

New and Revised Syllabus of M.Sc. (Ag.) Seed Science & Technology

(Implement from Academic Session 2026-27)



**School of Agriculture and Allied Science
HNB Garhwal University (A Central University)
Srinagar-Garhwal – 246 174**

**MASTER OF SCIENCE (AGRICULTURE)
(SEED SCIENCE & TECHNOLOGY)
DEPARTMENT OF SEED SCIENCE AND TECHNOLOGY
HNB GARHWAL UNIVERSITY (A CENTRAL UNIVERSITY)
SRINAGAR GARHWAL, UTTARAKHAND-246 174**

(Syllabus implemented from Academic session 2026-2027)

ORDINANCES:

Admission of the Master's Program in Seed Science & Technology shall be through entrance examination conducted by the University or any other guidelines, rules instructions issued time to time by the University. The program is based on credit system in which credit defines the quantum of content/ syllabus prescribed for a course system and determines the number of hours of instruction per week. The student shall be eligible for admission to M.Sc. (Ag.) program in Seed Science & Technology after he/she has successfully completed a four-year agriculture undergraduate degree or earned prescribed number of credits through the examinations conducted by university as equivalent to an undergraduate degree. In order to qualify a two-year master's degree, a student must acquire a minimum 70 credits. The students have to complete 20 credits of major courses, 08 credit of minor courses, 06 credits for supporting course, 05 credits for common courses, 01 credit seminar and 30 credits of Masters Research Thesis/ dissertation to obtain the Master's degree in Seed Science & Technology. The syllabus has been structured as per the course/ syllabi approved by ICAR. The programme is intended to develop competent professionals, researchers, academicians, policy makers and extension workers who can address real-world agriculture problems through scientific reasoning, innovation, and field-oriented approaches. It also seeks to enhance students' capacity in technical writing, communication, research ethics and awareness of intellectual property. Care has been taken to make the curriculum learner-centred, outcome-based, and aligned with national priorities in higher agricultural education.

There are only 19 seats sanctioned for M.Sc. (Ag) Seed Science & Technology. The essential qualifications for admission in this course is B.Sc. (Hons) Agriculture, Horticulture, Forestry and B.Sc. in Seed Technology awarded by a university or Institute incorporated by law and recognized by this University is the minimum qualifications for admission.

Framework of the course- The following nomenclature and Credit Hrs. need to be followed-

Courses Credits	M.Sc. (Agri.) Seed Science & Tech
Major courses	33
Minor courses	09
Supporting courses	06
Common courses	05
Seminar	01
Thesis	18
Total	72

Courses offered

M.Sc. (Ag) Seed Science and Technology
Implemented from Academic Session 2026-27

Couse Code	Course Title	Credits
Major Courses		
SAS/ST/C501*	Seed Developmental Biology	2+1
SAS/ST/C502	Seed Dormancy and Germination	2+1
SAS/ST/C503*	Seed Production Principles and Techniques in Field Crops	2+1
SAS/ST/C504*	Seed Production Principles and Techniques In Vegetable Crops	2+1
SAS/ST/C505	Seed Production Techniques in Fruits, Flowers, Spices, Plantation and Medicinal Crops	2+1
SAS/ST/C506	Seed Production Techniques in Forage, Pasture and Green Manure Crops	1+1
SAS/ST/C507*	Seed Legislation and Certification	2+1
SAS/ST/C508*	Post-Harvest Handling and Storage of Seeds	2+1
SAS/ST/C509*	Seed Quality Testing and Enhancement	2+1
SAS/ST/C510	Seed Technology of Tree Species	2+1
SAS/ST/C511	Seed Industry and Marketing Management	2+1
SAS/ST/C512	Seed Health Testing and Management	2+1
Seminar and Thesis		
SAS/ST/C591	Seminar	1
SAS/ST/CT599	Master's Research Thesis	18
Minor Courses		

SAS/ST/M501	Principles of Genetics	2+1
SAS/ST/M502	Principles in Plant Breeding	2+1
SAS/ST/M517	Germplasm Characterization and Evaluation	2+1
Supporting Courses		
SAS/ST/SC502	Statistical Methods for Applied Sciences	3+0
SAS/ST/SC511	Experimental Designs	2+1
Common Courses		
SAS/ST/CC01	Library and Information Services	0 +1
SAS/ST/CC02	Technical Writing and Communications Skills	0+1
SAS/ST/CC03	Intellectual Property and its Management in agriculture	1+0
SAS/ST/CC04	Basic concepts in laboratory techniques	0+1
SAS/ST/CC05	Agricultural Research, Research Ethics and Rural Development Programmes	1+0
*Indicates core course which are compulsory courses for M.Sc. (Agri.) Seed Science		

NEW AND REVISED SYLLABUS
MASTER OF SCIENCE (AGRICULTURE)
SEED SCIENCE AND TECHNOLOGY
(From the academic session 2026-27)

