Course Title: Advances in Plant Breeding Systems
Course Code: GPB 601
Credits Hours: 3 (3+0)

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Theory:

UNIT I

Advances in reproductive biology of crops; Genes governing the whorls formation and various models proposed; Pollen pistil interaction : biochemical and molecular basis, environmental factors governing anthesis and bottlenecks for gene transfer.

UNIT II

Plant Breeding methodologies: Classic versus modern; Overview of Pre and Post Mendelian breeding methods in self and cross pollinated crops; Molecular and transgenic breeding approaches; doubled haploid breeding, shuttle breeding, forward and reverse breeding, speed breeding, participatory plant breeding breeding for organic situations.

UNIT III

Principles and procedures in the formation of a complex population; Genetic basis of population improvement in crop plants; Recurrent selection methods in self and cross pollinated crops and their modifications; Convergent selection, divergent selection; Recurrent selection, usefulness in hybrid breeding programs; Reciprocal recurrent selection; Selectionin clonally propagated crops– Assumptions and realities.

UNIT IV

Choice of molecular markers for plant breeding efficiency, fingerprinting and genetic diversity assessment, application of MAS fors election of qualitative and quantitative traits; Gene pyramiding, accelerated backcrossing, marker-based utilization of exotic germplasm,introgressionlibraries.

UNIT V

Genetic resources: primary, secondary, tertiary and alien trans gene pool; Molecular andbiochemical basis of self-incompatibility and male sterility, nucleo cytoplasmic interactions with special reference to male sterility – genetic, biochemical and molecular bases.

UNIT VI

Genetic engineering technologies to create male sterility, prospects and problems , use ofself-incompatibility and sterility in plant breeding – case studies; Fertility restoration in male sterile lines and restorer diversification programs;Conversion of agronomically ideal genotypes into male sterile: Concepts and breeding strategies; Case studies – Generating new cyto-nuclear interaction system for diversification of male sterile; Stability of malesterile lines – Environmental influence on sterility, Environmentally Induced Genic MaleSterility (EGMS) – Types of EGMS; Influence on their expression, genetic studies; Photoand thermo sensitive genetic male sterility and its use in heterosis breeding; Temperaturesensitive genetic male sterility and its use heterosis breeding ; Apomixis and its use inheterosis breeding ; Incongruity : Factors influencing in congruity Methods to overcome in congruity mechanisms.

UNIT VII

Breeding for climate change -Improving root systems, abiotic stress tolerance, water use efficiency, flooding and sub-mergence tolerance; Biotic stress tolerance; Nutrient useefficiency, nitrogen fixation and assimilation, green house gases and carbon sequestration; Breeding for bio-fortification.

Resources:

- Agarwal RL. 1996. Fundamentals of Plant Breeding and Hybrid Seed Production.Oxford & IBH.
- Allard RW.1966.Principles of Plant Breeding. JohnWiley&Sons.
- Briggs FN & Knowles PF.1967.Introduction to Plant Breeding.Reinhold.
- Fehr WR. 1987. Principles of Cultivar Development: Theory and Technique. Vol I.Macmillan.
- Hayes HK, Immer FR & Smith DC. 1955. Methods of Plant Breeding. McGraw-Hill.
- Kang MS and Priyadarshan PM (Edit.).2007. Breeding Major Food Staples. Blackwell Publishing.
- Kole C. 2013. Genomics and Breeding for Climate-Resilient Crops. Springer. Volume2TargetTraits.
- Mandal AK, Ganguli PK & Banerji SP. 1995. Advances in Plant Breeding. Vol. I, II.CBS.
- Richards AJ.1986. Plant Breeding Systems.George Allen & Unwin.
- Sharma JR. 1994. Principles and Practice of Plant Breeding. Tata McGraw-Hill.
- Simmonds NW. 1979. Principles of Crop Improvement.Longman.
- Singh BD. 1997. Plant Breeding: Principles and Methods. 5th Ed., Kalyani Publ.
- Singh P. 1996. Essentials of Plant Breeding. Kalyani Publ.
- Welsh JR.1981.Fundamentals of Plant Genetics and Breeding. JohnWiley.

