VIDYASAGAR UNIVERSITY

Syllabus
for
M. Sc (Agriculture)in Genetics & Plant Breeding

[w.e.f.: 2022-2023]

MISSION

The **M.Sc. in Genetics and Plant Breeding** course is to train students in the field of Crop genetics and its breeding. Theoretical as well as practical training is imparted to the candidates in the subspecialties viz. Molecular genetics, Cytogenetics, Plant breeding, and Mutation breeding, so that they can participate in good crop breeding research and programmes as well as help farmers in grass root level. They are introduced to basic research methodology so that they can conduct fundamental and applied research. They are also imparted farmers training methods in the subject which may enable them to take up in research in Agricultural Colleges/Institutes.

OBJECTIVES OF THE COURSE

As a nation we have gone ahead in many respects. But there are still areas, which demand attention, care and concern. The area identified by our think-tanks is "Indian Council of Agricultural Research". This course will provide trained, qualified, technical personnel in the field of Crop genetics and its breeding to support the farmers and their profession. At the end of the course the students should be able to: Establish good number of services in various fields in agro based companies and different sectors related to agriculture. They will be able to plan, execute and evaluate teaching assignments and research work in Genetics and Plant Breeding.

ELIGIBILITY FOR ADMISSION

The students who have passed Bachelor's degree in Agricultural / Botany / Horticulture or Forestry with 50% marks for General and 45% marks for SC/ST category.

JOB PROSPECTS

The M. Sc in Genetics and Plant Breeding may be assigned to a specialized area of work in a large field. In fields they may refer variety of trials. They can also work as Plant Geneticists/Breeder, Research associates, Seed technology scientists/ officer, Botanists, Tissue Culture Experts, in various research farms, labs, institutes, multinational organizations etc.

MINIMUM ELIGIBILITY FOR APPEARANCE IN EXAMINATION

A Regular student i.e. a student who has undergone a regular course of study in a college for the period specified for that course of study by having been on the rolls of the college immediately preceding the examination and has his/her name submitted to the Controller of Examinations by the college Principal where he/she has pursued the course for the examination and has fulfilled the following conditions to be certified by the college Principal concerned:

- He/she has been a student of good conduct.
- He/she has attended not less than 75% of the lecture delivered including seminars, tutorials etc. in each course opted by him/her in that semester.
- He/she has passed in previous semester.

- In the case of laboratory course/practical, he/she has attended not less than 75% of the practical classes conducted (practical include field studies, workshop practice, surveying etc.).
- He/she has paid the prescribed fee.

SCHEME OF EXAMINATION

The evaluation of M.Sc.Genetics and Plant Breeding in course contains two parts: Internal Assessment (IA) and End-Semester Assessment (EA). The internal grade awarded to the students in the course in a semester shall be published on the notice board at least one week before the commencement of end semester examination. The responsibility of evaluating the internal assessment is vested on the teacher(s) who teaches the course. There will be University Examinations at the end of each semester for both Theory and Practical. Semester End Examinations for all theory papers shall be set/prepared by the Controller of Examinations as per existing norms and evaluation of all theory papers courses shall be done by eligible faculty members set in the Board of Studies meeting held before the examination and under the supervision and coordination of the Controller of Examination. When there is a single college in a subject it has the liberty either to join the nearest cluster or form a new cluster with a similarly placed college.

The students will learn 14 theory papers (Full Marks 50) and 16 practical papers (Full Marks 30) with Research paper (Full Marks 100) in total semester semester (it may be changed as per the recommendation of Board of Studies members and approved by the Hon'ble Vice Chancellor). The details of the syllabus should be approved by the Board of Studies members and or syllabus committee made for the course. The evaluation of a candidate shall be awarded and record thereof maintained in accordance with the Regulations prescribed:

Paper	**Internal Assessment**	**End Semester**	**Total Marks**
Theory	20	50	**100**
Practical	00	30	

Internal Assessment:

Categories	**Class Assignment**	**Class Attendance**	**Internal exam*(IA)**	**Total**
Number Distribution	05	05	10	20

*IA should be held two times. Best of the two should be awarded

The questions pattern of theory will be as follows:

Questions Pattern	Marks
05 Short Answer type Questions out of 08 Questions. Each carries 02 marks.	**05×02=10**
05 Medium Answer type Questions out of 08 Questions. Each carries 04 marks.	**05×04=20**
02 Long Answer type Questions out of 04 Questions. Each carries 08 marks.	**02×10=20**

The questions pattern of practical will be as follows:

Questions Pattern	Marks
2 experimental questions with full marks of 15	**15**
Laboratory Note Book	**05**
Viva-voce	**10**

PROMOTION TO NEXT SEMESTER

- The students should secure 40% marks in each paper for qualifying the semester.
- If a student fails in 1 or 2 papers in an end semester examination, he/she get chance (two times) to clear those supplementary papers in the next year.
- If a student fails in more than 3 papers in an end semester examination, he/ she has to repeat the semester.
- The internal marks of a paper secured by a student will not be changed if he/ she fail in the respective paper in the end semester examination.

