

MNS UNIVERSITY OF AGRICULTURE MULTAN

Registrar Office (Academics Section)

Tel: 061-9201560, E-mail: dr.acad@mnsuam.edu.pk

APPROVED SCHEME OF STUDIES



B.Sc. (HONS.) AGRICULTURE

MAJOR - SEED SCIENCE AND TECHNOLOGY

INSTITUTE OF PLANT BREEDING AND BIOTECHNOLOGY

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

B.SC. (HONS.) AGRI. MAJOR SEED SCIENCE & TECHNOLOGY

FOR SESSION 2021 AND ONWARDS

FOR SESSION 2021 ONWARDS

SEMESTER-IV		
Title	Credit Hours	Course Type
Basics of Seed Production	3(2-1)	Elective

SEMESTER-V (Students will opt for 5 credit hours from elective courses)			
Course #	Title	Credit Hours	Course Type
SST-501	Principles of Seed Science	3(2-1)	Major
SST-503	Physiology of Seed Development	3(2-1)	Major
SST-505	Seed Production in Various Crops	3(2-1)	Major
SST-507	Seed Health and Vigour	3(2-1)	Major
PBG-513	Hybrid Seed Production Technology	3(2-1)	Supporting
Sub-Total Credit Hours		15	
SST-509	Seed Production of Transgenic Crops	3(2-1)	Elective
PBG-509	Experimentation in Plant Breeding	3(2-1)	Elective
PBG-517	Mutation Breeding in Crop Plants	2(1-1)	Elective
SES-517	Soil Fertility Evaluation	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
SST-502	Principles of Seed Technology	3(2-1)	Major
SST-504	Seed Germination and Dormancy	3(2-1)	Major
SST-506	Seed Certification and Registration	2(1-1)	Major
PBG-518	IPR and Variety Development	2(1-1)	Supporting
FMP-510	Seed Processing Industries & their maintenance	3(2-1)	Supporting
MAB-516	Seed Trade Policies and Regulations	2(1-1)	Supporting
Sub-Total Credit Hours		15	
Agron-50 2	Seed Science and Technology	3(2-1)	Elective

ENT-508	Stored Products Pests & their Management	3(2-1)	Elective
SST-510	Biological Potential of Various Crops	2(1-1)	Elective
SES-508	Nutrient Management in Degraded Soils	3(2-1)	Elective
Total Credit Hours		20	

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

Course #	Title	Credit Hours	Course Type
SST-601	Seed Testing	3(1-2)	Major
SST-603	Seed Storage	3(2-1)	Major
HORT-60 7	Propagation and Nursery Management.	4(2-2)	Major
SST-611	Preparation of Research Project and Scientific Writing	2(1-1)	Major
PP-601	Plant Disease Management	3(2-1)	Supporting
MAB-615	Seed Marketing and Logistics	3(2-1)	Supporting
Sub-Total Credit Hours		18	
SST-605	Seed Enhancement	2(1-1)	Elective
PBG-613	Bio-Safety Measures in GM Crops	2(1-1)	Elective
HORT-61 7	Vegetable and Flower Seed Production	2(1-1)	Elective
ENT- 615	Postharvest Protection of Cereals	2(1-1)	Elective
Total Credit Hours		20	

SEMESTER-VIII

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

Detailed Course Contents

Revised		
SST-402 Basics of Seed Production 3(2-1)		
<p>Learning Objectives:- Students will learn:</p> <ul style="list-style-type: none"> ● Fundamentals of seed production. ● Basic knowledge of development, morphology and chemical composition of seed. ● Measures required for controlling seed quality during seed production in the field. <p>Course Learning Outcomes</p>		
Sr. No.	CLOs	Domains
1	Elaborate the plant reproductive system, modes of pollination and mechanisms of self and cross pollination.	Cognitive
2	Describe the process from pollination to seed formation and fruit development. Well aware of the system of male sterility and self-incompatibility and asexual reproduction	Cognitive
3	Apply the techniques of hybrid seed production, harvesting and storage.	Psycho motor
<p>SDGs addressed in the course: SDG 2 Zero hunger SDG 4 Quality education</p> <p>Teaching Mode: Blended learning</p> <p>Theory</p> <p>Reproduction systems in plants: floral structure and their modifications; Modes of pollination: mechanisms of self- and cross-pollination in crop plants; Essential seed structure; Development of embryo, seed and fruit; Factors affecting pollination; Fertilization and seed development; Seed quality: importance of seed quality, varietal deterioration, maintaining genetic purity; Seed multiplication system: classes of seed; Asexual reproduction in plants; Role of pollinating agents in seed production; Hybrid vs open pollinated varieties; Mechanisms of hybrid seed production; Hybrid seed production on commercial scale; Problems in hybrid seed production; Seed harvesting and storage requirements; postharvest issues.</p> <p>Practical</p> <p>Demonstration of floral modifications in different crop plants: wheat, maize, cotton, chickpea, sunflower and tomato; Illustration of floral parts of different crop plants. Demonstration of rouging practices; Standards for field evaluation of various crops for seed production; Seed identification; Seed sampling techniques; purity analysis of seed.</p> <p>Text Book</p>		

1. McDonald, M.B. and L. Copeland. 1998. **Seed Production: Principles and Practices.** CBS Publishers and Distributors, New Delhi, India.