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Course Title: Advances in Biometrical Genetics
Course Code: GPB 602
Credit Hours: 3 (2+1)

Theory:

UNIT I

Continuous variation- evolutionary studies; Genetic principles of continuous variation, Qualitative and quantitative techniques- differences, population types, approaches; various types of metrices, F_2, $F\alpha$ and mixed; Selection of parents Simultaneous selection models ; Use of Multiple regression analysis in selection of genotypes.

UNIT II

Components of mean- Additive effect, breeding value, coefficient of gene dispersion, dominance; Simple scaling test, expectation of mean of character in various types of families in coupling and dispersed phase; Epistasis-Specification, weighted and unweighted joint scaling test; Effect of linkage to generation mean, specification of mean to Gx E interaction.

UNIT III

Component of variances-advantages, variances of different generations, balance sheet of variance; estimation of parameters-weighted and un weighted, least square analysis; random mating population; experimental population - BIPs, NCD-I, II, III, Triple test cross for random mating population and in breds; Estimates of linkage and non- allelic interactions; Combining ability analysis, Hayman's Approach.

UNIT IV

G x E Interaction, stability and adaptability; Advanced models instability analysis-Pattern analysis - Additive Main Effect and Multiplicative Interaction (AMMI) analysis and other related models; Merits and limitation of different stability analysis methods; Analysis and selection of genotypes; Methods and steps to select the best model – Bi plots and mapping genotypes.

UNIT V

Construction of saturated linkage maps, concept of framework map development; QTLs different types of markers and mapping populations, linkage maps, mapping-Strategies for QTL mapping-desired populations statistical methods; MAGIC populations, Marker Assisted Selection (MAS) - Approaches to apply MAS in Plant breeding - selection based on markers - simultaneous selection based on marker and phenotype- Factors influencing MAS; Heritability of the trait, proportion of genetic variance, linkage disequilibrium between markers and traits and selection methods; Use of advanced software packages for biometrical analysis, interpretation of analysed data.

Practical:

- Generation mean analysis: ABC scaling test and Joints caling test-Analysis and interpretation;
- Estimation of variance of different filial generations and interpretations;
- Diallel analysis: Numerical, graphical and combining ability analysis; Triallel analysis;
- NC Designs : Triple test cross analysis
- Stability analysis: Eberhart and Russel model;
- AMMI model-Principal Component Analysis model- Additive and multiplicative model-Shifted multiplicative model-Analysis and selection of genotypes - Methods and steps to select the best model - Selection systems –Bi plots and mapping genotypes;
- Construction of linkage maps and QTL mapping-Strategies for QTL mapping; statistical methods in QTL mapping;
- Phenotype and Marker linkage studies;
- Use of advanced software in biometrical analysis.

Resources:

- BosI & Caligari P.1995.Selection Methods in Plant Breeding. Chapman & Hall.
- Dabholkar AR.1993. Elements of biometrical genetics. Concept Publishing Co. New Delhi.
- Falconer DS and Mackay J. 1996. Introduction to quantitative genetics (4Ed.). ELBS/Longman, London.
- Mather K & 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 Publ.
- Roy D. 2000.Plant Breeding, Analysis and Exploitation of Variation. Narosa Publishing House, New Delhi.
- Singh P & Narayanan SS. 1993. Biometrical Techniques in Plant Breeding. Kalyani Publ.
- Singh RK & Choudhary BD. 1987. Biometrical Methods in Quantitative Genetics. Kalyani Publ.
- Weir DS. 1990. Genetic Data Analysis. Methods for Discrete Population Genetic Data Sinauer Associates.
- Wricke G & Weber WE. 1986. Quantitative Genetics and Selection in Plant Breeding. Walterde Gruyter.

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Course Title: Molecular Cytogenetics for Crop Improvement
Course Code: GPB 603
Credit Hours: 2(2+0)

Theory:

UNIT I

Organization and structure of genome, Genome size, Organization of organell are genomes, Nuclear DNA organization, Nuclear and Cytoplasmic genome interactions and signal transduction; Inheritance and expression of organellar DNA; Variation in DNA content-C value paradox; Sequence complexity – Introns and Exons, Repetitive sequences, Role of repetitive sequence.

