DEPARTMENT OF GENETICS AND PLANT BREEDING
COLLEGE OF AGRICULTURE, JODHPUR
(AGRICULTURE UNIVERSITY, JODHPUR)

Course Requirements for M.Sc. (Ag.) Genetics and Plant Breeding

Field of specialization	Genetics, Plant Breeding, Molecular Genetics, Cytogenetics, Biotechnology, Seed Technology, Quantitative Genetics, Germplasm conservation, Cell Biology
Core courses	PBG-511, PBG-512, PBG-513, PBG-521
Optional courses	PBG-522, PBG-523, PBG-524, PBG-525, PBG-526, PBG-527 PBG-531, PBG-532, PBG-533, PBG-534, PBG-535 PBG 541 (seminar), PBG 543 (Research)
Minor & supporting Courses	STAT 511, STAT-521, PPHY-521 or as deemed suitable by advisory committee
Non-credit compulsory Courses	PBG 542 (comprehensive) PGS courses
Deficiency courses	Nil or as deemed suitable by advisory committee

Course Requirements for Ph. D. Genetics and Plant Breeding

Field of specialization	Plant Breeding, Quantitative Genetics, Plant Genetic Resources, Germplasm conservation, Genomics.
Core courses	PBG-611, PBG-612,
Optional courses	PBG-613, PBG-614, PBG-621, PBG-622 PBG 691, PBG 692 (seminar), PBG 699 (Research)
Minor & supporting Courses	MBB- 522, HORT-624, PPHY-522 or as deemed suitable by advisory committee
Non-credit compulsory Courses	PBG 531 (comprehensive) PGS courses
Deficiency courses	Nil or as deemed suitable by advisory committee

Postgraduate courses for Master degree

GPB 511* **PRINCIPLES OF GENETICS** **3 (2+1)**

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; Early concepts of inheritance, Mendel's laws; Discussion on Mendel's paper, Chromosomal theory of inheritance.

UNIT II

Multiple alleles, Gene interactions. Mechanism of 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

Fine structure of gene. Allelic complementation, Split genes, Transposable genetic elements, Overlapping genes, Pseudogenes, Oncogenes.

UNIT VI

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

UNIT VII

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

UNIT VIII

Introduction to genomics and proteomics. Methods of studying polymorphism at biochemical and DNA level; Transgenic bacteria and bioethics; Gene silencing; genetics of mitochondria and chloroplasts. Concepts of Eugenics, Epigenetics, Genetic disorders and Behavioural genetics and genomics.

Practical

Laboratory exercises in probability and chi-square; Introduction to Laboratory; Principles of fixation & fixatives. Life cycle of Laboratory organism ex. Drosophila / neurospora. 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 – if possible visit to transgenic glasshouse and learning the practical considerations.

Suggested Readings

Gardner EJ & Snustad DP. 1991. *Principles of Genetics*. John Wiley & Sons.

Klug WS & Cummings MR. 2003. *Concepts of Genetics*. Peterson Edu.

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

Russell PJ. 1998. *Genetics*. The Benzamin/Cummings Publ. Co.

Snustad DP & Simmons MJ. 2006. *Genetics*. 4th Ed. John Wiley & Sons.

Strickberger MW. 2005. *Genetics (III Ed)*. Prentice Hall, New Delhi, India

Tamarin RH. 1999. *Principles of Genetics*. Wm. C. Brown Publs.

Uppal S, Yadav R, Subhadra & Saharan RP. 2005. *Practical Manual on Basic and Applied Genetics*. Dept. of Genetics, CCS HAU Hisar.

GPB 512* CELL BIOLOGY AND MOLECULAR GENETICS 3 (3+0)

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 chloro/ chromoplast, mitochondria endoplasmic reticulum, Golgi complex, lysosomes, peroxisomes.

UNIT II

Bioenergetics; Ultrastructure and function of mitochondria and biological membranes; Chloroplast and other photosynthetic organelles; Interphase nucleus- Structure and chemical composition; Cell division and physiology of cell division.

UNIT III

Historical background of molecular genetics; Genetic material in organisms; Structure and properties of nucleic acid, DNA transcription and its regulation – Transcription factors and their role; Genetic code DNA sequencing, 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; Mini satellites and micro satellites organelle genomes; Structural and functional genomics. Marker assisted selection. Molecular mapping & tagging of genes. Gene amplification and its significance; Proteomics and protein-protein interaction; Signal transduction; Genes in development; Cancer and cell aging.

Suggested Readings

Brown, T.A. (1998). Genomes, John wiley and Sons (East Asia), Singapore.