Syllabus for M. Sc (Agriculture) in Genetics & Plant Breeding

COURSE CODE	COURSE TITLE	CONDUCT HOURS PER WEEK				TOTAL CREDITS	MARKS DISTRIBUTION			
		L	T	P	TOTAL		Int Asst.	Theory	Practical	Total
GPB-501*	Principles of Genetics	2		1	3	3	20	50	30	100
GPB-502*	Principles of Plant Breeding	2		1	3	3	20	50	30	100
GPB-503*	Fundamentals of Quantitative Genetics	2		1	3	3	20	50	30	100
GPB-504*	Varietal Development and Maintenance Breeding	1		1	2	2	20	50	30	100
GPB-505*	Principles of Cytogenetics	2		1	3	3	20	50	30	100
GPB-506*	Molecular Breeding and Bioinformatics	2		1	3	3	20	50	30	100
GPB-510@	Seed Production and Certification	1		1	2	2	20	50	30	100
GPB-511@	Crop Breeding-I (Kharif Crops)	2		1	3	3	20	50	30	100
GPB-512@	Crop Breeding-II (Rabi Crops)	2		1	3	3	20	50	30	100
GPB-516*	Breeding for Stress Resistance and Climate Change	2		1	3	3	20	50	30	100
GPB- 591	Master's Seminar	0		1	1	1	-	-	100	100
GPB-599	Thesis/ Master's Research	0		30	30	30	-	-	100	100
STAT-502#	Statistical methods for applied sciences	3		1	4	4	20	50	30	100
BIOCHEM-505#	Techniques in Biochemistry	2		2	4	4	20	50	30	100
PGS-501	Library and Information Services	0		1	1	1	-	-	100	100
PGS-502	Technical Writing and Communications Skills	0		1	1	1	-	-	100	100
PGS-503	Intellectual Property and its management in Agriculture	1		0	1	1	20	80	-	100
PGS-504	Basic Concepts in Laboratory Techniques	0		1	1	1	-	-	100	100
PGS-505	Agricultural Research, Research Ethics and RuralDevelopment Programmes	1		0	1	1	20	80	-	100
TOTAL THEORY					**25**	**25**				**1900**
TOTAL PRACTICAL					**17**	**17**				
RESEARCH					**30**	**30**				
TOTAL					**72**	**72**				

***: Major courses, @: Minor courses, #: Supporting subject, +: Common subject**

FIRST SEMESTER

COURSE CODE	COURSE TITLE	CONDUCT HOURS PER WEEK				TOTAL CREDITS	MARKS DISTRIBUTION			
		L	T	P	TOTAL		Int Asst.	Theory	Practical	Total
GPB-501	Principles of Genetics	2		1	3	3	20	50	30	100
GPB-502	Principles of Plant Breeding	2		1	3	3	20	50	30	100
GPB-503	Fundamentals of Quantitative Genetics	2		1	3	3	20	50	30	100
GPB-504	Varietal Development and Maintenance Breeding	1		1	2	2	20	50	30	100
GPB-505	Principles of Cytogenetics	2		1	3	3	20	50	30	100
GPB-512	Crop Breeding-II (Rabi Crops)	2		1	3	3	20	50	30	100
TOTAL THEORY					**11**	**11**				**600**
TOTAL PRACTICAL					**6**	**6**				
TOTAL					**17**	**17**				

SECOND SEMESTER

COURSE CODE	COURSE TITLE	CONDUCT HOURS PER WEEK				TOTAL CREDITS	MARKS DISTRIBUTION			
		L	T	P	TOTAL		Int Asst.	Theory	Practical	Total
GPB-506	Molecular Breeding and Bioinformatics	2		1	3	3	20	50	30	100
GPB-510	Seed Production and Certification	1		1	2	2	20	50	30	100
GPB-511	Crop Breeding-II (Kharif Crops)	2		1	3	3	20	50	30	100
STAT-502	Statistical methods for applied sciences	3		1	4	4	20	50	30	100
BIOCHEM-505	Techniques in Biochemistry	2		2	4	4	20	50	30	100
GPB- 591	Master's Seminar	0		1	1	1		100		100
TOTAL THEORY					**10**	**10**				**600**
TOTAL PRACTICAL					**7**	**7**				
TOTAL					**17**	**17**				

THIRD SEMESTER

COURSE CODE	COURSE TITLE	CONDUCT HOURS PER WEEK				TOTAL CREDITS	MARKS DISTRIBUTION			
		L	T	P	TOTAL		Int Asst.	End Sem	Practical	Total
GPB-516	Breeding for Stress Resistance and Climate Change	2		1	3	3	20	50	30	100
PGS-502	Technical Writing and Communications Skills	0		1	1	1	-	-	100	100
PGS-504	Basic Concepts in Laboratory Techniques	0		1	1	1	-	-	100	100
PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1		0	1	1	20	80	-	100
TOTAL THEORY					**3**	**3**	**400**			
TOTAL PRACTICAL					**3**	**3**				
TOTAL					**6**	**6**				

FOURTH SEMESTER

COURSE CODE	COURSE TITLE	CONDUCT HOURS PER WEEK				TOTAL CREDITS	MARKS DISTRIBUTION			
		L	T	P	TOTAL		Int Asst.	End Sem	Practical	Total
PGS-501	Library and Information Services	0		1	1	1	-	-	100	100
PGS-503	Intellectual Property and its management in Agriculture	1		0	1	1	20	80	-	100
GPB-599	Master's Research	0		30	30	30	-	-	100	100
TOTAL THEORY					1	1				**300**
TOTAL PRACTICAL					1	**1**				
RESEARCH					30	**30**				
TOTAL					32	**32**				

Research work for master's dissertation- 30

Major course - 20

Minor course - 8

Supporting course- 8

Common course-5

GENETICS AND PLANT BREEDING

FIRST SEMESTER

Principles of Genetics

Code: GPB-501 **Full Marks - 100**

Credit hours: 2L+1P

Credit-3

Objective

This course is aimed at understanding the basic concepts of inheritance of genetics, helping studentsto develop their analytical, quantitative and problem-solving skills from classical to molecular genetics.

Theory

UNIT I

Beginning of genetics, early concepts of inheritance, Mendel's laws; Discussion onMendel's paper, Chromosomal theory of inheritance; Multiple alleles, Geneinteractions, Sex determination, differentiation and sex-linkage, Sex-influenced andsex-limited traits; Linkage-detection, estimation; Recombination and genetic mappingin eukaryotes, Somatic cell genetics, Extra chromosomal inheritance.

UNIT II

Mendelian population, Random mating population, Frequencies of genes andgenotypes, Causes of change: Hardy-Weinberg equilibrium..

