# Department of Genetics and Plant Breeding

## ***M.Sc. Programme***

| *Course No.* | *Title of the course* | *Credits* |
|---|---|---|
| **1st Semester** | | |
| GPB-501 | Principles of Genetics | 2+1 |
| GPB-502 | Principles of Plant Breeding | 2+1 |
| GPB-503 | Principles of Cytogenetics | 2+1 |
| GPB-504 | Mutagenesis and Mutation Breeding | 1+1 |
| **2nd Semester** | | |
| GPB-551 | Plant Genetic Resource Management | 2+1 |
| *GPB-552* | *Principles of Quantitative Genetics* | *2+1* |
| *GPB-553* | *Biotechnology for Crop Improvement* | *2+2* |
| *GPB-554* | *Breeding for Important Field Crops* | *3+1* |
| **3rd Semester** | | |
| GPB-601 | Cell Biology and Molecular Genetics | 2+1 |
| GPB-602 | Breeding for Biotic and Abiotic Stress Resistance | 2+1 |
| GPB-603 | Population Genetics | 1+1 |
| GPB-604 | Heterosis Breeding | 2+0 |
| GPB-649 | Seminar- I | 1+0 |
| **4th Semester** | | |
| GPB-651 | Breeding for Quality Traits | 1+1 |
| GPB-652 | Variety Release and Seed Production | 1+1 |
| SWC-699 | Seminar-II | 1+0 |
| GPB-700 | Master's Research | 0+20 |

***Programme Details***

**GPB-501 Principles of Genetics 2+1**

**Theory**

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

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

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

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

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

UNIT VI: Organization of DNA in chromosomes, Genetic code; Protein biosynthesis. Micro-RNAs (miRNAs). Genomics and proteomics; Functional and pharmacogenomics

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

UNIT VIII: Concepts of Eugenics, Epigenetics, Genetic disorders and Behavioural genetics.

**Practical**

Laboratory exercises in probability and chi-square; Demonstration of genetic principles using laboratory organisms; Chromosome mapping using three point test cross; Tetrad analysis; induction and detection of mutations through genetic tests; DNA extraction and PCR amplification -Electrophoresis – basic principles and running of amplified DNA -Extraction of proteins and isozymes.

## GPB-502 Principles of Plant Breeding 2+1

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 and its significance.

UNIT II: Genetic basis of breeding self-and cross-pollinated crops including mating systems and response to selection-nature of variability, components of variation; Heritability and genetic advance, genotype-

environment interaction; General and specific combining ability; Types of gene actions and implications in plant breeding; Plant introduction and role of plant genetic resources in plant breeding.

UNIT III: Self-incompatibility and male sterility in crop plants and their commercial exploitation.

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

UNIT V: Breeding methods in cross pollinated crops; Population breeding-mass selection and ear-to-row methods; $S_1$ and $S_2$ progeny testing, progeny selection schemes, recurrent selection schemes for intra and inter-population improvement and development of synthetics and composites; Hybrid breeding : 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: Breeding methods in asexually/clonally propagated crops, clonal selection apomixes, clonal selection.

UNIT VII: Concept of plant ideotype and its role in crop improvement; Transgressive breeding.

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

UNIT IX: Cultivar development testing, release and notification, maintenance breeding, Participatory Plant Breeding; Plant breeder' 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.

## GPB-503 Principles of Cytogenetics 2+1

**Theory**

UNIT I: Architecture of chromosome in prokaryotes and eukaryotes; Chromonemata, chromosome matrix, chromomeres, centromere, secondary constriction and telomere; 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 - 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 - 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 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 – Bridge species.

UNIT VI: Fertilization barriers in crop plants at pre-and post fertilization levels- *In vitro* techniques to overcome the fertilization barriers in crops; Chromosome manipulations in wide hybridization; 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, pearl millet - Studies on the course of mitosis in onion and *Aloe vera* - Studies on the course of meiosis in cereals, millets and pulses - Studies on the course of meiosis in oilseeds and forage crops - Using micrometers and studying the pollen grain size in various crops -Various methods of staining and preparation of temporary and permanent slides - Pollen germination *in vivo* and *in vitro;* Agents employed for the induction of various ploidy levels.

**GPB-504 Mutagenesis and Mutation Breeding 1+1**

**Theory**

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

UNIT II: Mutagenic agents: physical -- Radiation types and sources: Ionising and non-ionizing radiations *viz*., X rays, γ rays, , and β particles, protons, neutrons and UV rays - Radiobiology: mechanism of action of various radiations

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

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 - 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 –Use of mutagens in genomics, allele mining, TILLING.

**Practical**

Learning the precautions on handling of mutagens; 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 M1 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.

