MNS UNIVERSITY OF AGRICULTURE MULTAN

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APPROVED SCHEME OF STUDIES

B.Sc. (HONS.) AGRICULTURE

MAJOR – PLANT BREEDING AND GENETICS

INSTITUTE OF PLANT BREEDING AND BIOTECHNOLOGY

Approved vide	Meeting	Date
Academic Council	7th	09.08.2021
Syndicate	31st	10.10.2021

B.SC. (HONS.) AGRI. MAJOR PLANT BREEDING AND GENETICS

FOR SESSION 2021 AND ONWARDS

SEMESTER-IV

Proposed			
Course #	**Title**	**Credit Hours**	**Course Type**
PBG-402	Introductory Plant Breeding	3(2-1)	FC

SEMESTER-V (*Students will opt for 5 credit hours from elective courses*)

Proposed			
Course #	**Title**	**Credit Hours**	**Course Type**
PBG-501	Principles of Genetics	3(2-1)	Major
PBG-503	Breeding Field Crops	3(2-1)	Major
PBG-505	Cytogenetics	3(2-1)	Major
PBG-507	Germplasm Resources of Field Crops	3(3-0)	Major
PBG-509	Experimentation in Plant Breeding	3(2-1)	Major
Sub-Total Credit Hours		**15**	
PBG-511	Breeding for Plant Quality Traits	3(2-1)	Elective
PBG-513	Hybrid Seed Production Technology	3(2-1)	Elective
PBG-515	**Heteroploidy and Apomixis in Crop Breeding**	**2(1-1)**	**Elective**
PBG-517	Mutation Breeding in Crop Plants	2(1-1)	Elective
Total Credit Hours		**20**	

SEMESTER-VI (*Students will opt for 5 credit hours from elective courses*)

Course #	**Title**	**Credit Hours**	**Course Type**
PBG-502	Breeding Climate Smart Crops	3(2-1)	Major
PBG-504	Modern Concepts in Plant Breeding	3(2-1)	Major
PBG-506	Genetics and Breeding of Fibre Crops	3(2-1)	Major
PBG-508	Genetics and Breeding of Oilseed Crops	3(2-1)	Major
PBG-510	Genetics and Breeding of Vegetable Crops	3(2-1)	Major
Sub-Total Credit Hours		**15**	
PBG-512	Genetics and Breeding of High-value (Minor and Medicinal) Crops	3(2-1)	Elective
PBG-514	Genetics and Breeding of Sugar Crops	3(2-1)	Elective
PBG-516	Outreach in Plant Breeding	2(1-1)	Elective
PBG-518	**IPR and Variety Development**	**2(1-1)**	**Elective**
Total Credit Hours		**20**	

SEMESTER-VII (*Students will opt for 2 credit hours from elective courses*)

Course #	**Title**	**Credit Hours**	**Course Type**
PBG-601	Genetics and Breeding of Cereal Crops	3(2-1)	Major
PBG-603	Genetics and Breeding of Pulse Crops	3(2-1)	Major

PBG-605	Genetics and Breeding of Fodder and Forage Crops	3(2-1)	Major
PBG-607	Bioinformatics in Plant Breeding	3(2-1)	Major
PBG-609	Quantitative Genetics and Biometry	4(3-1)	Major
PBG-611	Preparation of Research Project and Scientific Writing	2(1-1)	Major
Sub-Total Credit Hours		**18**	
PBG-613	Bio-Safety Measures in GM Crops	2(1-1)	Elective
PBG-615	**Plant Genomics**	2(1-1)	Elective
Total Credit Hours		**20**	

SEMESTER-VIII

Course #	Title	Credit Hours	Course Type
PBG-612	Internship and External Evaluation	6(0-6)	Major

Revised

PBG-402 Introductory Plant Breeding 3(2-1) FC

Learning Objectives

The students will learn:

- Basic concepts of plant breeding
- **Exploitation and integration of variation in crop improvement**
- Application of breeding methods in crops and commercial seed production

Program Learning Outcomes

Sr.	CLOs	Domains	PLOs
1	Explain the basic principles and procedures of plant breeding	Cognitive	1
2	Describe variation, its sources and application in crop improvement	Cognitive	3
3	Identify an efficient and best suitable method in different prevailing conditions for seed production and commercialization.	Cognitive,	1,13

SDGs addressed in the course: (4) Quality Education

Teaching Mode: Blended learning

Theory

Introduction to plant breeding; **strategies of plant breeding**; Role of plant breeding in agriculture. **Reproduction of crop plants; types of reproduction, mechanism of self- and cross-pollination in crop plants**; Variation, the basis of plant breeding; sources of genetic variation, its creation and exploitation, heteroploidy, chromosomal aberrations, and mutation breeding; Breeding methods of self- and cross-pollinated; **Heterosis: fertility regulating mechanisms,** breeding hybrid cultivars; Vegetatively propagated crop plants; Cultivar release and commercial seeds production.

Practical

Flower structure and modifications; mode of pollination, selfing and crossing techniques in wheat, cotton, maize, rice, gram, brassica, sorghum, soybean, and tomato.

Textbook

1. **J.M. Poehlman. 1987. Breeding Field Crops. 3rd Ed. Springer Science Business Media, LLC, Heidelberg, Germany.**

Suggested Readings

1. Sleper, D.A. and J.M. Poehlman. 2006. Breeding Field Crops. 5th Ed. Blackwell Publishing Company, Ames, Iowa, USA.
2. **Singh, B.D. 2003. Plant Breeding: Principles and Methods. Kalyani Publishers, New Delhi, India.**
3. **Brown J and Peter. D.S. Caligari. 2008. An introduction to plant breeding. Blackwell Publishing Company, Oxford, UK.**
4. **Faqir. M and H. Dawood. 2018. Statistical Methods and Data Analysis. 6th Ed. Kitab Markaz Amin Pur Bazar, Faisalabad, Pakistan.**

PBG-501 Principles of Genetics 3(2-1)

Learning Objectives

The students will learn:

- **The principles of inheritance as formulated by Mendel.**
- **The principles of extensions to Mendelian inheritance, including multiple allelism, lethal alleles, gene interactions, and sex-linked transmission**
- **The basic principles of DNA structure, replication, transcription and translation**

Program Learning Outcomes

Sr.	CLOs	Domains	PLOs
1	Explain the Basic principles of DNA structure, replication, transcription and translation	Cognitive	1
2	Differentiate the Mendelian and non-Mendelian modes of inheritance	Cognitive	1
3	Describe the application of genetic principles in crop improvement	Cognitive	4

SDGs addressed in the course: (2) Zero Hunger

Teaching Mode: Blended learning

Theory

Concepts in Mendelian Genetics; Multiple alleles, multiple factors and pleiotropic inheritance; Gene interaction; Sex-linked inheritance: sex influenced and sex limited traits; Population Genetics; **Quantitative Genetics**; Linkage and crossing over: Three-point and multipoint tests; Extra chromosomal inheritance; Evidences of DNA as hereditary material; Structure of DNA and its replication; Mutations and their consequences; Molecular basis of gene, Genetic codes; Gene expression and its control; Genetic transformation; **Epigenetics and its role in gene expression.**

Practical

Exercise for inheritance determination using plants, animals and human's data, Construction of models for DNA structure, replication, transcription and translation

Text Book

1. **Brooker, R. J. 2012. Genetics: Analysis and Principles. 5th Ed. McGraw-Hill, New York, NY, USA.**

Suggested Readings

1. **Alberts, B., Johnson A., Lewis J., Raff M., Roberts K. and Walter P. 2008. Molecular Biology of the Cell. 5th Ed. Garland science, Taylor & Francis Group. Madison Avenue, New York, NY, USA.**
2. Khan I. A., F. M. Azhar, Z. Ali and A. A. Khan. 2008. Solving Numerical Genetic Problems. Dept. Plant Breed. Genet. Uni. Agri. Faisalabad, Pakistan.
3. **Pierce, B. A. 2012. Genetics A Conceptual Approach. 4th Ed. W. H. Freeman and Company New York, NY, USA.**

PBG-502 Breeding Climate Smart Crops 3(2-1)

Learning Objectives

The students will learn:

- Significance of climate change, climate smart agriculture
- Breeding approaches for climate smart ideotypes
- Genes and traits for climate resilience crops

Program Learning Outcome

Sr.	CLOs	Domains	PLOs
1	Explain the influence of environment on plant growth, crop yields, and ways to modify the environment to improve plant growth and yields	Cognitive	5
2	Comprehend the plant response at molecular level to climate change	Cognitive	5
3	Evaluate the strategies and procedures to breed climate smart varieties	Psychomotor	4

SDGs addressed in the course:

(13) Climate action

Teaching Mode: Blended learning

Theory

Effects of climate change on agriculture; Climate smart agriculture: Climate smart breeding, breeding targets; Role of phenotypic plasticity in plant adaptation to erratic climate changes; Molecular responses of plants to environmental signal; Breeding and selection methods to transfer stress tolerance traits: Key functional genes and traits for climate smart ideotypes; Breeding approaches: phenotyping, genotyping, genome-wide association, gene expression analysis, gain/loss of function analysis; **Broadening genetic base of climate smart crops and their introduction;** Role of participatory or ecology specific breeding to cope erratic climate changes; Role of phenomics in breeding climate smart crops.