Suggested Readings

1. Bewley, J.D., K.J. Bradford, H.W.M Hilhorst and H. Nonogaki. 2013. **Seeds: Physiology of Development, Germination and Dormancy.** 3rd Ed. Springer, New York, NY, USA.
2. Copeland, L.O. and M.B. McDonald 2001. **Principles of Seed Science and Technology.** 4th Ed. Kluwer Academic Publishers, Norwell, MA, USA.
3. Ram, H.H. and H.G. Singh. 2003. **Crop Breeding and Genetics.** Kalyani Publishers, New Delhi, India.
4. Singhal, N. C. 2003. **Hybrid Seed Production in Field Crops: Principles and Practices.** Kalayani Publishers, New Delhi, India.
5. Sleper, D.A. and J.M. Poehlman. 2006. **Breeding Field Crops.** 5th Ed. Blackwell Publishing, Ames, IA, USA.

SST-501 Principles of Seed Science 3(2-1)

Learning Objectives:

Students will learn:

- **Basic principles of seed science for quality seed production**
- **Seed quality management during development, maturation and storage**
- **Seed germination process and factors affecting seed germination**

Course Learning Outcomes

Sr. No.	CLOs	Domains
1	Describe the importance of seed in agriculture and principles for quality seed production	Cognitive
2	Explain the seed structure and chemical composition as food source for human and germinating embryo after planting	Cognitive
3	Apply principles of seed science for seed quality enhancement and management	Psychomotor

SDGs Addressed in the Course

Number 2 and 4

SDG 2 Zero hunger

SDG 4 Quality education**Teaching Mode: Blended learning****Theory:**

Significance and scope of seed in agriculture and seed industry; Seed science: flower, fruit and seed development of various crops; Factors affecting seed development in different crops; Seed dormancy; deterioration and their induction agents; Role of imbibition, temperature, gases and enzyme activities during seed germination; **Seed processing: importance, operations; Seed treatments: priming, seed hardening, seed coating and pelleting. Seed marketing and distribution.**

Practical

Preparation, moistening and seed placement in substrata for germination; Counting procedures; Identification of normal and abnormal seedlings; Comparison of germination tests in laboratory and field; Observation and characterization of seed development phases in various crops; Breaking seed dormancy in various crops using different procedures; **Demonstration of seed treatment: seed inoculation, seed coating.**

Textbook

1. Copeland L.O., M.B. McDonald 2001. **Principles of Seed Science and Technology. 4th Ed. Kluwer Academic Publishers, Norwell, MA, USA.**

Suggested Readings

1. Basavaraju G.V., Ravishankar P., Gowdiperu Sarika 2014. **A Textbook of Seed Science and Technology. Kalyani Publishers, New Delhi, India.**
2. Joshi, A.K. and B.D. Singh. 2004. **Seed Science and Technology. Kalyani Publishers, New Delhi, India.**
3. McDonald, M.B. and L. Copeland. 1998. **Seed Production: Principles and Practices. CBS Publishers and Distributors, New Delhi, India.**
4. Natarajan, V.N., K. Natarajan, A. Bharathi, R. Umarani, and T. Sarvanan (Eds). 2008. **Advances in Seed Science and Technology, Vol. I: Recent Trends in Seed Technology and Management. Agrobios, Jodhpur, India**

SST-503**Physiology of Seed Development****3(2-1)****Learning Objectives****Students will learn :**

1. **Floral structure and physiological aspects of seed development**
2. **Embryogenesis and development of endosperm**
3. **Maturation and desiccation of seed**

Sr. No.	CLOs	Domains
1	Explain flower morphology and physiological aspects of seed development	Cognitive
2	Describe embryogenesis and endosperm development	Cognitive

3	Comprehend seed maturation, desiccation and dispersal mechanism	Cognitive
----------	--	------------------

SDGs addressed in the Course:

SDG 4 Quality education

SDG 8 Decent work and economic growth

Teaching Mode: Blended learning

Theory

Definition of seed; Biological significance of seeds; Structure and chemical composition of seed; Development of male and female gametophytes; **Pollination**; Fertilization; Embryo and endosperm development; **Seed maturation and hormonal balance during seed development**; Apomixes; Polyembryony, Accumulation of storage compounds; Source-sink relationships in seed development; Seed dispersal mechanisms.

Practical

Collection and identification of seeds of various plants; Morphological and anatomical features of monocot and dicot seeds; Seed germination and seedling development under controlled conditions; **Demonstration of impact of environmental stress on seed development.**

Text Book

- 1. Bewley, J.D., K.J. Bradford, H.W.M Hilhorst and H. Nonogaki. 2013. Seeds: Physiology of Development, Germination and Dormancy. 3rd Ed. Springer, New York, NY, USA.**

Suggested Readings

- 1. Basra, A.S. 2006. Handbook of Seed Science and Technology. Food Products Press. NY, USA.**
- Black, M., J.D. Bewley and P. Halmer. (Eds.). 2006. The Encyclopedia of Seeds: Science, Technology and Uses. CABI, Cambridge, MA, USA.
- Copeland, L.O. and M.B. McDonald 2001. Principles of Seed Science and Technology. 4th Ed. Kluwer Academic Publishers, Norwell, MA, USA.
- 4. Khare, D. and M.S. Bhale. 2000. Seed Technology. Scientific Publishers, Jodhpur, India.**
- Vanangamudi K., N. Natarajan, A. Bharathi, R. Umarani, K. Natrajan and T. Sarvanan (Eds). 2006. Advances in Seed Science and Technology. Vol. I: Recent Trends in Seed Technology and Management. Agrobios, Jodhpur, India.

