Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj

PG Degree Programme Syllabus as per ICAR

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

Department of Genetics and Plant Breeding

Session: 2023-2024 onwards

- **Programme Structure**
- **Programme Outcomes (POs) Course Outcomes**
- **Detailed Syllabus (Course Contents)**

PROGRAM OUTCOMES:

PO1: Student will be skilled in various plant breeding techniques, such as conventional breeding, hybridization, genetic engineering, and marker-assisted selection. They will be able to implement these techniques to develop improved crop varieties.

PO2: Student will get proficient in using genomic tools and technologies, including DNA sequencing, genotyping, and bioinformatics, to study plant genomes and apply this knowledge to breeding programs.

PO3: Master for a thorough understanding of plant genetic principles, including gene structure, function, and inheritance patterns. They will be able to apply this knowledge to understand and manipulate plant genetic material.

PO4: Student will possess strong research skills, including designing and conducting experiments, analyzing and interpreting genetic and breeding data, and using statistical methods and software tools.

PO5: Student will be capable of applying genetic and breeding knowledge to address complex agricultural problems, innovate crop improvement strategies, and contribute to sustainable agriculture.

PO6: Student will understand the ethical issues and regulatory requirements related to genetic research and plant breeding, including genetic modification, biosafety, and intellectual property rights.

PO7: Student will also have experience in managing research projects, including planning, executing, and evaluating projects. They will be equipped with leadership skills necessary for coordinating and leading research teams and programs.

PO8: Student will be able to effectively communicate their research findings through written reports, scientific papers, and presentations. They will also be able to engage with stakeholders, including farmers, policymakers, and industry professionals.

PO9: Student will get able to work collaboratively with professionals from other disciplines, integrating knowledge from genetics, plant science, agronomy, and related fields to achieve common goals in research and development.

PO 10: Student will be prepared for careers in academia, industry, government, or research institutions. They will demonstrate the skills necessary for continuous professional development, including critical thinking, ethical practice, and lifelong learning.

Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj

Contents

Frame work of the courses

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

Courses	Credits
Major courses	20
Minor courses	08
Supporting courses	06
Common courses	05
Seminar	01
Thesis	30
Total	70

M.Sc. (Ag.) Genetics and Plant Breeding Semester wise

Semester-I

					EVALUATION (MM-100)		
					INTERNAL		EXTERNAL
Course Code	**Title of the Course**	**Type**	**Credits**	**T/P**	**CIE**	**PRACTICAL**	**ETE**
GPB 501	Principles of Genetics	Major	3(2+1)	**T/P**	30	20	50
GPB 502	Principles of Plant Breeding	Major	3(2+1)	**T/P**	30	20	50
GPB-508	Mutagenesis and Mutation Breeding	Major	3(2+1)	**T/P**	30	20	50
GPB-509	Hybrid Breeding						
SST-501	Seed Development Biology	Minor	2(1+1)	**T/P**	30	20	50
PGS-502	Library and Information Service	Common	1(0+1)	**P**	40 + 10*	50	00
PGS-501	Technical writing and communication skills	Common	1(0+1)	**P**	40 + 10*	50	00

1. Select any one from GPB 508 & 509.
2. Minor course is taken from allied programme.
3. *Assignment/PPT Presentation/GD

Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj

Semester-II

					EVALUATION (MM-100)		
					INTERNAL		EXTERNAL
Course Code	**Title of the Course**	**Type**	**Credits**	**T/P**	**CIE**	**PRACTICAL**	**ETE**
GPB-503	Fundamental of Quantitative Genetics	Major	3(2+1)	**T/P**	30	20	50
GPB-510	Seed Production and Certification	Major	2(1+1)	**T/P**	30	20	50
GPB 517	Germplasm Characterization and Evaluation						
PP-510	Seed Physiology	Minor	3(2+1)	**T/P**	30	20	50
STAT-511	Experimental Designs	Supporting	3(2+1)	**T/P**	30	20	50
STAT-502	Statistical Method for Applied Science						
PGS-503	Intellectual Property and its Management in Agriculture	Common	1(1+0)	**T**	40 + 10*	00	50
PGS-504	Basic concepts in Laboratory Techniques	Common	1(0+1)	**P**	40 + 10*	50	00

1. Select any one from GPB 510 & 517.
2. Select any one from STAT-502 & 511
3. Minor course is taken from allied programme.
4. *Assignment/PPT Presentation/GD

Semester-III

					EVALUATION (MM-100)		
					INTERNAL		EXTERNAL
Course Code	**Title of the Course**	**Type**	**Credits**	**T/P**	**CIE**	**PRACTICAL**	**ETE**
GPB-506	Molecular Breeding and Bioinformatics	Major	3(2+1)	**T/P**	30	20	50
GPB 505	Principles of Cytogenetics	Major	3(2+1)	**T/P**	30	20	50
GPB-507	Breeding for Quality and Special Traits						
PGS-505	Agriculture Research, Research Ethics and Rural Development	Common	1(1+0)	**T**	40 + 10*	00	50
SST-503	Seed Production Principles and Techniques in Field Crops	Minor	3(2+1)	**T/P**	30	20	50
MCA-501	Computer Fundamentals and Programming	Supporting	3(2+1)	**T/P**	30	20	50

Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj

Semester-IV

Course Code	Title of the Course	Type	Credits	Internal	External
GPB-591	Seminar	Compulsory	1(0+1)	100	-
GPB-599	Thesis	Compulsory	30(0+30)	-	100

Thesis Guidelines:

1st Semester- a Supervisor/Advisor and a Topic/title allotment for his/her thesis.
2nd & 3rd Sem.-Synopsis presentation, Research field allotment, experimentation data collection etc.
4th Sem.- Seminar, Data Analysis, Thesis writing, Pre-submission, and Thesis

Evaluation. Criteria for Thesis Evaluation

1. Synopsis: There will be a research advisory committee also called (SAC) student advisory committee, at institutions level
2. Synopsis presentation will be conducted in presence of SAC members sixty percent of members will form the quorum SAC members.
3. The research advisor of Student shall be convenor of this committee. This committee will have following responsibilities:

i) To review the research title and finalize the topic of research.
ii) To guide the student to build up the study design and research methodology of research
iii) To periodically review and guide in the progress of research work of the students

4. There will be pre- submission presentation by the student before SAC at institution level
5. After incorporation of suggestion final thesis will be submitted to the university for evaluation
6. Pannal of external & internal examiner will be appointed by the university.
7. The place of final presentation viva voice examination will be decided by the university.

Note:

- Total credits to be earned by a student for completion of the PG program: 40+30 (Thesis) =70

Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj

*** Detailed Syllabus: Semester-I**

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-I**	**Semester-I**
Subject: Principles of Genetics		
Course Code: GPB-501	**Course Title:** Principles of Genetics	
Credits: 3(2+1)	**Major Course**	**Theory**

Course outcomes

CO1: Students will acquire comprehensive understanding of the chemical basis of heredity.

CO2: The knowledge required to design, execute, and analyze the results of genetic experim entation in Plant Breeding systems

CO3: Critical understanding on quantification of heritable traits that provides in sight into ce llular and molecular mechanisms.

CO4: The ability to evaluate conclusions that are based on genetic data.

CO5: Thorough understanding of the basic principles of DNA structure, replication, transcription and translation. CO6: An understanding of basic chromosome structure, and the significance of chromosomal change in evolution and illness.

CO7: Development of the ability to carry out genetic analyses on data sets comprised of codominant genetic markers such as allozymes, microsatellites and SNPs, in order to quantify variation, gene flow and evolutionary divergence

CO8: The ability to carry out complex genetic tests on genetic data for the purposes of forensic study

Unit	Course Content
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.
II	Mendelian population, Random mating population, Frequencies of genes and genotypes, Causes of change: Hardy-Weinberg equilibrium.
III	Nature, structure and replication of the genetic material; Organization of DNA in chromosomes, Genetic code; Protein biosynthesis, Genetic fine structure analysis, Allelic complementation, Split genes, overlapping genes, Pseudogenes, Oncogenes, Gene families and clusters; Regulation of gene activity in prokaryotes and eukaryotes; Molecular mechanisms of mutation, repair and suppression; Bacterial plasmids, insertion (IS) and transposable (Tn) elements; Molecular chaperones and gene expression, RNA editing.

