Department of Seed Science & Technology
Chaudhary Charan Singh University, Meerut-250004 (UP) India

Programme Syllabus

Master of Science (Agriculture) in Seed Science & Technology
M.Sc. (Ag.) Seed Science & Technology

8/7/2026

Department of Seed Science and Technology
Ch. Charan Singh University, Meerut

Syllabus for M. Sc. (Ag.) Seed Science and Technology (CBCS)

Course Type	Name of Course	Course Code	Credits L+P+T	Maximum Marks			
				Int.	Ext.	Prac.*	Total
SEMESTER I							
Compulsory Core	Floral Biology, Physiology of Seed Development and Maturation		4+1+0	40	40	20	100
	Fundamentals of Plant Breeding		4+1+0	40	40	20	100
	Fundamentals of Genetics		4+1+0	40	40	20	100
	Sub-total of credits		**15**				
Elective Core	Statistical Methods in Agriculture		4+1+0	40	40	20	100
	Sub-total of credits		5				
Thesis/Project/ Dissertation	Component-I		**8**				
	Total		**28**				**400**
SEMESTER II							
Compulsory Core	Seed Industry Development and Marketing		4+1+0	40	40	20	100
	Plant Genetic Resources: Conservation and Sustainable Use		4+1+0	40	40	20	100
	Principles of Hybrid Seed Production		4+1+0	40	40	20	100
	Sub-total of credits		15				
Elective Core	Computer Applications and Bioinformatics		4+1+0	40	40	20	100
	Sub-total of credits		**5**				
Open Elective¥	Concepts of Seed Science and Technology		4+0+0				Qualifying
Thesis/Project/ Dissertation	Component-II		**12**				
	Total		**32**				**400**
SEMESTER III							
Compulsory Core	Seed Pathology and Seed Entomology		4+1+0	40	40	20	100
	Seed Production Technology-I (Vegetable Crops)		4+1+0	40	40	20	100
	Seed Testing and Quality Control		4+1+0	40	40	20	100
	Sub-total of credits		**15**				
Elective Core	Seed Processing and Storage		4+1+0				
	Sub-total of credits		**5**				
Open elective ¥	Techniques in Seed Science and Technology		4+0+0				Qualifying
Thesis/Project/ Dissertation	Component-III		**12**				
	Total		**32**				**400**

SEMESTER IV							
Compulsory Core	Seed Biotechnology		4+1+0	40	40	20	100
	Sub-total of credits		**5**				
Elective Core	Seed Production Technology-II (Rabi and Kharif Crops)		4+1+0	40	40	20	100
	Sub-total of credits		**5**				
Thesis/Project/ Dissertation	Component-III		**18**				100
	Total		**28**				**200**
M.Sc. (Ag) Thesis/Project/ Dissertation							
M.Sc. (Ag) Thesis/Project/ Dissertation	Component-I (C_1): Periodic progress and progress report (15%)						
	Component-II (C_2): Results of work and draft report (15%)						
	Component-III (C_3): Final viva-voce and evaluation (70%) (a) The report evaluation (40%) (b) Viva-voce examination (30%)						
	Total credits in M.Sc. (Ag) Thesis/Project/ Dissertation		**50**				Satisfactory
	Grand Total of credits and Maximum marks in whole M.Sc. (Ag) program		**120**				**1400**

☛*In each semester, there shall be one joint external practical examination carrying 80 marks based on all the four courses (20+20+20+20 marks) of compulsory and elective core.

Thesis/Project/ Dissertation: May be conducted within department and/Or other academic/research organization in any part of India; If thesis will be conducted in department of Seed Science & Technology, CCS University, Meerut, then student have to bear experimental/research cost by their own.

¥credit course (qualifying)

One week (7-10 days) exposure/internship/training/hands-on training is desirable from all the students registered in M.Sc.(Ag.) Seed Science & Technology programme

☛Pattern of examination, passing marks, determination of CGPA/division shall be as per rules applicable in faculty of Agriculture campus courses running under CBCS.

8/7/2016

Programme Outcomes (POs)

PO1. Advanced Knowledge of Seed Science:
Graduates will acquire comprehensive knowledge of seed biology, genetics, plant breeding, seed production, seed processing, seed testing, seed storage, seed pathology, seed biotechnology, and quality assurance for the production of high-quality seeds.

PO2. Technical and Analytical Competence:
Graduates will apply scientific principles, laboratory techniques, molecular tools, statistical methods, and modern technologies for seed quality assessment, varietal identification, genetic purity testing, and seed production management.

PO3. Research and Innovation:
Graduates will demonstrate the ability to design, conduct, analyze, and interpret research in seed science and technology, utilizing conventional and advanced biotechnological approaches for crop improvement and sustainable seed systems.

PO4. Professional and Entrepreneurial Skills:
Graduates will develop competencies in seed industry management, seed certification, quality control, seed legislation, marketing, entrepreneurship, and agribusiness to contribute effectively to the public and private seed sectors.

PO5. Sustainable Agriculture and Resource Conservation:
Graduates will apply principles of sustainable agriculture, climate-resilient seed production, conservation of plant genetic resources, biodiversity management, and environmentally responsible seed technologies to enhance agricultural productivity and food security.

PO6. Digital and Technological Proficiency:
Graduates will utilize information technology, bioinformatics, precision agriculture, GIS, remote sensing, drones, molecular markers, and data analysis tools for decision-making and innovation in seed science and technology.

PO7. Communication, Leadership, and Ethics:
Graduates will demonstrate effective scientific communication, teamwork, leadership, ethical practices, and compliance with national and international seed laws, intellectual property rights, biosafety regulations, and professional standards.

PO8. Lifelong Learning and Global Competence:
Graduates will engage in lifelong learning, adapt to emerging technologies and global developments in seed science, and contribute to national and international seed research, education, policy, and industry.

COURSE OUTCOMES (COs)

M.Sc. (Ag.) Seed Science and Technology			
Semester	Course Name	Course Code	Course Outcome
	Floral Biology, Physiology of Seed Development and Maturation		**CO1.** Students will understand the floral biology, sporogenesis, gametogenesis, and reproductive structures of crop plants and their significance in pollination and seed production. **CO2.** Students will understand the mechanisms of pollination, fertilization, pollen physiology, and pollen preservation and their role in successful seed set and crop improvement. **CO3.** Students will understand the processes of embryogenesis, endosperm and seed development, and distinguish the structural characteristics of monocot and dicot seeds. **CO4.** Students will understand the principles, types, and applications of apomixis, polyembryony, and reproductive sterility in hybrid seed production and plant

			breeding. **CO5.** Students will understand the physiological and biochemical processes involved in seed development, maturation, dormancy, desiccation tolerance, and hormonal regulation, and their importance in improving seed quality and germination.
I	Fundamental of Plant Breeding		CO-1: Students will understand the significance of different plant breeding systems. CO-2: Students will understand the application of conventional breeding approaches and gene technology approaches in plant breeding programs. CO-3: Students will be well versed in practical emasculation and pollination methods of important crops. CO-4: Students will be able to describe the progression of stages within a modern breeding programme. CO-5: Students will be able to judge which plant breeding methods are appropriate for specific objectives and situations. CO-6: Students will be able to carry out specific plant breeding activities, such as selection of parental germplasm, observation and recording of phenotypic variation and selection among progeny
	Fundamentals of Genetics		**CO1.** Students will understand the historical development of genetics, Mendelian and non-Mendelian inheritance, gene interactions, multiple alleles, and the molecular basis of heredity. **CO2.** Students will understand the principles of linkage, crossing over, chromosome mapping, and the chromosomal basis of inheritance and their applications in genetic analysis. **CO3.** Students will understand the mechanisms of sex determination, sex differentiation, sex-linked inheritance, and human sex chromosome anomalies in plants and animals. **CO4.** Students will understand the concepts of extranuclear inheritance, mutation genetics, mutagenic agents, and methods for mutation detection and their significance in genetics and crop improvement. **CO5.** Students will understand the fine structure of genes, molecular and epigenetic regulation of gene expression, and the role of epigenetic mechanisms in inheritance and phenotypic variation.