COURSE STRUCTURE

CODES	COURSE TITLE	Total Marks	End Term Tests	Sessional/ Practical	Credits
SEMESTER-I					
Major Courses					
SAS/ ST/ C501*	Seed Development Biology	100	60	40	2+1
SAS/ST/C503*	Seed Production Principles and Techniques in Field Crops	100	60	40	2+1
SAS/ST/C504*	Seed Production Principles and Techniques In Vegetable Crops	100	60	40	2+1
Supporting Courses					
SAS/ST/SC502	Statistical Methods for Applied Sciences	100	60	40	3+0
SAS/ST/SC511	Experimental Designs	100	60	40	2+1
Common Courses					
SAS/ST/CC01	Library and Information Services	100	60	40	0+1
SAS/ST/CC02	Technical Writing and Communications Skills	100	60	40	0+1
SAS/ST/CC03	Intellectual Property and its Management in Agriculture	100	60	40	1+0
Sub total		800			18
SEMESTER-II					
Major Courses					
SAS/ ST/ C502	Seed Dormancy and Germination	100	60	40	2+1
SAS/ST/C506	Seed Production Techniques in Forage, Pasture and Green Manure Crops	100			2+1
SAS/ST/C507*	Seed Legislation and Certification	100	60	40	2+1
Minor courses					
SAS/ST/M501	Principles of Genetics	100	60	40	2+1
SAS/ST/M502	Principles of Plant Breeding	100	60	40	2+1
Common Courses					
SAS/ST/CC05	Agricultural Research, Research Ethics and Rural Development Programmes	100	60	40	1+0
SAS/ST/CC04	Basic concepts in laboratory techniques	100	60	40	1+0
SAS/ST/C591	Master's Seminar	100	60	40	1
SAS/ST/CT599	Sub Total	800			18
SEMESTER-III					

Major Courses					
SAS/ST/C508*	Post-Harvest Handling and Storage of Seeds	100	60	40	2+1
SAS/ST/C509*	Seed Quality Testing and Enhancement	100	60	40	2+1
SAS/ST/C512	Seed Health Testing and Management	100	60	40	2+1
SAS/ST/C511	Seed Industry and Marketing Management	100	60	40	2+1
SAS/ST/C510	Seed Technology of Tree Species	100	60	40	2+1
Minor course					
SAS/ST/M517	Germplasm Characterization and Evaluation	100	60	40	2+1
Sub Total		600			18
SEMESTER-IV					
SAS/ST/CT599	Master's Research Thesis	100	60	40	18
Grand Total of all the semesters (800+800+600+100)		2300			72

Syllabus
M.Sc. (Ag.) Seed Science & Technology
Semester-I

MAJOR COURSES

Course Title: Seed Developmental Biology*

Course Code: SAS/ST/C501

Credit Hours: 2+1

Objective: To acquire knowledge on development and maturation of essential structures of seed and their influence on seed quality.

Theory

UNIT I

Floral biology – types of pollination, mechanisms; sporogenesis – micro and mega sporogenesis; gametogenesis – development of male and female gametes and their structures; pollination and fertilization – mode of pollination, double fertilization, factors affecting pollination, fertilization; self-incompatibility and male sterility.

UNIT II

Embryogenesis – development of monocot and dicot embryos, embryo plane formation, development of endosperm, cotyledons and seed coat – hard seed, apomixis – identification, classification, significance and its utilization; polyembryony – types and significance; haplontic and diplontic sterility system, causes of embryo abortion, embryo rescue technique; somatic embryogenesis.

UNIT III

Seed development – source of assimilates – mechanism of translocation; chemical composition, synthesis and deposition of storage reserves – starch, protein, fat and secondary metabolites – hormonal regulation.

UNIT IV

Maturation drying – Orthodox and recalcitrant seeds – desiccation tolerance mechanism – structural changes during desiccation – role of LEA protein.

UNIT V

Seed maturity indices – physiological and harvestable maturity; biotic and abiotic factors influencing seed development – development of hard seeds.

Practical

- Study on floral biology of monocot
- Study on floral biology of dicot plants
- Study on pollen morphology of different crops; Pollen germination and viability test in major crops
- Seed embryo and endosperm development in monocots
- Seed embryo and cotyledon development in dicots, Anatomy and morphology of seed

coat during development; Hard seed coat development

- Study on external and internal structures
- Seed development and maturation in agricultural crops – physical and physiological changes
- Seed development and maturation in horticultural crops – physical and physiological changes
- Study of biochemical changes during seed development and maturation in agricultural crops; Study of biochemical changes during seed development and maturation in horticultural crops
- Study on physiological and harvestable maturity and maturity indices in different crops
- Study on acquisition of seed dormancy and germination at different stages of maturity
- Preparation of seed album and identification of seeds.

Teaching methods: Classroom teaching with AV aids, group discussion, assignment and class discussion

Learning outcome: Successful completion of this course enable student to take up advanced research on seed developmental biology and understanding on fundamental aspects of gametogenesis, seed development and maturity.

Suggested Reading

- Adkins SW, Ashmore SE and Navi SC. 2007. *Seeds: Biology, Development and Ecology*. CAB International, Oxford shire, UK.
- Bewley JD and Black M. 1994. *Seeds: Physiology of Development and Germination*. Springer, New York.
- Bewley JD, Bradford KJ, Hil horst HWM and Nanogaki H. 2013. *Seeds: Physiology of Development, Germination and Dormancy*. Springer, New York.
- Black M, Bewley JD and Halmer P. 2006. *The Encyclopedia of Seeds: Science, Technology and Uses*. CAB International publications, UK.
- Chhabra AK. 2006. *Practical Manual of Floral Biology of Crop Plants*. Department of Plant Breeding, CCSHAU, Hisar.
- Copeland, LO and McDonald MB. 2001. *Principles of Seed Science and Technology*. 4th Ed. Kluwer Academic publishers, USA.
- Frankel R and Galun E. 1977. *Pollination Mechanisms, Reproduction and Plant Breeding*. Springer Verlag, New York.
- Hesse MH, Haidemarie R, Zettler M, Webber R, Buchner AR, Radivo and Ulrich S. 2009. *Pollen Terminology. An illustrated hand book*. Springer Verlag, New York. Press Inc., New York.
- Maiti RK, Sarkar NC and Singh VP. 2006. *Principles of Post Harvest Seed Physiology and Technology*. Agrobios, Jodhpur, Rajasthan.

