

**Syllabus for  
Post Graduate Courses and  
Programme of Study for  
Master's Degree  
in  
Genetics and Plant Breeding of Affiliated  
Colleges  
(As per ICAR Recommendations  
for P.G. Degree)**

**Department of Genetics and Plant Breeding**  
**CCS University, Meerut – 250004 (U.P.)**

**M. Sc. (Ag) Genetics and Plant Breeding**

(As per ICAR Recommendations)

**Semester wise Course Distribution**

First Semester					
Course code	Course Title	Credit hours	Distribution of Marks		Total
			Theory	Internal	
J-1021	Principles of Genetics	3+1	50	50	100
J-1022	Principles of Cytogenetics	3+1	50	50	100
J1023	Principles of Plant Breeding	3+1	50	50	100
J-1004	Agricultural Statistics and Experimental Design	2+1	50	50	100
J-521	Practical				200

Second Semester					
Course code	Course Title	Credit Hours	Distribution of Marks		Total
			Theory	Internal	
J-2021	Principles of Quantitative Genetics	3+1	50	50	100
J-2022	Heterosis Breeding	3+1	50	50	100
J-2023	Cell Biology and Molecular Genetics	3+1	50	50	100
J-2024	Breeding cereals, Millets and Sugarcane	2+1	50	50	100
J-621	Practical				200

Third Semester					
Course code	Course Title	Credit hour	Distribution of Marks		Total
			Theory	Internal	
J-3021	Biotechnology for Crop Improvement	2+1	50	50	100
J-3022	Breeding for Biotic and Abiotic Stress Resistance	2+1	50	50	100
J-3023	Maintenance Breeding , Concepts of Variety Release and Seed Production	2+1	50	50	100
J-3024	Mutagenesis and Mutation Breeding	2+1	50	50	100
J-721	Practical				200

Fourth Semester					
Course Code	Course Title	Credit hour	Marks		Total
			Theory	Internal	
J-4021	Breeding Legumes, Oilseed and Fibre Crops	2+1	50	50	100
J-4022	Population Genetics	2+1	50	50	100
J-4023	Diseases and Pests of Crop Plants and their management	2+1	50	50	100
J-4024	Database Management, Evaluation and Utilization of PGR	2+1	50	50	100
J-821	Practical				200
J-822	Seminar	0+1		Internal	100
J-4025	Thesis –compulsory	20	Satisfactory/unsatisfactory		

# GENETICS AND PLANT BREEDING

## Course Contents

### J-1021 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.

#### Theory

##### UNIT I

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

##### UNIT II

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

##### UNIT III

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

##### UNIT IV

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

##### UNIT V

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

##### UNIT VI

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

##### UNIT VII

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

##### UNIT VIII

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

## Practical

Laboratory exercises in probability and chi-square; Demonstration of genetic principles using laboratory organisms; Chromosome mapping using three point test cross; Tetrad analysis; Induction and detection of mutations through genetic tests; DNA extraction and PCR amplification

Electrophoresis – basic principles and running of amplified DNA -Extraction of proteins and isozymes – use of *Agrobacterium* mediated method and Biolistic gun; practical demonstrations - Detection of transgenes in the exposed plant material; visit to transgenic glasshouse and learning the practical considerations.

## Suggested Readings

- Gardner EJ & Snustad DP. 1991. *Principles of Genetics*. John Wiley & Sons.
- Klug WS & Cummings MR. 2003. *Concepts of Genetics*. Peterson Edu.
- Lewin B. 2008. *Genes IX*. Jones & Bartlett Publ.
- Russell PJ. 1998. *Genetics*. The Benjamin/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.

J-1022

## PRINCIPLES OF CYTOGENETICS

### Objective

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

### Theory

#### UNIT I

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

#### UNIT II

Cell Cycle and cell division – mitosis and meiosis; Differences and significance – Synapsis, structure and function of synaptonemal complex and spindle apparatus, anaphase movement of chromosomes and crossing over-mechanisms and theories of crossing over- recombination models, cytological basis, - Variation in chromosome structure; Evolutionary significance - Introduction to techniques for karyotyping; Chromosome banding - *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 – Classification and role in plant Breeding..