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

Programme: M. Sc. Ag. Genetics and Plant Breeding **Year-I** **Semester-I**

Subject: Principles of Genetics

Course Code: GPB-501 **Course Title:** Principles of Genetics

Credits: 3(2+1) **Major Course** **Practical**

Unit **Course Content**

I • Laboratory exercises in probability and chi-square;

II • Demonstration of genetic principles using laboratory organisms;

III • Chromosome mapping using three-point test cross;

IV • Tetrad analysis; Induction and detection of mutations through genetic tests;

V • DNA extraction and PCR amplification;

VI • Electrophoresis: basic principles and running of amplified DNA; **VII** • Extraction of proteins and isozymes;

Reference Books:

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.
Kalyani Publishers (2nd Revised Edition) Snustad
DP and Simmons MJ. 2006.

Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj

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 Suggested equivalent online courses:
https://elearning.icar.gov.in/
www.iasri.icar.gov.in www.hau.ac.in/OPstat

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-I**	**Semester-I**
Subject: Principles of Plant Breeding		
Course Code: GPB-502	**Course Title:** Principles of Plant Breeding	
Credits: 3 (2+1)	**Major Course**	**Theory**

Course outcomes

CO1: Students will be well versed in practical emasculation and pollination methods of impo rtant crops.

CO2: To understand the various components to structure a plant breeding programme.

CO3: Know the requirements in breeding for biotic and abiotic stress tolerant varieties.

CO4: Learn the impact of IPRs including PBR, PVP and PPVFRA

CO5: Students will acquire independent ability to carry out statistical analysis of data and Int erpretation of results in breeding programs.

Unit	Course Content
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.
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.
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.

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: genetical and physiological basis of heterosis and inbreeding, production of inbreeds, breeding approaches for improvement of inbreeds, predicting hybrid performance; seed production of hybrid and their parent varieties/ inbreeds. Self-incompatibility, male sterility and apomixes in crop plants and their commercial exploitation.
V	Breeding methods in asexually/ clonally propagated crops, clonal selection.
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.
VII	Cultivar development: testing, release and notification, maintenance breeding, Participatory Plant Breeding, Plant breeders' rights and regulations for plant variety protection and farmers rights.

Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-I**	**Semester-I**
Subject: Principles of Plant Breeding		
Course Code: GPB-502	**Course Title:** Principles of Plant Breeding	
Credits: 3(2+1)	**Major Course**	**Practical**

Unit	Course Content
I	Floral biology in self and cross pollinated species;
II	Selfing and crossing techniques;
III	Selection methods in segregating populations and evaluation of breeding material;
IV	Analysis of variance (ANOVA);
V	Estimation of heritability and genetic advance; • Maintenance of experimental records;
VI	Learning techniques in hybrid seed production using male-sterility in field crops;
VII	Prediction of performance of double cross hybrid.

Reference Books:

Allard RW. 1981.
Principles of Plant Breeding. John Wiley & Sons
Gardner EJ and Snustad DP. 1991.
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.
Russell PJ. 1998.
Genetics. The Benzamin/ Cummings Publ. Co
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.
Singh BD. 2006
Plant Breeding. Kalyani Publishers, New Delhi.

Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-I**	**Semester-I**
Subject: Mutagenesis and Mutation Breeding		
Course Code: GPB-508	**Course Title:** Mutagenesis and Mutation Breeding	
Credits: 3(2+1)	**Major Course**	**Theory**

Course outcomes

CO1: Understand the basic concepts of the ultrastructure of cell, cell organelles, chromosomes and nucleic acids

CO2: Apply the principles of inheritance to plant breeding

CO3: Acquaint with the fundamentals of chromosomal and cytoplasmic inheritance, sex determination, mutations and chromosomal aberrations CO4: Learn molecular genetics.

CO5: Understand the role of mutation breeding in crop improvement.

CO6: Develop hand-on skill in applying mutagenesis techniques in the lab or field.

CO7: Learn various techniques for inducing mutation, including chemical mutagens, radiation.

CO8: Gain experience in designing experiments involving mutagenesis and mutation breeding.

Unit	Course Content
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. Paramutations in crops plants.
II	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.
III	Chemical mutagens: Classification – base analogues, antibiotics, alkylating agents, acridine dyes and other mutagens: their properties and mode of action; Dose determination and factors influencing chemical mutagenesis; Treatment methods using physical and chemical mutagens, Combination treatments; other causes of mutation – direct and indirect action, comparative evaluation of physical and chemical mutagens.

Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj

IV	Observing mutagen effects in M1 generation: plant injury, lethality, sterility, chimeras, etc.; Observing mutagen effects in M2 generation; Estimation of mutagenic efficiency and effectiveness – spectrum of chlorophyll and viable mutations; Mutations in traits with continuous variation; Factors influencing the mutant spectrum: genotype, type of mutagen and dose, pleiotropy and linkage, etc.; Individual plant based mutation analysis and working out effectiveness and efficiency in M3 generation; Comparative evaluation of physical and chemical mutagens for creation of variability in the some species- Case studies
V	Use of mutagens in creating oligogenic and polygenic variations – Case studies; In-vitro mutagenesis – Callus and pollen irradiation; Handling of segregating M2 generations and selection procedures; Validation of mutants; Mutation breeding for
	various traits (disease resistance, insect resistance, quality improvement, etc.) in different crops; Procedures for 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.

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-I**	**Semester-I**
Subject: Mutagenesis and Mutation Breeding		
Course Code: GPB-508	**Course Title:** Mutagenesis and Mutation Breeding	
Credits: 3(2+1)	**Major Course**	**Practical**

Unit	**Course Content**
I	Precautions on handling of mutagens; Dosimetry-Studies of different mutagenic agents:Physical mutagens and Chemical mutagens;
II	Learning on Radioactivity- Production source and isotopes at BRIT, Trombay, Learning about gamma chamber;
III	Radiation hazards: Monitoring – safety regulations and safe transportation of radioisotopes, visit to radio isotope laboratory; learning on safe disposal of radioisotopes;
IV	Hazards due to chemical mutagens – Treating the plant propagules at different doses of physical and chemical mutagens.
V	Procedures in combined mutagenic treatments
VI	Raising the crop for observation; Mutagenic effectiveness and efficiency, calculating the same from earlier literature
VII	Mutation breeding in cereals and pulses-achievements made and an analysis; • Mutation breeding in oilseeds and cotton- achievements and opportunities; • Mutation breeding in forage crops and vegetatively propagated crops; • Procedure for detection of mutations for polygenic traits in M2 and M3 generations.

Reference Books:

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

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-I**	**Semester-I**
Subject: Hybrid Breeding		
Course Code: GPB-509	**Course Title:** Hybrid Breeding	
Credits: 3(2+1)	**Major Course**	**Theory**

Course outcomes

CO1: Learning about the main commercialized hybrid crop varieties.

CO2: Have an insight into the main crop varieties that are commercialized as hybrids

CO3: Understand the scientific developments supplying new elements to create hybrids

CO4: The legal restrictions regarding access to germplasm, biosafety and intellectual property rights the theory with visits to practical breeding activities

CO5: The present a case study to an audience of international students and local plant breeders.

Unit	Course Content
I	Historical aspect of heterosis, nomenclature and definitions of heterosis; Heterosis in natural population and inbred population; Evolutionary aspects – Genetic consequences of selfing, sibbing and crossing in self-and cross-pollinated and asexually propagated crops; Pre-Mendelian and Post-Mendelian ideas – Evolutionary concepts of heterosis; Genetic theories of heterosis – Physiological, Biochemical and molecular factors underlining heterosis; theories and their estimation; Biometrical basis of heterosis.

Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj

II	Prediction of heterosis from various crosses, inbreeding depression, coefficient of inbreeding and its estimation, residual heterosis in F2 and segregating populations, importance of inbreeding in 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
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.
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 of single line hybrid; Organellar heterosis and complementation.
V	Hybrid breeding in wheat, rice, cotton, maize, pearl millet, sorghum and rapeseed mustard, sunflower, safflower and castor oilseed crops and pigeonpea.
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.
VII	Cultivar development: testing, release and notification, maintenance breeding, Participatory Plant Breeding, Plant breeders' rights and regulations for plant variety protection and farmers rights.

Programme: M. Sc. Ag. Genetics and Plant Breeding **Year-I** **Semester-I**

Subject: Hybrid Breeding

Course Code: GPB-509 **Course Title:** Hybrid Breeding

Credits: 3(2+1) **Major Course** **Practical**

Unit	Course Content
I	Characterization of male sterile lines using morphological descriptors;
II	Restorer line identification and diversification of male sterile sources
III	Selection methods in segregating populations and evaluation of breeding material;
IV	Male sterile line creation in crop plants, problems in creation of CGMS system, ways of overcoming them
V	Diversification and restoration; Success stories of hybrid breeding in Maize, Rice, Pearl millet, Sorghum and Pigeon pea;
VI	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;

VII	Hybrid seed production in field crops—an account on the released hybrids, their potential, problems and ways of overcoming it; Hybrid breeding at National and International level, opportunities ahead **Reference**

Books:

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

Akin E. 1979. The Geometry of Population Genetics. Springer-Verlag. Ben HL. 1998. Statistical Genomics – Linkage, Mapping and QTL Analysis. CRC Press.

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.

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-I**	**Semester-I**
Subject: Seed Development Biology		
Course Code: SST-501	**Course Title:** Seed Development Biology	
Credits: 2(1+1)	**Minor Course**	**Theory**

Course outcomes

CO1. Memories importance of seed and its botany

CO2. To get skill for differentiate the botanical development of monocot and dicot seeds

CO 3. Summarise seed development and maturation of various crop plants

CO 4. Examine pollination behavior and reproduction process in flowering plants

CO 5. To understand and explain accumulation pattern of food reserves in seeds

CO 6. Able to understand and evaluate the application of apomixes, polyembryony

Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj

Unit	Course Content
I	Floral biology – types of pollination, mechanisms; sporogenesis – micro and mega sporogenesis; gametogenesis – development of male and female gametes and their structures; pollination and fertilization – mode of pollination, double fertilization, factors affecting pollination, fertilization; self-incompatibility and male sterility.
II	Embryogenesis – development of monocot and dicot embryos – embryo plane formation – development of endosperm, cotyledons and seed coat – hard seed; apomixis – identification, classification, significance and its utilization; polyembryony – types and significance; haplontic and diplontic sterility system, causes of embryo abortion, embryo rescue technique; somatic embryogenesis.
III	Seed development – source of assimilates – mechanism of translocation; chemical composition – synthesis and deposition of storage reserves – starch, protein, fat and secondary metabolites – hormonal regulation
IV	Maturation drying – orthodox and recalcitrant seeds – desiccation tolerance – mechanism – structural changes during desiccation – role of LEA protein.
V	Seed maturity indices – physiological and harvestable maturity; biotic and abiotic factors influencing seed development – development of hard seeds

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-I**	**Semester-I**
Subject: Seed Development Biology		
Course Code: SST- 501	**Course Title:** Seed Development Biology	
Credits: 2(1+1)	**Minor Course**	**Practical**

Unit	Course Content
I	Study on floral biology of monocot dicot plants.
II	Study on pollen morphology of different crops.
III	Pollen germination and viability test in major crops.
IV	Seed embryo and endosperm development in monocots and dicots.

V	Anatomy and morphology of seed coat during development. Seed development and maturation in agricultural crops – physical and physiological changes Seed development and maturation in horticultural crops – physical and physiological changes Study on physiological and harvestable maturity and maturity indices in different crops; Study on acquisition of seed dormancy and germination at different stages of maturity; Preparation of seed album and identification of seeds

Reference Books:

- Adkins SW, Ashmore SE and Navi SC. 2007. Seeds: Biology, Development and Ecology. CAB International, Oxfordshire, UK.
- Bewley JD and Black M. 1994. Seeds: Physiology of Development and Germination. Springer, New York.
- Bewley JD, Bradford KJ, Hilhorst HWM and Nanogaki H. 2013. Seeds: Physiology of Development, Germination and Dormancy. Springer, New York.
- Black M, Bewley JD and Halmer P. 2006. The Encyclopedia of Seeds: Science, Technology and Uses. CAB International publications, UK.
- Chhabra AK. 2006. Practical Manual of Floral Biology of Crop Plants. Department of Plant Breeding, CCSHAU, Hisar.
- Copeland, LO and McDonald MB. 2001. Principles of Seed Science and Technology. 4th Ed. Kluwer Academic publishers, USA.
- Frankel R and Galun E. 1977. Pollination Mechanisms, Reproduction and Plant Breeding. Springer Verlag, New York.
- Hesse MH, Haidemarie R, Zettler M, Webber R, Buchner AR, Radivo and Ulrich S. 2009. Pollen Terminology. An illustrated hand book. Springer Verlag, New York.
- Kozlowski. TT. 2012. Seed Biology: Importance, Development and Germination. (Vol. I). Academic Press Inc., New York.
- Maiti RK, Sarkar NC and Singh VP. 2006. Principles of Post Harvest Seed Physiology and Technology. Agrobios, Jodhpur, Rajasthan

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-I**	**Semester-I**
Subject: Technical Writing and Communications Skills		
Course Code: PGS-501	**Course Title: Technical Writing and Communications Skills**	
Credits: 1(0+1)	**Common Course**	**Practical**

Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj

Course Outcomes: After completion of the course, Student will be able to:

Co1. Acquired the skills and knowledge necessary to excel in various forms of scientific writing. They will be proficient in crafting theses, technical papers, reviews, manuals, and other types of scientific documents. Students will have a deep understanding of the specific conventions, formats, and styles associated with each type of scientific writing. They will also be equipped with the ability to effectively communicate
complex scientific concepts, research findings, and technical information to diverse audiences.

This proficiency in scientific writing will enable students to contribute to academic and professional discourse, disseminate their research, and excel in their scientific careers."
Co2. Thesis and Research Communication will be able to compose various components of a thesis, including the title page, authorship details, table of contents, preface, introduction, literature review, methodology section, presentation of experimental results, and discussion. They will have the competence to structure and organize these components effectively, ensuring a coherent and logical flow of information in their research documents.
Co3. Writing Skills will be proficient in writing abstracts, summaries, précis, and citations with precision and clarity. They will demonstrate the ability to summarize complex research findings concisely and accurately for different audiences and purposes.
Co4. Abbreviations Usage will be familiar with commonly used abbreviations in theses and research communications, using them appropriately and consistently throughout their documents.
Co5. Visual Communication will possess the skills to incorporate illustrations, photographs, and drawings into their documents, accompanied by suitable captions for clear explanation. They will be proficient in pagination and numbering of tables and illustrations for easy reference and comprehension.
Co6. Numerical Representation will be able to present numbers and dates in scientific write-ups following established conventions and guidelines, ensuring consistency and accuracy.
Co7. Editing and Proofreading: Students will excel in the critical tasks of editing and proofreading, ensuring the correctness, coherence, and readability of their scientific documents.
Co8. Review Article Writing will have the ability to synthesize existing research effectively and write comprehensive review articles that critically analyze and summarize scientific literature. **Co9.** Communication Skills: Students will demonstrate proficiency in grammar, including tenses, parts of speech, clauses, and the appropriate use of punctuation marks. They will be skilled in error analysis, identifying and rectifying common writing errors, and achieving concord and collocation in their writing. Students will become familiar with phonetic symbols and transcription, enhancing their pronunciation and phonetic transcription abilities.
Co10. Accentual Patterns and Weak Forms will master accentual patterns and recognize weak forms in connected speech, improving their listening and spoken communication skills.

Unit	Course Content
I	Various forms of scientific writings- theses, technical papers, reviews, manuals, etc.
II	Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results, and discussion).
III	Writing of abstracts, summaries, précis, citations, etc.
IV	Commonly used abbreviations in the theses and research communications.