UNIT III

Nature, structure and replication of the genetic material; Organization of DNA inchromosomes, Genetic code; Protein biosynthesis, Genetic fine structure analysis,Allelic complementation, Split genes, overlapping genes, Pseudogenes, Oncogenes,Gene families and clusters; Regulation of gene activity in prokaryotes andeukaryotes; Molecular mechanisms of mutation, repair and suppression; Bacterialplasmids, insertion (IS) and transposable (Tn) elements; Molecular chaperones andgene expression, RNAediting.

UNIT IV

Gene isolation, synthesis and cloning, genomic and cDNA libraries, PCR basedcloning, 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; Genesilencing; 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 Readings

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

Principles of Plant Breeding

Code: GPB-502 **Full Marks - 100**

Credit hours: 2L+1P

Credit-3

Objective

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

Theory

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

Unit II

Genetic basis of breeding: self and cross pollinated crops including mating systems and response to selection; Nature of variability, components of variation; Heritability and genetic advance, genotype environment interaction; General and specific combining ability; Types of gene actions and implications in plant breeding.

Unit III

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

Unit IV

Breeding methods in cross pollinated crops; Population breeding: mass selection and ear-to-row methods; S1 and S2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and inter-population improvement and development of synthetics and composites. Hybrid breeding: genetical and physiological basis

of heterosis and inbreeding, production of inbreeds, breeding approaches for improvement of inbreeds, predicting hybrid performance; seed production of hybrid and their parent varieties/ inbreeds. Self-incompatibility, male sterility and apomixes in crop plants and their commercial exploitation.

Unit V

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

Unit VI

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

Unit VII

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

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 Readings

1. Allard RW.1981. PrinciplesofPlantBreeding.JohnWiley&Sons.
2. ChahalGSandGossal,SS.2002.PrinciplesandProceduresofPlantBreedingBiotechnologicalandConventionalapproaches.NarosaPublishingHouse.
3. ChopraVL.2004.PlantBreeding.Oxford&IBH.
4. GeorgeA.2012.PrinciplesofPlantGeneticsandBreeding.JohnWiley&Sons.GuptaSK.2005.PracticalPlantBreeding.Agribios.
5. JainHKandKharakwalMC.2004.PlantBreedingand–MendeliantoMolecularApproach,NarosaPublications,NewDelhi
6. RoyD.2003.PlantBreeding,AnalysisandExploitationofVariation.NarosaPubl.House.SharmaJR.2001.PrinciplesandPracticeofPlantBreeding.TataMcGraw-Hill.
7. SharmaJP.2010.PrinciplesofVegetableBreeding.KalyaniPubl,NewDelhi.SimmondsNW.1990.PrinciplesofCropImprovement.EnglishLanguageBookSociety.SinghBD.2006.PlantBreeding.KalyaniPublishers,New Delhi.
8. SinghSandPawarIS.2006.GeneticBasesandMethodsofPlantBreeding.CBS.

Fundamentals of Quantitative Genetics

Code: GPB-503 **Full Marks - 100**

Credit hours: 2L+1P

Credit-3

Aim

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

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 analysisof 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- Metroglyph and D2, Generation mean analysis, Parent progeny regression analysis

Unit IV

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

Unit V

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

Practical

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

- Diallel analysis;
- G × E interaction and stability analysis.

Suggested Reading

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

Varietal Development and Maintenance Breeding

Code: GPB-504 **Full Marks - 100**

Credit hours: 2L+1P

Credit-3

Aim:

The purpose of this course is to make students well acquainted with the techniques and procedures of varietal development. He will be associated with development of variety so the course aims is to provide knowledge on DUS testing, protocols of various breeding techniques, procedures of release of variety, maintenance of the variety and production of nucleus and breeder seed of variety/ hybrids.

Theory

Unit I

Variety Development systemsand 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, pearlmillet, sorghum, maize and ragi, etc.); Pulses (greengram, blackgram, cowpea, pigeonpea, chickpea, fieldpea, lentil); Oilseeds (groundnut, soybean, sesame, castor, sunflower, safflower, linseed, rapeseed and mustard); fibres (cotton/ jute) and forages (guar, forage sorghum, teosinte, oats, berseem, lucerne).

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

1. Agarwal RL. 1997. Seed Technology. 2nd Ed. OXford& IBH. Kelly AF. 1988. Seed Production of AgriculturalCrops. Longman.
2. McDonald MB Jr and Copeland LO. 1997. Seed Production: Principles and Practices. Chapman & Hall.
3. 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

Principles of Cytogenetics

Code: GPB-505 **Full Marks - 100**

Credit hours: 2L+1P

Credit-3

Objective

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

Theory

Unit I

Cell cycle and architecture of chromosome in prokaryotes and eukaryotes;Chromonemata,chromosomematrix,chromomeres,centromere,secondaryconstriction and telomere; artificial chromosome construction and its uses; Special types of chromosomes. Variation in chromosome

structure: Evolutionary significance; Introduction to techniques for karyotyping; Chromosome banding and painting -In situ hybridization and various applications.

Unit II

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

Unit III

Fertilization barriers in crop plants at pre-and postfertilization levels; In-vitro techniques to overcome the fertilization barriers in crops; Polyploidy. Genetic consequences of polyploidization and role of polyploids in crop breeding; Evolutionary advantages of autopolyploid vs allopolyploids; Role of aneuploids in basic and applied aspects of crop breeding, their maintenance and utilization in gene mapping and gene blocks transfer; Alien addition and substitution lines, creation and utilization; ApomiXis, evolutionary and genetic problems in crops with apomiXes.

Unit IV

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

Unit V

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

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 Readings

1. Becker K & Hardin. 2004. *The World of Cell*. 5th Ed. Pearson Edu.
2. Carroll M. 1989. *Organelles*.The Guilford Press.
3. Charles B. 1993. *Discussions in Cytogenetics*.Prentice Hall.
4. Darlington CD & La Cour LF. 1969. *The Handling of Chromosomes*.Georger Allen &Unwin Ltd.
5. Elgin SCR. 1995. *Chromatin Structure and Gene Expression*.IRL Press.
6. Gray P. 1954. *The Mirotomist'sFormulatory Guide*. The Blakiston Co.

