Centurion
UNIVERSITY

PG Degree programmeSyllabus as per BSMA, ICAR
M.Sc.(Agri.) and Ph.D. (Agri.) in Genetics & Plant Breeding

M.S. Swaminathan School of Agriculture

Centurion University of Technology and Management

AlluriNagar,P.O. - R Sitapur, Via- Uppalada, Paralakhemundi, Dist: Gajapati – 761211, Odisha, India

2022

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Preamble

(Genetics and Plant Breeding)

Plant improvement has a long history for its growth and development. Plant breeding became established as a science in the twentieth century following the rediscovery of Mendel's laws of inheritance. Nearly 50% of global increase in food production is attributed to plant breeding. 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 specialised 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. and Ph. D. students of the discipline.

The meetings were focussed 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 programmes 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. Considerable efforts have, therefore gone in for the preparation of this document.

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, Breeding Vegetable Crops, Breeding Fruit Crops, Breeding Ornamental Crops for M.Sc. and IPR and Regulatory Mechanism (e-course) as well as Population Genetics for Ph.D. programme.

Content

Framework of the courses

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

	M.Sc. (Agri.)	Ph.D. (Agri.)
I. Major courses	20	12
Minor courses	08	06
Supporting courses	06	05
Common courses	05	-
Seminar	01	02
II.Thesis	30	75
	70	100

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

Couse Code	Course title	Credit hours	Page no.
Major Course			
MGPB 0501*	Principles of Genetics	3(2+1)	
MGPB0502*	Principles of Plant Breeding	3(2+1)	
MGPB 0503*	Fundamentals of Quantitative Genetics	3(2+1)	
MGPB0504	Varietal Development and Maintenance Breeding	2(1+1)	
MGPB0505	Principles of Cytogenetics	3(2+1)	
MGPB0506*	Molecular Breeding and Bioinformatics	3(2+1)	
MGPB0507	Breeding for Quality and Special Traits	3(2+1)	
MGPB0508	Mutagenesis and Mutation Breeding	3(2+1)	
MGPB0509	Hybrid Breeding	3(2+1)	
MGPB0510	Seed Production and Certification	2(1+1)	

MGPB0511	Crop Breeding-I (Kharif Crops)	3(2+1)	
MGPB0512	Crop Breeding-II (Rabi Crops)	3(2+1)	
MGPB0513	Breeding Vegetable Crops	3(2+1)	
MGPB0514	Breeding Fruit Crops	3(2+1)	
MGPB0515	Breeding Ornamental Crops	3(2+1)	
MGPB0516	Breeding for Stress Resistance and Climate Change	3(2+1)	
MGPB0517	Germplasm Characterization and Evaluation	2(1+1)	
MGPB0518	Genetic enhancement for PGR Utilization	2(1+1)	
MGPB0591	Master's Seminar	01	
MGPB0599	Master's research	30	
Minor Course			
MMBB 0501	Principles of Biotechnology	**3+0**	
MMBB 0504	Techniques in Molecular Biology-I	**0+3**	
MMBB 0509	Plant Tissue Culture	**2+1**	
MMBB 0517	Stress Biology and Genomics	**2+0**	
Supporting Course			
STAT 0501	Mathematics for Applied Sciences	2+0	
STAT 0502	Statistical Methods for Applied Sciences	3+1	
STAT0511	Experimental Designs	2+1	
Common course			
MALI1101	Library and information services	1+0	
MACS1101	Technical writing and communications Skills	1+0	
MAIP1201 (e-Course)	Intellectual property and its management in agriculture	1+0	
MALT1201	Basic concepts in laboratory techniques	1+0	
MAAR2101 (e-Course)	Agricultural research, research ethics and rural Development programmes	1+0	