UNIT II

Karyotyping – Chromosome banding and chromosome painting; Tracking introgressions using FISH,GISH, localization and mapping of genes/genomic segments.

UNIT III

Pre-breeding and applications of cytogenetical methods for crop improvement; Location and mapping of genes on chromosomes: deficiency method; Interchange genetic consequence, identification of chromosomes involved and gene location; balanced lethal systems, their maintenance and utility; Multiple interchanges-use in producing inbreds, transfer of genes-linked marker methods; Duplication-production and use; Inversions and location of genes; B/A chromosome translocations and gene location.

UNIT IV

Trisomics- types, production, breeding behavior and location of genes, use of balanced tertiary trisomics in hybrid seed production; Monosomics methods of production, breeding behavior and location of genes; Inter varietal substitutions-allelic and non-allelic interactions; Telocentric method of mapping.

UNIT V

Cytogenomics:Concept, tools and techniques for crop improvement; Chromosome sorting: Isolation of specific chromosome for development of molecular maps and gene location.

UNIT VI

Role of polyploidy in crop evolution and breeding. Auto- and allopolyploids; Distant hybridization, barriers to inter specific and inter generic hybridization; Behaviour of inter specific and inter generic crosses.

Resources:

- Clark MS &Wall WJ. 1996. Chromosomes: The Complex Code. Chapman & Hall.30 June 1996
- Conger BV.(Ed.).1981. Cloning Agricultural Plants via invitroTechniques.CRCPress.31January 2018
- ConstabelF&VasilIK.(Eds.).1988.CellCultureandSomaticCellGeneticsofPlants.Vol.V.CellCulture andPhytochemicalsinPlantCellCultures.AcademicPress.
- GuptaPK.2006.Cytogenetics.RastogiPublisher
- LalR&LalS.(Eds.).1990.CropImprovementUtilizingBiotechnology.CRCPress.

- MantelSH&SmithH.1983.PlantBiotechnology.CambridgeUniversityPress.
- SenSK&GilesKL.(Eds.).1983.PlantCellCultureinCropImprovement.PlenumPress.13 July2013
- Yao-ShanF.2002.MolecularCytogenetics:ProtocolsandApplication.HumanPress.

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Course Title: Plant Genetic Resources, Conservation and Utilization
Course Code: GPB 604
Credit Hours: 2 (2+0)

Theory:

UNIT I

Concept of natural reserves and natural gene banks; In situ conservation of wild species in nature reserves: in situ conservation components, factors influencing conservation value, national plan for in situ conservation; in situ conservation of agro biodiversity on-farm; scientific basis of in situ conservation on-farm, building on farm conservation initiatives, implementation of on-farm conservation, management of insitu conserved genetic diversity on-farm, enhancing benefits for farmers from local crop diversity.

UNIT II

Ex situ conservation: components, plant genetic resources conservation in gene banks, national gene banks, gene repositories, preservation of genetic materials under natural conditions, perma-frost conservation, guidelines for seed multiplication and exchange to network of active/working collections, orthodox, recalcitrant seeds-differences in handling , clonal repositories, genetic stability under long term storage condition.

UNIT III

In vitro storage, maintenance of in vitro culture under different conditions, in vitro bank maintenance for temperate and tropical fruit crop species, spices, tubers, bulbous crops, medicinal and endangered plant species, conservation of embryos and ovules, cell/suspension cultures, protoplast and callus cultures, pollen culture, micro propagation techniques, problems, prospects of in vitro gene bank.

UNIT IV

Cryopreservation-procedure for handling seeds of orthodox and recalcitrant- cryoprotectants, desiccation, rapid freezing, slow freezing, vitrification techniques, encapsulation/dehydration techniques, national facilities, achievements, application of cryopreservation in agricultural, horticultural and forestry crops. Problems and prospects; challenges ahead.

UNIT V

Concept and procedure for PGR management, germplasm characterization, evaluation and utilization; Concept of core and minicore; collections and registration of plant germplasm.