Practical

Designing for climate smart ideotypes of major crops for various ecological zones of Pakistan; Screening of germplasm for stress tolerance in laboratory and field: Phenotyping through image analysis, Recording of stress responsive traits in different crops under greenhouse and laboratory conditions; Methods to study physiological **and biochemical** parameters under stress conditions; Statistical analysis and interpretation of data regarding tolerance related traits.

Text Book

1. **Yadav, S.S., R.J. Redden, J.L. Hatfield, A.W. Ebert, and D. Hunter. 2019. Food Security and Climate Change. John Wiley & Sons Ltd, West Sussex, UK.**

Suggested Readings

1. Ashraf, M. and P. J. C. Harris. 2005. Abiotic Stresses: Plant Resistance through Breeding and Molecular Approaches, Haworth Press, Binghamton, New York, USA.
2. **Fritsche-Neto R. and A. Borem. 2012. Plant Breeding for Abiotic Stress Tolerance. Springer-Verlag Berlin Heidelberg, Germany.**
3. Kole, C. (Ed.). 2013. Genomics and Breeding for Climate-resilient Crops. Springer-Verlag Berlin Heidelberg, Germany
4. Sutton, W.R., J.P. Srivastava and J.E. Neumann. 2013. Looking Beyond the Horizon: How Climate Change Impacts and Adaptation Responses Will Reshape Agriculture in Eastern Europe and Central Asia. Directions in Development. Washington, DC,World Bank, USA.

PBG-503 Breeding Field Crops 3(2-1)

Learning Objectives

The students will learn:

- **Significance of plant breeding methods**
- Strategies and methods in plant breeding
- Application of breeding methods

Program Learning Outcomes

Sr.	CLOs	Domains	PLOs
1	Know the basic knowledge of plant breeding including genetic variability and its exploitation in plants.	Cognitive	1
2	Elaborate the breeding methods used in self-pollinated and cross pollinated crops and concepts of hybrids, and male sterility for crop improvement.	Cognitive	5
3	Apply the knowledge for the development of new cultivars to feed the ever increasing population.	Psychomotor	8

SDGs addressed in the course

(1) No poverty

(2) Zero hunger

Teaching Mode: Blended learning

Theory

Plant breeding: Introduction, history and achievements, objectives and strategies; Genetic variability: basis of plant breeding methods, scales of variability; Threshold characters: penetrance and expressivity; Breeding methods in self-, cross-pollinated and asexually propagated crops; Development of doubled haploids, mutation breeding, polyploidy breeding and distant hybridization; **Speed Breeding: basic mechanism, scope and applications; Introgression Breeding: Development of RILs, BILs, NILs;** Heterosis: genetic basis and exploitation; Male sterility and self-incompatibility: types of male sterility and genetic resources, genetic mechanisms, exploitation and application in field crops: Fertility restoring mechanism; Ideotype breeding: concept, types and limitations; **Molecular Breeding techniques; Role of biotechnology in plant breeding; Scope and importance;** Release of new varieties, quality seed and its classes, maintenance of improved seed.

Practical

Maintenance of segregating populations, inbred lines and progeny lines; Selfing, emasculation and crossing techniques in various crops; **Techniques to develop male sterile an restorer lines; Data recording and maintenance of introgression lines; Descriptors for morphology, physiology and**

biochemical indicators in crop breeding/varietal prospective; Maintenance assessment of variability in segregating and non-segregating populations.

Text Book

1. Sleper, D.A. and J.M. Poehlman. 2006. Breeding Field Crops.5th Ed. Blackwell Publishing Company, Ames, Iowa, USA.

Suggested Readings

1. Acquaah, G. 2007. Principles of Plant Genetics and Breeding. Blackwell Publishing, Malden, Massachusetts, USA.
2. Chahal, G. S. and S. S. Gosal. 2002. Principles and Procedures of Plant Breeding: Biotechnological and Conventional Approaches. Alpha Science International Ltd. Pangbourne, UK.
3. Singh, B.D. 2003. Plant Breeding: Principles and Methods. Kalyani Publishers, New Delhi, India.

PBG-504 Modern Concepts in Plant Breeding 3(2-1)

Learning Objectives

The students will learn:

- **The concept and principles of advanced molecular approaches.**
- **Modern breeding techniques and methods.**
- **Advanced molecular techniques in plant breeding to provide a step-change in crop productivity.**

Program Learning Outcomes

Sr.	CLOs	Domains	PLOs
1	Explain the basic concept and principles of molecular biology and molecular techniques.	Cognitive	1, 4
2	Comprehend recent molecular techniques and methods to exploit genetic resources of different agricultural crops.	Cognitive	2, 3
3	Compare different modern molecular techniques to set-up smart breeding strategies for innovative solutions	Psychomotor	5, 8

SDGs addressed in the Course

(3) Good health and well-being.

Teaching Mode: Blended learning

Theory

Concept of molecular biology; Introduction to modern techniques: DNA amplification and Polymerase Chain Reaction, DNA fingerprinting, gene mapping and sequencing; Genomics tools: molecular markers and marker assisted selection in plant breeding; Phenomics and proteomics in plant breeding; *In-vitro* culture techniques; Methods of genetic transformation; Biotechnological approaches to develop tolerance/resistance against biotic and abiotic stresses; Importance of transgenic plants

Practical

Safety measures in the biotech laboratories; Orientation to various lab equipment; Introduction to aseptic techniques: autoclaving, sterilization, use of laminar flow and fume hoods; Stock-solutions and media preparation; Isolation, handling, and quantification of DNA; Preparation of gels: Ladder markers, Restriction digestion, electrophoresis, Gel documentation.

Textbook

1. **Brown, T. A., 2016. Gene Cloning and DNA Analysis: An Introduction; 7th Edition, John Wiley and Sons Ltd Chicester, UK.**

Suggested Readings

1. **Bilgrami, K. S. and A. K. Pandey. 1992. Introduction of Biotechnology. CBS Publishers & Distributers, New Delhi, India.**
2. **Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Scott, M. P., Bretscher, A. and Matsudaira, P. 2008. Molecular cell biology. 6th Edition. W. H. Freeman and Company, New York, NY, USA.**
3. Paul, C and K. Harry. 2004. Handbook of Plant Biotechnology. John Willy & Sons Inc, New York, USA
4. Razdan, M. K. Ed.. 2003. Introduction to Plant Tissue Culture. Science Publishers, Enfield, New Hampshire, USA.

PBG-505 Cytogenetics 3(2-1)

Learning Objectives

The students will learn:

- Structure and functions of cell organelles
- Chromosomal structure, number, functions and their abnormalities
- Role of cytogenetics in crop improvement

Program Learning Outcomes

Sr.	CLOs	Domains	PLOs
1	Describe the evolution, structure, functions of cell organelles and role in inheritance	Cognitive	1
2	Explain the chromosome packing, types of chromatin and anomalies	Cognitive	4
3	Identify the best cytogenetic tools for crop improvement	Psychomotor	3

SDGs addressed in the course:
(8) Decent work and economic growth
Teaching Mode: Blended learning

Theory

Cytogenetics: Introduction, tools and techniques; Plant cell organelles: evolution and role in inheritance; Chromosomes: morphology, fine structure and functions; Heterochromatin and euchromatin; Organisation/packaging of DNA and proteins in chromosomes; Specialized chromosomes: Polytene chromosomes, lambrush chromosomes, B chromosomes; Karyotype characteristics and construction of ideograms; Arm ratio and centromere index; Genetic regulation of cell cycle; Cytological differences in mitosis and meiosis. Heteroploidy: types and characteristics, structural changes in chromosomes and their effects; Chromosome banding techniques and mapping; **Modern techniques of cytogenetics: basic principle and examples of FISH and GISH techniques;** Flow cytometry for chromosome analysis.

Practical

Microscopy: Types and techniques; Micrometry; Preparation of different solutions: preservatives, fixatives and stains for mitotic and meiotic study of chromosomes; Identification and collection of materials suitable for cytogenetic studies; Pollen viability and germination test; Use of colchicine for chromosome duplication, Pollen and cell culture through artificial media.

Text Book

1. **Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Scott, M. P. Bretscher, A., Matsudaira, P. 2008. Molecular cell biology. 6th Ed. New York, USA.**

Suggested Readings

1. Campbell, N. A., L. G. Mitchell and J. B. Reece. 1994. Biology; concepts and connections. The Benjamin/ Cummings Publishing Co, Inc, New York, USA.
2. Singh, R.J. 2002. Plant Cytogenetics. CRC Press, New York, NY, USA.
3. Sumner, A.T. 2003. Chromosome: Organization and Function. Blackwell Publishing Co, Oxford, UK.
4. Weaver, R. F. 2002. Molecular Biology 2nd Ed. McGraw Hill Company Inc, NY, USA.