Ph.D. (Agri.) in Genetics and Plant Breeding

Couse Code	**Course title**	**Credit hours**	**Page no.**
Major Course			

DGPB 0601*	Advances in Plant Breeding Systems	3(3+0)	
DGPB 0502	Advances in Biometrical Genetics	3(2+1)	
DGPB 0603	Molecular Cytogenetics for Crop Improvement	2(2+0)	
DGPB 004	Plant Genetics Resources, Conservation and Utilization	2(2+0)	
DGPB 0605*	Genomics in Plant Breeding	3(3+0)	
DGPB 0606	Population Genetics	2(2+0)	
DGPB 0607	Crop Evolution	3(3+0)	
DGPB 0608	Breeding Designer Crops	2(1+1)	
DGPB 0609*	IPR and Regulatory Mechanism (e-course)	1(1+0)	
DGPB 0691	Doctoral Seminar I	01	
DGPB 0692	Doctoral Seminar II	01	
DGPB 0699	Thesis/Research	75	
Minor Course			
MMBB0502	Fundamentals of Molecular Biology	**3+0**	
MMBB0503	Molecular Cell Biology	**3+0**	
MMBB0505	Omics and System Biology	**2+1**	
Supporting Course			
STAT0521	Applied regression Analysis	2+1	
STAT0522	Data analysis using statistical packages	2+1	

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)

Why this course?

Genes are the backbone of all crop improvement activities. Their chemical structure and physical inheritance are pivotal for any breeding program. Therefore, it has to be the core course for master's degree in Genetics and Plant Breeding.

Aim of the course

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

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.

- 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.

Teaching methods

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

Course outcome

After passing out this course the student will be able to know the

difference between the genotype and phenotype can carry study on inheritance and also know the role of DNA and RNA in genotypic manifestation of characters.

Suggested reading

Daniel LH and Maryellen R. 2011. *Genetics:* "*Analysis of Genes and Genomes*".

Gardner EJ and Snustad DP. 1991. *Principles of Genetics.* John Wiley and Sons. 8th ed. 2006 Klug WS and Cummings MR. 2003. *Concepts of Genetics*. Peterson Edu. Pearson Education India; Tenth edition

Lewin B. 2008. *Genes XII*. Jones and Bartlett Publ. (International Edition) Paperback, 2018 Russell PJ. 1998. *Genetics*. The Benzamin/ Cummings Publ. Co

Singh BD. 2009. *Genetics.* Kalyani Publishers (2nd Revised Edition)

Snustad DP and Simmons MJ. 2006. *Genetics*. 4th Ed. John Wiley and Sons. 6th Edition International Student Version edition

Stansfield WD.1991. *Genetics.*Schaum Outline Series Mc Graw Hill

Strickberger MW. 2005. *Genetics* (*III Ed*). Prentice Hall, New Delhi, India; 3rd ed., 2015 Tamarin RH. 1999. *Principles of Genetics*. Wm. C. Brown Publs., McGraw Hill Education; 7 edition

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

Course Title : Principles of Plant Breeding*

Course Code : GPB 502

Credit Hours : 3(2+1)

Why this course?

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

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

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; S_1 and S_2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and inter-population improvement and development of synthetics and composites. Hybrid breeding: genetically 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 varietyprotection 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.

Teaching methods

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

Course outcome

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

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)

Why this course?

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

Aim of the course

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 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- Metroglyph and D^2, 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 andphenotype.

Practical

Analysis and interpretation of variability parameters;
Analysis and interpretation of Index score and Metroglyph;
Clustering and interpretation of D^2 analysis;
Genotypic and phenotypic correlation analysis and interpretation;
Path coefficient analysis and interpretation, Estimation of different types ofheterosis, 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.

Teaching methods

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

Course outcome

After studying this course, the student will be equipped with the

knowledge of additive dominance and epistatic gene action. He will also be introduced with the various designs for analysis of genotypic and phenotypic variance and QTL mapping.

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*. Walterde 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)*

Why this course?

It is an indispensable course which apprises the students about various practicesand procedures in the development of a variety and steps to maintain the purityof varieties/ hybrids. Further, it provides basics of nucleus and breeder seed production techniques.

Aim of the course

The purpose of this course is to make students well acquainted with the techniquesand 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 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 regulationsin 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; Seedproduction 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.

Teaching methods

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

Course outcome

Pass out student will have complete knowledge on the various procedures linked with the development and release of variety. This course will also enable student how to maintain and multiply variety for large scale distribution. It will also make student acquainted with the seed laws and acts related to plant variety protection.

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)*

Why this course?

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

Aim of the course

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

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 -*Insitu* 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.

- 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.

Teaching methods

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

Course outcome

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

Suggested Reading

Becker K and Hardin J. 2004. *World of the Cell*. 5th Ed. Pearson

Edu. 9th edition. Carroll M. 1989. *Organelles*. The Guilford Press.

