M.Sc. Major courses

GENETICS AND PLANT BREEDING

Course Title with Credit Load
M.Sc. (Ag) in Genetics and Plant Breeding (GPB)
*Compulsory Major Courses
Course Code Course Title Credit Hours
GPB 501* Principles of Genetics 3 (2+1)
GPB 502* Principles of Plant Breeding 3 (2+1)
GPB 503* Fundamentals of Quantitative Genetics 3 (2+1)
GPB 505 Principles of Cytogenetics 3 (2+1)
GPB 506* Molecular Breeding and Bioinformatics 3 (2+1)
GPB 516 Breeding for Stress Resistance and Climate Change 3 (2+1)
GPB 517 Germplasm Characterization and Evaluation 2 (1+1)
GPB 518 Genetic enhancement for PGR Utilization 2 (1+1)

I. Course Title : Principles of Genetics*
II. Course Code : GPB 501
III. Credit Hours : 3 (2+1)
IV. Why this course?
Genes are the backbone of all crop improvement activities. Their chemical structure and physical inheritance are pivotal for any breeding program. Therefore, it has to be the core course for master's degree in Genetics and Plant Breeding.
V. Aim of the course
This course is aimed at understanding the basic concepts of inheritance of genetic traits, helping students to develop their analytical, quantitative and problem-solving skills from classical to molecular genetics.
VI. Theory
Unit I
Beginning of genetics**,** early concepts of inheritance, Mendel's laws; Discussion on Mendel's paper, Chromosomal theory of inheritance; Multiple alleles, Gene interactions, Sex determination, differentiation and sex-linkage, Sex-influenced and sex-limited traits; Linkage-detection, estimation; Recombination and genetic mapping in eukaryotes, Somatic cell genetics, Extra chromosomal inheritance.
Unit II
Mendelian population, Random mating population, Frequencies of genes and genotypes, Causes of change: Hardy-Weinberg equilibrium.
Unit III
Nature, structure and replication of the genetic material; Organization of DNA in chromosomes, Genetic code; Protein biosynthesis, Genetic fine structure analysis, Allelic complementation, Split genes, overlapping genes, Pseudogenes, Oncogenes,

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

Unit IV

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 V

Genomics and proteomics; metagenomics; Transgenic bacteria and bioethics; Gene silencing; genetics of mitochondria and chloroplasts. Concepts of Eugenics, Epigenetics, Genetic disorders.

Course Contents

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VII. Practical

- Laboratory exercises in probability and chi-square;
- Demonstration of genetic principles using laboratory organisms;
- Chromosome mapping using three-point test cross;
- Tetrad analysis; Induction and detection of mutations through genetic tests;
- DNA extraction and PCR amplification;
- Electrophoresis: basic principles and running of amplified DNA;
- Extraction of proteins and isozymes;
- Use of *Agrobacterium* mediated method and Biolistic gun;
- Detection of transgenes in the exposed plant material;
- Visit to transgenic glasshouse and learning the practical considerations.

VIII. Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student’s presentations

IX. Learning outcome

After passing out this course the student will be able to know the difference between the genotype and phenotype, can carry study on inheritance and also know the role of DNA and RNA in genotypic manifestation of characters.

X. Suggested reading

Daniel LH and Maryellen R. 2011. *Genetics: "Analysis of Genes and Genomes*".
Gardner EJ and Snustad DP. 1991. *Principles of Genetics*. John Wiley and Sons. 8th ed. 2006
Klug WS and Cummings MR. 2003. *Concepts of Genetics*. Peterson Edu. Pearson Education India; Tenth edition
Lewin B. 2008. *Genes XII*. Jones and Bartlett Publ. (International Edition) Paperback, 2018
Russell PJ. 1998. *Genetics*. The Benzamin/ Cummings Publ. Co
Singh BD. 2009. *Genetics.* Kalyani Publishers (2nd Revised Edition)
Snustad DP and Simmons MJ. 2006. *Genetics*. 4th Ed. John Wiley and Sons. 6th Edition International Student Version edition
Stansfield WD.1991. *Genetics.*Schaum Outline Series Mc Graw Hill
Strickberger MW. 2005. *Genetics* (*III Ed*). Prentice Hall, New Delhi, India; 3rd ed., 2015
Tamarin RH. 1999. *Principles of Genetics*. Wm. C. Brown Publs., McGraw Hill Education; 7 edition
Uppal S, Yadav R, Singh S and Saharan RP. 2005. *Practical Manual on Basic and Applied Genetics*. Dept. of Genetics, CCS HAU Hisar.

