

PG Degree programme Syllabus as per BSMA, ICAR
M.Sc. (Agri.) Genetics and Plant Breeding



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Centurion
UNIVERSITY

Preamble

Plant breeding became established as a science in the twentieth century following the rediscovery of Mendel's laws of inheritance. Since genetic improvement in an inherent feature, products of plant breeding can have wide global impact as exemplified by the Green Revolution for wheat and rice varieties of 1960s or transgenic crops of recent decades. Therefore, developing sufficient human resources in Genetics and Plant Breeding with advanced knowledge and technical skill will further elevate the agricultural sector to attain a new peak in increasing food production matching the requirement of population.

Present agriculture research and international market demand the need for specialized human resource for teaching cutting edge technology with application of biotechnology, nanotechnology, artificial intelligence in crop improvement, increasing entrepreneurship, etc., would warrant students to have strong knowledge of practical and management skills which will help them to face the competitiveness in public and private sector.

Hence, restructuring of course curricula and delivery system to match with the present situation is the need of the time. In this proposed revision of curriculum in Genetics and Plant Breeding, the BSMA sub-group organized a series of meetings and electronic media- led consultations to develop a set of courses suitable for M. Sc. students of the discipline.

The meetings were focused on the basic principles as well as the innovative developments in Genetics and Plant Breeding, as the platform building status of Plant Sciences. Built on this platform with the latest state of the art technologies including biotechnology and molecular biology will enable a complete coverage of the subjects. The basic courses have therefore been kept as compulsory courses which need to be taken by all the students irrespective of the subject specialization or stream from which they entered into PG education. The BSMA Committee had thread bare discussions over four sessions on the topical issues concerning Genetics and Plant Breeding, Seed Science and Technology and Plant Genetic Resources. The curricula and syllabi of all these disciplines were discussed at length in the meetings and workshops. The opinions and suggestions invited from institutions, eminent scientists and other stakeholders were also reviewed by the committee. The new look and restructured PG programs in Genetics and Plant Breeding have been designed in considerations based on demands of private sector harnessing commercial aspects, modern research tools and their applications, supplementary skills required, and to enhance the global competitiveness and employability of our students.

Many existing courses were upgraded with addition and deletion as per the need of the present situation. The new courses have been incorporated based on their importance and social need both at national and international level are Molecular Breeding and Bioinformatics, Breeding for Quality and Special Traits, Seed Production and Certification,

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Framework of the courses

The following nomenclature and Credit Hrs. need to be followed while providing the syllabus for all the disciplines

Courses	M.Sc. (Agri.)
Major courses	20
Minor courses	08
Supporting courses	06
Common courses	05
Seminar	01
Thesis	30
Total	70

M.Sc. (Agri.) Genetics and Plant Breeding

Couse Code	Course Title	Credit hours	Page no.
Major Course			
MGPB 0501*	Principles of Genetics	3(2+1)	1
MGPB0502*	Principles of Plant Breeding	3(2+1)	2
MGPB 0503*	Fundamentals of Quantitative Genetics	3(2+1)	4
MGPB0504	Varietal Development and Maintenance Breeding	2(1+1)	5
MGPB0505	Principles of Cytogenetics	3(2+1)	6
MGPB0506*	Molecular Breeding and Bioinformatics	3(2+1)	8
MGPB0507	Breeding for Quality and Special Traits	3(2+1)	9
MGPB0508	Mutagenesis and Mutation Breeding	3(2+1)	11

MGPB0509	Hybrid Breeding	3(2+1)	12
MGPB0510	Seed Production and Certification	2(1+1)	14
MGPB0511	Crop Breeding-I (Kharif Crops)	3(2+1)	16
MGPB0512	Crop Breeding-II (Rabi Crops)	3(2+1)	19
MGPB0513	Breeding Vegetable Crops	3(2+1)	21
MGPB0514	Breeding Fruit Crops	3(2+1)	22
MGPB0515	Breeding Ornamental Crops	3(2+1)	23
MGPB0516	Breeding for Stress Resistance and	3(2+1)	24

	Climate Change		
MGPB0517	Germplasm Characterization and Evaluation	2(1+1)	25
MGPB0518	Genetic enhancement for PGR Utilization	2(1+1)	27
MGPB0591	Master's Seminar	01	-
MGPB0599	Master's research	30	-
Minor Course			
MMBB 0501	Principles of Biotechnology	3(3+0)	29
MMBB 0504	Techniques in Molecular Biology-I	3(0+3)	30
MMBB 0509	Plant Tissue Culture	3(2+1)	31
MMBB 0517	Stress Biology and Genomics	2(2+0)	32
Supporting Course			
STAT 0502	Statistical Methods for Applied Sciences	4(3+1)	34
STAT0511	Experimental Designs	3(2+1)	35
Common course			
PGSS 0501	Library and information services	1(1+0)	37
PGSS 0502	Technical writing and communications Skills	1(1+0)	37
PGSS 0503	Intellectual property and its management in agriculture	1(1+0)	38
PGSS 0504	Basic concepts in laboratory techniques	1(1+0)	39
PGSS 0505	Agricultural research, research ethics and rural Development programmes	1(1+0)	40

Course Contents

M.Sc. (Ag) in Genetics and Plant Breeding (GPB)

Course Title: Principles of Genetics* Course

Code: GPB 501

Credit Hours: 3 (2+1)

Objectives:

- 1: To impart the basic concepts of inheritance of genetic traits
- 2: To facilitate analytical, quantitative and problem-solving skills from classical to molecular genetics.
- 3: To bring the understanding of concepts of gene structure, function and isolation of nucleic acids

Course outcomes:

After completing of this course, students will be able to active the following outcomes:

CO1: Ability to gain knowledge on inheritance and principles of inheritance

CO2: Equip with the concepts of gene structure and functions.

CO3: Enable problem-solving skills on principles of inheritance

CO4: Develop skills in DNA extraction and separation

CO5: Summarize the concepts of genetic disorders and epigenetics

CO-PSO Mapping:

	PSO1	PSO2	PSO3
CO1		✓	
CO2	✓		
CO3	✓		
CO4	✓	✓	✓
CO5	✓		

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, Ontogenesis, 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.

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.

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 Pubs., 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

Course Title: Principles of Plant Breeding*

Course Code: MGPB 0502

Credit Hours: 3(2+1)

Objectives:

1. To impart theoretical knowledge and practical skill about plant breeding and its genetic consequences.
2. To facilitate understanding of genetic resources, evolution, and their role in development of noble varieties.
3. To improve the concepts of hybrid/ cultivar development and new breeding techniques like Marker-Assisted-Selection.

Course Outcomes:

After completion of this course the student will be able to active the following outcomes **CO1:** Enable the theoretical knowledge of breeding methods, hybridization techniques for genome reshuffling.

CO2: Enhance knowledge on PGR, evolution and their role in noble varieties development.

CO3: Ability to gain skills on selection, response to selection and its effects on breeding population

CO4: Equip with importance of floral biology, mutation breeding and participatory breeding

CO5: Summarize the cultivar/ hybrid development and seed production using male sterility system.

CO-PSO Mapping:

	PSO1	PSO2	PSO3
CO1	✓	✓	✓
CO2		✓	
CO3	✓	✓	
CO4		✓	✓
CO5		✓	✓

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: genetically 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. 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.

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; Prediction of performance of double cross hybrid.

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.

Course Title: Fundamentals of Quantitative Genetics*

Course Code: GPB 503

Credit Hours: 3 (2+1)

Objectives:

1. To impart theoretical concept on quantitative genetics, its inheritance, components of variation and variances, and gene effects.
2. To bring problem-solving ability on quantitative genetics
3. To improve the knowledge on different mating and experimental design

Course outcomes:

After completing of this course, students will be able to active the following outcomes:

CO1: Enhance knowledge on nature of quantitative traits and its inheritance

CO2: Equip with different mating and experimental designs

CO3: Ability to gain problems solving skills on quantitative genetics

CO4: Summarize with genetic diversity analysis, selection indices and its importance in crop improvement

CO5: Ability to select and adopt the appropriate breeding programmes for crop improvement

CO-PSO Mapping:

	PSO1	PSO2	PSO3
CO1	✓	✓	
CO2			✓
CO3		✓	✓
CO4		✓	
CO5		✓	✓

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 of variance and linear model, expected variance components, Random and fixed effect 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- Metro glyph and D2, Generation mean analysis, Parent progeny regression analysis

Unit IV: Mating designs- classification, Diallel, partial diallel, $L \times T$, NCDs, and TTC; Concept of combining ability and gene action, $G \times E$ 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.

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;

$L \times T$ analysis and interpretation, QTL analysis; Use of computer packages; Diallel analysis;

$G \times E$ interaction and stability analysis.

Suggested Reading:

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

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

Course Title: Varietal Development and Maintenance Breeding

Course Code: GPB 504

Credit Hours: 2(1+1)

Objectives:

1. To impart various practices and procedures in the development of a variety
2. To bring maintenance of the purity of varieties/ hybrids
3. To improve the knowledge on basics of nucleus and breeder seed production techniques.

Course outcomes:

CO1: Improve knowledge to apply the principles of genetics and plant breeding for varietal development

CO2: Summarize the knowledge on quality seed production of both self and cross-pollinated crops

CO3: Enhance practical knowledge on maintenance of parental line and hybrids

CO4: Equip with generation system of seed multiplication

CO5: Ability to understand the concepts of DUS testing and procedure of varietal release

CO-PSO Mapping:

	PSO1	PSO2	PSO3
CO1		✓	
CO2		✓	

CO3		✓	✓
CO4	✓		✓
CO5		✓	✓

Theory:

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

Unit II: DUS testing- DUS Descriptors for major crops; Genetic purity concept and maintenance breeding. Factors responsible for genetic deterioration of varieties - safeguards during seed production.