7. Gupta PK & Tsuchiya T. 1991. *Chromosome Engineering in Plants: Genetics, Breeding and Evolution*. Part A. Elsevier.
8. Gupta PK. 2000. *Cytogenetics*.Rastogi Publ.
9. Johannson DA. 1975. *Plant Microtechnique*. McGraw Hill.
10. Karp G. 1996. *Cell and Molecular Biology: Concepts and Experiments*.John Wiley &Sons.
11. Khush GS. 1973. *Cytogenetics of Aneuploids*. Academic Press.
12. Sharma AK & Sharma A. 1988. *Chromosome Techniques: Theory andPractice*. Butterworth.
13. Sumner AT. 1982. *Chromosome Banding*. Unwin Hyman Publ.Swanson CP. 1960. *Cytology and Cytogenetics*. Macmillan & Co.

Crop Breeding-II (*Rabi* Crops)

Code: GPB-512 **Full Marks - 100**

2L+1P

Credit-3

Objective

To provide insight into recent advances in improvement of Rabi cereals, legumes, oilseeds, fibre and vegetative propagated crops using conventional and modernbiotechnological approaches.

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 aliengene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, releasedvarieties, 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 aliengene(s) (if required), biotic and abiotic stress resistance, released varieties, examplesof MAS used for improvement.

Barley: Origin, evolution, center of origin, mode of reproduction, chromosomenumber; Genetics – cytogenetics and genome relationship; Breeding objectives:yield, quality characters, biotic and abiotic stress resistance, etc., breedingapproaches, introgression of alien gene(s) (if required), biotic and abiotic stressresistance, 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, qualitycharacters, 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 ofreproduction, 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 andabiotic stress resistance, heterosis breeding, released varieties, examples of MASused for improvement. Interspecific crosses attempted and its implications, reasonsfor failure, ways of overcoming them.

UNIT III

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

Sunflower, Safflower: Origin, mode of reproduction, chromosome number;Genetics, cytogenetics and genome relationship; Breeding objectives: yield, qualitycharacters, 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, qualitycharacters, 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, qualitycharacters, 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 aliengene(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 differentspecies;
- Trait based screening for stress resistance;
- Learning on the Standard Evaluation System (SES) and descriptors;
- Use of software for database management and retrieval

Suggested Readings

1. Agarwal RL. 1996. Identifying Characteristics of Crop Varieties. Oxford & IBH.
2. Bahl PN and Salimath PM. 1996. Genetics, Cytogenetics and Breeding of Crop Plants. Vol. I.Pulses and Oilseeds. Oxford & IBH.
3. Gupta SK. 2012. Technological Innovations in Major World Oil crops. Vol. I. Springer, USA.
4. Gupta SK. 2012. Technological Innovations in Major World Oil crops. Vol. II. Springer, USA.
5. Gupta SK. 2016. Breeding of Oilseed Crops for Sustainable Production. Academic Press, USA.

6. Kannaiyan S, Uthamasamy S, Theodore RK and Palaniswamy S. 2002. New Dimensions andApproaches for Sustainable Agriculture. Directorate of Extension Education, TNAU,Coimbatore.
7. Parthasarathy VA. 2017. Spices and Plantation Crops Vol.1 (Part A) Breeding of Breeding andGenetics. JohnWiley & Sons.

SECOND SEMESTER

Molecular Breeding and Bioinformatics

Code: GPB-506 **Full Marks - 100**

Credit hours: 2L+1P

Credit-3

Objective

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

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 quantitativetraits; 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 micropropagation unit;
- Transformation using Agrobacterium strains;
- GUS assay in transformed cells/ tissues;
- DNA isolation, DNA purity and quantification tests;
- Gel electrophoresis of proteins and isozymes, PCR-based DNA markers, gel scoring and data analysis for tagging and phylogenetic relationship;
- Construction of genetic linkage maps using computer software;
- NCBI Genomic Resources, GBFF, Swiss Prot, Blast n/ Blast p, Gene Prediction Tool, EXpasy Resources, PUBMED and PMC, OMIM and OMIA, ORF finder;
- Comparative Genomic Resources: - Map Viewer (UCSC Browser and Ensembl);
- Primer designing- Primer 3/ Primer BLAST

Suggested Readings

1. Azuaje F and Dopazo J. 2005. Data Analysis and Visualization in Genomics and Proteomics.
2. John Wiley and Sons.
3. Brown TA. 1991. Essential Molecular Biology: a practical Approach. OXford university press, 2002, 2nd edition
4. Chawala HS. 2000. Introduction to Plant Biotechnology. OXford& IBH Publishing Co. Pvt.
5. Ltd.
6. Chopra VL and Nasim A. 1990. Genetic Engineering and Biotechnology: Concepts, Methods and Applications. OXford& IBH.
7. Gupta PK. 1997. Elements of Biotechnology. Rastogi Publ.
8. Hackett PB, Fuchs JA and Messing JW. 1988. An Introduction to Recombinant DNA Technology
9. - Basic Experiments in Gene Manipulation. 2nd Ed. Benjamin Publ. Co.
10. Jollès P and Jörnvall H. 2000. Proteomics in Functional Genomics: Protein Structure Analysis.
11. Birkhäuser.
12. Lewin B. 2017. Genes XII. Jones & Bartlett learning, 2017.
13. Robert NT and Dennis JG. 2010. Plant Tissue Culture, Development, and Biotechnology. CRC Press.
14. Sambrook J and Russel D. 2001. Molecular Cloning - a Laboratory Manual. 3rd Ed. Cold Spring Harbor Lab. Press.
15. Singh BD. 2005. Biotechnology, Expanding Horizons. Kalyani Publishers, New Delhi. Watson J. 2006. Recombinant DNA. Cold Spring harbor laboratory press

Seed Production and Certification

Code: GPB-510 **Full Marks - 100**

Credit hours: 1L+1P

Credit-2

Objective

To impart knowledge on principles of seed production and certification. This willhelp the students to understand seed production practices and seed certificationprocedures in different crops.