V	Illustrations, photographs, and drawings with suitable captions; pagination, numbering of tables and illustrations.
VI	Writing of numbers and dates in scientific write-ups.
VII	Editing and proof-reading.
VIII	Writing of a review article.

IX	Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks);
X	Error analysis (Common errors), Concord, Collocation, Phonetic symbols, and transcription;
XI	Accentual pattern: Weak forms in connected speech.
XII	Participation in group discussion.
XIII	Facing an interview.
XIV	Presentation of scientific papers.

Reference Books:

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

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-I**	**Semester-I**
Subject: Library and Information Services		
Course Code: PGS-502	**Course Title: Library and Information Services**	
Credits: 1(0+1)	**Common Course**	**Practical**

Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj

Course Outcomes: After completion of the course, Student will be able to:

Co1. Introduction to Library and Services will help to be familiar with the fundamental functions and services offered by libraries, including lending services, reference assistance, and access to physical and digital collections.

Co2. Role of Libraries in Education and Research will help to understand the vital role that libraries play in supporting education, research, and the transfer of technology and knowledge within academic and professional contexts.

Co3. Classification Systems and Organization will help to be proficient in library classification systems and the organization of library materials, enabling them to locate resources efficiently.

Co4. Sources of Information will help to distinguish between primary sources, secondary sources, and tertiary sources, and recognize their importance in academic and research contexts.

Co5. Abstracting and Indexing Services will help to navigate abstracting and indexing services such as Science Citation Index, Biological Abstracts, Chemical Abstracts, and CABI Abstracts, gaining expertise in

accessing and using these databases for research purposes.
Co6. Reference Source Retrieval will help to be skilled in retrieving information from various reference sources, including dictionaries, encyclopedias, handbooks, and other specialized references.
Co7. Literature Survey will help to be capable of conducting literature surveys to identify relevant research and gather information from existing scholarly works.
Co8. Citation Techniques and Bibliography Preparation, they will understand and apply citation techniques, ensuring the proper attribution of sources in their research work. They will also learn to prepare bibliographies in recognized citation styles.
Co9. Use of Digital Resources, Students will proficiently use CD-ROM databases, online public access catalogues, and other computerized library services for searching, retrieving, and managing digital resources.
Co10. Internet and E-resources, Students will have the skills to effectively use the internet, including search engines, online databases, and electronic resources, for research, reference, and information retrieval. **Co11.** Accessing E-resources, Students will learn various methods for accessing electronic resources and databases available through libraries, enhancing their ability to access academic journals, e-books, and research materials online. Upon completing this course, students will have a strong foundation in library and information science, equipping them with valuable skills for conducting research, accessing information, and utilizing library services effectively in their academic and professional pursuits.

Unit	Course Content
I	Introduction to library and its services.
II	Role of libraries in education, research, and technology transfer.
III	Classification systems and organization of library.
IV	Sources of information- Primary Sources, Secondary Sources and Tertiary Sources;
V	Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.);
VI	racing information from reference sources; Literature survey;
VII	Citation techniques/ Preparation of bibliography.
VIII	Use of CD-ROM Databases,
IX	Online Public Access Catalogue and other computerized library services;
X	Use of Internet including search engines and its resources; E-resources access methods.

SECOND SEMESTER

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-I**	**Semester-II**
Subject: Fundamental of Quantitative Genetics		
Course Code: GPB-503	**Course Title:** Fundamental of Quantitative Genetics	
Credits: 3(2+1)	**Major Course**	**Theory**

Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj

Course Outcomes:

CO1: Analyze and evaluate literature involving quantitative genetic experiments.

CO2: Design and analyze quantitative genetic experiments

CO3: Statistically analyze the phenotypic data of plant traits collected taking into account G X E interaction.

CO4: Manage breeding populations to maximize progress from selection for accomplishme nt of breeding objectives.

CO5: Continuous variation analysis: mean, range, SD, CV; phenotypic and genotypic components of variance.

Unit	Course Content
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.
II	Designs for plant breeding experiments- principles and applications; Variability parameters, concept of selection, simultaneous selection modes and selection of parents, ANOVA.
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
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.
V	QTL mapping, Strategies for QTL mapping- Desired population and statistical methods, QTL mapping in genetic analysis; Markers, Marker assisted selection and factors influencing the MAS, Simultaneous selection based on marker and phenotype.

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-I**	**Semester-II**
Subject: Fundamental of Quantitative Genetics		
Course Code: GPB-503	**Course Title:** Fundamental of Quantitative Genetics	
Credits: 3(2+1)	**Major Course**	**Practical**

Unit	Course Content
I	Analysis and interpretation of variability parameters, Analysis and interpretation of Index score and Metroglyph
II	Clustering and interpretation of D^2 analysis
III	Selection methods in segregating populations and evaluation of breeding material; **IV** Genotypic and phenotypic correlation analysis and interpretation.

V	Path coefficient analysis and interpretation, Estimation of different types of heterosis, inbreeding depression and interpretation.
VI	A, B and C Scaling test, L × T analysis and interpretation, QTL analysis **VII** G × E interaction and stability analysis.

Reference Books:

Falconer DS and Mackay J. 1998. Introduction to Quantitative Genetics (3rd Ed.).ELBS/ Longman, London.

Mather K and Jinks JL.1985. Biometrical Genetics (3rd Ed.). Chapman and Hall, London. Nandarajan N and Gunasekaran M. 2008. Quantitative Genetics and Biometrical Techniques in Plant Breeding. Kalyani Publishers, New Delhi.

Naryanan SS and Singh P. 2007. Biometrical Techniques in Plant Breeding. Kalyani Publishers, New Delhi.

Roy D. 2000. Plant Breeding: Analysis and Exploitation of Variation. Narosa Publishing House, New Delhi.

Sharma JR. 2006. Statistical and Biometrical Techniques in Plant Breeding. New Age International Pvt. Ltd.

Singh P and Narayanan SS. 1993. Biometrical Techniques in Plant Breeding. Kalyani Publishers, New Delhi.

Singh RK and Chaudhary BD. 1987. Biometrical Methods in Quantitative Genetic analysis. Kalyani Publishers, New Delhi.

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

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

Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj

Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj

Programme: M. Sc. Ag. Genetics and Plant Breeding	Year-I	Semester-II
Subject: Seed Production and Certification		
Course Code: GPB-510	**Course Title:** Seed Production and Certification	
Credits: 1(1+1)	**Major Course**	**Theory**

Course outcomes

CO1: To really understand the basic principles of seed production in varieties and hybrids

CO2: To know the concept of and methods of hybrid seed production

CO3:To understand the importance of field standards and seed standards in quality seed production

CO4: To understand legal procedures related to seed quality control CO5:

To really understand the procedure for seed certification.

CO6: To grasp the importance of Indian minimum seed certification standards.

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

Programme: M. Sc. Ag. Genetics and Plant Breeding	Year-I	Semester-II

Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj

Subject: Seed Production and Certification		
Course Code: GPB-510	**Course Title:** Seed Production and Certification	
Credits: 1(1+1)	**Major Course**	**Practical**

Unit	Course Content
I	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;
II	Pollen collection and storage methods, pollen viability and stigma receptivity Pre-harvest sanitation, maturity symptoms, harvesting techniques;
III	Planning for seed production: cost benefit ratio, seed multiplication ratio and seed replacement rate;
IV	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;
V	Specifications for tags and labels to be used for certification purpose.
VI	Visits to seed production plots - visit to seed industries;

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-I**	**Semester-II**
Subject: Germplasm Characterization and Evaluation		
Course Code: GPB-517	**Course Title:** Germplasm Characterization and Evaluation	
Credits: 2(1+1)	**Major Course**	**Theory**

Course Outcome

CO1: Students will have knowledge on the conservation of biodiversity

CO2: They will be able to identify the various in situ and ex situ conservation techniques

CO3: They will acquire knowledge on various organizations involved in conservation and their policies

CO4: The students will have knowledge on plant quarantine regulations.

CO5: Procedures for creating core and mini core collections, how to validate them, and webbased data administration tools.