#### UNIT V

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

#### UNIT VI

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

#### Practical

Learning the cytogenetics laboratory, various chemicals to be used for fixation, dehydration, embedding, staining, cleaning etc. - Microscopy: various types of microscopes, - Observing sections of specimen using Electron microscope; Preparing specimen for observation – Fixative preparation and fixing specimen for light microscopy studies in cereals - Studies on the course of mitosis in wheat, pearl millet - Studies on the course of mitosis in onion - 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 allopolyploids - 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 ; Fluorescent *in situ* hybridization (FISH)- Genome *in situ* hybridization GISH.

#### Suggested Readings

- Becker K & Hardin. 2004. The World of Cell. 5th Ed. Pearson Edu.
- Carroll M. 1989. Organelles. The Guilford Press.
- Charles B. 1993. Discussions in Cytogenetics. Prentice Hall.
- Darlington CD & La Cour LF. 1969. The Handling of Chromosomes. Georger Allen & Unwin Ltd.
- Elgin SCR. 1995. Chromatin Structure and Gene Expression. IRL Press.
- Gray P. 1954. The Microtome's Formulary Guide. The Blakiston Co.
- Gupta PK & Tsuchiya T. 1991. Chromosome Engineering in Plants: Genetics, Breeding and Evolution. Part A. Elsevier.
- Gupta PK. 2000. Cytogenetics. Rastogi Publ.
- Johansson DA. 1975. Plant Microtechnique. McGraw Hill.
- Karp G. 1996. Cell and Molecular Biology: Concepts and Experiments. John Wiley & Sons.
- Khush GS. 1973. Cytogenetics of Aneuploids. Academic Press.
- Sharma AK & Sharma A. 1988. Chromosome Techniques: Theory and Practice. Butterworth.
- Sumner AT. 1982. Chromosome Banding. Unwin Hyman Publ.
- Swanson CP. 1960. Cytology and Cytogenetics. Macmillan & Co.

**J-1023**

## **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.

### **Theory**

#### **UNIT I**

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

#### **UNIT II**

Genetic basis of breeding self- and cross - pollinated crops including mating systems and response to selection - nature of variability, components of variation; Heritability and genetic advance, 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; concept of plant Ideotype and its role in crop improvement.

#### **UNIT III**

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

#### **UNIT IV**

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

#### UNIT V

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

#### UNIT VI

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

#### UNIT VII

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.

## J-1004 AGRICULTURAL STATISTICS AND EXPERIMENTAL DESIGN

### Unit-I

**Presentation of Data:** Frequency distributions; graphical presentation of data by histogram, frequency polygon, frequency curve and cumulative frequency curves.

## UNIT-II

**Measures of Locations and Dispersion:** Mean, median, mode and their simple properties (without derivation) and calculation of median by graphs; range, mean deviation, standard deviation, standard error, coefficient of variation.

## UNIT-III

**Probability and Distributions:** Random distributions; events exhaustive, mutually exclusive and equally likely; definition of probability (with simple exercises); definitions of binomial, Poisson and normal distributions; and simple properties of the above distributions (without derivation).

## UNIT-IV

**Correlation and Regression:** Bivariate data-simple correlation and regression coefficients and their relation; Spearman rank correlation; limits of correlation coefficient; effect of change of origin and scale on correlation coefficient; linear regression and equations of line of regression; association and independence of attributes.

## UNIT-V

**Sampling:** Concept of population and sample; random samples; methods of taking a simple random sample.

## UNIT-VI

**Tests of significance:** Sampling distribution of mean and standard error; z and t-test (equality of means; paired and unpaired t-test); t-test for comparison of means when variances of two populations differ; Chi-square test for goodness of fit; independence of attributes, and homogeneity of samples; interrelation between t-test and F-Test

## UNIT-VII

**Experimental Designs:** Principles of experimental designs; completely randomized, randomized complete block design (missing plot value in RBD); latin square design; augmented block design; simple factorial experiments (mathematical derivations not required); analysis of variance (ANOVA) and its use including estimation of LSD (CD)

### Suggested Readings

- Goulden, C.H. (1952). Methods of Statistical Analysis, 2/e, John Wiley, New York.
- Hoshmand A. Reza 1988. Statistical Methods for Agricultural Sciences. Timber Press, Portland, Oregon, USA.
- Kempthorne, O. (1957). An Introduction to Genetic Statistics, John Wiley, New York.
- Kempton RA and Fox PN (1997). Statistical Methods for Plant Variety Evaluation. Chapman and Hall
- Panse, V.C. and Sukhatme, P.V. (1967). Statistical Methods for Agricultural Workers, I.C.A.R., New Delhi.
- Snedecor, G.W. and Cochran, W.G. (1980). Statistical Methods, 7/e. Iowa State Univ. Press, Ames, Iowa.