Primrose, S.B. Twyman R.M. and old R.W. (2004) Principle of gene Manipulation Blackwell publishing, Italy.

Primrose S.B. and Twyman R.M. (2006). Principle of Gene Manipulation and Genomics, Blackwell Publishing, Italy.

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.

GPB 513* PRINCIPLES OF PLANT BREEDING 3 (2+1)

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: 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.

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

UNITVI: Self-incompatibility and male sterility in crop plants and their commercial exploitation; Concept of plant ideotype and its role in crop improvement; Transgressive breeding.

UNIT VII:Special breeding techniques- Mutation breeding; Breeding for abiotic and biotic stresses and MAS.

UNIT VIII: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. Prestigious organizations involved in crop breeding.

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.

GPB 521* PRINCIPLES OF QUANTITATIVE GENETICS 3 (2+1)

Objective

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

Theory

UNIT I

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, Comparison of means and variances for significance.

UNIT III

Designs for plant breeding experiments– principles and applications. Genetic diversity analysis – metroglyph, cluster, D^2 analyses and dendogram. Selection indices.

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 G x E analysis and stability parameters; AMMI analysis– principles and interpretation, bi-plot analysis.

UNIT V

QTL mapping; Strategies for QTL mapping - desired populations for QTL mapping - statistical methods in QTL mapping - QTL mapping in Genetic analysis; Marker assisted selection (MAS) - Approaches to apply MAS in plant breeding - selection based on marker - simultaneous selection based on marker and phenotype - factors influencing MAS.

Practical

Problems on multiple factors inheritance - Partitioning of variance -Estimation of heritability and genetic advance - Covariance analysis -Metroglyph analysis - D^2 analysis - Grouping of clusters and interpretation- Cluster analysis - Construction of cluster diagrams and dendrograms – interpretation. Correlation analysis - Path analysis. 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. QTL analysis, Use of softwares in data processing.

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 QuantitativeGenetics*. 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.

GPB 522 BIOTECHNOLOGY FOR CROP IMPROVEMENT 3 (2+1)**

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

Genotyping; Sequencing techniques; vectors, vector preparation and cloning, 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 IV

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

UNIT V

Biochemical and molecular markers: morphological, biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR,SNPs, ESTs etc.), mapping populations (F2s, back crosses, RILs, NILs and DH).

UNIT VI

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 VII

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 VIII

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

UNIT IX

Introduction to Bioinformatics & Bioinformatics tools. Introduction to Nanotechnology and its applications in crop improvement programmes.

Practical

Requirements for plant tissue culture laboratory-Techniques in plant tissue culture - Media components and media preparation -Aseptic manipulation of various explants ; observations on the contaminants occurring in media – interpretations - Inoculation of explants; Callus induction and plant regeneration - Plant regeneration; Standardizing the protocols for regeneration; Hardening of regenerated plants; Establishing a greenhouse and hardening procedures - Visit to commercial 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.

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.

GPB 523 PRINCIPLES OF CYTOGENETICS 3 (2+1)**

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, 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 - Introduction to techniques for karyotyping; Chromosome banding and painting - *in situ* hybridization and various applications.

UNIT III

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

UNIT IV

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

UNIT V

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

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 ; case studies – Production and use of haploids, dihaploids and doubled haploids in genetics and breeding.

Practical

Learning the cytogenetics laboratory, various chemicals to be used for fixation, dehydration, embedding, staining, cleaning etc. - Microscopy: various types of microscopes. Preparing specimen for observation – Fixative preparation and fixing specimen for light microscopy studies in cereals - Studies on the course of mitosis in wheat / pearlmillet - Studies on the course of mitosis in onion/*Aloe vera* - Studies on the course of meiosis in cereals, millets and pulses - Studies on the course of meiosis in oilseeds and forage crops. Various methods of staining and preparation of temporary and permanent slides - 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;– Morphological observations on synthesized autopolyploids - Observations on C-mitosis, learning on the dynamics of spindle fibre assembly – Morphological observations on alloployploids - Morphological observations on aneuploids - Cytogenetic analysis of interspecific and intergeneric crosses - Maintenance of Cytogenetic stocks and their importance in crop breeding e.g. maize, etc.

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 Mirotomist's Formulatory 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.

Johannson 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.

GPB 524 SEED CERTIFICATION AND GERMPLASM CONSERVATION 3 (2+1)**

Objective

To apprise the students about seed laws, production, seed certification and Germplasm conservation in self and cross pollinated crops.