	Statistical Methods in Agriculture		CO-1: Organize and present data using statistical tables and graphs, and compute basic descriptive statistics such as mean, median, mode, standard deviation, and coefficient of variation. CO-2: Analyze relationships between variables using correlation and regression techniques, including Spearman rank correlation and concepts of association and independence. CO-3: Apply the concepts of sampling and perform hypothesis testing using t-test, z-test, chi-square test, and understand their interrelations with F-test. CO-4: Design and analyze experiments using completely randomized, randomized block, Latin square, augmented block, and factorial designs, and interpret results using ANOVA and LSD (CD).
II	Seed Industry Development and Entrepreneurship		CO1: Students will have knowledge on the importance of quality seed, differentiate between formal and informal seed supply systems, and recognize the role of seed associations and federations in seed trade. CO2: Students will understand on Analyze the factors influencing seed demand and supply, including seed replacement rate (SRR), seed multiplication ratio (SMR), cost-benefit analysis, and seed pricing policies. CO3: Apply concepts of seed marketing intelligence, product mix, sales promotion strategies, distribution channels, and evaluate marketing costs and margins. CO4: Examine national seed policies, quality control and assurance programs, and understand the legal responsibilities of seed companies and dealers, including Seed Act and EXIM policies. CO5: Evaluate national and international trends in the seed industry, roles of various organizations like ISF and Indian seed associations, and the economic aspects of seed production and marketing including buyer behavior and sectoral roles.
	Plant Genetic Resources: Conservation and Sustainable Use		CO-1: Students will have knowledge on the conservation of biodiversity. CO-2: They will acquire knowledge on various organizations involved in conservation and their policies. CO-3: The students will have knowledge on plant quarantine regulations. CO-4: The students will be able to promote human capacity to appreciate, maintain, and promote utilization of plant genetic resources.

			CO-5: Students will understand different forms of IPRs and legislations related with IPRs. They will be well aware of Farmers' and Plant Breeders' rights.
	Principles of Hybrid Seed Production		CO-1: Students will be able to impart knowledge about various tools involved in hybrid seed production of crop plants. CO-2: To really understand the basic principles of seed production in varieties and hybrids. CO-3: Student will acquire knowledge on conventional and molecular breeding methods to obtain yield improved crop varieties. CO-4: Students will be able to understand pre-Mendelian and post-Mendelian aspects of heterosis
	Computer Applications and Bioinformatics		CO-1: Understand the history, scope, goals, and components of bioinformatics and its relevance in modern biological sciences. CO-2: Describe different types of biological databases, their structure, and methods for retrieving biological information including formats and classification. CO-3: Perform and interpret sequence alignments using alignment algorithms (e.g., BLAST, FASTA), dot plots, and scoring matrices like PAM and BLOSUM. CO-4: Explain molecular phylogenetics concepts and apply methods for constructing phylogenetic trees using distance and character-based approaches. *Mapped Topic:* Molecular phylogenetics
III	Seed Pathology and Seed Entomology		CO-1: Understand the fundamental concepts, terminology, and historical development of seed health testing and its importance in agriculture. CO-2: Identify major seed-borne pathogens including fungi, bacteria, viruses, and nematodes, and describe their location on or within seeds such as embryo, endosperm, seed coat, and pericarp. CO-3: Explain the principles of seed entomology, including the classification of insect pests and their impact on seeds as well as the role of pollinator insects. CO-4: Describe the mechanisms of seed infection by pathogens, including systemic and localized infection routes through flowers, fruit, seed coat, natural openings, and injuries. CO-5: Analyze the factors influencing seed infection such as host genotype, environmental conditions, crop management, and interactions between pathogens and pests.

			CO-6: Evaluate factors affecting seed transmission of pathogens including crop species, inoculum survival, cultural practices, and seed physiology. CO-7: Identify storage insect pests that infect seeds, understand their biology and economic impact, and apply methods for pest management, seed sampling, and loss estimation. CO-8: Understand seed deterioration caused by storage and field fungi, detect fungal damage, and apply control measures including seed production management, seed treatment, certification, quarantine, and disease resistance strategies.
	Seed Production Technology – I: Vegetable crops		**CO1.** Students will understand the principles, scope, and importance of vegetable seed production, seed multiplication systems, seed demand, and the vegetable seed production scenario in India. **CO2.** Students will understand the agro-climatic requirements, crop planning, isolation techniques, rouging, field inspection, pollination management, and maintenance of genetic purity in vegetable seed production. **CO3.** Students will understand the seed production technologies of major vegetable crops, including fruit, cole, root, bulb, tuber, leafy, and leguminous vegetables. **CO4.** Students will understand the application of protected cultivation, Good Agricultural Practices (GAP), organic seed production, and quality assurance systems for producing high-quality vegetable seeds. **CO5.** Students will understand the impact of climate change and the role of precision agriculture, digital technologies, seed traceability, and recent innovations in enhancing the efficiency and sustainability of vegetable seed production.
	Seed Testing and Quality Control		CO-1: To have a faith in seed certification procedure. CO-2: To sort out the rogues and off types from the seed production area and to understand the importance of seed testing. CO-3: Students will be in a position to emphasis on Seed Legislation, certification, labelling of different seed classes and truthfully labelled seeds. CO-4: To afford knowledge on various organizations involved in seed testing. CO-5: To provide knowledge about various seed testing procedure with tolerance.
	Seed Processing and Storage		CO-1: To impart knowledge on processing sequence for various crop plants.

			CO-2: Students will get knowledge principles and mode of action of various seed processing equipments. CO-3: Students will get knowledge on seed storage methods and seed treatment procedures. CO-4: Students will understand the importance of priming and treating seeds.
IV	Seed Biotechnology		**CO1.** Students will understand the principles and applications of plant tissue culture techniques, including micropropagation, somatic embryogenesis, embryo culture, anther culture, protoplast culture, and somatic hybridization for crop improvement. **CO2.** Students will understand the concept, production, storage, germination, and applications of synthetic seeds and their role in large-scale propagation and germplasm conservation. **CO3.** Students will understand the methods of gene transfer, development of transgenic plants, molecular farming, and biosafety regulations governing plant biotechnology. **CO4.** Students will understand the principles and applications of DNA-based molecular markers for varietal identification, genetic diversity analysis, and molecular characterization of crop plants. **CO5.** Students will understand the applications of molecular markers in plant breeding, including molecular mapping, gene tagging, QTL analysis, and marker-assisted crop improvement.
	Seed Production Technology-II (Rabi and Kharif Crops)		**CO1.** Students will understand the principles, objectives, and importance of seed production, seed classes, seed multiplication systems, seed replacement rate, varietal replacement rate, and the factors affecting seed quality and genetic purity. **CO2.** Students will understand the planning and management of seed production, including site selection, crop rotation, crop establishment, nutrient and irrigation management, weed management, post-harvest handling, and Good Agricultural Practices (GAP). **CO3.** Students will understand the seed production technologies and certification requirements of major **Kharif** field crops, including cereals, pulses, oilseeds, and fibre crops. **CO4.** Students will understand the seed production technologies and certification requirements of major **Rabi** field crops,

			including cereals, pulses, oilseeds, and fibre crops. **CO5.** Students will understand the principles of rouging, field inspection, isolation, pest and disease management, harvesting, processing, seed standards, certification, and economics of quality seed production in field crops.

Floral Biology, Physiology of Seed Development and Maturation

Course-I; Code- --------

Teaching Hours: 60

Unit	Content	Credits /hours
1	**Floral Biology and Gametogenesis:** Floral types, Floral structure, floral diagram and biology in relation to pollination mechanisms; sporogenesis: microsporogenesis and megasporogenesis; gametogenesis - development of male and female gametophyte and their structures	10
2	**Pollination and Fertilization Mechanisms:** Mode of pollination, Mechanism of outcrossing, Double fertilization – embryo sac structure, process, barriers to fertilization, Pollination mechanisms and control of pollination; pollen Viability & physiology, pollen preservation	12
3	**Embryogenesis** - Development of typical monocot and dicot embryos; endosperm development, modification of food storage structures with reference to crop plants; different types of embryos, endosperm and cotyledons; development and their structure in representative crop plants with reference to food storage; external and internal features of monocot and dicot seed; seed coat structure and development in representative crop plants.	12
4	**Apomixis and Polyembryony** – Types, hidentification, classification, significance and its utilization in different crops for hybrid seed production; Polyembryony - types and significance; haplontic and diplontic sterility.	12
5	**Seed dormancy** – types, causes, mechanisms of induction and release; factors affecting dormancy; methods to overcome dormancy and its significance in agriculture; physiology of seed development and maturation; chemical composition, synthesis and accumulation of seed reserves; induction of desiccation tolerance; hormonal regulation of seed development.	14