Resources:

- Ellis RH , Roberts EH & White Head J. 1980. A New More Economic and Accurate Approach to Monitor the Viability of Accessions During Storage in Seed Banks. FAO /IBPGR Pl. Genet. ResourcesNews41-3-18.
- Frankel OH & Hawkes JG.1975. Crop Genetic Resources for Today and Tomorrow. Cambridge University Press, Cambridge.
- Paroda RS and Arora RK.1991. Plant genetic resource conservation and management, NBPGR,New-Delhi.
- Simmonds NW.1979.Principles of Crop Improvement Longman.
- Westwood MN.1986.Operation Manual for National Clonal Germplasm Repository Processed Report. USDA-ARS and Oregon State Univ.Oregon, USA.
- WithersLA.1980.Tissue Culture Storage for Genetic Conservation. IBPGR Tech. Rep. IBPGR, Rome, Italy.

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Course Title: Genomics in Plant Breeding
Course Code: GPB 605
Credit Hours: 3 (3+0)

Theory:

UNIT I

Introduction to the plant genomes: nuclear, chloroplast and mitochondrial genomes; Concept of genome size and complexity: C-value paradox, repetitive and unique DNA

UNIT II

Genome sequencing: Principles and techniques of conventional approaches and next generation sequencing including sequencing- by- synthesis/ligation and single molecule real time (SMRT) technologies; Applications of sequence information: structural, functional and comparative genomics; Plant genome projects: Strategies for genome sequencing including shotgun and clone-by-clone method.

UNIT III

Molecular maps: Use of molecular markers/SNPs for development of genetic and physical maps; Linkage and LD-based gene mapping approaches including gene/QTL mapping, genome wide association studies (GWAS) and association analysis; Integration of genetic and physical map for map-based cloning of economically important genes. Concept of allele mining; Diversity array technology: concepts and applications.

UNIT IV

Functional genomics: concept of reverse and forward genetics; Use of activation tagging, transposon tagging, insertional mutagenesis, TILLING and eco TILLING for crop improvement; Genome-wide and gene-specific transcriptomics approaches: serial analysis of gene expression, massively parallel signature sequencing, next generation sequencing, microarray, northern hybridization, RT-PCR, qRT-PCR and molecular beacon.

UNITV

Development and management ofdatabase; Applications of bio informatics tools/software in genomics for crop improvement. Basic concepts of high-through put proteomics, metabolomics and phenomics.

UNITVI

Recent transgene free genome editing tools such as CRISPR-Cas9 system, TALENS and ZFNs for crop improvement. Cis genesis and Intra genesis tools as twin sisters for Crop Improvement; Genomics-based plant breeding: Genome-Wide Genetic Diversity Studies, Identification of molecular markers linked to single Genes and QTL, Marker Assisted Selection (Marker Assisted Back cross Selection, Association mapping, Breeding by Design, Genome selection).

Resources:

- Alonso JM, Stepanova AN. (2015). Plant Functional Genomics: Methods and Protocols. Springer
- Chopra VL, Sharma RP, Bhat SR and Prasanna BM.(2007) Search for New Genes. Academic Foundation, New Delhi

- Hackett PB, Fuchs JA & Messing JW. 1988. An Introduction to Recombinant DNA Technology-Basic Experiment sin Gene and Manipulation.2nd Ed.Benjamin Publication Co.
- Primose SB & Tywman RM.2006.PrinciplesofGeneManipulationandGenomics.7th Ed. Wiley-Blackwell Publishing
- SambrookJ&RusselD.2001.MolecularCloning-aLaboratoryManual.3rd Ed. Cold Spring Harbor LaboratoryPress.
- SinghBD.2005. Biotechnology: Expanding Horizons.KalyaniPubl.
- Somers DJ, Langridge P, Gustafson JP.(2009). Plant Genomics: Methods and Protocols. Springer
- http://gramene.org
- https://www.arabidopsis.org
- https://wheat.pw.usda.gov
- http://ncbi.nlm.nih.gov
- http://www.maizegenetics.net

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Course Title: Population Genetics
Course Code: GPB 606
Credit Hours: 2 (2+0)

Theory

UNITI

Population: Properties of population, Mendelian population; Genetic constitution of a population through time, space, age structure etc.; Frequencies of genes and genotypes; Causes of change: population size, differences in fertility and viability, migration and mutation.