SST-505 Seed Production in various Crops 3(2-1)

Learning Objectives:

Students will learn:

- **Seed production systems and classes of seed**
- **Principles and practices of seed production in various crops.**
- **Standards of quality seed and steps required for controlling seed quality during seed production in the field.**

Learning Outcomes:

Sr.No.	CLOs	Domains
1	Explain seed production system	Cognitive
2	Describe the steps involve in production, multiplication and certification of quality seed	Cognitive
3	Apply the skills to conduct seed quality test and manage the issues related to seed quality	Psychomotor

SDGs Addressed in the Course

SDG 2 Zero hunger

SDG 4 Quality education

Teaching Mode: Blended learning

Theory:

Seed production: principles; genetic and agronomic principles of seed production; hybrid and open pollinated varieties; modes of propagation; Growth requirements of plants; Seed planting and establishment of good stand for high seed production; Factors affecting flowering; Seed development, maturity; Production practices and maintenance of pre-basic, basic, certified seed; Biotic and abiotic stresses during seed production; Role of pollinating agents in seed production; Effect of weeds on quality seed production; Seed production in cereals, fiber crops, oilseeds, fodder crops, grain legumes, and vegetables; Seed production in asexually propagated crops.

Practical

Emasculation and pollination techniques to produce various classes of seeds; Rouging practices; Mechanized and non-mechanized methods of seed production; Field layout for seed production. Visit to Public and private seed production farms

Textbook

1. **McDonald, M.B. and L. Copeland. 1998. Seed Production: Principles and Practices. CBS Publishers and Distributors, New Delhi, India.**

Suggested Readings

Books

1. **Copeland, L.O. and M.B. McDonald 2001. Principles of Seed Science and Technology. 4th Ed. Kluwer Academic Publishers, Norwell, MA, USA.**
2. **Vanangamudi, K., N. Natarajan, A. Bharathi, R. Umarani, K. Natrajan and T. Sarvanan (Eds). 2006. Advances in Seed Science and Technology, Vol. I: Recent Trends in Seed Technology and Management. Agrobios, Jodhpur, India.**
3. **Singhal, N. C. 2003. Hybrid Seed Production in Field Crops: Principles and Practices. Kalayani Publishers, New Delhi, India.**

SST-507 Seed Health and Vigour 3(2-1)

Learning Objectives:

Students will learn

- Aspects of seed Health and Vigour evaluation and their relevance to crop performance.
- Principles and practices of seed health testing and management of seed-borne diseases.
- Methodology of conducting and applying the seed health and vigour tests for monitoring seed quality.

Learning Outcomes:

Sr.No.	CLOs	Domains
1	Explain the importance of seed health and vigour to manage seed-borne diseases	Cognitive
2	Demonstrate the methods used for testing seed health and vigour.	Affective
3	Analyze factors influencing seed health and vigour.	Psychomotor

SDGs Addressed in the Course

SDG 4 Quality education

SDG 12 Responsible consumption and production

Teaching Mode: Blended learning

Theory:

Importance of seed health and vigour in crop production; seed vigour: factors affecting, development and maintenance; vigour tests: standardization and referee testing of seeds of different crops, **objectives of seed health testing; factors responsible for seed vigour losses. Seed health standards;** selection criteria for healthy seed; morphological, anatomical and pathological observations for defective seed; methods of testing seed for presence of microbial activities. Seed traits for pathogen resistance. ISTA standards for determining seed health and vigour. Seed health and vigour standards for organic and GMO seeds: PCR, ELISA and Bio-assays.

Practical

Learning different laboratory techniques for determining pathological infections: **blotter methods, agar method, PCR and ELISA; Identification and handling of instruments used in laboratory for conducting seed health and Vigour;** Exercising international seed health standards for different crops; **Seed vigour tests EC test, cold test, accelerated aging test.**

Textbook

1. Elias, S.G., L.O. Copeland, M.B. McDonald and R.Z. Baalbaki. 2012. Seed testing: principles and practices. Michigan State University Press, MI, USA.

Suggested Readings

1. Kulkarni, G.N. 2002. Principles of Seed Technology. Kalyani Publishers, New Delhi, India.
2. Baalbaki, R. 2009. Seed Vigor Testing Handbook. Association of Official Seed Analysts. Wichita, KS, USA.
3. Karuna, V. 2007. Seed Health Testing-Principles and Protocols. Kalyani Publishers, New Delhi, India.
4. Basavaraju, G.V., P. Ravishankar and S. Gowdiperu. 2014. A Textbook of Seed Science and Technology. Kalyani Publishers, New Delhi, India.