Suggested Readings

1. Adkins, S.W., Ashmore, S.E. and Navi, S.C. 2007. Seeds: Biology, Development and Ecology. CAB International, Oxfordshire, UK.
2. Frankel, R. and Galun, E. 1977. Pollination Mechanisms, Reproduction and Plant Breeding. Springer Verlag, New York.
3. Bewley, J.D., Black, M. 1994. Seeds: Physiology of Development and Germination. Springer, New York.
4. Copeland, L. O. and McDonald, M. B. 2001. Principles of Seed Science and Technology. 4th Ed. Kluwer Academic publishers, USA.
5. Bhojwani SS & Bhatnagar SP. 1999. *The Embryology of Angiosperm*. Vikas Publ.
6. Black M, Bewley D & Halmer P. 2006. *The Encyclopedia of Seeds: Science, Technology and Uses. CABI.*
7. Chhabra AK. 2006. Practical Manual of Floral Biology of Crop Plants. Deptt. of Plant Breeding, CCS HAU, Hisar.
8. Copeland LO & McDonald MB. 2001. *Principles of Seed Science and Technology*. 4th Ed. Chapman & Hall.
9. Frankel R & Galun E. 1977. Pollination Mechanisms, Reproduction and Plant Breeding. Springer Verlag.
10. Suggested e-books https://www.springer.com/in/book/9783642810619
11. https://www.springer.com/in/book/9780792373223
12. https://www.worldcat.org/title/seed-development-and-ermination/oclc/44954614
13. https://books.google.co.in/books/about/Seeds.html?id=- Zbzr1F_z74C&redir_esc
14. https://books.google.co.in/books/about/Seeds.html?id=6S75BwAAQBAJ&printsec=frontcover&source=kp_read_button&redir_esc=y#v=onepage&q&f=false
15. https://agriinfo.in/botany/18/ http://www.seedbiology.de/structure.asp
16. http://www.fao.org/3/ad232e/AD232E02.htmsbc.ucdavis.edu/Research_pages/Seed_physiology_and_technology/
17. https://courses.lumenlearning.com/wmbiology2/chapter/development-seeds-fruit

Fundamentals of Plant Breeding
Course – II; Code----------

Teaching hours: 60

Unit	Content	Credits /hours
1	**Historical perspectives:** Past progress and future needs, green revolution, evergreen revolution, White revolution, Blue revolution, and Yellow revolution; Domestication of crop plants; Major Contributions of Scientists (eg.- Thomas Hunt Morgan, William Bateson, Barbara McClintock, Norman E. Borlaug and M. S. Swaminathan.	10
2	**Genetic basis of breeding:** self- and cross-pollinated crops including mating systems and response to selection; Nature of variability, components of variation; Heritability and genetic advance, genotype environment interaction; General and specific combining ability; Types of gene actions and implications in plant breeding.	10
3	**Breeding methods in self-pollinated crops:** Pure line theory, pure line and mass selection methods; pedigree, bulk, backcross, single seed descent and multiline breeding; Population breeding in self-pollinated crops with special reference to diallel selective mating; Transgressive breeding.	10
4	**Breeding methods in cross pollinated crops; Population breeding:** mass selection and ear-to-row methods; S1 and S2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and inter-population improvement and development of synthetics and composites.	10
5	**Special breeding techniques:** Mutation breeding, Polyploidy breeding, Concept of plant ideotype and its role in crop improvement, concept of MAS, and wide hybridization	10
6.	**Cultivar development:** testing, release and notification, maintenance breeding, Participatory Plant Breeding, Plant breeders' rights and regulations for plant variety protection and farmers rights.	10

Suggested Reading

1. Allard RW. 1981. *Principles of Plant Breeding*. John Wiley & Sons.
2. Chahal GS and Gossal, SS. 2002. *Principles and Procedures of Plant Breeding Biotechnological and Conventional approaches.* Narosa Publishing House.
4. Chopra VL. 2004. *Plant Breeding*. Oxford & IBH.
5. George A. 2012. *Principles of Plant Genetics and Breeding*. John Wiley & Sons.
6. Gupta SK. 2005. *Practical Plant Breeding*. Agribios.
7. Jain HK and Kharakwal MC. 2004. *Plant Breeding and–Mendelian to Molecular Approach*,
9. Roy D. 2003. *Plant Breeding, Analysis and Exploitation of Variation*. Narosa Publ. House.
10. Sharma JR. 2001. *Principles and Practice of Plant Breeding*. Tata McGraw-Hill.
11. Sharma JP. 2010. Principles of Vegetable Breeding. Kalyani Publ, New Delhi.
12. Simmonds NW.1990. *Principles of Crop Improvement*. English Language Book Society.
13. Singh BD. 2006. *Plant Breeding*. Kalyani Publishers, New Delhi.
14. Singh S and Pawar IS. 2006. *Genetic Bases and Methods of Plant Breeding*. CBS.

Fundamentals of Genetics
Course-III; Code- ----------

Teaching hours: 60

Unit	Content	Credits /hours
1	**Introduction and Gene Interaction and Multiple alleles:** Introduction- History of genetics, its scope and significance; Lethality, penetrance and expressivity; pleiotropic genes; forward and reverse genetics; brief idea of Mendel's laws and physical basis of heredity (chromosome theory of inheritance), forward vs. reverse genetics. Multiple alleles: Concept of multiple alleles; coat colour in rodents; blood groups in humans; antigen–antibody interaction in inheritance of A, B, AB and O blood groups; H–antigens, MNS system, Rh factor; epistasis and multiple allelism (e.g., Bombay blood groups); Modification of F2 ratio & gene interaction .	12
2	**Linkage and Chromosomal Basis of Inheritance:** Linkage and crossing over: Coupling and repulsion hypothesis; Types of Linkage: Detection of Linkage; theories of crossing over; three point test cross (interference and coincidence; calculation of recombination frequencies from F_2 data); brief idea about mapping function; cytological basis of crossing over (experiments of Stern in *Drosophila* and that of McClintock in corn).	12
3	**Sex Determination and Differentiation:** Sex inheritance, determination and differentiation: theories of sex determination—chromosome theory and genic balance theory of sex determination; sex determination in mouse and in man; genetic basis of sex differentiation (genes located on sex chromosomes and autosomes), single gene control of sex; hormonal control of sex, sex reversal and gynandromorphs; human sex anomalies (Klinefelter's syndrome and Turner's syndrome).	12
4	**Non-Mendelian Inheritance and Mutation Genetics:** Extra-chromosomal inheritance: Criteria for extra chromosomal inheritance; plastid inheritance in *Mirabilis*; iojap in corn; Kappa particles in *Paramecium*; coiling in snails; Mutations and mutagenic agents: Brief history of mutations; types of mutations; rate and frequencies of mutations; physical and chemical mutagens and deletogens; detection of mutations in *Drosophila* (ClB method, Muller–5 method).	12
5	**Biochemical, Molecular and Epigenetic Basis of Gene Function:** Fine structure of gene: Classical and modern gene concepts; pseudoallelism, position effect; intragenic crossing over and complementation (cistron, recon, muton); Benzer's work on rII locus in T4 phage, Epigenetics: Paramutation; DNA methylation and histone modification; genome imprinting (IGF2 in mammals), 'Solid gold' or Callipyge in sheep	12

Suggested Readings

1. Lewin B. 2008. Genes XII. Jones & Bartlett Publ. (International Edition) Paperback, 2018 Russell PJ. 1998. Genetics. The Benzamin/Cummings Publ. Co
2. Singh B D. 2009. Genetics. Kalyani Publishers (2nd Revised Edition) Stansfield W.D.1991. Genetics.Schaum Outline Series Mc Graw Hill
3. Gupta P K (2009). Genetics, 4/e. Rastogi Publications, Meerut.
4. Gupta P K (2007). Genetics: Classical to modern. Rastogi Publications, Meerut.
5. Griffith et *al* (2008). An introduction to Genetic Analysis. Freeman & Co.
6. Hartl DL and Jones EW (1997). Genetics: Principles and Analysis 4th Ed. Jones & Bartlett Publishers, Inc
7. Hartwell L *et al* (2000). Genetics: From genes to genomics. McGraw Hill, New Delhi.
8. Lewin B. (2007). Genes IX. Wiley Eastern Ltd., New Delhi.
9. Pierce, B. (2005). Genetics: A conceptual Approach 2nd Ed. WH Freeman
10. Snustad D P , Simmons NJ and Jenkins JB (2003). Principles of Genetics. John Wiely & Sons, New York.
11. Strickberger, N.W. (1985). Genetics 3rd Ed. Macmillan Co. New York.