- Steel, R.G.D. and Torrie, H.H. (1960). Principles and Procedures of Statistics. McGraw-Hill, New York.
- Gomez, AG and Gomez, AA (1994). Statistical Procedures for Agricultural Research, 2/e. John Wiley & Sons, New York.

## **J-2021                      PRINCIPLES OF QUANTITATIVE GENETICS**

### **Objective**

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

### **Theory**

#### **UNIT I**

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

#### **UNIT II**

Principles of Analysis 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<sub>2</sub> 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.

### **Practical**

Problems on multiple factors inheritance - Partitioning of variance - Estimation of heritability and genetic advance - Covariance analysis - Metroglyph analysis - D<sub>2</sub> analysis - Grouping of clusters and interpretation - Cluster analysis - Construction of cluster diagrams and dendrograms - interpretation - Correlation

analysis - Path analysis - Parent-progeny regression analysis - Diallel analysis: Griffing's methods I and II - Diallel analysis: Hayman's graphical approach - Diallel analysis: interpretation of results - NCD and their interpretations - Line x tester analysis and interpretation of results - Estimation of heterosis : standard, mid-parental and better-parental heterosis - Estimation of inbreeding depression - Generation mean analysis: Analytical part and Interpretation - Estimation of different types of gene actions. Partitioning of phenotypic variance and co-variance into components due to genotypes, environment and genotype x environment interactions - Construction of saturated linkage maps and QTL mapping - Strategies for QTL mapping; statistical methods in QTL mapping; Phenotype and Marker linkage studies - Working out efficiency of selection methods in different populations and interpretation, Biparental mating, Triallel analysis, Quadriallel analysis and Triple Test Cross (TTC) - use of softwares in analysis and result interpretation, Advanced biometrical models for combining ability analysis, Models in stability analysis, Additive Main Effect and Multiplicative Interaction (AMMI) model - Principal Component Analysis model - Additive and multiplicative model - Shifted 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.

## J-2022 HETEROSIS BREEDING

### Objective

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

### Theory

#### 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.

#### 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  $F_2$  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. Development of heterotic pools in germplasm/genetic stocks and inbreds, their improvement for increasing heterosis.

### UNIT IV

Types of male sterility and use in heterosis breeding; Maintenance, transfer and restoration of different types of male sterility; Use of self incompatibility in development of hybrids; Hybrid seed production system: 3-line, 2-line and 1-line system; Development of inbreds and parental lines-A, B and R lines – functional male sterility; Commercial exploitation of heterosis- maintenance breeding of parental lines in hybrids.

### UNIT V

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 VI

Organelle heterosis and complementation - Creation of male sterility through genetic engineering and its exploitation in heterosis.

### UNIT VII

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 Hui Lin. 1998. Statistical Genomics – Linkage, Mapping and QTL Analysis. CRC Press.
- De Joun 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.

## J-2023 CELL BIOLOGY AND MOLECULAR GENETICS

### Objective

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

### Theory

#### UNIT I

Ultrastructure of the cell; Differences between eukaryotic and prokaryotic cells, macromolecules; Structure and function of cell wall, nuclear membrane and plasma membrane; Cellular Organelles – nucleus, plastids/chloroplast, 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; 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

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

#### UNIT VI

Genomics and proteomics; Functional and pharmacogenomics; Metagenomics.

#### 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.

### J-2024 BREEDING CEREALS, FORAGES AND SUGARCANE

#### Objective

To provide insight into recent advances in improvement of cereals and forage crops and sugarcane using conventional and modern biotechnological approaches.

#### Theory

#### 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; Pearl millet: 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: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship - Minor millets: breeding objectives- yield, quality characters, biotic and abiotic stress resistance etc.