I. Course Title : Principles of Plant Breeding*

II. Course Code : GPB 502

III. Credit Hours : 3(2+1)

IV. Why this course?

Development of plant variety is the ultimate aim of any plant breeding program. A post graduate in the subject of agriculture must know what are the different selection methods, techniques and related crop improvement strategies. Further, knowledge of genetic resources, evolution and their role in development of noble varieties is the need of the hour.

V. Aim of the course

To impart theoretical knowledge and practical skills about plant breeding objectives, genetic consequences, breeding methods for crop improvement.

VI. Theory

Unit I

Early Plant Breeding; Accomplishments through plant breeding; Objectives of plant breeding; Patterns of Evolution in Crop Plants: Centre of Origin, Agro-biodiversity and its significance. Pre-breeding and plant introduction and role of plant genetic resources in plant breeding.

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.

Unit III

Pure line theory, pure line and mass selection methods; pedigree, bulk, backcross, single seed descent and multiline breeding; Population breeding in self-pollinated crops with special reference to diallel selective mating; Transgressive breeding.

Unit IV

Breeding methods in cross pollinated crops; Population breeding: mass selection and ear-to-row methods; S1 and S2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and inter-population improvement and development of synthetics and composites. Hybrid breeding: genetical and physiological basis of heterosis and inbreeding, production of inbreeds, breeding approaches for improvement of inbreeds, predicting hybrid performance; seed production of hybrid and their parent varieties/ inbreeds. Self-incompatibility, male sterility and apomixes in crop plants and their commercial exploitation.

Unit V

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

Unit VI

Special breeding techniques: Mutation breeding, Breeding for abiotic and biotic stresses; Concept of plant ideotype and its role in crop improvement, concept of MAS, concept of polyploidy and wide hybridization, doubled haploidy.

Unit VII

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

VII. 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;

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• Learning techniques in hybrid seed production using male-sterility in field crops;
• Prediction of performance of double cross hybrid.

VIII. Teaching methods

• Power point presentation
• Chalk and Board
• Smart board
• Lectures
• Assignments, quiz

• Group tasks, student's presentations

IX. Learning outcome

The knowledge of this course will enable the student to know breeding methods, different hybridization techniques for genomic reshuffling. The course will also acquaint the student with importance of floral biology, mutation breeding and participatory plant breeding, etc.

X. Suggested Reading

Allard RW. 1981. *Principles of Plant Breeding*. John Wiley & Sons.

Chahal GS and Gossal, SS. 2002. *Principles and Procedures of Plant Breeding Biotechnological and Conventional approaches.* Narosa Publishing House.

Chopra VL. 2004. *Plant Breeding*. Oxford & IBH.

George A. 2012. *Principles of Plant Genetics and Breeding*. John Wiley & Sons.

Gupta SK. 2005. *Practical Plant Breeding*. Agribios.

Jain HK and Kharakwal MC. 2004. *Plant Breeding and–Mendelian to Molecular Approach*, Narosa Publications, New Delhi

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.

Sharma JP. 2010. Principles of Vegetable Breeding. Kalyani Publ, New Delhi.

Simmonds NW.1990. *Principles of Crop Improvement*. English Language Book Society.

Singh BD. 2006. *Plant Breeding*. Kalyani Publishers, New Delhi.

Singh S and Pawar IS. 2006. *Genetic Bases and Methods of Plant Breeding*. CBS.

I. Course Title : Fundamentals of Quantitative Genetics*

II. Course Code : GPB 503

III. Credit Hours : 3 (2+1)

IV. Why this course?

Yield and quality characters are controlled by many genes and show the quantitative inheritance. If one has to go for improvement even for the components characters the knowledge of this course is very essential.