Theory

UNIT I

History of Seed Industry in India and role of various seed organizations.

UNIT II

Indian seed act and Enforcement and Jurisdiction – Seed laws and plant variety protection regulations in India & international systems. DUS testing, DUS Descriptors for major crops.

UNIT III

Notification of variety – variety testing, release and notification systems in India. Definition – variety, cultivar, extant variety essentially derived variety, independently derived variety, reference variety, farmers' variety, hybrid and population.

UNIT IV

General principles of seed production, maintenance of nucleus, breeder and foundation seed – production of certified seed. Seed production technology of self and cross – pollinated crops varieties viz. cereals & millets (wheat, paddy, pearl millet, sorghum and maize); Pulses (greengram, blackgram, cowpea, pigeonpea, chickpea); Oilseeds (groundnut, soybean, castor, linseed, rapeseed and mustard); Fibres (cotton) and forages (guar, forage sorghum, berseem, Lucerne).

UNIT V

Minimum field & seed certification procedures and standards.

UNIT VI

Gene pool : Primary, secondary and tertiary. Principles, strategies and practices of exploration, collection, characterization, evaluation and cataloguing of PGR.

UNIT VII

Germplasm introduction and exchange, Germplasm conservation : *In situ, Ex situ*. PGR access and benefit sharing : IPR, PBR, Farmer's right and CBD Issues.

Practical

(1) Seed sampling oils methods (2) Seed testing: Viability, Seed Health, Moisture and Purity. (3) Heterogenity test (4) Cultiver purity test = KOH, HaOH (5) Seed Vigour test, (6) Visit to seed testing laboratories (7) Characterization of germplsam.

Suggested Readings

R.L. Agarwal, 1991. Seed Technology, Oxford & IBG Publishing Co. Delhi.

O.H. Frankel and Ewajee, 1975. Crop Genetic Resources for Today and Tomorrow (Ed.). Cambridge Univ., Press.

J.H.W. Holden and J.T. Williams, 1984. Crop Genetic Resources, Conservation and Evaluation. Oxford Books and Stationary Co., Delhi.

F.L. Brian and M. Jackson, 1986. Plant Genetic Resources – An introduction to their conservation and use. Edward Annold, London.

N. Kameswara Rao and Paula J. Bramel, 2000. Manual of Gene bank Operations and Procedures. Technical Manual No.6. ICRISAT, Patancheru, A.P., India.

Sustainable Management of Plant Biodiversity. Lecture Notes (2nd Trainers Training Programme) NATP Cell, NBPGR, New Delhi.

GPB 525 BREEDING FOR QUALITY TRAITS 3 (3+0)

Objective

To provide insight into recent advances in improvement of quality traits in rice, millets, legumes, oilseeds and forage crops and for physiological efficiency using conventional and modern biotechnological approaches.

Theory

UNIT I

Developmental biochemistry and genetics of carbohydrates, proteins, fats, vitamins, aminoacids and anti-nutritional factors - Nutritional improvement - A human perspective - Breeding for grain quality parameters in rice and its analysis - Golden rice 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 II

Breeding for baking qualities in wheat; Characters to be considered and breeding strategies - Molecular and cytogenetic manipulation for quality improvement in wheat.

UNIT III

Breeding for quality improvement in Sorghum and pearl millet; Quality protein maize – Concept and breeding strategies – Breeding for quality improvement in forage crops - Genetic resource management for sustaining nutritive quality in crops.

UNIT IV

Breeding for quality in pulses - Breeding for quality in groundnut, sesame, sunflower and minor oilseeds – Molecular basis of fat formation and manipulation to achieve more PUFA in oil crops; 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.

Suggested Readings

Chahal GS & Ghosal SS. 2002. *Principles and Procedures of Plant Breeding - Biotechnological and Conventional Approaches*. Narosa Publ.

Chopra VL. 1997. *Plant Breeding*. Oxford & IBH.

FAO 2001. *Speciality Rices of the World - Breeding, Production and Marketing*. Oxford & IBH.

Ghosh P. 2004. *Fibre Science and Technology*. Tata McGraw Hill.

Hay RK. 2006. *Physiology of Crop Yield*. 2nd Ed. Blackwell.

Nigam J. 1996. *Genetic Improvement of Oilseed Crops*. Oxford & IBH.

Singh BD. 1997. *Plant Breeding*. Kalyani.

Singh RK, Singh UK & Khush GS. 2000. *Aromatic Rices*. Oxford & IBH.