### 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: Evolution and distribution of species and forms – Wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters and palatability studies; Biotic and abiotic stress resistance etc., synthetics, composites and apomixes.

### 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; Wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters, biotic and abiotic stress resistance etc, palatability studies.

### 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 their evaluation - 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; Visit to animal feed producing factories, learning the practice of value addition; visiting the animal husbandry unit and learning the animal experiments related with palatability and digestibility of fodder.

## 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.
- Walden DB. 1978. Maize Breeding and Genetics. John Wiley & Sons.

## J-3021 BIOTECHNOLOGY FOR CROP IMPROVEMENT

### Objective

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

### Theory

#### 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 (F<sub>2</sub>s, 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, soybean, oilseeds, sugarcane etc. Commercial releases.

#### UNIT VII

Biotechnology applications in male sterility/hybrid breeding, molecular farming.

#### UNIT VIII

MOs and related issues (risk and regulations); GMO; International regulations, biosafety issues of GMOs; Regulatory procedures in major countries including India, ethical, legal and social issues; Intellectual property rights

#### UNIT IX

Bioinformatics & Bioinformatics tools.

#### UNIT X

Nanotechnology and its applications in crop improvement programmes.

#### UNIT XI

Elementary idea of Genomics, Transcriptomics and Proteomics.

#### 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 micropropagation unit. Transformation using *Agrobacterium* 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.

## **J-3022 BREEDING FOR BIOTIC AND ABIOTIC STRESS RESISTANCE**

### **Objective**

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

### **Theory**

#### **UNIT I**

Importance of plant breeding with special reference to biotic and abiotic stress resistance; Classification of biotic stresses – major pests and diseases of economically important crops - Concepts in insect and pathogen resistance; Host defence responses to pathogen invasions- Biochemical and molecular mechanisms; Acquired and induced immunity and systemic acquired resistance (SAR); Host-pathogen interaction, gene-for-gene hypothesis, molecular evidence for its operation and exceptions; Concept of signal transduction and other host-defense mechanisms against viruses and bacteria.

#### **UNIT II**

Types and genetic mechanisms of resistance to biotic stresses –Horizontal and vertical resistance in crop plants. Quantitative resistance/Adult plant resistance 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 for identifying resistant types in important crops like rice, sorghum, wheat, cotton etc; Breeding for resistance to stresses caused by toxicity, deficiency and pollutants/contaminants in soil, water and environment.

#### 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, chitinases 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 screening 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 strategies; 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.

## **J-3023      MAINTENANCE BREEDING AND CONCEPTS OF VARIETY RELEASE AND PRODUCTION**

### **Objective**

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

### **Theory**

#### **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, pearl millet, sorghum, maize and ragi etc.); 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, oats, berseem, lucerne); Seed certification procedures; Seed laws and plant variety protection regulations in India and international systems.

### **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 and Practices. 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.

## **J-3024      MUTAGENESIS AND MUTATION 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 advances made.

### **Theory**

#### **UNIT I**

Mutation and its history - Nature and classification of mutations: spontaneous and induced mutations, micro and macro mutations.

#### **UNIT II**

Mutagenic agents: physical -- Radiation types and sources: Ionising and non-ionizing radiations viz., X rays,  $\gamma$  rays,  $\alpha$  and  $\beta$  particles, protons, neutrons and UV rays - Radiobiology: mechanism of action of various radiations ( $\alpha$ , 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; Comparative evaluation of physical and chemical mutagens.

#### **UNIT V**

Observing mutagen effects in M<sub>1</sub> generation: plant injury, lethality, sterility, chimeras *etc.*, - Observing mutagen effects in M<sub>2</sub> 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 M<sub>3</sub> 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 micromutations breeding/polygenic mutations- Achievements of mutation breeding- varieties released across the world- Problems associated with mutation breeding.

#### UNIT VIII

Use of mutagens in genomics, allele mining, TILLING.

#### 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 propagules 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 M<sub>1</sub> generation – Parameters to be observed; Study of M<sub>2</sub> 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 vegetatively propagated crops; Procedure for detection of mutations for polygenic traits in M<sub>2</sub> and M<sub>3</sub> 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. 3<sup>rd</sup> Ed. Prentice Hall.