Theory

UNIT I

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

UNIT II

Nucleus seed production and its maintenance - Maintenance of parental lines ofhybrids, Production of breeder, foundation and certified seed and their qualitymaintenance; Principles of seed production in self- and cross-pollinated crops; Hybridseed production - system and techniques involved in Seed village concept; Organicseed production and certification.

Unit III

Principles of seed production in field crops; Floral structure, pollination mechanismand seed productiontechniques in self- and cross-pollinated cereals and millets.

Unit IV

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

Unit V

Floral structure, pollination mechanism and methods and techniques of seedproduction in major commercial fibres. Hybrid-seed production techniques in majorvegetatively propagated crops.

Unit VI

Seed certification - history, concept, objectives;Central seed certification board Seedcertification agency/ organization and staff requirement; Legal status - Phases ofseed certification, formulation, revision and publication of seed certificationstandards; Minimum Seed Certification Standards (MSCS) for different crops - General and specific crop standards, Field and seed standards; Planning andmanagement 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 ofmale and female lines, synchronization of parental lines and methods to achievesynchrony;
- 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 seedreplacement rate;
- General procedure of seed certification, identification of weed and other crop seedsas per specific crops, field inspection at different stages of a crop and observationsrecorded on contaminants andreporting of results, inspection and sampling,harvesting/ threshing, processing and after processing forseed law enforcement;
- Specifications for tags and labels to be used for certification purpose.

Suggested Readings

1. Agrawal PK and Dadlani M. 1987. Techniques in Seed Science and Technology, South AsianPublishers, Delhi.
2. Agrawal RL. 1997. Seed Technology, Oxford & IBH Publishing.
3. Anon, 1965. Field Inspection Manual and Minimum Seed Certification Standards, NSCPublication, New Delhi.
4. Anon. 1999. Manual of Seed Certification procedures. Directorate of Seed Certification,Coimbatore, Tamil Nadu.
5. Joshi AK and Singh BD. 2004. Seed Science and Technology, Kalyani Publishers, New Delhi.
6. Kelly AF. 1988. Seed Production of Agricultural Crops. John Wiley, New York.
7. Mc Donald MB and Copeland LO. 1997. Seed Science and Technology, Scientific Publisher,Jodhpur.
8. Ramamoorthy K, Sivasubramaniam K and Kannan M. 2006. Seed Legislation in India. Agrobios(India), Jodhpur, Rajasthan.
9. Singhal NC. 2003. Hybrid Seed Production in Field Crops, Kalyani Publications, New Delhi
10. Tunwar NS and Singh SV. 1988. Indian Minimum Seed Certification Standards. Central SeedCertificationBoard, Ministry of Agriculture, New Delhi.

Crop Breeding-I (Kharif Crops)

Code: GPB-511 **Full Marks - 100**

Credit hours: 2L+1P

Credit-3

Objective

To provide insight into recent advances in improvement of kharif cereals, legumes,oilseeds, fibre, sugarcane and vegetative propagated crops using conventional andmodern biotechnological approaches.

Theory

UNIT I

Rice: 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 ofalien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Aerobic rice, itsimplications 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 ofalien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, Releasedvarieties, examples of MAS used for improvement- QPM and Bt maize –strategies and implications.

Small millets: Evolution and distribution of species and forms - wild relatives andgermplasm; Cytogenetics and genome relationship - breeding objectives yield, qualitycharacters, 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 ofalien 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 Nationaland 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 ofalien 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 ofreproduction, 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), releasedvarieties, examples of MAS used for improvement. Interspecific crosses attemptedand 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, qualitycharacters, 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 andgenome relationship; Breeding objectives: yield, qualitycharacters, biotic and abiotic stress resistance, etc.;Breeding approaches,introgression of alien gene(s) (if required), released varieties, examples of MASused for improvement; Hybrid breeding in castor – opportunities, constraints andachievements.

UNIT IV

Cotton: 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 ofalien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Development andmaintenance 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 ofalien 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 andgermplasm; 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 relativesand 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, qualitycharacters, 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;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 betweenblack 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 softwarefor database management and retrieval;
- Practical learning on the cultivation of fodder crop species on sewage water,analyzing them for yield components and palatability;
- Laboratory analysis of forage crops for crude protein, digestibility percent andother quality attributes;
- Visit to animal feed producing factories;
- Learning the practice of value addition; Visiting the animal husbandry unit andlearning the animal experiments related with palatability and digestibility of fodder.

Suggested Readings

1. Agarwal RL. 1996. Identifying Characteristics of Crop Varieties. Oxford & IBH.
2. Bahl PN and Salimath PM. 1996. Genetics, Cytogenetics and Breeding of Crop Plants. Vol. I.Pulses and Oilseeds. Oxford & IBH.
3. Chandraratna MF. 1964. Genetics and Breeding of Rice. Longmans.
4. Chopra VL and Prakash S. 2002. Evolution and Adaptation of Cereal Crops. Oxford & IBH.
5. Gill KS. 1991. Pearl Millet and its Improvement. ICAR.
6. IRRI. 1964. Rice Genetics and Cytogenetics. Elsevier.
7. IRRI. 1986. Rice Genetics. Proc. International Rice Genetics Symposium. IRRI, Los Banos,Manila, Philippines.
8. IRRI. 1991. Rice Genetics II. Proc. International Rice Genetics Symposium. IRRI, Los Banos,Manila, Philippines.
9. IRRI. 1996. Rice Genetics III. Proc. International Rice Genetics Symposium. IRRI, Los Banos,Manila, Philippines.