Unit III: Maintenance of varieties in self and cross-pollinated crops, isolation distance; Principles of seed production; Methods of nucleus and breeder seed production; Generation system of seed multiplication -nucleus, breeders, foundation, certified.

Unit IV: Quality seed production technology of self and cross-pollinated crop varieties, viz., cereals and millets (wheat, barley, paddy, pearl millet, sorghum, maize and ragi, etc.); Pulses (green gram, black gram, cowpea, pigeon pea, chickpea, field pea, lentil); Oilseeds (groundnut, soybean, sesame, castor, sunflower, safflower, linseed, rapeseed and mustard); fibres (cotton/ jute) and forages (guar, forage sorghum, teosinte, oats, berseem, lucerne).

Unit V: Seed certification procedures; Seed laws and acts, 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; PGMS and TGMS;

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; DUS testing and descriptors in major crops; Variety release proposal formats in different crops

Suggested Reading:

Agarwal RL. 1997. Seed Technology. 2nd Ed. Oxford & IBH. Kelly AF. 1988. Seed Production of Agricultural Crops. Longman.

McDonald MB Jr and Copeland LO. 1997. Seed Production: Principles and Practices. Chapman & Hall.

Poehlman JM and Borthakur D. 1969. Breeding Asian Field Crops. Oxford & IBH. Singh BD. 2005. Plant Breeding: Principles and Methods. Kalyani. 2015 Thompson JR. 1979. An Introduction to Seed Technology. Leonard Hill.

Course Title: Principles of Cytogenetics

Course Code: GPB 505

Credit Hours: 3 (2+1)

Objectives:

1. To impart knowledge on cell, cell cycle and architecture of chromosome in prokaryotes and eukaryotes
2. To improve the knowledge of variations in chromosome numbers and structures.
3. To sensitize the production, use of haploids, apomictic populations and their role in genetics and plant breeding

Course outcomes:

After completing of this course, students will be able to achieve the following outcomes:

CO1: Enable knowledge to apply the principles of cytogenetics to plant breeding

CO2: Equip the chromosome mapping in polyploids, chromosome manipulations and their applications in plant breeding.

CO3: Enhance practical knowledge on cell cycle and cell division

CO4: Summarize knowledge on the various procedures linked with cell development.

CO5: Ability to understand the concepts of synthesis of new crops

CO-PSO Mapping:

	PSO1	PSO2	PSO3
CO1	✓		
CO2	✓		
CO3	✓	✓	✓
CO4	✓		
CO5		✓	

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 post-fertilization 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; Apomixes, 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.

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.

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. IRL Press, Oxford. Gupta PK and Tsuchiya T. 1991. Chromosome Engineering in Plants:

Genetics, Breeding and Evolution. Part A. Gupta PK. 2010. Cytogenetics. Rastogi Publishers. 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.

Course Title: Molecular Breeding and Bioinformatics*

Course Code: GPB 506

Credit Hours: 3(2+1)

Objectives:

1. To facilitate the students about basic concepts of molecular markers, nanotechnology and its application in plant breeding
2. To impart knowledge and practical skills in tissue culture for plants
3. To improve the understanding and practical skills to use innovative approaches and bioinformatics in plant breeding

Course outcomes:

After completing of this course, students will be able to active the following outcomes

CO1 Enhance knowledge on the Marker-assisted selection for both qualitative and quantitative characters; allele mining and its importance in biological research and gene mapping

CO2 Enable hands-on experience on bioinformatics tools to analyze biological experimental data

CO3 Equip with the knowledge on nanotechnology principles and its applications in crop improvement

CO4 Ability to develop technical skills on tissue culture principles and its applications in plants biotechnology

CO5 Acquire knowledge on identification of transgenes and its introgression in the plant through direct and indirect methods

CO-PSO Mapping:

	PSO1	PSO2	PSO3
CO1	✓		
CO2			✓
CO3	✓	✓	

CO4			✓
CO5	✓	✓	

Theory:

Unit I: Genotyping; Biochemical and Molecular markers; Morphological, biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR, SNPs, ESTs, etc.), Functional markers; Mapping populations (F2s, back crosses, RILs, NILs and DH); Molecular mapping and tagging of agronomically important traits; Statistical tools in marker analysis.

Unit II: Allele mining; 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; Human genome project; Arabidopsis genome project; 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, biological data bases (primary and secondary), implications in crop improvement.

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;

Visit to commercial micro propagation 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 PredictionTool, 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.

Suggested Reading:

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. Watson

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

Course Title: Breeding for Quality and Special Traits

Course Code: GPB 507

Credit Hours: 3(2+1)

Objectives:

1. To facilitate the students about basic concepts of grain quality parameters in field crops
2. To impart knowledge and practical skills in Grain quality evaluation
3. To improve the understanding and practical skills to use innovative approaches and Biofortification in crops

Course outcomes:

CO1: Enhance knowledge of recent advances in the improvement of quality traits in cereals, pulses, and oilseed crops

CO2: Ability to understand the methods of improvement of forage and industrial crops using conventional and modern biotechnological approaches.

CO3: Ability to develop ideal/ novel varieties for quality parameters.

CO4: Enable in depth knowledge of genetic engineering protocols for quality improvement

CO5: Equip with the knowledge on different mapping populations like, RIL, NIL, etc. for quality improvement using MAS procedures.

CO-PSO Mapping:

	PSO1	PSO2	PSO3
CO1		✓	
CO2		✓	

CO3		✓	✓
CO4			✓
CO5		✓	✓

Theory:

Unit I: Developmental biochemistry and genetics of carbohydrates, proteins, fats, vitamins, amino acids and anti-nutritional factors; Nutritional improvement - A human perspective.

Unit II: 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; 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, pearl millet, barley and oats; Quality protein maize, specialty corns, concept and breeding strategies; Breeding for quality improvement in important forage crops for stay green traits; Genetic resource management for sustaining nutritive quality in crops.

Unit IV: Breeding for quality improvement in pulses – Chickpea, pigeon pea, green gram and black gram cooking quality; Breeding for quality in oilseeds - groundnut, mustard, soybean, 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. Breeding for quality improvement in Sugarcane, potato.

Unit V: Genetic engineering protocols for quality improvement: Achievements made; Biofortification 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 anti-nutritional factors like tannins in different varieties/ hybrids: A

comparison; Quality parameters evaluation in wheat, pulses and oilseeds; Evaluation of quality parameters in cotton, sugarcane and potato; Value addition in crop plants; Post-harvest processing of major field crops; Quality improvement in crops through tissue culture techniques; Evaluating the available populations like RIL, NIL, etc. for quality improvement using MAS procedures; Successful example of application of MAS for quality trait in rice, mustard, maize, etc.

Suggested Reading:

Chahal GS and SS Ghosal. 2002. Principles and procedures of plant breeding - Biotechnological and Conventional approaches, Narosa Publications
Chopra VL. 1997. Plant Breeding. Oxford & IBH. 2018.

FAO 2001. Specialities of the World - Breeding, Production and Marketing. OXford & IBH, 1 Nov 2001.

Ghosh P. 2004. Fibre Science and Technology. Tata McGraw Hill. Gupta SK. 2007. Advances in Botanical Research Vol. 45 Academic Press USA. 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 Publishers, New Delhi.

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

Course Title: Mutagenesis and Mutation Breeding

Course Code: GPB 508

Credit Hours: 3 (2+1)

Objectives:

1. To facilitate the students about basic concepts mutation in field crops
2. To impart knowledge and practical skills in use of mutagens in creating variations
3. To improve the understanding and practical skills to use mutation breeding approaches

Course outcomes:

CO1: Acquired knowledge basic of mutation, mutagens and their application in crop breeding

CO2: Acquired depth knowledge about genomics, allele mining, TILLING, etc and its application in crop breeding

CO3: Ability to understand the effects of mutation breeding on society, nations and globs.

CO4: Acquired the practical skill on handling of M1 and later generations

CO5: Equip with the knowledge on varietal development through mutation breeding

CO-PSO Mapping:

	PSO1	PSO2	PSO3
CO1		✓	
CO2	✓		
CO3		✓	✓
CO4			✓
CO5		✓	✓

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. Para mutations in crops plants. Mutagenic agents: physical – radiation types and sources: Ionizing and non-ionizing radiations. Radiobiology: mechanism of action of various radiations (photoelectric absorption, Compton scattering and pair production) and their biological effects – RBE and LET relationships;

Unit II: 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 III: 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 IV: Observing mutagen effects in M1 generation: plant injury, lethality, sterility, chimeras, etc.; Observing mutagen effects in M2 generation; Estimation of mutagenic efficiency and effectiveness – spectrum of chlorophyll and viable mutations; Mutations in traits with continuous variation; 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 M3 generation; Comparative evaluation of physical and chemical mutagens for creation of variability in the some species- Case studies.

Unit V: Use of mutagens in creating oligogenic and polygenic variations – Case studies; In- vitro mutagenesis – Callus and pollen irradiation; Handling of segregating M2 generations and selection procedures; Validation of mutants; Mutation breeding for various traits (disease resistance, insect resistance, quality improvement, etc.) in different crops; Procedures for micro mutations breeding/ polygenic mutations; Achievements of mutation breeding- varieties released across the world, problems associated with mutation breeding. Use of mutagens in genomics, allele mining, TILLING.

Practical:

Precautions on handling of mutagens; Dosimetry-Studies of different mutagenic agents: Physical mutagens and Chemical mutagens; Learning on Radioactivity- Production 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;

Procedures in combined mutagenic treatments;

Raising the crop for observation; Mutagenic effectiveness and efficiency, calculating the same from earlier literature;

Study of M1 generation – Parameters; Study of M2 generation – Parameters;

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 M2 and M3 generations.