PBG-506 Genetics and Breeding of Fibre Crops 3(2-1)

Learning Objectives

The students will learn:

- **Evolution of various fiber crops**
- **Genetic basis of yield, quality, stress resistance, colored and transgenic cotton improvement in fiber crops**
- Issues, problems and solutions in the breeding and production of various fibre crops with a special emphasis on the cotton crop

Program Learning Outcomes

Sr.	CLOs	Domains	PLOs
1	Describe the basic genetic concept about evolution, transgenics and germplasm resources of cotton	Cognitive	1, 2
2	Demonstrate skills on problem identification and scientific data recording from field visits	Psychomotor	4
3	Identify, analyze and suggest solutions for the major threats to cotton production in the region	Psychomotor	11

SDGs addressed in the course

(1) No poverty

(3) Good health and well being

Teaching Mode: Blended learning

Theory

Fiber Crops: origin, history and classification of fibers; Various species in fibre crops; Preservation and utilization of germplasm in fibre crops Breeding work done on cotton, jute and other fibre crops; Evolution of tetraploid cotton; Cotton genomics; Transgenic Cotton: contemporary issues in transgenic cotton production; Breeding climate smart cotton: breeding objectives, accomplishments, and methods in cotton and other fiber crops, hybrid breeding in cotton; Molecular breeding and cotton genome mapping for crop improvement; Introduction to CLCuD: genome organization of CLCuD, source of resistance/tolerance against CLCuD, gene pyramiding for the development of virus tolerant varieties; Research on Bt cotton in Pakistan; Wide Hybridization in cotton improvement; Ideotype in cotton breeding; Salient features of wild and cultivated species of *Gossypium*, Utilization of wild species of *Gossypium* in breeding programs, Insect pest resistance and components of genetic defense umbrella, R gene mediated resistance, nomenclature of resistance genes; Organic and colored cotton; Cotton fiber quality traits, cotton fibre developmental stages, linear growth mode of fibre cell, control of fiber elongation; Control of fiber maturity; cellulose synthesizing machinery and its deposition; Cotton fibre: a model to study plant cell wall; Cotton fibre genomics: transcriptome profiling, gene families involved in fibre development, strategies to

improve cotton fiber quality, prospects of genetic engineering in improvement of fiber crops. Cotton seed processing and storage. Breeding cotton for resistance to insect pests and diseases. Development of transgenic cotton. Research on *Bt* cotton in Pakistan. Prospects of genetic engineering in improvement of fiber crops.

Practical

Cotton descriptors; Selfing and crossing techniques in fiber crops; Identification of different wild and cultivated species and varieties of cotton; Identification of insect pests and diseases of cotton plant; Visit to HVI lab and testing of fibre quality traits; Identification of cotton defense umbrella traits; Collection of data on different quantitative characters of cotton and calculation of variances, heterosis and estimate of heritability. Methods of measuring cotton fibre strength, fineness and maturity; Data recording on plant and fibre characters and genetic analyses; **Research institutes working on cotton; Cotton genomic databases; Cotton species sequencing and resequencing.**

Text Book

1. Sleper, D.A. and J.M. Poehlman. 2006. Breeding Field Crops. 5th Ed. Iowa State University Press, Ames, Iowa, USA.

Suggested Readings

1. Basra, A. S. Ed. 1999. Cotton Fibers: Developmental Biology, Quality Improvement, and Textile Processing, Haworth Press, New York, USA.
2. **Paterson, A. H. Ed. 2008. Genomics of Cotton. New York, NY, USA Springer.**
3. Shiron, J. Ed. 2004. Transgenic cotton. Science Pren 16 Dong Huang Chenggen, Beijing, China.
4. Wakelyn, P. J. and M. R. Chaudhry. 2010. Cotton: Technology for the 21st Century. ICAC Washington DC, USA.
5. **Wendel, J. F., Brubaker, C., Alvarez, I., Cronn, R., & Stewart, J. M. 2009. Genetics and genomics of Cotton. Springer, New York, NY. USA.**

PBG-507 Germplasm Resources of Field Crops 3(2-1)

Learning Objectives

The students will learn:

- Importance of biodiversity and germplasm in plant breeding
- Strategies related to germplasm collection and conservation
- Novel techniques in germplasm identification and preservation

Program Learning Outcomes

Sr.	CLOs	Domains	PLOs
1	Explain the significance of genetic resources in plant breeding	Cognitive	2
2	Describe the procedures related to germplasm collection, maintenance and conservation	Cognitive	2
3	Demonstrate about novel techniques in germplasm identification and preservation	Psychomotor	8

SDGs addressed in the course

(2) Zero Hunger

(15) Life and land

Teaching Mode: Blended learning

Theory

Importance of plant genetic resources; Origin and distribution patterns of different crop species; Gene pool and its various types, basic and derived genetic resources; Principles and strategies of exploration, collection, **evaluation, documentation, distribution and utilization; Germplasm**

collection and its types: base collection, backup collection, active collection, working collection, core collections and mini core collections; Managing plant genetic resources: regeneration of accession, monitoring seed viability and genetic integrity during harvest and storage; Molecular and genomic techniques in identification and preservation; *In-situ*, *ex-situ* conservation, *in-vitro* and on-farm types of germplasm conservation; Short, medium and long-term strategies for conservation of orthodox and recalcitrant seed; Introduction and exchange of germplasm with its legislation

Practical

Utilization of different databases of various crops and role their usage in crop improvement; Application of genetic data for germplasm management and identification; Visit of different national level germplasm resource centres; Introduction to international organizations for PGR management; Germplasm import procedure; Visit to plant quarantine and phytosanitary station and phytosanitation certification procedure

Text Book

1. Smale, M. 2005. Valuing crop biodiversity: on-farm genetic resources and economic change. CABI Publishing, Massachusett, USA.

Suggested Readings:

2. **Xu, Y. 2010. Molecular plant breeding. CABI Publishing, Boston, Massachusett, USA.**
3. **Khan, A.S., Ali, Z. and N. Islam. 2018. Plant Breeding. University of Agriculture Faisalabad. MAS Computers, Press Market, Aminpur Bazar, Faisalabad, Pakistan.**
4. Sleper, D.A. and J.M. Poehlman. 2006. Breeding field crops. No. Ed. 5. Blackwell publishing, Ames, Iowa, USA.
5. Rao, R., and G. Corrado. 2018. Plant Genetics and Biotechnology in Biodiversity. Multidisciplinary Digital Publishing Institute. Switzerland.

PBG-508 Genetics and Breeding of Oilseed Crops 3(2-1)

Learning Objectives

The students will learn:

- **Significance and status of oilseed crops**
- **Genetic basis of yield and quality related traits and their improvement**
- **Constraints and solutions related to oilseed breeding and future vision of improvement**

Program Learning Outcomes

Sr.	CLOs	Domains	PLOs
1	Explain the basic concepts genetics and breeding of oilseed crops	Cognitive	1
2	Elaborate techniques used in the field of breeding of oilseed crops	Cognitive	3
3	Develop research interest to address local problems regarding oilseed breeding in Pakistan	Psychomotor	7

SDGs addressed in the course

(2) Zero Hunger

(3) Good health and well being

Teaching Mode: Blended learning

Theory

Oilseed crops: Introduction, conventional and non-conventional crops, Origin, classification and importance; Role of edible oilseeds in agriculture and economy of Pakistan; Oil yield and quality parameters and its constraints; Strategies for genetic improvement: Seed/oil yield and quality parameters; Genetic diversity and its exploitation; Genetics of qualitative and quantitative traits; Breeding objectives; Modified methodologies and selection procedures: recurrent selection, general and specific combining ability, use of back cross; male sterility, genetics of male sterility

mechanisms and techniques and implementation for its induction for hybrid seed production; Exploitation of heterotic potential, development of inbred lines, synthetics, hybrids and polycrosses; **Genomics and marker based selection in oilseed crops.**

Practical

Identification of different oilseeds: their reproductive biology; Estimation of oil quality; Development of hybrid populations of oilseed crops; Selection practices in segregating populations; **Use of oilseed crop specific databases for modern breeding;** Visit to various research institutes

Text Book

1. **Gupta, S.K. 2016. Breeding oilseed crops for sustainable production: opportunities and constraints. Academic press, London, UK.**

Suggested Readings

1. Bos, I. and P. Caligari. 2008. Selection Methods in Plant Breeding. 2nd Ed. Springer, Dordrecht, Netherlands.
2. Kimber, D. 1995. Brassica Oilseeds: Production and Utilization. Cambridge University Press, Wallingford, Oxon, UK.
3. Kole, C. 2007. Oilseeds. Springer Berlin Heidelberg, New York. USA.
4. Nagata, T. and S. Tabata Ed. 2003. Brassica and Legumes - From Genome Structure to Breeding. Springer Verlag, New York, USA.