Charles B. 1993. *Discussions in Cytogenetics*. Prentice Hall Publications.

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

Course Title : *Molecular Breeding and Bioinformatics**

Course Code : **GPB 506**

Credit Hours : *3(2+1)*

Why this course?

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

Aim of the course

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 (F_2s, 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.

Teaching methods

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

Course outcome

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

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)*

Why this course?

Quality consciousness is growing in the society and only quality products are in demand in the market so has to be the new varieties. This course acquaints breeding for grain quality parameters in field crops. It will also teach about the genetic engineering protocols for quality improvement: Biofortification in crops and Nutritional genomics and Second generation transgenics.

Aim of the course

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

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.

Teaching methods

Power point presentation

Chalk and Board
Smart board
Lectures
Assignments, quiz
Group tasks, student's presentations

Course outcome

The knowledge of this course will expose the student to know about various Conventional and genetic engineering techniques for the improvement of quality characters in agricultural and horticultural field crops.

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. *SpecialityRices 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)

Why this course?

The knowledge of this course will enable the students to learn about mutation, various methods of inducing mutations and their utilization in plant breeding. It will also give in depth knowledge

about genomics, allele mining, TILLING, etc. andtheir utilization in crop improvement programmes.

Aim of the course

To impart the knowledge about general principles of mutagenesis for crop improvement and various tests/ methods for detection of mutations.

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; 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 mutag*ens.*

Unit IV: Observing mutagen effects in M_1 generation: plant injury, lethality, sterility, chimeras, etc.; Observing mutagen effects in M_2 generation; Estimation of mutagenic efficiency and effectiveness – spectrum of chlorophyll and viable mutations; Mutations in traits with continuous variation; Factors influencing the mutant spectrum: genotype, type of mutagen and dose, pleiotropy and linkage, etc.; Individual plant based mutation analysis and working out effectiveness and efficiency in M_3 generation; Comparative evaluation of physical and chemical mutagens for creation of variability in the 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 M_2 generations and selection procedures; Validation of mutants; Mutation breeding for various traits (disease resistance, insect resistance, quality improvement, etc.) in different crops; Procedures for micromutations breeding/ polygenic mutations; Achievements of mutation

breeding- varieties released across the world, problems associated with mutation breeding. 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 M_1 generation – Parameters;
Study of M_2 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 M_2 and M_3 generations.

Teaching methods

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

Course outcome

This course will make the student well versed with the process of mutation and its use in crop improvement. This course will also give in depth knowledge of mutations in genomics, allele mining and TILLING.

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 Energey Agency, Vienna, Italy.
Shu QY, Forster BP and Nakagawa N. 2012. *Plant Mutation Breeding and Biotechnology*.
Gutecnberg 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)

Why this course?

This course will expose the students with the basic concepts of hybrid varieties and various techniques for development of hybrids in crop plants. This will also give an overview of various kinds of male sterility and their utilization in hybrid seed production of important field crops.

Aim of the course

To provide knowledge of understanding about mechanisms of heterosis and itsexploitation.

Theory

Historical aspect of heterosis, nomenclature and definitions of heterosis; Heterosisin 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 F_2 and segregating populations, importance of inbreeding in exploitation of heterosis – case studies.; Relationship between genetic distance and expression of heterosis, case studies; Divergence and genetic distance analyses, morphological and molecular genetic distance in predicting heterosis; Development of heterotic pools in germplasm/ genetic stocks and inbreeds, 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 inbreeds 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 crops, asexually/ clonally propagated crops, problems and prospects; Apomixis in fixing heterosis-concept ofsingle 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 pigeonpea.*

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, theirpotential, problems and ways of overcoming it;
Hybrid breeding at National and International level,opportunities ahead.

Teaching methods

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

Course outcome

After completing this course, the student will be able to know about importance of heterosis, the various conventional and biotechnological approaches for the development of hybrids. This will also enable student to know about the use of male sterility in hybrid seed production of important field crops.

Suggested Reading

Agarwal RL. 1998. *Fundamental of Plant Breeding and hybrid Seed Production*. SciencePublisher London.
Akin E. 1979. *The Geometry of Population Genetics*. Springer-Verlag.
Ben HL. 1998. *Statistical Genomics – Linkage, Mapping and QTL Analysis*. CRC Press.
Chal 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)

Why this course?