V. Aim of the course

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

VI. Theory

Unit I

Introduction and historical background of quantitative genetics, Multiple factor hypothesis, Qualitative and quantitative characters, Analysis of continuous variation mean, range, SD, CV; Components of variation- Phenotypic, Genotypic, Nature of gene action- additive, dominance and epistatic, linkage effect. Principles of analysis

 variance and linear model, Expected variance components, Random and fixedeffect model, Comparison of means and variances for significance.

Unit II

Designs for plant breeding experiments- principles and applications; Variability parameters, concept of selection, simultaneous selection modes and selection of parents, MANOVA.

Unit III

Association analysis- Genotypic and phenotypic correlation, Path analysis Discriminate function and principal component analysis, Genetic divergence analysis- Metroglyph and D2, Generation mean analysis, Parent progeny regression analysis

Unit IV

Mating designs- classification, Diallel, partial diallel, L × T, NCDs, and TTC; Concept of combining ability and gene action, G × E interaction-Adaptability and stability; Methods and models for stability analysis; Basic models- principles and interpretation, Bi-plot analysis.

Unit V

QTL mapping, Strategies for QTL mapping- Desired population and statistical methods, QTL mapping in genetic analysis; Markers, Marker assisted selection and factors influencing the MAS, Simultaneous selection based on marker and phenotype.

VII. Practical

• Analysis and interpretation of variability parameters;
• Analysis and interpretation of Index score and Metroglyph;
• Clustering and interpretation of D2 analysis;
• Genotypic and phenotypic correlation analysis and interpretation;
• Path coefficient analysis and interpretation, Estimation of different types of heterosis, inbreeding depression and interpretation;
• A, B and C Scaling test;
• L × T analysis and interpretation, QTL analysis;
• Use of computer packages;
• Diallel analysis;
• G × E interaction and stability analysis.

VIII. Teaching methods

• Power point presentation
• Chalk and Board
• Smart board
• Lectures,
• Assignments, quiz
• Group tasks, student’s presentations

IX. Learning outcome

After studying this course, the student will be equipped with the knowledge of additive dominance and epistatic gene action. He will also be introduced with the

various designs for analysis of genotypic and phenotypic variance and QTL mapping.

X. Suggested Reading

Bos I and Caligari P. 1995. *Selection Methods in Plant Breeding*. Chapman & Hall.
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Falconer DS and Mackay J. 1998. *Introduction to Quantitative Genetics* (3rd Ed.).ELBS/ Longman, London.
Mather K and Jinks JL.1985. *Biometrical Genetics* (3rd Ed.). Chapman and Hall, London.
Nandarajan N and Gunasekaran M. 2008. *Quantitative Genetics and Biometrical Techniques in Plant Breeding*. Kalyani Publishers, New Delhi.
Naryanan SS and Singh P. 2007. *Biometrical Techniques in Plant Breeding*. Kalyani Publishers, New Delhi.
Roy D. 2000. *Plant Breeding: Analysis and Exploitation of Variation*. Narosa Publishing House, New Delhi.
Sharma JR. 2006. *Statistical and Biometrical Techniques in Plant Breeding*. New Age International Pvt. Ltd.
Singh P and Narayanan SS. 1993. *Biometrical Techniques in Plant Breeding.* Kalyani Publishers, New Delhi.
Singh RK and Chaudhary BD. 1987. *Biometrical Methods in Quantitative Genetic* analysis. Kalyani Publishers, New Delhi.
Weir DS. 1990. *Genetic Data Analysis. Methods for Discrete Population Genetic Data*. Sinauer Associates.
Wricke G and Weber WE. 1986. *Quantitative Genetics and Selection in Plant Breeding*. Walter de Gruyter.

e-Suggested Reading

www.iasri.icar.gov.in
www.hau.ac.in/OPstat

I. Course Title :**Principles of Cytogenetics**

II. Course Code :**GPB 505**

III. Credit Hours :**3 (2+1)**

IV. Why this course?

The very purpose of this course is to acquaint the students with cell cycle and architecture of chromosome in prokaryotes and eukaryotes, special types of chromosomes, techniques for karyotyping. This course aims to impart knowledge of variations in chromosomes numbers and their structures. It acquaints the students for the production and use of haploids, apomictic populations and their role in genetics and breeding.