GPB 526 BREEDING FOR LEGUMES, OILSEEDS, FIBRE AND VEGETATIVE PROPAGATED CROPS 3 (3+0)

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, cowpea, 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: castor and sesame: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; breeding objectives- yield, quality characters.

UNIT VIII

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.

UNIT IX

Sugarcane & Potato: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship, breeding objectives yield, quality characters and achievements.

UNIT X

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

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.

GPB 527 POPULATION GENETICS 3 (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 in Non-dominance and 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 in case of Migration, Mutation, Recurrent and nonrecurrent- Selection, Balance between selection and mutation, Selection favouring heterozygotes and 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- Adapative 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 genesubstitution 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.

GPB 531 HETEROSIS BREEDING 3 (2+1)

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 crops.

UNIT II

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

UNIT III

Prediction of heterosis from various crosses- Inbreeding depression, frequency of inbreeding and residual heterosis in F2 and segregating populations, importance of inbreeding in exploitation of heterosis – case studies. Relationship between genetic distance and expression of heterosis– case studies; Divergence and Genetic Distance analyses-morphological and molecular genetic distance in predicting heterosis, 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; Apomixis in fixing heterosis.

UNIT VI

Organellar 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 oil seeds, pulses and cotton ; problems in creation of CGMS system; Ways of overcoming them - Male sterile line creation, diversification and restoration in forage crops; Understanding the difficulties in breeding apomicts; Estimation of heterotic parameters in self, cross and asexually propagated crops - Estimation from the various models for heterosis parameters -Hybrid seed production in field crops – an account on the released hybrids; their potential; Problems and ways of overcoming it; hybrid breeding at National and International level; Opportunities ahead.

Suggested Readings

Proceedings of *Genetics and Exploitation of Heterosis in Crops* – An International Symposium CIMMYT, 1998.

Akin E. 1979. *The Geometry of Population Genetics*. Springer-Verlag.

Ben Hiu Lin. 1998. *Statistical Genomics – Linkage, Mapping and QTL Analysis*. CRC Press.

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

Hartl DL. 2000. *A Primer of Population Genetics*. 3rd Ed. Sinauer Assoc.

Mettler LE & Gregg TG. 1969. *Population Genetics and Evolution*. Prentice-Hall.

Montgomery DC. 2001. *Design and Analysis of Experiments*. 5th Ed., Wiley & Sons.

Richards AJ. 1986. *Plant Breeding Systems*. George Allen & Unwin.

Srivastava S & Tyagi R. 1997. *Selected Problems in Genetics*. Vols. I, II. Anmol Publ.

GPB 532 BREEDING FOR BIOTIC AND ABIOTIC STRESS RESISTANCE 3 (2+1)

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; Analysis and inheritance of resistance variation; Host defence responses to pathogen invasions- Biochemical and molecular mechanisms; Acquired and induced immunity and systemic acquired resistance (SAR); 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. Gene pyramiding methods and their implications.

UNIT III

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 IV

Genetics of abiotic stress resistance; Genes and genomics in breeding cultivars suitable to low water regimes, high temperatures; Utilizing MAS procedures for identifying resistant types in important crop like rice / sorghum / wheat / cotton etc; Breeding for resistance to stresses caused by toxicity, deficiency and pollutants/contaminants in soil, water and environment.

UNIT V

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

Practical

Phenotypic screening techniques for sucking pests and chewing pests – Traits to be observed at plant and insect level - Phenotypic 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; 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.

Panda, N. and Khush, G.S. 1995 Host Plant Resistance to Insects. CAB.

Sharma, J.R. 1994. Principles and Practices of Plant Breeding. Tata Megraw hill publishing & company Ltd. New Delhi.

GPB 533 MUTAGENESIS AND MUTATION BREEDING 3 (2+1)

Objective

To impart the knowledge about general principles of radiation and varioustests/methods for detection of radiation effects on the living cells, geneticrisks 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, pre and post adaptive mutations - Detection of mutations in lower and higher organisms – paramutations.

UNIT II

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

UNIT III

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

UNIT IV

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

UNIT V

Observing mutagen effects in M_1 generation: plant injury, lethality, sterility, chimeras *etc*., - Observing mutagen effects in M_2 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_3 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 genrations 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_1 generation – Parameters to be observed; Study of M_2 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_2 and M_3 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 Energey Agency. 1970. *Manual on Mutation Breeding*. International Atomic Energey Agency, Vienna, Italy.

Singh BD. 2003. *Genetics*. Kalyani.

Strickberger MW. 2005. *Genetics*. 3rd Ed. Prentice Hall.