Seed is the essence of life. Its improvement, production and maintenance is an essential feature of any variety. Seed chain concept is highly relevant in commercial promotion of new varieties whereas process of certification is mandatory for quality assurance of seed.

Aim of the course

To impart knowledge on principles of seed production and certification. This will help the students to understand seed production practices and seed certification procedures 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, 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 seedreplacement 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.

Teaching methods

- Power point presentation
- Chalk and Board

- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentation

Course outcome

After completing this course the student will be able to know about seed production of different crop varieties and hybrids, their processing, marketing and seed laws.

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)

Why this course?

Botanical features, reproductive systems, genetics involved and important breeding techniques are essential to undertake any crop improvement programme. This course is designed for important/ major

Kharif field crops.

Aim of the course

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

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 xam

- 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

palatability and digestibility of fodder.

Teaching methods

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

Course outcome

After completing this course, the student will be able to know about important botanical status and reproductive structures of crops and genetics of important kharif field crops.

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 : 3(2+1)

Why this course?

Botanical features, reproductive systems, genetics involved and important breeding techniques are essential to undertake any crop improvement programme. This course is designed for important/ major Rabi field crops.

Aim of the course

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

Teaching methods

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

Course outcome

After completion of this course the student will be able to know about the different breeding methods and genetics of major *Rabi* field crops.

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)

Why this course?

This course enables the students to learn about breeding objectives, methodologies and genetics involved for the improvement of major vegetable crops.

Aim of the course

To educate about principles and practices adopted for breeding of vegetable crops.

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 knolkhol. 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 breeding population, observations and analysis of various qualitative and quantitative traits in germplasm;
- Hybridization and handling segregating generations;
- Induction of flowering, palanological 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.

Teaching methods

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

Course outcome

After completion of this course the students will be able to know about the different

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.
Kalloo G. 1988. *Vegetable Breeding*. Vols. I-III. CRC Press.
Kalloo 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)

Why this course?

This course is aimed to educate the students about the breeding strategies andavenues in Fruit crops.

Aim of the course

To educate students about principles and practices adopted for breeding of fruitcrops.

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 andregion 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.

Teaching methods

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

Learning outcome

After completion of this course the students will be able do the breeding of fruit crops through various conventional and biotechnological methods besides mutation breeding.

Suggested Reading

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

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)*

Why this course?

The course will impart knowledge to student about breeding of Ornamental Cropsthrough conventional and biotechnological interventions.

Aim of the course

To educate about principles and practices adopted for breeding of ornamental crops.

Theory

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

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 F_1 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.

Teaching methods

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

Course outcome

After completion of this course the students will be able to do the breeding of ornamental crops by conventional breeding and biotechnological methods and to know the genetics of major ornamental crops.

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)

Why this course?

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

Aim of the course

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

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 andbreeding strategies;
- Screening forage crops for resistance to sewage water and tannery effluents; Qualityparameters evaluation.

Teaching methods

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

Course outcome

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

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)

Why this course ?

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

Aim of the course

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

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.

Teaching methods

a. Lectures
b. Power point presentations
c. assignments, quiz
d. Group tasks, student's presentations

Course outcome

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

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)

Why this course ?

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

Aim of the course

To teach theoretical and practical know how on CWRs reproductive behavior, acclimatization and adaptation for utilization in prebreeding programmes usig advanced tools.

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. Assessmentof 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.

Teaching methods

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

Course outcome

Students would be conversant with handling of unadapted germplasm, screening methods for special traits-biotic and abiotic resistance, nutritional traits, characterization of CWR, breeding, 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 No: MMBB0501
Credit Hour: 3+0
Course title: Principles of Biotechnology
Objectives:

- To understand the basics of Molecular biology, plant and microbial Biotechnology
- Importance and applications in agriculture, case studies and success stories
- Public education, perception, IPR and related issues

Course Outcome:

On completion of the courses students will be able • To explain genome organization in higher organisms. • To describe kinetic classes of DNA and Gene families. • To understand the steps involved in recombinant DNA technology. • To explain the construction of DNA & c DNA library and their applications.