PBG-509 Experimentation in Plant Breeding 3(2-1)

Learning Objectives

The students will learn:

- **The basic statistical principles relevant to data analysis in plant breeding programmes.**
- **The use of statistical methods, particularly those of experimental design, correlation, regression etc. to be able to interpret the results correctly.**
- **To use the computer software useful for statistical analyses of plant breeding data.**

Program Learning Outcomes

Sr.	CLOs	Domains	PLOs
1	Describe the basic concepts of experimental designs, their layout and relative importance.	Cognitive	4
2	Apply the management, analysis and interpretation of real data from experiments common to plant breeding.	Psychomotor	6
3	Demonstrate the use of computer software for the analysis of experimental data.	Psychomotor	8

SDGs addressed in the course

(4) Quality education

(8) Decent work and economic growth

Teaching Mode: Blended learning

Theory

Principles: types and layout of experimental designs; Basic statistics of variability and comparison tests; Concepts of variances: heritability estimation in segregating and non-segregating populations; Components of variance (genetic and environmental) from expected mean squares for heritability estimation; Selection intensity, selection differential and response to selection, realized heritability and expected genetic advance; Analysis of data from a series of experiments; Measuring competition effects; Regression and correlation analysis; Concept of biplot, its analysis and application.

Practical

Use of softwares for estimation of basic statistics. Construction of ANOVA. Solving numerical problems to estimate genetic, environmental and phenotypic variances/co-variances from ANOVA/ANCOVA. Biplot analysis, Cluster analysis, correlation and path analysis

Text Book

1. Gomez, K.A. and A.A. Gomez. 1984. Statistical Procedures for Agricultural Research. 2nd Ed. John Wiley and Sons, New York, USA.

Suggested Readings

1. Dougals. C and Montgomery**. 2017. Designs and analysis of Experiments. (9th Ed.). John Wiley and Sons, Arizona, USA.**
2. **Pierce B.A. 2012. Genetics a conceptual approach. 4th Ed. W. H. Freeman and company, New York. USA.**
3. Singh, R.K. and B.D. Chaudhary. 2004. Biometrical Methods in Quantitative Genetic Analysis. Kalyani Publishers, New Delhi, India.
4. **Faqir. M and H. Dawood. 2018. Statistical Methods and Data Analysis. 6th Ed. Kitab Markaz Amin Pur Bazar, Faisalabad, Pakistan.**

PBG-510 Genetics and Breeding of Vegetable Crops 3(2-1)

Learning Objective

The students will learn:

- **Traditional and molecular breeding methods for the enhancement of vegetable crops.**
- **Methods of hybrid seed production in major vegetables.**
- **knowledge of short-term and long-term goals for vegetable breeding**

Program Learning Outcomes

Sr.	CLOs	Domains	PLOs
1	Know the significance and diversity of different vegetables.	Cognitive	2
2	Recall the breeding objectives and breeding methods of different vegetable crops.	Cognitive	4
3	Develop the ability to plan work, use time effectively and manage small projects related to the vegetable breeding.	Psychomotor	9,11

SDGs addressed in the course

(1) No Poverty

(2) Zero Hunger

(3) Good Health and well being

Teaching Mode: Blended learning

Theory

Introduction, classification and significance of vegetable crops; Vegetable seed industry scenario in Pakistan and Worldwide; Reproductive systems and breeding objectives of important vegetable crops; Breeding and hybridization constraints and improvement strategies; Hybrid seed production; Genetics and breeding for quality, biotic and abiotic stresses, shelf-life, **peri-urban** and off season cultivation; **Trends in commercial vegetable production: tunnel farming and hydroponics;** Role of biotechnology and molecular techniques for improving vegetable crops.

Practical

Reproductive biology of important vegetables; Selfing and crossing techniques in major vegetables; Layout of field experiments and data recording for various parameters; **How to become an organic inspector;** Visit to research stations.

Text Book

1. **Ram, H. H. 2013. Vegetable Breeding: Principles and Practices. 3rd Ed. Kalyani publishers, Ludhiana, India.**

Suggested Readings

1. Jaime P and F. Nuez. 2007. Vegetables I: Asteraceae, Brassicaceae, Chenopodicaceae, and Cucurbitaceae. Vol. 2. Springer Science & Business Media, New York, USA.
2. **Jaime P and F. Nuez. 2007. Vegetables II: Fabaceae, Liliaceae, Solanaceae, and Umbelliferae. Vol. 2. Springer Science & Business Media, New York, USA.**
3. **Sinha, N., Hui, Y.H, Evranuz, E.Ö, Siddiq, M, and Ahmed, J. 2010. Handbook of vegetables and vegetable processing. 1st Ed. John Wiley & Sons, Iowa, USA.**
4. **Tychonievich, J. 2013. Plant breeding for the home gardener: how to create unique vegetables and flowers. 1st Ed. Timber Press, Portland, Oregon, USA.**

PBG-511 Breeding for Plant Quality Traits 3(2-1)

Learning Objectives

The students will learn:

- Standards of quality traits and their evaluation
- Evaluation of quality parameters in crops
- **Hidden hunger and solutions to address it**
- **To analyze the nutritional scenario in the world and expectations with biofortification**

Program Learning Outcomes

Sr.	CLOs	Domains	PLOs
1	Describe the genetic basis of breeding for quality parameters in plants	Cognitive	1
2	Explain the association of quality standards with sustainability of crops yields	Cognitive	9
3	Analyze the procedures regarding plant quality traits improvement in crop plants	Affective	5

SDGs addressed in the course:

(3) Good health and well being

Teaching Mode: Blended learning

Theory

Defining the quality aspects of crop products; **Factors affecting crop quality (genetics, environmental and cultural), main management practices affecting crop quality (e.g. hormones and plant bio regulators); Fruit maturation and ripening;** Role of WTO in classification and standardization of quality parameters; Quality standards in various crops; Relationship of crop quality with yield and yield components; Techniques and procedures to evaluate quality traits in different crops; Genetic improvement of quality traits in different crops; **Developing biofortified staple crops; Role of biotechnology for improvement of quality traits.**

Practical

Descriptors of quality for different economic parts of plants; Instrumentation in evaluation of quality parameters in crop plants; Techniques for measuring quality traits in various crops; **Tools for predicting the harvesting time of crops;** Visits to research Stations/institutes.

Text Book

1. Gupta, U. S. 2000. Crop Improvement: Quality Characters. (Vol 3). Science Publishers Incorporated, New Delhi, India.

Suggested Readings

1. A.O.C.S. 1999. Official and Tentative Methods of the American Oil Chemists Society. Chicago, Illinois, USA.
2. A.S.T.M. 1999. Standards on Textile Materials. Amer. Soc. for Testing and Materials, Philadelphia, USA.
3. **Connor D.J., Loomis R.S, Cassman K.G. 2012. Crop Ecology - Productivity and Management in Agricultural Systems. 2nd Ed. Cambridge University Press, Cambridge. UK.**
4. Jullano, B. O. 1993. Grain Quality Evaluation of World Rices, IRRI, Manila, Philippines.

PBG-512 Genetics and Breeding of High-value (Minor and Medicinal) Crops 3(2-1)

Learning Objectives

The students will learn:

- **Reproductive systems of different minor crops in Pakistan**
- **Sources and types of genetic variation and their importance for plant improvement**
- **How important traits can be integrated in breeding programs of minor crops**

Program Learning Outcomes

Sr.	CLOs	Domains	PLOs
1	Explain the importance of minor crops in the scenario of climate change	Cognitive	2
2	Describe breeding methodologies appropriate for different minor crops with different mating system	Cognitive	4
3	Apply the conventional and modern tools of genetic manipulation, for quality breeding under biotic and abiotic stresses	Psychomotor	5,6

SDGs addressed in the course:

(2) Zero Hunger

(13) Climate action

Teaching Mode: Blended learning

Theory

High-value crops: introduction, classification and significance of minor and medicinal crops; Reproductive systems and breeding objectives of important minor and medicinal crops; History of using plants for medicinal purposes; Germplasm collection, evaluation, and diversity in medicinal plants; Genetic variability of minor crops. Genetics of important plant traits and methods for genetic improvement; Breeding and hybridization: constraints and improvement strategies; Hybrid seed production; **Speed breeding of minor crops;** Breeding for quality, biotic and abiotic stresses; Role of biotechnology and molecular techniques for improving minor and medicinal crops.

Practical

Reproductive biology of important minor and medicinal plants; Techniques to overcome the problems of crossing minor and medicinal crops; Selfing and crossing techniques in minor and medicinal plants; Genetic problems to develop hybrid varieties; Layout of field experiments and data recording for various genetic parameters; Handling of segregation generations; Measurement of economic yield and medicinal value related traits; Visit to research stations.

Text Books

1. Sleper, D.A. and J.M. Poehlman. 2006. Breeding Field Crops. 5th Ed. Iowa State University Press, Ames, Iowa, USA.
2. Yaniv, Z. and U. Bachrach. 2005. Handbook of Medicinal Plants. The Haworth Press Inc, New York, USA.