## **J-4021 BREEDING LEGUMES, OILSEEDS AND FIBRE CROPS**

### **Objective**

To provide insight into recent advances in improvement of legumes, oilseeds and fibre crops using conventional and modern biotechnological approaches.

### **Theory**

#### **UNIT I**

Pigeonpea: Evolution and distribution of species and forms; Wild relatives and germplasm; Genetics, cytogenetics and genome relationship; Morphological and molecular descriptors used for differentiating the accessions; Breeding objectives- yield, quality characters, biotic and abiotic stress *etc*- Hybrid technology; maintenance of male sterile, fertile and restorer lines, progress made at ICRISAT and other Institutes.

#### **UNIT II**

Chickpea: Evolution and distribution of species and forms - Wild relatives and germplasm - cytogenetics and genome relationship; Breeding objectives- yield, quality characters, biotic and abiotic stress *etc*; Protein quality improvement; Conventional and modern plant breeding approaches, progress made - Breeding for anti nutritional factors.

#### **UNIT III**

Other pulses: Greengram, blackgram, fieldpea, lentil, lathyrus, cowpea, lablab, mothbean: Evolution, cytogenetics and genome relationship; Learning the descriptors; Breeding objectives- yield, quality characters, biotic and abiotic stress *etc*; Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them.

#### **UNIT IV**

Groundnut: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; Pod and kernel characters; Breeding objectives- yield, quality characters, biotic and abiotic stress *etc*.

#### **UNIT V**

Rapeseed and Mustard: Breeding objectives, utilization of wild relatives for yield and quality improvement, biotic and abiotic stress *etc*; Oil quality – characteristics in different oils; Evolution and distribution of species and forms; Wild relatives and germplasm; Genetics, cytogenetics and genome relationship.

#### **UNIT VI**

Soybean: Breeding objectives, utilization of wild relatives for yield and quality improvement, biotic and abiotic stress etc. - Oil quality – characteristics; Evolution and distribution of species and forms; Wild relatives and germplasm; Genetics, cytogenetics and genome relationship.

#### UNIT VII

Other oilseed crops: Sunflower, sesame, safflower, niger: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; breeding objectives- yield, quality characters, biotic and abiotic stress; Sunflower: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship, hybrid sunflower, constraints and achievements.

#### UNIT VIII

Castor: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship, breeding objectives yield, quality characters, biotic and abiotic stress *etc* - Hybrid breeding in castor – opportunities, constraints and achievements.

#### UNIT IX

Cotton: Evolution of cotton; Breeding objectives- yield, quality characters, biotic and abiotic stress etc; Development and maintenance of male sterile lines – Hybrid development and seed production – Scenario of Bt cottons, evaluation procedures for Bt cotton. Jute: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; breeding objectives- yield, quality characters, biotic and abiotic stress etc; Mesta and minor fibre crops: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; breeding objectives- yield, quality characters, biotic and abiotic stress etc.

#### UNIT X

Distinguishing features of the released varieties in pulses, oilseeds and cotton; Maintenance of seed purity and seed production.

#### Practical

Use of descriptors for cataloguing – Floral biology - emasculation – pollination techniques; Study of range of variation for yield and yield components - Study of segregating populations in Redgram, Greengram, Blackgram and other pulse crops; Attempting crosses between blackgram and greengram. Use of descriptors for cataloguing – Floral biology, emasculation, pollination techniques of oilseed crops like Sesame, Groundnut, Sunflower and Castor, Cotton: Use of descriptors for cataloguing – Floral biology - Learning on the crosses between different species - Cotton: Study of range of variation for yield and yield components - Study of segregating populations - evaluation - Trait based screening for stress resistance - Cotton fibre quality evaluation – conventional and modern approaches; analysing the lint samples of different species, interspecific and interracial derivatives for fibre quality and interpretation –Development and maintenance of male sterile lines Evaluation of cotton cultures of different species for insect and disease resistance – Learning the mechanisms of resistance, quantifying the resistance using various parameters; Evaluating the germplasm of cotton for yield, quality and resistance parameters – learning the procedures on development of Bt cotton - Visit to Cotton Technology Laboratory and Spinning Mills – Learning on cotton yarn production, its quality evaluation and uses.