Suggested Reading:

Alper T. 1979. Cellular Radiobiology. Cambridge Univ. Press, London. Chadwick KH and Leenhouts HP. 1981. The Molecular Theory of Radiation Biology. Springer-Verlag.

Cotton R, Edkin E and Forrest S. 2000. Mutation Detection: A Practical Approach. Oxford Univ. Press.

International Atomic Energy Agency. 1970. Manual on Mutation Breeding. International Atomic Energy Agency, Vienna, Italy.

Shu QY, Forster BP and Nakagawa N. 2012. Plant Mutation Breeding and Biotechnology. Gutenberg Press Ltd. Rome Italy ISBN:978-925107-022-2 (FAO). Singh BD. 2003. Genetics. Kalyani Publishers, New Delhi.

Strickberger MW. 2005. Genetics. 3rd Ed. Prentice Hall. www.barc.gov.in

Course Title: Hybrid Breeding

Course Code: GPB 509

Credit Hours: 3(2+1)

Objectives:

1. To impart knowledge on basic concept of heterosis and its evolutionary aspects
2. To facilitate advanced studies in heterosis phenomenon and fixation of heterosis
3. To improve understanding of modern breeding strategies to develop hybrid seeds

Course outcomes:

At the end of the course the students will be able to achieve the following outcomes:

CO1 Enhance knowledge on heterosis and its phenomenon

CO2 Equip with the knowledge on various kinds of male sterility and their utilization in hybrid seed production of important field crops

CO3 Acquire knowledge on various techniques for the development of hybrids in crop improvement

CO4 Summarize the mechanisms of heterosis and its exploitation for yield improvement through conventional and biotechnological approaches

CO5 Enable technical knowledge on commercial exploitation of the hybrid seed production in different crops

CO-PSO Mapping:

	PSO1	PSO2	PSO3
CO1	✓		
CO2		✓	✓
CO3	✓	✓	✓
CO4	✓		
CO5	✓	✓	✓

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, sibbing and crossing in self-and cross-pollinated and asexually propagated crops; Pre- Mendelian and Post-Mendelian ideas – Evolutionary concepts of heterosis; Genetic theories of heterosis – Physiological, Biochemical and molecular factors underlining heterosis; theories and their estimation; Biometrical basis of heterosis.

Unit II: Prediction of heterosis from various crosses, inbreeding depression, coefficient of inbreeding and its estimation, residual heterosis in F₂ and segregating populations, importance of inbreeding in the 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 III: Male sterility and use in heterosis breeding; Male sterile line creation and diversification in self-pollinated, cross-pollinated and asexually propagated crops; Creation of male sterility through genetic engineering and its exploitation in heterosis; Maintenance, transfer and restoration of different types of male sterility; Use of self-incompatibility in development of hybrids.

Unit IV: 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; Fixation of heterosis in self, cross and often cross-pollinated, asexually/ clonally propagated crops, problems and prospects; Apomixis in fixing heterosis-concept of single line hybrid; Organellar heterosis and complementation.

Unit V: Hybrid breeding in wheat, rice, cotton, maize, pearl millet, sorghum and rapeseed-mustard, sunflower, safflower and castor oilseed crops and pigeon pea.

Practical:

Characterization of male sterile lines using morphological descriptors; Restorer line identification and diversification of male sterile sources;

Male sterile line creation in crop plants, problems in creation of CGMS system, ways of overcoming them;

Diversification and restoration;

Success stories of hybrid breeding in Maize, Rice, Pearl millet, Sorghum and Pigeonpea;

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 Reading:

Agarwal RL. 1998. Fundamental of Plant Breeding and hybrid Seed Production. Science Publisher London.

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

Ben HL. 1998. Statistical Genomics – Linkage, Mapping and QTL Analysis. CRC Press.

Chahal GS and Gossal SS. 2002. Principles and procedures of Plant Breeding, Biotechnology and Convetional Approaches. Narosa Publishing House. New Delhi De JG.

1988. Population Genetics and Evolution. Springer-Verlag.

30 January 2012 Hartl DL. 2000. A Primer of Population Genetics. 3rd Ed. Sinauer Assoc.

Mettler LE and Gregg TG. 1969. Population Genetics and Evolution. Prentice-Hall. 25 April 1988

Montgomery DC. 2001. Design and Analysis of Experiments. 5th Ed., Wiley & Sons. 2013

Mukherjee BK. 1995. The Heterosis Phenomenon. Kalyani Publishers, New Delhi.

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

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

Unwin. 30 May 1997 Singh BD. 2006. Plant Breeding. Kalyani Publishers, New Delhi.

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

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

Course Title: Seed Production and Certification

Course Code: GPB 510

Credit Hours: 2(1+1)

Objectives:

1. To facilitate the students about basic concepts seed production and its maintenance
2. To impart knowledge and practical skills seed production in various crops
3. To improve the understanding of seed certification

Course outcomes:

CO1: Summarize the importance of seed production, multiplication of different crops

CO2: Enable the understanding the seed processing and marketing aspects

CO3: Equip with the floral structure, pollination mechanism of different crops

CO4: Enable the details of Seed certification and various laws associated with it

CO5: Summarize the development of hybrid varieties of different crops

CO-PSO Mapping:

	PSO1	PSO2	PSO3
CO1		✓	✓
CO2		✓	✓
CO3		✓	
CO4			✓
CO5		✓	✓

Theory:

Unit I: Importance of seed as basic input in agriculture; Seed quality concept and importance; Generation system of seed multiplication -Varietal replacement rate, Seed multiplication ratios, Seed replacement rate, Seed renewal period and seed demand and supply; Various factors influencing seed production –Physical and Genetic purity in seed production; Factors responsible for varietal and genetic deterioration.

Unit II: Nucleus seed production and its maintenance - Maintenance of parental lines of

hybrids, Production of breeder, foundation and certified seed and their quality maintenance; Principles of seed production in self- and cross-pollinated crops; Hybrid seed production - system and techniques involved in Seed village concept; Organic seed production and certification.

Unit III: Principles of seed production in field crops; Floral structure, pollination mechanism and seed production techniques in self- and cross- pollinated cereals and millets.

Unit IV: Floral structure, pollination mechanism and methods and techniques of seed production in major pulses and oilseed crops; Varietal and hybrid seed production techniques in Pigeon pea, Mustard, Castor and Sunflower.

Unit V: Floral structure, pollination mechanism and methods and techniques of seed production in major commercial fibres. Hybrid-seed production techniques in major vegetatively propagated crops.

Unit VI: Seed certification - history, concept, objectives; Central seed certification board Seed certification agency/ organization and staff requirement; Legal status - Phases of seed certification, formulation, revision and publication of seed certification standards; Minimum Seed Certification Standards (MSCS) for different crops - General and specific crop standards, Field and seed standards; Planning and management of seed certification programs; Eligibility of a variety for certification, area assessment, cropping history of the seed field.

Practical:

Planting design for variety- hybrid seed production techniques, planting ratio of male and female lines, synchronization of parental lines and methods to achieve synchrony; Identification of rogues and pollen shedders, supplementary pollination, detasseling, hand emasculation and pollination;

Pollen collection and storage methods, pollen viability and stigma, receptivity; Pre-harvest sanitation, maturity symptoms, harvesting techniques;

Visits to seed production plots - visit to seed industries;

Planning for seed production: cost benefit ratio, seed multiplication ratio and seed replacement rate;

General procedure of seed certification, identification of weed and other crop seeds as per

specific crops, field inspection at different stages of a crop and observations recorded on contaminants and reporting of results, inspection and sampling, harvesting/ threshing, processing and after processing for seed law enforcement;

Specifications for tags and labels to be used for certification purpose.

Suggested Reading:

Agrawal PK and Dadlani M. 1987. Techniques in Seed Science and Technology, South Asian Publishers, Delhi.

Agrawal RL. 1997. Seed Technology, Oxford & IBH Publishing.

Anon, 1965. Field Inspection Manual and Minimum Seed Certification Standards, NSC Publication, New Delhi.

Anon. 1999. Manual of Seed Certification procedures. Directorate of Seed Certification, Coimbatore, Tamil Nadu.

Joshi AK and Singh BD. 2004. Seed Science and Technology, Kalyani Publishers, New Delhi. Kelly AF. 1988. Seed Production of Agricultural Crops. John Wiley, New York.

Mc Donald MB and Copeland LO. 1997. Seed Science and Technology, Scientific Publisher, Jodhpur.

Ramamoorthy K, Sivasubramaniam K and Kannan M. 2006. Seed Legislation in India.

Agrobios (India), Jodhpur, Rajasthan.

Singhal NC. 2003. Hybrid Seed Production in Field Crops, Kalyani Publications, New Delhi

Tunwar NS and Singh SV. 1988. Indian Minimum Seed Certification Standards. Central Seed Certification Board, Ministry of Agriculture, New Delhi.

Course Title: Crop Breeding I (Kharif crops)

Course Code: GPB 511

Credit Hours: 3(2+1)

Objectives:

1. To facilitate the students about basic concepts of mode of reproduction of different crops
2. To impart knowledge and practical skills of breeding procedures of various kharif crops
3. To improve the understanding of crop improvement of various kharif crops

Course outcomes:

CO1: Summarize the importance of genetics- biotic and abiotic stress resistance

CO2: Ability to understand the origin, evolution and mode of reproduction of different crops

CO3: Distinguish the floral biology, pollination techniques of different kharif crops

CO4: Equip with the concept of breeding objectives and procedures of various kharif crops

CO5: Enable the understanding the development of hybrid varieties of different kharif crops

CO-PSO Mapping:

	PSO1	PSO2	PSO3
CO1	✓	✓	✓
CO2		✓	
CO3		✓	
CO4		✓	✓
CO5		✓	✓

Theory:

Unit I: Rice: Origin, evolution, mode of reproduction, chromosome number; Genetics- biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Aerobic rice, its implications and drought resistance breeding. Maize: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic

and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement- QPM and Bt maize- strategies and implications.

