# 13 Genetics

## TRIMESTERWISE DISTRIBUTION OF COURSES

### I TRIMESTER

| | | L | P |
|---|---|---|---|
| **GP 500** | ELEMENTS OF GENETICS | 3 | 2 |
| **GP 510** | PRINCIPLES OF CYTOGENETICS | 3 | 2 |
| **GP 521** | BREEDING FIELD CROPS-I | 2 | 1 |
| **GP 530** | QUANTITATIVE GENETICS | 4 | 1 |
| **GP 540** | INTRODUCTION TO BIOINFORMATICS | 3 | 1 |
| **GP 550** | FUNDAMENTAL CONCEPTS OF PLANT BREEDING | 3 | 2 |
| **GP 607/ PGR 607** | REGULATORY MECHANISMS AND INTELLECTUAL PROPERTY RIGHTS | 3 | 1 |
| **GP 691** | SEMINAR | 1 | 0 |

### II TRIMESTER

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| **AGR 010** | ELEMENTS OF GENETICS AND PLANT BREEDING | 2 | 1 |
| **GP 520** | ELEMENTS OF PLANT BREEDING | 3 | 2 |
| **GP 522** | BREEDING FIELD CROPS-II | 2 | 1 |
| **GP 600** | DEVELOPMENT OF GENE CONCEPT | 4 | 0 |
| **GP 610** | CROP CYTOGENETICS | 2 | 1 |
| **GP 612** | DIVERSITY ANALYSIS | 2 | 1 |
| **GP 643** | CONCEPTS IN HETEROSIS BREEDING | 2 | 1 |
| **GP 691** | SEMINAR | 1 | 0 |

### III TRIMESTER

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| **PGS 506** | HISTORY OF AGRICULTURE | 1 | 0 |
| **GP 602** | MUTAGENESIS | 3 | 2 |
| **GP 603** | TOPICS IN POPULATION GENETICS | 2 | 1 |
| **GP 604** | INNOVATIVE APPROACHES IN PLANT BREEDING | 2 | 1 |
| **GP 605** | BREEDING FOR STRESS RESISTANCE | 3 | 0 |
| **GP 606** | PLANT GENE EXPRESSION AND REGULATION | 3 | 0 |

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| **GP 620** | APPLIED CYTOGENETICS | 3 | 1 |
| **GP 621** | BREEDING FOR CROP QUALITY | 2 | 2 |
| **GP 640** | ADVANCES IN PLANT BREEDING | 3 | 0 |
| **GP 691** | SEMINAR | 1 | 0 |

**Core Courses**

**M.Sc.:** GP500, GP510, GP520, GP530

**Ph.D.:** GP550, GP600, GP 604

# GENETICS

**Major Fields :** Genetics

Plant Breeding

**Minor Fields :** Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.

M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

## DESCRIPTION OF COURSES

### PGS 506 HISTORY OF AGRICULTURE (1L+0P) III

**Objective**

To learn about the evolution and achievements of agricultural science in India, lessons learnt and vision for future

UNIT I

Agriculture in ancient India: archaeological findings and literature.

UNIT II

Ancient literature on: farm implements, forecast of weather and rains, types of lands, manure, irrigation, seed and sowing, pests and their management, horticulture and arboriculture, cattle management etc.

UNIT III

Agricultural research, education and extension in pre-and post-independent India. Green revolution, success, associated problems, lessons learnt.

UNIT IV

Challenges to Indian agriculture: future needs and capabilities, environmental problems, international agriculture and partnership. Emerging scenario and expectations.

**Suggested Readings**

Jain, H.K. 2010. The Green Revolution: History, Impact and Future. Studium Press LLc, Houston USA, 276 pp.

Saxena, R.C., Choudhary, S.L. and Nene, Y.L. 2009. A Text Book on Ancient History of Indian Agriculture. Asian Agri-History Foundation, Secundarabad, 148 pp.

Nene, Y.L. (Ed.) 2007. Glimpses of the Agricultural Heritage of India. Asian Agri-History Foundation, Secundarabad, 912 pp.

### AGR 010 ELEMENTS OF GENETICS AND PLANT BREEDING (2L+1P) II

**Objective**

To provide a basic introduction to Genetics and Plant Breeding to students from a non agriculture background.

**Theory**

UNIT I

History of Genetics and Plant Breeding. Cell and cell division.

UNIT II

Mendelism. Linkage and recombination. Common statistical tools for research.

UNIT III

Role of genetics in crop improvement. Polyploidy and mutation.

UNIT IV

Modes of reproduction. Breeding methods for self-pollinated, cross-pollinated and asexually reproducing crops. Male sterility and incompatibility. Heterosis and hybrid development.

UNIT V

Breeding for biotic and abiotic stresses. Variety development and seed production.

UNIT VI

Agricultural Biotechnology, Molecular Biology in Crop improvement

**Practicals**

Parts of Microscope, Basics of mitotic and meiotic slide preparations, Stages of Mitosis, Meiosis, field visit and study of floral biology, crossing techniques, variability and breeding methods in different crops - Wheat, Chick pea and Brassica.

**Suggested Reading**

Snustad, D. P. and Simmons M.J. 2006. Genetics, 4th Ed. John Wiley & Sons.

Blumm, A. 1988. Plant Breeding for Stress Environments. CRC Press Inc., USA.

Chopra, V.L. and Shyam Prakash. 2002. Evolution and adaptation of cereal crops. Oxford and IBH.

**GP 500 PRINCIPLES OF GENETICS (3L+2P) I**

**Objective**

The aim of this course is to understand basic concepts of genetics and to develop analytical, quantitative and problem-solving skills in classical and molecular genetics.

**Theory**

UNIT I

History of Genetics; Mitosis & Meiosis, Pre-Mendelian concepts of inheritance, Mendel's laws; Discussion of Mendel's paper; Probability, Chromosomal theory of inheritance. Multiple alleles, Sex-linkage, Linkage Detection, Linkage estimation by various methods in test crosses, intercrosses; recombination and genetic mapping in eukaryotes -classical to modern, Somatic cell genetics.

UNIT II

Structural and numerical changes in chromosomes; Nature, structure and replication of the genetic material; Organization of DNA in chromosomes, Epigenetics.

Genetic code; Protein biosynthesis,Genetic fine structure analysis, Allelic complementation, Split genes, Transposable genetic elements, Overlapping genes, Pseudogenes, Gene families and clusters.

UNIT III

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

UNIT IV

DNA sequencing Gene cloning, genomic and cDNA libraries, PCR-based cloning, Nucleic acid hybridization and immuno-chemical detection; DNA restriction and modification, Anti-sense RNA, Gene silencing and ribozymes; Micro-RNAs (miRNAs).

Genomics: Functional, structural & comparative, proteomics,metagenomics

UNIT V

Methods of studying polymorphism; Transgenic bacteria and bioethics; genetics of mitochondria and chloroplasts, Extra chromosomal inheritance. Eugenics, Genetic Disorders and Behavioural Genetics

UNIT VI

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

**Practicals**

Laboratory exercises in probability and chi-square; Demonstration of genetic principles using laboratory organisms; Gene mapping using three point test cross; Tetrad analysis; Induction and detection of mutations, complementation. Study of chromosome aberrations, (deletions, inversion, translocations ); DNA extraction and PCR amplification - Electrophoresis – basic principles separation of DNA; Visit to transgenic glasshouse.