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.
- 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.**

SST-509**Seed Production of Transgenic Crops****3(2-1)****Learning Objectives:****Students will learn**

1. Principles and practices for development of transgenic crops
2. Quality standards for transgenic seed production
3. Biosafety concerns related to transgenic crops

Learning Outcomes:

Sr.No.	CLOs	Domains
1	Explain the basic concepts for transgenic seed production	Cognitive
2	Describe the standards for transgenic seed production	Cognitive
3	Discuss biosafety concerns related to transgenic crops	Cognitive

SDGs Addressed in the Course**SDG 4 Quality education****SDG 12 Responsible consumption and production****Teaching Mode: Blended learning****Theory:**

Concept and significance of transgenic seed; Development procedure of transgenics; Difference between transgenic and non-transgenic seed handling; Traits used for transgenic development: insect resistance genes, herbicide resistance genes, stress resistance genes, therapeutic protein producing genes, bio-fortifying genes; Quality standards for transgenic seeds; Transgenic seed production of cross pollinated crop: case study of transgenic male sterile and restorer system in corn, self-pollinated crops: case study of Roundup ready Soyabean; Often cross pollinated

crops, case study of Bt cotton. Biosafety protocols for genetically modified seed production; IPR issues of transgenic crops.

Practical

PRACTICAL

Confirmation techniques during transgenic plant development; PCR, southern, northern, realtime PCR. Qualitative testing of transgenic crops; Immunoblot strip test, qualitative PCR. Quantitative testing of transgenic crops; ELISA, western, real time PCR. Practical assignment of seed market survey to assess the adoption rate of GM crops.

Textbook

1. Curtis, I.S. 2004. Transgenic crops of the world: essential protocols. Springer Science & Business Media. Springer, Netherlands.

Suggested Readings

1. Peña, L. 2005. Transgenic plants: Methods and protocols. Methods in Mol. Biol. 286. Humana Press, Totowa, NJ, USA.
2. Altman, A. and P.M. Hasegawa. 2012. Plant Biotechnology and Agriculture: Prospects for the 21st Century. Academic Press, London, UK.
3. Thomas, B.R., A.V. Deynze and K.J. Bradford. 2002. Production of Therapeutic Proteins in Plants. ANR Publication 8078, University of California, Davis, CA, 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.

Faqir. M and H. Dawood. 2018. Statistical Methods and Data Analysis. 6th Ed. Kitab Markaz Amin Pur Bazar, Faisalabad, Pakistan.

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.**
- 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.**

SST-502 Principles of Seed Technology 3(2-1)

Learning Objectives

Students will learn:

- **Principles of seed production and innovations in seed technology**
- **About process of seed multiplication, certification and distribution and constraints to quality seed production**
- **Skills of seed quality testing and management**

Course Learning Outcomes

Sr. No.	CLOs	Domains
1	Describe the principles of seed production and innovations in seed technology	Cognitive
2	Demonstrate the skills of seed multiplication, certification and distribution and constraints to quality seed production	Psychomotor
3	Handle the issues of seed quality management	Psychomotor

SDGs addressed in the course:

SDG 4 Quality education

SDG 8 Decent work and economic growth

Teaching Mode: Blended learning

Theory

Significance and scope of seed technology in seed industry; Classes of seed: role and minimum standards of seed purity, germination and moisture, standards of seed production, certification, tagging; Storage, logistic and distribution of various crops; Quality seed: definition, **seed viability, seed vigor and longevity**, factors affecting quality of seed; **Seed processing, conditioning and enhancements**; Seed industry: definition, its different components and institutional arrangements for its operation; National and international seed industries.

Practical

Seed identification of different varieties of various major crops, vegetables and fruit trees; **Seed sampling techniques, Equipments used for seed testing**; Rapid methods of testing seed viability; Variations and tolerances in various seed tests and its calculation.

Text Book

1. **Kulkarni, K.N. 2002. Principles of Seed Technology. Kalyani Publishers, New Delhi, India.**

Suggested Readings

1. **Bewley, J.D., K.J. Bradford, H.W.M Hilhorst and H. Nonogaki. 2013. Seeds: Physiology of Development, Germination and Dormancy. 3rd Ed. Springer, New York, NY, USA.**
2. **Copeland L.O., M.B. McDonald 2001. Principles of Seed Science and Technology. 4th Ed. Kluwer Academic Publishers, Norwell, MA, USA.**
3. **International Rules for Seed Testing. 2020. Chapter 9: Seed Moisture Test. International Seed Testing Association, Switzerland.**
4. **Khare, D. and M.S. Bhale. 2000. Seed Technology. Scientific Publishers, Jodhpur, India.**

5. Natarajan, V.N., K. Natarajan, A. Bharathi, R. Umarani, and T. Sarvanan (Eds). 2008. Advances in Seed Science and Technology, Vol. I: Recent Trends in Seed Technology and Management. Agrobios, Jodhpur, India.

