Course Title: Hybrid Seed Production Technology
Course Code: SST-601
Credit Hours: 3(2+1)

Theory

Unit I

Introduction - history - scope - importance of hybrid development - national and international scenario of seed industry - popular public sector hybrids in various crops. Heterosis- definition - expression - types - utilization of heterosis in hybrid development, hybrid vigour and seed vigour.

Unit II

Types of hybrids - intra-specific, inter-specific hybrids, single, double, three way cross, top cross hybrids - apomixes; generation system of seed multiplication in different types of hybrids. Development and maintenance of inbred lines - male sterile - maintainer lines - fertility restoration - transgenic hybrids - principles and method of development.

Unit III

Breeding tools - genetic mechanism - male sterility - types : CMS, GMS, CGMS, TGMS, PGMS - barnase and barstar system - pistillateness - self incompatibility. Manual creation of male sterility - emasculation and pollination - gametocides - mode of action, mechanism. Synchronization of flowering - problems - methods to achieve synchrony - planting ratio and supplementary pollination methods.

Unit IV

Techniques of hybrid seed production in major agricultural crops - cereals (Wheat, Rice), millets (Maize, Sorghum, Bajra), pulses (Red gram), oilseeds (Sunflower, Castor, Mustard), Cotton and Forage crops.

Unit V

Hybrid seed production techniques in horticultural crops - Tomato, Brinjal, Chilli, Bhendi, Onion, Bitter gourd, Bottle gourd, Ridge gourd, Cucumber, Melon, Cabbage, Cauliflower, Potato, Coconut and Papaya.

Practical

- Characteristics features of parental lines and their hybrids
- Floral biology of rice, maize, pearl millet, sunflower, castor and cotton
- Study on floral biology of vegetable crops - solanaceous and other vegetables
- Study on floral biology of cucurbitaceous crops
- Production and maintenance of A, B and R lines
- Practicing planting design and border rows - rice, maize, pearl millet, sunflower and red gram; Brinjal and Chillies
- Practicing planting design and border rows in tomato, cotton and cucurbitaceous vegetables
- Manipulation for synchronization - rice, sunflower, pearl millet and sorghum
- Practicing supplementary pollination - rice and sunflower
- Practicing field inspection in hybrid seed production plot - crops planted in ratio -

sunflower, pearl millet, sorghum etc.,

- Practicing field inspection in hybrid seed production field - red gram, Castor, Cotton, Cucurbits and Tomato.
- Practicing roguing and identification of off-types - pollen shedders - shedding tassel - selfed fruits.
- Visit to hybrid seed production fields
- Visit to potato seed production plots
- Determination of cost benefit of hybrid seed production
- Visit to seed Industry and assessing problems and perspectives in hybrid seed production

Resources

- McDonald, M. F. and Copeland, L. O. 2012. Seed Production: Principles and Practices.Springer Science & Business Media, Boston, United States.
- Basra, A. 1999. Heterosis and Hybrid Seed Production in Agronomic Crops. CRC Press.,Florida, United States.
- Singhal, N. C. 2003. Hybrid Seed Production. Kalyani Publishers., New Delhi, India.
- Vanangamudi, K., Prabhu, M., Kalaivani, S., Bhaskaran, M and Manonmani, V. 2010. VegetableHybrid seed Production and Management. Agrobios., Jodhpur, India.
- Krishnan, M. 2012. Plant breeding and Hybrid Seed Production. Domin and Publishers &Distributors., New Delhi, India.
- Maiti, R. K., Sarkar, N.C. and Singh, V.P. 2006. Principles of Post Harvest Seed Physiologyand Technology. Agrobios., Jodhpur, India.
- Singhal, N. C. 2003. Hybrid Seed Production in Field Crops. Kalyani Publications, New Delhi.
- Frankel, R and Galun, E. 1977. Pollination Mechanisms, Reproduction and Plant Breeding.Springer Verlag, New York.
- Chhabra, A. K. 2006. Practical Manual of Floral Biology of Crop Plants. Department of PlantBreeding, CCSHAU, Hisar.
- Agarwal, R. L. 2012. Seed Technology. 3rd Ed. Oxford & IBH Publishers, New Delhi.
- Dar, S. H. 2018. Methods of Hybrid Seed Production in Major Crops. Educreation Publishing,Chhattisgarh.