**Suggested Readings**

Gardner, E.J. and Snustad, D.P. 1991. Principles of Genetics. John Wiley & Sons.

Klug, W.S. and Cummings, M.R. 2003. Concepts of Genetics. Peterson Education.

Lewin, B. 2008. Genes IX. Jones & Bartlett Publ.

Russell, P.J. 1998. Genetics. The Benjamin/Cummings Publ. Co.

Strickberger, M.W. 2008. Genetics. Pearson Education.

Tamarin, R.H. 1999. Principles of Genetics. Wm. C. Brown Publs.

Snustad, D.P. and Simmons, M.J. 2006. Genetics, 4th Ed. John Wiley & Sons

**GP 510 PRINCIPLES OF CYTOGENETICS (3L+2P) I**

**Objective**

The aim is to provide insight into chromosomes structure and function, mapping, variations in chromosomal ploidy and structure; its role in crop evolution.

**Theory**

UNIT I

Chromosome architecture in prokaryotes and eukaryotes; Eukaryotic chromosome structure & organisation Artificial chromosomes- BACS, YACs, construction and its uses; Special types of chromosomes.

UNIT II

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

UNIT III

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

UNIT IV

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

UNIT V

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

UNIT VI

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

**Practicals**

Preparation of tissues for cytogenetical analyses (Fixatives, fixation, dehydration, embedding, staining, cleaning etc.) - Microscopy: various types of microscopes, Mitosis in wheat, pearl millet,onion, *Aloe vera,* oilseeds, forage crops and pulses, Measuring pollen grain size in various crops with micrometer, Methods of preparing permanent slides, Pollen germination *in vivo* and *in vitro,* Identification of polyploids in different crops, Morphological observations on autopolyploids and alloployploids - Morphological observations on aneuploids, Cytogenetic analysis of interspecific and intergeneric crosses, Maintenance of Cytogenetic stocks and their importance in crop breeding;Fluorescent in situ hybridization (FISH), Genome in situ hybridization GISH.

**Suggested Readings**

Becker, Kleinsmith and Hardin. 2004. The World of Cell. 5th edition. Pearson Education.

Carroll, M. 1989. Organelles. The Guilford Press, New York.

Charles, Burnham. 1993. Discussions in Cytogenetics. Prentice Hall Publications, London

Darlington, C.D. and L.F. La Cour. 1969. The handling of chromosomes. Georger Allen and Unwin Ltd.

Elgin, S.C.R. 1995. Chromatin Structure and Gene Expression. IRL Press, Oxford. 224p

Gupta, P.K. and Tsuchiya, T. 1991. Chromosome Engineering in Plants. Part A. Elsevier.

Gupta, P.K. 2000. Cytogenetics. Rastogi Publications

Johannson, D.A. 1975. Plant Microtechnique. Mc Graw Hill Co, New York.

Karp, G. 1996. Cell and Molecular Biology: Concepts and Experiments. John-Wiley & Sons, Inc., 773p.

Khush, G.S. and Rick R. 1981. Cytogenetics of Aneuploids, Academic Press.

Sharma, A.K. and Sharma, A. 1988. Chromosome techniques: Theory and practice, Butterworth, London.

Sumner, A.T. 1982. Chromosome banding. Unwin Hyman Publishers, London.

## GP 520 ELEMENTS OF PLANT BREEDING (3L+2P) II

### Objectives

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. - Centres of Origin-biodiversity and its significance

UNIT II

Genetic basis of breeding self- and cross - pollinated crops, 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. Self-incompatibility and male sterility in crop plants and their commercial exploitation.

UNIT III

Breeding self pollinated crops, Pure line theory; pure line selection and mass selection methods, line breeding, pedigree, bulk, backcross, single seed descent and multiline method.

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 inter-population improvement and development of synthetics and composites.

UNIT V

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

Self-incompatibility and male sterility in crop plants and their commercial exploitation; concept of plant ideotype and its role in crop improvement. Special breeding techniques- Mutation breeding,polyploids.

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 VI

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

testing, Quality seeds-types and production. Parent selection. Combining ability and type of crosses. Biotechnology in crop improvement-An overview. Transgenic crops- current status and future prospects, integration of transgenics into breeding programmes.

Molecular breeding-molecular markers (isozymes, RFLP, RAPD AFLP), mapping populations (RILs, NILs, DH, Backross), their merits and demerits, markers assisted selection

**Practicals**

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, R.W. 1981. Principles of Plant Breeding, John Wiley & Sons.

Chopra, V.L. 2001. Breeding Field Crops. Oxford & IBH.

Chopra, V.L. 2004. Plant Breeding. Oxford & IBH.

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

Poehlman, J.M. and Borthakur, D.N. 1972. Breeding Asian Field Crops. Oxford & IBH.

Sharma, J.R. 2001. Principles and Practice of Plant Breeding. Tata McGraw-Hill.

Simmonds, N.W. 1990. Principles of Crop Improvement. English Language Book Society.

Singh, B.D. 2006. Plant Breeding. Kalyani.

**GP 521 BREEDING FIELD CROPS-I (2L+1P) I**

**Objectives**

To provide insight into recent advances in improvement of cereals, pulses, oilseeds and fiber crop grown during Kharif Season using conventional and modern biotechnological approaches

**Theory**

UNIT I CEREALS

Rice: 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 and hybrid development: Breeding approaches-conventional and non conventional including MAS, emerging challenges at national and international level, Maintenance breeding, coordinated system of testing.

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/tolerance - Heterosis breeding, Breeding approaches –conventional and non conventional including MAS, Emerging challenges at national and international level.

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/tolerance, exploitation of heterosis and hybrid development; Breeding approaches-conventional and non conventional including MAS, emerging challenges at national and international level.

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, exploitation of heterosis and hybrid development; Breeding approaches-conventional and non conventional including MAS, emerging challenges at national and international level.

UNIT II PULSES

Pigenopea: 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 conventional and non conventional including MAS, progress made - Breeding for anti nutritional factors; Progress in hybrid development, emerging challenges at national and international level.

Urd bean: evolution, cytogenetics and genome relationship, - breeding objectives: yield, quality characters, biotic and abiotic stress, Breeding approaches-conventional and non conventional including MAS, - interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them – emerging challenges at national and international level.

Moong bean: evolution, cytogenetics and genome relationship, - breeding objectives: yield, quality characters, biotic and abiotic stress, Breeding approaches-conventional and non conventional including MAS, - interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them – emerging challenges at national and international level.

UNIT III OILSEEDS

Soybean: evolution and distribution of species and forms wild relatives and germplasm - genetics - cytogenetics and genome relationship; breeding objectives, utilization of wild relatives for yield and quality improvement, biotic and abiotic stress, Breeding approaches conventional and non conventional including MAS - Oil quality – characteristics in different oils emerging challenges at national and international level.