Small millets: 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: Pigeon pea: evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement - Hybrid technology; maintenance of male sterile, fertile and restorer lines, progress made at National and International institutes. Groundnut: Origin, evolution mode of reproduction, chromosome number; Genetics cytogenetics and genome relationship, breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement. Other pulses: Urdbean, mungbean, cowpea, Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship, breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), released varieties, examples of MAS used for improvement. Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them.

Unit III: Soybean: Origin, evolution, mode of reproduction, chromosome number; Genetics: cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement. Castor and Sesame: Origin, evolution mode of reproduction, chromosome number; Genetics –cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), released varieties, examples of MAS used for improvement; Hybrid breeding in castor –

opportunities, constraints and achievements.

Unit IV: Cotton: Origin, evolution, mode of reproduction, chromosome number; Genetics – biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Development and maintenance of male sterile lines – Hybrid development and seed production- Scenario of Bt cottons, evaluation procedures for Bt cotton. Jute: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement.

Unit V: 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 crops: 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. Seed spices: Origin, evolution, mode of reproduction, chromosome number; Genetics, cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, Achievements of important spice crops.

Practical:

Floral biology, emasculation, pollination techniques in rice, maize, pigeon pea, soybean, sesame, cotton;

Study of range of variation for yield and yield components;

Study of segregating populations in cereal, pulses and oilseed crops;

Learning on the crosses between different species; attempting crosses between black gram and green gram;

Evaluating the germplasm of cotton for yield, quality and resistance parameters, learning the procedures on development of Bt cotton;

Visit to Cotton Technology Laboratory and Spinning Mills;

Learning on the Standard Evaluation System (SES) and descriptors; Use of software for database management and retrieval;

Practical learning on the cultivation of fodder crop species on sewage water, analysing them for yield components and palatability;

Laboratory analysis of forage crops for crude protein, digestibility percent and other quality attributes;

Visit to animal feed-producing factories;

Learning the practice of value addition; Visiting the animal husbandry unit and learning the animal experiments related with the palatability and digestibility of fodder.

Suggested Reading:

Agarwal RL. 1996. Identifying Characteristics of Crop Varieties. Oxford & IBH. Bahl PN and 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 and 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 and Kauffman HE. 1979. Rice Improvement. IRRI, Los Banos, Manila, Philippines.

Kannaiyan S, Uthamasamy S, Theodore RK and Palaniswamy S. 2002. New Dimensions and Approaches for Sustainable Agriculture. Directorate of Extension Education, TNAU,

Coimbatore.

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

Nanda JS. 1997. Manual on Rice Breeding. Kalyani Publishers. Parthasarathy VA. 2017. Spices and Plantation Crops Vol.1 (Part A) Breeding of Horticultural Crops Vol.1 (Part-B), Today and Tomorrow Printers and Publishers

Poehlman, JM. 1987. Breeding of Field Crops. AVI Publishing Co. Inc. East Post Connecticut, USA.

Ram HH and Singh HG. 1993. Crop Breeding and Genetics. Kalyani.

Sharma, AK.2005. Breeding Technology of Crop Plant. Yesh Publishing House, Bikaner
Slafer GA. (Ed.). 1994. Genetic Improvement of Field Crops. Marcel Dekker.

Singh HG, Mishra SN, Singh TB, Ram HH and Singh DP. (Eds.). 1994. Crop Breeding in India. International Book Distributing Co.

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

Course Title: Crop Breeding-II (Rabi Crops)

Course Code: GPB 512

Credit Hours: (2+1)

Objectives:

1. To facilitate the students about basic concepts of mode of reproduction of different rabi crops
2. To impart knowledge and practical skills of breeding procedures of various rabi crops
3. To improve the understanding of crop improvement of various rabi crops

Course outcomes:

CO1: Summarize the genetics of biotic and abiotic stress resistance in rabi crops

CO2: Equip with the origin, evolution and mode of reproduction of different crops

CO3: Distinguish the floral biology, pollination techniques of different rabi crops

CO4: Analyze the concept of breeding objectives and procedures of various rabi crops

CO5: Enable the understanding the development of hybrid varieties of different rabi crops

CO-PSO Mapping:

	PSO1	PSO2	PSO3
CO1	✓	✓	✓
CO2		✓	
CO3		✓	✓
CO4		✓	✓
CO5		✓	✓

Theory:

Unit I: Wheat: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement.

Oats: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

Barley: Origin, evolution, center of origin, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

Unit II: Chickpea: Origin, evolution mode of reproduction, chromosome number; Genetics, cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement. Other pulses: Lentil, field pea, Rajma, Horse gram: Origin, evolution, mode of reproduction, chromosome number; Genetics. cytogenetics and

genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement. Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them.

Unit III: Rapeseed and Mustard: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives; yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Oil quality, Improvement for oil quality.

Sunflower, Safflower: Origin, mode of reproduction, chromosome number; Genetics, cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement.

Unit IV: Mesta and minor fibre crops: Origin, mode of reproduction, chromosome number; Genetics– cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement. Forage crops: Origin, evolution mode of reproduction, chromosome number; Genetics– cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance.

Unit V: Seed spices: Origin, evolution, mode of reproduction, chromosome number; Genetics– cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, scope of heterosis breeding, released varieties, examples of MAS used for crop improvement.

Practical:

Floral biology, emasculation and pollination techniques in wheat, oats, barley, chickpea,

rajma, rapeseed mustard, sunflower;

Study of range of variation for yield and yield components;

Study of segregating populations in cereal, pulses and oilseed crops; Use of descriptors for cataloguing; Learning on the crosses between different species;

Trait-based screening for stress resistance;

Learning on the Standard Evaluation System (SES) and descriptors; Use of software for database management and retrieval.

Suggested Reading:

Agarwal RL. 1996. Identifying Characteristics of Crop Varieties. Oxford & IBH. Bahl PN and Salimath PM. 1996. Genetics, Cytogenetics and Breeding of Crop Plants. Vol. I.

Pulses and Oilseeds. Oxford & IBH.

Gupta SK. 2012. Technological Innovations in Major World Oil crops. Vol. I. Springer,

USA. Gupta SK. 2012. Technological Innovations in Major World Oil crops. Vol. II.

Springer, USA. Gupta SK. 2016.

Breeding of Oilseed Crops for Sustainable Production. Academic Press, USA.

Kannaiyan S, Uthamasamy S, Theodore RK and Palaniswamy S. 2002. New Dimensions and Approaches for Sustainable Agriculture. Directorate of Extension Education, TNAU, Coimbatore.

Parthasarathy VA. 2017. Spices and Plantation Crops Vol.1 (Part

A) Breeding of Breeding and Genetics. John Wiley & Sons.

Course Title: Breeding Vegetable Crops

Course Code: GPB 513

Credit Hours: 3(2+1)

Objectives:

1. To facilitate the students about basic concepts of mode of reproduction of different vegetable crops
2. To impart knowledge and practical skills of breeding procedures of various vegetable crops
3. To improve the understanding of crop improvement of various vegetable crops

Course outcomes:

CO1: Summarize the importance of genetics- biotic and abiotic stress resistance in different

vegetables

CO2: Enhance the understanding the origin, evolution and mode of reproduction of different crops

CO3: Distinguish the floral biology, pollination techniques of vegetable crops

CO4: Enable the concept of breeding objectives and procedures of various vegetable crops

CO5: Equip with understanding the development of hybrid varieties of different vegetables crops

CO-PSO Mapping:

	PSO1	PSO2	PSO3
CO1	✓	✓	✓
CO2		✓	
CO3		✓	✓
CO4		✓	✓
CO5		✓	✓

Theory:

Unit I: Breeding for Leafy vegetables: Amaranth, chenopods and lettuce.

Unit II: Breeding for Cucurbits: Gourds, melons, pumpkins and squashes.

Unit III: Breeding for Solanaceae: Potato and tomato, eggplant, hot pepper, sweet pepper

Unit IV: Breeding for Cole crops: Cabbage, cauliflower, broccoli and knol khol.

Breeding for root vegetables: Carrot, beetroot, radish, sweet potato and tapioca.

Unit V: Breeding for other vegetable crops: Peas, beans, onion, garlic and okra.

Practical:

Selection of desirable plants from the breeding population, observations and analysis of various qualitative and quantitative traits in germplasm;
Hybridization and handling segregating generations;
Induction of flowering, palynological studies, selfing and crossing techniques in vegetable crops;
Hybrid seed production of vegetable crops in bulk;
Screening techniques for insect pests, disease and environmental stress resistance in vegetable crops;
Demonstration of sib-mating and mixed population;
Molecular marker techniques to identify useful traits in the vegetable crops and special breeding techniques;
Visit to breeding blocks, MAS for incorporating traits governed by major and polygenes.