Statistical Methods in Agriculture
Course-IV; Code- ----------

Teaching hours: 60

Unit	Content	Credits /hours
1	**Presentation of Data and Correlation Analysis:** Frequency distribution, Box-plot, Measures of central tendency (Mean, Mode, Median), Measures of dispersion (range, variance, mean & standard deviation), Graphical representations of data by histogram, frequency polygon, frequency curve and cumulative frequency curves).	12
2	**Sampling and Tests of Significance:** Sampling and tests of significance: concept of population and sample; random samples; methods of taking a simple random sample; sampling distribution of mean and standard error; z and t-test (equality of means; paired and unpaired t-test); chi-square test for goodness of fit, independence of attributes and homogeneity of samples; interrelation between t-test and F-test.	14
3	**Field Designs:** Experimental designs: principles of experimental designs; completely randomized design (CRD); randomized complete block design (RCBD) including missing plot value in RBD; Latin square design; augmented block design; simple factorial experiments (mathematical derivations not required); analysis of variance (ANOVA) and its use including estimation of LSD (CD).	14
4	**Experimental Designs:** Non-parametric tests – sign, Wilcoxon, Mann-Whitney U-test, Run test for the randomness of a sequence. Median test.	10
5	**Probability**: Discrete and continuous probability distributions, Binomial, Poisson, Negative Binomial, Normal distribution, Beta and Gamma distributions and their applications.	10

Suggested Reading

1. Goon A.M, Gupta M.K and Dasgupta B. 1977. An Outline of Statistical Theory. Vol. I. The World Press.
2. Goon A.M, Gupta M.K. and Dasgupta B. 1983. Fundamentals of Statistics. Vol. I. The World Press.
3. Hoel P.G. 1971. Introduction to Mathematical Statistics. John Wiley.
4. Hogg R.V and Craig T.T. 1978. Introduction to Mathematical Statistics. Macmillan.
5. Morrison D.F. 1976. Multivariate Statistical Methods. McGraw Hill.
6. Hogg RV, McKean JW, Craig AT. 2012. Introduction to Mathematical Statistics 7th Edition.
7. Siegel S, Johan N & Casellan Jr. 1956. Non-parametric Tests for Behavior Sciences. John Wiley.
8. Anderson TW. 2009. An Introduction to Multivariate Statistical Analysis, 3rd Ed. John Wiley

Seed Industry Development and Entrepreneurship
Course-V; Code- ---------

Teaching Hours: 60

Unit	Content	Credits /hours
1	**Seed Industry and Seed Supply Systems:** Importance and promotion of quality seed; formal and informal seed supply systems; basic concepts of marketing with special reference to seed; importance and scope of seed industry in India; major constraints/problems in seed industry/seed sector; role of seed associations/federations in seed trade.	12
2	**Seed Demand, Supply and Pricing:** Demand and supply of seed; role of seed replacement rate (SRR) and seed multiplication ratio (SMR); cost of production and returns; determining seed needs; seed pricing and price policy; seed processing and packaging; demand forecasting.	12
3	**Seed Marketing Strategies:** Seed marketing intelligence and product mix; sales promotion; distribution channels; marketing costs and margins.	8
4	**Seed Policies, Regulations and Quality Assurance:** Historical development and evolution of seed legislation in India; need, objectives and significance of seed laws; salient features and provisions of the Seeds Act, 1966, Seeds Rules, 1968, Seeds (Control) Order, 1983, Principles, objectives and procedures of seed certification; classes of seed; eligibility for certification; field inspection, seed labelling and tagging, certification standards for major crops. Seed law enforcement, powers and functions of Seed Inspectors and Seed Analysts, Organization and functions of Central and State Seed Certification Agencies, Central Seed Committee, Recent advances in seed legislations.	14
5	**National and International Seed Trade and Economics:** WTO, GATT, IMF, World Bank policies, Trends in national and international seed industry development; International Seed Trade Federation (ISF) and Indian seed associations; economics of seed production; market survey; demand forecasting; pricing policies; marketing channels; planning and sales promotion; buyer behaviour; role of Government, semi-Government, cooperative and private sectors in seed trade.	14

Suggested Readings

1. Acharya, S.S. Agricultural marketing in India, Oxford and IBH, New Delhi.
2. B.P. Ghildyal and R.P. Gupta, 2002. Soil Structure: problems and Management, ICAR, New Delhi.
3. Hunt, D. 1968. Farm Power and Machinery Management, Vth edition, IOWA State, U.S.A.
4. ISTA (1983). Seed Technology in the tropics. The International Seed Testing Association, reprinted by Scientific Publishers, India
5. John, E. Kadlec, Farm management, Decision, operation, control. Prentice Hall, Inc. Englewood, Chiffs, New Jersey, U.S.A.
6. Kahlon, A.S. and Singh Karan. Economics of farm management in India, Allied Publishers Pvt. Ltd., 13/14, Asaf Ali Road, New Delhi
7. Kundu KK & Suhag KS. 2006. Teaching Manual on Seed Marketing and Management. Department of Agricultural Economics CCS HAU Hisar.
8. Micheal, D. Boehlje and Verman, R. Ediman. Farm Management. Kalyani Publishers.
9. Miller, B. McDonald and Lawrence O. Copeland, 1998. Seed Production: Principles and Practices. CBS publishers and distributors, 11 Darya ganj, New Delhi. Raju,
10. V.T and Rao, DVS. Economics of farm production and management, IBH Publishing Comp. Pvt. Ltd., New Delhi.
11. Venugopal P. 2004. State of Indian Farmers: A Millennium Study. Vol. VIII. Input Management. Academic Foundation, Department of Agriculture and Cooperation, Ministry of Agriculture, New Delhi. Vigneshwara Varmudy 2001. Marketing of vegetables in India.

Plant Genetic Resources: Conservation and Sustainable Use
Course-VI; Code- ---------

Teaching hours: 60

Unit	Content	Credits /hours
1	**Origin, Diversity and Classification of Plant Genetic Resources:** Centers of diversity and centers of origin; a brief idea of modern system of classification (Angiosperm Phylogeny Groups) and gene pools.	8
2	**Biodiversity and Plant Genetic Resources:** Biodiversity vs. genetic resources: Definition and explanation; alpha vs. beta biodiversity and methods of their study; present levels of biodiversity and rate of loss of biodiversity; causes for the loss of biodiversity; uses of biodiversity; extent of biodiversity in plants; exploration and germplasm collection, introduction and exchange of PGR; Red Data Books and endangered plant species.	12
3	**Conservation of Plant Genetic Resources and International Organizations**: Techniques for conservation of plant germplasm: In situ and ex situ methods of conservation; cryopreservation of genetic materials; gene banks and cryobanks; Biodiversity International (IPGRI) and NBPGR; Future Harvest Centers (formerly IARCs); their role in conservation of PGR.	12
4	**International Treaties and Access to Genetic Resources:** CBD and sustainable use of biodiversity; Gene treaty; Cartagena Protocol; harmonization of international and national treaties; Role of FAO/CGIAR system for access to genetic resources: ITPGRFA (International Treaty on Plant Genetic Resources for Food and Agriculture) and global system of PGR; FAO's Commission on PGR (CPGR); International Code of Conduct for PGR collection and transfer; multilateral system for access to PGR	14
5	**Intellectual Property Rights and Legal Framework in Plant Breeding**: IPRs in plant breeding: UPOV; Plant Breeders' Rights (PBRs); essentially derived varieties and farmers' rights (FRs); Protection of Plant Varieties and Farmers' Rights Act (PPV & FRA) 2001; intellectual property rights—patents, copyrights, trademarks; GATT and TRIPs; patents for higher plants; terminator and traitor techniques (v-GURT and t-GURT); Protection of Plant Varieties and Farmers' Rights Rules 2003; Biodiversity Act 2002; Geographical Indications Act 1999; amendments to Patent Act 1970.	14

Suggested Readings

1. Briggs D. 1997. Plant Variation and Evolution. Science Publ. Cronquist AJ. 1981. An Integrated System of Classification of Flowering Plants. Columbia Univ. Press.
2. Dhillon BS, Varaprasad KS, Kalyani S, Singh M, Archak S, Srivastava U & Sharma GD. 2001. Germplasm Conservation A Compendium of Achievements. NBPGR, New Delhi.
3. di Castri F & Younes T. 1996. Biodiversity Science and Development: Towards New Partnership. CABI & International Union for Biol. Sci. France.
4. Paroda RS & Arora RK. 1991. Plant Genetic Resources Conservation and Management Concepts and Approaches. IPGRI Regional office for South and South Asia, New Delhi.
5. Erbisch FH and Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.
6. Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.
7. Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC and Aesthetic Technologies.
8. Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Technology Generation and IPR Issues. Academic Foundation.
9. Rothschild M and Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.
10. Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House.
11. The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003;