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Course Title: Physiology and Biochemistry of Seeds

Course Code: SST 603
Credit hours: 2 (1+1)

Theory

Unit I

Seed development and maturation - role of cell organelles - embryogeny - translocation of assimilates - synthesis of starch, protein, lipid, secondary metabolites and toxic compounds - possible alteration in metabolic pathway.

Unit II

Development of embryo, endosperm and seed coat - translocation of assimilates and food reserves; desiccation tolerance - mechanism, hypothesis, role of LEA proteins; development of hardseeds - mechanisms and factors.

Unit III

Seed dormancy - types - physiology and biochemistry of seed dormancy induction and release - hormonal regulation of seed dormancy - environmental control - genetic inheritance and control of dormancy; physiology of orthodox, recalcitrant and intermediate seeds.

Unit IV

Seed germination - acquisition of viability and capacity of germination during development-genetics of germination acquisition; types of germination - phases of germination - requirements-imbibition - enzyme activation and hormonal regulation - respiration - mitochondrial activity and ATP synthesis - protein and nucleic acid synthesis - metabolism of starch, protein, lipid - physiology of embryo growth and development.

Unit V

Seed deterioration - theories, causes - ultra-structural, cell membrane and functional changes; biochemical changes - enzyme activity, storage reserves and genetic changes; lipid peroxidation - biological effects - free radicals and secondary products.

Practical

- Study on the pattern of seed development and maturation
- Study on the structural changes during seed maturation
- Estimation of seed moisture content, fresh and dry weight and acquisition of germinationand dormancy
- Estimation of different hormones during seed development and maturation - GA andABA
- Estimation of phenolic compounds during seed maturity
- Estimation of food reserves accumulation - starch, protein and oil at different stages of maturity

- Study on the pattern of seed development in recalcitrant seeds
- Studying the germination behaviour of different type of seeds
- Study on imbibition pattern and soaking injury in seeds
- Estimation of enzymes in dormant and non-dormant seeds
- Estimation of hormones in dormant and non-dormant seeds
- Studying the effect of light and temperature on dormancy
- Study on deterioration pattern of orthodox and recalcitrant seeds
- Estimation of lipid peroxidation product and free fatty acid
- Studying the cytological and chromosomal changes in deteriorated seeds
- Estimation of volatile aldehydes during seed storage and deterioration

Teaching methods

Classroom lectures

Assignments and presentationsField and laboratory experiments

Learning outcome

Completion of this course will enable the students to understand the mechanism of seedevelopment, regulation of dormancy, germination and deterioration and help them to understand the mysteries in seed to address the problems in quality seed production and storage.

Resources

- Khan, A. A. 1977. Physiology and Biochemistry of Seed Dormancy and Germination. NorthHolland Co, Amsterdam., New York, United States.
- Ovcharov, K. E. 1977. Physiological Basis of Seed Germination, Amerind Publishing Co,New Delhi and New York, United States.
- Bewley, J. D. and Black, M. 1982. Physiology and Biochemistry of Seeds in Relation to Germination (Vol. I & II). Springer Verlage, Berlin Heldelberg, New York, United States.
- Mayer, A. M. and Mayber, A. P. 1989. Germination of Seeds. Pergamon Press, Oxford, United kingdom.
- Vanangamudi, K. 2006. Seed Physiology. Associated Publishing Company, New Delhi, India.
- Maiti, R. K., Sarkar, N. C. and Singh, V. P. 2006. Principles of Post Harvest Seed Physiologyand Technology. Agrobios., Jodhpur, India.
- Barton, L. V. 1961. Seed Preservation and Longevity, (Vol. 1). Leonard Hill, London.
- Prakash, M. 2011. Seed Physiology of Crops. Satish Serial Publishing house. Azadpur. New Delhi.
- Justice, O. L. and Bass, L. N. 1978. Principles and Practices of Seed Storage. Agriculture Hand Book No. 506, Castle House Publication Ltd., Washington.
- Bewley, J.D., Bradford, K.J., Hilhorst, H.W.M. and Nanogaki, H. 2013. Seeds: Physiology of Development, Germination and Dormancy. Springer, New York.
- Roberts, E.H. 1972. Viability of seeds. Springerlink, New York, USA.
- David R. Murray. 1985. Seed Physiology. Volume 2: Germination and Reserve Mobilisation. Academic Press, London, UK.