UNIT IV: FIBRE CROP

Cotton: evolution, breeding objectives: yield, quality characters, biotic and abiotic stress etc,Breeding,development and maintenance of male sterile lines, Hybrid development and seed production – Scenario of Bt cottons, evaluation procedures for Bt cotton.

UNIT V

Distinguishing features of popular released varieties in – Rice, maize, pearl millet, sorghum, pigeonpea, urd bean, moong bean, cotton and their application to DUS testing - Maintenance of seed purity - Nucleus and Breeder Seed Production.Maintenance Breeding and All India Co-ordinated System of testing and release of crop varieties and hybrids.

**Practicals**

Floral biology – emasculation - pollination techniques; Study of variation for yield and yield components - Trait based screening for stress resistance in important crops– Use of descriptors for cataloguing Germplasm maintenance; Using Standard Evaluation System (SES) and descriptors, Field and lab visit of the concerned crops

**Suggested Readings**

Agarwal, R.L. 1996. Identifying Characteristics of Crop Varieties. Oxford & IBH Publishing Co Pvt Ltd.

Bahl, P.N. and Salimath, P.M. 1996. Genetics, Cytogenetics and Breeding of Crop Plants. Vol 1 Pulses and Oilseeds. Oxford & IBH Publsihing Co Pvt Ltd, New Delhi.

Chandraratna, M.F. 1964. Genetics and Breeding of Rice. Longmans. 389p.

Chopra, V.L. and Shyam Prakash. 2002. Evolution and adaptation of cereal crops. Oxford and IBH

Gill, K.S. 1991. Pearl Millet and its Improvement. Indian Council of Agricultural Research, New Delhi.

IRRI. 1964. Rice Genetics and Cytogenetics. Elsevier Publishing Company. Amsterdam.

IRRI. 1996. Rice Genetics III. Proceedings of the International Rice Genetics Symposium. IRRI, Philippines.

IRRI. 2000. Rice Genetics IV. Proceedings of the International Rice Genetics Symposium, Philippines.

Jennings, P.R., Coffman, W.R. and Kauffman, H.E. 1979. Rice Improvement. IRRI, Philippines. 186p.

Murty, D.S., Tabo, R. and Ajayi, O. 1994. Sorghum Hybrid Seed Production and Management. ICRISAT, Patancheru

Nanda, J.S. 1997. Manual on Rice Breeding, Kalyani Publishers, Ludhiana. 120p.

Ram, H.H. and Singh, H.G. 1993. Crop Breeding and Genetics. Kalyani Publishers, Ludhiana.

Singh, H.G., Mishra, S.N., Singh, T.B., Ram, H.H. and Singh, D.P. (Eds). 1994. Crop Breeding in India. International Book Distributing Co. Chandigarh.

Slafer GA. (Ed). 1994. Genetic Improvement of Field Crops. Marcel Dekker Inc.

Walden DB. 1978. Maize Breeding and Genetics. John Wiley and Sons, New York.

## GP 522 BREEDING FIELD CROPS-II (2L+1P) II

### Objectives

To provide insight into recent advances in improvement of cereals, Pulses, Oilseeds and forage crops grown during Rabi Season using conventional and modern biotechnological approaches

### Theory

UNIT I CEREALS

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 Breeding approaches-conventional and non conventional including MAS, emerging challenges at national and international level.

Barley: evolution and distribution of species and forms - wild relatives and germplasm – cytogenetics breeding objectives: yield, quality characters, biotic and abiotic stress resistance, Breeding approache –conventional and non conventional including MAS, Breeding for malt barley; emerging challenges at national and international level.

UNIT II PULSES

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 conventional and non conventional including MAS, progress made - Breeding for anti nutritional factors; emerging challenges at national and international level.

Lentil: evolution, cytogenetics and genome relationship, - breeding objectives: yield, quality characters, biotic and abiotic stress etc, Breeding approaches-conventional and non conventional including MAS, - interspecific crosses –problems, prospects and implications, emerging challenges at national and international level.

Fieldpea evolution, cytogenetics and genome relationship, - breeding objectives: yield, quality characters, biotic and abiotic stress, Breeding approaches-conventional and non conventional including MAS, - interspecific crosses problems, prospects and implications,emerging challenges at national and international level.

Rajmash: evolution, cytogenetics and genome relationship, - breeding objectives: yield, quality characters, biotic and abiotic stress etc, Breeding approaches-conventional and non conventional including MAS, - interspecific crosses problems, prospects and implications,emerging challenges at national and international level.

UNIT III OILSEEDS

Rapeseed and Mustard: evolution and distribution of species and forms wild relatives and germplasm - genetics - cytogenetics and genome relationship; breeding objectives, utilization of wild relatives for yield and quality improvement, biotic and abiotic stress etc. Breeding approaches conventional and non conventional including MAS, emerging challenges at national and international level.Utilisation of wild relatives for yield and quality improvement.

UNIT VI

Distinguishing features of popular released varieties in - Wheat, barley, lentil, chickpea, fieldpea, rajmash, mustard and toria and their application to DUS testing - Maintenance of seed purity - Nucleus and Breeder Seed Production; Maintenance Breeding and All India Co-ordinated system of testing and release of crop varieties and hybrids.

**Practicals**

Floral biology – emasculation and pollination techniques; Study of range of variation for yield and yield components - Trait based screening for stress resistance in crops of importance– Use of descriptors for cataloguing Germplasm maintenanceUsing Standard Evaluation System (SES) and descriptors, Field and lab visit of the concerned crops

**GP 530 QUANTITATIVE GENETICS (4L+1P) I**

**Objective**

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

**Theory**

UNIT I

Probability and its application in genetic analyses; Random variables and Probability distributions.

UNIT II

Genotypic and Phenotypic variation. Genetic component analyses; Partitioning of main effects and variances – ANOVA-MANOVA.

UNIT III

General concepts of gene action – single and multigene models –genetical parameters and their estimations.

Heritability & components of gene action. Linkage & Linkage Disequilibrium. Inbreeding and covariance between relatives.

UNIT IV

Mating systems and designs; Combining ability – effects and variance; Genetic divergence. Heterosis; Populations- concepts and their improvement approaches.

**Practicals**

Problems on multiple factors inheritance - Partitioning of variance -Estimation of heritability and genetic advance - Covariance analysis - D2 analysis - Grouping of clusters and interpretation - Cluster analysis - Construction of cluster diagrams and dendrograms - interpretation - 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.

**Suggested Readings**


Bos, I. and Caligari, P. 1995. Selection Methods in Plant Breeding. Chapman & Hall.

Falconer, D.S. and Mackay, J. 1998. Introduction to Quantitative Genetics. Longman.

Mather, K. and Jinks, J.L. 1971. Biometrical Genetics. Chapman & Hall.

Mather, K. and Jinks, J.L. 1983. Introduction to Biometrical Genetics. Chapman & Hall.

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

Naryanan, S.S. and Singh, P. 2007. Biometrical Techniques in Plant Breeding. Kalyani.

Singh, P. and Narayanan, S.S. 1993. Biometrical Techniques in Plant Breeding. Kalyani.