SST-504

Seed Germination and Dormancy

3(2-1)

Learning Objectives

Students will learn:

- **Processes of seed germination**
- **Dormancy types and factors responsible for seed dormancy**
- **About seed germination and dormancy influences**

CLOs Vs PLOs

Sr. No.	CLOs	Domains
1	Understand the processes of seed germination	Cognitive
2	Comprehend dormancy types and factors responsible for seed dormancy	Cognitive
3	Apply the best suitable techniques to manage seed germination and dormancy influences	Psychomotor

SDGs addressed in the course:

SDG 1 Zero hunger

SDG 4 Quality education

SDG 8 Decent work and economic growth

Teaching Mode: Blended learning

Theory

Germination: Imbibition, factors affecting imbibition, respiration and metabolic activation, reserve mobilization during germination, initiation of embryo growth, molecular aspects of germination; Environmental and hormonal regulation of germination; Seed dormancy and its bases; Induction and regulation of dormancy; Methods of breaking dormancy; Hormonal regulation of dormancy.

Practical

Demonstration of epigeal and hypogeal seedling establishment; effect of temperature and water on seed germination; **Seed dissection and study of anatomical features of seed in various monocot and dicot crops**; Estimation of seed growth rate in various crops under normal and stress environments; **Methods of breaking seed dormancy**

Text Book

1. **Bewley, J.D., K.J. Bradford, H.W.M Hilhorst and H. Nonogaki. 2013. Seeds: Physiology of Development, Germination and Dormancy. 3rd Ed. Springer, New York, NY, USA.**

Suggested Readings

1. Baskin, C. and J. Baskin. 2014. Seeds Ecology, Biogeography, and Evolution of Dormancy and Germination. 2nd ed. Elsevier, USA.
2. **Benech-Arnold, R.L. and R. A. Sanchez. 2004. Handbook of Seed Physiology. Application to agriculture. Haworth Press. New York, USA.**
3. Black, M., J.D. Bewley and P. Halmer. (Eds.). 2006. The Encyclopedia of Seeds: Science, Technology and Uses. Cambridge, MA, USA.
4. **Bradford, K.J. and H. Nonogaki. 2008. Seed Development, Dormancy and Germination. Annual Plant Reviews. Wiley, USA.**

SST-506 Seed Certification and Registration 2(1-1)

Learning Objectives:

Students will learn:

- **Legislative provisions and processes and the mechanisms of seed quality control.**
- **Seed certification concepts, objectives and phases**
- **Field inspection techniques**

Learning Outcomes:

Sr. No	CLOs	Domains
1	Explain the procedure of crop and field inspection to ensure seed quality	Cognitive
2	Describe the IPR of plant breeding and seed property.	Cognitive
3	Appraise the rules and procedure of seed certification of the conventional and transgenic crops	Cognitive

SDGs Addressed in the Course

SDG 2 Zero hunger

SDG 4 Quality education

Teaching Mode: Blended learning

Theory:

Need of seed certification and registration; its importance; classes of seed; crop inspection; field inspection techniques; rules and procedures for certification and registration of transgenic and non-transgenic seeds; Distinctness, Uniformity and Stability test (DUS) testing; release of variety; legislations; IPR in relation to plant breeding and seed proprietary; Seed Act; seed certification agencies; international quarantine rules/laws and certification policy for imported seed; **Historical development of seed industry in Pakistan; regulatory mechanism of seed quality control.**

Practical

Descriptors for various crops; Data recording; Documentation for seed import and export; orientation with different performas used during field inspection; certification and registration process; preparation of proposals for variety/hybrid approval; **Specifications for tags and labels to be used for certification purpose; plant quarantine procedures** and agencies

Textbook

1. Copeland, L.O. and M.B. McDonald 2001. Principles of Seed Science and Technology. 4th Ed. Kluwer Academic Publishers, Norwell, MA, USA.

Suggested Readings

1. Basavaraju G.V., Ravishankar P., Gowdiperu Sarika 2014. A Textbook of Seed Science and Technology. Kalyani Publishers, New Delhi, India.
2. Joshi, A.K. and B.D. Singh. 2004. Seed Science and Technology. Kalyani Publishers, New Delhi, India.
3. McDonald, M.B. and L. Copeland. 1998. Seed Production: Principles and Practices. CBS Publishers and Distributors, New Delhi, India.

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

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.

FMP-510 Seed Processing Industries and their Maintenance 3(2-1)

Learning Objectives

Students will learn:

- **Basics of seed processing industries**
- **Working principles of different equipment’s and operation of seed processing.**
- **Role of post-harvest operations in seed quality**

Course Learning Outcomes:

Sr. No.	CLO	Domain
1.	Describe seed processing operations	Cognitive
2.	Explain working of various seed processing equipment	Cognitive
3.	Handle the issues during seed processing and post-harvest operations	Psychomotor

SDGs addressed in the course:

SDG 9 Industry, Innovation and Infrastructure

SDG 11 Sustainability

Teaching Mode: Blended Learning

Theory

Seed Processing: **seed processing industries importance, different feature of seed processing plant, Seed pre-cleaning and operational process, Basic cleaning process, Air screen cleaners and its types, Mobile seed cleaners, seed processing layout planning, Seed Processing Plant Building Layout: cum drying platform, processing area, Auxiliary building;** Processing plant operation and maintenance; processing sequences, matching capacity, seed handling conveyor system in industries, movement of seed in seed processing

industries; Seed dryers, Pre cleaners and Fine cleaners: gravity separators, indented cylinders, spiral separators magnetic separators, Electronic color separators; Seed graders; Seed drying: stage of moisture elimination, equilibrium moisture contents; Principles of seed drying, moisture drying methods: physical drying and artificial drying methods; purpose of seed storage: **types of seed storages, seed purity test, factors affecting seed longevity in storage; storage conditions, storage sanitation;** seed treatment; Seed packaging: classification of packaging materials, **Seed selection for extended storability,** storage maintenance, **storage insect management,** mode of heat transfer, different type of heat exchangers in seed processing industries.