#### 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.
- Chahal GS & Ghosal SS. 2002. Principles and Procedures of Plant Breeding - Biotechnological and Conventional Approaches. Narosa Publ.
- Chopra VL. 1997. Plant Breeding. Oxford & IBH.
- Nath V & Lal C. 1995. Oilseeds in India. Westvill Publ. House.
- Nigam J. 1996. Genetic Improvement of Oilseed Crops. Oxford & IBH.
- Ram HH & Singh HG. 1993. Crop Breeding and Genetics. Kalyani.
- Singh DP. 1991. Genetics and Breeding of Pulse Crops. Kalyani.
- Singh HG, Mishra SN, Singh TB, Ram HH & Singh DP. (Eds.). 1994. Crop Breeding in India. International Book Distributing Co.
- Smartt J. 1994. The Groundnut Crop - a Scientific Basis for Improvement. Chapman & Hall.

## J-4022 POPULATION GENETICS

2+1

### Objective

To impart knowledge on structure, properties and their breeding values of different population.

### Theory

#### UNIT I

Population - Properties of population - Mendelian population - Genetic constitution of a population through time, space, age structure etc. Mating systems - Random mating population - Frequencies of genes and genotypes - Causes of change: population size, differences in fertility and viability, migration and mutation.

#### UNIT II

Hardy-Weinberg equilibrium - Hardy-Weinberg law - Proof - Applications of the Hardy-Weinberg law - Test of Hardy-Weinberg equilibrium - Mating frequencies - Non-dominance - Codominance - Snyder's ratio, importance and its effect over random mating in succeeding generations.

#### UNIT III

Multiple alleles - More than one locus - Sex linked genes; Use of gene and genotypic frequencies evaluation in field population level; Interpretations - Changes of gene frequency - Migration - Mutation - Recurrent and nonrecurrent - Selection - Balance between selection and mutation - Selection favouring heterozygotes - Overdominance for fitness.

#### UNIT IV

Non random mating: selfing –inbreeding coefficient - panmictic index – sibmating - Assortative mating and disassortative mating – Pedigree populations and close inbreeding - Estimation of selection - Estimation of disequilibrium - Estimation of linkage - Correlation between relatives and estimation of F; Effect of inbreeding and sibbing in cross pollinated crops.

#### UNIT V

Gene substitution and average effects; Breeding value- Genetic drift; Genetic slippage, Co-adapted gene complexes; Homoeostasis- Adaptive organization of gene pools, Polymorphism- Balanced and Non-balanced polymorphism, heterozygous advantage- Survival of recessive and deleterious alleles in populations.

#### Practical

Genetic exercise on probability; Estimation of gene frequencies; Exercises on factors affecting gene frequencies; Estimation of average affect of gene substitution and breeding value; Exercises on inbreeding and linkage disequilibrium- Cavalli's joint scaling test; Exercises of different mating designs; Estimation of different population parameters from experimental data; Measurement of genotype-environment interaction; Genetic divergence.

#### Suggested Readings

- Chawla V &Yadava RK. 2006. *Principles of Population Genetics – A Practical Manual*. Dept. of Genetics, CCS HAU Hisar.
- Falconer DS & Mackay J.1996. *Introduction to Quantitative Genetics*.Longman.
- Jain JP, Jain J &Parbhakaran, VT. 1992. *Genetics of Populations*. South Asia Books.
- Li CC. 1955. *Population Genetics*. The Univ. of Chicago Press.
- Mather K &Jinks JL. 1982. *Biometrical Genetics*. Chapman & Hall.
- Sorrens D & Doniel G. 2007. *Methods in Quantitative Genetics*. Series: *Statistics for Biology and Health*. Likelihood.
- Tomar SS. 1992. *Text Book of Population Genetics*. Universal Publication.

## J-4023 Diseases and Insect-Pests of Crop Plants and their Management

UNIT-I . Introduction: Definition, importance and general classification of plant diseases; causal organisms (necrotrophic and biotrophic); need for plant protection.

UNIT II. Principles of plant disease control: Attack on the parasite; strengthening of the host, modification of environments; biological control of plant pathogens; immune system (plant-microbe interaction); gene-for-gene interaction, acquired and systemic resistance (PR proteins); transgenics.

UNIT III. Crop pests and their control: Brief idea about the pests of rice, wheat, maize, Sorghum, pea, gram, sugarcane, cotton.