Singh, R.K. and Choudhary, B.D. 1987. Biometrical Methods in Quantitative Genetics. Kalyani.

Weir, D.S. 1990. Genetic Data Analysis. Methods for Discrete Population Genetic Data. Sinauer Associates.

Wricke, G. and Weber, W.E. 1986. Quantitative Genetics and Selection in Plant Breeding. Walter de Gruyter.


## GP 540 INTRODUCTION TO BIOINFORMATICS (3L+1P) I

**Objective**

To introduce basic concepts of bioinformatics

**Theory**

UNIT I

History and development of concept of bioinformatics; overview of protein and DNA sequences; sequences databases, retrieval and analysis; methods of sequence alignment - local, global pair wise and multiple alignment; Collection and storage of sequences in the laboratory: DNA sequencing; genomic sequencing; cDNA libraries and sequencing cDNA; processing and

submission of sequences; computer storage; sequence formats- Gen Bank, EMBL, NCBI, Stanford University, etc.

UNIT II

Introduction to database management and DBMS. Introduction to Perl and Bioperl.

UNIT III

Phylogenetic prediction: Phylogeny and sequence variations; concept of evolutionary trees; methods in phylogeny-maximum parsimony, distance methods, maximum likelihood, reliability of prediction.

UNIT IV

Gene prediction: Gene structure and characteristics; ORF; methods for microbial and Eukaryotic gene predictions. Internet Resources.

UNIT V

Genome analysis: Genome structure and organization-Prokaryotes and Eukaryotes; sequence assembly and gene identification; methods - comparative genomics, proteomics; synteny, functional genomics.

**Practicals**

Sequence searching and alignment, writing programs in Perl for bioinformatics applications, Phylogenetic prediction, gene prediction

**Suggested Readings**

Baxevanis, A.D. and Ouellette, B.F.F. 2001. Bioinformatics: A practical guide to the analysis of genes and proteins. Wiley Interscience. New York. USA.

Mount, D.W. 2001. Bioinformatics. Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press. New York. USA.

Tisdall James. 2002. Beginning Perl for Bioinformatics. O' Reilly publication

Web based Public databases and softwares

**GP 550 FUNDAMENTAL CONCEPTS OF PLANT BREEDING (3L+2P) I**

**Objectives**

To learn principles of Mendelian and quantitative genetics and it's applications in practical plant breeding.

**Theory**

UNIT I

Variability -phenotypic, genetic and environmental and their role in breeding, adaptation and evolution.

UNIT II

Concepts of quantitative traits and Mendalian genetics and their molecular basis; Nature of quantitative traits and their inheritance - Multiple factor hypothesis - analysis of continuous variation - Variations associated with polygenic traits - phenotypic, genotypic and environmental - non-allelic interactions; Resemblance between relatives; Heritability; Estimation of variance components-additive and dominance variances, combining ability-GCA, SCA effects.

UNIT III

Mating designs, examples from crops to illustrate inferences drawn for plant breeding decisions. Generation mean analysis, mating designs- Diallel, Partial Diallel, Line x tester analysis, NCDs and TTC,

UNIT IV

Genetic diversity analysis; phenotypic and genotypic correlations, Path analysis; Heterosis-relationship between Heterosis and genetic diversity. Concepts of combining ability and gene action–- Inbreeding and cross breeding: changes of mean and variance and applications.

UNIT V

Simple concepts of selection, selection - heritability and genetic advance; various selection methods through specific examples from various crops. Response to selection, the speed of advance under selection, correlated response under selection, Selection for multiple characters, Tandem selection, Selection index. Basic concepts of Marker assisted selection.

UNIT VI

G x E interactions- principle and interpretation -various methods of their estimation with illustrative examples from crop plants. Analysis of genotype x environment interaction - adaptability and stability,

**Practicals**

Problems on multiple factors inheritance - Partitioning of variance - Estimation of heritability and genetic advance Cluster analysis; Correlation and Path analysis - Diallel analysis: Griffin's method II & HAYMAN's graphical approach; NCD and Line x tester analysis; Generation mean analysis; Partitioning of phenotypic variance and co-variance into components due to genotypes, environment and genotype x environment interactions. Practical on G x E interaction.

**Suggested Readings**


Bos, I. and Caligari, P. 1995. Selection methods in Plant Breeding. Chapman and Hall, London.

Dabholkar, A.R.1992. Elements of Biometrical Genetics. Concept Publishing Company, New Delhi.

Falconer, D.S. 1998. Introduction to Quantitative Genetics, Longman, London

Kang, Manjit S. 2002. Quantitative Genetics, Genomics & Plant Breeding. CABI Publishing.

Mather, K. and Jinks, J.L. 1971. Biometrical Genetics. Chapman and Hall. London.

Mather, K. and Jinks, L. 1983. Introduction to Biometrical Genetics. Chapman and Hall, London

Singh, R.K. and Choudhary, B.D. 1987. Biometrical methods in Quantitative Genetics. Kalyani Publishers.

Weir, D.S. 1990. Genetic Data Analysis. Methods for discrete population genetic data. Sinauer Associates, Wricke G and W E. Weber. 1986. Quantitative Genetics and Selection in Plant Breeding. Walter de Gruyter.


## GP 600 DEVELOPMENT OF GENE CONCEPT (4L+0P) II

**Objectives**

To give insight in to the dynamic concept of gene, its structure, function and regulation of expression in prokaryotes and eukaryotes

**Theory**

UNIT I

Pre-Mendelian concepts of gene: physical basis of heredity; Gene concept in classical genetics: Mendelian concepts of inheritance, gene interactions, recombination and linkage in lower and higher organisms, crisscross inheritance, gene mapping; Intra- and inter-genic complementation: complementation as test of allelism, complex loci, pseudoalleles.

UNIT II

Evolving concept of gene: Genetic control of metabolism, Garrod's principle, Beadle and Tatums experiments; fine structure of gene- Beads-on-string, recombination within gene, between adjacent nucleotide, co-linearity principle: homoalleles and heteroalleles; genetic definition of gene-complementation test as an operational definition, intragenic complementation, rII locus of bacteriophage T4, deletion mapping, gene-within-gene, overlapping gene, gene-protein relationship.

UNIT III

Chemical nature of gene: structure and properties of DNA and RNA; DNA, RNA and Prion as genetic material; Replication of genetic material in prokaryotes and eukaryotes; Transfer of genetic information: Central dogma of molecular biology,transcription and translation in prokaryotes and eukaryotes; reverse transcription,multiple factor hypothesis and quantitative traits, genetic code: deciphering and analysis of genetic code, nature and properties of genetic code, one code-two amino acids; Mutation: nature and molecular mechanism of mutation, intra- and inter-genic mutation suppression.

UNIT IV

Regulation of gene expression in prokaryotes: inducible and repressible system, operon concept, attenuation, feedback inhibition; Regulation of gene expression in eukaryotes: level of gene regulation, gene activation through promoter-binding and enhancer-binding protein interaction, transcription regulation, post-transcriptional modifications including RNA processing, RNA editing, post-translational modifications; ncRNA,miRNA, siRNA, significance and ncRNA mediated regulation of gene expression, gene silencing, riboswitches.

