Department of Agricultural Botany
Mahatma Phule Krishi Vidyapeeth, Rahuri
Tal. Rahuri 413 722, Dist. Ahmednagar (MS)

Doctoral Programme
in
Genetics and Plant Breeding

Course Layout

Minimum Credit Requirements

Sr. No.	Subject	Minimum credit(s)
1.	Major	15
2.	Minor	08
3.	Supporting	05
4.	Seminar	02
5.	Research	45
	Total Credits	**75**
	Compulsory Non Credit Courses	06

Sr. No.	Course Number	Course Title	Credits
A) Major subjects (Min. 15 credits)			
1.	GP-601	Plant Genetic Resources and Pre Breeding	2+0=2
2.	GP-602	Advanced Biometrical and Quantitative Genetics	2+1=3
3.	GP-603**	Genomics in Plant Breeding	2+1=3
4.	GP-604**	Molecular and Chromosomal Manipulations for Crop Breeding	2+0=2
5.	GP-605**	Advances in Plant Breeding Systems	2+0=2
6.	GP-608	Advances in Breeding of Major Field Crops	3+0=3
B) Minor Subjects (Min. 8 credits)			
1.	Bio-Chem-602	Advances in molecular biology	3+0=3
2.	BIOCHEM-603	Biochemistry of biotic and abiotic stress	3+0=3
3.	ENTO-608	Advance Host plant resistance	1+1=2
C) Supporting Subjects (Min. 05 credits)			
	STAT-604	Genetical Statistics	1+2=3
	SST-604	DUS Testing for Plant Variety Protection	2+1=3

D) Seminar (2 credits)			
1.	GP-691	Doctoral Seminar-I	0+1=1
2.	GP-692	Doctoral Seminar-II	0+1=1
E) Doctoral Research (45 credits)			
		Doctoral Research	0+45=45
F) Non Credit Compulsory Courses			
1.	PGS-501	Library and Information Services	0+1=1
2.	PGS-504	Basic concepts in Laboratory techniques	0+1=1
3.	PGS-502	Technical Writing and Communication Skill	0+1=1
4.	PGS-503	Intellectual Property and Its Management in Agriculture	1+0=1
5.	PGS-505	Agriculture Research Ethics and Rural Development Programmes	1+0=1
6.	PGS-506	Disaster Management	1+0=1

**** Compulsory course**

Note: Ph. D. students may be exempted from NCCC, if already completed during Master's degree ..

Course Contents

A) Major Subjects:

Syllabus of Theory and practical with suggested Readings/Books

Course No. : GP 601 PLANT GENETIC RESOURCES AND PRE-BREEDING

Credit :2+0 = 2

THEORY

Lecture No.	*Topic*
1	**Plant Genetic Resources:** History, component areas of activities on PGR, need for PGR conservation, Importance of plant genetic resources, Mandate of national bureau of PGR and objectives.
2	**Taxonomical classification of cultivated plants:** Taxonomic principles, sources difficulties in taxonomy of cultivated plants, taxonomic groups, classification.
3	**Gene pool:** Definition, concept, classification of gene pool - primary, secondary and tertiary.
4	**Centres of origin and global pattern of diversity**: 8 Centres of origin, global plant genetic resources activities, global pattern of diversity.
5	**Global plan of action** – four major areas i.e. in situ conservation and development, ex situ conservation, utilization of plant genetic resources, institutions and capacity building.
6	**Basic genetic resources and transgene:** Definition of transgenics, role of biotechnology- genetic engineering, transgenic resistance to pests, resistance to diseases, abiotic stress tolerance/resistance, research efforts in transgenic crops in India.

7	**Exploration:** Definition of germplasm exploration, Need for collection, Two kinds of explorations – single crop & multi crop exploration, Principles, Objectives, Strategies and practices of exploration : diversity includes – a) obsolete cultivars & genetic stocks b) land races & primitive cultivars c) genetically related wild & weedy species, Guidelines for explorer's daily routine, Merits & limitations of exploration.
10	Evaluation of diverse type of collections – those derived from centers of diversity, those derived from areas of cultivation, those derived from breeding programs, Cataloging of PGR, Germplasm multiplication & distribution, Germplasm utilization.
11	**Plant quarantine**: Definition of plant quarantine, Indian plant quarantine regulations, Principles & procedure, Phytosanitary certification.
12	**Germplasm introduction and exchange:** Definition, Principle, Primary & secondary introduction, Exchange in India, Procedure: steps – procurement, quarantine, cataloguing, evaluation, multiplication & distribution, Purpose, important achievements, Merits & demerits.
13	**In vitro and cryopreservation:** Definition, Principle, Technical approaches – maintenance of in vitro culture under normal growing condition, maintenance under growth limitation, reduced temperature incubation, use of growth regulators, use of minimal growth media & restrictive growth conditions.
14	Cryopreservation prospects – orthodox seeds, recalcitrant species seed, conservation of embryos & ovules, preservation of cell/suspension culture, freeze preservation of protoplast & callus culture, conservation of pollen, Storage using cryopreservation, Cryoprotectants, Cryopreservation techniques.
15	**Germplasm conservation**: Definition, Types, In situ – Definition, Priorities for in situ, Merits & demerits, Ex- situ – Definition, Ways – seed gene banks, plant or field gene banks, cell & organ gene banks, DNA gene banks,
16	On-farm – Basis of on-farm conservation, diversity management by farmers: 4 components – seed flows, variety selection, variety adaptation, seed selection & storage, Short, medium and long term conservations strategies for conservation of orthodox seed and vegetatively propagated crops.
17	**Registration of plant genetic resources**: Guidelines – nature of materials to be registered, crops to be covered, criteria for eligibility for registration, Registration committee, Nodal agency, Time schedule, Notification of registered material, Maintainance of registered material, Procedure for submission of application.
18, 19	PGR data base management: Definition, Two types of techniques – hierarchical & relational, Advantages, multivariate and clustering analysis, basic unit of information, Descriptors – scoring, coding and recording, global efforts – germplasm holding database, collecting database, other germplasm databases, Passport descriptors – accession descriptors, characterization descriptors, evaluation descriptors.
20	National and international protocols for PGR management – components of activities, PGR for food and agriculture (PGRFA) – goal & objectives, PGR access and benefit sharing.
21	Role of CGIAR system in the germplasm exchange – purpose, International Agricultural Research centrers under CGIAR, Seed Act, sui generis system.
22	**Intellectual property** – Definition, History, Protection of Intellectual property rights: main forms- trade secrets, patents, plant breeder's rights, copyrights, trade secret – Definition, Advantages.
23	Patents : Definition, Requirements – novelty, inventiveness, industrial application & usefulness, patentability, disclosure, Limits of a patent – limitation of time, limitation of space, Procedure of patenting, Copyrights.