Suggested Readings

1. Heywood, V. 1991. Conservation of Medicinal Plants: International Consultation Papers. World Conservation Union, World Health Organization, World Wide Fund for Nature. Cambridge University Press, UK.
2. **Jain, S. M., and S. D. Gupta. 2013. Biotechnology of Neglected and Underutilized Crops. Springer, New York, USA.**
3. Johnson, C.B. and C. Franz. 2002. Breeding Research on Aromatic and Medicinal Plants. The Haworth Press Inc, New York, USA.

PBG-513 Hybrid Seed Production Technology 3(2-1)

Learning Objectives

The students will learn:

- **Genetic mechanisms behind heterosis and fertility regulating mechanisms.**
- **Benefits of hybrid seed over conventional varieties**
- Limitations and IPR issues in hybrid seed production

Program Learning Outcomes

Sr.	CLOs	Domains	PLOs
1	Compare the benefits of hybrid seed production over conventional methods of seed production.	Cognitive	4
2	Analyze the different methods of hybrid seed production and identify the differences between cytoplasmic and genetic male sterility.	Cognitive	8
3	Comprehend and apply methods of producing inbred lines and progeny testing required for hybrid seed production.	Psychomotor	5

SDGs addressed in the course

(2) Zero hunger

(3) Good health and well being

Teaching Mode: Blended learning

Theory

Heterosis: concepts and its genetic basis, development of inbred line; Inbreeding depression in cross-pollinated crops; Male sterility: types and limitations, development of male sterile lines through conventional and modern approaches; Types and estimation of combining ability; Broad versus narrow based testers; Hybrid seed production in various crops; **Compare the benefits of hybrid seed over traditional farming; Constraints related to Hybrid seed production and their solutions;** Procedures for Hybrid seed Multiplication and Commercialization; **BLA technology for hybrid seed production**; Limitations and IPR issues in hybrid seed production.

Practical

Development, identification and maintenance of inbred lines, sterile lines and restorer lines, and layouts for hybrid seed development; Estimation of heterosis and combining abilities; Visit to research stations/organizations working on hybrid seed production

Textbook

1. Sleper, D.A. and J.M. Poehlman. 2006. Breeding Field Crops. 5th Ed. Iowa State University Press, Ames, Iowa, USA.

Suggested Readings

1. **Bos, I. and P. Caligari. 2008. Selection Methods in Plant Breeding. 2nd Ed. Springer, Dordrecht, Netherlands.**
2. **Khan, A.S., Z. Ali and N. Islam. 2018. Plant Breeding. Dept. Plant Breed. Genet. Uni. Agri. Faisalabad.**

3. Singhal, N. C. 2003. Hybrid Seed Production in Field Crops. Kalayani Publishers, New Delhi, India.
4. **Yadav, S.S., R.J. Redden, J.L. Hatfield, A.W. Ebert, and D. Hunter. 2019. Food Security and Climate Change. John Wiley& Sons Ltd, West Sussex, UK.**

PBG-514 Genetics and Breeding of Sugar Crops 3(2-1)

Learning Objectives

The students will learn:

- Significance and status of sugar crops
- Genetic systems in sugar crops
- Constraints and solutions related to breeding and seed production of sugar crops

Program Learning Outcomes

Sr.	CLOs	Domains	PLOs
1	Explain the basic system of sugar crops and their economic significance	Cognitive	1
2	Describe the genetic basis of yield and quality related traits and their improvement	Cognitive	3
3	Identify the problems with suitable solution related to seed production and cultivation of sugar crops	Affective	8

SDGs addressed in the course:

(2) Zero hunger

(7) Affordable and clean energy

Teaching Mode: Blended learning

Theory

Sugar crops: introduction, origin, classification and botanical features; Genetics of *Officinarum* canes, their evolution and present status; Flowering: a breeding constraint, artificial induction of flowering and hybridization techniques; Philosophy of sugarcane breeding; Selection strategies and evolution of new clones; Exploitation of somaclonal variation and micropropagation for improvement of sugarcane; **Products and** by-products of sugarcane; **Sugarcane as a source of bio and renewable energy; Breeding for better sugarcane processing;** Sugarbeet: botany, genetics, induction of flowering and breeding objectives; Agro-ecological and industrial problems being faced for adaptation of sugarbeet in Punjab; Seed production strategies; Alternate sources of sugar.

Practical

Identification of sugarcane species and varieties; Growing of fuzz and evaluation of nursery; Development of clones from seedling population; Estimation of brix value of sugar plant; Estimations of losses due to ratoon crop of sucrose content and cane yield; **Procedure of sugarcane processing;** Morphogenetic features of sugar beet. Evaluation of quality parameters in sugarcane and sugar beet; Visit to sugar industries/research institutes.

Text Book

1. **Malik, K. B. 2010. Cane and sugar production. Punjab Agricultural Research Board. Punjab, Pakistan.**
2. **Draycott., A. P. 2007. Sugar Beet. Blackwell Publishing Company, Ames, Iowa, USA.**

Suggested Readings

1. **Biancardi, E. L.G. Campbell. G.N. Scaracis and M.D. Biaggi. 2005. Genetics and Breeding of Sugar Beet. Science Publishers, Plymouth, UK.**
2. Jaggard, K. W. (Ed.) 1989. Sugar Beet; A Grower's Guide. Sugar Beet Research and Education Committee, London, UK.
3. **Kole, C., R. J. Henry. 2010. Genetics, Genomics and Breeding of sugarcane. . Science Publishers, Enfield, New Hampshire, USA.**
4. Sleper, D.A. and J.M. Poehlman. 2006. Breeding Field Crops. 5th Ed. Iowa State University Press, Ames, Iowa, USA.

PBG-515 Heteroploidy and Apomixis in Crop Breeding 2(1-1)

Learning Objectives

The students will learn:

- Mechanisms of Heteroploidy
- Apomixes and its use in crop breeding
- Development of synthetic polyploids

Program Learning Outcomes

Sr.	CLOs	Domains	PLOs
1	Explain the genetic basis of polyploids in crop plants	Cognitive	3
2	Comprehend the significance of polyploids and apomixes in plant breeding	Cognitive	5
3	Apply the knowledge to play a role in crop improvement	Affective	7

SDGs addressed in the course:

(4) Quality Education

Teaching Mode: Blended learning

Theory

Heteroploidy: types, occurrence in crop plants, euploidy, aneuploidy, allopolyploids, autopolyploids; Producing haploid and doubled haploid plants; Polyploidy series in crop plants; Apomixes: types, occurrence, indicators and confirmation; Genetics of polyploidy and apomixis and exploitation in crop breeding; Apomixis to fix heterosis, concept of single line hybrid; **Procedures to identify the** polyploids and apomictic plants in natural populations. Development of synthetic polyploids.

Practical

Identification of different forms of heteroploids through microscopy; Handling and maintenance of double and single haploids in various crops: Raising and handling of apomictic plants and their identification in succeeding generations; Identification of polyploids and apomictic plants in natural populations.

Text Book

1. Sleper, D.A. and J.M. Poehlman. 2006. Breeding Field Crops. 5th Ed. Iowa State University Press, Ames, Iowa, USA.

Suggested Readings

1. Chahal, G.S. and S.S. Gosal. 2002. Principles and Procedures of Plant Breeding: biotechnological and conventional approaches. Narosa Publishing House, New Delhi, India.

2. Singh, B.D. 2003. Plant Breeding: Principles and Methods. Kalyani Publishers, New Delhi. India
3. Singh, P. 2003. Essentials of Plant Breeding. Kalyani Publishers, New Delhi.
4. Singh, R.J. 2002. Plant Cytogenetics. CRC Press, New York, NY, USA.

PBG-516 Outreach in Plant Breeding 2(1-1)

Learning Objectives

The students will learn:

- Concept and type of various extension methods
- Use of ICT in agriculture
- Development of the seed enterprise

Program Learning Outcomes

Sr.	CLOs	Domains	PLOs
1	Explain the basic system of extension education relevant to plant breeding	Cognitive	10
2	Describe the mechanisms and process of technology transfer	Cognitive	14
3	Identify the links for better enterprise in the public private partnership scenarios	Affective	14

SDGs addressed in the course:

(17) partnership for the goals

Teaching Mode: Blended learning

Theory

Introduction of outreach in plant breeding: concept and types of education, preparing an instructional design for extension teaching, planning, conducting and making follow-up of various extension methods: individual, group, mass and participatory methods; Concept and significance of using audio-visual aids in agricultural extension, Strategies and types of audio-visual aids: non-projected aids (variety display), projected aids; Electronic media: need and importance of technology transfer in agricultural development, agencies responsible for agricultural technology transfer, role of farmers in the generation of agricultural technologies; Recent technological developments in agriculture: characteristics of promising agricultural technology; Preparing feasibility reports of seed enterprises: choosing, planning, and managing a selected enterprise.