Unit	Course Content

Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj

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.
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.
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

Programme: M. Sc. Ag. Genetics and Plant Breeding Year-I Semester-II

Subject: Germplasm Characterization and Evaluation

Course Code: GPB- 517	**Course Title:** Germplasm Characterization and Evaluation	
Credits: 2(1+1)	**Major Course**	**Practical**

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

Reference Books:

- 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

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-I**	**Semester-II**
Subject: Seed Physiology		
Course Code: PP-510	**Course Title:** Seed Physiology	
Credits: 3(2+1)	**Minor Course**	**Theory**

Course outcomes

CO1. Define physiological processes involved in seed

CO2. Relate physiological mechanism involved in dormancy and germination

CO3. Judge different climatic factors in seed aging and physiological changes

CO4. Explain and estimate seed vigour and their measurement

CO 5. Able to understand the mechanism of assimilation of storage food reserve

CO 6. Able to apply the methods of breaking dormancy

CO7: To understand the physiological mechanism involved in dormancy and germination

CO8: To compare the role of growth regulators in seed germination

Unit	Course Content
I	Introduction to Seed Physiology: Importance of seed as a propagule, seed structure and functions; chemical composition of seeds. Embryogenesis: pollination and fertilization, pollen and pistil interaction, signal for interaction; pollen load hypothesis; genetical and environmental influence on seed development. Source-Sink relationship affecting seed yield and quality. Concept of seed viability and seedling vigour and their relevance; approaches to improve the storability of seeds. Physiological and molecular mechanisms of seed germination; approaches to improve seed germination; seed size and its influence on seed germination.
II	Seed Development: Physiology and molecular mechanisms of embryo, endosperm and seed coat development; cellularization during endosperm development; morphological and cellular changes during seed coat development, anatomy and function of seed coat, programmed cell death (PCD) in seed coat, Deposition of seed storage reserves during development.

Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj

III	Seed Maturation: Seed maturation and maturation indices; physiological and anatomical changes during seed maturation; Seed drying and acquisition of desiccation tolerance in seeds; mechanisms of desiccation tolerance; role of ABA LEA's, HSP's, dehydrins and other stress proteins during seed maturation and drying, Seed abortion and approaches to reduce it.
IV	Metabolism in Developing Seed: Chemical composition of seeds (carbohydrates, proteins, fats etc.), source of assimilates for seed development, pathways of movement of assimilates to developing seed, approaches to increase the chemical composition of seeds. Seed respiration and mitochondrial activity; seed respiration rate and storability of seeds. Seed ageing, Mobilization of stored resource in seeds; Chemistry of oxidation of starch, proteins and fats; Utilization of breakdown products by embryonic axis.
V	Seed germination: Seed germination, types of germination, imbibition kinetics of germinating seed; Physiological events during germination: seed respiration, mitochondrial activity, mobilization of food reserve; energy utilization by the germinating seed. Environmental regulation of germination: hydro-time, thermal time and hydrothermal time models; Influence of environmental factors on germination; Role of plant hormones/PGR's during seed germination.
	VI Seed Dormancy and Viability: Physiological and molecular basis of seed dormancy, hormonal regulation of dormancy, After ripening, dormancy breaking treatments; Ecological perspective of seed dormancy. Seed viability: concept and physiology of seed viability, theories of seed ageing, seed storage and regulation of storage life of seeds; methods to prolong seed viability; Conservation of orthodox and recalcitrant seeds. Seed vigour: concept, importance, measurement; Physiological, biochemical and molecular basis of seed vigour.

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-I**	**Semester-II**
Subject: Seed Physiology		
Course Code: PP- 510	**Course Title:** Seed Physiology	
Credits: 3(2+1)	**Minor Course**	**Practical**

Unit	**Course Content**
I	Determination of seed reserves: carbohydrates, proteins and lipids. Study of different seed structures
II	Kinetics of seed imbibition; Seed germination test, enzymatic activities and respiration during germination and vigour testing methods etc.
III	Accelerated ageing test to know the seed vigour and storability Measurement of seed moisture content Determination of amylase activity in germinating seeds
IV	Measurement of electrical conductivity in seed leachate Measurement of seed viability using tetrazolium chloride
V	Determination of dehydrogenase activity • Seed germination study- Determination of Germination Index and seedling growth
VI	Measurement of seed vigour index, Dormancy breaking treatments, Seed priming techniques Effect of environmental stresses on seed germination and seedling growth Effect of hormones on seed germination **Reference Books:**

- Bewley, JD, Bradford K, Hilhorst H, Nonogaki H. (2013). Seeds: Physiology of Development, Germination and Dormancy, Springer-Verlag
- Larkins BA and Vasil IK (Ed), Cellular and Molecular Biology of Plant Seed Development, 2010, Springer.
- Vanangamudi K, Natarajan K and Vanangamudi M et al. 2017. Seed Physiology. Associated Publishing Company.
- Bewley JD and Black M. 1994. Seeds: Physiology of Development and Germination, Springer
- Pammenter NW and Patricia Berjak. 2000. Aspects of recalcitrant seed physiology. R.Bras. Fisiol. Veg., 12: 56-69.
- Prakash. M. 2011. Seed physiology of crops.(ed). Satish Serial Publishing house, New Delhi.
- Roberto Benech-Arnold, Rodolfo Sanchez. 2004. Handbook of Seed Physiology: Applications to Agriculture. CRC Press.
- Vijayakumar A. 2001. Seed Dormancy an overview. In: Recent techniques and Participatory Approachs in Quality seed production (eds. K. Vanangamudi et al.) TNAU, Coimbatore. 287-396.
- Padmavathi SM, Prakash S, Ezhil Kumar G, Sathianarayanan and Kamaraj A. 2012. A Text Book of Seed Science and Technology. New India Publishing Agency, New Delhi.

- Tina Steinbrecher Gerhard Leubner-Metzger. 2017. The biomechanics of seed germination. Journal of Experimental Botany, 68(4): 765–783.
- http://sbc.ucdavis.edu/Research_pages/Seed_physiology_and_technology/.
- Bench ALR and Sanchez RA. 2004. Handbook of Seed Physiology. Food Product Press.

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-I**	**Semester-II**
Subject: Experimental Designs		
Course Code: STAT-511	**Course Title: Experimental Designs**	
Credits: 3(2+1)	**Supporting Course**	**Theory**

Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj

Course outcome:

CO1: Describe some of the factors affecting reproducibility and external validity.

CO2: List the different types of formal experimental designs (e.g. completely randomised, randomised block, repeated measures, Latin square and factorial experimental designs).

CO3: Explain the concept of variability, its causes and methods of reducing it

CO4: Describe possible causes of bias and ways of alleviating it

CO5: Identify the experimental unit and recognise issues of non-independence (pseudoreplication).

CO6: Describe the six factors affecting significance, including the meaning of statistical power and "p-values".

CO7: Identify formal ways of determining sample size.

CO8: Explain the fundamental principles behind the output of an ANOVA, including "blocking" and "interactions".

CO9: Completely randomized designs: t-test, power and sample size calculations, nonnormal observations.

CO10: Factorial designs: factorial structures, main effects and interactions, interaction plots, general factorial model, hierarchical factorial model, factorial contrasts, power and sample size calculation for factorial models

Unit	Course Content
I	Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication, and local control.
II	Uniformity trials, size and shape of plots and blocks, Analysis of variance, completely randomized design, randomized block design and Latin square design.
III	Factorial experiments, (symmetrical as well as asymmetrical). orthogonality and partitioning of degrees of freedom. Concept of confounding.
IV	Split plot and strip plot designs, analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, Balanced Incomplete Block Design, resolvable designs and their applications, Lattice design, alpha design - concepts, randomization procedure, analysis and interpretation of results. Response surfaces. Combined analysis.