24	PBR – Definition, history, Requirements for PBR, Breeder's exemption, Farmer's privilege, Farmer's Rights, The protection of plant varieties & Farmer's Right Act, Benefits from PBR, Disadvantages from PBR, Benefits & problems from IPR, Geographical indications.
25	**Journey from wild to domestication:** Definition of domestication, Selection under domestication – natural & artificial, Changes in plant species under domestication.
26	**Genetic enhancement:** Need for genetic enhancement, Uses of genetic enhancement, Genetic enhancement in pre Mendelian era and 21 st century; Genetic enhancement and plant breeding, reasons for failure in genetic enhancement, sources of genes/traits- novel genes for quality.
27	**Distant hybridization:** Definition, History, Inter-specific, Inter-generic hybridization, Scope and limitation, barriers to the production of distant hybrids, techniques to overcome the limitations.
28	**Gene transfer tools and techniques into cultivated species:** Methods- use of Ti or Ri plasmid of *Agrobacterium* species as vectors, Gemini virus vectors, direct DNA uptake by cell, polyethylene glycol- induced DNA uptake, electroporation, microinjection, particle gun, calcium phosphate precipitation & liposome mediated DNA transfer, Validation of transferred genes and their expression.
29	Post genomic tools for genetic enhancement of germplasm : Transfer germplasm from wild to cultivated species – methods : direct hybridization, chromosome manipulation, other techniques- in vitro technique, Application of biotechnology for genetic enhancement- achievements.
30	Utilization of genetic resources: Current status, Reasons for poor utilization of germplasm, Strategies for enhancing the exploitation of PGR in breeding programme.
31	**Core and mini-core collections**: Concept, selecting the core collection, size of core collections, uses of core collections : I) management of genetic resources-addition of new accessions, conservation, characterization, evaluation, germplasm distribution, II) utilization of genetic resources.
32	Genetic enhancement /Pre-breeding for crop improvement including hybrid development: Various steps proposed for the development of germplasm, First step- tropical, temperate, traditional farming systems, high input farming systems, marginal lands, Second step- classify germplasm in each area, Third step- field evaluation, Process of pre-breeding.

Reading:

Dhillon B.S., Tyagi R.K., Arjun Lal, Saxena S. 2004. Plant Genetic Management

Francel O.H. & Bennet E. 1970 Genetic Resources in plants-their exploration and conservation

Gautam P L , Dass B S Srivastava U & Duhoon S S 1998. Plant Gremplasm Collection : Principle and Procedures

Paroda R S & Arora R K 1991 Plant genetic resources, conservation and management. concept and approaches

Course No. :GP 602 -ADVANCED BIOMETRICAL AND QUANTITATIVE GENETICS.

Credit : 2+1 = 3

THEORY

Lecture No.	Topic and subtopics
	Unit I
1-2	Basic principles of Biometrical Genetics, selection of parents
3-4	Advanced biometrical models for combining ability analysis
5	Simultaneous selection models
6-8	Use of multiple regression analysis in selection of genotypes Designs and systems, selection of stable genotypes
	Unit II
9-11	Models in stability- pattern analysis, Additive main effect and Multiplicative interaction (AMMI) analysis and other related models
12	Principal Component Analysis
	Unit III
13-14	Additive and multiplicative model-Shifted multiplicative model, analysis and selection of genotypes
15	Methods and steps to select the best model
16	Biplots and mapping genotypes
	Unit IV
17-19	Genetic architecture of quantitative traits, conventional analyses to detect gene action-Partitioning of phenotypic / genotypic variance
20	Construction of saturated linkage maps
21	Concept of framework map development
22	QTL mapping- strategies for QTL mapping-desired populations, statistical methods
23	Marker Assisted Selection (MAS) Approaches to apply MAS I plant breeding Selection based on markers-simultaneous selection based on marker and phenotype Factor influencing MAS
24-25	Heritability of the trait, proportion of genetic variance, linkage disequilibrium between markers and traits and selection methods

Practical:

