MNS UNIVERSITY OF AGRICULTURE, MULTAN
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No: MNS-UAM/RO(A)-38/961
Date: 15.12.202

NOTIFICATION

The Syndicate in its 35th meeting held on 19.11.2022 has approved the recommendations made by the Academic Council in its 9th meeting held on 02.11.2022, regarding revisions in scheme of studies of Master of Science (Honours) and Doctor of Philosophy (PhD) Plant Breeding and Genetics from session 2023 and onwards (as per attached Appendix).

Aisha Bibi
Deputy Registrar (Acad.)
For Registrar

Distribution: -

- Director Quality Enhancement Cell
- Dean Faculty of Agriculture and Environmental Sciences
- Director Graduate Studies
- Director, Institute of Plant Breeding and Biotechnology
- Controller of Examinations
- Treasurer
- Deputy Registrar (HR)
- Secretary to the Vice Chancellor
- Office File

Appendix

REVISION IN SCHEME OF STUDIES

MASTER OF SCIENCE (HONOURS) AND DOCTOR OF PHILOSOPHY (PhD)

PLANT BREEDING AND GENETICS

Approved vide	Meeting	Date
Academic Council	9th	02.11.2022
Syndicate	35th	19.11.2022

FACULTY OF AGRICULTURE AND ENVIRONMENTAL SCIENCES

MNS UNIVERSITY OF AGRICULTURE, MULTAN

Course Contents

Approved

PBG-701 Principles of Plant Breeding 3(2-1)

Learning Objectives

This course will enable the students to learn:

- Genetic variation and explain their importance for plant breeding.
- Breeding methods for self and cross-pollinated crops.
- The principles and procedures of seed production and seed certification.

Learning Outcomes

After completing the course, the students will be able to:

Sr. No	CLOs	Domain	PLOs
1	Explain different seed production systems at the commercial level.	Cognitive	3
2	Apply the methods of breeding crops for specific objectives.	Psychomotor	1
3	Prepare cases for variety approval and seed certification.	Psychomotor	14

SDGs addressed in the course:

Goal 1: No Poverty

Goal 2: Zero Hunger

Teaching Mode: Hybrid/Blended Learning Mode

Course Contents

Theory

Plant breeding and crop improvement; Variability: its genetic basis and exploitation in crop improvement; Reproductive systems; Breeding methods and breeding plans in field crops; Evolutionary prospects of traits development in field crops; Fertility regulating mechanisms and their utilization; Heterosis and its genetic basis; Inbred line development: selection, development and maintenance of parental lines in various hybrid seed production systems; Systems of hybrid seed production; Problems of hybrid seed production; Breeding strategies for genetically modified crops; Reverse breeding; Marker-assisted selection in plant breeding; Integration of genomics and bioinformatics in plant breeding; Seed act and Plant Breeders Rights; Variety approval and seed certification system; Production of certified seed.

Practical

Field plot techniques and data recording; Use of software for layouts; Handling of the breeding material in various segregating generations; Progeny nomenclature and maintenance; Development and maintenance of pure/inbred lines; Selection and maintenance of A, B and R lines; BLA system for hybrid seed production; Case preparations for variety approval.

Text Book

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

Approved

Suggested Readings

1. B.D. Singh. 2009. Plant Breeding: Principles and Methods. Kalyani Publishers, New Delhi, India
2. GOP. 2015. Seed Act (Amendment) 2014. Govt. of Pakistan.
3. Khan, A.S., Z. Ali and N. Islam. 2018. Plant Breeding. Dept. Plant. Breed. Genet. Uni. Agri. Faisalabad, Pakistan.
4. Plant Breeders right 2016.
5. Singhal, W.C. 2004. Hybrid Seed Production. Kalyani Publishers, New Delhi, India.

PBG-702 Biometrical and Population Genetics 3(2-1)

Learning Objectives

This course will enable the students to learn:

- Concepts and characters of populations.
- The forces that determine changes in the composition of a population.
- Different biometrical techniques and tools for analyzing and interpreting the data.

Learning Outcomes

After completing the course, the students will be able to:

Sr. No	CLOs	Domain	PLOs
1	**Describe the concepts of population and biometrical genetics.**	**Cognitive**	**4, 5**
2	**Apply the biometrical techniques to study the populations**	**Psychomotor**	**3, 6**
3	**Use software for the biometrical analysis of data**	**Psychomotor**	**5, 10, 14**

SDGs addressed in the course:

(2) Zero Hunger

(13) Climate action

(15) Life on land

Teaching Mode: Hybrid/Blended Learning Mode

Course Contents

Theory

Introduction to biometrical and population genetics; Genetic variations in natural populations; Genetic and environmental components of variation and their estimation; Regression and correlation coefficients and their use in selection; Genotype×environment interaction and adaptation; Visual selection and its characteristics: influence and efficiency of visual selection; Selection indices and their uses; Mating designs: Biometrical analysis and their utility in plant breeding; PCA and Bi-plot analysis; Elements of population genetics; Random-mating population and Hardy-Weinberg law; Factors affecting population structure; Linkage and linkage disequilibrium; Population structure and gene flow; Inbreeding in small populations;

Approved

Effective population size; Patterns of migration and F statistics; Natural selection; Mutation and selection balance; Genetic erosion: consequences and gene conservation; Molecular population genetics.