UNIT V

Nuclear architecture and gene expression: nuclear compartments, chromatin domains, non-random nuclear architecture; Genetic basis of antibody diversity; alternate splicing; split gene: properties and evolution, Extra-chromosomal genes; Mobile genetic elements; Genetic regulation of virus, viroids, virusoids and prions; Genome complexity: C-value paradox, gene cluster, gene families.

UNIT VI

Genes in population: Hardy- Weinberg law, molecular evolution, linkage disequilibrium.

**Suggested Readings**

Gardner, M.J., Simmons, D.P. Snustad 2008. Principles of Genetics, 5th Edition. JohnWiley and Sons.

Lewin, B. 2008. Genes IX. Jones & Bartlett

Watson, J.D., et al. 2004. Molecular Biology of the gene. Pearson Education

**GP 602 MUTAGENESIS (3L+2P) III**

**Objectives**

To provide insight into mutations, mutagens & their mode of action,effects, screening and their utility and application in crop improvement.

**Theory**

UNIT I

History of mutation and experimental mutagenesis- nature and classification of mutations: spontaneous mutations and induced mutations, micro and macro mutations, forward and reverse mutations,role of mutation in evolution, multi gene families.

UNIT II

Mutagens: Physical mutagens: properties and effect of ionizing radiations, RBE and LET, direct and indirect effects; Chemical mutagens- nature of action, classification, comparative evaluation of physical and chemical mutagens; Transposons as mutagens.

UNIT III

Application methodology of mutagens and modification of their action in cell; Mutation repair; Mutagenic effectiveness and efficiency: Estimation and implications in mutation breeding, biological and environmental parameters influencing mutagenic efficiency. Genetic sieves in mutation induction. Screening techniques and selection procedures of induced mutations; test systems in M1 and subsequent generations.

UNIT IV

Crop improvement through induced mutagenesis; targeted gene replacement; gene silencing. Somaclonal variations. *In vitro* mutagenesis. Mutation in the organellar genome.

UNIT V

Use of mutagens in genomics, TILLING and Eco TILLING: Use of specific chemical mutagens in creating lesions associated with physical changes in the nucleotide sequence of DNA and analysis of popymorphism for detection of SNPs, functional alleles etc.

UNIT VI

Mutation breeding in animals and microorganisms- scope and achievements. Mutational reconstruction of crop ideotype. Mutagens as carcinostatic agents. Environmental mutagenesis-bacteria, mammalian cell cultures, *Drosophila*; transgenics as environmental mutagen monitors. Comparative assessment of various types of mutations.

**Practicals**

Precautions of handling mutagens; Dosimetry - Studies of mutagenic agents: Radiation hazards-safety regulations and safe transportation, use and disposal of radioisotopes, gamma chamber, treating seeds with gamma rays, Chemical mutagens- learning hazards due to chemical mutagens - Treating plant propagules with physical and chemical mutagens - combined mutagenic treatments in M1 and subsequent generations in different crops – cereal, pulses, oilseeds, vegetatively propagated crops.

**Suggested Readings**

International Atomic Energey Agency, 1970. Manual on Mutation Breeding. IAEA, Vienna,

Alper, T. 1979. Cellular Radiobiology. Cambridge University Press, London.

Chadwick, K.H. and Leenhouts, H.P. 1981. The Molecular theory of Radiation Biology. Springer-Verlag, New York.

Strickberger. 1996. Genetics. Prentice Hall Publications

Mutation detection: a practical approach. 2000. Cotton, R.G.H., E. Edkin and S. Forrest

## GP 603 POPULATION GENETICS (2L+1P) III

### Objective

To study the genetic properties of populations and the effect of various evolutionary forces on population genetic parameters.

UNIT -I

Introduction to population genetics; Review of math and probability theory; Measures of genetic variation and genetic distance

UNIT II

Genetic constitution of a population – frequencies of genes and genotypes, Hardy-Weinberg Equilibrium, two alleles, multiple alleles, linkage and sex linked inheritance, HWE testing

UNIT III

Changes of gene frequency under selection, mutation and migration: basic selection model, gametic selection, selection against recessives, dominants and heterozygotes; Allele frequency change caused by mutation, forward and backward mutation, fate of a single mutation, mutation-selection balance; Gene flow and population structure, Continent-Island and general model, Wahlund's principle, F coefficients.

UNIT IV

Genes in small populations: Genetic drift, inbreeding and effective population size, Founder Effect and Bottlenecks

UNIT V

Linkage Disequilibrium and Association Genetics, Nested Association Mapping (NAM)

### Practicals

Exercises on probability, calculation of genes and genotypic frequencies, testing of HWE, estimation of allele frequencies under forces of selection, mutation and migration. Inbreeding coefficient and estimation of linkage disequilibrium.

### Suggested Readings

Falconer and Mackay.1996. Introduction to Quantitative Genetics. 4th edition, Longman.

Hartl and Clark, 2007. Principles of Population Genetics, Fourth Edition

Li, C.C. 1955. Population Genetics. The Univ. of Chicago Press.

Philip W Hedrick. 2005. Genetics of populations. Jones and Bartlett publishers, Inc

## GP 604 INNOVATIVE APPROACHES IN PLANT BREEDING (2L+0P) III

### Objective

To familiarize students with the latest in plant breeding approaches.

### Theory

UNIT I

Introduction, Markers: morphological, isozymes, DNA markers (RFLP, RAPD, AFLP, SSR, SNP). Construction of linkage map; use of mapping populations (F2, RILs, NILs, back cross, doubled haploids)-applications, advantages, constraints.

UNIT II

Applications of molecular markers-fingerprinting, phylogenetic relationships. Tagging agronomically important traits. Assessing heterotic performance; Marker assisted selection (MAS) for oligogenic traits, MAS for QTLs. Gene pyramiding using molecular markers.

UNIT III

Transgenic plants-applications of transgenic technology, molecular farming, antisense RNA technology examples from published literature (crop quality, herbicide resistance, insect resistance, disease resistance, viral resistance)-organelle transformation, stability of transgenes, integration of transgenics in plant breeding.

UNIT IV

Biosafety issues of transgenics. Somatic hybridization applications and constraints. Somaclonal variation in crop improvement-overview and future prospects,

UNIT V

Plant genetic resources- characterization and utilization. Breeding for biotic stress resistance, abiotic stress tolerance and nutritional quality. Apomixis and its utilization.

UNIT VI

Functional markers, Reverse genetics approaches: Targeting Induced Local Lesions IN Genomes (TILLING), ECOTILLING and its application in crop breeding, Allele mining, Genome assisted breeding, Metabolomics assisted breeding, Overcoming domestication bottlenecks using molecular tools.

**Suggested Readings**


Caetano-Anolles,G. and Gresshoff, P.M. 1998. DNA Markers: Protocols, Applications and Overviews. Wiley.

Gupta, P.K. 2010 Plant Biotechnoloy. Rastogi Publications.

Jain, C.M. and Brar, D.S. 2010. Molecular Techniques in Crop Improvemoent 2nd ed. Springer

Jordan, B.R. 2001. DNA Microarrays: Gene Expression Applications.Springer-Verlag.