*2nd Semester*

**GPB-551 Plant Genetic Resource Management 2+1**

UNIT I: History and importance of germplasm exploration; Distribution and extent of prevalent genetic diversity; Phyto-geographical regions/ecological zones and associated diversity; Mapping eco-geographic distribution of diversity, threatened habitats, use of flora.Core identification, estimation of sample size during plant explorations impact of sampling on population structure, sequential sampling for viability estimation;

UNIT II: Concept of population and gene pool; Variations in population and their classification; Gene frequencies in populations rare and common alleles; Gene pool sampling in self and cross pollinated and vegetative propagated species; Non-selective, random and selective sampling strategies. Management and utilization of germplasm collections; Concept of core collection, molecular markers and their use in characterization; Evaluation and utilization of genetic resources; Pre-breeding/genetic enhancement, utilizing wild species for crop improvement;. Use of *in vitro* methods in germplasm collection. Germplasm documentation.

UNIT III: Ethnobotanical aspects of PGR; collecting wild relatives of crop plants; Collection and preservation of specimens; Importance and use of herbaria and preparation of herbarium specimens. Germplasm management system – global scenario; Genetic variation in crop plants and management of germplasm collection, limitations in use of germplasm collections; necessity of germplasm evaluation; Predictive methods for identification of useful germplasm; Characterization of germplasm and evaluation procedures including specific traits; Gene markers and their use in PGR management.

UNIT IV: Post-exploration handling of germplasm collections; Present status and future strategies in collection of major crops of Indian origin such as rice, maize, sorghum, sesame, Brassica, okra, eggplant, cotton, mango etc; approaches for collection including indigenous knowledge.

UNIT V: History, principles objectives and importance of plant introduction; Pre-requisites, conventions, national and international legislations and policies on germplasm collection and exchange; Documentation and information management; Plant quarantine-introduction, history, principles, objectives and relevance; Regulations and plant quarantine set up in India; Pest risk analysis, pest and pathogen information data base; Quarantine in relation to integrated pest management; Economic significance of seed-borne pests (insects, mites, non-insect pests, nematodes fungi, bacteria, viruses, phytoplasma etc.).

UNIT VI: Detection and identification of pests including use of recent techniques like ELISA, PCR etc., Symptoms of pest damage, salvaging techniques for infested/infected germplasm, post-entry quarantine operation, seed treatment and other prophylactic treatments and facilities; Domestic quarantine; seed certification; International linkages in plant quarantine; weaknesses and future thrust.

UNIT VII: Genetically modified organisms (GMOs) or genetically engineered plants (GEPs), Concepts of biosafety, risk analysis and consequences of spread of GE crops on the environment; Treaties and multilateral agreements governing trans-boundary movement of GEPs or GMOs, Indian regulatory system for biosafety.

**Practical**

Basics of computer and operating systems; Identification useful germplasm, evaluation of crop germplasm; Techniques of Characterization of germplasm; Molecular markers and their use in characterization. Plant exploration and collection; Techniques of course and fine grid surveys; Identification of wild relatives of crop plants-Example of collection, cataloguing and preservation of specimens; Sampling techniques of pant materials; Visiting ports, airports to study the quarantine regulations; Techniques for the detection of insects, mites, nematodes, bacteria, weeds, pathogens and viruses on seed and planting materials and salvaging; Use of visual, qualitative, quantitative, microscopic, molecular and plant growth related techniques ( controlled green houses/growth chambers, etc);Detection of GMOs and GEPs; Study of post-entry quarantine operation, seed treatment and other prophylactic treatments.

**GPB-552 Principles of Quantitative Genetics 2+1**

**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 Anaylis of Variance (ANOVA) - Expected variance components, random and fixed models; MANOVA, biplot analysis; Comparison of means and variances for significance.

UNIT III: Designs for plant breeding experiments – principles and applications; Genetic diversity analysis – metroglyph, cluster and $D^2$ analyses - Association analysis - phenotypic and genotypic correlations; Path analysis and Parent - progeny regression analysis; Discriminant function and principal component analyses; Selection indices - selection of parents; Simultaneous selection models- concepts of selection - heritability and genetic advance.

UNIT IV: Generation mean analysis; Mating designs- Diallel, partial diallel, line x tester analysis, NCDs and TTC; Concepts of combining ability and gene action; Analysis of genotype x environment interaction - adaptability and stability; Models for GxE analysis and stability parameters; AMMI analysis – principles and interpretation.

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

**GPB-553 Biotechnology for Crop Improvement** **2+2**

**Theory**

UNIT I: Biotechnology and its relevance in agriculture; Definitions, terminologies

and scope in plant breeding.

UNIT II: Tissue culture- History, callus, suspension cultures, cloning; Regeneration; Somatic embryogenesis; Anther culture; somatic hybridization techniques; Meristem, ovary and embryo culture; cryopreservation.