GPB 534 BREEDING FOR CEREALS, FORAGES AND SEED SPICES 3 (3+0)

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 and its implications.

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.

UNIT III

Maize: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives: yield, quality characters - 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 - Small millets: breeding objectives yield, quality characters.

UNIT IV

Forage legumes: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters.

UNIT V

Seed spices: Evolution and distribution of species and forms - wild relatives and germplasm; Breeding objectives- yield, quality characters and palatability studies.

UNIT VI

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

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.

GPB 535 GENE REGULATION AND EXPRESSION 3 (2+1)

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

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

UNIT II

Coordinated genetic regulation-examples- Anthocyanin and gene families and maize; Genetic and molecular basis depending on 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 geneshorizontal 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.

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

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

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

Russell PJ. 1996. *Essential Genetics*. Blackwell Scientific Publ.

Brown TA. 2002. *Genomes.* Bios Scientific Publ.

Tamarin RH. 1999. *Principles of Genetics*. Wm C Brown Publ.

Griffiths AJF. 2000. *An Introduction to Genetic Analysis*. WH Freeman.

Hexter W & Yost HT. 1976. *The Science of Genetics*. Prentice Hall.

Singer M & Berg P.1991. *Genes and Genomes*. John Wiley & Sons.

Hartl DL & Jones EW. 1998. *Genetics Principles and Analysis*. Jones & Barlett Publ.

Micklos DA & Freyer G. 2003. *DNA Science - A First Course*. CPL Scientific Publ.

Brooker RJ. 2004. *Genetics Analysis and Principles*. Addison-Wesley Longman.

Watson JD. 2004. *Molecular Bilology of the Gene*. Pearson Edu.

GPB 611* ADVANCES IN PLANT BREEDING SYSTEMS 3 (3+0)

Objective

To impart theoretical knowledge and computation methods for non allelic interactions, mating designs and component analysis and their significance in plant breeding.

Theory

UNIT I

Mating systems and their exploitation in crop breeding; Types of pollination, mechanisms promoting cross pollination. Self- incompatability and sterility – Types of self incompatability: Homomorphic (sporophytic and gametophytic) and heteromorphic - Breakdown of incompatibility - Floral adaptive mechanisms - Spatial and temporal - Genetic and biochemical basis of self incompatibility; Sterility: male and female sterility – Types of male sterility: genic, cytoplasmic and cytoplasmic-genic; Exploitation of germplasm, difficulties in exploiting CGMS system in dicots – Case studies and breeding strategies; Nucleocytoplasmic interactions with special reference to male sterility – Genetic , biochemical and molecular bases.

UNIT II

Population formation by hybridization - Types of populations – Mendelian population, gene pool, composites, synthetics etc.; Principles and procedures in the formation of a complex population; Genetic basis of population improvement. Applications of cytogenetical methods for crop improvement; Location and mapping of genes on chromosomes: deficiency method; Interchage genetic consequence, identification of chromosomes involved and gene location; balanced lethal systems, their maintenance and utility.

UNIT III

Selection in self fertilizing crops; Creation of genetic variability and selection methods - Selection methods: mass selection, pure line selection, pedigree method (selection in early generations vs advanced generations); Backcross, poly cross and test cross.

UNIT IV

Selection in cross fertilizing crops – Poly cross and top cross selections, Mass and recurrent selection methods and their modifications – Mass selection: grided mass selection, ear to row selection, modified ear to row selection; Convergent selection, divergent selection; Recurrent selection: Simple recurrent selection and its modifications (restricted phenotypic selection, selfed progeny selection and full sib recurrent selection) - Recurrent selection for general combining ability (GCA) – Concepts and utilization - Recurrent selection for specific combining ability (SCA) – usefulness in hybrid breeding programmes - Reciprocal recurrent selection (Half sib reciprocal recurrent selection, Half sib reciprocal recurrent selection with inbred tester and Full

sib reciprocal recurrent selection); Prebreeding for crop improvement including hybrid development. Selection in clonally propagated crops – Assumptions and realities.

UNIT V

Breeding of crop ideotypes; Genetic manipulations through recombination breeding, genomics and transgenics for physiological efficiency, nutritional enhancement and special compounds-proteins/vaccines/gums/starch/fats.