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Course Title: Genetic Purity and DUS Testing
Course Code: SST 604
Credit hours: 3 (2+1)

Theory

Unit I

Genetic purity - importance - factors influencing genetic purity; genetic / cultivar purity test- objectives - principles - methods; laboratory tests - green house and field plot methods, grow - out test, seed and seedling growth tests; chemical and biochemical methods; anthocyanin pigmentation, secondary compounds, phenol, peroxidase and fluorescence tests - chromatography techniques.

Unit II

Electrophoretic analysis of proteins and isozymes; DNA finger printing methods - RAPD,AFLP, SSR, SNP and other markers; computer based machine vision technique and image analysis for varietal identification.

Unit III

Genesis of plant variety protection (PVP); International Union for Protection of New Varieties of Plants (UPOV) and its functions - GATT agreement in relation to plant variety protection; Protection of Plant Varieties and Farmer's Rights (PPV& FR) Act 2001 - objectives, salient features, farmer's rights, breeder's rights, researcher's rights - PPV& FRA Rules 2003.

Unit IV

Criteria for protection of new varieties of plants; Distinctness, Uniformity and Stability (DUS) testing - principles and procedures, guidelines, sample size, test duration, testing option; varieties of common knowledge - extant variety - essentially derived variety - collection of reference samples - grouping of varieties - example varieties; types and categories of characters - recording observations on characteristics - colour characteristics.

Unit V

Assessment of DUS characters of major crops based on morphological, biochemical andmolecular markers - rice, maize, wheat, barley, black gram, green gram, red gram, cowpea, rajma,sunflower, groundnut, castor, mustard, tomato, brinjal, onion, potato, chilli, bhendi, cucurbits, colecrops, sugarcane, cotton, flower, fruit and tree species; statistical procedure - computer software for DUS testing; guidelines for registration of germplasm - impact of plant variety protection on seed industry growth.

Practical

- Genetic purity assessment based on seed characters
- Genetic purity assessment based on seedling growth tests, anthocyanin pigmentation
- Genetic purity assessment based on secondary compounds, phenol, peroxidase and fluorescence tests

- Chromatography analysis of secondary compounds Electrophoretic analysis of seed protein and isozymes
- DNA fingerprinting using PCR techniques.
- DUS testing based on morphological descriptors of plant - rice and millets
- DUS testing based on morphological descriptors of plant - pulses and oil seeds
- DUS testing based on morphological descriptors of plant - vegetable crops
- DUS testing based on morphological descriptors of plant - flower, fruit and tree species
- Recording observations and interpretation of data
- Tree method of classification of varieties / cultivars
- Chemical and biochemical test applicable for DUS testing.
- Practical exercise on recording DUS characteristics, statistical analysis and interpretation in major agricultural crops
- Practical exercise on recording DUS characteristics, statistical analysis and interpretation in major horticultural crops
- Visit to DUS test centers

Teaching methods

- Classroom lectures
- Power point presentations
- Field and laboratory experiments
- Demonstration
- Field visits

Learning outcome

After completion of this course, the students will gain knowledge on the methods ofassessing genetic purity and able to distinguish varieties based on DUS characters.