UNIT IV. Causal organism, general symptoms and control measures of the following diseases:

(i) Bacterial diseases of plants: Red stripe of sugarcane; bacterial leaf blight of rice; bacterial leaf streak disease of rice; bacterial brown rot or wilt disease of potato; black leg and softrot of potato; stalk rot of maize.

(ii) Fungal diseases of plants: Early blight and late blight of potato; white rust of crucifers; green ear disease (downy mildew) of bajra; powdery mildew of pea and cereals; ergot of bajra; loose smut of wheat; covered smut of barley; grain smut of sorghum; smut of bajra; Karnal bunt of wheat; bunt of rice; flag smut of wheat; rusts of wheat; blast of rice; red rot of sugarcane; wilt of pigeon pea and gram; Aschochyta blight of gram.

(iii) Diseases caused by nematodes: Ear cockle of wheat; molya disease of barley; root knot of vegetable crops.

(iv) Viral diseases: Leaf roll, mild mosaic, rugose mosaic and crinckle of potato; leaf curl of tomato; yellow vein mosaic of bhindi; mungbean yellow mosaic virus (MYMV); sterility mosaic of pigeonpea.

UNIT V. Physiological disorders: Black heart of potato; tip burn of paddy; khaira disease of rice. 2

#### Suggested Readings

1. Agrios, G.N. (1998). Plant Pathology. Acad. Press, New York.
2. Campbell, R. (1989). Biological Control of Microbial Plant Pathogens. Cambridge Univ. Press, Cambridge
3. Dent, David. (1995). Integrated Pest Management. Chapman & Hall, London.
4. Fenemore. P.G. (1984). Plant Pests and Their Control. Butterworths, London.
5. Mundkur, B.B. (1949). Fungi and Plant Diseases. Macmillan & Co, London.
6. Mukherjee, K. G. (1991). Recent Developments in Biocontrol of Plant Diseases. Aditya Books, New Delhi.
7. Rangaswami, G. (2002). Diseases of Crop Plants in India. Prentice Hall of India, New Delhi.
8. Singh, R.S. (2002). Introduction to Principles of Plant Pathology. Oxford & IBH Publishing Co. New Delhi.
9. Tarr, S.A.J. (1972). The Principles of Plant Pathology. Macmillan Press, London.
10. Walker, J.C. (1969). Plant Pathology. McGraw Hill Book Co., New York.
11. Science (special issue), May 8, 2009.

## **J-4024 DATA BASE MANAGEMENT, EVALUATION AND UTILIZATION OF PGR**

### **Objective**

To train the students in germplasm data base management using modern tools and softwares.

### **Theory**

#### **UNIT I**

Statistical techniques in management of germplasm; Core identification, estimation of sample size during plant explorations, impact of sampling on population structure, sequential sampling for viability estimation; Introduction of binomial, normal and negative cumulative normal, use of

Probit scales, viability equations and numograms; Estimation of sample size for storage and viability testing.

#### **UNIT II**

Germplasm documentation; Basics of computer and operating systems; Database management system, use of statistical softwares, pictorial and graphical representation of data; introduction to communication network.

#### **UNIT III**

Germplasm management system- global scenario; Genetic variation in crop plants and management of germplasm collection, limitations in use of germplasm collections; necessity of germplasm evaluation; Predictive methods for identification of useful germplasm; Characterization of germplasm and evaluation procedures including specific traits; Gene markers and their use in PGR management.

#### **UNIT IV**

Management and utilization of germplasm collections; Concept of core collection, molecular markers and their use in characterization; Evaluation and utilization of genetic resources; Pre-breeding/ genetic enhancement, utilizing wild species for crop improvement; Harmonizing agrobiodiversity and agricultural development crop diversification participatory plant breeding.

### **Practical**

Basics of computer and operating systems; Identification of useful germplasm, evaluation of crop germplasm; Statistical techniques in management of germplasm- estimation of sample size for storage and viability testing; Evaluation procedure and experimental protocols (designs and their analysis), Assessment of genetic diversity; Techniques of Characterization of germplasm; Molecular markers and their use in characterization.

### **Suggested Readings**

- Painting KA, Perry MC, Denning RA & Ayad WG. 1993. Guide Book for Genetic 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.