Principles of Hybrid Seed Production
Course-VIII; Code- ----------

Teaching hours: 50

Unit	Content	Credits /hours
1	**Concept and Utilization of Heterosis:** Heterosis: definition, expression and estimation of hybrid vigour; utilization of heterosis in crop improvement, Genetic load and inbreeding depression.	8
2	**Principles and Prerequisites of Hybrid Seed Production**: Pre-requisites for hybrid seed production; mechanisms and management of pollination in autogamous and allogamous crops; genetic constitution of varieties and hybrids; basic principles in seed production.	12
3	**Techniques and Genetic Systems in Hybrid Seed Production:** Techniques of hybrid seed production – emasculation and crossing; hand pollination and controlled pollination techniques; synchronization of flowering in parental lines; isolation requirements and pollination management; development, maintenance and utilization of parental lines (A, B and R lines); two-line and three-line hybrid seed production systems; genetic purity maintenance through rouging and field inspection; seed production, Hybrid Seed Harvesting and Post-harvest Handling; salient features of hybrid seed production in major field crops	16
4	**Biotechnological Approaches in Heterosis Breeding:** Biotechnological applications in heterosis breeding: (a) Barnase and barstar genes in hybrid seed production (b) Marker-assisted heterosis breeding (c) Possible use of molecular markers in selection of diverse parents for hybrid breeding.	14
5	**Hybrid Seed Production and Productivity Enhancement**: Hybrid seed production and role of hybrids in enhancing crop productivity in India; hybrid seed value chain, future challenges and opportunities in hybrid seed technology	10

Suggested Readings

1. Basra AS. 2000. Heterosis and Hybrid Seed Production in Agricultural Crops. Food Product Press.
2. McDonald MB & Copeland LO. 1997. Seed Production: Principles and Practices. Chapman & Hall. Singhal NC. 2003. Hybrid Seed Production. Kalyani Publishers.
3. Chahal, G. S. and Gosal, S. S. (2003). Principles and Procedures of Plant Breeding: Biotechnological and Conventional Approaches. Narosa Publishing House, New Delhi
4. Poehlman, J. M. and Sleper, D. A. (1995) Breeding Field Crops, 4th. edition. Iowa State Univ. Press, Ames, Iowa
5. Gupta, P. K. (2003). Biotechnology and Genomics. Rastogi Publications, Meerut.
6. Chopra, V. L. (ed.) (2000). Plant Breeding: Theory and Practice, 2/e. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi
7. Singh, B. D. (2003). Plant Breeding. Kalyani Publishers, New Delhi

Computer Applications and Bioinformatics
Course –VII; Code- ----------

Teaching hours: 50

Unit	Content	Credits /hours
1	**Introduction to computers:** Types, general characteristics, input/output units, memory, internal representation of data (binary, octal and hexa-decimal system, bits and bytes). History, What is bioinformatics? Components of bioinformatics, Scope & Goal of bioinformatics, Role of internet in bioinformatics, Applications & Limitations.	12
2	**Brief idea of operating systems & networking:** Disc operating systems (DOS), UNIX and its versions (Linux), WINDOWS and its upgraded version, LAN (local area network), WAN (wide area network), MAN (metropolitan area network) including www (World Wide Web)	10
3	**Microsoft (MS) office and its applications:** Introduction to MS Excel and its applications for statistical analyses with particular reference to agricultural data (tabular and graphical representation of data, analyses of variance, regression and correlation); introduction to MS Word and its application for document preparation; Power Point and its application for preparing presentations.	12
4	**Molecular Phylogenetics**; Terminology, Types of phylogentics tree, Phylogenetics tree construction methods: Distance-based methods, Character based methods, Phylogenetics Programs.	12
5	**Biological databases**: Database: Definition, Types of Databases, Biological Databases, Information retrieval from biological databases, File formats: Primary databases, Secondary databases & Structure databases, SAS (Statistical Analysis Software) packages for statistical analysis of agricultural data, handling software for data analyses, introductory knowledge of SPSS (Statistical Package for the Social Sciences).	14

Suggested book

1. Mount DW (2004). Bioinformatics: Sequence and Genome Analysis, 2/e. Cold Spring Harbor laboratory Press, USA
2. Brown SM (2000). Bioinformatics: A Biologist's Guide to Biocomputing and the Internet. Eaton Publishing
3. Rastogi SC, Mendiratta N, Rastogi P (2003). Bioinformatics: Concepts, Skills and Applications. CBS Publishers, New Delhi
4. Baxevanis AD, Ouellette BFF Eds. (2001). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins (2nd Edition). John Wiley & Sons
5. Sharma TR (2009). Genome Analysis and Bioinformatics: A Practical Approach. IK International, New Delhi

1. Rajaraman V (2018). *Fundamentals of Computers*. PHI Learning Pvt. Ltd., New Delhi
2. Sinha PK, Sinha P (2013). *Computer Fundamentals*. BPB Publications, New Delhi
3. Alexander M, Kusleika D (2019). *Microsoft Office 365 Bible*. Wiley India Pvt. Ltd.
4. Gupta SC, Kapoor VK (2020). *Fundamentals of Applied Statistics*. Sultan Chand & Sons, New Delhi
5. Sharma MK (2017). *SPSS for Beginners*. Pearson India Education Services
6. Mount DW (2004). *Bioinformatics: Sequence and Genome Analysis, 2/e*. Cold Spring Harbor Laboratory Press, USA
7. Lesk AM (2014). *Introduction to Bioinformatics, 4/e*. Oxford University Press
8. Rastogi SC, Mendiratta N, Rastogi P (2003). *Bioinformatics: Concepts, Skills and Applications*. CBS Publishers, New Delhi
9. Baxevanis AD, Ouellette BFF Eds. (2001). *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins (2nd Edition)*. John Wiley & Sons
10. Sharma TR (2009). *Genome Analysis and Bioinformatics: A Practical Approach*. IK International, New Delhi
11. Nei M, Kumar S (2000). *Molecular Evolution and Phylogenetics*. Oxford University Press

Seed Pathology and Seed Entomology
Course –IX; Code- ----------

Teaching Hours: 50

Unit	Content	Credits /hours
1	**Introduction to Seed Pathology and Entomology**: Introduction; terminology; historical development; seed health testing and significance. Principles of seed entomology; pollinator insects, insect pests and their classification based on mode of infestation etc.	8
2	**Seed-Borne Pathogens and Location of Inoculum**: Seed-borne pathogens – fungi, bacteria, viruses and nematodes; location of seed-borne inoculum: embryo, endosperm and perisperm, seed coat and pericarp and glume; seed contamination or infestation.	10
3	**Mechanism and Factors Affecting Seed Infection**: Mechanism of seed infection: fruit or seed stock; penetration through stigma, ovary wall and seed coat, natural openings and injuries; Factors affecting seed infection: host genotype, environment, crop management, stages of plant infection, insect infestation, antagonism and synergism; Longevity of seed-borne pathogens and factors influencing longevity; seed transmission – systemic and non-systemic; Factors affecting seed transmission: crop species.	14
4	**Storage Pests and Seed Losses:** Storage insect pests (eg. *Rice weevil, Pulse beetle,* and *Indian meal moth*) infecting seeds, their development and economic importance; storage losses due to pests; control of storage pests; management of storage insect pests, mites and rodents; seed sampling and loss estimation.	14
5	**Storage Fungi and Control of Seed-Borne Pathogens:** Deterioration of grains by storage and field fungi: invasion by storage fungi (eg.- Fusarium spp., Alternaria spp., Aspergillus spp., and Mucor spp.) losses, conditions favoring storage fungi development and detection of damage; Control of seed-borne pathogens: selection of seed production areas, crop management, seed treatment,	14