Practical

Preparation and presentation of projected and non-projected aids in the class; Training in handling and maintenance of audio-visual equipment; Recording techniques along with script writing; Practical training aspects of various technologies learnt in theory classes.

Text Book

1. Memon, R.A. and E. Bashir. Eds. 1993. Extension Methods. National Book Foundation, Islamabad. Pakistan

Suggested Readings

1. Barden, R. & M. Hacker. 1990. Communication Technology. Delmar Publishing Inc., New York. NY, USA
2. Lionberger, H.F. and P.H. Gwin, 1991. Technology Transfer: From Researchers to Users. University of Missouri, Columbia, South Carolina, USA.
3. FAO, Agricultural Extension: A Reference Manual, FAO, Rome, Italy.
4. Groverman, V. 1994. The Group Promoters Resource Book, FAO, Rome, Italy.

PBG-517 Mutation Breeding in Crop Plants 2(1-1)

Learning Objectives

The students will learn:

- Current situation and future prospects of mutation breeding
- The agents and protocols of inducing mutations
- High throughput screening and handling of mutant populations

Program Learning Outcomes

Sr.	CLOs	Domains	PLOs
1	Comprehend scientific principles behind mutation breeding, use of mutagens, directional mutations and mutation repair mechanisms.	Cognitive	1
2	Demonstrate the handling of mutant populations and breeding procedure of mutant cultivar development.	Psychomotor	3
3	Consider and evaluate the cytological aspects of mutations and the radio sensitivity of field crops.	Affective	7,8

SDGs addressed in the course

(3) Good health and well being

(8) Decent work and economic growth

Teaching Mode: Blended learning

Theory

Concepts, kinds and characteristics of mutations and its role in evolution and plant breeding; Physical and chemical mutagens; Techniques of induction of mutation, detection, evaluation and utilization of induced mutants; Classes of mutagens: Somatic and germinal mutations, Mutation rate and frequency, Observations in M_1, procedure for selection in later generations, use of mutants in hybridization programme; Factors modifying the effectiveness of irradiation in seed treatment; Determination of LD_{50}; Effectiveness and efficiency for inducing cytogenetical changes; Gamma garden; cytological studies of mutants;. Improvement of specific characters through induced mutation; Mutation breeding research in some vegetatively propagated plants; Targeting Induced Local Lesions in Genomes (TILLING); Making Kill Curve, high throughput screening of point mutations; Effect of mutations on DNA; Repair mechanisms operating at DNA, chromosome, cell and organism level to counteract the mutation effects; Development and handling of mutant populations; Mutagen effects: in first generation after seed treatment, Plant injury and lethality; Prospects and applications of induced mutations in plant breeding; **Targeted mutations, their types and recent advances.**

Practical

Precautionary measures in handling and using mutagens; Mutation induction methods; Radiation treatment techniques of seeds and other parts of plants; Radio sensitivity of field crops; Cytological analysis of mutants; Field observations and selection procedure of irradiated material; Estimation of mutation rate and frequency from the Lab assays and field data of mutagenized populations; Handling mutant generations; Mutant gene identification. Selection and generation advancing in TILLING populations; Visit to various Labs and mutation breeding stations.

Text Book

1. **Spencer-Lopes, M. M., Brian P. F and Liupcho J. 2018. Manual on mutation breeding. 3rd Ed. Food and Agriculture Organization of the United Nations, Vienna.**

Suggested Readings

1. **Meksem, K. and G. Kahl.Eds. 2010. The Handbook of Plant Mutation Screening. Wiley-VCH Verlag GmbH & Co, Weinheim, Germany.**
2. **Sleper, D.A. and J.M. Poehlman. 2006. Breeding Field Crops Blackwell Publishing Company, Ames, Iowa, USA.**
3. **Albert B., A. Johnson, J. Lewis, M. Raff, K. Robert and P. Walter. 2008. Molecular Biology of the Cell 5th Ed. Garland Science, Taylor and Francis group, New York, NY, USA.**
4. **Urry, L.A., M.L. Cain, J.B. Reece, S.A. Wasserman, R.B. Jackson, P.V. Minorsky and N.A. Campbell. 2010. Campbell biology. Benjamin Cummings/Pearson, San Francisco, California, USA.**

PBG-518 IPR and Variety Development 2(1-1)

Learning Objectives

The students will learn:

- **Introduction to Intellectual Property Rights**
- **Variety registration and seed certification system in Pakistan**
- **Plant Breeders and farmers' rights**

Program Learning Outcome

Sr.	CLOs	Domains	PLOs
1	Explain IPRs and their regulation in Pakistan	Cognitive	14
2	Describe plant breeder rights and seed system in Pakistan	Cognitive	14
3	Analyze the application of IPRs and varietal registration	Affective	14

SDGs Addressed in the Course

(16) Peace

(17) Justice & Partnership

Teaching Mode: Blended learning

Theory:

Intellectual Property Rights: introduction and ways to protect IPR; IPR in agriculture: issues and challenges; Strategies to maximize benefits from IPR; Seed Act and seed rules; Seed certification and registration; Plant Variety Protection (PVP) and Farmer's Rights Act; Plant Breeder's rights; The Biological Diversity Act: background, need, requirements, advantages and disadvantages; Patenting biological material; International harmonization of patent laws; A critical review on "WTO, TRIPS and seed industry in Pakistan".

Practical

Identification of different classes of seed and tags; Field inspections, samples inspections; Seed and plant material import and export policy: Application filling for variety approval, registration and certification; VCU standards and protocols; DUS testing; zonal and regional trail systems; Case studies

Text Book

1. **Adhikari, K., & Jefferson, D. J. (Eds.). 2020. Intellectual Property Law and Plant Protection: Challenges and Developments in Asia. Abingdon, Oxon, New York, NY, Routledge, USA**

Suggested Readings

1. Anonymous. 2014. Seed Act. Ministry of National Food Security and Research, Govt. of Pakistan.

2. Erbisch, F.U. and K.M. Maredia (Eds). 2007. Intellectual Property Rights in Agricultural Biotechnology. 2nd Ed. CABI Publishing Company, Willingford, Arkansas, USA
3. Helfer, L.R. 2002. Intellectual Property Rights in Plant Varieties: an overview with options for national governments. FAO Legal Papers, Online #31, Food and Agriculture Organization of United Nations, Rome, Italy
4. Helfer, L.R. 2004. Intellectual Property Rights in Plant Varieties: international legal regimes and policy options for national governments. FAO Legislative Study 85, Food and Agriculture Organization of United Nations, Rome, Italy.

PBG-601 Genetics and Breeding of Cereal Crops 3(2-1)

Learning Objectives

The students will learn:

- Genetic principles in cereal breeding
- Breeding methods and cultivar development
- Genetic basis of male sterility, adaptability and yield contributing traits in cereals.

Program Learning Outcomes

Sr.	CLOs	Domains	PLOs
1	**Compare** conventional and Heterosis breeding for hybrid cultivars	Cognitive	1,2
2	**Develop** an apprehension for cultivar development with desired traits	Psychomotor	8
3	**Analyze** Sterility system and its utilization in Hybrid development	Psychomotor	5,8

SDGs addressed in the course:

(1) No Poverty
(2) Zero Hunger
(3) Good health and well being

Teaching Mode: Blended learning

Theory

Importance of food cereals; Cereal situation: global and local; Evolution, origin, and phenology of cereals (wheat, rice, maize, oat, barley, sorghum); Genetic basis of various yield contributing traits; Breeding objectives; strategies and methods for different cereal crops; Cultivar development under stressed and non-stressed environments; Genetic improvement using novel techniques; Heterosis: genetic basis and exploitation; Male sterility and self-incompatibility: genetic mechanisms and exploitation in cereals; Development of commercial hybrids: exploitation of male sterility system for hybrid development; Genetics of adaptability to biotic and abiotic stresses; Future strategies and use of non-conventional technologies; **Bio-fortification in cereals; Progress and prospects.**

Practical

Planning and designing experiments in cereals; Identification of cereal diseases; Data collection on phenological stages of cereal crops; Techniques for assessing breeding material; Handling of segregating populations; Data recording on various plant attributes and its statistical interpretation; Screening for useful traits and genes for high yield, quality and against various stresses; **Review of latest papers in cereal breeding**

Text Book

1. **Kole, C. 2006. Genome Mapping and Molecular Breeding in Plants (Cereals and Millets). Springer Berlin Heidelberg, Germany.**
2. Sleper, D.A. and J.M. Poehlman. 2006. Breeding Field Crops. 5th Ed. Iowa State University Press, Ames, Iowa, USA.

Suggested Readings

1. Bennetzen, J. L. and S. C. Hake. 2009. Handbook of Maize: Its Biology. Springer, New York, USA.
2. **Gupta, P.K. and R.K. Varshney. 2004. Cereal Genomics. Kluwer Academic Publishers, New York, USA.**
3. **Khan, A.S., Z. Ali and N. Islam. 2018. Plant Breeding. Dept. Plant Breed. Genet. Uni. Agri. Faisalabad, Pakistan**.