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:

1.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
2.Brown, T. A. (2010) Gene Cloning and DNA analysis an Introduction 6th edition, Wiley Blackwell
3.Primrose, S. B. and Twyman, R. (2006) Principles of gene Manipulation 7th edition, Wiley Blackwell
4.Singh, B. D, Biotechnology: Expanding Horizons (2012) 4th edition, Kalyani publisher, New Delhi, India

Course No: MMBB0504
Credit Hour: 0+3
Course title: Techniques in Molecular Biology I
Objectives:

- To get a basic overview of molecular biology techniques, good lab practices and recombinant DNA technology.
- To get a hands on training in chromatography, protein analysis, nucleic acid analysis, bacterial and phage genetics.

Course Outcome:

On completion of the courses students will be able • To have knowledge on Biomolecules,their importance and Classification . • To explain the properties of Biomolecules • To describe the conversion of Biomolecules into Energy. • To describe the biophysical techniques for the Isolation, Identification and Quantification of Biomolecules. • To understand Biostatistical Analysis of the Biological Experiments

Topics for conduction wet lab exercises:

1. Good lab practices, preparation of buffers and reagents.
2. Principle of centrifugation and spectrophotometry.
3. Growth of bacterial culture and preparation of growth curve, Isolation of Genomic DNA from bacteria.
4. Isolation of plasmid DNA from bacteria.
5. Growth of lambda phage and isolation of phage DNA.
6. Isolation and restriction of plant DNA (e.g. Rice / Moong / Mango / Merigold).
7. Quantification of DNA by (a) Agarose Gel electrophoresis and (b) Spectrophotometry
8. PCR using isolated DNA.
9. PAGE Gel electrophoresis.
10. Restriction digestion of plasmid and phage DNA, ligation, Recombinant DNA construction.
11. Transformation of E. coli and selection of transformants
12. Chromatographic techniques

a. TLC

b. Gel Filtration Chromatography,
c. Ion exchange Chromatography,
d. Affinity Chromatography
13. Dot blot analysis, Southern hybridization, and Northern hybridization.
14. Western blotting and ELISA.
15. Radiation safety and non-radio isotopic procedure.

Suggested Readings

1. Sambrook, J., and Russell, R.W (2001) Molecular cloning: A laboratory manual 3rd Edition, Cold spring harbor laboratory press, cold spring harbor, New York.
2. Wilson, K., and Walker, J., (2018) Principles and Techniques of Biochemistry and Molecular Biology 8th edition, Cambridge University Press.
3. 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 No: MMBB0517
Credit Hour: 2+0
Course title: Stress Biology and Genomics
Objectives:

- To provide advanced knowledge on genomics with reference to abiotic stress tolerance and biotic stress resistance in plants tolerance.

Course Outcome

On completion of the courses students will be able • To understand principles of animal culture, media preparation . • To explain Invitro fertilization and embryo transfer technology. • To describe meristem culture and clonal propagation of plants on a commercial scale. • To get insight in applications or recombinant DNA technology in agriculture, production of therapeutic proteins.

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 Osmoprotectants - synthesis of proline, glycine betaine, poly amines and sugars; ROS and antioxidants; hormonal metabolism - ABA signaling; signaling 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 channeling. 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 ProteomicsPerspective, Volume 1, Springer.
HeribertHirt, (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 No: STAT 0502
Credit hours: 3+1
Course Title: STATISTICAL METHODS FOR APPLIED SCIENCES

Objective

This course is meant for students who do not have sufficient backgroundof Statistical Methods. The students would be exposed to concepts ofstatistical methods and statistical inference that would help them inunderstanding the importance of statistics. It would also help them inunderstanding the concepts involved in data presentation, analysis andinterpretation.

The students would get an exposure to presentation ofdata, probability distributions, parameter estimation, tests ofsignificance, regression and multivariate analytical techniques.

Course Outcome:

Upon successful completion of this course, students will be able to: • Organize, manage and present data. • Analyze statistical data graphically using frequency distributions and cummulative frequency distributions. • Analyze statistical data using measures of central tendency, dispersion and location. • Use the basic probability rules, including additive and multiplicative

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 distributionsand their applications. Concept of sampling distribution: chi-square, tand F distributions. Tests of significance based on Normal, chi-square, tand 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 ethods, confidence interval for sensitivity; Testing for heterogeneity.