Kole, C. and Abbott, A.G.2008. Priniciples and Practices of Plant Genomics. Volume I Genome Mapping.; Volume II: Molecular Breeeding.Science Publishers.

Liu, B.H. 1997. Statistical Genomics: Linkage, Mapping and QTL Analysis.CRS Press.

Lynch, M. and Walsh, B. 1998. Genetics and Analysis of Quantitative Traits.Sinauer Associates.

Mount, D.W. 2001. Bioinformatics. Sequence and Genome Analysis. CSHL Press.

Paterson, A.H. 1996. Genome Mapping in Plants. Academic Press.

Sharma, T.R. 2009. Genome Analysis and Bioinformatics-A pratical Approch. IK International, New Delhi.

Rao, D.C and Province, M.A. 2001. Genetic Dissection of Complex Traits. Academic Press.

Yunbi, Xu. 2010. Molecular Plant Breeding. CABI


**GP 605 BREEDING FOR STRESS RESISTANCE (3L+0P) III**

UNIT I

Nomenclature and classification of stresses. Nature and importance of viral, bacterial, fungal and other diseases, insect pests. Genetic, physiological and molecular mechanisms of disease and insect pest resistance.

UNIT II

Host-parasite interaction-variation in pathogen and host, factors affecting host reactions, gene-for-gene concept, implications and significance in plant breeding.

UNIT III

Identification of pathogen variation, multipathotype testing, gene postulation using infection type data. Creation of artificial epiphytotics, screening techniques for breeding materials. Sources of resistance, shuttle breeding, stability of resistance, gene deployment over time and space-resistance. Concepts of varietal blends, mixtures and multilines for disease resistance.

UNIT IV

Marker aided selection. Introgression of genes from the wild relatives of crop plants, pyramiding of resistance genes, elimination of linkage drag. Transgenics in the management of biotic stresses. Use of Bt toxins, rotease inhibitors, electins, chitinases and glucanases for insect pest management.

UNIT V

Importance and crop specificity of stresses due to temperature, drought, salinity, alkalinity, Aluminium toxicity, water logging and excessive rains.

Genetic and physiological mechanisms governing abiotic stress resistance. Breeding procedures for abiotic stress resistance in selected and important crop plants. Achievements in breeding crop plants for abiotic stress resistance.

**Suggested Readings**


Fritz, R.S. and Simms, E.L. (Eds). 1992. Plant resistance to herbivores and pathogens: Ecology, evolution and genetics. The University of Chicago Press. Chicago.

Russel, G.E. 1978. Plant breeding for pest and disease resistance. Butterworths. London.

van der Plank, J.E. 1982. Host -pathogen interactions in plant disease. Academic Press, London.

Blumm, A. 1988. Plant Breeding for Stress Environments. CRC Press Inc., USA.

Christiansen, M.N. and Lewis, C.F. 1982. Breeding plants for less favourable environments. Wiley International science, New York.

Turener, N.C. and Kramer, P.J. 1980. Adaptation of plants to water and high temperature stress. Jon Wiley & Sons, New York.


**GP 606 PLANT GENE EXPRESSION AND REGULATION (3L+0P) III**

**Objective**

To provide insight into recent advances in the phenomenon of gene regulation and mechanisms by which plants and microbes express different traits and how these are modified during different stages.

**Theory**

UNIT I

Gene regulation-purpose; Process and mechanisms in prokaryotes and eukaryotes; Levels of gene controls.

UNIT II

Coordinated genetic regulation-examples- Anthocyanin gene family in maize; Genetic and molecular basis of tissue specificity.

UNIT III

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

UNIT IV

Transgene expression and gene silencing mechanisms; Regulatory genes, horizontal and vertical homology; Transformation-regulatory genes as visible markers; Reporter systems to study gene expression; Combinatorial gene control.

UNIT V

Eukaryotic transcriptional control; Translational and post-translational regulation; Signal transduction; Stress-induced gene expression; Gene traps and enhancer traps.

**Suggested Readings**


Lewin, B. 2008. Genes IX. John Wiley & Sons.

Schleif, R.1986. Genetics and Molecular Biology. Addison-Wesley.

Russell, P.J. 1996. Essential Genetics. Blackwell Scientific Publ.

Brown, T.A. 2002. Genomes. Bios Scientific Publ.

Tamarin, R.H. 1999. Principles of Genetics. Wm C Brown Publ.

Griffiths, A.J.F. 2000. An Introduction to Genetic Analysis. WH Freeman.

Hexter, W. and Yost, H.T. 1976. The Science of Genetics. Prentice Hall.

Singer, M. and Berg, P. 1991. Genes and Genomes. John Wiley & Son

Hartl, D.L. and Jones, E.W. 1998. Genetics Principles and Analysis. Jones &Barlett Publ.

Micklos, D.A. and Freyer, G. 2003. DNA Science - A First Course. C.P.L. Scientific Publ.

Brooker, R.J. 2004. Genetics Analysis and Principles. Addison-WesleyLongman.

Watson, J.D. 2004. Molecular Bilology of the Gene. Pearson Edu.


## GP 607/ PGR 607 REGULATORY MECHANISMS AND INTELLECTUAL PROPERTY RIGHTS AND INTELLECTUAL PROPERTY RIGHTS (3L+0P) I

**Objectives**

To educate students about concepts and instruments of intellectual property rights, plant breeders's rights, farmer's rights, access and benefit sharing, international treaties and national legislation related to plant genetic resources.

**Theory**

UNIT I

Concept of intellectual property, need for IP protection, Dimensions and nature of IPR, conflicting community interest with private right. Forms of IPR, patents, copyright, trademark, design, trade secret/ confidential information, GI registration. Process of obtaining an IPR, World Intellectual Property Organization, patent cooperation treaty (PCI).

UNIT II

Plant breeder's rights, protection of plant varieties, UPOV; registration of plant varieties and essentially derived varieties, during and effect of registration; traditional knowledge systems,

farmer's rights, fork lore, code of conduct, access and benefit sharing; compulsory license; plant varieties protection appellate tribunal; finance, accounts and audit; infringement, offenses, penalties and procedure.

UNIT III

International instruments concerning agro-biodiversity, Agenda 21, convention on biological diversity (CBD), FAO and global system of PGR, the International Treaty on Plant Genetic Resources for food and agriculture (ITPGR), Global Plan of Action, TRIPS agreement and IPR protection of life forms, geographical appellations.

UNIT IV

Multilateral agreement on trade in goods – relevance to agriculture, agreement on agriculture (AOA); agreement on application of sanitary and phyto-sanitary measures (SPS, international plant protection convention, agreement on technical barriers to trade (TBT), Plant quarantine, bio-safety related issues.

UNIT V

National legislations related to biodiversity conservation and IPR protection

**Suggested Readings**

Valuation and Conservation of Biodiversity; Interdisciplinary Perspectives on the Convention on Biological Diversity by Michael Markussen et al. Springer 2005.

Use of Biodiversity: Access to Genetic Resources and Benefit Sharing by Kerry Ten Kate and Sarah A Lai4rd; Earthscan 2002.