Suggested Readings

1. Agrawal, V.K. & Sinclair, J.B. 1997. Principles of Seed Pathology. Vol. I & II. CBS Pub. Delhi. (Boca Raton).
2. Jha, D.K. 1993. A Text Book on Seed Pathology. Vikash Publ. House, New Delhi.
3. Neergaard P. 1988. Seed Pathology, (2vols). Mac Millan.
4. Singh, T. Seed Technology and Seed Pathology. Scientific Publ. India
5. Karuna V. 2007. *Seed Health Testing*. Kalyani.
6. Agarwal, N.A. and Girish, G.K. 1977. *An Introduction to Action Programme to Regress on Farm Storage Losses in India*. FAO/NORAD Seminar on Farm Storage Grain in India,
7. Anderson, J.A. and Aleock, A.W. 1954. *Storage of Cereal Grain & their Products*. American Assoc. Cereal Chemists, St. Pauls, Minn.
8. Cottong, R.T. 1963. *Insect Pests of Stored Grain and Grain Products*. Burgess Publ. Co., Minneopolis, Minn., USA.
9. Monro. 1969. *Manual of Fumigation for Insect Control*. FAO Rome Agril. Studies No. 79. Subramanyam, B. and Hagstrum, D.W. 1995. *Interrelated Management of Insects in Stored*

Seed Production Technology – I: Vegetable crops
Course-X; Code-SST----------

Teaching Hours: 50

Unit	Content	Credits /hours
1	**General aspects of seeds production technology:** Concept, scope and importance of vegetable seed production, Concept, scope and importance of vegetable seed production; Seed demand, vegetable seed production scenario and seed replacement rate in India; Seed multiplication system in vegetable crops; Agro-climatic and soil requirements for vegetable seed production; Isolation requirements and maintenance of genetic purity; Crop planning and selection of suitable seed production areas; Pollinators and their role in vegetable seed production. Principles of rouging and field inspection in vegetable seed production; Seed production under protected cultivation (polyhouse, insect-proof net house and low tunnel).	12
2	**Seed Production Technology of Vegetable crops;** Climate change and its impact on vegetable seed production; Good Agricultural Practices (GAP) and quality assurance in vegetable seed production; Organic vegetable seed production: concepts, opportunities and challenges; Scope of precision agriculture and digital technologies (GIS, drones, remote sensing, sensors) in vegetable seed production; Seed traceability and quality assurance in vegetable seed supply chains; Recent advances in vegetable seed production technologies	12
3	a) **Fruit vegetables:** Tomato, brinjal, bhindi, chilli, okra and cucurbits b) **Cole Crops**: Cabbage, cauliflower, knol-khol and broccoli	12
4	c) **Root Crops:** Carrot, radish, turnip and beetroot d) **Bulb and Tuber Crops:** Onion, garlic, potato(TPS), sweet potato	12
5	e) **Green Leafy Vegetables:** Spinach, amaranth and lettuce f) **Leguminous Vegetables:** Garden pea, cowpea, and cluster bean	12

Suggested Resources:

1. Arya, P.S. 1999. *Vegetable Seed Production: Principles and Practices.*
2. Ram, H.H., Upadhyay, R., Dubey, R.K. and Mandal, B.C. 2017. *Vegetable Seed Production: Principles and Practices.*
3. Mathad, R.C., Gowda, B. and Patil, S.B. 2015. *Vegetable Seed Processing.*
4. Verma, O.P. 2011. *Seed Production Techniques of Major Crops.*
5. Agrawal, R.L. 2010. *Seed Technology.* (2nd Edition). Oxford & IBH Publishing Co., New Delhi.
6. Copeland, L.O. and McDonald, M.B. 2001. *Principles of Seed Science and Technology.* 4th Edition. Kluwer Academic Publishers.
7. George, R.A.T. 2009. *Vegetable Seed Production.* 3rd Edition. CABI Publishing.
8. Bose, T.K., Som, M.G. and Kabir, J. *Vegetable Crops.* Naya Udyog, Kolkata.
9. Singh, D.K. 2007. *Modern Vegetable Varieties and Production Technology.* International Book Distributing Co., Lucknow.
10. Thakur, M.R. 2018. *Vegetable Crops: Production and Seed Technology.* New India Publishing Agency, New Delhi.
11. Kelly, A.F. 1988. *Seed Production of Agricultural Crops.* Longman Scientific & Technical.
12. Justice, O.L. and Bass, L.N. 1978. *Principles and Practices of Seed Storage.* USDA Handbook.
13. Bewley, J.D., Bradford, K.J., Hilhorst, H.W.M. and Nonogaki, H. 2013. *Seeds: Physiology of Development, Germination and Dormancy.* Springer.
14. Basra, A.S. (Ed.). 2006. *Handbook of Seed Science and Technology.* Food Products Press.

Seed Testing and Quality Control
Course –XI; Code ----------

Teaching Hours: 60

Unit	Content	Credits /hours
1	**Seed Sampling and Physical Purity Analysis:** Brief history of seed testing: ISTA & other national and International organization; Seed sampling: definition, objectives, seed lot and its size; types of samples; sampling devices; procedure of seed sampling; sampling intensity; methods of preparing composite and submitted samples; sub-sampling techniques; dispatch, receipt and registration of submitted samples in the laboratory; sampling in the seed testing laboratory. Physical purity: definition, objective and procedure; weight of working samples for physical purity analysis; determination of other distinguishable varieties (ODV)	14
2	**Seed Moisture and Germination Testing:** Seed moisture content: importance of moisture content; equilibrium moisture content; principles and methods of moisture estimation – types, instruments and devices used; pre-drying and grinding requirements; procedural steps in moisture estimation; calculation and reporting of results; Germination: importance; definitions; requirements for germination; working sample and choice of method; general procedure for each type of method.	12
3	**Seed Viability and Vigour Testing:** Viability and vigour testing: definition and importance of viability tests; different viability tests; quick viability test (TZ test) – advantages, principle, preparation of seeds and solutions, procedure, evaluation and calculation of test results; Vigour testing: concept, historical development, definitions, principles and procedures of different methods used for testing vigour.	12
4	**GM Seed Testing and Reporting**: Testing of GM seeds and trait purity; limit of detection (LOD); preparation and dispatch of seed testing reports; storage of guard samples; application and use of seed standards and tolerances	10
5	**Genetic purity testing : objective and criteria for genetic purity testing;** types of test; laboratory, Growth Chamber and field testing based on seed , seedling and mature plant morphology; principles and procedures of chemical, biochemical and molecular tests, DUS (Distinctness, Uniformity and Stability) descriptors in varietal identification, Grow out testing, Seed traceability	12

Suggested Readings

1. Agrawal PK. (Ed.). 1993. Handbook of Seed Testing. Ministry of Agriculture, GOI, New Delhi.
2. Agrawal, R.L. 1975. Beej utpadan Evam Pramanikaran (Hindi). G.B.Pant Univ. of Ag. & Tech. Pantnagar.
3. Agrawal, R.L. 1997. Seed Technology (IInd Ed.) Oxford & IBH Publ. Co. New Delhi.
4. ANON 1996. International rules for seed testing. Seed Science and Technology, 24 (suppl): 1-335
5. AOSA. 1991. Cultivar purity testing handbook. Contribution no.33 to the Handbook on seed testing (MB McDonald & R. Payne, eds.)
6. Chalam, G.V and L. Neelkantam 1962. Improved Seed. Agricultural Production Manual, ICAR. New Delhi. Chapman and Hall, New York.
7. Copland LO & McDonald MB. 1996. Principles of Seed Science and Technology.
8. Kluwer. F.A.O. Quality declared seeds 1997. (United Nations Rome.) Daya Publ. House
9. ISTA(2008) International Rules For Seed Testing. ISTA, Bassersdrof, CH. Switzerland.
10. ISTA 2006. Seed Testing Manual. ISTA, Switzerland. Martin C & Barkley D. 1961. Seed Identification Manual. Oxford & IBH.
11. Nema, N.P. Principles of Seed Certification and Testing. Daya Publ. House
12. Seed Act, 1966. Govt. of India, Manager Publications, G.I.O., New Delhi.
13. Seed Rules, 1968. Govt. of India, Manager Publications, G.I.O., New Delhi. Tunwar NS & Singh SV. 1988. Indian Minimum Seed Certification Standards. Central Seed Certification Board, Ministry of Agriculture, New Delhi.