Resources

- Joshi, A. K. and Singh, B. D. 2004. Seed Science and Technology, Kalyani Publishers, New Delhi, India.
- Choudhary, D. R. 2009. Guidelines for Storage and Maintenance of Registered Plant Varieties in the National Gene Bank. Published by Protection of Plant Varieties and Farmer'sRights Authority. Ministry of Agriculture, GOI, New Delhi, India.
- ISTA. 2010. Handbook of Variety Testing. International Seed Testing Association, Switzerland.

- Maiti, R. K., Sarkar, N. C. and Singh, V. P. 2006. Principles of Post Harvest Seed Physiologyand Technology. Agrobios., Jodhpur, India.Anon, 2016. Manual of Seed Certification Procedures. Directorate of Seed Certification,Coimbatore, Tamil Nadu.
- Ramamoorthy, K., Sivasubramaniam, K. and Kannan, M. 2006. Seed Legislation in India.Agrobios, Jodhpur, Rajasthan.
- Mishra, D. K., Khare, D., Bhale, M. S. and Koutu, G. K. 2011. Handbook of Seed Certification.Agrobios, Jodhpur, Rajasthan.
- Chakrabarthi, S. K. 2010. Seed Production and Quality Control. Kalyani Publishers, New Delhi.Trivedi, P. C. 2011. Seed Technology and Quality Control. Publications, Jaipur,Rajasthan.
- Suggested e-books
  https://books.google.co.in/books?isbn=16118603932.
  https://books.google.co.in/books?isbn=81894220303.
  https://books.google.co.in/books?id=2FbwZwEACAAJ
  https://books.google.co.in/books?id=J5bQtgAACAAJ

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Title: Advances in Seed Science
Course Code: SST 606
Credit hours: 2 (2+0)

Theory

Unit I

Physiological and molecular aspects of seed development - gene expression during seed development - selective elimination of cells - theories and concepts; physiological and molecular regulation of germination and dormancy; desiccation and stress tolerance - gene expression - mechanism - structural changes in membranes of developing seeds; prediction of seed dormancy and seed longevity using mathematical models; climate change effects on pollination, seed formation, development and quality.

Unit II

Recent techniques in seed production of self incompatible, protogyny, protandry and apomictic plant species - Gene Use Restriction Technology (GURT) - terminator and verminator technology - Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) Cas - gene editing; seed proteomics - principles, methods, applications in seed science- genetic analysis and QTL mapping of traits related to seed vigour, ageing and longevity - OMICS in related to seed science and technology; somatic embryogenesis - principles and methods of production of synthetic / somatic seeds - merits and demerits.

Unit III

Modern techniques for identification of varieties and hybrids - principles and procedures; DNA fingerprinting and other molecular techniques and their utilization - GM seeds and their detection techniques; Use of machine vision and image analysis techniques for varietal identification. Application of artificial intelligence (AI) and machine learning (ML) and virtual reality (VR) in seed science.

Unit IV

Recent accomplishments in seed enhancement research - seed coating, pelleting and priming techniques - physiological, molecular and sub-cellular basis of seed priming - detection and identification of seed borne diseases and insect pests through advanced techniques - ELISA and PCR based techniques.

Unit V

International movement of seeds - OECD seed certification schemes - recent developments in seed laws and policies - ethical issues and IPR system related to seed trade and movement.

Teaching methods

- Classroom lectures
- Power point presentations
- Student assignment and presentations

Learning outcome

After completion of this course the students will be able to take up research on seed biotechnology.