Suggested e-book

<https://www.springer.com/in/book/9783642810619>

<https://www.springer.com/in/book/9780792373223>

<https://www.springer.com/gp/book/9780792346456>

<https://www.cabi.org/bookshop/book/9780851997230> <https://www.worldcat.org/title/seed-development-and-germination/oclc/44954614>

https://books.google.co.in/books/about/Seeds.html?id=ZbZr1F_z74C&redir_

Course Title: Seed Production Principles and Techniques in Field Crops*

Course Code: SAS/ST/C503

Credit Hours: 2+1

Objective: To impart knowledge on principles and practices involved in quality seed production of field crops.

Theory

UNIT I

Importance of seed – seed quality concept – factors influencing seed production; generation system of seed multiplication – classes of seed, stages of seed multiplication in varieties and hybrids – seed multiplication ratio (SMR) – seed replacement rate (SRR) – seed renewal period (SRP) – varietal replacement rate (VRR).

UNIT II

Genetic and agronomic principles of variety and hybrid seed production; methods and techniques of seed production in varieties and hybrids of important cereals and millets – wheat, oat, rice, maize, sorghum and pearl millet; varietal seed production in small millets, finger millet, fox tail millet, little millet, kodo millet, proso millet and barnyard millet.

UNIT III

Methods and techniques of varietal seed production in major pulses – black gram, green gram, cowpea, chickpea, horse gram, soybean and lentil – varietal and hybrid seed production in red gram.

UNIT IV

Methods and techniques of seed production in major oil seed crops – groundnut, sesame, varietal and hybrid seed production in sunflower, castor and mustard; varietal seed production in minor oilseed crops (safflower, linseed, Niger) – varietal and hybrid seed production in cotton – varietal seed production in jute.

UNIT V

Seed production planning for varieties and hybrids of major crops; participatory seed production – seed hubs, seed village concept and community seed bank.

Practical

- Seed selection – quality of seed on field establishment
- Sowing and nursery management techniques
- Planting – age of seedling on crop establishment – rice and pearl millet
- Isolation distance and border rows in hybrid seed production field – space and barrier isolation; modifying isolation based on border rows in maize

- Planting design for hybrid seed production – rice, maize, pearl millet, cotton, red gram, sunflower
- Practicing breeding tools for hybrid seed production – detasseling – emasculation and dusting
- Study on methods of achieving synchronization – rice, bajra, sunflower
- Practicing supplementary pollination – rice and sunflower
- Study on foliar nutrition and influence on seed yield
- Practicing rouging operation – identification of off-types, pollen shedders, shedding tassels, partials, selfed bolls
- Pre- and post-harvest sanitation operations – cereals, millets and pulses
- Estimation of shattering and shattering loss; study on in-situ germination and loss
- Visit to seed production fields
- Visit to seed industry
- Seed production planning and economics of seed production – varieties
- Seed production planning and economics of seed production – hybrids.

Teaching methods: Classroom teaching with AV aids, group discussion, assignment and class discussion

Learning outcome: Successful completion of this course enable student to take up seed production venture in scientific manner to ensure seed quality and profitability.

Suggested Reading

- Agrawal RL. 2019. *Seed Technology*. Oxford & IBH Publishing Company Pvt. Ltd., New Delhi. Hebblethwaite PD. 1980. *Seed Production*. Butterworth Heinemann Ltd., London, UK.
- Joshi AK and Singh BD. 2004. *Seed Science and Technology*. Kalyani Publishers, New Delhi. Kulkarni GN. 2011. *Principles of Seed Technology*. Kalyani Publishers, New Delhi.
- Maiti RK, Sarkar NC and Singh VP. 2006. *Principles of Post Harvest Seed Physiology and Technology*. Agrobios, Jodhpur, Rajasthan.
- McDonald MB and Copeland L. 1998. *Seed Production Principles and Practices*. CBS Publishers, New Delhi.
- Mondal SS, Saha M and Sengupta K. 2009. *Seed Production of Field Crops*. New India Publishing Agency, New Delhi.
- Singhal NC. 2003. *Hybrid Seed Production in Field Crops*. Kalyani Publications, New Delhi. Sen S and Ghosh N. 2010. *Seed Science and Technology*. Kalyani Publishers, New Delhi.
- Singhal NC. 2010. *Seed Science and Technology*. Kalyani Publishers, New Delhi.

Suggested e-book

<https://www.springer.com/in/book/9780792373223>

<https://www.springer.com/in/book/9780412075513>
<https://www.nipabooks.com/info/9788190723763/seed-production-of-field-crops>
<https://www.amazon.in/Production-Field-Crops-Brajesh-Tiwari/dp/9380179405>
<https://www.cambridge.org/core/journals/journal-of-agricultural-science/article/seed-production-of-agricultural-crops-by-kelly-a-f-227-pages-harlow-longman-1988-price-2500-hard-covers-isbn-0-582-40410-X/8BE3C99DFDC0F02D48E/CB53418504D10>

Suggested Website

<https://agriinfo.in/botany/18/>
<http://www.fao.org/3/a-e8935e.pdf>
http://www.agriquest.info/seed_production.php
http://agritech.tnau.ac.in/seed_certification/seedtech_indeX.html

Course Title: Seed Production: Principles and Techniques in Vegetable Crops*

Course Code: SAS/ST/C504

Credit Hours: 2+1

Objective: To impart knowledge on principles and practices involved in quality seed production of vegetable crops.