Practical

Assumptions underlying the data; Transformation of data; Estimation of genotypic and phenotypic correlations; Estimation of genetic components; Heritability and genetic advance from different mating designs; Response to selection; Stability analysis; Use of software for biometrical and population data analyses.

Text Books

1. Gillespie, J.H. 2004. Population Genetics: A Concise Guide. JHU Press, Baltimore, London, UK.
2. Hallauer, A.R., M.J. Carena, and J.B.M. Filho. Quantitative Genetics in Maize Breeding. 2010. Vol. 6. Springer Science & Business Media, Springer, New York, NY, USA.

Suggested Readings

1. Backer, W.A. 1992. Manual of Quantitative Genetics. 5th Ed. Academic Enterprises, Pullman, WA, USA.
2. Holsinger, E. Kent. 2012. Lecture notes in population genetics. Creative Commons License, California, CA USA.
3. Kang, M.S. and M. Kang. 2003. Handbook of Formulas and Software for Plant Geneticists and Breeders. Harworth Press Inc, LA, USA.
4. Phundan, S and S.S. Narayanan. 2015. Biometrical Techniques in Plant Breeding. 5th Ed. Kalyani Publishers, New Delhi, India.

PBG-703 Crop Biotechnology and Molecular Breeding 3(2-1)

Learning Objectives

This course will enable the students to learn:

- Biotechnological tools and techniques to breed crop plants.
- Role of molecular markers in plant breeding.
- Effects of domestication and breeding on the crop genomes.

Learning outcomes

After completing the course, the students will be able to:

Sr. No.	CLOs	Domain	PLOs
1	Explain scientific principles of molecular breeding	Cognitive	1
2	Analyze information from molecular markers and implementation in crop improvement.	Cognitive	3
3	Demonstrate hands-on skills in emerging tools and applications in plant breeding like PCR, Gel electrophoresis and data mining.	Psychomotor	3

SDGs addressed in the course:

(01) No poverty

Approved

(02) Zero hunger
(13) Climate action

Teaching Mode: Hybrid/Blended Learning Mode

Course Contents
Theory
Use of molecular breeding and biotechnology in crop improvement and its significance in plant breeding; Micropropagation; Genetics of cultured plant cells; Somaclonal variation and its use in plant improvement; Doubled haploids and mapping populations; Somatic hybridization; Production and handling of transgenic and apomictic plants; Nucleotide sequencing techniques; Molecular markers and QTLs; Selection schemes for marker-assisted breeding: opportunities and challenges in molecular breeding and probes mining; Gene expression and silencing; Introducing DNA into living cells; Selection for recombinants; Development of transgenic plants; Issues of genetically engineered plants and biosafety measures; Use of bioinformatics in plant breeding.

Practical
In vitro culture; DNA/protein data mining and phylogenetic analyses; Extraction, purification and quantification of genomic DNA and RNA; Primer designing and development of molecular markers i.e. RAPD, AFLP, SSR, ISSR, CAPS, dCAPS, KASP; Analyses, interpretation and validation of molecular breeding results; Use of electrophoresis and qPCR machine for result interpretation; Development of transgenic plants; Visit to National Research Institutes involved in molecular genetics and gene manipulation.

Text Book:
1. Xu, Y. 2012. Molecular Plant Breeding. CABI, Wallingford, Oxfordshire, UK.

Suggested Readings

1. Fleury, D. and Whitford, R. 2014. Crop breeding: methods and protocols. New York: Humana Press.
2. Lodge, J., L. Peter and M. Steve. 2008. Gene Cloning: Principles and Applications. Taylor and Francis Group, Oxon, UK.
3. Old, R.W. and S.B.P. Primose. 2000. Principles of Gene Manipulation: An introduction to Genetic Engineering. Blackwell, London, UK.
4. Paul, C. and K. Harry. 2004. Handbook of Plant Biotechnology. John Wiley & Sons, New York, NY, USA.

PBG-704 Cytogenetics and Evolution of Crop Plants 3(2-1)

Learning Objectives
This course will enable the students to learn:
- Chromosome structure and functions at the molecular level.
- Factors and processes of speciation and evolution of crop plants.
- Modern tools and techniques in cytogenetics and evolutionary studies.

Learning Outcomes
After completing the course, the students will be able to:

Approved

Sr. No	CLOs	Domains	PLOs
1	Explain the importance and uses of cytogenetic studies in plant breeding	Cognitive	5
2	Comprehend the development of new species and the evolution of crop plants.	Cognitive	5
3	Imply the cytogenetic and molecular techniques in evolutionary studies.	Psychomotor	4