Suggested Reading:

- Allard RW. 1999. Principles of Plant Breeding. John Wiley & Sons.
- Fageria MS, Arya PS and Choudhary AK. 2000. Vegetable Crops: Breeding and Seed Production. Vol. I. Kalyani Publishers, New Delhi.
- Kaloo G. 1988. Vegetable Breeding. Vols. I-III. CRC Press.
- Kaloo G. 1998. Vegetable Breeding. Vols. I-III (Combined Ed.). Panima Edu. Book Agency. Peter KV and Pradeep KT. 2008. Genetics and Breeding of Vegetables. ICAR.
- Rai N and Rai M. 2006. Heterosis Breeding in Vegetable Crops. New India Publication Agency. Ram HH. 2005. Vegetable Breeding-Principles and Practices. Kalyani Publishers
- Sharma JP. 2010. Principles of Vegetable Breeding. Kalyani Publishers, New Delhi. Singh BD. 1983. Plant Breeding. Kalyani Publishers

Course Title: Breeding Fruit Crops

Course Code: GPB 514

Credit Hours: 3(2+1)

Objectives:

1. To facilitate the students about basic concepts of mode of reproduction of different fruit crops

2. To impart knowledge and practical skills of breeding procedures of various fruit crops
3. To improve the understanding of crop improvement of various fruit crops

Course outcomes:

CO1: Summarize the importance of genetics- biotic and abiotic stress resistance in different fruits

CO2: Enable the understanding the origin, evolution and mode of reproduction of different crops

CO3: Distinguish the floral biology, pollination techniques of fruit crops

CO4: Equip with the concept of breeding objectives and procedures of various fruit crops

CO5: Enhance the understanding the development of hybrid varieties of different fruit crops

CO-PSO Mapping:

	PSO1	PSO2	PSO3
CO1	✓	✓	✓
CO2			
CO3		✓	✓
CO4		✓	✓
CO5		✓	✓

Theory:

Unit I: Fruit crop breeding: History, importance of fruit breeding, centers of diversity, distribution, domestication, and adaptation of commercially important fruits.

Unit II: Issues in fruit crop breeding – heterozygosity, polyploidy, polyembryony, parthenocarpy and seed lessness, incompatibility and sterility systems.

Unit III: Apomixis - merits and demerits, types, variability for economic traits, role of genetic engineering and biotechnology in improvement of fruit crops.

Unit IV: Crop improvement in Mango, Banana, Citrus, Grapes, Papaya, Sapota and Pomegranate, Pineapple and Guava, Apple and other Rosaceous crops and region-specific fruit crops.

Practical:

Germplasm documentation;

Floral biology of mango, guava, citrus, grape, pomegranate, pollen viability in major fruit crops;

Pollen germination to study time of anthesis and stigma receptivity;

Hybridization technique in important fruit crops, hybrid seed collection and raising; Colchicine treatment for induction of polyploidy;

Exposure to resistance breeding and screening techniques;

Mutation breeding practices raising and evaluation of segregating populations; Use of mutagens to induce mutations and polyploidy;

Visit to Biotechnology Lab and study of in-vitro breeding techniques.

Suggested Reading:

Bhojwani SS and Razdan MK. 2006. Plant Tissue Culture -Theory and Practice. Elsevier Publication, Amsterdam.

Chadha KL and Pareek, OP. 1996. (Eds.). Advances in Horticulture. Vol. I to IV. Malhotra Publ. House, New Delhi.

Chadha KL and Shikhamany SD. 1999. The Grape: Improvement, Production and Post-Harvest Management. Malhotra Publ. House, New Delhi.

Janick and Moore JN. 1996. Advances in Fruit Breeding, AVI Pub., USA. Janick J and Moore JN. 1996. Fruit Breeding.

Vols. I to III. John Wiley & Sons.

Kumar N. 2006. Breeding of Horticultural Crops - Principles and Practices. New India Publishing Agency, New Delhi.

Moore JN and Janick Jules. 1996. Methods in Fruit Breeding. Purdue University Press, South Campus Court D., USA.

Parthasarathy VA, Bose TK, Deka PC, Das P, Mitra SK. and Mohanadas

S. 2001. Biotechnology of Horticultural Crops. Vols. I-III. Naya Prokash, Kolkata.

Ray PK. 2002. Breeding of Tropical and Sub-tropical Fruits. Narosa Publishing House, New Delhi.

Simmonds NW. 1976. Evolution of Crop Plants, Orient Longman, London

Course Title: Breeding Ornamental Crops

Course Code: GPB 515

Credit Hours: 3(2+1)

Objectives:

1. To facilitate the students about basic concepts of mode of reproduction of different ornamental crops
2. To impart knowledge and practical skills of breeding procedures of various ornamentals
3. To improve the understanding of crop improvement of various ornamental crops

Course outcomes:

CO1: Summarize the history of improvement of diverse ornamental crops

CO2: Equip with the understanding the origin, evolution and mode of reproduction of ornamentals

CO3: Distinguish the floral biology, pollination techniques of ornamental crops

CO4: Enable the concept of breeding objectives and procedures of various ornamentals

CO5: Enhance the understanding the development of hybrid varieties of different ornamental crops

CO-PSO Mapping:

	PSO1	PSO2	PSO3
CO1	✓	✓	✓
CO2			
CO3		✓	✓
CO4		✓	✓
CO5		✓	✓

Theory:

Unit I: History of improvement of ornamental plants; Centre of origin of ornamental crop; Objectives and techniques in ornamental plant breeding.

Unit II: Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops, viz., Rose, Jasmine, Chrysanthemum, Tuberose, Gerbera, Gladiolus, Dahlia, Lilium, Gaillardia, Petunia, Bouganvillea, Pansy, Marigold, Geranium, Antirrhinum, China aster, Orchids, Carnation, Hibiscus, etc.

Unit III: Development of promising cultivars of important ornamental and flower crops; Role of Heterosis and its exploitation, production of F1 hybrids and utilization of male sterility.

Unit IV: Production of open-pollinated seeds, harvesting, processing and storage of seeds; Seed certification.

Practical:

Study of floral biology and pollination in important species and cultivars of ornamental crops; Techniques of inducing polyploidy and mutation; Production of pure and hybrid seed; Methods of breeding suited to seed propagated plants; Polyploidy and mutations to evolve new varieties; Breeding methods for biotic and abiotic stresses; Visit to research institutes involved in ornamental crop breeding.

Suggested Reading:

Alexander V. 2002. Breeding for ornamentals: Classical and Molecular Approaches. Kluwer Academic Publishers, London.

Allard RW. 1999. Principles of Plant Breeding. John Wiley & Sons.

INC. New York. Bhattacharjee SK and De LC. 2003. Advanced Commercial Floriculture Vol. 1 Aavishkar Publishers & Distributors, Jaipur.

Bose TK and Yadav LP. 2003. Commercial Flowers. Naya Prokash Publishers, Kolkata.

Chadha KL and Bhattacharjee SK. Advances in Horticulture Vol. 12, Malhotra Publishing House, New Delhi.

Mc Donald MB and Kwong FY. 2005. Flower Seeds Biology and Technology, CABI Publishing, Oxfordshire, UK.

Watts L.1980. Flower and Vegetable Plant Breeding. Grower Books

Course Title: Breeding for Stress Resistance and Climate Change

Course Code: GPB 516

Credit Hours: 3(2+1)

Objectives:

1. To impart knowledge about various abiotic and biotic stresses influencing crop yield, mechanisms and genetics of resistance and methods to breed stress-tolerant varieties
2. To bring examples of strategies and successes of employing plant genetic resources to help plants adapt to climate change.
3. To facilitate the potential use of plant genetic resources in breeding for climate change mitigation.

Course outcomes:

After completion of this course the student will be able to well verse with the stress and its causes

CO1: Equip the student about the concept and impact of climatic change on agricultural crops

CO2: Enable the importance of plant breeding with reference to biotic and abiotic stress resistance

CO3: Enhance the knowledge about genetic mechanisms of resistance to biotic and abiotic stresses

CO4: Ability to understand the climatological parameters and predisposal of biotic and abiotic stress factors

CO5: Summarize the breeding procedures to develop biotic and abiotic stress resistance varieties

CO-PO Mapping:

	PSO1	PSO2	PSO3
CO1			✓
CO2		✓	
CO3		✓	✓
CO4		✓	✓
CO5		✓	✓

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.

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.

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.

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.

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.

Course Title: Germplasm Characterization and Evaluation

Course Code: GPB 517

Credit Hours: 2(1+1)

Objectives:

1. To impart knowledge about various morphological and quality agronomic traits of accessions
2. To bring examples and importance of plant genetic resources
3. To facilitate the potential use of plant germplasms in breeding programs

Course outcomes:

CO1: Enhance knowledge of basic concepts of germplasm characterization and evaluation

CO2: Enable the knowledge and understanding of plant genetic resources

CO3: Summarize the knowledge and understanding of germplasm collections

CO4: Equip with the ability on field layout and experimental designs

CO5: Ability to develop knowledge of high throughput phenotyping systems

CO-PSO Mapping:

	PSO1	PSO2	PSO3
CO1		✓	
CO2	✓	✓	
CO3		✓	✓
CO4		✓	✓
CO5		✓	✓

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.

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.

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.

Course Title: Genetic enhancement for PGR Utilization

Course Code: GPB 518

Credit Hours :2(1+1)

Objectives:

1. To impart knowledge about various gene pools
2. To bring examples and importance of crop adaptation and pre-breeding
3. To facilitate the potential use of plant germplasms in breeding programs

Course outcomes:

CO1: Enhance knowledge of basic concepts of gene pool

CO2: Enable the knowledge and understanding of crop adaptation

CO3: Summarize the knowledge and understanding of pre-breeding

CO4: Equip with the ability to gene transfer

CO5: Ability to develop knowledge of cytological studies, fluorescence microscopy, embryo rescue methods, pollen physiology

CO-PSO Mapping:

	PSO1	PSO2	PSO3
CO1		✓	
CO2	✓	✓	

CO3			
CO4		✓	✓
CO5		✓	✓

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.

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 post- zygotic barriers.

Practical:

Characterization of CWRs by visiting the fields;

Screening methods for special traits-biotic and abiotic resistance; Screening for nutritional traits;

Crossability studies in CWRs of cereals, legumes, oilseeds, vegetables. Assessment of pre and post-zygotic barriers in wide hybridization crosses;

Pollen storage studies;

Special requirements for growing CWRs, inducing flowering by manipulating daylength, temperature, chemical spraying, etc.