Practical

Operation process of seed threshing; Precautions and safety in seed processing industries; Study of different conveyors system in seed processing industries; **Use of different tools for repairing and maintains of seed processing machinery; Adjustment and maintenance of different seed processing equipment;** Visit to local seed industry in Pakistan;

Text Book

1. **FAO. 2018. SEEDS TOOLKIT: Module 2: Seed processing: principles, equipment and practice. Licence: CC BY-NC-SA 3.0 IGO.**

Suggested Readings

1. FAO., 2018. SEEDS TOOLKIT: Module 3: Seed quality assurance. Licence: CC BY-NC-SA 3.0 IGO
2. **Bhutta A.K., Hussain A., Rehman, M.R. 2004. Handbook on Seed processing and storage, Ministry of Food and Agriculture, Government of Pakistan.**
3. Brooker, D.B., F.W.B. Arkema and C.W. Hall. 1974. Drying Cereal Grains. The AVI Publishing Company. Inc., Wesport, CT, USA.
4. **McCormack, J. H. 2004. Seed processing and storage: principles and practices of seed harvesting, processing, and storage: an organic seed production manual for seed growers in the Mid-Atlantic and Southern US. Pittsboro, NC, USA.**

MAB-516 Seed Trade Policies and Regulations 2(1-1)

Learning Objectives:

This course will learn

- **Basic concepts of seed trade policies and regulations in Pakistan**
- **Certification process of seeds**
- **Seed trade under WTO agreements**

Learning Outcomes

Sr. No.	CLO	Domain
1.	Comprehend the seed trade policies and its regulations	Cognitive
2.	Discuss the seed trade under WTO	Cognitive
3.	Analyze the certification process of seeds.	Psychomotor

Theory

Objectives and Scope of Seed Trade and Regulations; Formal and Informal Seed Systems; Growth Trends in Seed Industry; National Policies and Laws for Seed Production, Certification, Processing and Marketing; International Seed Trade; International Seed Trade Conventions and Collaborations; Rules and Regulations for Export and Import of Seed; Impact of Trade Liberalization on Seed Trade under WTO; Technical Barriers to Seed Trade; Seed Sector Development: Options and Strategies; Seed Trade in Rural Regulations;

Practical

Filing for Intellectual Property Protection for Seed Industry; Approval for Sanitary and Phyto-Sanitary Standards; The GMO Clearance from NBC Pakistan

Textbooks

1. FAO. 2000. Seed Policy and Programmes for Asia and the Pacific. FAO Plant Production and Protection Papers.

Suggested Readings

1. **Ali, I. and S. M. Ali. 2004. A Note on Seed Business in Pakistan. Lahore University of Management Sciences (LUMS) Pakistan.**
2. World Trade Organization (WTO). 2008. Understanding the WTO. World Trade Organization. Geneva, Switzerland.

SST-510 Biological Potential of Various Crops 2(1-1)

Learning Objectives:

Students will learn:

- **Biological potential of different crops to produce quality seed.**
- **Understanding the multiple uses of seed crops.**
- **Effect of climate change on quality of seed**

Learning Outcomes:

Sr. No	CLOs	Domains
1	Describe the purpose of growing cereals, oilseed, vegetables, sugar-crops, medicinal or biofuel crops.	Cognitive
2	Analyze the potential of primary or byproduct of a crop plant and the use of multipurpose crops.	Psychomotor
3	Explain the effect of changing climate on seed production potential of various crops	Cognitive

SDGs Addressed in the Course

SDG 2 Zero hunger

SDG 4 Quality education

Teaching Mode: Blended learning

Theory:

Crop seed producing potential: purpose of growing the crop as cereal, oilseed, Sugar-crop, vegetable, medicinal or bio-fuel; Organic vs In-organic farming and crop yield potential, Crop's primary product potential and its economic benefits, Crop's byproduct socio-economic importance, Introduction to new crops for multipurpose use; Seed availability, access and utilization for specific purpose; Responses of various crops to changing environment; Transgenic crops and their seed uses.

Practical

Methods for measuring leaf area. Determination of leaf area and dry weight of field crops to calculate relative growth rate, net assimilation rate etc. calculation of leaf area index; leaf area duration and harvest index of field crops; estimation of light interception; field demonstration of economic parts of crop plants.