10. IRRI. 2000. Rice Genetics IV. Proc. International Rice Genetics Symposium. IRRI, Los Banos,Manila, Philippines.
11. Jennings PR, Coffman WR and Kauffman HE. 1979. Rice Improvement. IRRI, Los Banos, Manila,Philippines.
12. Kannaiyan S, Uthamasamy S, Theodore RK and Palaniswamy S. 2002. New Dimensions andApproaches for Sustainable Agriculture. Directorate of Extension Education, TNAU,Coimbatore.
13. Murty DS, Tabo R and Ajayi O. 1994. Sorghum Hybrid Seed Production and Management.ICRISAT, Patancheru, India.
14. Nanda JS. 1997. Manual on Rice Breeding. Kalyani Publishers.
15. Parthasarathy VA. 2017. Spices and Plantation Crops Vol.1 (Part A) Breeding of HorticulturalCrops Vol.1 (Part-B), Today and Tomorrow Printers and Publishers
16. Poehlman, JM. 1987. Breeding of Field Crops. AVI Publishing Co. Inc. East Post Connecticut,USA.
17. Ram HH and Singh HG. 1993. Crop Breeding and Genetics. Kalyani.
18. Sharma, AK. 2005. Breeding Technology of Crop Plant. Yesh Publishing House, Bikaner
19. Slafer GA. (Ed.). 1994. Genetic Improvement of Field Crops. Marcel Dekker.
20. Singh HG, Mishra SN, Singh TB, Ram HH and Singh DP. (Eds.). 1994. Crop Breeding in India.International Book Distributing Co.
21. Walden DB. 1978. Maize Breeding and Genetics. John Wiley & Sons.

Statistical methods for applied sciences

Code: STAT-502 **Full Marks - 100**

Credit hours: 3L+1P

Credit-4

Objective

This course is meant for students who do not have sufficient background of Statistical Methods. The students would be exposed to concepts of statistical methods andstatistical inference that would help them in understanding the importance ofstatistics. It would also help them in understanding the concepts involved in datapresentation, analysis and interpretation. The students would get an exposure topresentation of data, probability distributions, parameter estimation, tests ofsignificance, regression and multivariate analytical techniques.

Theory

UNIT I

Box-plot, Descriptive statistics, Exploratory data analysis, Theory of probability,Random variable and mathematical expectation.

UNIT II

Discrete and continuous probability distributions, Binomial, Poisson, NegativeBinomial, Normal distribution, Beta and Gamma distributions and their applications.Concept of sampling distribution: chi-square, t and F distributions. Tests ofsignificance based on Normal, chi-square, t and F distributions.

UNIT III

Introduction to theory of estimation and confidence-intervals, Simple and multiplecorrelation coefficient, partial correlation, rank correlation, Simple and multiplelinear regression model, test of significance of correlation coefficient and regressioncoefficients, Coefficient of determination, Fitting of quadratic models..

UNIT IV

Non-parametric tests – sign, Wilcoxon, Mann-Whitney U-test, Run test for therandomness of a sequence. Median test.

UNIT V

Introduction to ANOVA: One way and Two Way, Introduction to SamplingTechniques, Introduction to Multivariate Analysis, Transformation of Data.

Practical

- Exploratory data analysis, fitting of distributions ~ Binomial, Poisson, NegativeBinomial, Normal.
- Large sample tests, testing of hypothesis based on exact sampling distributions ~chisquare, t and F.
- Confidence interval estimation and Correlation and regression analysis, fitting ofLinear and Quadratic Model.
- Non-parametric tests. ANOVA: One way, Two Way, SRS.

Suggested Readings

1. Goon A.M, Gupta M.K and Dasgupta B. 1977. An Outline of Statistical Theory. Vol. I. TheWorld Press.
2. Goon A.M, Gupta M.K. and Dasgupta B. 1983. Fundamentals of Statistics. Vol. I. TheWorldPress.
3. Hoel P.G. 1971. Introduction to Mathematical Statistics. John Wiley.
4. Hogg R.V and Craig T.T. 1978. Introduction to Mathematical Statistics. Macmillan.
5. Morrison D.F. 1976. Multivariate Statistical Methods. McGraw Hill.
6. Hogg RV, McKean JW, Craig AT. 2012. Introduction to Mathematical Statistics 7th Edition.
7. Siegel S, Johan N &Casellan Jr. 1956. Non-parametric Tests for Behavior Sciences. JohnWiley.
8. Anderson TW. 2009. An Introduction to Multivariate Statistical Analysis, 3rd Ed. John Wiley

Techniques in Biochemistry

Code: BIOCHEM-505 **Full Marks - 100**

Credit hours: 2L+2P

Credit-4

Objective

To provide hands-on experience to different biochemical techniques commonly usedin research along with the knowledge on principles and the instrumentation.

Theory

Block 1: Separation Techniques: Principles and applications of separation techniques.

Unit 1: Chromatography techniques (4 Lectures)

Principles and applications of paper, thin layer, gel filtration, ion-exchange, affinity,column & HPTLC, GC, HPLC and FPLC.

Unit 2: Electrophoretic technique (2 Lectures)

General principles,paper and gel electrophoresis, native and SDS-PAGE, 2D-PAGE,capillary electrophoresis.

Unit 3: Hydrodynamic methods (2 Lectures)

Hydrodyanmic methods of separation of biomolecules such as viscosity andsedimentation velocity,- their principles.

Unit 4: Centrifugation (2 Lectures)

Basic principles of sedimentation, type, care and safety aspects of centrifugepreparative and analytical centrifugation.

Block 2:Spectroscopic Techniques

Unit 1: Spectrophotometry (3 Lectures)

Principles and applications of UV-visible, Fluorescence, IR and FTIR, Raman, NMRand FTNMR, ESR and X-Ray spectroscopy.