Practical No.	Topic and subtopics
1.	Working out the efficiency of selection methods in different populations and interpretation
2.	Biparental mating –use of softwares in analysis and result interpretation
3.	Triallel analysis- use of softwares in analysis and result interpretation
4.	Quadriallel analysis- use of softwares in analysis and result interpretation
5.	Triple test cross (TTC)- use of softwares in analysis and result interpretation
6.	Advanced biometrical models for combining ability analysis
7.	Selection of stable genotypes using stability analysis

8.	Models in stability analysis
9.	Additive main effect and Multiplicative interaction (AMMI)
10.	Principal Component Analysis model
11.	Additive and multiplicative model
12.	Shifted multiplicative model
13.	Analysis and selection of genotypes
14.	Methods and steps to select the best model
15.	Selection systems
16.	Biplots and mapping genotypes
17.	Construction of linkage maps and QTL mapping
18.	Strategies for QTL mapping
19.	Statistical methods in QTL mapping
20.	Phenotype and Marker linkage studies

Suggested Readings:

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

Falconer DS & Mackay J. 1996. Introduction to Quantitative Genetics.Longman.

Mather K & Jinks L. 1983. Introduction to Biometrical Genetics. Chapman& Hall.

Nadarajan N & Gunasekaran M. 2005. Quantitative Genetics and Biometrical Techniques in Plant Breeding. Kalyani.

Singh P & Narayanan SS. 1993. Biometrical Techniques in Plant Breeding.Kalyani.

Singh RK & Choudhary BD. 1987. Biometrical Methods in Quantitative Genetics. Kalyani.

Weir DS. 1990. Genetic Data Analysis. Methods for Discrete Population Genetic Data. Sinauer Associates.

Wricke G & Weber WE. 1986. Quantitative Genetics and Selection in Plant Breeding. Walter de Gruyter.

Course No. :GP 603 GENOMICS IN PLANT BREEDING. Credit : 2+1 = 3

THEORY:

Lecture No.	Topic
	UNIT I
1,2	Introduction to the plant genome- Plant nuclear genomes and their molecular description
3,4	The chloroplast and the mitochondrial genomes in plants - Genome size and complexity.
	UNIT II
5	Establishment of plant genome mapping projects -
6,7	Genome mapping and use of molecular markers in plant breeding
8	Strategies for mapping genes of agronomic traits in plants-
9,10	Approaches for mapping quantitative trait loci; Map based cloning of plant genes
	UNIT III
11	Regulation of Plant gene expression - Functional genomics

12	Expression Analysis using Microarrays
13,14	Transposon tagging and Insertional mutagenesis- methods and significance- Diversity Array Technology
	UNIT IV
15,16	Genome sequencing in plants–Principles and Techniques.
17	Applications of sequence information in plant genome analyses.
18, 19	Comparative genomics– Genome Comparison Techniques- Classical and advanced approaches.
	UNIT V
20, 21	Detection of Single Nucleotide Polymorphism; TILLING and Eco-TILLING.
22,23	Role of transcriptomics, proteomics and metabolomics in linking genome and phenomenon.
24	Importance of understanding the phenotypes for exploiting the outcome of genomic technologies-
25	Knock out mutant studies and high throughput phenotyping.
	UNIT VI
26	Concept of database development, management and bioinformatics.
27,28	Plant genome projects and application of bioinformatics tools in structural and functional genomics.

Practical:

Practical No.	Topic
1,2	Chromosome analysis in major field crops - Fluorescence in situ hybridization.
3	Comparative genomic hybridization – Comparative analysis of plant genomes using molecular markers.
4	Genetic map construction using molecular markers.
5	Mapping major genes using molecular markers.
6	QTL mapping in plants – Comparison across mapping populations
7	Understanding the need genetic algorithms in QTL mapping
8	Plant Genome Databases – Computational tools to explore plant genome databases
9, 10	Comparative genomics – Comparison of genome sequences using tools of bioinformatics
10, 11	Advanced genomic technologies: TILLING and Eco-TILLING
12	DNA Array Technology – Linking genome sequences to phenotypes.
13-14	Tools of transcriptomics, proteomics and metabolomics.

Suggested Readings:

Baxevanis AD & Ouellette BFF. 2001. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. Wiley Interscience.

Brown TA. 2002. Genomes. Wiley-LISS.

Caetano-Anolles G & Gresshoff PM. 1998. DNA Markers: Protocols, Applications and Overviews. Wiley-VCH.

Cantor CR & Smith CL (2004). Genomics. Wiley, New York.

Galas DJ & McCormack SJ. 2002. Genomic Technologies: Present and Future. Calster Academic Press.

Jordan BR. 2001. DNA Microarrays: Gene Expression Applications. Springer-Verlag.

Liu BH. 1997. Statistical Genomics: Linkage, Mapping and QTL Analysis. CRS Press.

Lynch M & Walsh B. 1998. Genetics and Analysis of Quantitative Traits. Sinauer Associates.
Mount DW. 2001. Bioinformatics. Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press..
Palzkill T. 2002. Proteomics. Kluwer.
Paterson AH. 1996. Genome Mapping in Plants. Academic Press.
Pennington SR & Dunn MJ. 2002. Proteomics: From Protein Sequence to Function. Viva Books.
Rampal JB. 2001. DNA Arrays: Methods and Protocols. Humana Press.