Textbook

1. **Martin, J.H., R.P. Waldren and D.L. Stamp. 2006. Principles of Field Crop Production, 4th Ed., the MacMillan Co., New York, NY, USA.**

Suggested Readings

Books

1. Caldentey, K.M.O. and W.H. Barz. 2002. Plant Biotechnology and Transgenic Plants. Marcel Dekker, New York, NY, USA.
2. Jenks, M.A. and P.M. Hasegawa. 2005. Plant Abiotic Stress. Blackwell Publishing Ltd, Ames, IA, USA.
3. Multor, J.L., A.M. Rainbest, D. Marsh, A.J. Eydt (Eds). 1989. Preservation and Storage of Grain, Seeds and their Bye-Product: Cereals, Oilseeds, Pulses and Animal Feed. CBS Publishers and Distributors, New Delhi, India.
4. Sinnamon, L. 1993. Organic Gardening in Tropical Climates. Earth Garden Books Publishers, Trentham, Victoria.
5. **Sharma, P. 2007. Precision Farming. Gene Tech Book, New Delhi, India**

SST-601

Seed Testing

3(1-2)

Learning Objectives

Students will learn:

- Seed testing principles and procedures
- Seed quality tests
- Role of seed testing in seed certification and registration

Learning Outcomes:

Sr. No.	CLOs	Domains
1	Understand the procedure of seed testing, its importance in crop production.	Cognitive

2	Know about quality seed and how it helps in crop improvement.	Cognitive
3	Apply the skills to test seed vigor and seed viability	Psychomotor

SDGs addressed in the course:

SDG 4 Quality education

SDG 8 Decent work and economic growth

Teaching Mode: Blended learning

Theory

Concept of seed testing; sources of variation in seed testing results; types of seed samples for testing; measuring seed quality, seed vigor, objectives and principles of seed purity; application of computers in seed testing; tests standards for seed certification and registration of various crops.

Practical

Collection of seed samples for testing; tagging seed samples; Testing seed samples of various crop plants for moisture, purity, germination and vigour; **biochemical tests for viability and vigor evaluation; seedling evaluation;** Analysis of data and reporting results of various seed tests.

Text Book

1. **Elias, S.G., L.O. Copeland, M.B. Mc Donald M.B. and R.Z. Baalbaki. 2012. Principles and Practices of Seed Testing, Michigan State University Press, East Lansing, MI, USA.**

Suggested Readings

1. Black, M., J.D. Bewley and P. Halmer. (ed.). 2006. The Encyclopedia of Seeds: Science, Technology and Uses. CABI, Cambridge, MA, USA.
2. **ISTA. 2020. International Rules for Seed Testing. International Seed Testing Association, Switzerland.**
3. Joshi, A.K. and B.D. Singh. 2004. Seed Science and Technology. Kalyani, New Delhi, India.
4. **Karuna V. 2011. Seed Health Testing Principles and Protocols. Kalyani Publishers, New Delhi, India.**

SST-603

Seed Storage

3(1-2)

Learning Objectives

Students will learn:

1. Seed storage behavior and principles
2. The mechanism of seed deterioration and symptoms
3. Seed storage system management

Learning Outcomes:

Sr. No.	CLOs	Domains
1	Explain the seed storage behavior and principles	Cognitive
2	Describe mechanism of seed deterioration and symptoms	Cognitive
3	Apply skills for seed storage system management	Psychomotor

SDGs addressed in the course:**SDG 2 Zero hunger****SDG 9 Industry innovation and infrastructure****Teaching Mode: Blended learning****Theory**

Seed storage behavior; Orthodox seeds, recalcitrant seeds; Intermediate storage behavior, **Factors influencing the storage life of seeds**, seed moisture isotherms, Storage systems and infrastructures, **Seed drying methods, Methods of seed storage, Standards for Gene bank storage**, Prediction of seed deterioration, Seed viability equation and its application, mechanism of seed deterioration, symptoms of seed deterioration, physiology of seed deterioration

Practical

Equipments for seed cleaning, processing, and treatment; Preparing seed for processing. Operation and handling of mechanical drying equipments; seed extraction methods; determination of seed moisture content; **Determination of equilibrium seed moisture**; visit to seed processing plant and commercial controlled and uncontrolled seed stores.

Text Book

1. Copeland, L.O. and M.B. McDonald 2001. **Principles of Seed Science and Technology**. 4th Ed. Kluwer Academic Publishers, Norwell, MA, USA.

Suggested Readings

1. Basra, A.S. 2006. Handbook of Seed Science and Technology. Food Products Press, New York, NY, USA.
2. Bewley, J.D., K.J. Bradford, H.W.M Hilhorst and H. Nonogaki. 2013. **Seeds: Physiology of Development, Germination and Dormancy**. 3rd Ed. Springer, New York, NY, USA.
3. Black, M., J.D. Bewley and P. Halmer. (Eds.). 2006. The Encyclopedia of Seeds: Science, Technology and Uses. CABI, Cambridge, MA, USA.
4. Elias, S.G., L.O. Copeland, M.B. McDonald and R.Z. Baalbaki. 2012. Seed Testing: Principles and Practices. Michigan State University Press. East Lansing, MI, USA.