UNIT III: Techniques of DNA isolation, quantification and analysis; Genotyping; Sequencing techniques; Vectors, vector preparation and cloning, Biochemical and Molecular markers: morphological, biochemical and cNA-based markers (RFLP, RAPD, AFLP, SSR,SNPs, ESTs etc.), mapping populations ($F_2$s, back crosses, RILs, NILs and DH).

UNIT IV: Molecular mapping and tagging of agronomically important traits. Statistical tools in marker analysis, Robotics; Marker-assisted selection for qualitative and quantitative traits; QTLs analysis in crop plants, Gene pyramiding.

UNIT V: Marker assisted selection and molecular breeding; Genomics and genoinformatics for crop improvement; Integrating functional genomics information on agronomically/economically important traits in plant breeding; Marker-assisted backcross breeding for rapid introgression,

UNIT VI: Recombinant DNA technology, transgenes, method of transformation, selectable markers and clean transformation techniques, vector-mediated gene transfer, physical methods of gene transfer. Production of transgenic plants in various field crops: cotton, wheat, maize, rice, soybean, oilseeds, sugarcane etc. Commercial releases.

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

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

UNIT IX: Bioinformatics & Bioinformatics tools.

UNIT X: Nanotechnology and its applications in crop improvement programmes.

**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, DNA purity and quantification tests, gel electrophoresis of

proteins and isozymes, PCR-based DNA markers, gel scoring and data analysis for tagging and phylogenetic relationship, construction of genetic linkage maps using computer software.

**GPB-554 Breeding for Important Field Crops 3+1**

**Theory**

UNIT I (Cereals and Forage)

Rice: Evolution and distribution of species and forms - wild relatives and germplasm; Genetics – cytogenetics and genome relationship – Breeding objectives- yield, quality characters, biotic and abiotic stress resistance *etc.* – Hybrid rice breeding- potential and outcome - Aerobic rice, its implications and drought resistance breeding.

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;

Maize: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc - QPM and Bt maize – strategies and implications - Heterosis breeding

Forage legumes: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters, biotic and abiotic stress resistance etc -

UNIT II:

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

UNIT III (Pulse):

Pigeonpea: 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 *etc* - Hybrid technology; maintenance of male sterile, fertile and restorer lines, progress made at ICRISAT and other Institutes.

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.

Other pulses: Greengram, blackgram, fieldpea, lentil,, lathyrus, cowpea, lablab, mothbean: Evolution, cytogenetics and genome relationship; 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 (Oil Seed):

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.

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 V (Fibre Crops):

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

Jute: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; breeding objectives- yield, quality characters, biotic and abiotic stress etc; Mesta and minor fibre crops: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; breeding objectives- yield, quality characters, biotic and abiotic stress etc.

UNIT VI: Distinguishing features of popular released varieties in Rice -Wheat, Maize – Jute and their application to DUS testing - Maintenance of seed purity - Nucleus and Breeder Seed Production

**Practical**

Floral biology – emasculation - pollination techniques in cereals, pulses oilseed; Study of range of variation for yield and yield components – Study of segregating populations and their evaluation - Trait based screening for stress resistance in crops of importance– Use of descriptors for cataloguing Germplasm maintenance; learning on the Standard Evaluation System (SES) and descriptors; Practical learning on the cultivation of fodder crop species on sewage water; analyzing them for yield components and palatability; Laboratory analysis of forage crops for crude protein, digestibility percent and other quality attributes; Visit to animal feed producing factories, learning the practice of value addition; . Study of segregating populations in Redgram, Greengram, Blackgram and other pulse crops; Attempting crosses between blackgram and greengram. Groundnut

Attempt Interspecific crosses for fibre quality. Evaluation of Jute cultures of different species for insect and disease resistance –Evaluating the germplasm of jute for yield, quality and resistance Visit to Jute Technology Laboratory and Spinning mills

**3rd Semester**

**GPB-601 Cell Biology and Molecular Genetics 2+1**

**Theory**

UNIT I: Ultrastructure of the cell; Differences between eukaryotic and prokaryotic cells, acromolecules; Structure and function of cell wall, nuclear membrane and plasma membrane; Cellular organelles – nucleus, plastidschloro/ 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, regulation of protein synthesis in prokaryotes and eukaryotes – ribosomes, t-RNAs and translational factors.

UNIT IV: Transposable elements; Mechanisms of recombination in prokaryote; DNA organization in eukaryotic chromosomes – DNA content variation, types of DNA sequences – Unique and repetitive sequences; organelle genomes; Gene amplification and its significance; Proteomics and protein-protein interaction; Signal transduction; Genes in development; Cancer and cell aging.

**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; Preparation of competent cells and transformation; 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.

**GPB-602 Breeding for Biotic and Abiotic Stress Resistance 2+1**

**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; Acquires 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; Behavioral, physiological and insect gain studies.