Course No. :GP 604 MOLECULAR AND CHROMOSOMAL MANIPULATION FOR CROP BREEDING. Credit : 2+0 = 2

THEORY:

Lecture No.	Topics
	UNIT I
1	Organization and structure of genome-prokaryotic- bacterial, viral genome & eukaryotic genome, genome size
2	Organization of organellar genome- mitochondria and chloroplast structure, inheritance and expression of organellar DNA
3	Nuclear DNA organization- variation in DNA content, C value paradox
4	Nuclear and cytoplasmic genome interactions and signal transduction
5	Transcriptional & translational changes
6	Sequence complexity- introns, exons, repetitive sequences & its role
	UNIT II
7	Karyotyping - symmetric & asymmetric, idiogram, bimodal karyotype, euchromatin & heterochromatin, chromosome banding & chromosome painting
8	Tracking introgressions using FISH, GISH
9	Localization and mapping of genes/genomic segments
10	Distant hybridization - barriers of interspecific and intergeneric hybridization, behaviour of interspecific and intergeneric crosses
11	Role of polyploids in crop evolution and breeding -autopolyploids
12	Role of polyploids in crop evolution and breeding- allopolyploids
	UNIT III
13	Application of cytogenetical methods for crop improvement - location and mapping of genes on chromosomes, deficiency method
14	Interchange- genetic consequences, identification of chromosomes involved and gene location
15	Balanced lethal systems, their maintenance and utility
16	Multiple interchanges - its use in production of inbreds, transfer of genes- linked marker methods
17	Duplication - production and use
18	Inversions - location of genes, B/A chromosome translocation and gene location

	UNIT IV
19	Trisomics - types, production, breeding behavior and location of genes,
	Use of balanced tertiary trisomics in hybrid seed production
20	Monosomics - method of production, breeding behavior and location of genes
21	Intervarietal substitutions - allelic and non-allelic interactions, telocentric method of mapping
	UNIT V
22	Totipotency of cells, morphogenesis- in vivo and in vitro Different pathways of in vitro morphogenesis, organogenesis and somatic embryogenesis,
23	Totipotency of cells, morphogenesis- in vivo and in vitro Different pathways of in vitro morphogenesis, organogenesis and somatic embryogenesis,
24	Meristem culture
25	Anther and pollen culture
26	Ovule, ovary culture, embryo and endosperm culture
27	Protoplast isolation and culture, protoplast fusion
28	In vitro mutant/somaclone selection for biotic and abiotic stresses

Suggested Readings :

Clark MS & Wall WJ. 1996. Chromosomes: The Complex Code. Chapman & Hall.
Conger BV. (Ed.). 1981. Cloning Agricultural Plants via in vitro Techniques. CRC Press.
Constabel F & Vasil IK. (Eds.). 1988. Cell Culture and Somatic Cell Genetics of Plants. Vol. V. Cell Culture and Phytochemicals in Plant Cell Cultures. Academic Press.
Lal R & Lal S. (Eds.). 1990. Crop Improvement Utilizing Biotechnology. CRC Press.
Mantel SH & Smith H. 1983. Plant Biotechnology. Cambridge University Press.
Sen SK & Giles KL. (Eds.). 1983. Plant Cell Culture in Crop Improvement. Plenum Press.

Course No. : GPB 605 ADVANCES IN PLANT BREEDING SYSTEMS

Credits: 2+0 = 2

THEORY:

Lecture No.	Topic and subtopics
	Unit I
1	Facts about plant breeding before the discovery of Mendelism
1	Evolutionary concepts of genetics and plant breeding- Flower development and its importance , genes governing the whorls formation and various models proposed
1	Mating systems and their exploitation in crop breeding
1	Types of pollination, mechanisms promoting cross pollination
	Unit II
2	Self-incompatibility – Types of self incompatibility, Homomorphic (sporophytic and gametophytic) and heteromorphic , breakdown of incompatibility Floral adaptive mechanism- Spatial and temporal,Genetic and biochemical basis of self incompatibility.
2	Sterility -male and female sterility, Types of male sterility- GMS, CGMS, CMS Exploitation in monocots and dicots, difficulties in exploiting CGMS in dicots-case studies and breeding strategies

1	Nucleocytoplasmic interactions with special reference to male sterility- Genetic, Biochemical and molecular bases.
	Unit III
1	Population formation by Hybridization- Types of populations-Mendelian population, gene pools, composites, synthetics etc.,
1	Principles and procedures in the formation of a complex population
1	Genetic basis of population improvement
	Unit IV
1	Selection in self fertilizing crops
1	Creation of genetic variability
2	Selection methods- Mass selection, pure line selection, pedigree method (selection in early generations vs advanced generations
	Unit V
1	Selection in cross fertilizing crops
1	Poly cross and top cross selections, Mass selection, methods and their modifications
2	Mass selection, grided mass selection, ear to row selection, modified ear to row selection, Convergent selection, divergent selection
2	Recurrent selection, simple recurrent selection and its modifications (restricted phenotypic election, selfed progeny selection and full sib recurrent selection
2	Recurrent selection for general combining ability (GCA)- Concepts and utilization- Recurrent selection for specific combining ability (SCA) usefulness in hybrid breeding programmes- Reciprocal recurrent selection(Half sib reciprocal recurrent selection, Half sib reciprocal recurrent selection with inbred tester and full sib reciprocal recurrent selection)
1	Selection in clonally propagated crops- Assumption and realities
	Unit VI
1	Genetic engineering to create male sterility; Prospects and Problems
1	Use of self-incompatibility and sterility in plant breeding- case studies
1	Fertility restoration in male sterile lines and restorer diversification programmes- conversion of agronomically ideal genotypes into male steriles- concepts and breeding strategies
1	Case studies – generating new cytonuclear interaction system for diversification of male steriles- stability of male sterile lines
1	Environmental influence on sterility- EGMS- Types of EGMS, Influence on their expression, genetic studies, Photo and thermo sensitive genetic male sterility and its use in heterosis breeding,Teperature sensitive genetic male sterility and its use in heterosis breeding
1	Apomixis and its use in heterosis breeding – Incongruity- Factors influencing incongruity- Methods to overcome incongruity mechanism.