V. Aim of the course

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

VI. Theory

Unit I

Cell cycle and 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.Variation in chromosome structure: Evolutionary significance; Introduction to techniques for karyotyping; Chromosome banding and painting -*In situ* hybridization and various applications.

Unit II

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 lethal and chromosome complexes; Inter-varietal chromosome substitutions.

Unit III

Fertilization barriers in crop plants at pre-and postfertilization levels; *In-vitro* techniques to overcome the fertilization barriers in crops; Polyploidy. Genetic consequences of polyploidization and role of polyploids in crop breeding; Evolutionary advantages of autopolyploid *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 IV

Reversion of autopolyploid to diploids; Genome mapping in polyploids; Interspecific hybridization and allopolyploids; Synthesis of new crops (wheat, *Triticale, Brassica***,** and cotton); Hybrids between species with same chromosome number, alien translocations; Hybrids between species with different chromosome number; Gene transfer using amphidiploids, bridge species.

Unit V

Chromosome manipulations in wide hybridization; case studies; Production and use of haploids, dihaploids and doubled haploids in genetics and breeding.

VII. Practical

• Learning the cytogenetical laboratory techniques, 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 mitosis and meiosis in crop plants;

• Using micrometres and studying the pollen grain size in various crops. Pollen germination *in vivo* and *in-vitro*;
• Demonstration of polyploidy.

VIII. Teaching methods

• Power point presentation
• Chalk and Board
• Smart board
• Lectures
• Assignments, quiz
• Group tasks, student's presentations

IX. Learning outcome

The course will provide full knowledge to the student on the various procedures linked with cell development and chromosome structure and function. This course will also enable student how to tailor and utilize the variation in chromosome number and structures in the development and synthesis of new species and varieties.

X. Suggested Reading

Becker K and Hardin J. 2004. *World of the Cell*. 5th Ed. Pearson Edu. 9th edition.
Carroll M. 1989. *Organelles*. The Guilford Press.
Charles B. 1993. *Discussions in Cytogenetics*. Prentice Hall Publications.
Darlington CD and La Cour LF. 1969. *The Handling of Chromosomes*. George Allen & Unwin Ltd.
Elgin SCR. 1995. *Chromatin Structure and Gene Expression*. IRLPress,Oxford.
Gupta PK and Tsuchiya T. 1991. *Chromosome Engineering in Plants: Genetics, Breeding and Evolution*. Part A.
Gupta PK. 2010. *Cytogenetics*. Rastogi Pubishers.
Johannson DA. 1975. *Plant Micro technique*. McGraw Hill.
Karp G. 1996. *Cell and Molecular Biology: Concepts and Experiments*. John Wiley & Sons.
Khush GS. 1973. *Cytogenetics of aneuploids*. Elsevier. 1 edition.
Roy D.2009. *Cytogenetics*. Alpha Science Intl Ltd.
Schulz SJ.1980. *Cytogenetics- Plant, animals and Humans*. Springer.
Sharma AK and Sharma A. 1988. *Chromosome Techniques: Theory and Practice*. Butterworth-Heinemann publisher 2014.3rd edition
Singh RJ. 2016. Plant *Cytogenetics* 3rd Edition. CRC Press.
Sumner AT. 1982. *Chromosome Banding*. Unwin Hyman Publ. 1 edition, Springer pub.
Swanson CP. 1960. *Cytology and Cytogenetics*. Macmillan & Co.

I. Course Title : Molecular Breeding and Bioinformatics*

II. Course Code : GPB 506

III. Credit Hours : 3(2+1)

IV. Why this course?

The course will provide deep knowledge to the students on genotyping and kinds of markers including biochemical and molecular, mapping populations, allele mining. This will also add ways to perform marker-assisted selection and gene pyramiding to evolve superior varieties.

V. Aim of the course

To impart knowledge and practical skills to use innovative approaches and Bioinformatics in Plant Breeding.

VI. Theory

Unit I

Genotyping; Biochemical and Molecular markers; Morphological, biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR, SNPs, ESTs, ISSR etc.), Functional markers; Mapping populations (F_2s, back crosses, NAAM, MAGIC, RILs, NILs and DH); Molecular mapping and tagging of agronomically important traits; Statistical tools in marker analysis.