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-I**	**Semester-II**
Subject: Experimental Designs		
Course Code: STAT-511	**Course Title: Experimental Designs**	
Credits: 3(2+1)	**Supporting Course**	**Practical**

Unit	Course Content

I	Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law, Analysis of data obtained from CRD, RBD, LSD, Analysis of factorial experiments,
II	Analysis with missing data,
III	Split plot and strip plot designs.
Reference Books:	
Cochran WG and Cox GM. 1957.	Experimental Designs. 2nd Ed. John Wiley.
Dean AM and Voss D. 1999.	Design and Analysis of Experiments. Springer.
Montgomery DC. 2012.	Design and Analysis of Experiments, 8th Ed. John Wiley.
Federer WT. 1985.	Experimental Designs. MacMillan.
Fisher RA. 1953.	Design and Analysis of Experiments. Oliver & Boyd.
Pearce SC. 1983. The Agricultural Field Experiment: A Statistical Examination of Theory and Practice. John Wiley.	

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-I**	**Semester-II**
Subject: Intellectual Property and Its Management in Agriculture		
Course Code: PGS-503	**Course Title: Intellectual Property and Its Management in Agriculture**	
Credits: 1(1+0)	**Common Course**	**Theory**

Course Outcome:

CO1: Acquire Skill to pursue the professional programs in Company Secretaryship, Law, Business, Agriculture, International Affairs, Public Administration and Other fields.

CO2: Develop procedural knowledge to Legal System and solving the problem relating to intellectual property rights.

CO3: Establishment of Legal Consultancy and service provider, Employability as the Compliance Officer, Public Relation Officer and Liaison Officer.

CO4: Apply Skill to understand the concept of intellectual property rights.

CO5: Knowledge of intellectual property rights. Students are learn about intellectual property rights (IPR) protection systems, their significance, and how IPR can be used to create value in a knowledge-based economy.

CO6: Ability to pursue professional programs Students develop the skills to pursue professional programs in agriculture, law, business, and other fields.

CO:7 Understanding of farming practices Students learn about farming practices and how to improve them in rural areas and the environment.

CO8: Application of basic science Students apply knowledge of basic science through agricultural microbiology, plant biochemistry, and biotechnology.

CO9: Application of agri-business management and finance

Students apply knowledge of agri-business management and finance to develop profitable agricultural systems.

Unit	**Course Content**

I	Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs
II	Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection
III	Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity
IV	International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Reference Books:

Erbisch FH and Maredia K.1998.	Intellectual Property Rights in Agricultural Biotechnology. CABI.
Ganguli P. 2001.	Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.
Ministry of Agriculture, Government of India. 2004.	State of Indian Farmer. Vol. V. Technology Generation and IPR Issues. Academic Foundation.

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-I**	**Semester-II**
Subject: Basic Concepts in Laboratory Techniques		
Course Code: PGS-504	**Course Title: Basic Concepts in Laboratory Techniques**	
Credits: 1(0+1)	**Common Course**	**Practical**

Course Outcomes:

CO1. Impart the basic knowledge about safety measures and good laboratory practices.

CO2. Develop understanding of basics of sterilization techniques.

CO3. Develop the skills to analyze different methods of preparations of solutions.

CO4. Knowledge of handling sophisticated laboratory equipment's and instruments

CO5. Understand and explain the differential behavior of Organic compounds based on fundamental concepts learnt.

CO6. Formulate the mechanism of organic reactions by Recalling and correlating the fundamental properties of the reactants involved.

Unit	Course Content
I	Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets;
II	Washing, drying and sterilization of glassware; Drying of solvents/ chemicals; Weighing and preparation of solutions of different strengths and their dilution; Handling techniques of solutions;
III	Preparation of different agro-chemical doses in field and pot applications; Preparation of solutions of acids; Neutralisation of acid and bases; Preparation of buffers of different strengths and pH values;

IV	Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sand bath, water bath, oil bath; Electric wiring and earthing; Preparation of media and methods of sterilization;
V	Seed viability testing, testing of pollen viability; Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy.
Reference Books:	
Furr AK. 2000.	CRC Hand Book of Laboratory Safety. CRC Press.
Gabb MH and Latchem WE. 1968.	A Handbook of Laboratory Solutions. Chemical Publ. Co.

Semester-III

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-II**	**Semester-III**
Subject: Molecular Breeding and Bioinformatics		
Course Code: GPB -506	**Course Title:** Molecular Breeding and Bioinformatics	
Credits: 3(2+1)	**Major Course**	**Theory**

Course outcome

CO1: Understanding of genetics Students learn about the genetics of bacteria and viruses, the structure of chromosomes, and how genes interact.

CO2: Knowledge of molecular methods Students learn about the most significant molecular methods used to understand biology.

CO3: Ability to design research programs Students learn how to design, execute, and analyze the results of molecular markers in gene manipulation systems.

CO4: Ability to use bioinformatics tools Students learn how to use bioinformatics tools and databases to retrieve, analyze, and manage biological data.

CO5: Problem-solving skills Students learn how to develop new algorithms and analysis methods to solve problems.

CO6: Understanding of the intersection of life and information sciences Students learn about the shared concepts, language, and skills of life and information sciences.

CO7: Ability to use bioinformatics to relate sequence to structure Students learn how to use bioinformatics methods to relate sequence to structure.

CO8: Ability to identify genetic variants Students learn how to identify and characterize genetic variants that affect traits of interest, such as growth, health, or behavior.

CO9: Demonstrate different biological databases and tools and apply algorithms for searching the biological databases.

CO10: Categorize sequence alignment methods, Implement phylogenetic tree construction algorithms, Predict gene and protein secondary structure and Analyse genomic sequence.

Unit	**Course Content**

Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj

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

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-II**	**Semester-III**
Subject: Molecular Breeding and Bioinformatics		
Course Code: GPB -506	**Course Title:** Molecular Breeding and Bioinformatics	
Credits: 3(2+1)	**Major Course**	**Practical**

Unit	**Course Content**
I	Requirements for plant tissue culture laboratory, Techniques in plant tissue culture;
II	Media components and media preparation, Aseptic manipulation of various explants, observations on the contaminants occurring in media, interpretations;
III	Inoculation of explants, callus induction and plant regeneration; Standardizing the protocols for regeneration, Hardening of regenerated plants; Establishing a greenhouse and hardening procedures;
IV	Visit to commercial micropropagation unit, Transformation using Agrobacterium strains;
V	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
VI	Comparative Genomic Resources: - Map Viewer (UCSC Browser and Ensembl), Primer designing- Primer 3/ Primer BLAST

Reference Books:

- 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.

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-II**	**Semester-III**
Subject: Principles of Cytogenetics		
Course Code: GPB -505	**Course Title:** Principles of Cytogenetics	
Credits: 3(2+1)	**Major Course**	**Theory**

Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj

Course Outcomes:

CO1: Students will understand the ethical issues related to genetic testing and counseling, and be able to discuss the implications of genetic information for individuals and society. CO2: Students will be able to effectively communicate complex cytogenetic concepts to both scientific and non-scientific audiences, including preparing clear and concise reports and presentations.

CO3: Students will integrate cytogenetic knowledge with other biological sciences, including molecular biology and genetics, to provide a comprehensive understanding of genetic phenomena and their applications.

CO4: Students gain insight into the structure and functions of chromosomes, as well as chromosome mapping and polyploidy.

CO5: Students will demonstrate a thorough understanding of the fundamental principles of cytogenetics, including chromosomal structure, function, and the role of genetics in cellular processes.

CO6: Students will be able to identify and describe various genetic disorders related to chromosomal abnormalities and understand their mechanisms.

CO7: Students will be proficient in the techniques used for cytogenetic analysis, including karyotyping, fluorescence in situ hybridization (FISH), and chromosomal banding methods.

CO8: Students will be able to apply cytogenetic principles to clinical scenarios, including diagnosing genetic disorders and understanding their implications for patients and families.

CO9: Students will be skilled in analyzing and interpreting cytogenetic data, including the identification of chromosomal abnormalities and the use of software tools for genetic analysis.

CO10: Students will integrate cytogenetic knowledge with other biological sciences, including molecular biology and genetics, to provide a comprehensive understanding of genetic phenomena and their applications.