Theory

UNIT I

Importance and present status of vegetable seed industry – factors influencing vegetable seed production; varietal and hybrid seed production techniques in major solanaceous vegetable crops – tomato, brinjal, chilli; malvaceous vegetable crop – seed production techniques of bhendi.

UNIT II

Varietal and hybrid seed production techniques in important cucurbitaceous vegetables – gourds and melons, cole crops – cauliflower, cabbage, knol-khol, root vegetables – carrot, beetroot, turnip, radish and other temperate/ hilly vegetable crops.

UNIT III

Varietal seed production techniques in major leguminous vegetables – peas and beans; seed production techniques in leafy vegetables – amaranthus, palak, spinach and lettuce.

UNIT IV

Seed production techniques in tuber crops – potato, sweet potato, colocasia, tapioca and yam, seed-plot technique in potato – true potato seed (TPS) Production techniques – seed production techniques in bulb crops – onion, garlic.

UNIT V

Vegetative and clonal multiplication – methods, merits and demerits; clonal multiplication – potato, sweet potato, colocasia, tapioca and yam.

Practical

- Identification of vegetable seeds

- Study on sowing and nursery management
- Study on transplanting and age of seedling on crop establishment
- Studying floral biology of solanaceous, malvaceous and cucurbitaceous vegetable crops
- Studying floral biology of other vegetable crops
- Practicing planting design for hybrid seed production
- Modification of sex ratio in cucurbits
- Practicing emasculation and pollination methods
- Practicing rouging operations – identification of off-types – selfed fruits
- Harvesting methods – single and multiple harvesting method
- Practicing seed extraction methods – wet methods – tomato, brinjal, other cucurbitaceous fruits
- Seed extraction – dry methods – chillies, bhendi, cucurbitaceous
- Visit to seed production fields
- Visit to private seed industry
- Planning and economics of varietal seed production
- Planning and economics of hybrid seed production.

Teaching methods: Classroom teaching with AV aids, group discussion, assignment and class discussion

Learning outcome: Successful completion of this course enable student to gain confidence and to become seed entrepreneur in high value low volume vegetable crops.

Suggested Reading

- Agarwal RL. 2012. *Seed Technology*. Oxford & IBH Publishing Company Pvt. Ltd., New Delhi.
- Chadha KL. 1995. *Advances in Horticulture*. Volume 1 to 13. Malhotra Publishing House, New Delhi.
- George RAT. 1985. *Vegetable Seed Production*. Lonhman Inc., New York.
- Hebblethwaite PD. 1980. *Seed Production*. Butterworth Heinemann Ltd, London, UK.
- Kulkarni GN. 2011. *Principles of Seed Technology*. Kalyani Publishers, New Delhi.
- Maiti RK, Sarkar NC and Singh VP. 2006. *Principles of Post Harvest Seed Physiology and Technology*. Agrobios, Jodhpur, Rajasthan.
- McDonald MB and Copeland L. 1998. *Seed Production: Principles and Practices*. CBS Publishers, New Delhi.
- Sen S and Ghosh N. 2010. *Seed Science and Technology*. Kalyani Publishers, New Delhi.
- Singhal NC. 2010. *Seed Science and Technology*. Kalyani Publishers, New Delhi.

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 in Vegetables*. Agro bios, Jodhpur.

Suggested e-book

<https://www.springer.com/in/book/9780792373223>

<http://203.64.245.61/fulltext-pdf/EB/1900-2000/eb0021.pdf>

<http://www.worldseed.org/wp-content/uploads/2017/01/Seed-Production-Good-practice-10.01.17-final.pdf>

<https://trove.nla.gov.au/work/6862691?q&sort=holdings+desc&1541066209257&versionId=45008917+251246346>

Suggested Website

<https://agriinfo.in/botany/18/>

http://agritech.tnau.ac.in/seed_certification/seedtech_index.html

<http://www.yspuniversity.ac.in/vgc/caft/Compendium2017-18.pdf>

<https://www.hort.vt.edu/Welbaum/seedproduction/Principles5.html>

<http://www.agrimoon.com/wp-content/uploads/Seed-Production-of-Vegetable.pdf>

<http://www.ciks.org/downloads/seeds/4.%20Seed%20Production%20Techniques%20for%20Vegetables.pdf>

SUPPORTING COURSES

Course Title: Statistical Methods for Applied Sciences

Course Code: SAS/ST/SC502

Credit Hours: 3+1

Objective: This course is meant for students who do not have sufficient background of Statistical Methods. The students would be exposed to concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.

Theory

UNIT I

Classification, tabulation and graphical representation of data. Box-plot, Descriptive statistics. Exploratory data analysis; Theory of probability. Random variable and mathematical expectation.

UNIT II

Discrete and continuous probability distributions: Binomial, Poisson, Negative Binomial, Normal distribution, Beta and Gamma distributions and their applications. Concept of sampling distribution: chi-square, t and F distributions. Tests of significance based on Normal,

chi-square, t and F distributions. Large sample theory.

UNIT III

Introduction to theory of estimation and confidence-intervals. Correlation and regression. Simple and multiple linear regression model, estimation of parameters, predicted values and residuals, correlation, partial correlation coefficient, multiple correlation coefficient, rank correlation, test of significance of correlation coefficient and regression coefficients. Coefficient of determination. Polynomial regression models and their fitting. Probit regression analysis by least squares and maximum likelihood methods, confidence interval for sensitivity; Testing for heterogeneity.