Seed Processing and Storage
Course –XII; Code- ----------

Teaching Hours: 60

Unit	Content	Credits /hours
1	**Introduction to Seed Processing and Plant Layout**: Seed processing concept, introduction and importance; Plan for seed processing plant – layout and installation	8
2	**Seed Drying and Processing Operations:** Seed drying – different methods of seed drying including dehumidification, Seed dryers; Preparing seed for processing; seed cleaning and grading – scalper, debearder, scarifier, huller, seed cleaners and graders, screen cleaners, specific gravity separators, spiral separators, disc separators and other types of separators, and color sorters.	12
3	**Seed Treatment and Seed Packaging**: Seed treatment – methods of treatment, seed treatment compounds and seed disinfestation. Seed packaging – principles, practices and materials; economics of seed processing and management of seed processing plants.	10
4	**Seed Storage and Deterioration:** Concept of seed ageing and deterioration, its causes, symptoms, mechanisms and related theories; different changes associated with the loss of vigour and viability during storage; Seed physiological, biochemical and cytological changes during seed ageing; effect of seed ageing on crop performance; maintenance of viability and vigour during storage, methods to minimize; prediction of seed storability, Storage of certified: foundation and breeder seed and germplasm; seed packing, construction and equipping, seed amelioration techniques, mid storage corrections etc.	16
5	**Storage Pests and Loss Management:** Storage losses due to pests (eg. *Trogoderma granarium, Sitotroga cerealella, Rattus rattus, and Acarus siro*); factors influencing storage losses; storage pests and methods of control.	14

Suggested Readings

1. Agrawal, P.K. & M. Dadlani, 1995. Techniques In Seed Science And Technology (2nd Ed.) South Asian Publ. New Delhi.
2. Agrawal, R.L. 1997. Seed Technology (IInd Ed.) Oxford & IBH Publ. Co. Daryaganj, New Delhi.
3. Bailly, R. Gregg, Alvin, G. Law, S.S. Virde and Balis, J.S. Seed Processing. Cooperatively published by NSC, New Delhi and Mississippi State University and UNSAID.
4. Barton LV. 1985. Seed Preservation and Longevity. International Books and Periodicals Supply Service, New Delhi.
5. Chakravarty, A. Post Harvest Technology of Cereals, Pulses and Oil Seeds.
6. Copeland, R.A. 1996. Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis. VCH Publishers, New York.
7. Desai, B.B., Kotecha. P.M. and Salunkhe, D.K. 1997. Seeds Handbook. Marcel Decker Inc., New York
8. Justice, O.L. and Bass, L.N. 1978. Principles and practice of seed storage. USDA Agricultural Handbook no. 506, Washington. Castle House Pub. Ltd
9. Khare Dhirendra & Bhale Mohan S. 2000. Seed Technology. Scientific Publ. India
10. Mc Donald, M.B. 1997. Seed Production: Principles and Practices.
11. Sahay KM & Singh K. K. 1991. Unit Operations in Food Engineering. Vikas Publ.
12. Simmonds, NW. 1979. Principles of Crop Improvement, Longman, London and New York.
13. Virdi SS & Gregg BG. 1970. Principles of Seed Processing. National Seed Corp., New Delhi.

Seed Biotechnology
Course –XIII; Code- SST-4001

Teaching hours: 60

Unit	Content	Credits /hours
1	**Plant Tissue Culture and Its Applications:** Plant organ, tissue and cell culture; totipotency; micro-propagation and its uses; somaclonal variation and its use in crop improvement; embryo culture; anther culture; somatic embryogenesis; techniques of protoplast culture, regeneration and somatic cell hybridization, achievements and limitations, and their utility in improvement of crop plants; application in production of secondary metabolites and transformations.	12
2	**Synthetic Seed:** Induction of somatic embryos; synchronization, development and maturation; drying and storage of somatic embryos; effects of stresses on desiccation tolerance; methods of drying; induction of quiescence/dormancy; protective encapsulation; germination and Application	12
3	**Gene Transfer and Transgenic Plants**: Methods of gene transfer in plants: *Agrobacterium*-mediated gene transfer (dicots and monocots); direct DNA delivery methods (microinjection, particle gun method, electroporation); gene targeting (including zinc finger nucleases); molecular farming for production of foreign proteins and edible vaccines; biosafety regulations (role of IBC, RCGM and GEAC or NBRA).	12
4	**DNA-Based Molecular Markers:** A brief idea of DNA-based molecular markers for varietal identification: Restriction Fragment Length Polymorphism (RFLP); Randomly Amplified Polymorphic DNA (RAPD); Simple Sequence Repeats (SSRs); Sequence Tagged Sites (STSs); Amplified Fragment Length Polymorphism (AFLP) and its variations (such as SAMPL etc.); Single Nucleotide Polymorphisms (SNP); DArT markers.	12
5	**Applications of Molecular Markers in Plant Breeding:** A brief idea of applications of molecular markers: construction of molecular maps (using F_2, DH and RILs); gene tagging using bulked segregant analysis (BSA) and near-isogenic lines (NILs); QTL analysis; map-based cloning of genes, KASP assays, Next-Generation Sequencing	12

Suggested Readings

1. Batra, Amla. 2001. Fundamentals of plant Biotechnology, Capital Publ. Comp. 7/28, Mahaveer Street, Ansari Road, Daryaganj, New Delhi-110 002.
2. Bhojwani, S.S. and Razdan, M.K. (Eds.) 1996). Plant Tissue Culture: Theory and Practice; Revised Edition, Elsevier, Amsterdam.
3. Brown T.A. Gene Cloning: An introduction. VNA Co. Ltd., U.K. Hand book of plant cell culture. Eds.
4. Evans DA, Sharp W.R, Ammirato P.V & Tamada Y (Eds.) McMillan, New York, 1983.
5. Kalyan Kumar De (2004). An introduction to Plant Tissue Culture.New central Book Agency,(P) Lte, Culcutta.
6. Kumar, A. and Kumar, V.A. 1996. Plant Biotechnology and Tissue Culture. Principles and perspectives. International Book distributing Comp. Lucknow.
7. Mantell, S.H. Matthews, J.A, McKee and Blackwell, R.A. Principles of plant Biotechnology. Scientific Publishers, 1987.
8. Mantell, S.H and Smith, H. 1983. (Eds.) Plant Biotechnology. Cambridge University Press, Cambridge.
9. Purohit, S.S. 2001. Biotechnology: Fundamentals and Applications. Agrobios (India) Publ. Agro House, behind Nasrani Cinema, Chopasani Road, Jodhpur-342 002.
10. Purohit, S.S. (2003) Agricultural Biotechnology, second enlarge Edition, Agrobios(India) Ramawat,
11. K.G. 2003. Plant Biotechnology. S. Chand & Co., Ram Nagar, New Delhi-110055.
12. Redenbaugh, K. (Ed) 1993. Synseeds: Application of synthetic seeds to crop improvement, CRC Press, Boca Raton, Florida.
13. Y.P.S. Bajaj (Ed), 1989. Plant protoplast and genetic engineering. I. II. Springer, Verlag, Berlin.

Seed Production Technology -II (Rabi and Kharif Crops)
Course –XIV; Code- SST----------

Teaching hours: 60

Unit	Content	Credits /hours
1	**General aspects of seeds production technology:** Concept, scope and objectives of seed production, history and development of seed industry in India, importance of quality seed in agricultural production, seed classes: Nucleus, Breeder, Foundation and Certified seed, seed replacement rate (SRR) and varietal replacement rate (VRR), seed multiplication system, Causes of seed deterioration and maintenance of genetic purity.	12
2	**Seed Production Planning and Management:** Site and land selection, crop rotation, seed source, planning of seed production programme, crop establishment, nutrient and irrigation management, weed management, crop monitoring and record keeping, harvest maturity, post-harvest handling, economics of seed production and Good Agricultural Practices.	10
3	**Culture Practice require for:(Kharif & Rabi Crops)** field crops with special emphasis on origin, land requirement, isolation requirement, cultural practices, rouging, field inspection, insect and disease control, harvesting, threshing and post-harvest handling, pre- processing care, sealing and bagging, seed standards and certification.	10
4	**Kharif Season Crops:** **a) Cereals:** Rice, Maize, Sorghum and Pearl millet. **b) Pulses:** Pigeon pea (Red gram), Green gram (Mungbean) and Black gram (Urdbean). **c) Oilseed Crops:** Groundnut, Soybean, Sunflower and Castor. **d) Fibre Crops:** Cotton and Jute.	14
5	**Rabi Season Crops:** **a) Cereals:** Wheat and Barley. **b) Pulses:** Chickpea (Gram), Lentil, Rajmash (French bean) and Broad bean. **c) Oilseed Crops:** Indian mustard, Rapeseed and Linseed. d) **Fibre Crop:** Sunn hemp.	14