Providing Protection For Plant Genetic Resources: Patents, Sui Generis Systems And Biopartnerships; Publisher: Kluwer Academic Press, ISBN : 9041188754; Distributer : Landmark Ltd.

**GP 610 CROP CYTOGENETICS (2L+1P) II**

**Objective**

To study crop evolution and cytogenetic approaches for crop improvement.

**Theory**

UNIT I

Origin and evolution of species; Centres of diversity/origin, diffused centres; domestication; Patterns of evolution and domestication-examples and case studies. Domestication and uniformity – Characteristics of early domestication and changes – Concept of gene pools and crop evolution; Selection and Genetic drift - Consequences.

UNIT II

Speciation and domestication – The process of speciation – Reproductive isolation barriers – Genetic differentiation during speciation –Hybridization - speciation and extinction.

UNIT III

Exploitation of natural variation – Early attempts to increase variation –Distant hybridization and introgression- Inter-specific, inter-generic hybridization, scope and limitations, techniques to overcome the limitations; Gene transfer into cultivated species, tools and techniques;Validation of transferred genes and their expression; Controlled introgressions.

UNIT IV

Processes in crop evolution and stabilization of polyploids, cytogenetic and genetic stabilization; Genome organization – Transgenesis in crop evolution – Multifactorial genome – Intragenomic interaction – Intergenomic interaction – Genome introgression. Cytogenetic analysis of species relationships and evolution of wheat, rice, maize,sugarcane, Brassica, cotton, jute, tobacco, potato, tomato, pulse crops, forage crops and cucurbits.

UNIT V

Methods to study crop evolution - Contemporary Methods – Cytogenetic analysis – Allozyme variations and crop evolution – DNA markers, genome analysis and comparative genomics.

UNIT VI

Evolutionary significance of polyploidy, Evolution of crop plants through ploidy manipulations; polyploids: methods of induction, use of autopolyploids;Haploidy-method of production and use; allopolyploids- synthesis of new crops; - Case studies – Cereals – Pulses – Oilseeds – vegetables, Fibre crops - Plantation crops – Forage crops – Tuber crops – Medicinal Plants.

**Practicals**

Patent Information Search; Patent Drafting; Opinion on Patentability; Patent Infringement

**Suggested Readings**

Hancock, J.F. 2004. Plant Evolution and the Origin of Crop Species. 2nd Ed.CABI.

Ladizinsky, G. 1999. Evolution and Domestication. Springer.

Miller, A.J. 2007. Crop Plants: Evolution. John Wiley & Sons.

Smartt, J. and Simmonds, N.W. 1995. Evolution of Crop Plants. Blackwell.

**GP 612 DIVERSITY ANALYSIS (2L+1P) II**

**Objective**

To expose students to various aspects of genetic diversity, its measurement, grouping and study of phylogenetic relationship

UNIT I

The meaning of diversity, history, importance and its use in agriculture. Assessment of diversity: Morphological, biochemical and molecular.

UNIT II

Statistical techniques for measuring diversity: Measures of quantitative and qualitative variability, diversity indices; and methods for marker data analysis. Statistical techniques for clustering: Hierarchical and non-hierarchical cluster analysis, algorithms for forming clusters/ dendrograms, data transformation and choice of scales, exposure to various clustering softwares.

UNIT III

Evolution and Diversity: Phylogenetics, concept of evolutionary trees, rooted and unrooted topology, methods for studying phylogeny-maximum, parsimony, distance methods, maximum likelihood, reliability of prediction. Exposure to various softwares (MEGA, Phylip. NTSYS etc.)

UNIT IV

Collection of germplasm diversity, required sample size and introduction to various germplasm sampling models, Spatial tools for studying plant germplasm diversity

**Practical**

Estimation of diversity, Practical exercises using statistical software for clustering. Developing phylogenic trees based on various methods, estimating and locating diversity using DIVA GIS, determination of sample size for collecting diversity

**Suggested Reading**

Philip W Hedrick. 2005. Genetics of Populations. Jones & Bartlett Publishers. USA.

Sapra R L, Prem Narayan, S V S Chauhan, S K Lal and B B Singh. 2003. Sample size for collecting germplasms- a polyplody model with mixed mating system. J Biosci.28 (2):155-161.

Weir D S. 1990. Genetic Data Analysis. Methods for Discrete Population Genetic Data. Sinauer Associates.

**GP 620 APPLIED CYTOGENETICS (3L+1P) III**

**Objectives**

This course aims to teach advanced techniques in manipulating cytogenetics for genome analysis in crop species.

**Theory**

UNIT I

Karyotyping – Chromosome banding and chromosome painting Tracking introgressions using FISH, GISH, loclalization and mapping of genes/genomic segments. – Distant hybridization - Role of polyploids in crop evolution and breeding - auto and allopolyploids.

UNIT II

Location and mapping of genes on chromosomes by various cytogenetical tools : Deficiency method, Interchanges, all arms marker method, linked marker method, Inversions, Telocentrics. Relative efficiency of different methods

UNIT III

Applications of cytogenetical methods for crop improvement; balanced lethal systems, their maintenance and utility; multiple interchanges-use in producing inbreds, transfer of genes- linked marker methods;

UNIT IV

Duplication - production and use; inversions and location of genes; B/A chromosome translocations and gene location Duplications- Production and use. Balanced tertiary trisomics-use in hybrid seed production. Polyploidy induction methods: Use of auto-polyploids. Haploidy-methods of production and use.

UNIT V

Trisomics- different types, production, breeding behaviour and location of genes using trisomics. Monosomics -methods of production, intervarietal substitutions, allelic and non-allelic interactions.

UNIT VI

Gene transfer by distant hybridization: scope and limitation, methods to overcome barriers-tissue culture. Allopolyploids-synthesis of new crop species and varieties, Alien chromosome addition and substitutions. Chromosomal control of meiotic pairing and induced transfer of alien genetic variation.

**Suggested Readings**

Clark M.S. and W.J. Wall. 1996. Chromosomes: The complex code. Chapman and Hall, London.

Conger B.V. (Ed) 1981. Cloning Agricultural Plants via in vitro Techniques. CRC Press Inc.

Constabel F and Vasil I.K. (Eds) 1988. Cell Culture and Somatic Cell Genetics of Plants. Vol. 5. Cell.

Lal R and Lal S. (Eds) 1990. Crop Improvement utilizing Biotechnology. CRC Press Inc.

Mantel S.H. and Smith H. 1983. Plant Biotechnology. Cambridge University Press, Cambridge.

**GP 621 BREEDING FOR CROP QUALITY TRAITS (2L+2P) III**

**Objectives**

To understand recent advances in improving quality traits in cereals, millets, legumes, oilseeds and forage crops by conventional and modern approaches.

**Theory**

UNIT I

Nutritional improvement - A human perspective, Developmental biochemistry and genetics of carbohydrates, proteins, fats, vitamins, aminoacids and anti-nutritional factors - Wheat quality-nutritional, rheological, baking properties and fractional aspects; - Molecular and cytogenetic manipulation for quality improvement in wheat - Breeding for quality improvement in barley and oats.