Suggested Reading:

Andey Pereira. 2006. Plant Reverse Genetics, Methods and Protocols, Humana Press Bisht et al. 2004. Broadening the genetic base of sesame (*Sesamum indicum* L.) through genetic enhancement. *Plant Genetic Resources* 2(3): 143–151.

Dale JW and von Schantz M. 2007. From genes to genomes. Concepts and applications of DNA technology. John Wiley & Sons Ltd., Chichester, England.

Duvick DN. 1990. Genetic enhancement and plant breeding. p. 90–96. In: J. Janick and J.E.

Simon (eds.), *Advances in new crops*. Timber Press, Portland. Goodman, RM. 2004.

Encyclopedia of plant and crop science. Marcel Dekker Inc., Switzerland. Kimber, G and

Feldman, M. 1987. *Wild Wheat: An introduction*. Special report 353, College of Agriculture, University of Missouri-Columbia.

Lynch M. and Walsh B. 1998. *Genetics and analysis of quantitative traits*. Sinauer Associates Inc., MA, USA.

Murphy D. 2007. *Plant breeding and biotechnology: Societal context and the future of agriculture*.

Cambridge University Press, Cambridge, UK. Ram JS. 2010. *Plant Cytogenetics*. CRC

Press. Ramanatha Rao V, Brown AHD, Jackson M. 2001. *Managing Plant Genetic Diversity*. CABI publication.

Sharma S, Upadhyaya HD, Varshney RK, et al. 2013. Pre-breeding for diversification of primary gene pool and genetic enhancement of grain legumes. *Front. Plant Sci.* 4: 309.

Yunbi Xu. 2010. *Molecular plant breeding*, CABI publishers

e-Resources:

<https://www.integratedbreedPlaning.net/pre-breeding-effective-use-plant-genetic-resources>

<http://www.croptrust.org/>

http://www.bioversityinternational.org/training/training_materials/pre_breeding.htm

<http://www.grdc.com.au/director/research/prebreeding>.

SYLLABUS FOR MINOR COURSE

Course title: Principles of Biotechnology Course No: MMBB0501

Credit Hour:

Objectives:

1. To impart the basic knowledge of molecular biology, plant and microbial biotechnology
2. To facilitate the classical and new-age technologies associated with biotechnology
3. To improve knowledge on importance and applications of biotechnology in agriculture, case studies, IPR and related issues

Course Outcomes:

After completing this course, the students will be able to achieve the following outcomes:

CO1: Enhance the knowledge of genes, genomes and their organization, gene expression, genetic variation, genetic engineering, protein expression and post-translational modifications.

CO2: Equip with knowledge on basic concepts and techniques of crop improvement through biotechnological approaches.

CO3: Enhance with skills in various biotechnological approaches for problem-solving in a sustainable way

CO4: Ability to understand the concept of biotechnology for maintaining the sustainability of agriculture worldwide.

CO5: Summarize the concepts of public education, perception, IPR and related issues.

CO-PSO Mapping:

	PSO1	PSO2	PSO3
CO1	✓		
CO2	✓	✓	
CO3	✓		
CO4	✓	✓	
CO5		✓	✓

Theory:

Unit I: History, scope, and importance of Biotechnology; Specializations in Agricultural Biotechnology: Genomics, Genetic engineering, Tissue Culture, Bio-fuel, Microbial Biotechnology, Food Biotechnology etc. Basics of Biotechnology, Primary metabolic pathways, Enzymes, and its activities.

Unit II: Structure of DNA, RNA and protein, their physical and chemical properties. DNA function: Expression, exchange of genetic material, mutation. DNA modifying enzymes and vectors; Methods of recombinant DNA technology; Nucleic acid hybridization; DNA/RNA libraries; Applications of gene cloning in basic and applied research, Plant transformation: Gene transfer methods and applications of GM crops.

Unit III: Molecular analysis of nucleic acids -PCR and its application in agriculture and industry, Introduction to Molecular markers: RFLP, RAPD, SSR, SNP etc, and their applications; DNA sequencing, different methods; Plant cell and tissue culture techniques and their applications. Introduction to genomics, transcriptomics, ionomics, metabolomics and proteomics. Plant cell and tissue culture techniques and their applications.

Unit IV: Introduction to Emerging topics: Genome editing, gene silencing, Plant microbial interactions, Success stories in Biotechnology, Careers and employment in biotechnology. Public perception of biotechnology; Bio-safety and bioethics issues; Intellectual property rights in biotechnology.

Suggested Readings:

Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M & Losick R (2014) Molecular Biology of the Gene, 7th edition, Cold Spring Harbor Laboratory Press, New York

Brown, T. A. (2010) Gene Cloning and DNA analysis an Introduction 6th edition, Wiley Blackwell

Primrose, S. B. and Twyman, R. (2006) Principles of gene Manipulation 7th edition, Wiley Blackwell

Singh, B. D, Biotechnology: Expanding Horizons (2012) 4th edition, Kalyani publisher, New Delhi, India

Course title: Techniques in Molecular Biology I Course No: MMBB0504

Credit Hour: 3 (0+3) Objectives:

1. To bring an overview of good lab practices and preparation of buffers and lab reagents.
2. To impart an overview of molecular biology techniques and recombinant DNA technology.
3. To facilitate hands-on training in chromatography, protein analysis, nucleic acid analysis, bacterial and phage genetics.

Upon completing this course, you will be able to do the following:

Course Outcomes:

CO1: Enhance knowledge of good lab practices and making of different lab reagents.

CO2: Enable the knowledge and understanding of fundamental concepts of molecular biology techniques.

CO3: Summarize the knowledge and understanding of fundamental concepts of recombinant DNA technology and various chromatographic techniques.

CO4: Equip with the ability of nucleic acid and protein analysis techniques.

CO5: Ability to develop knowledge of molecular biology and chromatographic techniques to solve research problems.

CO-PSO Mapping:

	PSO1	PSO2	PSO3
CO1	✓		
CO2	✓	✓	
CO3	✓		
CO4	✓	✓	✓
CO5	✓	✓	✓

Practical:

Good lab practices, preparation of buffers and reagents. 2. Principle of centrifugation and spectrophotometry.

Growth of bacterial culture and preparation of growth curve, Isolation of Genomic DNA from bacteria.

Isolation of plasmid DNA from bacteria.

Growth of lambda phage and isolation of phage DNA.

Isolation and restriction of plant DNA (e.g., Rice / Moong / Mango / Merigold).

Quantification of DNA by (a) Agarose Gel electrophoresis and (b) Spectrophotometry PCR using isolated DNA.

PAGE Gel electrophoresis.

Restriction digestion of plasmid and phage DNA, ligation, Recombinant DNA construction.

Transformation of E. coli and selection of transformants

Chromatographic techniques, TLC

Gel Filtration Chromatography, Ion exchange Chromatography, Affinity Chromatography

Dot blot analysis, Southern hybridization, and Northern hybridization. 14. Western blotting and ELISA.

Radiation safety and non-radio isotopic procedure.

Suggested Readings

Sambrook, J., and Russell, R.W (2001) Molecular cloning: A laboratory manual 3rd Edition, Cold spring harbor laboratory press, cold spring harbor, New York.

Wilson, K., and Walker, J., (2018) Principles and Techniques of Biochemistry and Molecular Biology 8th edition, Cambridge University Press.

Ausubel, F. M., Brent, R., Kingston, R. E., Moore, D. D., Seidman, J. G., Smith, J. A., &Struhl, K., (2002) Short Protocols in Molecular Biology 5th edition, Current Protocols publication.

Course Title: Plant Tissue Culture

Course Code: MMBB 0509

Credit Hour: 2+1

Objectives:

To provide insight into principles of plant cell culture and genetic transformation. To get a hands-on training in basic plant tissue culture techniques, callusing, micropropagation and analysis.

Course outcomes:

CO1: Enhance knowledge of basic concepts of plant tissue culture

CO2: Enable the knowledge and understanding of plant cell types and cell suspension culture

CO3: Summarize the knowledge and understanding of fundamental concepts of culture media composition, sterilization techniques, and aseptic laboratory practices

CO4: Equip with the ability on androgenesis and gynogenesis

CO5: Ability to develop knowledge of protoplast culture

CO-PSO Mapping:

	PSO1	PSO2	PSO3
CO1			✓
CO2		✓	
CO3			✓
CO4	✓	✓	✓
CO5		✓	✓

Theory:

Unit I: History of plant tissue culture, principle of Totipotency; Tissue culture media; Plant hormones and morphogenesis; Direct and indirect organogenesis; Direct and indirect somatic embryogenesis; Applications of plant tissue culture; National certification and Quality management of TC plants; Genetic Fidelity testing and Virus indexing methods –

PCR, ELISA.

Unit II: Micropropagation of field and ornamental crops; Virus elimination by meristem culture, meristem tip culture and micrografting; Androgenesis and gynogenesis - production of androgenic and gynogenic haploids - diploidization; Protoplast culture - isolation and purification; Protoplast culture; Protoplast fusion; Somatic hybridization - Production of Somatic hybrids and Cybrids; Wide hybridization - embryo culture and embryo rescue techniques; Ovule, ovary culture and endosperm culture.

Unit III: Large-scale cell suspension culture - Production of alkaloids and other secondary metabolites- techniques to enhance secondary metabolite production, Somaclonal and gametoclonal variations – causes and applications; Callus culture and in vitro screening for stress tolerance; Artificial seeds, In vitro germplasm storage and cryo- preservation. Commercial Tissue Culture: Case studies and success stories, Market assessment; project planning and preparation, economics, government policies

Practical:

Preparation of stocks - macronutrients, micronutrients, vitamins and hormones, filter sterilization of hormones and antibiotics. Preparation of Murashige and Skoog medium.

Micro-propagation of plants by nodal and shoot tip culture.