UNIT IV

Non-parametric tests - sign, Wilcoxon, Mann-Whitney U-test, Wald Wolfowitz run test, Run test for the randomness of a sequence. Median test, Kruskal- Wallis test, Friedman two-way ANOVA by ranks. Kendall's coefficient of concordance.

UNIT V

Introduction to multivariate analytical tools- Hotelling's T² Tests of hypothesis about the mean vector of a multinormal population. Classificatory problems and discriminant function, D²-statistic and its applications; Cluster analysis, principal component analysis, canonical correlations and Factor analysis.

Practical

- Exploratory data analysis, Box-Cox plots
- Fitting of distributions Binomial, Poisson, Negative Binomial, Normal
- Large sample tests, testing of hypothesis based on exact sampling distributions ~ chi square, t and F
- Confidence interval estimation and point estimation of parameters of binomial, Poisson and Normal distribution
- Correlation and regression analysis, fitting of orthogonal polynomial regression Applications of dimensionality reduction and discriminant function analysis Nonparametric tests.

Suggested Reading

Anderson TW. 1958. An Introduction to Multivariate Statistical Analysis. John Wiley. Dillon WR & Goldstein M. 1984. Multivariate Analysis - Methods and Applications. John Wiley.

Goon AM, Gupta MK & Dasgupta B. 1977. An Outline of Statistical Theory. Vol. I. The World Press.

Goon AM, Gupta MK & Dasgupta B. 1983. Fundamentals of Statistics. Vol. I. The World Press.

Hoel PG. 1971. Introduction to Mathematical Statistics. John Wiley.304

Hogg RV & Craig TT. 1978. Introduction to Mathematical Statistics. Macmillan.

Morrison DF. 1976. Multivariate Statistical Methods. McGraw Hill. Siegel S, Johan N & Casellan Jr. 1956.Non-parametric Tests for Behavior Sciences. John Wiley. Learning Statistics: <http://freestatistics.altervista.org/en/learning.php>. Electronic

Statistics Text Book:

<http://www.statsoft.com/textbook/stathome.html>.

Course Title: Experimental Designs

Course Code: SAS/ST/SC511

Credit Hours: 2+1

Objective: This course is meant for students of agricultural and animal sciences other than Statistics. Designing an experiment is an integrated component of research in almost all sciences. The students would be exposed to concepts of Design of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental data.

Theory

UNIT I

Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control.

UNIT II

Uniformity trials, size and shape of plots and blocks; Analysis of variance; Completely randomized design, randomized block design and Latin square design.

UNIT III

Factorial experiments, (symmetrical as well as asymmetrical) orthogonality and partitioning of degrees of freedom, Confounding in symmetrical factorial experiments, Factorial experiments with control treatment.

UNIT IV

Split plot and strip plot designs; Analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, cross over designs, balanced incomplete block design, resolvable designs and their applications ~ Lattice design, alpha design -concepts, randomization procedure, analysis and interpretation of results. Response surfaces. Experiments with mixtures.

UNIT V

Bioassays- direct and indirect, indirect assays based on quantal dose response, parallel line and slope ratio assays potency estimation.

Practical

- Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law
- Analysis of data obtained from CRD, RBD, LSD
- Analysis of factorial experiments without and with confounding
- Analysis with missing data; Split plot and strip plot designs

- Transformation of data: Analysis of resolvable designs
- Fitting of response surfaces

Suggested Reading

Cochran WG & Cox GM. 1957. Experimental Designs. 2nd Ed. John Wiley. Dean AM & Voss D. 1999. Design and Analysis of Experiments. Springer. Federer WT. 1985. Experimental Designs. MacMillan.

Fisher RA. 1953. Design and Analysis of Experiments. Oliver & Boyd.

Nigam AK & Gupta VK. 1979. Handbook on Analysis of Agricultural Experiments. IASRI Publ. Pearce SC. 1983. The Agricultural Field Experiment: A Statistical Examination of Theory and Practice. John Wiley. Design Resources Server: www.iasri.res.in/design

COMMON COURSES

Course Title: Library and Information Services

Course Code: SAS/ST/CC01

Credit Hours: 0+1

Objective: To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines, etc.) of information search.

Practical

- Introduction to library and its services
- Role of libraries in education, research and technology transfer
- Classification systems and organization of library
- Sources of information- Primary Sources, Secondary Sources and Tertiary Sources
- Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.)
- Tracing information from reference sources
- Literature survey; Citation techniques/ Preparation of bibliography
- Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services
- Use of Internet including search engines and its resources; e- resources access methods

Course Title: Technical Writing and Communications Skills

Course Code: SAS/ST/CC02

Credit Hours: 0+1

Objective: To equip the students/ scholars with skills to write dissertations, research papers, etc. To equip the students/ scholars with skills to communicate and articulate in English (verbal as well as writing).

Practical

- Various forms of scientific writings- theses, technical papers, reviews, manuals, etc.
- Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion)
- Writing of abstracts, summaries, précis, citations, etc.
- Commonly used abbreviations in the theses and research communications
- Illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations
- Writing of numbers and dates in scientific write-ups;
- Editing and proof-reading
- Writing of a review article
- Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks)
- Error analysis (Common errors), Concord, Collocation, Phonetic symbols and transcription
- Accentual pattern: Weak forms in connected speech
- Participation in group discussion
- Facing an interview
- Presentation of scientific papers

Suggested Reading

Barnes and Noble. Robert C. (Ed.). 2005. *Spoken English: Flourish Your Language. Chicago Manual of Style*. 14th Ed. 1996. Prentice Hall of India.