SDGs addressed in the course:
(4) Quality Education

Teaching Mode: Hybrid/Blended Learning Mode

Course Contents

Theory

Cytogenetics in relation to crop improvement; Molecular structure, properties, and functions of various morphological features of chromosomes: centromeres and kinetochores; Nucleolus and nucleolar organizer region; Telomeres; Changes in chromosomes and karyotypes in relation to evolution; Chromosome engineering and artificial chromosomes; Modern tools and techniques in cytogenetic studies; Structural changes in chromosomes and their role in evolution; Heteroploidy: production methods, genetic and cytological behavior, and their uses in crop breeding; Alien gene transfer through chromosome manipulations; Use of flow cytometry in cytogenetic studies; Evidences, theories and patterns of evolution, early life genesis, micro and macro evolution; Co-evolution; Phylogenetic history and evolution; Evolution of Crop under domestication; Current directions in the study of crop evolution; Concept of species, isolating mechanisms, different types/modes of speciation; Various sources of variation, role of genetic polymorphism, mutation, hybridization and polyploidy in evolution; Natural selection and patterns of selection; Wide crosses and species resynthesis in crops; Evolution and species relationship in important crop plants; Evolutionary trends in crops, important plant adaptations in climatic vagaries; Evolution of genes and genomes. Issues arising from the study of crop evolution; The origin of crops and ownership of biological resources.

Practical

Conventional Techniques for studying chromosomes; solution preparations; sample collection: Preparation of karyotypes of different crop plants; Banding techniques; Advanced methods of chromosome analysis, Utilization of fluorescence in situ hybridization (FISH), Genome in situ hybridization (GISH) techniques and Flow cytometry; Cytotaxonomic background of some major crops.

Text Books

1. Futuyma, D. J., and K. Mark. 2017. Evolution, 4th Ed, Oxford University Press, Oxford, UK.
2. Sumner, A.T. 2003. Chromosomes: organization and functions. Blackwell Publishing Co. USA.

Suggested Readings

1. Gupta, P.K. 2007. Cytogenetics. Rastogi Publishers, Meerut, India.

2. Hancock, J. 2004. Plant Evolution and the Origin of Crop Species. 2nd Ed. Oxford University Press, Oxford, UK.
3. Larramendy, M.L. and Soloneski, S. 2019. Cytogenetics: Past, Present and Further Perspectives, 1st Ed. IntechOpen, London, United Kingdom.
4. Singh, R.J. 2018. Practical Manual on Plant Cytogenetics. 2018. 1st Ed. CRC Press, Florida, United States.
5. Ridley, M. 2004. Evolution 3rd Ed. Blackwell Publishing, Massachusetts, USA.

PBG-705 Crop Breeding for Biotic and Abiotic Stresses 3(2-1)

Learning Objectives

This course will enable the students to learn:

- The traits conferring resistance to various stresses.
- The manipulation of genes involved in stress tolerance.
- Breeding techniques for biotic and abiotic stress tolerance.

Learning Outcomes

After completing the course, the students will be able to:

Sr. No	CLOs	Domain	PLOs
1	Explain the plant responses to various stresses.	Cognitive	3
2	Apply analytical techniques for trait evaluation under diverse stresses.	Psychomotor	5
3	Develop breeding strategies for improving resistance.	Cognitive	8

SDGs addressed in the course:

Goal 2: Zero Hunger
Goal 3: Good Health and Well-being
Goal 13: Climate Action

Teaching Mode: Hybrid/Blended Learning Mode

Course Contents

Theory

Pathogenicity and virulence; Gene for gene hypothesis; Mendelian, quantitative and cytoplasmic resistance in the host; Molecular basis of horizontal and vertical resistance; Identification and evaluation of disease resistance traits and genes; Genetics of host-pest interactions; Evolution of host-pathogen systems and its molecular mechanism; Manipulation of genes involved in insect pest and diseases resistance; Gene Pyramiding; Environmental stresses: Plant physiological and molecular responses to environmental stress; Induction of stress tolerance and adaptive mechanisms; Genetic mechanisms of abiotic stress tolerance and phenotyping for selection; Genotype×environment interaction and selection in multi-environment trials; Breeding strategies for stress tolerance; Global climate change; Stress and plant productivity; Recent biotechnological approaches to improve stress tolerance.

Approved

Practical

Layout for biotic and abiotic stress experiments; Field and laboratory study of stress parameters; Screening under simulated stress conditions; Plant responses under stress: observations, analysis and interpretation; Inoculation techniques for various plant diseases; Measurement of resistance by using different scoring scales and their statistical analysis.

Text Books

1. Pareek, A., S.K. Sopory, H.J. Bohnert and Govindjee. 2010. Abiotic Stress Adaptation in Plants. Springer, Dordrecht, Netherlands.
2. Sadasivam, S. and B. Thayumanavan. 2003. Molecular host Plant Resistance to Pest. Marcel Dekker Inc, New York, NY, USA.

Suggested Readings

1. Griffiths, M. 2005. Understanding pathogen behaviour. CRC Press, New York, NY, USA
2. Hall, A.E. 2001. Crop Responses to Environment. CRC Press LLC, Boca Raton, FL, UK.
3. Xu, Y. 2010. Molecular Plant Breeding. CABI, Wallingford, Oxon, UK.

PBG-706 Crop Breeding for Quality and Biofortification 3(2-1)

Learning Objectives

This course will enable the students to learn:

- Breeding strategies for improvement of the plant quality traits.
- The concept of biofortification and its significance.
- The manipulation of genes and traits for biofortification.