UNIT IV: Non-parametric tests - sign, Wilcoxon, Mann-Whitney U-test, WaldWolfowitz run test, Run test for the randomness of a sequence. Mediantest, 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 ofhypothesis about the mean vector of a multinormal population.Classificatory problems and discriminant function, D2-statistic and itsapplications; 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 ofparameters of binomial, Poisson and Normal distribution; Correlationand regression analysis, fitting of orthogonal polynomial regression;applications of dimensionality reduction and discriminant functionanalysis; 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 Behavior Sciences.John Wiley.Learning Statistics: http://freestatistics.altervista.org/en/learning.php. Electronic

Statistics Text Book:

http://www.statsoft.com/textbook/stathome.html.

Course No:STAT 0511
Credit hours:2+1
Course Title: EXPERIMENTAL DESIGNS

Objective: This course is meant for students of agricultural and animal sciences other than Statistics. Designing an experiment is an integrated component of research in almost all sciences. The students would be exposed to concepts of Design of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental data

Course Outcome

Upon successful completion of this course, students will be able to: Translate real-world problems into probability models. • Derive the probability density function of transformation of random variables. • Calculate probabilities, and derive the marginal and conditional distributions of bivariate random variables.

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 ofvariance; Completely randomized design, randomized block design andLatin square design.

UNIT III: Factorial experiments, (symmetrical as well as asymmetrical)orthogonality and partitioning of degrees of freedom, Confounding insymmetrical factorial experiments, Factorial experiments with controltreatment.

UNIT IV: Split plot and strip plot designs; Analysis of covariance and missing plottechniques 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 doseresponse, parallel line and slope ratio assays potency estimation

.Practical

Uniformity trial data analysis, formation of plots and blocks, FairfieldSmith Law; Analysis of data obtained from CRD, RBD, LSD; Analysisof factorial experiments without and with confounding; Analysis withmissing 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

SUPPORTING COURSES

Course No: STAT 0502
Credit hours: 3+1
Course Title: STATISTICAL METHODS FOR APPLIED SCIENCES

Objective

This course is meant for students who do not have sufficient backgroundof Statistical Methods. The students would be exposed to concepts ofstatistical methods and statistical inference that would help them inunderstanding the importance of statistics. It would also help them inunderstanding the concepts involved in data presentation, analysis andinterpretation. The students would get an exposure to presentation ofdata, probability distributions, parameter estimation, tests ofsignificance, regression and multivariate analytical techniques.

Course Outcome

Upon successful completion of this course, students will be able to: • Use discrete and continuous probability distributions, including requirements, mean and variance, and making decisions. • Define binomial outcomes and compute probability of getting X successes in N trials. • Identify the characteristics of different discrete and continuous distributions. • Identify the type of statistical equation.

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 distributionsand their applications. Concept of sampling distribution: chi-square, tand F distributions. Tests of significance based on Normal, chi-square, tand 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 ethods, confidence interval for sensitivity; Testing for heterogeneity.

UNIT IV: Non-parametric tests - sign, Wilcoxon, Mann-Whitney U-test, WaldWolfowitz run test, Run test for the randomness of a sequence. Mediantest, 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 ofhypothesis about the mean vector of a multinormal population.Classificatory problems and discriminant function, D2-statistic and itsapplications; 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 ofparameters of binomial, Poisson and Normal distribution; Correlationand regression analysis, fitting of orthogonal polynomial regression;applications of dimensionality reduction and discriminant functionanalysis; Nonparametric tests.

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

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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 Behavior Sciences.John Wiley.Learning Statistics: http://freestatistics.altervista.org/en/learning.php. Electronic

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

Course No:STAT 0511
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Course Title: EXPERIMENTAL DESIGNS

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Course Outcome

Use Poisson, exponential distributions to solve statistical problems.. • Use the normal probability distribution including standard normal curve calculations of appropriate areas. • Use different distributions to solve simple practical problems. • Analyze Statistical data using MS-Excel.

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 ofvariance; Completely randomized design, randomized block design andLatin square design.

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UNIT V: Bioassays- direct and indirect, indirect assays based on quantal doseresponse, parallel line and slope ratio assays potency estimation

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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