Unit	Course Content
I	Cell cycle and architecture of chromosome in prokaryotes and eukaryotes; Chromonemata, chromosome matrix, chromomeres, centromere, secondary constriction and telomere; artificial chromosome construction and its uses; Special types of chromosomes.Variation in chromosome structure: Evolutionary significance; Introduction to techniques for karyotyping; Chromosome banding and painting -In situ hybridization and various applications.
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.
III	Fertilization barriers in crop plants at pre-and postfertilization levels; In-vitro techniques to overcome the fertilization barriers in crops; Polyploidy. Genetic consequences of polyploidization and role of polyploids in crop breeding; Evolutionary advantages of autopolyploid vs allopolyploids; Role of aneuploids in basic and applied aspects of crop breeding, their maintenance and utilization in gene mapping and gene blocks transfer; Alien addition and substitution lines, creation and utilization; Apomixis, evolutionary and genetic problems in crops with apomixes.

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

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-II**	**Semester-III**
Subject: Principles of Cytogenetics		
Course Code: GPB -505	**Course Title:** Principles of Cytogenetics	
Credits: 3(2+1)	**Major Course**	**Practical**

Unit	**Course Content**
I	Learning the cytogenetical laboratory techniques, various chemicals to be used for fixation, dehydration, embedding, staining, cleaning, etc.;
II	Microscopy: various types of microscopes;
III	Preparing specimen for observation
IV	Fixative preparation and fixing specimen for light microscopy studies in cereals
V	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
VI	Demonstration of polyploidy.

Reference Books:

- 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.
- ButterworthHeinemann 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.

Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-II**	**Semester-III**
Subject: Breeding for Quality and Special Traits		
Course Code: GPB -507	**Course Title:** Breeding for Quality and Special Traits	
Credits: 3(2+1)	**Major Course**	**Theory**

Course outcome

CO1: Student will develop the ability to identify desirable traits and select for them in breeding programs. This involves both phenotypic (observable characteristics) and genotypic (genetic makeup) considerations.

CO2: Student will acquire skills in assessing the quality of breeding outcomes, including evaluating traits, performance metrics, and overall health of the organisms being bred.

CO3: Student will learn how to analyze and interpret data related to breeding experiments and programs. This includes statistical analysis, record-keeping, and using software tools for data management.

CO4: Apply screening techniques: Learn how to apply analytic and statistical screening techniques to value traits

CO5: Learn about recent advances: Learn about recent advances in improving quality traits in crops like millets, rice, legumes, oilseeds, and forage crops.

CO6: Student will develop the ability to identify desirable traits and select for them in breeding programs. This involves both phenotypic (observable characteristics) and genotypic (genetic makeup) considerations.

CO7: Student will learn various breeding techniques and methodologies, such as crossbreeding, selection, hybridization, and genetic modification. This includes practical

skills for implementing these techniques in a breeding program.

CO8: Student will develop problem-solving skills to address challenges that arise in breeding programs, such as genetic disorders, trait stability, and adaptation to changing conditions.

CO9: Student will be able to apply your knowledge to real-world breeding programs, whether in agriculture, horticulture, animal husbandry, or other fields. This might include designing

and implementing a breeding program or improving existing ones.

CO10: Effective communication of breeding strategies, results, and recommendations is crucial. You'll learn how to present your findings and collaborate with other professionals in the field.

Unit	**Course Content**
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. Paramutations in crops plants.

II	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 – repair mechanisms operating at and LET relationships; Effect of mutations on 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
III	Chemical mutagens: Classification – base analogues, antibiotics, alkylating agents, acridine dyes and other mutagens: their properties and mode of action; Dose determination and factors influencing chemical mutagenesis; Treatment methods using physical and chemical mutagens, Combination treatments; other causes of mutation – direct and indirect action, comparative evaluation of physical and chemical mutagens.
IV	Observing mutagen effects in M1 generation: plant injury, lethality, sterility, chimeras, etc.; Observing mutagen effects in M2 generation; Estimation of mutagenic efficiency and effectiveness – spectrum of chlorophyll and viable mutations; Mutations in traits with continuous variation; Factors influencing the mutant spectrum: genotype, type of mutagen and dose, pleiotropy and linkage, etc.; Individual plant based mutation analysis and working out effectiveness and efficiency in M3 generation; Comparative evaluation of physical and chemical mutagens for creation of variability in the some species- Case studies.
V	Use of mutagens in creating oligogenic and polygenic variations – Case studies; In-vitro mutagenesis – Callus and pollen irradiation; Handling of segregating M2 generations and selection procedures; Validation of mutants; Mutation breeding for various traits (disease resistance, insect resistance, quality improvement, etc.) in different crops; Procedures for 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

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-II**	**Semester-III**

Subject: Breeding for Quality and Special Traits		
Course Code: GPB -507	**Course Title:** Breeding for Quality and Special Traits	
Credits: 3(2+1)	**Major Course**	**Practical**

Unit	**Course Content**
I	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
II	Radiation hazards: Monitoring – safety regulations and safe transportation of radioisotopes, visit to radio isotope laboratory; learning on safe disposal of radioisotopes;
III	Hazards due to chemical mutagens – Treating the plant propagules at different doses of physical and chemical mutagens;
IV	Procedures in combined mutagenic treatments, Raising the crop for observation; Mutagenic effectiveness and efficiency, calculating the same from earlier literature;

V	Study of M1 generation – Parameters, Study of M2 generation – Parameters;
VI	Mutation breeding in cereals and pulses-achievements made and an analysis, Mutation breeding in oilseeds and cotton- achievements and opportunities;
VII	Mutation breeding in forage crops and vegetatively propagated crops, Procedure for detection of mutations for polygenic traits in M2 and M3 generations

Reference Books:

- 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.

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-II**	**Semester-III**
Subject: Seed Production Principles and Techniques in Field Crops		
Course Code: SST -503	**Course Title:** Seed Production Principles and Techniques in Field Crops	
Credits: 3(2+1)	**Minor Course**	**Theory**

Course Outcomes:

CO1: Gain a comprehensive understanding of the fundamental principles of seed production, including the biology of seed development, seed types, and stages of seed maturity.

CO2: Learn specific techniques for seed production tailored to various field crops, such as cereals, legumes, and oilseeds, including methods for enhancing seed quality and yield.

CO3: Develop strategies for managing pests and diseases that affect seed crops. Learn about integrated pest management (IPM) practices and disease control measures to ensure healthy seed production.

CO4: Learn the principles of soil preparation, fertility management, and crop nutrition to create optimal conditions for seed production and ensure high seed quality.

CO5: Post-Harvest Processing: Gain skills in post-harvest processing techniques, including seed cleaning, drying, storage, and handling, to preserve seed viability and prevent deterioration.

CO6: Learn Economic and Business Aspects, Understand the economic factors involved in seed production, such as cost management, pricing strategies, market analysis, and business planning for seed production enterprises.

CO7: Found Regulatory and Certification Standards, Familiarize yourself with national and international seed production regulations and certification standards, including labeling requirements and quality assurance protocols.

CO8: Student will get knowledge on sustainable Practices, Learn about sustainable seed production practices, including conservation tillage, crop rotation, and organic methods, to promote environmental stewardship and long-term viability of seed production systems.

CO9: Get the best practices for sowing, managing, and harvesting crops to optimize seed quality and quantity. This includes timing, equipment, and techniques for both small and large-scale operations.

CO10: Understand methods to maintain genetic purity and improve seed quality, including isolation techniques, seed certification processes, and laboratory testing for seed health and viability.

Unit	Course Content
I	Importance of seed – seed quality concept – factors influencing seed production; generation system of seed multiplication – classes of seed, stages of seed multiplication in varieties and hybrids – seed multiplication ratio (SMR) – seed replacement rate (SRR) – seed renewal period (SRP) – varietal replacement rate (VRR).
II	Genetic and agronomic principles of variety and hybrid seed production; methods and techniques of seed production in varieties and hybrids of important cereals and millets – wheat, oat, rice, maize, sorghum and pearl millet; varietal seed production in small millets – finger millet, fox tail millet, little millet, kodo millet, proso millet and barnyard millet.
III	Methods and techniques of varietal seed production in major pulses – black gram, green gram, cowpea, chickpea, horse gram, soybean and lentil – varietal and hybrid seed production in red gram

IV	Methods and techniques of seed production in major oil seed crops – groundnut, sesame – varietal and hybrid seed production in sunflower, castor and mustard; varietal seed production in minor oilseed crops (safflower, linseed, niger) – varietal and hybrid seed production in cotton – varietal seed production in jute.
V	Seed production planning for varieties and hybrids of major crops; participatory seed production – seed hubs, seed village concept and community seed bank.