Resources

- Benech-Arnold, R. and Rodolfo, S., 2004. Handbook of Seed Physiology: Applications to Agriculture. CRC Press., Florida, United States.
- Black, M. and Bewley, J. D. 2000. Seed Technology and its Biological Basis. CRC Press. Florida, United States.
- Figeys, D. 2005. Industrial Proteomics: Applications for Biotechnology and Pharmaceuticals (No. TP248. 65. P76 I535 2005). United States.
- Lombardo, L. 2014. Genetic Use Restriction Technologies: a review. Plant biotechnology journal. 12(8): 995-1005.
- Nicolas, G., Bradford, K. J., Come, D. and Pritchard, H.W., 2003. The Biology of Seeds: Recent Research Advances. Proceedings.
- Patterson, S. D. and Aebersold, R. H. 2003. Proteomics: the first decade and beyond. Nature genetics. 33(3s): 311.
- Maiti, R. K., Sarkar, N. C. and Singh, V. P. 2006. Principles of Post Harvest Seed Physiology and Technology. Agrobios., Jodhpur, India.
- Redenbaugh, K. 1993. Synseeds: Application of Synthetic Seeds to Crop Improvement.CRC Press, London, UK.
- Bewley, J. D. and Black, M. 1994. Seeds: Physiology of Development and Germination.Springer, New York, USA.
- Kozlowski. T. T. 2012. Seed Biology: Importance, Development and Germination. (Vol. I). Academic Press Inc., New York.
- Bewley, J.D., Bradford, K.J., Hilhorst, H.W.M. and Nanogaki, H. 2013. Seeds: Physiology of Development, Germination and Dormancy. Springer, New York.
- Rakshit, A. and Singh, H.B. 2018. Advances in Seed Priming. Springer Nature Singapore Ltd., Singapore.
- Baskin, C. and Baskin, J.M. (2014) Seeds: Ecology, Biogeography, and Evolution of Dormancy

and Germination. Academic Press, Cambridge, UK.

- David R. Murray. 1985. Seed Physiology. Volume 2: Germination and Reserve Mobilisation. Academic Press, London, UK.

uggested e-books :

- https://www.springer.com/gp/book/9783540574484
- https://www.synthego.com/resources/crispr-101-ebook
- https://link.springer.com/book/10.1007/978-981-13-0032-5
- https://www.springer.com/gp/book/9780306447471#aboutBook
- https://link.springer.com/chapter/10.1007/978-1-4615-1619-4_13
- https://www.cambridge.org/core/journals/experimental-agriculture/article/biology-ofseeds-recent-research-advances-edited-by-g-nicolas-k-j-bradford-d-come-and-h-wpritchard-wallingford-uk-cabi-international-2003-pp-472-9500-isbn-0851996 531/57DACB0A07CFD0246AAD11713540F1E6
- https://www.researchgate.net/publication/240592094_Black_M_Bewley_JD_eds_2000_Seed_technology_and_its_biological_basis_419_pp_Sheffield_Sheffield_Academic_Press
- _89_hardback https://www.crcpress.com/Handbook-of-Seed-Physiology-Applications-to-
- Agricu lture/Benech-Arnold-Snchez/p/book/9781560229292
- https://www.elsevier.com/books/seeds/baskin/978-0-12-416677-6
- https://international.neb.com/tools-and-resources/feature-articles/crispr-cas9-andtargeted-genome-editing-a-new-era-in-molecular-biology https://www.omicsonline.org/scholarly/seed-science-and-technology-journals-articlesppts-list.php
- https://libgen.is/book/index.php?md5=F63727B21E14953F0003168A2452B3FE https://www.researchgate.net/publication/228621809_Techniques_for_detecting_genetically_modified_crops_and_products https://www.intechopen.com/books/new-challenges-in-seed-biology-basic-andtranslational-research-driving-seed-technology/recent-advances-in-seed-enhancements
- https://books.google.co.in/books/about/Advances_in_Seed_Priming.html?id=iBtfDwAAQB

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Course Title: Advances in Seed Quality Enhancement
Course Code: SST 607
Credit hours: 2 (1+1)

Theory

Unit I

Seed quality - importance and enhancement - principles, concept, significance, strategies; types of seed enhancement - physical, physiological and biological enhancement techniques.

Unit II

Physical seed quality enhancement - concept and principles of grading - upgrading magnetic, electromagnetic, irradiation, coating, pelleting, colouring; plasma treatment - thermal and cold plasma - treatment; application of nano formulations - concepts - principles - mode of action on improving germination.