UNIT VI

Genetic engineering technologies to create male sterility; Prospects and problems - Use of self-incompatibility and sterility in plant breeding – case studies; - Fertility restoration in male sterile lines and restorer diversification programmes - Conversion of agronomically ideal genotypes into male steriles – Concepts and breeding strategies; Case studies - Generating new cytonuclear interaction system for diversification of male sterile lines - Stability of male sterile lines – Environmental influence on sterility– Environmentally Induced Genetic Male Sterility (EGMS) – Types of EGMS; Influence on their expression, genetic studies; Photo and thermo sensitive genetic male sterility and its use in heterosis breeding - Temperature sensitive genetic male sterility and its use heterosis breeding - Apomixis and its use in heterosis breeding.

Suggested Readings

Agarwal RL. 1996. *Fundamentals of Plant Breeding and Hybrid Seed Production*. Oxford & IBH.

Allard RW. 1966. *Principles of Plant Breeding*. John Wiley & Sons.

Briggs FN & Knowles PF. 1967. *Introduction to Plant Breeding*. Reinhold.

Fehr WR. 1987. *Principles of Cultivar Development: Theory and Technique*. Vol I. Macmillan.

Hayes HK, Immer FR & Smith DC. 1955. *Methods of Plant Breeding*. McGraw-Hill.

Mandal AK, Ganguli PK & Banerji SP. 1995. *Advances in Plant Breeding*. Vol. I, II. CBS.

Richards AJ. 1986. *Plant Breeding Systems*. George Allen & Unwin.

Sharma JR. 1994. *Principles and Practice of Plant Breeding*. Tata McGraw-Hill.

Simmonds NW. 1979. *Principles of Crop Improvement*. Longman.

Singh BD. 1997. *Plant Breeding: Principles and Methods*. 5th Ed., Kalyani.

Singh P. 1996. *Essentials of Plant Breeding*. Kalyani.

Welsh JR. 1981. *Fundamentals of Plant Genetic and Breeding*. John Wiley.

Williams W. 1964. *Genetical Principles and Plant Breeding*. Blackwell.

GPB 612* **ADVANCES IN BIOMETRICAL AND QUANTITATIVE GENETICS** **3 (2+1)**

Objective

To impart theoretical knowledge and computation methods for non allelic interactions, mating designs and stability analysis and their significance in plant breeding.

Theory

UNIT I

Introduction to biometrical genetics and historical background. Generation mean analysis, Variance of different generations and gene action.

UNIT II: Half sib and full sib covariances and their relation to genotypic variance.

Mating designs its type and use in different crop plants. Concept and analysis of combining ability and use in plant breeding.

UNIT III

Multivariate analysis. Simultaneous selection. Discriminate function analysis.Principal component analysis and selection indices.

UNIT IV

G x E interaction, stability and adaptability. Different mehods of stability analysis, their merits and limitations. Additive main effects and multiplicative interaction (AMMI) analysis, bi-plot analysis. Additive, multiplicative and shifted multiplicative models.

UNIT V

QTL mapping- different methods/ markers, desired populations and statistical methods, linkage maps. Study of variability using markers. Marker assistated selection.(MAS)

Practical

Generation mean analysis. Variances of different filial generations. Analysis and interpretation of different mating designs. Working out efficiency of different selection methods and selection indises. Analysis and interpretation of stability by different methods. Methods used in analysis of variability and divergence in marker analysis. QTL mapping. Use of computer software like SAS, SPSS, Nt Sys, Mapmaker etc.

Suggested Readings

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

Falconer DS & Mackay J. 1996. *Introduction to Quantitative Genetics*. Longman.

Mather K & Jinks L. 1983. *Introduction to Biometrical Genetics*. Chapman & Hall.

Nadarajan N & Gunasekaran M. 2005. *Quantitative Genetics and 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.

GPB 613 PLANT GENETIC RESOURCES, *IN SITU* AND *EX SITU* CONSERVATION AND THEIR UTILIZATION 3 (3+0)

Objective

1. To provide information about collection, evaluation, documentation, maintenance and use of plant genetic resources for crop improvement.
2. To impart knowledge on the methods of germplasm conservation.

Theory

UNIT I

Historical perspectives and need for PGR conservation; Importance of plant genetic resources; Taxonomical classification of cultivated plants; Gene pool: primary, secondary and tertiary; Centres of origin and global pattern of diversity; Basic genetic resources and transgenes.

UNIT II

Principles, strategies and practices of exploration, collection, characterization, evaluation and cataloging of PGR; Plant quarantine and phytosanitary certification; Germplasm introduction and exchange; Principles of *in vitro* and cryopreservation. Germplasm conservation- *in situ, ex situ*, and on-farm; short, medium and long term conservation strategies for conservation of orthodox seed and vegetatively propagated crops; Registration of plant genetic resources.