UNIT II

Breeding for grain quality parameters in rice and its analysis- aroma, amylose, GT, gel consistency, elongation ratio, cooking quality, post harvest manipulation for quality improvement – vitamin A enriched and aromatic rice – breeding strategies, achievements and application in Indian context - Molecular basis of quality traits and their manipulation in rice - Post harvest manipulation for quality improvement.

UNIT III

Breeding for quality improvement in Sorghum and pearl millet; Quality protein maize- – concept and breeding strategies –kernel mutants and their uses in breeding for quality; Speciality corns; Breeding for quality improvement in forage crops; Genetic resource management for sustaining nutritive quality in crops

UNIT IV

Breeding for quality in pulses; groundnut, sesame, sunflower and minor oilseeds – Fatty acid metabolism and its manipulation to increase PUFA in oil, Brassica-breeding for low erucic acid and glucosinolates; Soybean- breeding for amelioration of anti nutritional factors; Genetic manipulation for quality improvement in cotton.

UNIT V

Genetic engineering protocols for quality improvement – Achievements made - Value addition in crops; classification and importance - Nutritional genomics and Second generation transgenics

**Practicals**

Grain quality evaluation in rice; correlating ageing and quality improvement in rice - Quality analysis in millets; a comparison - Quality parameters evaluation in wheat; Quality parameters

evaluation in pulses - Quality parameters evaluation in oilseeds - Value addition in crop plants; Post harvest processing of major field crops - Quality improvement in crops through tissue culture techniques - Evaluating the available populations like RIL, NIL etc. for quality improvement using MAS procedures.

**Suggested Readings**


Chahal G.S. and S.S. Ghosal. 2002. Principles and procedures of plant breeding – Biotechnological and Conventional approaches. Narosa Publications.

Chopra, V.L. 1997. Plant breeding. Oxford and IBH Publishing Company.

Jafar, Nigam. 1996. Genetic improvement of oilseed crops. Oxford and IBH Publishing Co.

Ghosh, Premamoy. 2004. Fibre Science and Technology. Tata McGraw Hill Publishers,

Singh, B.D. 1997 Plant breeding. Kalyani Publishers.

Singh, R.K., Singh, U.K. and Khush, G.S. 2000. Aromatic rices. Oxford IBH Publishers.

Speciality rices of the World – Breeding, production and marketing. 2001. FAO Oxford IBH.

Hay Robvert, K. 2006. Physiology of Crop Yield. 2nd Ed. Blackwell.


**GP 640 ADVANCES IN PLANT BREEDING (3L+0P) III**

**Objective**

To impart knowledge on advancement in plant breeding methodology, approaches and their implications in crop improvement.

**Theory**

UNIT I

Introduction, course outline, overview & Perspectives; Different approaches to crop breeding including improvement for quality and resistance attributes: concepts and new developments;

Marker assisted selection-Approaches, applications and outcomes, for realizing specific objectives; Variations at genomic level, analysis and implications- from plant breeding point of view.; Stability-Concept and applications;

UNIT II

Current developments in breeding and improvement of important cereals (wheat, Rice) and oil seed crops (Brassica & Sunflower); pulses.

UNIT III

Crop domestication, adaptation and selection: an update; Classical experiments in crops – long term selection,its consequences and utility; Comparison and contrasts between crop domestication, classical breeding and molecular breeding; Hybrid technology in plant breeding: Concept development, utilization & consequences;

UNIT IV

Associations mapping & in silico mapping: application and implications in plant breedingGene introduction and selection –Natural and induced; utilization in plant breeding; Mutational variation and long term selection response;

UNIT V

Approaches and effectiveness of breeding for drought tolerance, in different crops; Current developments in improvement of pulses; Hybrid technology in Sunflower, brassica.

UNIT VI

Implication of plant variety protection on plant breeding – past experience from other countries; Implication of PVP&FR on crop improvement efforts in India; gearing up for change and meeting specific requirements and obligations; EDV *vs* IDV – Approaches of development and differentiation;Issues and impact of current & prospective approaches- (i) Participatory plant breeding (ii) Organic farming (iii)Processing, post harvest requirements & value addition

**Selected Readings**

Lamkey, K.R. and Lee, M. 2006. Plant Breeding: The Arnel R. Hallauer Symposium. Blackwell Publishing.

Kirakosyan, P. and Kaufman, B. 2009. Recent Advances in Plant Biotechnology. Springer.

Lal, R. and Lal, S. (Eds.). 1990. Crop Improvement Utilizing Biotechnology.CRC Press.

Yunbi, Xu. 2010. Molecular Plant Breeding. CABI.

## GP 643 CONCEPTS IN HETEROSIS BREEDING (2L+1P) II

**Theory**

UNIT I

Heterosis: Introduction, Nomenclature and definitions of heterosis - Heterosis in natural and bred population; Evolutionary aspects - Genetic consequences of selfing and crossing in self-and cross-pollinated and asexually propagated crops crops;

UNIT II

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

UNIT III

Prediction of heterosis from various crosses - Inbreeding depression, frequency of inbreeding and residual heterosis in $F_2$ 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, and transfer of different types of male sterility.Fertility restoration- Genetics,Allelic relationship and breeding of new restorer lines. Hybrid seed production methods involving 3-lines, 2-lines and 1-line system, Development of inbreds and parental lines- A, B and R lines Use of self-incompatibility in development of hybrids

UNIT V

Fixation of heterosis in self, cross and often cross pollinated crops, asexually / clonally propagated crops, Apomixis in fixing heterosis-concept of single line hybrid.

UNIT VI

Molecular basis of heterosis, molecular basis of male sterility and fertility restoration, genetic basis of inbreeding depression. Heterosis breeding in wheat, rice, cotton, maize, pearl millet, sorghum and oilseed crops

**Practicals**

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**


Akin, E. 1979. The geometry of population genetics. Springer-Verlag, Berlin Ben Hiu Lin. 1998. Statistical genomics – linkage, mapping and QTL analysis. CRC Press

Coors, J.C. and Pandey, S. 1999. Genetics and Exploitation of Heterosis in Crops. American Society of Agronomy, Inc. & Crop Science Society of American, Inc.

Hartl, D.L. 2000. A primer of population genetics. 3rd ed. Sinauer Assoc. Inc. Publishers

De Joung, G. 1988. Population Genetics and Evolution. Springer-Verlag, Berlin

Montgomery, D.C. 2001. Design and analysis of experiments. 5th edition, Wiley and Sons

Mukherjee, B.K. 1995. The Heterosis Phenomenon. Kalyani Publishers

Srivastava, S. and Tyagi, R. 1997. Selected problems in Genetics, 2 Volumes, Anmol Publications.

Rai, M. and Maurya, S. 1995. Hybrid Research and Development;Indian Society of Seed Technology.

Virmani, S.S. 1994. Heterosis and Hybrid Rice Breeding. Monographs of "Theoretical and Applied Genetics", Springer-Verlag.

James A. Birchler, et al. 2010. Heterosis. The Plant Cell. Vol.22: 2105-2112.