Learning Outcomes

After completing the course, the students will be able to:

Sr. No	(CLOs)	Domain	(PLOs)
1	Understand the importance of food quality and its evaluation parameters.	Cognitive	14
2	Examine the association among quality parameters and yield of crop plants.	Cognitive	6
3	Apply breeding strategies to develop biofortified crop varieties.	Psychomotor	6

SDGs addressed in the course:

(2) Zero Hunger
(3) Good Health and Well being

Teaching Mode: Hybrid/Blended Learning Mode

Approved

Course Contents

Theory

Nutritional scenario and concepts of hidden hunger; Biofortification; Present status and prospects; Potential elements for biofortification; Benefits of bio-fortification and its health and agricultural benefits; Quality traits in crops; Evaluation of quality parameters in relation to international standards; Sources of quality traits; Association of quality characters with yield and yield components; Genetic basis of quality traits and bio-fortification in crops; Breeding strategies to improve quality traits and biofortification crops; Bio-fortified cultivars and their sensory characteristics; Integration of genomic tools for improvement of quality traits.

Practical

Estimation of quality characteristics in various crops; Potential crops for biofortification; Assessment and evaluation of biofortified traits for their efficacy and impact; Visit to different public and private sector institutions/industry; Standards and protocols of BCI, Klean Cotton, Global Gap certification.

Textbook

1. Qureshi, A.M.I., Z. A. Dar and S.H. Wani. 2019. Quality Breeding in Field Crops. Springer Nature, Switzerland.

Suggested Readings

1. Acquaah, G. 2007. Principles of Plant Genetics and Breeding 2nd Ed. Blackwell Publishing Ltd., London, UK.
2. Gupta, O.P., V. Pandey, S. Narwal, P. Sharma, S. Ram, G. P. Singh. 2020. Wheat and Barley Grain Biofortification. Elsevier Woodhead Publishing, London, UK.
3. Singh, U., C. S. Praharaj, S. S. Singh and N. P. Singh. 2016. Biofortification of Food Crops. Springer, New Delhi, India.

PBG-707 Participatory and Integrated Climate Smart Plant Breeding 3(2-1)

Learning Objectives

This course will enable the students to learn:

- Incorporation of knowledge and preferences of end-users into variety development.
- Climate-smart crop plants with the integration of genomics and phenotypic principles and techniques.
- Commercialization of hybrid plants.

Learning Outcomes

After completing the course, the students will be able to:

Sr. No	CLOs	Domain	PLOs
1	Analyze the procedure of variety evaluation activities.	Cognitive	4, 5
2	Disseminate the knowledge about quality seed and how it helps in crop improvement.	Affective	5, 10
3	Convey knowledge about the development of the desired hybrid.	Affective	5, 10, 14

SDGs addressed in the course:

(1) No poverty.

(2) Zero hunger
(13) Climate action

Teaching Mode: Hybrid/Blended Learning Mode

Course Contents
Theory
Introduction to participatory and integrated plant breeding; Need of participatory plant breeding and involvement of farmers in variety evaluation activities; Scope of academia-industry linkages for smart plant breeding; Genetic adaptability and water-fertilizer intelligent regulation mechanism of climate smart varieties; Use of improved seed: seed multiplication and distribution systems; Outreach in plant breeding; Cropping patterns in different ecological zones; Factors affecting cropping patterns; Crop modeling and meteorology; Management, constraints and technological measures to optimize crop productivity; Modern techniques for crop improvement; Ideotype: its construction and limitations; Quantitative genetics and plant improvement; Dissection of genotype × environment interaction (GEI) to identifying trait(s) of interest (TOI); Physiological/molecular dissection of GEI and TOI to understand genetic architecture and identify gene(s) of interest (GOI); Molecular maps and types of mapping; Introduction to quantitative trait loci; QTL mapping; Multiple QTLs; Problems and possible solutions in QTL analysis; Construction of molecular linkage map: a case study from cereals; Fine mapping of QTL and map based cloning; Marker(s)/ gene(s)/QTL(s) assisted selection and introgression; Validation of marker-trait associations; Future prospects of participatory and integrated plant breeding and commercialization of crop varieties/hybrids.

Practical
Phenotypic and genotypic data collection; Techniques of maintaining optimum plant population under field conditions; Plant characteristics and phonological development of major crops; Software-based data analysis to develop biplots and QTLs and analyze GEI; Genome browsing of sequenced plant genomes; In silico mapping; Physical position of a marker: a case study in completely sequenced plant genome; In silico expression analysis; Synteny analysis; Domain analysis; Motif analysis; Gene structure analysis.

Text Book
1. Kole, C. 2020. Genomic Designing of Climate Smart Cereal Crops. Springer, Nature, Switzerland.

Suggested Readings
1. Camp, N.J. and A. Cox. 2002. Quantitative Trait Loci: Methods and Protocols. Humana Pr Inc., New Jersey, USA.
2. Wu, R., C. Ma, G. Casella. 2010. Statistical Genetics of Quantitative Traits: Linkage, Maps and QTL. Springer Publishing Company, Incorporated, Berlin, Germany.
3. Xu Y. 2010. Molecular Plant Breeding: CABI Publishing. Wallingford, Oxon, USA.