Unit II

Allele mining, TILLING and Eco-TILLING) ; Marker-assisted selection for qualitative and quantitative traits; QTLs analysis in crop plants; Marker-assisted backcross breeding for rapid introgression; Genomics- assisted breeding; Generation of EDVs; Gene pyramiding.

Unit III

Introduction to Comparative Genomics; Large scale genome sequencing strategies; Arabidopsis genome project; Latest Rice genome project; Comparative genomics tools; Introduction to proteomics; 2D gel electrophoresis; chromatography and sequencing by Edman degradation and mass spectrometry; Endopeptidases; Nanotechnology and its applications in crop improvement.

Unit IV

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. and commercial releases; Biotechnology applications in male sterility/ hybrid breeding, molecular farming; Application of Tissue culture in molecular breeding; 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; Introduction to bioinformatics: bioinformatics tools (BLAST, FASTA, ORF, Primer 3, CLUSTALW), biological data bases (primary and secondary), implications in crop improvement.

VII. 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; Standardizing the protocols for regeneration;
• Hardening of regenerated plants; Establishing a greenhouse and hardening procedures; Plant Sciences–Genetics and Plant Breeding 19
• Visit to commercial micropropagation unit;
• Transformation using Agrobacterium strains;
• GUS assay in transformed cells/ tissues;
• DNA isolation, DNA purity and quantification tests;
• Gel electrophoresis of proteins and isozymes, PCR-based DNA markers, gel scoring and data analysis for tagging and phylogenetic relationship;
• Construction of genetic linkage maps using computer software;
• NCBI Genomic Resources, GBFF, Swiss Prot, Blast n/ Blast p, Gene Prediction Tool, Expasy Resources, PUBMED and PMC, OMIM and OMIA, ORF finder;
• Comparative Genomic Resources: - Map Viewer (UCSC Browser and Ensembl);
• Primer designing- Primer 3/ Primer BLAST.

VIII. Teaching methods

• Power point presentation
• Chalk and Board
• Smart board
• Lectures
• Assignments, quiz
• Group tasks, student's presentations

IX. **LearningOutcome**:

The knowledge of this course will enable the student to know about various molecular tools and approaches for genotyping and marker assisted breeding, intellectual property rights, bioinformatics tools and their uses in crop improvement.

X **SuggestedReading**

Azuaje F and Dopazo J. 2005. Data Analysis and Visualization in Genomics and Proteomics. John Wiley and Sons.

Brown TA. 1991. Essential Molecular Biology: a practical Approach. Oxford university press, 2002, 2nd edition

Chawala HS. 2000. Introduction to Plant Biotechnology. Oxford & IBH Publishing Co. Pvt. Ltd.

Chopra VL and 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 and Messing JW. 1988. An Introduction to Recombinant DNA Technology - Basic Experiments in Gene Manipulation. 2nd Ed. Benjamin Publ. Co.

Jollès P and Jörnvall H. 2000. Proteomics in Functional Genomics: Protein Structure Analysis. Birkhäuser.

Lewin B. 2017. Genes XII. Jones & Bartlett learning, 2017.

Robert NT and Dennis JG. 2010. Plant Tissue Culture, Development, and Biotechnology. CRC Press.

Sambrook J and Russel D. 2001. Molecular Cloning - a Laboratory Manual. 3rd Ed. Cold Spring Harbor Lab. Press.

Singh BD. 2005. Biotechnology, Expanding Horizons. Kalyani Publishers, New Delhi.

Singh, B. D. and Singh, A. K. 2015. *Marker-Assisted Plant Breeding: Principles and Practices* Springer (India) Pvt. Ltd.

Watson J. 2006. Recombinant DNA. Cold Spring harbor laboratory press.

I. Course Title : Breeding for Stress Resistance and Climate Change

II. Course Code : GPB 516

III. Credit Hours : 3(2+1)

IV. Why this course?

Climate change is a big challenge to sustain higher crop productivity and nutritional quality. Concept of breeding for stress tolerance and development of hybrids/ varieties for climate change is of prime importance in plant breeding. Therefore this course is essential for budding plant breeders.

V. Aim of the course

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

VI. Theory

Unit I

Concept and impact of climatic change; 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.

