Experiment or Bateson and Punnet – Chromosomal theory of linkage of Morgan – Complete and incomplete linkage,
16. Crossing over – significance of crossing over - cytological proof for crossing over - Stern's experiment - Strength of linkage and recombination - Two point and three point test cross - Double cross over, interference and coincidence - genetic map.
17. **Mid-semester examination**
18. Sex determination – chromosomes mechanism of sex determination and its types – Genic balance theory of sex determination of Bridges.
19. Sex linked inheritance – Criss cross inheritance – reciprocal difference – Holandric genes – sex limited inheritance – sex determination in plants – *Melandrium*, papaya and maize.
20. Cytoplasmic inheritance – its characteristic features – examples of chloroplast, mitochondrial, plasmid and episomic inheritance.
21. DNA, the genetic material – Griffith's experiment, experiment of Avery, McCleod and McCarthy – confirmation by Hershey and Chase; RNA as genetic material – Frankel, Conrat and Singer experiment.
22. Structure of DNA – Watson and Crick model – mechanisms of DNA replication.
23. Models of DNA replication – Proof for semi-conservative method of DNA replication.
24. RNA types - mRNA, tRNA, rRNA; genetic code – Characteristic features – Central dogma of life.
25. Gene expression – protein synthesis.
26. Regulation of gene expression – operon model of Jacob and Monad; Structural genes and regulator genes.
27. Split genes, exons and introns – modern concept of gene – gene as cistron, muton and recon, complementation testy.
28. Special chromosomes – Polytene, Lamp brush. B. Ring and Iso chromosomes.
29. Variation in chromosome structure – deletion and duplication – genetic and cytological implications.
30. Inversion and translocation – genetic and cytological implications.
31. Variation in chromosome number – Euploid, aneuploid – types of euploids.
32. Polyploid – auto and allopolyploids.
33. Role of polyploidy in evolution of crops – wheat, cotton, tobacco and brassica
34. Types of aneuploids and their origin.

PRACTICAL SCHEDULE

1. Principles of dominance, recessive, back cross, test cross, incompletes and co-dominance and lethal factor – principles of Chi- square test.
2. Study on genetic ratios – monohybrid – incomplete dominance and test cross ratios and in combination of one or two of the above.
3. Dihybrid ratio – dominance, incomplete dominance and test cross ration and in combination of one or two of the above.
4. simple interaction of genes – comb character in fowls and Duplicate recessive epitasis.
5. Dominant epistasis and recessive epistasis.
6. Duplicate and additive epistasis. Duplicate dominant epistastis, duplicate recessive epistasis and dominant and recessive epistasis.
7. Multiple alleles and polygenic inheritance
8. Estimation of linkage with F_2 and test cross data, coupling and repulsion
9. Problems on two point test cross.
10. Three point test cross – working out interference, coincidence and drawing genetic maps.
11. Principles of killing and fixing – preparation of stains and preservatives
12. Studying the stages of mitosis and meiosis
13. Study of mitotic phases in root tips of onion / Aloe spa and Arabidopsis
14. Procedure for fixing and observing different meiotic phases in the inflorescence of Maize and pearl millet.
15. Repeating the exercise
16. Repeating the exercise with Maize, Pearl millet
17. Procedure for making temporary slides to permanent slides.

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14. Simmons S 2006, Principles of genetics, 4th Edition, John Wiley & Sons (Asia) Pte Ltd. New Jersey.

Outcome

1. Students will acquire comprehensive understanding of the chemical basis of heredity.
2. The knowledge required to design, execute, and analyze the results of genetic experimentation in Plant Breeding systems
3. Critical understanding on quantification of heritable traits that provides insight into cellular and molecular mechanisms.
4. The ability to evaluate conclusions that are based on genetic data.

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	**1**							
CO2		**2**	**1**					
CO3					**2**			
CO4			**3**					