SYLLABUS FOR THE ALL INDIA COMPETITIVE EXAMINATION FOR ADMISSION TO DOCTORAL DEGREE PROGRAMMES AND THE AWARD OF JRF/SRF (PGS)

01 GENETICS & PLANT BREEDING

Unit 1: General Genetics and Plant Breeding

Mendelian inheritance. Cell structure and division, Linkage, its detection and estimation. Epistasis. Gene concept, allelism and fine structure of gene. Extra chromosomal inheritance. DNA – structure, function, replication and repair. Genetic code. Gene-enzyme relationship. Replication, Transcription and Translation. Gene regulation in prokaryotes and eukaryotes. Nuclear and cytoplasmic genome organization. Spontaneous and induced mutations and their molecular mechanisms. Crop domestication, evolution of crops and centres of diversity. Emergence of scientific plant breeding. Objectives and accomplishments in plant breeding and the role of National and International institutes. Gametogenesis and fertilization. Modes of sexual and asexual reproduction and its relation to plant breeding methodology. Apomixes, incompatibility and male sterility systems and their use in plant breeding. Epigenetics.

Unit 2: Economics Botany and Plant Breeding Methods

Origin, distribution, classification, description and botany of cereals (wheat, rice, maize, sorghum, pearl millet, small millets); pulses (pigeonpea, chickpea, black gram, green gram, cowpea, soybean, pea, lentil, horse gram, lab-lab, rice bean, lathyrus, lima bean; oilseeds (groundnut, sesamum, castor, rapeseed mustard, sunflower, safflower, niger, linseed); fibre and sugar crops, fodder and green manures; Breeding methods for self-pollinated, cross-pollinated and asexually propagated crops. Combination, recombination and transgressive breeding. Single seed descent. Populations, their improvement methods and maintenance, Hybrid breeding and genetic basis of heterosis. Ideotype breeding. Mutation breeding, Concept of tree breeding. Speed breeding methods, Pre-breeding, Reverse Breeding.

Unit 3: Genome Organization and Cytogenetics of Crop Plants

Chromosome number, structure, function and replication. Sex determination & sex linkage. Recombination and crossing over. Molecular and cytological mechanism of crossing over. Karyotype analysis.Chromosomal theory of inheritance. Cell cycle and its regulation. Banding techniques. *In situ* hybridization. GISH and FISH Special types of chromosomes. Chromosomal interchanges, inversions, duplications and deletions. Polyploids, haploids, aneuploids, their utility and their meiotic behaviour. Wide hybridization and chromosomal manipulations for alien gene transfer. Pre-and post- fertilization barriers in wide hybridization. Genome organization and Cytogenetics of important crop species- wheat, maize, rice, sorghum, *Brassica*, groundnut, cotton, *Vigna*, potato and sugarcane. Cytogenetic techniques for gene location and gene transfer, Construction and use of molecular marker based chromosome maps.

Unit 4: Quantitative and Biometrical Genetics

Quantitative characters. Multiple factors inheritance. Genetic control of polygenic characters. Genetic advance and types of selection their effects on population mean and variance. Metric characters under natural selection. Repeatability and asymmetry of response. Breeding value. Dominance and interaction deviations. Hardy Weinberg law and changes in gene frequency due to migration, mutation and selection. Linkage disequilibrium. Genetic load. Polymorphism. Breeding value, heritability. Response to selection, correlated response. Estimates of variance components and covariance among relatives. Mating designs with random and inbred parents. Estimation of gene effects and combining ability. Effects of linkage and epistasis on estimation of genetic parameters. Maternal effects. Genotype-environment interactions, stability of performance and stability analysis. Heterosis and its basis (Genetic, biochemical and physiological). Mating system and mating design- diallel, line X tester, NC-I NC-II and NC-III designs, approaches to estimate and exploit components of self and cross pollinated crops. . GGE biplot analysis, Principal component analysis, AMMI and GGI analysis.

Unit 5: Genetic Engineering and Biotechnological Tools in Plant Breeding

Somatic hybridization, micropropagation, somaclonal variation, *in vitro* mutagenesis. Anther culture. Cryopreservation. Genetic and molecular markers, generation of molecular markers and their application in genetic analyses and breeding. Molecular markers in genetic diversity analysis and breeding for complex characters. Gene tagging, QTL mapping, MAS, MARS and MABB. Vectors. DNA libraries, DNA fingerprinting, DNA sequencing. Nucleic acid hybridization and immunochemical detection. Chromosome walking, Recombinant DNA technology, Gene cloning strategies. Gene transfer methods. Artificial synthesis of gene. Genetic transformation, transgenics and cisgenics. Antisense RNA, RNAi and micro RNA techniques in crop improvement. Genome editing using CRISPER/cas, Genomic selection, RNA Seq analysis,

Unit 6: Plant Breeding for Stress Resistance and Nutritional Quality

Genetic and molecular basis and breeding for resistance to diseases and insect-pests. Breeding for vertical and horizontal resistance to diseases. Genetic and physiological basis of abiotic stress tolerance. Breeding for resistance to heat, frost, flood, drought and soil stresses. Important quality parameters in various crops, their genetic basis and breeding for these traits. Role of molecular markers in stress resistance breeding using biotechnological tools (MAS, MARS and MABB and transgenics). Biofortification.

Unit 7: Plant Genetic Resources and their Regulatory System; Varietal Release and Seed Production

Plant exploration, germplasm introduction, exchange, conservation, evaluation and utilization of plant genetic resources. Types of genetic resources. Centres of diversity of cultivated plants. Genetic erosion and genetic vulnerability. Convention on Biological Diversity and International Treaty on Plant Genetic Resources for Food and Agriculture. Intellectual Property Rights and its different forms for protection of plant genetic resources. Biodiversity Act. Protection of Plant

Varieties and Farmers' Rights Act and its features. System of variety release and notification. Types of seeds and seed chain. Maintenance breeding- nucleus and breeder seed production. Seed production and certification.

Unit 8: Statistical Methods and Field Plot Techniques

Frequency distribution. Measures of central tendency, probability theory and its applications in genetics. Probability distribution and tests of significance. Correlation, linear, partial and multiple regression. Genetic divergence. Multivariate analysis. Designs of experiments - basic principles, completely randomized design, randomized block design and split plot design. Complete and incomplete block designs. Augmented design, Grid and honeycomb design. Hill plots, unreplicated evaluation. Data collection and interpretation.