Unit II

Concepts of resistance to 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-defence mechanisms against viruses and bacteria.

Unit III

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

Classification of abiotic stresses - Stress inducing factors, moisture stress/ drought and water logging and 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 and water logging and 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.

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Unit V

Use of crop wild relatives as a source of resistance to biotic and abiotic factors in major field crops; Transgenics in management of biotic and abiotic stresses, use of toxins, protease inhibitors, lectins, chitinases and Bt for diseases and insect pest management.

VII. Practical

• Understanding the climatological parameters and predisposal of biotic and abiotic stress factors- ways of combating them for diseases caused by fungi and bacteria;
• Symptoms and data recording; use of MAS procedures;
• 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;
• Evaluating the available populations like RIL, NIL, etc. for pest resistance;
• Use of standard MAS procedures. Breeding strategies - Weeds – ecological, environmental impacts on the crops;

• Breeding for herbicide resistance;
• 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;
• Screening forage crops for resistance to sewage water and tannery effluents; Quality parameters evaluation.

VIII. Teaching methods

• Power point presentation
• Chalk and Board
• Smart board
• Lectures
• Assignments, quiz
• Group tasks, student's presentations

IX. Learning outcome

After completion of this course the student will be able to well verse with the stress and its causes. This will enable the students for the development of RIL, NIL, etc. for pest resistance and Use of standard MAS procedures

X. Suggested Reading

Blum A. 1988. *Plant Breeding for Stress Environments*. CRC Press.
Christiansen MN and Lewis CF. 1982. *Breeding Plants for Less Favourable Environments*. Wiley International.
Fritz RS and Simms EL. (Eds.). 1992. *Plant Resistance to Herbivores and Pathogens: Ecology, Evolution and Genetics*. The University of Chicago Press.
Li PH and Sakai A. 1987. *Plant Cold Hardiness*. Liss, New York Springer
Luginpill P. 1969. *Developing Resistant Plants - The Ideal Method of Controlling Insects*. USDA,
ARS, Washington DC.
Maxwell FG and Jennings PR. (Eds.). 1980. *Breeding Plants Resistant to Insects*. John Wiley & Sons. Wiley-Blackwell.
Roberto F. 2018. *Plant Breeding for Biotic and Abiotic Stress Tolerance*. Springer.
Russel GE. 1978. *Plant Breeding for Pest and Disease Resistance*. Butterworths.
Sakai A and Larcher W. 1987. *Frost Survival in Plants*. Springer-Verlag.
Plant Sciences–Genetics and Plant Breeding
Singh BD. 2006. *Plant Breeding*. Kalyani Publishers, New Delhi.
Turener NC and 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.

I. Course Title : Germplasm Characterization and Evaluation

II. Course Code : GPB 517

III. Credit Hours : 2(1+1)

IV. Why this course ?

Students need to learn about morphological and quality agronomic traits of accessions as well as their reaction to biotic and abiotic stresses. This will increase the importance of the germplasm.

V. Aim of the course

Students will gain knowledge on germplasm characterisation, evaluation and documentation of information. Recording of morphological and agronomic traits, including quality, as well as those for resilience to biotic and abiotic stresses that will promote utilisation. Exposure to development of web based tools for systematic description for efficient use of germplasm.

VI. Theory

Unit I

Understanding genetic diversity in crop plants; Crop descriptors, descriptor states; germplasm characterization/ evaluation procedures; evaluation of germplasm for specific traits; Measuring diversity using agro-morphological data, statistical procedures to measure population genetic variation, markers and their use in PGR, evaluation of biotic and abiotic stresses, Principles and methods for formulating core and mini core collections and their validation, Web based tools for management of data.

Unit II

Principles and practices of germplasm regeneration and maintenance, breeding systems and mode of reproduction; maintaining sufficiently large populations for effective conservation of farmer landraces, evaluation and maintenance of wild relatives of crop plants. Genetic enhancement, Use of CWRs genetic resources for crop improvement.

Unit III

High throughput phenotyping systems- imaging and image processing concepts for automated germplasm characterization (phenotyping) – evaluation for nutritional traits, resistance traits -Biochemical and molecular markers for characterization.