Unit 2: Mass spectroscopy (3 Lectures)

MS/MS, LC-MS, GC-MS, MALDI-TOF, applications of mass spectrometry inbiochemistry.

Unit 3: Atomic absorption spectrophotometry (2 Lectures)

Principle, function and instrumentation ofatomic absorption spectrophotometry.

Block 3. Microscopy

Unit 1: Microscopic techniques (2 Lectures)

Principles and applications, light, UV, phase contrast, fluorescence and electronmicroscopy, flow cytometry.

Block 4: Tracer, Imaging, Immunochemical and Other Techniques

Unit 1: Tracer technique (2 Lectures)

Tracer techniques in biology: concept of radioactivity, radioactivity counting methodswith principles of different types of counters, concept of á, â and ã emitters,scintillation counters, γ-rayspectrometers, autoradiography, applications ofradioactive tracers in biology.

Unit 2: Imaging techniques (2 Lectures)

Principles and applications of phosphor imager, MRI and CT scan.

Unit 3: Immunochemical technique (2 Lectures)

Production of antibodies, immunoprecipitation, immunoblotting, immunoassays,RIA and ELISA.

Unit 4: Other techniques (2 Lectures)

Cryopreservation, polymerase chain reaction (PCR), FACS.

Practicals

- Expression of concentration in terms of dilution, molarity, normality, percentexpression
- pH measurement and buffer preparation
- Determination of absorption maxima of biomolecules
- Estimation of biomolecules through spectrophotometry and other methods
- Separation of carbohydrates and amino acids by paper chromatography
- Separation and analysis of fatty acids/lipids by GC
- Separation/estimation of biomolecules through HPLC and FPLC
- Separation of proteins using ion exchange, gel filtration and affinity chromatography
- Electrophoretic separation of proteins and nucleic acids
- Centrifugation- differential and density gradient
- (NH4)2SO4 precipitation and dialysis
- Use of radioisotopes in metabolic studies
- PCR
- ELISA
- Western blotting/ Dot blotting

Suggested Reading

1. Boyer R. 2011. Biochemistry Laboratory: Modern Theory and Techniques 2nd Edition. Pearson

2. Hofmann A and Clokie S. 2010. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology. 7th edition. Cambridge University Press.
3. Sawhney SK and Singh R. 2000. Introductory Practical Biochemistry. 2nd Ed. Narosa
4. Katoch R. 2011. Analytical Techniques in Biochemistry and Molecular Biology. Springer
5. Boyer R. 2009. Modern Experimental Biochemistry. Fifth impression. Pearson
6. Lottspeich F and Engels JW. (Eds). 2018. Bioanalytics: Analytical Methods and Concepts in Biochemistry and Molecular Biology. Wiley-VCH
7. Wilson K and Walker J. 2010. Principles and Techniques of Biochemistry and Molecular Biology, 7th Edition. Cambridge University Press

Master's Seminar

Code: GPB-591 **Full Marks - 100**
Credit Hours: 0L+1P
Credit-1

The seminar paper will be evaluated only by the internal.

THIRD SEMESTER

Breeding for Stress Resistance and Climate Change

Code: GPB-516 **Full Marks - 100**
Credit Hours: 2L+1P
Credit-3

Objective

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

Theory

UNIT I

Concept and impact of climatic change; Importance of plant breeding with specialreference 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 inheritanceof resistance variation; Hostdefense responses to pathogen invasions- Biochemicaland molecular mechanisms; Acquired and induced immunity and systemic acquiredresistance (SAR); Host-pathogen interaction, gene-for-gene hypothesis, molecularevidence for its operation and exceptions; Concept of signal transduction and otherhost-defense mechanisms against viruses and bacteria.

UNIT III

Types and genetic mechanisms of resistance to biotic stresses –Horizontal andvertical resistance in crop plants; Quantitative resistance/ adult plant resistanceand slow rusting resistance; Classical and molecular breeding methods – Measuringplant resistance using plant fitness; Behavioural, physiological and insect gainstudies; Phenotypic screening methods for major pests and diseases; Recording ofobservations; Correlating theobservations using marker data – Gene pyramidingmethods and their implications.

Classification of abiotic stresses - Stress inducing factors, moisture stress/ droughtand 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 developingbreeding methodologies.

UNIT IV

Genetics of abiotic stress resistance; Genes and genomics in breeding cultivarssuitable to low water regimes and water logging and submergence, high and low/freezing temperatures; Utilizing MAS procedures for identifying resistant types inimportant crops like rice, sorghum, wheat, cotton, etc.; Breeding for resistance tostresses caused by toxicity, deficiency and pollutants/ contaminants in soil, waterand environment.

UNIT V

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

Practical

- Understanding the climatological parameters and predisposal of biotic and abioticstress 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 tobe observed at plant and insect level;
- Phenotypic screening techniques for nematodes and borers; Ways of combatingthem;
- 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 andbreeding strategies;
- Screening varieties of major crops for acidity and alkalinity- their effects andbreeding strategies;
- Screening forage crops for resistance to sewage water and tannery effluents; Qualityparameters evaluation..

Suggested Readings

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

12. van der Plank JE. 1982. Host-Pathogen Interactions in Plant Disease. Academic Press.

TECHNICAL WRITING AND COMMUNICATIONS SKILLS

Code: PGS-502 **Full Marks – 100**

Credit hours: 0L+1P

Credit-1

Aim:

To equip the students/ scholars with skills to write dissertations, research papers,etc. To equip the students/ scholars with skills to communicate and articulate inEnglish (verbal as well as writing).

Practical (Technical Writing):

- 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 Readings

1. Barnes and Noble. Robert C. (Ed.). 2005. Spoken English: Flourish Your Language.
2. Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.
3. Collins' Cobuild English Dictionary. 1995.
4. Harper Collins. Gordon HM and Walter JA. 1970. Technical Writing. 3rd Ed.
5. Holt, Rinehart and Winston. Hornby AS. 2000. Comp. Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford University Press.
6. James HS. 1994. Handbook for Technical Writing. NTC Business Books.
7. Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East-West Press.
8. Mohan K. 2005. Speaking English Effectively. MacMillan India.
9. Richard WS. 1969. Technical Writing.