Suggested Readings:

Agarwal RL. 1996. Fundamentals of Plant Breeding and Hybrid Seed Production. Oxford & IBH.

Allard RW. 1966. Principles of Plant Breeding. John Wiley & Sons.

Briggs FN & Knowles PF. 1967. Introduction to Plant Breeding. Reinhold.

Fehr WR. 1987. Principles of Cultivar Development: Theory and Technique. Vol I. Macmillan.

Hayes HK, Immer FR & Smith DC. 1955. Methods of Plant Breeding. McGraw-Hill.

Mandal AK, Ganguli PK & Banerji SP. 1995. Advances in Plant Breeding. Vol. I, II. CBS.

Richards AJ. 1986. Plant Breeding Systems. George Allen & Unwin.
Sharma JR. 1994. Principles and Practice of Plant Breeding. Tata McGraw-Hill.
Simmonds NW. 1979. Principles of Crop Improvement. Longman.
Singh BD. 1997. Plant Breeding: Principles and Methods. 5th Ed., Kalyani.
Singh P. 1996. Essentials of Plant Breeding. Kalyani.
Welsh JR. 1981. Fundamentals of Plant Genetic and Breeding. John Wiley.
Williams W. 1964. Genetical Principles and Plant Breeding. Blackwell.

Course No. : GPB 608- ADVANCES IN BREEDING MAJOR FIELD CROPS

Credit : 3+0 = 3

THEORY:

Lecture No.	Topic and subtopics
	Unit I
	History , description, classification, origin and phylogenetic relationship, genome status in cultivated and alien species of major cereals, millets and non cereal crops like
1	Rice
2	Wheat
3	Maize
4	Pearlmillet
5	Sorghum
6-7	Pulses
8-9	Oilseeds
10	Cotton
11	Sugarcane
12	Arid legumes
13	Other forage crops
	Unit II
	Breeding objectives , genetic resources and their utilization, genetics of quantitative and qualitative traits in crops like
14	Rice
15	Wheat
16	Maize
17	Pearlmillet
18	Sorghum
19-20	Pulses
21-22	Oilseeds
23	Cotton
24	Sugarcane
25	Arid legumes
26	Other forage crops
	Unit III
27-29	Breeding for value addition in different important crops
30-34	Breeding resistance to abiotic and biotic stresses in important major crops
	Unit IV

35-38	Conventional (line breeding, population improvement, hybrids) in major crops
39-42	Other approaches (DH populations, Marker Assisted Breeding , Development of new male sterility), trangenics in important crops
	Unit V
43-44	National and International accomplishments in genetic improvement of major field crops and their seed production.

Suggested Readings:

Chopra VL. 2001. Breeding Field Crops - Theory and Practice. Oxford & IBH.
Davis DD.1978. Hybrid Cotton Specific Problems and Potentials. Adv. Agron. 30: 129-157.
Heyne EG. 1987. Wheat and Wheat Improvement. 2nd Ed. ASA, CSSA, SSSA Inc Publ.
Khairwal, IS, Rai KN & Harinaryanan H. (Eds.). 1999. Pearl Millet Breeding. Oxford & IBH.
Khairwal I, Ram C & Chhabra AK. 1990. Pearl Millet Seed Production and Technology. Manohar Publ.
Nagarajan S, Singh G & Tyagi BS. 1998. Wheat Research Needs Beyond 2000 AD. Narosa.
Nanda JS. 2000. Rice Breeding and Genetics - Research Priorities and Challenges. Oxford & IBH.
Rao VS, Singh G & Misra SC. 2004. Wheat: Technologies for Warmer Areas. Annamaya Publ.
Reynolds MP, Rajaram S, McNab A. 1996. Increasing Yield Potential in Wheat: Breaking the Barriers. Proc. Workshop held in Ciudad, Obregon, Sonora, Mexico.
Seth BL, Sikka SM, Dastur RH, Maheshwari P, Rangaswamy NS & Josi
AB. 1960. Cotton in India – A Monograph. Vol. I. ICAR.
Singh BD. 2006. Plant Breeding - Principles and Methods. Kalyani.
Singh P & Singh S. 1998. Heterosis Breeding in Cotton. Kalyani.
Singh P. 1998. Cotton Breeding. Kalyani.
Singh S & Singh P. 2006. Trends in Wheat Breeding. Kalyani Publ.

B) Minor Subjects:

Course No. BIOCHEM 602- ADVANCED MOLECULAR BIOLOGY. Credits 3+0=3

THEORY

UNIT I

Organization of prokaryotic genome, nuclear and organelle genes, concept of genome mapping, molecular evolution, cell development and differentiation.

UNIT II

Prokaryotic and eukaryotic gene regulation, RNA editing, molecular biology of viruses.

UNIT III

Methods of gene isolation and transfer in plants and animals, molecular basis of male sterility, Application of genetic engineering in different fields.