PBG-603 Genetics and Breeding of Pulse Crops 3(2-1)

Learning Objectives

The students will learn:

- Significance and status of pulse crops
- Genetic basis of yield and quality related traits and their improvement
- Constraints and solutions related to pulse breeding

Program Learning Outcomes

Sr.	CLOs	Domains	PLOs
1	Explain the concept of genetics and breeding of pulse crops	Cognitive	1
2	Elaborate the basic techniques used in the breeding of pulse crops	Cognitive	1,2
3	Develop research interest to address local problem related to pulse crops	Affective	6

SDGs addressed in the course:

(2) Zero Hunger

(3) Good health and well being

Teaching Mode: Blended learning

Theory

Pulse Crops: Origin, history, botanical description, significance and current status of pulses; Inheritance and genetic variability for various traits; Causes of low yield; Breeding objectives for pulse crops; Conventional breeding methods and use of modern techniques; **Genetics and breeding pulse crops for biotic and abiotic stresses, yield and quality improvement;** Special consideration **in ideotype** breeding: tall plant type, double podded, multi seeded characters, reduced photoperiod sensitivity etc.; Interspecific hybridization: desi-Kabuli introgression; Breeding for fertilizer and irrigation responsive cultivars; Germplasm and genomic resources for pulse crops; **Introduction to genomic databases for pulses improvement; Molecular breeding techniques in pulse crops.**

Practical

Pulse crops: Reproductive biology, Selfing, emasculation and crossing procedures; Layout of experimental designs, data recording and analyzing of data of various plant parameters; **Use of Bioinformatics for pulse improvement; Use of genetic resources regarding important traits in pulse crops;** visit to research institutes

Text Book

1. **Mohar, S., S.B. Ishwari and D. Manoranjan. 2020. Broadening the genetic base of grain legumes. Springer, New Delhi, India.**

Suggested Readings

1. Ali, M. 2006. Drought Management Strategies for Pulse crops. Agrotech Publishing Academy, Udairpur, India.
2. **Kumar S., P. Gupta, H. Choukri, K.H.M. Siddique. 2020. Efficient Breeding of Pulse Crops. In: Gosal S.S., Wani S.H. Eeds. Accelerated Plant Breeding, Volume 3, Springer, Cham. Switzerland.**
3. Poehlman, J.M. 1991. The Mungbean. Oxford and IBH Publishing. New Delhi, Bombay, India.

4. Singh, D.P. 2001. Genetics and Breeding of Pulse Crops. Kalyani Publishers, New Delhi, India
5. **Smartt, J. 2008. Grain legumes: evolution and genetic resources. Cambridge University Press. Cambridge. United Kingdom.**

PBG-605 Genetics and Breeding of Fodder and Forage Crops 3(2-1)

Learning Objectives

The students will learn:

- Reproductive systems and breeding methods in fodder and forages.
- Genetic basis of fodder quality, yield and resistance related traits and their improvement.
- **Different ways to preserve the fodder.**

Program Learning Outcomes

Sr.	CLOs	Domains	PLOs
1	Describe the reproductive systems and breeding methods in fodder and forages	Cognitive	2,3
2	Explain the genetic basis of fodder yield and quality related traits and their improvement	Cognitive	1,2
3	Utilize breeding and genetic tools for improvement of fodder crops	Psychomotor	8

SDGs addressed in the course

(4) Quality Education

(8) Decent Work and Economic Growth

Teaching Mode: Blended learning

Theory

Introduction to major fodder and forage crops; grasses and legumes; Introduction, origin, botanical description and importance of fodder crops. Reproductive systems in fodder crops; vegetative and sexual reproduction. apomixis; male sterility and self-incompatibility: genetic and cytoplasmic basis; Genetics and breeding of high productivity, and quality parameters. Procedures for breeding self-, cross-pollinated, apomictic and polyploid fodder/forage species. Interspecific and intergeneric crosses in fodder/forage crops; Development and application of modern technologies in fodder/forage improvement; Methods and limitations hay and silage production; Anti- quality agents in fodder and forage crops and remedies; Fodder quality components; Mix cropping in forage crops and mechanical heterosis; **Molecular breeding and genomic tools for enhanced fodder and forage production.**

Practical

Floral biology of different fodder/forage crops; Identification and classification of various winter and summer fodders; Pollination, fertilization and seed setting in fodder and forage crops; Selfing and crossing techniques; Multiplication and maintenance of breeding material for self-, cross- pollinated and apomictic fodder and forage species; Determination of nutritive quality; nutritive value; Visit to research organizations: livestock farms and feed industry.

Textbook:

1. Boller, B., U.K. Posselt and F. Veronesi.Ed. 2010. Fodder Crops and Amenity Grasses. Springer, London, UK.
2. J.M. Poehlman. 1987. Breeding Field Crops. 3rd Ed. Springer Science Business Media, New York, USA.

Suggested Readings

1. Hopkins, A., Z.Y. Wang., R. Mian, M. Sledge and R.E. Barker Eds. 2004. Molecular Breeding of Forage and Turf. Kluwer Academic Publishers, New York, USA.
2. Rognli, O.A.; E.T. Solberg, I. Schjelderup. Eds. 1994. Breeding Fodder Crops for Marginal Conditions. Series: Developments in Plant Breeding (Vol. 2). Springer, UK.
3. Sleper, D. A., K. H. Asay and J.F. Pedersen, Ed. 1989. Contributions from Breeding Forage and Turf Grasses. CSSA Special Publication 15, Amer. Soc. Agron, Madison, Wisconsin, USA.

PBG-607 Bioinformatics in Plant Breeding 3(2-1)

Learning Objectives

The students will learn:

- **Crop genomics resources**
- **Software and tools in plant breeding**
- **Retrieval and handling of large genomic datasets**

Program Learning Outcomes

Sr.	CLOs	Domains	PLOs
1	Comprehend the latest bioinformatics tools for DNA and protein sequence analysis.	Cognitive	1, 2
2	Demonstrate use of bioinformatics to predict structural and functional aspects of biological sequences.	Psychomotor	4
3	Analyze gene family for evolution, genetic diversity, structural variations and functional aspects through bioinformatics tools	Psychomotor	3,11

SDGs addressed in the course: In SDGs, the course fall under the category of (4) Quality education

Teaching Mode: Blended learning

Theory

Introduction to bioinformatics web resources: Orientation to various genomics databases (DBs), NCBI, Phytozome, Genebank, EMBL, SWISS-port etc.; Construction and access to various DBs; Genome browsing and data mining: use of keywords and Basic Local Alignment Search Tool (BLAST) of nucleotide and/or amino acid queries, Various input query formats; Retrieval and processing of data; FASTA format conversion; Paralogous and Orthologous genes/proteins/sequences; Tools for pairwise and multiple sequence alignment like clustal W, MUSCLE etc., phylogenetic tree construction like MEGA; Phylogenetic analysis and interpretation of data; Neighbour-joining and Maximum likelihood; Gene and ORF finders; Motif analysis and its tools; Concept and analysis of conserved motifs and domains; Gene expression under various stresses; Identification of promoter and *cis*/*trans* regulatory elements; Retrieval of gene expression data; *In silico* gene expression analysis and use in plant breeding.

Practical

Data mining; Primer designing for full length genes; CDS, ESTs, promoters, markers etc. Important rules for primer designing. Manual primer designing vs software-aided primer designing (using Amplifix, primer; Multiple sequence alignment and phylogenetic tree construction using softwares. Exploring QTL - a case study in completely sequenced plant genome (Chickpea, rice, soybean etc); Gene flow detection and population structure analysis using softwares like Power-Marker, Structure, Network etc; Possible use of generated molecular information in Plant Breeding.

Textbook

1. Krawetz, S. A., & Womble, D. D. Eds. 2003. Introduction to bioinformatics: a theoretical and practical approach. Springer Science & Business Media. Totowa, New Jersey, USA.

Suggested Readings

1. Balding, D.J., M. Bishop and C. Cannings. Eds. 2007. Handbook of Statistical Genetics. 3rd Ed. John Wiley & Sons Ltd, Chichester, West Sussex, UK.
2. **Bult, C. J. 1998. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. Science, Willey Inter-science, New York, USA.**
3. Baxevanis, A.D. and B. F. F. Ouellette. Ed. 2004. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. 3rd Ed. John Wiley & Sons Inc, Chichester, West Sussex, UK.
4. Rastogi, S.C., N. Medirratta and P. Rastogi. 2005. Bioinformatics: Methods and Applications; Genomics, Proteomics and drug Discovery. Prentice Hall of India, New Delhi, India.