Collins' Cobuild English Dictionary. 1995.

Harper Collins. Gordon HM and Walter JA. 1970. *Technical Writing*. 3rd Ed.

Holt, Rinehart and Winston. Hornby AS. 2000. *Comp. Oxford Advanced Learner's Dictionary of Current English*. 6th Ed. Oxford University Press.

James HS. 1994. *Handbook for Technical Writing*. NTC Business Books.

Joseph G. 2000. *MLA Handbook for Writers of Research Papers*. 5th Ed. Affiliated East-West Press.

Mohan K. 2005. *Speaking English Effectively*. MacMillan India. Richard S. 1969. *Technical Writing*.

Sethi J and Dhamija PV. 2004. *Course in Phonetics and Spoken English*. 2nd Ed. Prentice Hall of India.

Wren PC and Martin H. 2006. *High School English Grammar and Composition*. S. Chand & Co.

Course Title: Intellectual Property and its Management in Agriculture

Course Code: SAS/ST/CC03

Credit Hours: 0+1

Objective: The main objective of this course is to equip students and stakeholders with knowledge of Intellectual Property Rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.

Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Reading

- Erbisch F and Maredia K. 1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.
- Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.
- Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC and Aesthetic Technologies.
- Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol.
- V. Technology Generation and IPR Issues. Academic Foundation.
- Rothschild M and Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.
- Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House. 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;
- The Biological Diversity Act, 2002.

Semester-II

Course Title: Seed Dormancy and Germination

Course Code: SAS/ST/C502

Credit Hours: 2+1

Objective: To impart knowledge on significance, mechanism of dormancy, induction and release of seed dormancy and germination, types and factors influencing germination and their management.

Theory

UNIT I

Seed dormancy – definition, concept and theories – significance – evolution; classification and mechanism of dormancy – ecological significance.

UNIT II

Induction of dormancy during development – hormonal, physiological, molecular and genetic control of dormancy – maternal and paternal contribution; environmental factors influencing dormancy induction and release – seasonal influence – winter and summer annuals – secondary dormancy induction mechanism; artificial induction of dormancy and release; soil seed bank – natural release of dormancy and its mechanism; dormancy breaking – principles and methods.

UNIT III

Seed germination–types and phases of germination; imbibition–pattern and water kinetics–events of germination–physical, physiological, biochemical changes: aerobic and anaerobic respiration quiescent.

UNIT IV

Physiological and biochemical changes

Enzyme activation – mechanism – factors affecting enzyme activation, breakdown of stored materials – starch, protein and fat – energy generation, mobilization of storage reserves – changes in phenolic compounds.

UNIT V

Molecular and genetic mechanisms

Molecular and genetic control of seed germination – auto tropism; factors affecting germination – media – temperature – light – gases; *in-situ* and viviparous germination, causes and mechanism – pattern of seed germination – tri-phasic curve.

Practical

- Seed dormancy – identification of dormancy
- Estimation of ABA and GA in dormant and non-dormant seeds
- Study on artificial induction of dormancy
- Dormancy breaking methods – scarification and stratification
- Dormancy breaking methods – hormonal and chemical treatments
- Dormancy breaking methods – after ripening and leaching of inhibitors.
- Dormancy breaking methods – combined treatments.

- Assessing the period of natural release of seed dormancy
- Seed germination – studying the pattern of imbibition
- Studying the pattern of seed germination in different media
- Study on influence of light and temperature on germination and seedling development
- Estimation of hydrolytic enzyme – amylase in different species
- Estimation of hydrolytic enzyme – protease
- Estimation of hydrolytic enzyme – lipase
- Estimation of dehydrogenase enzyme and respiratory quotient in seeds
- Estimation of food reserve composition during seed germination.

Teaching methods: Classroom teaching with AV aids, group discussion, assignment and class discussion

Learning outcome: By learning this course, students will understand the fundamental theories and mechanism underlying in seed dormancy and germination which will be useful for both basic research and development.

Suggested Reading

- Baskin C and Baskin JM. 2014. Seeds: Ecology, Biogeography, and Evolution of Dormancy and Germination. Academic Press, Cambridge, UK.
- Bewley J and Black M. 1994. Physiology of Development and Germination. Springer, New York.
- Bewley JD, Bradford KJ, Hilhorst HWM and Nanogaki H. 2013. Seeds: Physiology of Development, Germination and Dormancy. Springer, New York. Bewley JD and Black M. 1982. Physiology and Biochemistry of Seeds in Relation to Germination. Volume 2: Viability, Dormancy and Environmental Control. SpringerLink, New York, USA.
- Benech-Arnold R and Rodolfo S. 2004. Handbook of Seed Physiology: Applications to agriculture. CRC Press., Florida, USA.
- Black M and Bewley JD. 2000. Seed Technology and its Biological Basis. CRC Press. Florida, USA.
- Bradbeer JW. 1988. Seed Dormancy and Germination. Chapman and Hall, New York, USA.
- David R. Murray. 1985. Seed Physiology. Volume 2: Germination and Reserve Mobilisation. Academic Press, London, UK.
- Heydecker W. 1985. Seed Ecology. Pennsylvania State University Press, USA.
- Khan AA. 1977. The Physiology and Biochemistry of Seed Dormancy and Germination. North Holland Publishing Company, USA.