UNIT IV

Site directed mutagenesis, gene targeting and gene therapy, bioethics and biosafety guidelines and IPR in recombinant DNA research.

Suggested Readings:

Alberts B, Bray D, Lewis J, Raff M, Roberts K & Watson JD. 2006. Molecular Biology of the Cell. 6th Ed. Garland Publ.
Lewin B. 2008. Gene IX. 9th Ed. Pearson Publ.
Selected articles from journals.

THEORY :

TEACHING SCHEDULE

No of Lecture	Name of the topics
3	Organization of prokaryotic genome
3	Nuclear and organelle genes- genes in chloroplasts and mitochondria in plants
2	Concept of genome mapping
4	Molecular evolution, cell development and differentiation
5	Prokaryotic and eukaryotic gene expression,
4	RNA editing, molecular biology of viruses
5	Methods of gene isolation and transfer in plants and animals
3	Molecular basis of male sterility
3	Application of genetic engineering in different fields.
4	Site directed mutagenesis
5	Gene targeting and gene therapy
4	Bioethics and biosafety guidelines
3	IPR in recombinant DNA research
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Course No: BIOCHEM 603- BIOCHEMISTRY OF BIOTIC AND ABIOTIC STRESSES
Credits: 3+0=3

THEORY

UNIT I

Plant-pathogen interaction and disease development; molecular mechanisms of fungal and bacterial infection in plants; changes in metabolism, cell wall composition and vascular transport in diseased plants.

UNIT II

Plant defence response, antimicrobial molecules; genes for resistance, hypersensitive response and cell death; systemic and acquired resistance.

UNIT III

Plant viruses, host-virus interactions, disease induction, virus movement, and host range determination; viroids, pathogen-derived resistance.

UNIT IV

Biochemical basis of abiotic stresses namely osmotic (drought, salinity), temperature, heavy metals, air and water pollutants, synthesis and functions of proline and glycine betaine in stress tolerance interaction between biotic and abiotic stresses; stress adaptation.

UNIT V

Reactive oxygen species and biotic and abiotic stress, antioxidants, enzymes defense system. Role of calcium, nitric oxide and salicylic acid in plant development. Molecular strategies for imparting tolerance against biotic and abiotic stress.

Suggested Readings:

Basra AS. 1997. Stress Induced Gene Expression in Plants. Harwood Academic Publ.
Chessin M, DeBorde D & Zipf A. 1995. Antiviral Proteins in Higher Plants. CRC Press.
Crute IR, Burdon JJ & Holub EB. (Eds.). 1997. Gene-for-Gene Relationship in Host-Parasite Interactions. CABI. 40

THEORY :

TEACHING SCHEDULE

No of Lectures	Name of the topics
2	Plant-pathogen interaction and disease development
6	Molecular, mechanisms of fungal and bacterial infection in plants changes in metabolism, cell wall composition and vascular transport in diseased plants
3	Plant defense response, antimicrobial molecules
2	Genes for resistance
2	Hypersensitive response and cell death
2	Systemic and acquired resistance
4	Plant viruses, host-virus interactions, disease induction, virus movement, and host range determination; viroids, pathogen-derived resistance
4	Biochemical basis of abiotic stresses namely drought and salinity
2	Biochemical basis of abiotic stresses namely temperature
2	Biochemical basis of abiotic stresses namely heavy metals
2	Biochemical basis of abiotic stresses namely air and water polluntants
5	Synthesis and functions of proline and glycine betaine in stress tolerance interaction between biotic and abiotic stresses; stress adaptation.
3	Reactive oxygen species and biotic and abiotic stress
4	Antioxidants in enzymes defense system
3	Role of calcium, nitric oxide and salicylic acid in plant development
2	Molecular strategies for imparting tolerance against biotic and abiotic stress
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ENT 608 ADVANCED HOST PLANT RESISTANCE 1+1

Theory

UNIT I

Importance of plant resistance, historical perspective, desirable morphological, anatomical and biochemical adaptations of resistance; assembly of plant species – gene pool; insect sources – behaviour in relation to host plant factors.

UNIT II

Physical and chemical environment conferring resistance in plants, role of trypsin inhibitors and protease inhibitors in plant resistance; biochemistry of induced resistance – signal transduction pathways, methyl jasmonate pathways, polyphenol oxidase pathways, salicylic acid pathways; effects of induced resistance; exogenous application of elicitors.

UNIT III

Biotechnological approaches in host plant resistance- genetic manipulation of secondary plant substances; incorporation of resistant gene in crop varieties; marker- aided selection in resistance breeding.

UNIT IV

Estimation of plant resistance based on plant damage- screening and damage rating; evaluation based on insect responses; techniques and determination of categories of plant resistance; breakdown of resistance in crop varieties.

Practical

Understanding mechanisms of resistance for orientation, feeding, oviposition etc., allelochemical bases of insect resistance; macroculturing of test insects like aphids, leaf/plant hoppers, mites and stored grain pests; field screening- microplot techniques, infester row technique, spreader row technique and plant nurseries; determination of antixenosis index, antibiosis index, tolerance index, plant resistance index.

Suggested Readings

Panda N. 1979. Principles of Host Plant Resistance to Insects. Allenheld, Osum & Co., New York.

Rosenthal GA & Janzen DH. (Eds.). 1979. Herbivores – their Interactionswith Secondary Plant Metabolites. Vol. I, II. Academic Press, New York.