Suggested Readings

1. Singhal, N. C. 2003. Hybrid Seed Production in Field Crops. Kalyani Publications, New Delhi.
2. Joshi, A. K. and Singh, B. D. 2004. Seed Science and Technology. Kalyani Publishers, New Delhi.
3. Kulkarni, G. N. 2011. Principles of Seed Technology. Kalyani Publishers, New Delhi. Singhal, N. C. 2010. Seed
4. Hebblethwaite, P. D. 1980. Seed Production. Butterworth Heinemann Ltd., London, UK. Agrawal, R.L. 2019.
5. Seed Technology. Oxford & IBH Publishing Company Pvt. Ltd., New Delhi.
6. McDonald, M.B. and Copeland, L. 1998. Seed Production Principles and Practices. CBS Publishers, New Delhi.
7. Maiti, R.K., Sarkar, N.C. and Singh, V.P. 2006. Principles of Post-Harvest Seed Physiology and Technology. Agrobios, Jodhpur, Rajasthan.
8. Vanangamudi, K., Natarajan, N., Srimathi, P., Natarajan, K., Saravanan, T., Bhaskaran, M., Bharathi, A., Natesan, P. and Malarkodi, K. 2006. Advances in Seed Science and Technology. Vol. 2. Quality Seed Production inVegetables. Agro bios, Jodhpur. Hebblethwaite, P. D. 1980. Seed Production. Butterworth Heinemann Ltd, London, UK. George, R.A.T.1985. Vegetable Seed Production. Lonhman Inc., New York.
9. Maiti, R.K., Sarkar, N.C. and Singh, V.P. 2006. Principles of Post-Harvest Seed Physiology and Technology.Agrobios, Jodhpur, Rajasthan.
10. Chadha, K.L. 1995. Advances in Horticulture. Volume 1 to 13. Malhothra Publishing House, New Delhi.
11. Bahl PN &Salimath PM. 1996. Genetics, Cytogenetics and Breeding of Crop Plants. Vol. I. Pulses and Oilseeds.

Open Elective
Concepts of Seed Science and Technology
Code----------

Teaching Hours: 60

Unit	Content	Credits /hours
1	**Importance of seed as basic input in agriculture:** Seed quality concept and importance; Generation system of seed multiplication -Varietal replacement rate, Seed multiplication ratios, Seed replacement rate, Seed renewal period and seed demand and supply; Various factors influencing seed production –Physical and Genetic purity in seed production; Factors responsible for varietal and genetic deterioration, general principles of nucleus, breeder, foundation and certified seed production	10
2	**Floral structure, pollination mechanism and methods and techniques of seed Production:** Varietal and hybrid seed production techniques in rice, maize, pearl millet, pigeon pea, sunflower, tomato, brassica, cotton.	10
3	**Seed Certification and seed law enforcement:** General and specific crop standards, Field and seed standards; Planning and management of seed certification programs; Eligibility of a variety for certification, area assessment, cropping history of the seed field, Seed Act-1966 & 2004, Seed rules 1968.	14
4	**Seed testing**: Importance, history and development; seed testing laboratory; sampling and its methods; purity analysis, germination tests and seedling evaluation; moisture test; viability tests; reporting of results; seed priming; synthetic seeds; taped seeds, ISTA national and international organizations.	12
5	**Seed processing and packaging:** Principles and practices; seed drying and conditioning; seed cleaning and grading; methods of seed packing and storage; factors affecting seed storage	14

Suggested Readings

1. Anonymous (2004). International rules for seed testing. ISTA, Switzerland.
2. Douglas, J.E. (1967). Seed certification manual. NSC and Rockefeller Foundation, New Delhi.
3. Agarwal, R.L. (2003). Seed Technology. Oxford & I.B.H. Delhi.
4. Feistritzer,W.P (1975). Cereal Seed Technology, F.A.O. Agricultural Development Paper No. 98.
5. Indian Minimum Seed Certification Standards. The Central Seed Certification Board, New Delhi, 1988.
6. Chalam, G.V., Singh, A. and Douglas, J. E. (1967). Seed Testing Manual. ICAR & USDA Publication, New Delhi.
7. Nema, N. P. (1987). Principles of Seed certification and Testing.
8. McDonald, M.B. and Copeland, L. O. (1995). Principles and practices of seed Production. Chapman & Hall, London.
9. Kelly, A.F. and George, R.A.T.(eds,). (1998). Encyclopedia of Seed production of world crops. John Wiley & Sons, England.
10. Desai, B.B., Kotecha, P.M. and Salunkhe, D.K. (1995). Principles and practices of seed production. Chapman & Hall, New York.
11. Agrawal, P.K. (2002). Principles of Seed Technology. ICAR, New Delhi.
12. ISTA Handbook on Seedling Evaluation, 3/e. ISTA, Basserdorf, CH- Switzerland
13. Singh, NP, Bhardwaj, AK, Kumar, banish and Singh KM ((2004). Modern Technology on Vegetable Production. International Book Co., Lucknow
14. Singh, S. P. (2001). Seed Production of Commercial Vegetables. Agrotech Publishing Academy, Udaipur
15. Singhal, N. C. (2003). Hybrid Seed Production in Field Crops. Kalyani Publishers, New Delhi

Open Elective
Techniques in Seed Science and Technology
Code----------

Teaching Hours: 60

Unit	Content	Credits /hours
1	**Seed testing laboratory establishment, Seed sampling and Seed purity analysis** Objectives and functions of a seed testing laboratory: Establishment and infrastructure requirements; Laboratory organization, equipment and safety measures; Accreditation and quality assurance, Objectives and principles of seed sampling: Types of seed samples; Sampling methods for different seed lots; Sampling equipment and procedures; Sample handling, labeling and storage, Objectives and importance of purity analysis: Components of seed purity; Procedures for physical purity analysis	10
2	**Seed processing unit, storage and Drying** Seed Processing Unit: Layout and establishment of a seed processing plant; Seed processing equipment and their functions; Sequence of seed processing operations; Maintenance and operational efficiency of processing units, Seed Drying: Importance and principles of seed drying; Methods of seed drying; Factors affecting seed drying and quality, Seed Storage: Seed storage behavior; Types of storage structures and storage containers	10
3	**Germination and Viability testing** Seed Germination Testing: principles of germination testing; Factors affecting seed germination; Standard germination testing methods and procedures, Seed Viability Testing: Principles and procedures of viability testing; Tetrazolium (TZ) test; Factors influencing accuracy and reproducibility of germination and viability tests	14
4	**Seed moisture testing and Priming** Seed Moisture Testing Techniques: Oven-drying method; Universal moisture meter method; Electrical conductivity moisture meter method; Infrared moisture determination method; Karl Fischer titration method; Near Infrared Reflectance (NIR) method, Seed Priming Techniques: Hydropriming; Osmopriming; Halopriming; Hormonal priming; Nutripriming; Biopriming; Solid Matrix Priming (SMP); Nanopriming; Chemopriming.	12
5	**Seed health testing** Dry Seed Inspection Method; Blotter Method (Standard Blotter Test); Agar Plate Method; Deep-Freezing Blotter Method; Seed Washing Test; Growing-on Test; Indicator Plant Method; Embryo Count Method; Serological Techniques (ELISA);	14

Suggested Readings

1. **Agarwal, R.L.** (2018). *Seed Technology* (2nd ed.). Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
2. **Copeland, L.O. & McDonald, M.B.** (2012). *Principles of Seed Science and Technology* (5th ed.). Springer Science & Business Media, New York.
3. **Agrawal, P.K. & Dadlani, M.** (1992). *Techniques in Seed Science and Technology* (2nd ed.). South Asian Publishers, New Delhi.
4. **Basu, R.N.** (2006). *Seed Quality: Basic Mechanisms and Agricultural Implications*. Kalyani Publishers, New Delhi.
5. **Justice, O.L. & Bass, L.N.** (1978). *Principles and Practices of Seed Storage*. USDA Agriculture Handbook No. 506.
6. **Delouche, J.C., Baskin, C.C., Baskin, J.M. & others.** *Seed Biology and Technology*. Mississippi State University Seed Technology Laboratory.
7. **International Seed Testing Association (ISTA).** (Latest Edition). *International Rules for Seed Testing*. ISTA, Bassersdorf, Switzerland.
8. **Indian Minimum Seed Certification Standards (IMSCS).** (Latest Edition). Department of Agriculture & Farmers Welfare, Government of India.
9. **Seed Act, 1966, Seed Rules, 1968, and Seed (Control) Order, 1983** (Latest Amendments). Government of India.