UNIT III

Utilization of genetic resources, concept of core and mini-core collections, genetic enchancement/Prebreeding for crop improvement including hybrid development.

UNIT IV

Ex situ conservation: components, plant genetic resources conservation in gene banks, national gene banks, gene repositories, preservation of genetic materials under natural conditions, *perma-frost* conservation, guidelines for sending seeds to network of active/ working collections, orthodox, recalcitrant seeds- differences in handling ,clonal repositories, genetic stability under long term storage condition.

UNIT V

In vitro storage, maintanence of *in vitro* culture under different conditions, *in vitro* bank maintanence for temporate and tropical fruit crop species, spices, tubers, bulbous crops, medicinal and endangered plant species, conservation of embryos and ovules, cell/suspension cultures, protoplast and callus cultures, pollen culture, micropropagation techniques, problems, prospects of *in vitro* gene bank.

UNIT VI

Cryopreservation- procedure for handling seeds of orthodox and recalcitrants-cryoprotectants,dessication, rapid freezing, slow freezing, vitrification techniques, encapsulation/dehydration techniques, national facilities, achievements, application of cryopreservation in agriculture, horticulture and forestry crops. Problems and prospects; challenges aheads.

Suggested Readings

Frankel OH & Bennett E. 1970. *Genetic Resources in Plants – their Exploration and Conservation*. Blackwell.

Gautam PL, Dass BS, Srivastava U & Duhoon SS. 1998. *Plant Germplasm Collecting: Principles and Procedures*. NBPGR, New Delhi.

Painting KA, Perry MC, Denning RA & Ayad WG. 1993. *Guide Book for Genetic Resources Documentation*. IPGRI, Rome, Italy.

Paroda RS & Arora RK. 1991. *Plant Genetic Resources, Conservation and Management. Concepts and Approaches*. IPGRI Regional office for South and South Asia, New Delhi.

Puzone L & Hazekamp TH. 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.

Singh RJ & Jauhar PP. 2005. *Genetic Resources, Chromosomal Engineering and Crop Improvement*. Vol. I. *Grain Legumes*, Vol. II. *Cereals*. CRC Press, Taylor & Francis Group, USA.

Ellis RH & Roberts EH & White Head J. 1980. *A New More Economic and Accurate Approach to Monitor the Viability of Accessions During Storage in Seed Banks*. FAO / IBPGR Pl. Genet. Resources News 41-3-18.

Frankel OH & Hawkes JG. 1975. *Crop Genetic Resources for Today and Tomorrow*. Cambridge University Press, Cambridge.

Simmonds, N.W. 1979. *Principles of Crop Improvement* Longman.

Westwood MN. 1986. *Operation Manual for National Clonal Germplasm Repository Processed Report*. USDA-ARS and Orgon State Univ. Oregon, USA.

Withers LA. 1980. *Tissue Culture Storage for Genetic Conservation*. IBPGR Tech. Rep. IBPGR, Rome, Italy.

GPB 621 CROP EVOLUTION 3 (3+0)

Objective

To impart knowledge on crop evolutionary aspects and manipulation at ploidy level for crop improvement.

Theory

UNIT I

Origin and evolution of species; Centres of diversity/origin, diffused centres; Time and place of domestication; Patterns of evolution and domestication-examples and Case studies.

UNIT II

Domestication and uniformity – Characteristics of early domestication and changes – Concept of gene pools and crop evolution; Selection and Genetic drift - Consequences.

UNIT III

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

UNIT IV

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 V

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.

UNIT VI

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

UNIT VII

Evolutionary significance of polyploidy, Evolution of crop plants through ploidy manipulations; polyploids: methods, 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.

Suggested Readings

Hancock JF. 2004. Plant Evolution and the Origin of Crop Species. 2nd Ed. CABI.

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

Miller AJ. 2007. *Crop Plants: Evolution*. John Wiley & Sons.

Smartt J & Simmonds NW. 1995. *Evolution of Crop Plants*. Blackwell.

GPB 622 MICROBIAL GENETICS 3 (2+1)

Objective

The objective of this course is to apprise the students of molecular processes at DNA and RNA level in different microorganisms, especially bacteria and viruses.

Theory

UNIT I

Nature of bacterial variation; Molecular aspects of mutation; Episomes and plasmids; Gene mapping in bacteria; Life cycle of bacteriophages; Genetic fine analysis of rII locus; Circular genetic map of phage T4; Transposable elements; Gene manipulation; Biochemical genetics of *Neurospora and Sacharomyces* ; One gene - one enzyme hypothesis.