Embryo culture to overcome incompatibility, Anther culture for haploid production.

Callus induction in tobacco leaf discs, regeneration of shoots, root induction, role of hormones in morphogenesis.

Acclimatization of tissue culture plants and establishment in greenhouse. Virus indexing in tissue culture plants. (Using PCR and ELISA).

Plan of a commercial tissue culture UNIT.

Suggested Reading:

Razdan, M. K. (2003) Introduction to plant tissue culture, 2nd edition, Oxford publications group

Butenko, R. G. (2000) Plant Cell Culture University Press of Pacific

Herman, E. B. (2008) Media and Techniques for Growth, Regeneration and Storage, Agritech Publications, New York, USA.

Bhojwani, S.S and Dantu, P. 2013. Plant Tissue Culture – An Introductory Text. Springer Publications

Gamborg, O. L and G.C. Philips (eds.). 2013. Plant Cell, Tissue and Organ culture- Lab Manual. Springer Science & Business media.

Course title: Stress Biology and Genomics

Course No: MMBB0517

Credit Hour: 2+0

Objectives:

1. To impart advanced knowledge on genomics and functional genomics.
2. To improve insight into the abiotic stress tolerance in plants.
3. To impart knowledge of the biotic stress resistance in plants.

Course Outcomes (CO):

CO1: Enhance knowledge and understanding of plant stress physiology.

CO2: Enable knowledge and understanding of the mechanisms of abiotic stress signaling and responses in plants.

CO3: Summarize the knowledge and understanding of the mechanisms of biotic stress signaling and responses in plants.

CO4: Ability to gain knowledge of genomics in the improvements of plant stress tolerance.

CO5: Equip with the knowledge of functional genomics and genome editing in the improvements of plant stress tolerance.

CO-PSO Mapping:

	PSO1	PSO2	PSO3
CO1			✓
CO2		✓	
CO3		✓	✓
CO4	✓	✓	✓
CO5	✓	✓	✓

Theory:

Unit I: Different kinds of stresses (biotic and abiotic) and adaptation strategies: Plant cell as a sensor of environmental changes; role of cell membranes in signal perception; Ways of signal transduction in cells and whole plants as a response to external factors. Abiotic stresses affecting plant productivity – Drought, salinity, water logging, temperature stresses, light stress and nutrient stress; Drought stress – Effects on plant growth and development; Components of drought resistance; Physiological, biochemical and molecular basis of tolerance mechanisms; Biotic stress (insect and pathogen) resistance mechanism.

Unit II: Strategies to manipulate drought tolerance – Osmotic adjustment and Osmo protectants - synthesis of proline, glycine betaine, poly amines and sugars; ROS and antioxidants; hormonal metabolism - ABA signalling; signalling components – transcription factors. Water logging stress – effects on plant growth and metabolism; adaptation to water logging, tolerance mechanisms -hormones and flooding tolerance. Strategies for improving submergence tolerance. Salinity stress – effects on physiology and metabolism of plants, SOS pathways and ion homeostasis, Strategies to improve salinity tolerance in plants. Water logging stress – effects on plant growth and metabolism; tolerance mechanisms. Physiological and biochemical changes – High & Low temperature tolerance mechanisms - molecular basis of thermo tolerance. Morphological and physiological changes in plants due to high and low light stresses - photo oxidation -plastid development. Characters of heliophytes and sciophytes – solar tracking – sieve effect and light channelling. Heavy metal stress – Al and Cd stress - effects on plant growth and development, biotech Strategies to overcome heavy metal stress Nutrient stress- effects on plant growth and development. Genetic manipulation strategies to overcome the stress effects.

Unit III: Genomics; transcriptomes, small RNAs and epigenomes; functional genomics; transfer of tolerance/resistant genes to model plants and validation of gene function. Different techniques for the functional validation of genes. Signaling pathway related to defense gene expression, R proteins, RNAi approach and genes from pathogens and other sources, coat protein genes, detoxification genes, transgenic and disease management. Bt proteins, resistance management strategies in transgenic crops, ecological impact of field release of transgenic crops. Bioinformatics approaches to determine gene function and network in model plants under stress.

Suggested Reading:

Buchanan, B. B., Gruissem, W. and Jones R, (2015) Biochemistry and Molecular Biology of Plants, 2nd edition, Wiley and Blackwell Publications.

Sarwat, M., Ahmad, A., Abdin, M.Z. (2013) Stress Signaling in Plants: Genomics and Proteomics Perspective, Volume 1, Springer.

Heribert Hirt, (2010) Plant Stress Biology: From Genomics to Systems Biology, John Wiley. Pandey, G. K., Elucidation of Abiotic Stress Signaling in Plants, Wiley.

SUPPORTING COURSES

Course Title: Statistical Methods for Applied Sciences

Course No: STAT 0502

Credit hours: 3+1

Objectives:

1. To impart the concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics.
2. To bring the concepts involved in data presentation, analysis and interpretation.
3. To facilitate presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.

Course Outcomes (CO):

CO1: Equip with the comprehensive understanding of fundamental statistical concepts, including descriptive statistics, probability theory, and the principles of exploratory data analysis.

CO2: Enable the understanding discrete and continuous probability distributions their applications in real-world problems.

CO3: Enhance the proficiency in conducting statistical inference, interpreting correlation coefficients, and performing regression analysis.

CO4: Analyze the skills to perform non-parametric tests as valuable alternatives to parametric tests.

CO5: Ability to perform advanced statistical techniques, enabling effective application of statistical methods in real-world research and analysis.

	PSO1	PSO2	PSO3
CO1	✓		
CO2		✓	
CO3		✓	
CO4	✓		
CO5	✓		

Theory:

Unit I: Classification, tabulation, and graphical representation of data. Box-plot, Descriptive statistics. Exploratory data analysis; Theory of probability. Random variable and

mathematical expectation.

Unit II: Discrete and continuous probability distributions: Binomial, Poisson, Negative Binomial, Normal distribution, Beta and Gamma distributions and their applications. Concept of sampling distribution: chi-square, t and F distributions. Tests of significance based on Normal, chi-square, t and F distributions. Large sample theory.

Unit III: Introduction to theory of estimation and confidence-intervals. Correlation and regression. Simple and multiple linear regression model, estimation of parameters, predicted values and residuals, correlation, partial correlation coefficient, multiple correlation coefficient, rank correlation, test of significance of correlation coefficient and regression coefficients. Coefficient of determination. Polynomial regression models and their fitting. Probit regression analysis by least squares and maximum likelihood methods, confidence interval for sensitivity; Testing for heterogeneity.

Unit IV: Non-parametric tests - sign, Wilcoxon, Mann-Whitney U-test, Wald Wolfowitz run test, Run test for the randomness of a sequence. Median test, Kruskal- Wallis test, Friedman two-way ANOVA by ranks. Kendall's coefficient of concordance.

Unit V: Introduction to multivariate analytical tools- Hotelling's T² Tests of hypothesis about the mean vector of a multinormal population. Classificatory problems and discriminant function, D²-statistic and its applications; Cluster analysis, principal component analysis, canonical correlations and Factor analysis.

Practical

Exploratory data analysis, Box-Cox plots; Fitting of distributions Binomial, Poisson, Negative Binomial, Normal; Large sample tests, testing of hypothesis based on exact sampling distributions ~ chi square, t and F; Confidence interval estimation and point estimation of

parameters of binomial, Poisson and Normal distribution; Correlation and regression analysis, fitting of orthogonal polynomial regression; applications of dimensionality reduction and discriminant function analysis; Nonparametric tests.

Suggested Readings

Anderson TW. 1958. An Introduction to Multivariate Statistical

Analysis. John Wiley. Dillon WR & Goldstein M. 1984. Multivariate Analysis - Methods

and Applications. John Wiley.

Goon AM, Gupta MK & Dasgupta B. 1977. An Outline of Statistical Theory. Vol. I. The World Press.

Goon AM, Gupta MK & Dasgupta B. 1983. Fundamentals of Statistics. Vol. I. The World Press. Hoel PG. 1971. Introduction to Mathematical Statistics. John Wiley.304

Hogg RV & Craig TT. 1978. Introduction to Mathematical Statistics. Macmillan.

Morrison DF. 1976. Multivariate Statistical Methods. McGraw Hill. Siegel S, Johan N &

Casellan Jr. 1956. Non-parametric Tests for Behaviour Sciences. John Wiley. Learning Statistics: <http://freestatistics.altervista.org/en/learning.php>. Electronic

Statistics Text Book: <http://www.statsoft.com/textbook/stathome.html>.

Course Title: Experimental Designs

Course No: STAT 0511

Credit hours: 2+1

Objectives:

1. To impart the concepts involved in planning, designing their experiments and analysis of experimental data
2. To train the basic principles of experimental design, including the concept of uniformity trials, the size and shape of plots and blocks.
3. To facilitate fundamental experimental designs (CRD, RBD and LSD) including split plot and strip plot design.

At the end of the course students will be able to achieve the following outcomes:

Course Outcomes:

CO1: Ability to understanding the basic principles of experimental design.

CO2: Enable learners to plan and implement experiments using basic designs (CRD, RBD and LSD)

CO3: Summarize both symmetrical and asymmetrical factorial experiments

CO4: Enable split plot and strip plot experiments enhancing their agricultural research capabilities.

CO5: Equip with the use of bioassays (direct and indirect) based on quantal dose response.

	PSO1	PSO2	PSO3
CO1	✓	✓	
CO2	✓	✓	
CO3		✓	
CO4		✓	
CO5	✓		

Theory:

Unit I: Need for designing of experiments, characteristics of a good design. Basic principles of

designs- randomization, replication and local control.

Unit II: Uniformity trials, size and shape of plots and blocks; Analysis of variance; Completely randomized design, randomized block design and Latin square design.