UNITII

Hardy-Weinberg equilibrium, Hardy-Weinberg law, Proof and applications of the HardyWeinberg law, Test of Hardy-Weinberg equilibrium; Mating frequencies: Non dominance, Codominance, Snyder'sratio, importance and its effect over random mating in succeeding generations.

UNITIII

Multiple alleles, More than one locus, Sex linked genes; Use of gene and genotypic frequencies evaluation in field population level; Interpretations-Changes of gene frequency, Migration, Mutation, Recurrent and non-recurrent Selection; Balance between selection and mutation; Selection favoring heterozygotes; Over dominance forfitness.

UNITIV

Mating systems , Random mating population, Nonrandom mating: selfing–inbreeding coefficient , panmictic index , sibmating , Assortative mating and disassortative mating; Pedigree populations and close inbreeding, Estimation of linkage disequilibrium, Correlation between relatives and estimation of F; Effect of inbreeding and sibbing in cross pollinated crops; Gene substitution and average effects; Breeding value- Genetic drift; Genetic slippage, Co-adapted gene complexes; Homoeostasis-Adaptive organization of gene pools; Polymorphism-Balanced and Non-balanced polymorphism, heterozygous advantage-Survival of recessive and deleterious alleles in populations.

Resources:

- Chawla V & Yadava RK. 2006. Principles of Population Genetics – A Practical Manual. Dept.of Genetics, CCSHAU Hisar.
- Falconer DS & Mackay J.1996. Introduction to Quantitative Genetics. Longman.
- Jain JP, Jain J & Parbhakaran VT. 1992. Genetics of Populations. South Asia Books.
- LiCC. 1955.PopulationGenetics. The Univ. of Chicago Press.
- MatherK&JinksJL.1982.BiometricalGenetics.Chapman&Hall.
- Sorrens D & Doniel G. 2007. Methods in Quantitative Genetics. Series: Statistics for Biology and Health. Likelihood.
- TomarSS.1992.Text Book of Population Genetics. Universal Publication

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Course Title: Breeding Designer Crops
Course Code: GPB 608
Credit Hours: 2 (1+1)

Theory:

UNIT I

Breeding of crop ideotypes ; Genetic manipulations through recombination breeding, genomics and transgenics for physiological efficiency, nutritional enhancement, special compounds-proteins, vaccines, gums, starch and fats.

UNIT II

Physiological efficiency as a concept, parametric and whole plant physiology in integrated mode; Physiological mechanism of improvement in nutrient use efficiency, water use efficiency, osmotic adjustment, photosynthetic efficiency, stay green trait and its significance in crop improvement; Breeding for special traits viz., oil, protein, vitamins, amino acids etc.; Eco specific ideotypes, Ideotypes for high and low moisture conditions, low and high input conditions, conversion mechanism of C_3 to C_4 plants; Determination of genetics of above mentioned traits.

UNIT III

Improvement in yield potential under sub-optimal conditions by manipulating source and sink, canopy architecture, plant-water relationships, effect of suboptimal conditions on cardinal plant growth and development processes, enhancing input use efficiency through genetic manipulations.

UNITIV

Concept of biopharming and development of varieties producing targeted compounds, nutraceuticals and industrial products; Success stories in vaccines, modified sugars, gums and starch through biopharming.

UNITV

Biosafety management, segregation and isolation requirements in designer crop production and post-harvest management.

Practical

- Demonstration of plant responses to stresses through recent techniques;
- Water use efficiency ,transpiration efficiency,
- Screening technique sunder stress conditions such as electrolyte leakage, TTC, chlorophyll fluorescence,
- canopy temperature depression, stomatal conductance, chlorophyll estimation,
- heat/drought/salt shock proteins

Resources:

- Balint A. 1984. Physiological Genetics of Agricultural Crops.
- AK Ademiaikiado. Hay RK. 2006. Physiology of Crop Yield. 2nd Ed. Blackwell.
- Pessarakli M. 1995. Handbook of Plant and Crop Physiology.
- Marcel Dekker. Tai zL & Zeiger E.2006. Plant Physiology.4th Ed. Sinauer Associates.

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Course Title: IPR and Regulatory Mechanism (e-course)
Course Code: GPB 609
Credit Hours: 1(1+0)

Theory:

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; 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 farmer's rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement

Resources:

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

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