UNIT III: Phenotypic screening methods for major pests and diseases; Recording of observations; Correlating the observations using marker data – Gene pyramiding methods and their implications.

UNIT IV: Classification of abiotic stresses – Stress inducing factors – moisture stress/drought and water logging & submergence; Acidity, salinity/alkalinity/sodicity; High/low temperature, wind etc. Stress due to soil factors and mineral toxicity; Physiological and phenological responses; Emphasis of abiotic stresses in developing breeding methodologies.

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

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

**Practical**

Phenotypic screening techniques for sucking pests and chewing pests – Traits to be observed at plant and incest 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 – phenotypes screening methods for diseases caused by fungi and bacteria; Symptoms and data recording; use of MAS procedures – Screening forage crops for resistance to sewage water and tannery effluents; Quality parameters evaluation – Screening crops for drought and flood resistance; factors to be considered and breeding strategies – Screening varieties of major crops for acidity and

alkalinity – their effects and breeding strategies; Understanding the climatological parameters and predisposal of biotic and abiotic stress factors – ways of combating them.

**GPB-603 Population Genetics 1+1**

**Theory**

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

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

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

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

UNIT V: Gene substitution and average effects; Breeding value- Genetic drift; Genetic slippage, Co-adapted gene complexes; Homoeostasis- 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 gene substitution and breeding value; Exercises on inbreeding and linkage disequilibrium- Cavalli's joint scaling test; Exercises of different mating designs; Estimation of different population parameters from experimental data; Measurement of genotype-environment interaction; Genetic divergence.

**GPB-604 Heterosis Breeding 2+0**

**Theory**

UNIT I: Historical aspect of heterosis – Nomenclature and definitions of heterosis – Heterosis in natural population and inbred population; Evolutionary aspects – Genetic consequences of slfing and crossing in self and cross-pollinated and asexually propagated crops.

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

UNIT III: Physiological, biochemical, cytoplasmic and molecular basis of Heterosis. Prediction of heterosis from various crosses – Inbreeding depression, 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 prediction heterosis, Development of heterotic pools in germplasm/genetic stocks and inbreds, their improvement for increasing heterosis.

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

UNIT V: Fixation of heterosis in self, cross and often cross pollinated crops, asexually/clonally propagated crops; Male sterile line creation and diversification in self pollinated, cross pollinated and asexually propagated crops; problems and prospects; Apomixis in fixing heterosis-concept of single line hybrid.

UNIT VI: 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.

GPB-649 Seminar I 1+0

**4th Semester**

**GPB-651 Breeding for Quality Traits 1+1**

UNIT I: Developmental biochemistry and genetics of carbohydrate, proteins, fats, vitamins, amino acids 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 – Breeding for quality improvement in barley and oats.

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.

**Practical**

Grain quality evaluation in rice ; Correlating ageing and quality improvement in rice – Quality analysis in millets; Estimation of antinutritional factors, like tannins in different varieties/hybrids; 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 loke RIL, NIL etc. for quality improvement using MAS procedures.

**GPB-652 Variety Release and Seed Production 1+1**

**Theory**

UNIT I: Variety Development and Maintenance; Definition – variety, cultivar, extant variety, essentially derived variety, independently derived variety, reference variety, farmers' variety, hybrid, and population; Variety testing, release and notification systems in India and abroad.

UNIT II: DUS testing – DUS Descriptors for major crops; Genetic purity concept and maintenance breeding.

UNIT III: Factors responsible for genetic deterioration of varieties – safeguards during seed production; Maintenance of varieties in self and cross-pollination crops – isolation distance; Principles of seed production; Methods of nucleus and breeder seed production.

UNIT IV: Generation system of seed multiplication – nucleus, breeders, foundation, certified, - Quality seed production technology of self and cross-pollinated crop varieties viz. cereals & millets (wheat, barley, paddy, pearlmillet, sorghum, maize and ragi etc. ) ; Pulses (greengram, blackgram,cowpea, pigeonpea, chickpea, fieldpea, lentil) ; Oilseeds (groundnut, soybean, sesame, castor, sunflower, safflower, linseed, rapeseed and mustard) ; fibres (cotton, jute) and forages (guar, forage sorghum, teosinte, oats, berseem, Lucerne) ; Seed certification procedures; Seed laws and plant variety protection regulations in India and international systems.

**Practical**

Identification of suitable areas/locations for seed production; Ear-to-row method and nucleus seed production – Main characteristics of released and notified varieties, hybrids and parental lines; Identification of important weeds/objectionable weeds; Determination of isolation distance and planting

ratios in different crops; Seed production techniques of varieties in different crops; Hybrid seed production technology of important crops.

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| **GPB-699** | **Seminar II** | **1+0** |
| **GPB-700** | **Master's Research** | **0+20** |