VII. Practical

• Field layout and experimental designs;
• Recording field data on germplasm evaluation in different agri-horticultural crops,
• post harvest handling;
• Evaluating quality traits, biochemical and phyto-chemical evaluation of crop germplasm, data processing;
• Documentation, analysis of diversity and cataloguing, data analysis, viability equations, sampling strategies, data documentation, cataloguing, biochemical analyses of samples.

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VIII. Teaching methods

• Lectures
• Power point presentations
• assignments, quiz
• Group tasks, student's presentations

IX. Learning Outcome

To educate students about science of managing genetic resources including principles involved in maintaining genetic integrity during regeneration, germplasm characterization and evaluation.

X. Suggested Reading

Brown AHD, Clegg MT, Kahler AL, Weir BS (eds.) 1990. *Plant Population Genetics, Breeding, and Genetic Resources*, Sinauer Associates, USA.

Frankel R and Galun E 1977. *Pollination Mechanisms, Reproduction and Plant Breeding. Monographs on Theoretical and Applied Genetics*, Springer-Verlag, Berlin, Heidelberg.

Hayward MD, Bosemak NO and Romagosa I. 1993. *Plant Breeding: Principles and Practices*, Chapman & Hall.

Holden JHN and Williams JT 1984. *Crop genetic resources: conservation and evaluation*, IBPGR.

Puzone, L and Th. Hazekamp 1996. *Characterization and Documentation of Genetic Resources Utilizing Multimedia Database*. NBPGR, New Delhi.

Rana RS, Sapra RL, Agrawal RC and Gambhir R 1991. Plant Genetic Resources, *Documentation and Information Management*. NBPGR, New Delhi.

Stoskopf NC 1993. *Plant Breeding: Theory and Practice*, Westview Press.

Sundeep Kumar, *et al.* 2016. *Evaluation of 19,460 wheat accessions conserved in the Indian national genebank to identify new sources of resistance to rust and spot blotch diseases*. PloS One Vol 11, pages 0167702.

Tripathi K, Bhardwaj R, Bhalla S, Kaur V, Bansal R, Yadav R, Gangopadhyay KK, Kumar A and Chaudhury R. 2018. *Plant Genetic Resources Evaluation: Principles and Procedures*, Indian Council of Agricultural Research - National Bureau of Plant Genetic Resources (ICAR-NBPGR), New Delhi. vi+50 p.

I. Course Title : Genetic enhancement for PGR Utilization

II. Course Code : GPB 518

III. Credit Hours : 2(1+1)

IV. Why this course ?

Pre-breeding is a vital step in the link between plant genetic resources conservation and its use; Hence, this course is designed to inculcate theoretical and practical know how to understand and use classical and advanced plant breeding methods for planning and execution of prebreeding programmes so that the PGR is put into effective use for food and agriculture.

V. Aim of the course

To teach theoretical and practical know how on CWRs reproductive behavior,

acclimatization and adaptation for utilization in prebreeding programmes usig advanced tools.

VI. Theory

Unit I

Concepts of gene pools; Introduction, potential of pre-breeding. Role of crop wild relatives, semi exotics, creating and managing variation, basic concepts to set up a successful pre-breeding programme.

Plant Sciences–Genetics and Plant Breeding

Unit II

Understanding crop adaptation, handling and maintenance of CWRs, synchronization of flowering, overcoming impediments to flowering through photoperiodic adjustments, role of other barriers to flowering, role of amphidiploids, semi exotics and other unadapted germplasm, identifying desirable traits in natural populations, screening for biotic and abiotic stress resistance traits; screening of nutritionally important traits, genetic analysis to understand the inheritance of novel traits.

Unit III

Parental selection for prebreeding, search for superior genotypes, breeding methods for trait transfer; moving the genes - unadapted to adapted, wide hybridization, Incongruity and its management, modern tools for incongruity management, cytogenetical approaches for gene transfer such as alien addition and substitution, segregating populations and their management in wide crosses, purging the undesirable traits, testing and improving the adaptability of wide cross derivatives, cytological studies, florescence microscopy, embryo rescue methods, pollen physiology and storage, pollen storage methods to facilitate wide hybridization, pre- and postzygotic barriers.