PBG-609 Quantitative Genetics and Biometry 4(3-1)

Learning Objectives

The students will learn:

- Biometrical techniques in crop breeding
- Data recording for qualitative and quantitative traits and biometrical analyses
- **Concept and application of mating designs in plant breeding**

Program Learning Outcomes

Sr.	CLOs	Domains	PLOs
1	Analyze different biometrical techniques available for plant breeding.	Cognitive	1, 3, 8
2	Develop the procedure of work in the field for the selection of parents and plants from the segregating populations.	Psychomotor	7, 9
3	Apply biometrical techniques used in the process of cultivar development.	Psychomotor	8, 14

SDGs addressed in the course:

(4) Quality education

Teaching Mode: Blended learning

Theory

Introduction to quantitative genetics and biometry; Genetic and somatic analysis; Sources of variation: genic, plasmatic, and interaction of genotype and environment; Introduction to different models for genetic analysis; Principles of scaling and scaling tests; Components of means and variation. Detection of additive-dominance components and non-allelic interaction; Introduction to stability analysis; Biplot analysis for G × E interaction studies; Introduction to different mating design and their application in plant breeding; Heritability: factors affecting magnitude of heritability, and its significance in plant breeding. Estimation of heterosis and interpretation; Correlation and regression analysis. Chi-square test.

Practical

Collection and tabulation of data on different parameters in field experiments; Methods of comparisons of means; Estimation of components of means and variances using weighted least square analysis; Estimation of heterosis and heritability; Computation of simple correlation coefficient and its tests of significance; Calculation for combining ability effects. Use of software for the analysis of biometrical data.

Text Book

1. Ali, Z. 2010. Analyzing and Understanding Genetic Problems: Classical and conventional approach. VDM, Germany.

Suggested Readings

1. Kang, M.S. and M. Kang.Eds. 2003. Handbook of Formulas and Software for Plant Geneticists and Breeders. Harworth Press Inc, LA, USA.
2. Kearsey, M.J., and H.S. Pooni. 1996. The Genetic Analysis of Quantitative Traits. Chapman & Hall, London, UK.
3. Mather, K., and J.L. Jinks. 1982. Biometrical Genetics. 3rd Ed. Chapman and Hall Ltd. London, UK.

PBG-611 Preparation of Research Project and Scientific Writing 2(1-1)

Learning Objectives

This course will enable the students to:

Course Contents Theory

The concept of science and scientific method, Reading skills. The concept, purpose and kinds of research. Types of Scientific Reports, Collection and organizing source materials: reviewing the literature and preparing bibliography. The techniques of composition: rules of scientific writing, word usage in scientific writing, style for composing scientific writing. Writing thesis, scientific papers, and project reports; table of contents, list of tables, the use of scientific quotations, illustrations, appendices, statistics and tables, standard abbreviations. Preparing preliminary draft, editing, and evaluating the final draft. Writing Research proposals, Preparation of PC forms. Plagiarism, its types and testing methods. Policy of HEC on Plagiarism.

Practical

Exercise of scientific writing and research proposal, Exercise of collecting material from different sources on assigned topics, oral presentations. Using Track Change in MS word for editing drafts. Use of reference manager, endnote and Turnitin software

Suggested Readings

1. Anderson, J., B. H. Durston and M. Poole. 1992. Thesis and Assignment Writing. Wiley Eastern Ltd. New Delhi, India
2. Andrew, C.O. 1993. Applied Agricultural Research: Foundations and Methodology. West view Press
3. Everything You Wanted to Know About Making Tables and Figures. http://abacus.bates.edu/~ganderso/biology/resources/writing/HTWtablefigs.html
4. Gatner, E. S. M. and F. Cordasco. 1959. Research and Report Writing. Barnes and Noble, Inc., New York, USA
5. George D. Gopen and Judith A. Swan. 1990. The Science of Scientific Writing. American Scientist, 78: 550-558.

6. Ghafoor, A. 2007. Manual for Synopsis and Thesis Preparation. University of Agriculture, Faisalabad.
7. Ghafoor, A., G. Murtaza, and S.I. Hussain. 2006. Fundamentals of Scientific Communications and Presentations. Allied Book Centre, Lahore.
8. Guidelines for Writing Scientific Papers. http://www.bms.bc.ca/library/Guidelines
9. Handbook of postgraduate Research students. UHI Millennium Institute, Perth College, Scotland, UK. WWW.PERTH.AC.UK
10. Hopkins, W. G. 1999. Guidelines on style for scientific writing. Sport Science 3(1), sportsci.org/jour/9901/wghstyle.html.
11. McGranaghan, M. Guidelines on writing a research. http://www2.hawaii.edu/~matt/proposal.html, http://www.imechanica.org/node/588
12. Plagiarism policy. 2007. HEC booklet.
13. Tischler, M. E. Scientific Writing Booklet. Dept. of Biochemistry and Biophysics, University of Arizona. www.biochem.arizona.edu/marc/Sci-Writing.pdf

William R. L. 2001. Fine-Tuning Your Writing. Wise Owl Publishing Co., Madison, USA

PBG-613 Bio-Safety Measures in GM Crops 2(1-1)

Learning Objectives

The Students will learn:

- **Understand the Principles and primary controls of biosafety**
- **Explain the risk mitigation schemes at field**
- **Comprehend the biosafety issues in the genetically modified crops.**
- **Recognize the existing Biosafety system in Pakistan.**

Program Learning outcomes

Sr.	CLOs	Domains	PLOs
1	Explain the basics of biosafety approaches	Cognitive	1
2	Know how to implement different biosafety model at field	Cognitive	7
2	Apply the integrated biosafety, approaches and law to mitigate the risk in genetically modified crops.	Psychomotor	11

SDGs addressed in the Course

(3) Good health and well-being

(4) Quality education

Teaching Mode: Blended learning

Theory

Concept of biosafety measures, comparison of conventional breeding and GM, regulation of Cartagena protocol; field and laboratory biosecurity and biosafety, development of biosafety measures in crop improvement, The Institutional Biosafety Committee, National Biosafety Committee, Potential threats of agricultural biotechnology, hazards from donor and recipients organisms, transgenic plants and animals. Regulations to access safety of GM crops; **Clean gene technology; Non-target and biodiversity risk assessment; Gene flow and its consequences; GMOs as potential environmental hazards and management of field releases; Biggest threat to field biosafety.**

Practical

Classes of chemicals: handling, storage and transportation of hazardous chemicals; Safe work practices; biosafety levels for labs; autoclaving and sterilization; handling radioactive material; Assays to quarantine biological materials; **Shipment of biological substances; Hand washing and beak method; Risk groups; GM Crop Modeling; Contingency plans.**

Textbook

1. **Furr, A.K. 2000. Handbook of Laboratory Safety. 5th Ed. CRC press, Boca Raton, FL, USA.**

Suggested Readings

1. **Krishna, S.V. 2011. Bioethics & Biosafety in Biotechnology. 2nd Ed. New Age International, New Delhi, India.**
2. **Bio Prism 2018: A laboratory Safety Training Initiative Program Manual. USA.**
3. **Pakistan Biosafety Rules. 2005. Notified under S.R.O (1)336/(I)/2005-Published in the Gazette of Pakistan.**
4. **World Health Organization. 2004. Laboratory Biosafety Manual, 3rd Ed. Geneva, Switzerland.**

PBG-615 Plant Genomics 2(1-1)

Learning Objectives

The students will learn:

- Genome organization and its browsing
- Construction and exploitation of DNA libraries
- **Advances in crop development**

Program Learning Outcomes

Sr.	CLOs	Domains	PLOs
1	Understand the contribution of genetic factors for the development of crop plants	Cognitive	1
2	Explanation of genomic variations, its sources and application in crop improvement	Cognitive	3
3	Development of improved crop to ensure a better future for all	Psychometry	13

SDGs addressed in the course:

(2) Zero Hunger

(4) Quality education

Teaching Mode: Blended learning

Theory

Genomics: Introduction, scope and application in agriculture; Genome organization and structure; Methods of DNA and RNA sequencing; **whole genome sequencing; Pan-genomics;** construction of DNA libraries, gene identification in a genome sequence; Transcriptome analysis: Microarray and DNA chip, genomic variation analysis; Application of genomics in forward and reverse genetics, metabolomics and proteomics.

Practical

In silico promoter analysis using Online Web tools (PLACE, PlantCARE, Plantpan); Exploring the database for gene/protein sequences and retrieval, primer designing, translation tools,

construction of a phylogentic tree, sequence annotation tools, submitting a gene/protein sequence in Gene bank.

Text Book

1. **Manjit, S.K. 2020. Quantitative genetics, genomics and plant breeding. CABI international publications, Boston, Massachusett, USA.**

Suggested Readings

1. Lesk, A.M. 2000. Introduction to Bioinformatics. Oxford University Press, Inc. New York, NY, USA.
2. Orengo, C., D. Jones, and J. Thornton. 2003. Bioinformatics: genes, proteins and computers. BIOS Scientific Publishers Limited. Cornwell Press, Trowbridge, UK.
3. Slater, A., N. Scott, and M. Fowler. 2004. Plant Biotechnology: The genetic manipulation of plants. Oxford University Press Inc., Oxford, UK.

PBG-612 Internship and External Evaluation 6(0-6)