- Kozlowski TT. 2012. Seed Biology: Importance, Development and Germination. (Vol. I). Academic Press Inc., New York.
- Maiti RK, Sarkar NC and Singh VP. 2012. Principles of Post Harvest Seed Physiology and Technology. Agrobios, Jodhpur.
- Maiti RK, Sarkar NC and Singh VP. 2006. Principles of Post Harvest Seed Physiology and Technology. Agrobios, Jodhpur, Rajasthan.
- Mayer AM and Mayber AP. 1963. Germination of Seeds. Pergamon Press, Oxford, New York.
- Prakash M. 2011. Seed Physiology of Crops. Satish Serial Publishing house. Azadpur. New Delhi.
- Roberts EH. 1972. Viability of seeds. Springerlink, New York, USA.

Suggested e-book

<https://www.springer.com/in/book/9780792373223>
<https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1756-1051.2000.tb01610.X>
<https://www.elsevier.com/books/seeds/baskin/978-0-12-416677-6>
https://books.google.co.in/books/about/Physiology_and_Biochemistry_of_Seeds_in.html?id=91nsCAAQBAJ&printsec=frontcover&source=kp_read_button&redir_esc=y#v=onepage&q&f=false
https://books.google.co.in/books/about/The_Germination_of_Seeds.html?id=aV62AgAAQBAJ&printsec=frontcover&source=kp_read_button&redir_esc=y#v=onepage&q&f=false
https://books.google.co.in/books/about/Seed_Dormancy_and_Germination.html?id=aV62AgAAQBAJ&printsec=frontcover&source=kp_read_button&redir_esc=y#v=onepage&q&f=false

Suggested Website

<https://agriinfo.in/botany/18/https://sproutnet.com/seed-dormancy/>
<https://www.britannica.com/science/germination>
<http://www.biologyreference.com/Re-Se/Seed-Germination-and-Dormancy.html>
<https://www.intechopen.com/books/advances-in-seed-biology/seed-dormancy>

Course Title: Seed Production Techniques in Forage, Pasture and Green Manure Crops

Course Code: SAS/ST/C506

Credits Hours: 1+1

Objective: To impart knowledge on basic principles and methods of quality seed production in forage and green manure crops.

Theory

UNIT I

Scope and importance of seed production in forage, pasture and green manure crops, factors influencing seed production – seasonal influence; problems and constraints in seed production – seed set, shattering and seed dormancy; vegetative and clonal propagules and apomictic seed.

UNIT II

Quality seed production techniques in major fodder crops – lucerne, hedge lucerne, leucaena,

fodder sorghum, fodder maize and oats.

UNIT III

Seed and planting material production techniques of major forage grasses – bajra-napier grass, guinea grass, deenanath grass and *Cenchrus* sp.; forage legumes *Stylosanthus*, cowpea and berseem.

UNIT IV

Seed production techniques in major green manure crops – *Glyricidia*, *Sesbania* sp., sunnhemp, daincha, jute and *Tephrosia* sp.

UNIT V

Post-harvest seed handling – processing, threshing, grading and upgrading; dormancy breaking and germination improvement – quality standards for seed and vegetative propagules.

Practical

- Seed collection and identification of seeds
- Estimation of seed setting and shattering loss
- Maturity indices – determination of physiological and harvestable maturity
- Seed extraction and threshing methods
- Separation of ill filled seeds – practicing different methods
- Study of seed and clonal materials – standards
- Quality of planting material and vegetative propagules on crop establishment
- Seed quality analysis in forage and fodder crops – tiller wise quality analysis
- Seed quality analysis in determinate and indeterminate crops
- Study on effect of ratooning on seed quality
- Practicing seed quality enhancement techniques
- Practicing different seed extraction and dormancy breaking treatments
- Preparation of vegetative propagules and planting
- Planning for seed production in fodder and green manure crops
- Economics of seed production in fodder, forage crops and green manure crops
- Visit to forage and fodder seed production farms.

Teaching methods: Classroom teaching with AV aids, group discussion, assignment class discussion and field visit.

Learning outcome: After completion of course the students gain confidence to start a seed venture on forage and green manure crops.

Suggested Reading

FAO. 2007. *Quality Declared Seed System*. FAO Plant Production and Protection Publication, FAO, Rome.

Farity DT and Hampton JC. 1997. *Forage Seed Production*. Vol. I.

Temperate Species. CAB International Publications. UK.

Froma J. 1997. *Temperate Forage Legumes*. CAB International Publications. UK.
Gutterridge RG. 1997. *Forage Tree Legumes in Tropical Agriculture*. CAB International Publications, UK.

Masilamani S and Sivasubramanian K. 2016. *Seed Production in Green Manures*. Kalyani Publications, New Delhi.

Suggested e-book

<https://www.cabi.org/bookshop/book/9780851992143>
<https://cgspace.cgiar.org/handle/10568/49375>
<http://www.fao.org/docrep/009/a0503e/a0503e00.htm>
http://www.igfri.res.in/pdf/old_bulletins/tropical_pasture.pdf
<https://cgspace.cgiar.org/bitstream/handle/10568/4479/Seed.pdf?sequence=1&isAllowed=y>

Suggested Website

www.igfri.res.in/
<https://cgspace.cgiar.org/handle/10568/4479> <https://www.euroseeds.eu/grasses-and-clovers>
<https://www.sare.org/learning-center/green-manures>
www.ndri.res.in/ndri/Design/forageres_mag_cen.html
<http://orgprints.org/30588/1/Sort%20Out%20Your%20Soil.pdf>

Course Title: Seed Legislation and Certification*

Course Code: SAS/ST/C507

Credit Hours: 2+1

Objective: To impart knowledge on seed legislation in relation to seed certification and quality control systems.

Theory

UNIT I

Genesis of seed Industry in India; seed quality control – concept and objectives; regulatory mechanisms – Seed Act (1966) – Seed Rules (1968) – statutory bodies– Central Seed Committee – Central Seed Certification Board.