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

MAB-615

Seed Marketing and Logistics

3(2-1)

Learning Objectives:

Students will learn

- **Basic concepts of seed marketing and its various approaches.**
- **Functions and seed marketing system existing in Pakistan.**
- **Issues and their solutions related to seed marketing in Pakistan.**

Learning Outcomes

Sr. No.	CLOs	Domains
1	Comprehend the seed marketing strategies	Cognitive
2	Analyze the factors affecting demand and supply of seed	Psychomotor
3	Discuss the policy options for effective and efficient marketing system	Cognitive

SDGs

SDG 4 Quality Education

SDG12 Responsible Consumption and Production

Teaching Mode: Blended Learning

Theory

Nature and Scope of seed marketing; Approaches to understand seed marketing problems: functional approach, institutional approach, market structure, conduct and performance approach; Marketing information system; Factors affecting supply and demand of seed; Seed market planning: strategic planning; operational planning; Seed pricing policy; Marketing channels and margins; Management and operations of seed business in Pakistan; Seed distribution systems; Management of seed Logistics and Sales; Seed Industry in Pakistan; Organizational structure of public seed sector; Processing and marketing; Importance and role of public and private sector in seed industry; Public private partnership in seed business; Growth potential of seed industry in Pakistan; Challenges to seed industry; Policy options for effective and efficient seed marketing.

Practical

Visit to public and private sector seed companies to learn and understand marketing structure and their marketing strategies; Seed regulations; Quality control and certification procedure; Orientation of participants towards latest marketing skills for better learning; Content writing of marketing brochures and preparation of attractive slogans.

Textbooks

1. Mohy-ud-Din, Q. and H. Badar. 2011. Marketing of Agricultural Products in Pakistan: Theory & Practice. Publisher: Higher Education Commission (HEC). Pakistan.

Suggested Readings:

1. Ali, I. and S.M. Ali. 2004. A note on Seed Business in Pakistan. Lahore University of Management Sciences (LUMS). Pakistan.
2. FAO. 2000. Seed Policy and Programmes for Asia and the Pacific. FAO Plant Production and Protection Papers.
3. Lipper, L., L. Anderson and T.J. Dalton. 2010. Seed Trade in Rural Markets: Implications for Crop Diversity and Agricultural Development. FAO and Earthscan Publications Ltd.
4. Mohy-ud-Din, Q. 1998. Agricultural Marketing. A Publishers, Al-Fazal Market, Urdu Bazar, Lahore. Pakistan.
5. **Kotler P.T. and G. Armstrong. 2017. Principles of Marketing. 17th Ed. Pearson Higher Education Ltd. New York, NY, USA.**
6. Mumby, G. 1994. Seed Marketing. Food and Agriculture Organization. Rome, Italy.

SST-605 Seed Enhancements 2(1-1)

Learning Objectives

- **Concept and significance of seed enhancements**
- **To familiarize students with various seed enhancement techniques**
- **Physiological, biochemical and molecular aspects of seed enhancements**

Learning Outcomes:

Sr. No.	CLOs	Domains
1	Understand the role of seed enhancements in improving seed quality	Cognitive
2	Describe the physiological, biochemical and molecular aspects of seed enhancements	Cognitive
3	Manage the commercial scale application of various seed enhancements	Affective

SDGs addressed in the course:

SDG 8 Decent work and economic growth

SDG 9 Industry innovation and infrastructure

Teaching Mode: Blended learning

Theory

Concept and significance of seed enhancements; **Mechanism of seed enhancements; Seed conditioning;** Seed priming: **different priming types, physiological,** biochemical and molecular changes associated with priming; benefits of seed priming; **osmohardening;** Magnetic seed stimulation; **Seed coating;** Pelleting; Encrusting and film coating; Biological seed treatments: advantages of biological seed treatments.

Practical

Seed enhancements: methods and techniques, equipments required for seed treatment, film coating; seed invigoration/priming - hydropriming, osmopriming, solid matrix priming,

hormonal priming, bio priming, on-farm priming, effects of priming; **demonstration of seed treatment**; practical demonstration of primed seeds under normal and saline conditions in lab.

Text Book

1. Copeland, L.O. and M.B. McDonald 2001. Principles of Seed Science and Technology. 4th Ed. Kluwer Academic Publishers, Norwell, MA, USA.

Suggested Readings

1. Afzal, I., H. Rehman, M. Naveed, M. and S.M.A. Basra. 2016. Recent advances in seed enhancements. In: New Challenges in Seed Biology-Basic and Translational Research Driving Seed Technology, pp.47-74.
2. Bench-Arnold, L.R. and R.A. Sanchez. 2004. Handbook of Seed Physiology: applications to agriculture. Food Product Press, New York, NY, USA.
3. Black, M., J.D. Bewley and P. Halmer. (Eds.). 2006. The Encyclopedia of Seeds: Science, Technology and Uses. CABI, USA.
4. Taylor, A.G., P.S. Allen, M.A. Bennett, K.J. Bradford, J.S. Burris and M.K. Misra. 1998. Seed enhancements. Seed Science Research, 8(2):245-256.

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. **Krishn*a, 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.**

World Health Organization. 2004. Laboratory Biosafety Manual, 3rd Ed. Geneva, Switzerland.