PBG-708 Entrepreneurship in Plant Breeding 3(2-1)

Learning Objectives
The course will enable the students to learn:
- The concept of entrepreneurship, challenges and innovative solutions associated with entrepreneurship.

- Analytical skills and innovative thinking for entrepreneurial interventions in plant breeding.

Learning Outcomes

After completing the course, the students will be able to:

Sr. No	CLOs)	Domain	PLOs
1	Built-in their ability to critically analyze and compare different business models, identify the key strengths and weaknesses of these models	Cognitive	9 & 11
2	Demonstrate an ability to work effectively with others and have a knowledge of the legal and ethical environment impacting business.	Cognitive	12
3	Apply advanced project management tools and market analysis to identify future avenues of entrepreneurship in Plant Breeding and Seed business.	Psychomotor	9 & 12

SDGs addressed in the course:

(8) Descent Work and Economic Growth
(9) Industry, Innovation and Infrastructure

Teaching Mode: Hybrid/Blended Mode

Course Contents

Theory

Concept of entrepreneurship: characteristics of entrepreneurs, entrepreneurial mind, entrepreneurial opportunities; Innovations and environment in business sector; Creativity and business ideas; Business plan: Feasibility and concepts of planning; Entrepreneurship ventures; Corporate entrepreneurship; Product and services concepts; Marketing concepts; Marketing strategies and functions: marketing plan, organizational plan, financial plan, and legal issues in business, sources of capital; Need for entrepreneurship in agribusiness sector especially in plant breeding and seed business; Avenues of agribusiness entrepreneurship in public and private sector; Entrepreneurship development and strategies for plant breeding: seed and other agri-business; Risk assessment and mitigation; Success stories of successful entrepreneurs at national and international level.

Practical

Develop a business plan for plant breeding and seed business; Critical evaluation and implementation of a business plan; Identifying hurdles and solutions to tackle those problems; Registration of seed companies.

Textbook

1. Samuel, K. 2018. Seeds Toolkit Module 1: Development of small-scale seed enterprises. The Food and Agriculture Organization of the United Nations and Africa Seeds. Rome.

Approved

Suggested Readings

1. Gabrielle J.P. and V.M. Anthony. 2017. The Business of Plant Breeding; Market-Led Approaches to New Variety Design in Africa. CABI, USA.
2. Haque, N. 2007. Entrepreneurship in Pakistan. Pakistan Institute of Development Economics, Islamabad, Pakistan.
3. Hisrich, R., M. Peter and D. Shepherd. 2008. Entrepreneurship. Erwin McGraw Hill, New York, NY, USA.
4. Sharma, M.C., R. Tiwari and J.P. Sharma. 2010. Entrepreneurship in Livestock and Agriculture. CBS Publishers and Distributors Pvt. Ltd., New Delhi, India

PBG-709 Advances in Breeding Cereal and Legume Crops 3(2-1)

Learning Objectives

This course will enable the students to learn:

- The importance of genetic resources for the improvement of cereal and legume crops.
- Role of next-generation sequencing, mapping populations and molecular breeding techniques in cereals and legumes.
- Speed breeding and hybrid seed production using BLA system.

Learning Outcomes

After completing the course, the students will be able to:

Sr.	CLOs	Domains	PLOs
1	Explain the significance of genetic resources for breeding novel traits	Cognitive	2
2	Demonstrate the application of MAS and sequencing techniques in crop improvement	Psychomotor	4
3	Demonstrate the gene editing and breeding informatics tools/software in breeding cereals and legumes	Psychomotor	9,11

SDGs addressed in the course

(1) No Poverty
(2) Zero Hunger
(13) Life on Land

Teaching Mode: Hybrid/Blended Learning Mode

Course Contents

Theory

Cereals and legumes genetic resources and their utilization in modern breeding; Global View of Pulse Security; Yield and quality parameters in cereals; Strategies for improvement of cereal and legume crops for specific traits; Genetics of various traits; Application of genetic and cytogenetics of the traits; Genomic and metabolomic diversity; Genetic basis and mining approaches; Hybridization and introgression strategies; Types and construction of cereals and legumes mapping populations; Genomic resources for cereals and legumes; Genetic mechanism of nitrogen fixation in pulses; Genomics-assisted breeding in cereals and legumes; Achievements and prospects; Next generation sequencing and genotyping technologies in cereals and legumes; Trait mapping in cereals and legumes using breeding informatics tools;

Transcriptomics, proteomics and metabolomics for gene/trait discovery in cereals and legumes; Contribution of transposable elements in generation of natural variation; Speed breeding in cereal and legume crops; Gene editing tools; Use of BLA and other systems in hybrid seed production.

Practical

Assessment of various phenological stages in cereal and legume crops; Handling of segregating populations; Hybridization techniques in major pulse crops; Tissue culture techniques for fast breeding of cereals and legumes; Gene functional testing (in planta) and validation techniques; Biosafety testing in cereals and legumes; Application and use of breeding informatics tools/software in breeding cereals and legumes; Genotyping by sequencing protocol and data analysis.