10. Sethi J and Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India.
11. Wren PC and Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.

BASIC CONCEPTS OF LABORATORY TECHNIQUES

Code: PGS-504 **Full Marks – 100**

Credit hours: 0L+1P

Credit-1

Aim:

To acquaint the students about the basics of commonly used techniques in laboratory.

Practical:

- Safety measures while in Lab;
- Handling of chemical substances;
- Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel,condensers, micropipettes and vaccupets;
- 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;
- Neutralisation 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, sandbath, waterbath,oilbath;
- 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 Readings

1. Furr AK. 2000. CRC Hand Book of Laboratory Safety. CRC Press.
2. Gabb MH and Latchem WE. 1968. A Handbook of Laboratory Solutions. ChemicalPubl. Co.

Agricultural Research, Research Ethics and Rural Development Programmes

Code: PGS-505 **Full Marks – 100**

Credit hour: 1L+0P

Credit-1

Aim:

To enlighten the students about the organization and functioning of agriculturalresearch systems at national and international levels, research ethics, and rural development programmes and policies of Government

UNIT I

History of agriculture in brief; Global agricultural research system: need,scope, opportunities; Role in promoting food security, reducing poverty and protectingthe environment; National Agricultural Research Systems (NARS) and RegionalAgricultural Research Institutions; Consultative Group on International AgriculturalResearch (CGIAR): International Agricultural Research Centres (IARC), partnershipwith NARS, role as a partner in the global agricultural research system,strengthening capacities at national and regional levels; International fellowshipsfor scientific mobility.

UNIT II

Research ethics: research integrity, research safety in laboratories, welfareof animals used in research, computer ethics, standards and problems in researchethics.

UNIT III

Concept and connotations of rural development, rural development policiesand strategies. Rural development programmes: Community DevelopmentProgramme, Intensive Agricultural District Programme, Special group – AreaSpecific Programme, Integrated Rural Development Programme (IRDP) PanchayatiRaj Institutions, Co-operatives, Voluntary Agencies/ Non-GovernmentalOrganisations. Critical evaluation of rural development policies and programmes.Constraints in implementation of rural policies and programmes.

Suggested Readings

1. Bhalla GS and Singh G. 2001. Indian Agriculture - Four Decades of Development.Sage Publ.
2. Punia MS. Manual on International Research and Research Ethics. CCS HaryanaAgricultural University, Hisar.
3. Rao BSV. 2007. Rural Development Strategies and Role of Institutions - Issues,Innovations and Initiatives. Mittal Publ.
4. Singh K. 1998. Rural Development - Principles, Policies and Management. SagePubl

FOURTH SEMESTER

LIBRARY AND INFORMATION SERVICES

Code: PGS-501 **Full Marks – 100**

Credit hours: 0L+1P

Credit-1

AIM:

To equip the library users with skills to trace information from libraries efficiently,to apprise them of information and knowledge resources, to carry out literaturesurvey, to formulate information search strategies, and to use modern tools (Internet,OPAC, search engines, etc.) of information search.

Practical:

Introduction to library and its services; Role of libraries in education, research andtechnology transfer; Classification systems and organization of library; Sources ofinformation- Primary Sources, Secondary Sources and Tertiary Sources; Intricaciesof abstracting and indexing services (Science Citation Index, Biological Abstracts,Chemical Abstracts, CABI Abstracts, etc.); Tracing information from referencesources; Literature survey; Citation techniques/ Preparation of bibliography; Useof CD-ROM Databases, Online Public Access Catalogue and other computerized

library services; Use of Internet including search engines and its resources; e-resources accessmethods.

Intellectual Property and Its Management In Agriculture

Code: PGS-503 **Full Marks – 100**

Credit hour: 1L+0P

Credit-2

Aim:

The main objective of this course is to equip students and stakeholders withknowledge of Intellectual Property Rights (IPR) related protection systems, theirsignificance and use of IPR as atool for wealth and value creation in a knowledgebased economy.

Theory:

Historical perspectives and need for the introduction of Intellectual Property Rightregime; TRIPs and various provisions in TRIPS Agreement; Intellectual Propertyand Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislationsfor the protection of various types of Intellectual Properties; Fundamentals ofpatents, copyrights, geographical indications, designs and layout, trade secrets andtraditional knowledge, trademarks, protection of plant varieties and farmers' rightsand biodiversity protection; Protectable subject matters, protection in biotechnology,protection of other biological materials, ownership and period of protection; NationalBiodiversity protection initiatives; Convention on Biological Diversity; InternationalTreaty on Plant Genetic Resources for Food and Agriculture; Licensing oftechnologies, Material transfer agreements, Research collaboration Agreement,License Agreement.

Suggested Readings

1. Erbisch FH and Maredia K.1998. Intellectual Property Rights in AgriculturalBiotechnology. CABI.
2. Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy.McGraw-Hill.
3. Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC andAesthetic Technologies.

4. Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol.V. Technology Generation and IPR Issues. Academic Foundation.
5. Rothschild M and Scott N. (Ed.). 2003. Intellectual Property Rights in AnimalBreeding andGenetics. CABI.
6. Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other DevelopingCountries: A Compendium on Law and Policies. Daya Publ. House.
7. The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; TrademarksAct, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; The Biological Diversity Act, 2002.

Master's Research

Code: GPB-599 **Full Marks - 100**

Credit- 30

Objective

This course is meant for students who want to undertake research work in future and get training through this course. During their M.Sc. dissertation/project work students will be able to know the different aspects of a research work in nutshell. Besides experimental works, learners will learn how to write a M.Sc. thesis starting from introduction (including literature review), objectives of the work through material & methods, results, discussion, conclusion and lastly references.