Unit III: Factorial experiments, (symmetrical as well as asymmetrical) orthogonality and partitioning of degrees of freedom, Confounding in symmetrical factorial experiments, Factorial experiments with control treatment.

Unit IV: Split plot and strip plot designs; Analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, crossover designs, balanced incomplete block design, resolvable designs and their applications ~ Lattice design, alpha design -concepts, randomisation procedure, analysis and interpretation of results. Response surfaces. Experiments with mixtures.

Unit V: Bioassays- direct and indirect, indirect assays based on quantal dose response, parallel line and slope ratio assays potency estimation

Practical:

Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law; Analysis of data obtained from CRD, RBD, LSD; Analysis of factorial experiments without and with confounding; Analysis with missing data; Split plot and strip plot designs; Transformation of data; Analysis of resolvable designs; Fitting of response surfaces.

Suggested Readings:

Cochran WG & Cox GM. 1957. Experimental Designs. 2nd Ed. John Wiley. Dean AM & Voss D. 1999. Design and Analysis of Experiments. Springer. Federer WT. 1985. Experimental Designs. MacMillan.

Fisher RA. 1953. Design and Analysis of Experiments. Oliver & Boyd.

Nigam AK & Gupta VK. 1979. Handbook on Analysis of Agricultural Experiments. IASRI Publ. Pearce SC. 1983. The Agricultural Field Experiment: A Statistical Examination of Theory and Practice. John Wiley. Design Resources Server: www.iasri.res.in/design

COMMON COURSES

Course Title: Library and Information Services

Course Code: PGSS 0501

Credit Hours: 0+1

Objectives:

1. To facilitate the library users with skills to trace information from libraries efficiently.
2. To impart students about information and knowledge resources, to carry out literature survey.
3. To improve information search strategies, with the application of modern tools.

Upon completion of the course the students will be able to achieve the following outcomes:

CO1: Acquaint with basic terms of library services

CO2: Distinguish the methods of tracing information from different source.

CO3: Ability to relate one information with another information of interest.

CO4: Enhance the knowledge on abstracts, review collection, citation, bibliography and tracking information.

CO 5: Equip with to compose of review of literatures and scientific reports.

	PSO1	PSO2	PSO3
CO1	✓	✓	✓
CO2	✓	✓	✓
CO3	✓	✓	✓
CO4	✓	✓	✓
CO5	✓	✓	✓

Practical:

Introduction to library and its services

Role of libraries in education, research and technology transfer Classification systems and organization of library

Sources of information- Primary Sources, Secondary Sources and Tertiary Sources

Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts,

Chemical Abstracts, CABI Abstracts, etc.)

Tracing information from reference sources

Literature survey; Citation techniques/ Preparation of bibliography

Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services

Use of Internet including search engines and its resources; e- resources access methods

Course Title: Technical Writing and Communications Skills

Course Code: PGSS 0502

Credit Hours: 0+1

Objectives:

1. To impart the students/scholars with skills to write dissertations, research papers, etc.
2. To facilitate the students/scholars with skills to communicate and articulate in English (verbal as well as writing).
3. To improve the students on composing abstracts, review articles, research paper writing etc.

Upon completion of the course the students will be able to achieve the following outcomes:

Course outcomes:

CO1 Equip with the various forms of writings frequently required in a preparation of documents, reports, manuscripts, manual, etc.

CO2 Analyze the understanding of principles and method of effective and professional communication and speech.

CO3 Enable the ability to differentiate among and to use facts, inferences and judgments and editing and proof-reading and

CO4 Enhance the ability to organizing information for research communication, report, thesis and other publication

CO5 Ability to develop the skills in composing the abstracts, content, notation, citation, captions, pagination, bibliography, review of literature, scientific manuscript, research article, review article, etc.

	PSO1	PSO2	PSO3
CO1	✓	✓	✓
CO2	✓	✓	✓
CO3	✓	✓	✓
CO4	✓	✓	✓
CO5	✓	✓	✓

Practical

Various forms of scientific writings- theses, technical papers, reviews, manuals, etc.

Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion) Writing of abstracts, summaries, précis, citations, etc.

Commonly used abbreviations in the theses and research communications

Illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations

Writing of numbers and dates in scientific write-ups; Editing and proof-reading

Writing of a review article

Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks) Error analysis (Common errors), Concord, Collocation, Phonetic symbols and transcription
Accentual pattern: Weak forms in connected speech

Participation in group discussion Facing an interview Presentation of scientific papers

Suggested Reading:

Barnes and Noble. Robert C. (Ed.). 2005. Spoken English: Flourish Your Language. Chicago
Manual of Style. 14th Ed. 1996. Prentice Hall of India.

Collins' Cobuild English Dictionary. 1995.

Harper Collins. Gordon HM and Walter JA. 1970. Technical Writing. 3rd Ed. James HS. 1994.
Handbook for Technical Writing. NTC Business Books.

Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East-West
Press.

Mohan K. 2005. Speaking English Effectively. MacMillan India. Richard WS. 1969. Technical
Writing.

Sethi J and Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall
of India.

Wren PC and Martin H. 2006. High School English Grammar and Composition.

S. Chand & Co.

Course Title: Intellectual Property and its Management in Agriculture

Course Code: PGSS 0503

Credit Hours: 0+1

Objectives:

1. To facilitate the students and stakeholders with knowledge of intellectual property (IPR)
2. To impart the significance of fundamentals of patents and copyright policy
3. To improve the knowledge and biodiversity protection and initiatives

Course outcomes:

CO1: Enhance the meaning of intellectual property and differentiate it from tangible property.

CO2: Summarize the process of IPR, their eligibility and various treaties and conventions.

CO3: Ability to analyze TRIPs and various provisions in TRIPS Agreement, GI, ITK.

CO4: Equip with the understand protection of plant varieties, researcher's right and farmers' right.

CO5: Enable to evaluate ethical and professional issues that arise in the intellectual property law.

CO-PSO Mapping:

	PSO1	PSO2	PSO3
CO1			✓
CO2		✓	
CO3		✓	✓
CO4		✓	✓
CO5		✓	✓

Theory:

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other

biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Reading:

Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw- Hill.

Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC and Aesthetic Technologies.

Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol. V. Technology Generation and IPR Issues. Academic Foundation.

Rothschild M and Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.

Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House. The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; The Biological Diversity Act, 2002.

Course Title: Basic Concepts in Laboratory Techniques

Course Code: PGSS 0504

Credit Hours: 0+1

Objectives:

1. To improve the students about the basics of commonly used techniques in laboratory.
2. To impart handling techniques and preparation of acid and bases.
3. To facilitate seed viability testing, tissue culture of plants and description of flowering plants

Course outcomes:

Upon completion of the course the students will be able to achieve the following outcomes:

CO1: Ability to educate about basic rules and regulations of laboratory use

CO2: Summarize the principles and protocols of commonly used instruments in soil sciences.

CO3: Develop on understanding of principles and methods of handling chemicals and equipment, preparation of solution, testing samples, etc. in the laboratory.

CO4: Develop the skills to operate laboratory equipment efficiently and safely

CO5: Develop the ability to design appropriate procedure of scientific works in the laboratory in such a way that accuracy of results remains higher

	PSO1	PSO2	PSO3
CO1	✓	✓	✓
CO2	✓	✓	✓
CO3	✓	✓	✓
CO4	✓	✓	✓
CO5	✓	✓	✓

Practical:

Safety measures while in Lab Handling of chemical substances

Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes

Washing, drying and sterilization of glassware Drying of solvents/ chemicals

Weighing and preparation of solutions of different strengths and their dilution Handling techniques of solutions

Preparation of different agro-chemical doses in field and pot applications Preparation of solutions of acids

Neutralization of acid and bases

Preparation of buffers of different strengths and pH values

Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sand bath, water bath, oil bath

Electric wiring and earthing

Preparation of media and methods of sterilization Seed viability testing, testing of pollen viability

Tissue culture of crop plants

Description of flowering plants in botanical terms in relation to taxonomy

Suggested Reading:

Furr AK. 2000. CRC Hand Book of Laboratory Safety. CRC Press.

Gabb MH and Latchem WE. 1968. A Handbook of Laboratory Solutions. Chemical Publ. Co.

Course Title: Agricultural Research, Research Ethics and Rural Development Programs

Course Code: PGSS 0505

Credit Hours: 1+0

Objectives:

1. To train the students about the organization and functioning of agricultural research systems at national and international levels
2. To impart knowledge in programs and policies of Government
3. To facilitate information and evaluation of rural development policies and programs.

Course outcomes:

Upon completion of the course the students will be able to achieve the following outcomes:

CO1: Impart the knowledge about basics of Agricultural Research, Research Ethics and Rural Development Programs in India

CO2: Develop the understanding of research ethics

CO3: Develop and understanding of rural developmental programs, policies, strategies and their evaluation system.

CO4: Get insights into intensive agriculture development programs.

CO5: Able to analyze the constraints in implementation of rural policies and programs.

	PSO1	PSO2	PSO3
CO1	✓	✓	✓
CO2	✓	✓	✓
CO3	✓	✓	✓
CO4	✓	✓	✓
CO5	✓	✓	✓

Theory:

Unit I: History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research

(CGIAR):International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

Unit II: Research ethics: research integrity, research safety in laboratories, the welfare of animals used in research, computer ethics, standards and problems in research ethics.

Unit III: Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Comm Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/ Non- Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Reading:

Bhalla GS and Singh G. 2001. Indian Agriculture - Four Decades of Development. Sage Publ. Punia MS. Manual on International Research and Research Ethics.

CCS Haryana Agricultural University, Hisar.

Rao BSV. 2007. Rural Development Strategies and Role of Institutions-Issues, Innovations and Initiatives. Mittal Publ. Singh K. 1998. Rural Development - Principles, Policies and Management. Sage Publ.