Unit III

Physiological methods of seed quality enhancement - seed priming – principles, methods, mode of action - physiological, biochemical and molecular mechanism of priming techniques; seedinfusion - principles and methods, mode of action - imparting abiotic stress tolerance - hardening -principles and methods.

Unit IV

Application of biological formulations - bacterial, fungal agents - concepts, formulations and compatibility; methods of application - growth promotion - protection - control over pest and disease infection and mode of action; designer/ smart seed - concept, methods, applicability to different crops.

Unit V

Effect of different treatments on crop establishment and modulation of seedling growth -crop geometry, phenology and yield improvement; storability of primed, coated and pelleted seeds- pre-storage and mid-storage enhancement techniques - hydration-dehydration techniques, moisture equilibrium drying and halogenations - principles, methods and application.

Practical

- Physical seed quality up gradation - specific gravity separator, density grading, floatation technique
- Practicing seed pelleting - methods of pelleting for different crop species
- Performing seed coating - polymer, colouring and nano emulsion coating
- Study on the effect of magnetic and electromagnetic seed treatment on seed germination and vigour
- Practicing seed priming - hydro, osmo, halo and solid matrix priming methods
- Nutrient and bio priming and assessing the performance of primed seeds
- Assessing the storability of primed seed
- Study on seed hardening on the performance of seed under abiotic stress
- Preparation of designer/ smart seed for different crops
- Biological seed treatment - biological formulations, bacteria, fungi, protectants and bio fertilizers
- Study on the effect of biological seed treatment on seedling growth and disease incidence
- Estimating the microbial population in biologically treated seeds
- Assessing the storability and vigour potential of treated seeds
- Performing mid-storage seed treatment - hydration-dehydration, moisture equilibrium and drying

- Halogenation of seeds and their effect on seed performances
- Assessing the performance of treated seeds under field condition

Resources

- Doijode, S.D. 2006. Seed Quality in Vegetable Crops. In: Handbook of Seed Science and Technology, Basra, AS (Ed.). The Haworth Press, New York, United States. pp. 677–702.
- Bewley, J.D., Bradford, K.J., Hilhorst, H.W.M., and Nonogaki, H. 2013. Seeds: Physiology of Development, Germination and Dormancy, Third Edition. Springer, New York, United States.
- Filatova, I., Azharonok, V., Lushkevich, V., Zhukovsky, A., Gadzhieva, G., Spasic, K., Zivkovic, S., Puac, N., Lazovic, S., and Malovic, G. 2013. Plasma Seeds Treatment as aPromising Technique for Seed Germination Improvement. 31st International Conference onPhenomena in Ionized Gases, Granada, Spain.
- Glick, B.R., 2012. Plant Growth-Promoting Bacteria: Mechanisms and Applications. Hindawi Publishing Corporation, Scientifica.
- Thomas, B., Murphy, D.J., Murray, B.G. 2003. Encyclopedia of Applied Plant Sciences (3volume set). Elsevier Science, Netherland.
- Maiti, R.K., Sarkar, N.C. and Singh, V.P. 2006. Principles of Post Harvest Seed Physiologyand Technology. Agrobios., Jodhpur, India.
- Halmer, P. 2003. Methods to improve seed performance. In: Benech-Arnold, RL, Sanchez, RA (Eds.). Seed Physiology, Applications to Agriculture. Food Product Press, New York, United States.
- McDonald, M. F. and Copeland, L. O. 2012. Seed Production: Principles and Practices. Springer Science & Business Media., Boston, United States.

Suggested e-books

- https://www.springer.com/gp/book/9781461446927
- https://link.springer.com/chapter/10.1007/978-1-4615-1619-4_1.
- https://www.intechopen.com/recent-advances-in-seed-enhancements
- https://link.springer.com/content/pdf/bfm%3A978-981-13-0032-5%2F1.pdf
- https://www.researchgate.net/publication/297732007_Advances_in_Seed_En ha ncements
- https://www.researchgate.net/publication/309040118_Recent_Advances_in_ Seed_Enhan cements https://www.cambridge.org/core/journals/seed-science-research/article/seed

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