UNIT II

Regulation of gene activity in prokaryotes; Molecular mechanisms of mutation, repair and suppression; Molecular chaperones and gene expression; Genetic basis of apoptosis.

UNIT III

Transgenic bacteria and bioethics; genetic basis of nodulation, nitrogen fixation and competition by rhizobia, genetic regulation of nitrogen fixation and quorum sensing in rhizobia; genetics of mitochondria and chloroplasts.

Practical

Preparation and sterilization of liquid and agar bacterial nutrient media; Assessment of generation time in the log-phage bacterial cultures. Handling of microorganisms for genetic experiments; Isolation of rhizobia from nodules; Gram staining of rhizobial cells; Examination of polyhydroxy butyrate (PHB) production in rhizobia; Demonstration of N2- fixing nodules/bacterial inoculation in the legume- *Rhizobium* symbiotic system. Induction, isolation and characterization of auxotrophic and drug resistant mutants in bacteria; determination of spontaneous and induced mutation frequencies; Discrete bacterial colony counts for the preparation of survival curves and determination of LD50 of a mutagen. Tn-mediated mutagenesis; Analysis and isolation of plasmid DNA; Curing of plasmids.

Suggested Readings

Brooker RJ. 2004. *Genetics Analysis and Principles*. Addison-Wesley Longman.

Brown TA. 2002. *Genomes.* Bios Scientific Publ.

Griffiths AJF. 2000. *An Introduction to Genetic Analysis*. WH Freeman.

Hexter W & Yost HT 1976. *The Science of Genetics*. Prentice Hall.

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Russell PJ. 1996. *Essential Genetics*. Blackwell Scientific Publ.

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Tamarin RH. 1999. *Principles of Genetics*. Wm C Brown Publ.

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Yadav AS, Vasudeva M, Kharab P & Vashishat RK. 2002. *Practical Manual on Microbial and Molecular Genetics*. Dept. of Genetics, CCS HAU Hisar.

GP 623

GENOMICS IN PLANT BREEDING 2+1

Objective

To impart practical skills in advanced molecular techniques in genome mapping structural/functional genomics and development of transgenic crops.

Theory

UNIT I

Introduction to the plant genome- Plant nuclear genomes and their molecular description - The chloroplast and the mitochondrial genomes in plants - Genome size and complexity.

UNIT II

Establishment of plant genome mapping projects - Genome mapping and use of molecular markers in plant breeding; Strategies for mapping genes of agronomic traits in plants- Approaches for mapping quantitative trait loci; Map based cloning of plant genes.

UNIT III

Regulation of Plant gene expression - Functional genomics – Expression Analysis using Microarrays – Transposon tagging and Insertional mutagenesis- methods and significance- Diversity Array Technology.

UNIT IV

Genome sequencing in plants–Principles and Techniques; Applications of sequence information in plant genome analyses; Comparative genomics– Genome Comparison Techniques- Classical and advanced approaches.

UNIT V

Detection of Single Nucleotide Polymorphism; TILLING and EcoTILLING; Role of transcriptomics, proteomics and metabolomics in linking genome and phenome; Importance of understanding the phenotypes for exploiting the outcome of genomic technologies- Knock out mutant studies and high throughput phenotyping.

UNIT VI

Concept of database development, management and bioinformatics; Plant genome projects and application of bioinformatics tools in structural and functional genomics.

Practical

Chromosome analysis in major field crops - Fluorescence in situ hybridization - Comparative genomic hybridization – Comparative analysis of plant genomes using molecular markers – Genetic map construction using molecular markers – Mapping major genes using molecular markers – QTL mapping in plants – Comparison across mapping populations – Understanding the need genetic algorithms in QTL mapping – Plant Genome Databases – Computational tools to explore plant genome databases – Comparative genomics – Comparison of genome sequences using tools of bioinformatics- Advanced genomic technologies: TILLING and Eco-TILLING -

DNA Array Technology – Linking genome sequences to phenotypes: Tools of transcriptomics, proteomics and metabolomics.

Suggested Readings

Baxevanis AD & Ouellette BFF. 2001. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. Wiley Interscience.

Brown TA. 2002. Genomes. Wiley-LISS.

Caetano-Anolles G & Gresshoff PM. 1998. DNA Markers: Protocols, Applications and Overviews. Wiley-VCH.

Cantor CR & Smith CL (2004). Genomics. Wiley, New York.

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

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

Mount DW. 2001. Bioinformatics. Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press..

Palzkill T. 2002. Proteomics. Kluwer.

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