Text Books

1. Tuberosa, R., A. Graner, E. Frison. 2014. Genomics of Plant Genetic Resources. Springer, Dordrecht, Netherlands.
2. Wani, S.H. and M. Jain. 2018. Pulse Improvement Physiological, Molecular and Genetic Perspectives. Springer Nature, Switzerland.

Suggested Readings

1. Breeding informatics. IRRI. Available with updates on https://www.irri.org/breeding-informatics.
2. Kole, C. 2007. Genome Mapping and Molecular Breeding in Plants: Springer Berlin Heidelberg New York. USA
3. Morris, P. C. and J. H. Bryce. 2000. Cereal Biotechnology. Woodhead, New York, USA.
4. Saraswathy, N., and P. Ramalingam. 2011. Genome mapping. Concepts and Techniques in Genomics and Proteomics, Woodhead Publishing, UK.
5. Singh B.D. and A.K. Singh. 2015. Marker-assisted plant breeding: principles and practices. Springer, New Delhi, India.

PBG-710 Advances in Breeding Fibre and Oilseed Crops 3(2-1)

Learning Objectives

This course will enable the students to learn:

- The source, genetic basis and utilization of genetic and genomic resources of fibre and oilseed crops.
- Genomic tools for improvement of fibre and oilseed crops.
- Concepts and importance of colored and organic cotton.

Learning Outcomes

After completing the course, the students will be able to:

Sr. No.	CLOs	Domains	PLOs
1	Apply the basic knowledge of genetics for the evolution of fibre and oilseed crops.	Cognitive	1, 2
2	Identify the major threats to fibre and oilseed crops production in the region and suggest possible solution	Cognitive	11

Approved			
3	Apply the concepts of breeding and biotechnological tools for the improvement of fiber and oilseed crops	Psychomotor	4

SDGs addressed in the course:
(1) No poverty
(3) Good health and well being

Teaching Mode: Blended learning

Course Contents

Theory
Genetic diversity utilization in improvement of fiber and oilseed crops; The worldwide gene pool of fiber and oilseed crops and their improvement; Role of breeding and biotechnology in sustainable fiber and oilseed crop production; Genetics and genomics of fiber and oilseed crops; Molecular basis of evolution of the fiber and oilseed crops; Hybridization and introgression strategies; Types and construction of fiber and oilseed crops mapping populations and QTL's for specific traits; Deployment of reverse and forward genetics in breeding fiber and oilseed crops; Breeding for biotic and abiotic stress resilience; Breeding for value added traits in fiber and oilseed crops; Fine mapping fiber and oilseed crops; Physical composition and organization of the fiber and oilseed crop genomes; Genetic and transcript maps; Bridging classical and genomics-assisted breeding for trait discovery and development in fiber and oilseed crops; SNP, Next generation sequencing and genotyping technologies in fiber and oilseed crops; Impacts of transgenic fiber and oilseed crops on agroecosystems; Fiber and oilseed seed systems and supply chain; Advancement in colored and organic cottons for commercialization; Breeding cotton for international trade; Role of transcriptomics, proteomics metabolomics and comparative genomics in fiber and oilseed crops.

Practical
Protocols for tissue culture and genetic transformation of fiber and oilseed crops; Gene functional testing (in planta) and validation techniques; Genotyping by sequencing protocol and data analysis; Protein-protein interactions and VIGS; CMS lines development and molecular testing; Yeast-1 and yeast-2 hybrid techniques; Development of mapping populations and generation advancement; Biosafety guidelines and regulations for transgenic experiments; Quarantine requirement; Colored Cotton; Application and use of breeding informatics tools/software in breeding fiber and oilseed crops.

Text Books

1. Andrew. A. P. 2009. Plant Genetic Vol 3. Genetics and Genomics of cotton. Springer Science and business LLC Media. NY, USA.
2. Edwarsd., D, J. Bately, I. Parkin and C. Kole. 2012. Genetics, Genomics and Breeding of Oilseed Brassicas. CRC Press Taylor & Francis Group. LLC. FL, USA.

Suggested Readings

1. Kalloo, G. and B. O. Bergh. 1999. Genetic Improvement of Oilseed Crops. Pergoman Press, New York, NY, USA.
2. Khan, Z., Z. Ali and A.A. Khan. 2022. Cotton Breeding and Biotechnology-Challenges and Opportunities. CRC Press Taylor & Francis Group. LLC. New York, NY, USA.

Approved

3. Nagata, T. and S. Tabata. 2003. Brassica and Legumes - From Genome Structure to Breeding. Springer Verlag, New York, NY, USA.
4. Ramanath. 2004. Applied Genetics of Oilseed Crops. Daya, New Delhi, India.