Sadasivam S & Thayumanavan B. 2003. Molecular Host Plant Resistance to Pests. Marcel Dekker, New York.

Smith CM, Khan ZR & Pathak MD. 1994. Techniques for Evaluating Insect Resistance in Crop Plants. CRC Press, Boca Raton, Florida.

C) Supporting Courses:

Course No. : STAT-604 - GENETICAL STATISTICS. Credits: 1+2=3

Theory:

Unit I

Elements of probability, use of probability theory in genetical study; Detection of linkage and crossing over.

Unit II

Estimation of linkage from back cross F2 and F3 data, Components of variation and their estimation (M, D, H); Tests for linkage and epistasis.

Unit III

Scaling tests; Elements of path analysis; Heritability and different methods of estimation; Mating designs - Line x Tester analysis, Diallel crosses and their analysis.

Unit IV

Stability models, D^2 Analysis. (Mahalonobis)

Practical:

Detection of linkage; Estimation of linkage from back cross F2 and F3 data, Components of variation; Tests for linkage and epistasis correlation between relative randomly breeding population; Polygenic systems, scaling tests; Elements of path analysis; Heritability and different methods of estimation; Line x Tester analysis, Diallel crosses and their analysis; Concept of (GxE) interaction and its estimation; Stability models, D^2 Analysis.

Suggested Readings:

1. Prem Narain.1979. Statistical Genetics, , Wiely Eastern, New Delhi

2. Singh and Chowdhary. 1952. Biometrical Methods in Quantitative Genetic Analysis, Kalyani Publishers, New Delhi.

Course No. : SST 604- TESTING FOR PLANT VARIETY PROTECTION

Credit : 2+1 = 3

THEORY

Lect. No.	Name of topic
1-2	Genesis of plant variety protection and farmers right (PVP & FR) act 2001
3-4	International Union for Protection of New Varieties of Plants (UPOV) and its functions
5	General agreements on Tariff and Trades (GATT) agreement in relation to protection of plant varieties;
6-7	Protection of Plant Varieties and Farmers' Rights (PPV &FR) Act, 2001; PPV&FR rules, 2003.
8	Criteria for protection of new varieties of plants.
9-10	Principles and procedures of Distinctness, Uniformity and Stability (DUS) testing;
11-13	Test guidelines, planting material, duration, testing options, varieties of common knowledge, reference collection, grouping of varieties, types and categories of characters; technical questionnaire.
14-16	Assessment of DUS characters based on morphological, biochemical and molecular markers
17-19	statistical procedures; computer software for use in DUS testing;
20	impact of PVP on growth of seed industry
21-23	Procedure of DUS testing –seed material required conduct of test, methods and observation , grouping of varieties etc.
24-26	Procedure of DUS testing in Rice
27	Procedure of DUS testing in Sorghum
28	Procedure of DUS testing in pearl millet
29	Procedure of DUS testing in Rose
30	Procedure of DUS testing in Cauliflower

Practical

1	Study of morphological description of plant parts and plant	
2-4	Study of character expression and states, recording observation	
5-6	Study of interpretation of data	
7-8	Study of chemical tests and markers applicable for DUS tests	
9-11	Demonstration of conduct of DUS testing in sorghum	
12-13	Demonstration of conduct of DUS testing in pearl Millet	
14	Demonstration of conduct of DUS testing in Red gram	
15	Demonstration of conduct of DUS testing in Chick pea	
16	Demonstration of conduct of DUS testing in wheat	

Suggested Readings :

1. Chakrabarty SK, Prakash S, Sharma SP & Dadlani M. 2007. Testing Of Distinctiveness, Uniformity And Stability For Plant Variety Protection . IARI, New Delhi.
2. Joshi AK & Singh BD. 2004. Seed Science And Technology . Kalyani.
3. The Protection of Plant Varieties And Farmers' Rights Act 2001.
4. Bare Act With Short Notes 2006. Universal Law Publ.

D) **Seminar**

F) Doctoral Research

F) Compulsory Non Credit Courses

Course No. : PGS 501 -LIBRARY AND INFORMATION SERVICES
Credits : 0+1=1

PRACTICAL :

Exercise No.	Title of the exercise
1-2	Introduction to library and its services; types of library.
3	Role of libraries in education, research and technology transfer;
4	Classification systems and organization of library;
5-6	Sources of information- Primary sources, secondary sources and tertiary sources;
7-9	Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABs reference sources;
10	Literature survey;
11	Citation techniques/Preparation of bibliography;
12	Use of CD-ROM Databases,
13	Online Public Access Catalogue and other computerized library services;
14-15	Use of Internet including search engines and its resources;
16	e-resources access methods.

Course No. : PGS 502 - TECHNICAL WRITING AND COMMUNICATIONS SKILLS Credits : 0+1=1

PRACTICAL :

Exercise No.	Title of the exercise
1	Various forms of scientific writings- theses, technical papers, reviews, manuals, etc;
2	Various parts of thesis and research communications (title page, authorship, contents page, preface, introduction, review of literature, material and methods, experimental results and discussion);
3	Writing of abstracts, summaries, précis, citations etc.;
4	Commonly used abbreviations in the theses and research communications;
5	Illustrations, photographs and drawings with suitable captions;
6	Pagination, numbering of tables and illustrations;
7	Writing of numbers and dates in scientific write-ups;
8	Editing and proof-reading;
9	Writing of a review article.
10-11	Grammar (Tenses, parts of speech, clauses, punctuation marks);
12	Error analysis (Common errors);
13	Concord; Collocation; Phonetic symbols and transcription; Accentual pattern:
14	Weak forms in connected speech:
15	Participation in group discussion: Facing an interview;
16	Presentation of scientific papers.