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-II**	**Semester-III**

Subject: Seed Production Principles and Techniques in Field Crops

Course Code: SST -503 **Course Title:** Seed Production Principles and Techniques in Field Crops

Credits: 3(2+1)	**Minor Course**	**Practical**
Unit	**Course Content**	
I	Seed selection – quality of seed on field establishment, Sowing and nursery management techniques;	
II	Planting – age of seedling on crop establishment – rice and pearl millet; Isolation distance and border rows in hybrid seed production field – space and barrier isolation; modifying isolation based on border rows in maize,	
III	Planting design for hybrid seed production – rice, maize, pearl millet, cotton, red gram, sunflower; Practicing breeding tools for hybrid seed production – detasseling – emasculation and dusting,	
IV	Study on methods of achieving synchronization – rice, bajra, sunflower; • Practicing supplementary pollination – rice and sunflower Study on foliar nutrition and influence on seed yield, Practicing roguing operation – identification of off-types, pollen shedders, shedding tassels, partials, selfed bolls;	
V	Pre and post harvest sanitation operations – cereals, millets and pulses; • Estimation of shattering and shattering loss; study on insitu germination and loss. **VI** Visit to seed production fields, Visit to seed industry;	
VII	Seed production planning and economics of seed production – varieties, Seed production planning and economics of seed production – hybrids	

Reference Books:

- Agrawal RL. 2019. Seed Technology. Oxford & IBH Publishing Company Pvt. Ltd., New Delhi. Hebblethwaite PD. 1980. Seed Production. Butterworth Heinemann Ltd., London, UK.
- Joshi AK and Singh BD. 2004. Seed Science and Technology. Kalyani Publishers, New Delhi. Kulkarni GN. 2011. Principles of Seed Technology. Kalyani Publishers, New Delhi.
- Maiti RK, Sarkar NC and Singh VP. 2006. Principles of Post Harvest Seed Physiology and Technology. Agrobios, Jodhpur, Rajasthan.
- McDonald MB and Copeland L. 1998. Seed Production Principles and Practices. CBS Publishers, New Delhi.

- Mondal SS, Saha M and Sengupta K. 2009. Seed Production of Field Crops. New India Publishing Agency, New Delhi.
- Singhal NC. 2003. Hybrid Seed Production in Field Crops. Kalyani Publications, New Delhi.
- Sen S and Ghosh N. 2010. Seed Science and Technology. Kalyani Publishers, New Delhi.
- Singhal NC. 2010. Seed Science and Technology. Kalyani Publishers, New Delhi.

Programme: M. Sc. Ag. Genetics and Plant Breeding		**Year-II**	**Semester-III**
Subject: Computer Fundamentals and Programming			
Course Code: MCA-501		**Course Title: Computer Fundamentals and Programming**	
Credits: 3(2+1)		**Supporting Course**	**Theory**
Unit	**Course Content**		
I	Functional units of computer, I/O devices, primary and secondary memories. Number systems: decimal, octal, binary and hexadecimal; Representation of integers, fixed and floating point numbers, Operator precedence, character representation; ASCII, Unicode.		
II	Programming Fundamentals with C - Algorithm, techniques of problem solving, flowcharting, stepwise refinement; Constants and variables; Data types: integer, character, real, data types; Arithmetic expressions, assignment statements, logical expressions. Control flow		
III	Arrays and structures. Pointers, dynamic memory allocations		
IV	Program Structures – functions, subroutines		
V	I/O operations, Program correctness; Debugging and testing of programs.		

Programme: M. Sc. Ag. Genetics and Plant Breeding		**Year-II**	**Semester-III**
Subject: Computer Fundamentals and Programming			
Course Code: MCA-501	**Course Title: Computer Fundamentals and Programming**		
Credits: 3(2+1)	**Supporting Course**		**Practical**

Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj

Course Outcome

CO1: Understand fundamental data structures (such as arrays, lists, stacks, and queues) and algorithms (including sorting and searching) to efficiently handle and process data.

CO2: Gain practical experience by working on hands-on programming projects that reinforce theoretical knowledge and enhance practical coding skills.

CO3: Learn about ethical considerations in programming and computer use, including data privacy, intellectual property, and professional conduct in the field of technology.

CO4: Understand the basics of the software development life cycle, including requirements analysis, design, implementation, testing, and maintenance.

CO5: Develop skills in debugging and testing code to identify and fix errors, ensuring that programs run efficiently and correctly.

CO6: Gain a solid foundation in computer hardware and software components, including an understanding of operating systems, file management, and basic troubleshooting techniques.

CO7: Gain a solid foundation in computer hardware and software components, including an understanding of operating systems, file management, and basic troubleshooting techniques.

CO8: Enhance your problem-solving abilities through algorithm design and implementation.

Learn how to break down complex problems into smaller, manageable parts and solve them using programming techniques.

CO9: Acquire essential programming skills, including understanding syntax, logic, and structure of common programming languages such as Python, Java, or C++. Develop the ability to write, debug, and execute basic programs.

CO10: Possess the knowledge of basic hardware peripherals, Know and use different number systems and the basics of programming, Solve basic computational problems with C language and apply the basic concepts into solving broader problems.

Unit	Course Content
I	Conversion of different number types;
II	Creation of flow chart, conversion of algorithm/flowchart to program;
III	Mathematical operators, operator precedence;
IV	Sequence, control and iteration;
V	Arrays and string processing;
VI	Matrix operations, Sorting, Pointers and File processing – Reading and writing text files.

Reference Books:

Balaguruswamy E. 2019.
Programming with ANSI C. Tata McGraw Hill.
Gottfried B. 2017.
Programming with C, Schaum Outline Series. Tata Mc Graw Hill.
Kanetkar Y. 1999.
Let Us C. BPB Publ.

Programme: M. Sc. Ag. Genetics and Plant Breeding	**Year-II**	**Semester-III**
Subject: Agricultural Research, Research Ethics and Rural Development Programmes		
Course Code: PGS-505	**Course Title: Agricultural Research, Research Ethics and Rural Development Programmes**	
Credits: 1(1+0)	**Common Course**	**Theory**

Course outcome

CO1: Learn how to translate research findings into practical solutions for rural development, including the design and implementation of programs that address agricultural productivity, food security, and rural livelihoods.

CO2: Develop the ability to make informed ethical decisions in research scenarios, addressing potential conflicts of interest and ensuring integrity in the research process.

CO3: Develop skills in designing and conducting research projects, including formulating research questions, setting objectives, and selecting appropriate research methods for agricultural studies.

CO4: Gain comprehensive knowledge of agricultural research methodologies, including experimental design, data collection, and analysis techniques used to address agricultural challenges.

CO5: Acquire proficiency in statistical tools and techniques for analyzing research data, interpreting results, and drawing valid conclusions in the context of agricultural research. CO6: Understand and apply ethical principles in research, including issues related to consent, confidentiality, and the responsible conduct of research involving human subjects and animal testing.

CO7: Understand the role of agricultural research in shaping policies and programs related to rural development, including the analysis of policy impacts and the development of evidencebased recommendations.

CO8: Gain skills in planning, implementing, and evaluating rural development programs, with an emphasis on project management, stakeholder engagement, and impact assessment.

CO9: earn strategies for engaging rural communities in the research process and development programs, fostering participation, and addressing local needs and priorities.

CO10: Develop an interdisciplinary perspective by integrating knowledge from agricultural sciences, social sciences, and ethics to address complex issues in rural development and agricultural research.

Unit	**Course Content**

Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj

I	History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.
II	Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.
III	Concept and connotations of rural development, rural development policies and strategies. 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, Voluntary Agencies/ Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Reference Books:

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