PBG-711 Advances in Breeding Vegetable and Fodder Crops 3(2-1)

Learning Objectives

This course enables the students to learn:

- The achievements and prospects of genomics-assisted breeding in Vegetables and Fodder crops.
- The genomics resources, tools and data analysis for the improvement of vegetables and fodder crops

Learning outcomes

After completing the course, the students will be able to:

Sr.	CLOs	Domains	PLOs
1	Apply the advance level of theoretical knowledge and practical ability for the improvement of vegetable and fodder crops.	Cognitive	1,8
2	Demonstrate skills on problem identification and scientific data recording from field visits.	Psychomotor	2, 5
3	Identify problems and their solutions to introduce new vegetables and fodders in Pakistan.	Cognitive	7, 11

SDGs addressed in the course:

(1) No poverty
(3) Good health and well being
(13) Climate action

Teaching Mode: Blended learning

Course Contents

Theory

Genetic and genomic resources of vegetables and fodders and their utilization in modern plant breeding; Genetics and cytogenetics of important traits; Gomestication and genetic diversity; Introgression strategies; Ideotype breeding for yield; Stress tolerance and quality improvement; Types and construction of mapping populations; High throughput and cost-effective genomic resources; Genomic-assisted breeding; Modern sequencing & genotyping technologies and fine mapping; Trait mapping in vegetables and fodders using bioinformatic tools; Transcriptomics, proteomics and metabolomics for gene/trait discovery.

Practical

Pollination, fertilization and seed setting in fodders and vegetables; Protocols for tissue culture and genetic transformation; Gene functional testing and validation techniques of fodders and vegetables; Genotyping by sequencing protocol and data analysis; Application and use of bioinformatic tools/software in breeding vegetables and fodder crops; Visit to research stations, progressive fodders, vegetables and dairy farms; Identification of the crops and areas to introduce new vegetables and fodders.

Approved

Text Books

1. Arya, P.S. 2003. Vegetable Breeding: Production and Seed Production. Kalyani Publisher, New Delhi, India.
2. Cai, H., Yamada, T. and Kole, C. 2013. Genetics, genomics and breeding of forage crops. CRC Press. Florida, USA.

Suggested Readings

1. Borém, E. P. Guimarães, L. C. Federizzi, and J. F. F. Toledo. 2002. From Mendel to genomics, plant breeding milestones: a review, Crop Breeding and Applied Biotechnology, vol. 2, no. 4, pp. 649–658, 2002.
2. Kalloo, G. and B. O. Bergh. 1999. Genetic Improvement of Vegetables Crops. Pergoman Press, New York, USA.
3. Ram. J. Sing. 2007. Genetic Resources, Chromosome, Engineering and Crop Improvement/Vegetable Crops. CRC Press Taylor & Francis Group. LLC. USA.
4. Singh B.D. and Singh A.K. 2015. Marker-assisted plant breeding: principles and practices. Springer, New Delhi, India.

PBG-712 Recent Trends in Crop Genetics and Cytogenetics 3(2-1)

Learning Objectives

This course enables the students to learn:

- Advanced knowledge of crop genetics and cytogenetics principles.
- Modern tools and techniques being used for crop evolution and speciation
- To review literature for identification of current and future avenues of research and trends in genetics and cytogenetics of crop plants.

Learning Outcomes

After completing the course, the students will be able to:

Sr.	CLOs	Domains	PLOs
1.	Comprehend advanced knowledge of genetics and cytogenetics principles for crop genetic improvement.	Cognitive	4 & 5
2	Apply modern tools and techniques for crop genetic improvement.	Psychomotor	7 & 8
3	Groom students for the development and application of modern knowledge in genetics relevant to the needs of society.	Affective	10 & 11

SDGs addressed in the course:

(4) Quality Education

Teaching Mode: Blended learning

Course Contents

Theory

Evolving concepts of gene; Synthetic biology; Genome sequencing; Concepts and methods in reverse genetics; Effects of stress on genome regulation and structure; Mating systems and polyploidy; Polyploidy and genome evolution in plants; Polyploidy and speciation; Synthetic polyploids; Genome plasticity and success of polyploidy under domestication; Genetic and

epigenetic interactions in allopolyploid; Advantages and challenges of polyploidy; Evolution of organelle genome; Inheritance of extra genomic variation, use of extranuclear genomes in crop improvement; Genetic control of cell cycle; Flow cytometry and its uses in the identification of ploidy level and DNA contents; Ancestry probing in polyploids through molecular techniques; Epigenetics and its role in character expression and inheritance; Cryopreservation of phytodiversity; Genome editing; Discussion and presentations on recent publications on plant genetics, genomics, biotechnology and cytogenetics.

Practical

Calculation of segregating ratios in polyploids and aneuploids; Orientation with different molecular techniques including RFLPs, AFLPs, RAPDs, GISH, FISH and SSRs; Collection of recent research papers on cytogenetics; oral presentations and group discussions.

Text Book

1. Puertas, M.J. and T. Naranjo. 2005. Plant Cytogenetics: Cytogenetic and Genome Research. S. Karger Pub.

Suggested Readings

1. Hartl, D.L. and E.W. Jones. 2009. Genetics: Analysis of genes and genomes. Springer, NY, USA.
2. Lodish, H., A. Berk, P. Matsudaira, C.A. Kaiser and M. Kriger. 2005. Molecular Cell Biology. W.H. Freeman, NY, USA.
3. Lorz, H. and G. Wenzel. 2004. Molecular Marker Systems in Plant Breeding and Crop Improvement. Springer, NY, USA.