Suggested Readings :

1. *Chicago Manual of Style*. 14th Ed. 1996. Prentice Hall of India.
2. *Collins' Cobuild English Dictionary*. 1995. Harper Collins.
3. Gordon HM & Walter JA. 1970. *Technical Writing*. 3rd Ed. Holt, Rinehart & Winston.
4. Hornby AS. 2000. *Comp. Oxford Advanced Learner's Dictionary of CurrentEnglish*. 6th Ed. Oxford University Press.
5. James HS. 1994. *Handbook for Technical Writing*. NTC Business Books.
6. Joseph G. 2000. *MLA Handbook for Writers of Research Papers*. 5th Ed. Affiliated East-West Press.
7. Mohan K. 2005. *Speaking English Effectively*. MacMillan India.
8. Richard WS. 1969. *Technical Writing*. Barnes & Noble.
9. Robert C. (Ed.). 2005. *Spoken English: Flourish Your Language*. Abhishek.
10. Sethi J & Dhamija PV. 2004. *Course in Phonetics and Spoken English*. 2nd Ed. Prentice Hall of India.
11. Wren PC & Martin H. 2006. *High School English Grammar and Composition*. S. Chand & Co.

Course No. : PGS 503 INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE Credits : 1+0=1

Theory Teaching schedule

Lecture No.	Topics to be covered
1-2	Historical perspectives and need for the introduction of Intellectual Property Right regime
3-4	TRIPs and various provisions in TRIPS Agreement
5	Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs
6	Indian Legislations for the protection of various types of Intellectual Properties
7-9	Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and bio-diversity protection
10-11	Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection
12	National biodiversity protection initiatives
13	Convention on biological diversity
14-15	International Treaty on Plant Genetic Resources for Food and Agriculture
16	Licensing of technologies, Material transfer agreements, Research Collaboration Agreement, License Agreement

Suggested Readings :

1. Erbisch FH & Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.
2. Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.
3. Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies. Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol. V.

4. Technology Generation and IPR Issues. Academic Foundation. Rothschild M & Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.
5. Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House.
6. The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; National Biological Diversity Act, 2003.

Course No. : PGS 504 -BASIC CONCEPTS IN LABORATORY TECHNIQUES
Credits : 0+1=1

PRACTICAL :

Exerc. No.	Title of the exercise
1	Safety measures while in Lab;
2	Handling of chemical substances;
3	Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets;
4	washing, drying and sterilization of glassware;
5	Drying of solvents/chemicals.
6	Weighing and preparation of solutions of different strengths and their dilution;
7	Handling techniques of solutions;
8	Preparation of different agro-chemical doses in field and pot applications;
9	Preparation of solutions of acids;
10	Neutralization of acid and bases;
11	Preparation of buffers of different strengths and pH values.
12	Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath;
13	Electric wiring and earthlings.
14	Preparation of media and methods of sterilization;
15	Seed viability testing, testing of pollen viability;
16	Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy

Suggested Readings :

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

Course No. : PGS 505 -AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES

Credits : 1+0=1

Theory Teaching schedule

Lecture No.	Topics to be covered
1	History of agriculture in brief;
2	Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment;
3	National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions;
4	Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS,
5	role as a partner in the global agricultural research system, strengthening capacities at national and regional levels;
6	International fellowships for scientific mobility.
7	Research ethics: research integrity, research safety in laboratories,
8	Welfare of animals used in research,
9	Computer ethics,
10	Standards and problems in research ethics.
11	Concept and connotations of rural development,
12-13	rural development policies and strategies.
14	Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP), Panchayati Raj Institutions, Co-operatives, and Voluntary Agencies/Non R Governmental Organizations.
15	Critical evaluation of rural development policies and programmes.
16	Constraints in implementation of rural policies and programmes.

Suggested Readings :

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

Course No. : PGS 506- DISASTER MANAGEMENT. Credits : 1+0=1

Theory Teaching schedule

Lecture No.	Topics to be covered
1-3	To introduce learners to the key concepts and practices of natural disaster management; to equip them to conduct thorough assessment of hazards and risks vulnerability; and capacity building.
4-5	Natural Disasters- Meaning and nature of natural disasters, their types and effects. Floods, Drought, Cyclone, Earthquakes, Landslides, Avalanches, Volcanic eruptions, Heat and cold waves
6-7	Climatic Change: Global warming, Sea level rise, Ozone depletion
8-10	Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire. Oil fire, air pollution, water pollution, deforestation, Industrial wastewater pollution, road accidents, rail accidents, air accidents, sea accidents
11-12	Disaster Management- Efforts to mitigate natural disasters at national and global levels.
13-14	International Strategy for Disaster reduction.
15-16	Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, Community-based organizations, and media. Central, State, District and local Administration; Armed forces in Disaster response; Disaster response: Police and other organizations.

Suggested Readings :

1. Gupta HK. 2003. Disaster Management. Indian National Science Academy. Orient Blackswan.
2. Hodgkinson PE & Stewart M. 1991. Coping with Catastrophe: A Handbook of Disaster Management. Routledge.
3. Sharma VK. 2001. Disaster Management. National Centre for Disaster Management, India.