PBG-713 Recent Trends in Crop Breeding and Evolution 3(2-1)

Learning Objectives

This course will enable the students to learn:

- Next-generation breeding tools.
- The role of genetic mechanisms in crop evolution.

Learning Outcomes

After completing the course, the students will be able to:

Sr.	CLOs	Domains	PLOs
1	Apply modern breeding tools for developing new crop varieties resilient to climate change.	Psychomotor	8
2	Demonstrate how the evolution of plants is associated with the morphological and physiological adaptations required for terrestrial life.	Cognitive	13
3	Review the process of crop domestication and evolution.	Cognitive	2

SDGs addressed in the course:

(1) No poverty
(3) Good health and well being
(15) Life on land

Teaching Mode: Blended learning

Approved

Course Contents

Theory

Genetic erosion; Germplasm resources and their conservation; Speciation in plants; Microevolution leading towards macroevolution; ~~and speciation in crop plants~~. Developing plant ideotypes; Breeding climate-smart crops; Overcoming genetic erosion through the exploitation of germplasm resources; Breeding strategies: setting up priorities and specific objectives for production system-based stress tolerance in field crops; Organic agriculture; Bioenergy and high economic value crops; Breeding for hydroponic and greenhouse systems; Wide hybridization; Introgression breeding; Crop re-synthesis; Polyploidy, and hybrid breeding; Mutation breeding: past and future milestones in developing mutants to enhance yield and quality potential; Phenomics deployment in plant breeding; Student presentations and discussion on latest journal papers.

Practical

Precise phenotyping techniques; Next generation breeding tools; High throughput genotyping and phenotyping platforms: protocols, and data analysis; Genomic selection; Transcriptome mapping and allele mining approaches; Participation in online workshops, conferences, and webinars for the understanding recent development in the field of plant molecular breeding; Writing a review article and publication (crop of choice).

Text Book

1. Azhar, M.T. and S.H. Wani. 2021. Wild Germplasm for Genetic Improvement in Crop Plants. Elsevier Intl Publ. Amsterdam, The Netherlands.
2. Fahad, S., Sonmez, O., Saud, S., Wang, D., Wu, C., Adnan, M. and Turan, V. eds., 2021. Developing climate-resilient crops: improving global food security and safety. CRC Press. Oxon. UK.

Suggested Readings

1. Aftab, T. and A. Roychoudhury. 2021. Plant Perspectives to Global Climate Changes. Academic Press, London, UK.
2. Jain, H. K. and M. C. Kharkwal. 2004. Plant Breeding: Mendelian to Molecular Approach. Kluwer Academic, Dordrecht, The Netherlands.
3. Kang, M., and P.M. Priyadarshan. 2007. Breeding major food staples. Wiley Blackwell publishers, NJ, USA.

PBG-714 Advances in Plant Hormones and their Molecular Interaction 3(2-1)

Learning objectives

This course will enable the students to:

- Understand the biosynthesis and signalling mechanism of plant hormones
- Differentiate between mode of action of different plant hormones
- Apply different plant hormones in Agricultural crop improvement programs

Learning outcomes

After completing the course, the student will be able to:

Sr. No.	CLOs	Domain	PLOs
1.	Apply knowledge about synthesis, transport and signal transduction of plant hormones and its importance for growth and development in plants.	Cognitive	1

Approved			
2.	Independently seek, analyze, evaluate and summarize role of phytohormone and theirs use in agriculture.	Cognitive	1
3.	Conduct measurements related to phytohormone and Independently perform practical experiment.	Psychomotor	4

SDGs addressed in the course:
In SDGs, the course fall under the category of
(2) Zero Hunger
(3) Good Health and Well being

Teaching Mode: Hybrid/Blended Learning Mode

Theory
Introduction to plant hormones and discovery; Plant growth regulators and inhibitors; Biosynthesis, signalling and action of auxin, abscisic acid, gibberellins, strigolactones, jasmonic acid, and salicylic acid; Interactions between plant hormones; Plant hormonal regulation of various environmental stresses; Utilization of plant hormones in agriculture.

Practical
Isolation, purification and quantification of plant hormones and their data analysis.

Text Book

1. Hano, C. , (Ed.) (2022). Plant Hormones - Recent Advances, New Perspectives and Applications. IntechOpen, London, United Kingdom.

Suggested Readings

1. Gupta, D. K., & Corpas, F. J. (Eds.). (2021). Hormones and Plant Response (Vol. 2). Springer Nature, Urdorf, Switzerland.
1. Li, J., Li, C., & Smith, S. M. (2017). Hormone metabolism and signaling in plants. Academic press. Elsevier, Amsterdam, Netherlands.
2. Moore, T. C. (2012). Biochemistry and physiology of plant hormones. Springer Science & Business Media.

PBG 719 Special Problem 1 (0-1)
Student will be assigned a special topic for searching literature relevant to a particular problem or conducting an experiment or any other appropriate activity. Student has to compile a comprehensive report on the title assigned.

PBG 720 Seminar 1(1-0)
Student will be given a topic on a particular problem in the field of plant breeding and genetics. Student has to deliver a presentation in an open house gathering on the title assigned.

PhD student has to defend his/her synopsis in an open house gathering as Seminar II.