UNIT II

Seed Control Order (1983) – New Policy on Seed Development (1988) – Exim Policy – National Seed Policy (2002) – Plant Quarantine Act.

UNIT III

Introduction to WTO and IPR – UPOV and its role – OECD seed certification schemes – PPV & FR Act (2001) and Rules (2003) – Seed Bill (2004 and 2011): Seed certification system in SAARC countries, Europe, Canada, Australia and USA.

UNIT IV

Seed certification – history and objectives; general and specific crop standards, field and seed standards; seed certification agency – role of certification agency/ department and seed certification officers, phases of seed certification; field inspection – counting procedures – liable for rejection (LFR) – downgrading and partial rejection – reporting.

UNIT V

Post-harvest inspection – construction of seed lot number; seed sampling – testing

– labeling, sealing and grant of certificate – types and specifications for tags and labels; seed lot validity and revalidation; appellate authority, stop sale order, penalties records and registers to be maintained by seed processing units and seed dealers – verification procedures, role of seed analyst and seed inspector in quality regulation.

Practical

- Preparation of sowing report – varieties – transplanted and direct sown crops and hybrids
- Verification of sowing report – seed certification procedures
- Field inspection – estimation of area and isolation distance, stages of inspection for varieties and hybrids – procedures
- Practicing field counting procedures – methods for row planting, broadcasted – varieties
- Practicing field counting procedures – direct sown and transplanted crop varieties
- Study on field counting procedures – hybrids – planting design, planting ratio and block method and double count
- Identification of contaminants – genetic and physical contaminants, procedure to remove partials, pollen shedders and shedding tassels
- Assessing and calculation of field standards for important crops
- LFR, partial rejection and downgrading – reasons, procedures and preparation of reports
- Yield estimation – single and multiple harvest crops
- Post-harvest inspection – groundnut, cotton, pulses
- Inspection and maintenance (license and renewal) of records in processing unit – Visit to seed certification agency/ department
- Visit to grow-out test field
- Visit to seed retail shop – procedures followed by Seed Inspector, verification of records and reporting
- Procedure to issue tag, specification, bagging, tagging, labelling and sealing.

Teaching methods: Classroom teaching with AV aids, group discussion, assignment class discussion and field visit.

Learning outcome: This course will be useful to develop human resource on seed certification and legislation. Successful completion of this course enables students to become a Seed Certification Officer and Seed Inspector.

Suggested Reading

Agarwal RL. 2012. *Seed Technology*. Oxford & IBH Publishing Company Pvt. Ltd., New Delhi. Anon. 2016. *Manual of Seed Certification Procedures*. Directorate of Seed Certification, Coimbatore, Tamil Nadu.

- Chakrabarthy SK. 2010. *Seed Production and Quality Control*. Kalyani Publishers, New Delhi.
- Mishra DK, Khare D, Bhale MS and Koutu GK. 2011. *Handbook of Seed Certification*. Agrobios, Jodhpur, Rajasthan.
- Neema NP. 1986. *Principles of Seed Certification and Testing*. Allied Publishers, New Delhi
- Ramamoorthy K, Sivasubramaniam K and Kannan M. 2006. *Seed Legislation in India*. Agrobios, Jodhpur, Rajasthan.
- Renugadevi J, Srimathi P, Renganayaki PR and Manonmani V. 2012. *A Handbook of Seed Testing*. Agrobios, Jodhpur, Rajasthan.
- Sharma P. 2008. *Seed Legislation*. Gene-tech Book Publishers, New Delhi.
- Trivedi PC. 2011. *Seed Technology and Quality Control*. Pointer Publications, Jaipur, Rajasthan.
- Tunwar NS and Singh SV. 2003. *Indian Minimum Seed Certification Standards*. Central Seed Certification Board, Ministry of Agriculture, GOI, New Delhi.

Suggested e-book

<http://cms.tn.gov.in/sites/default/files/documents/seed-certification-0.pdf>
<http://odishaseedsportal.nic.in/SeedPortalData/Resource%20Material/INDIAN-MINIMUM-SEED-CERTIFICATION-STANDARDS.pdf>
<https://www.india.gov.in/my-government/documents/e-books>
https://books.google.co.in/books/about/Principles_of_Seed_Certification_and_Tes.html?id=SQWHAAAACAAJ&redir_esc=y
<https://dl.sciencesocieties.org/publications/books/tocs/cssaspecialpubl/theroleofseedce>

Suggested Website

www.fao.org www.agri.nic.in www.agricoop.nic.in www.gov.mb.ca
<http://agritech.tnau.ac.in> www.betterseed.org
www.oecd.org/india/
<http://www.tnagrisnet.tn.gov.in/>
https://pir.sa.gov.au/_data/assets/pdf_file/0003/148134/SeedCertification_Manual.pdf

MINOR COURSES

Course title: Principles of Genetics

Course Code: SAS/ST/M501

Credits :3 (2+1)

Objective: Genes are the backbone of all crop improvement activities. Their chemical structure and physical inheritance are pivotal for any breeding program. Therefore, it has to be the core course for master's degree in Genetics & Plant Breeding.

Aim of the course: This course is aimed at understanding the basic concepts of inheritance of genetic traits, helping students to develop their analytical, quantitative and problem-solving skills from classical to molecular genetics.

Theory

Unit I

Beginning of genetics, early concepts of inheritance, Mendel's laws; Discussion on Mendel's paper, Chromosomal theory of inheritance; Multiple alleles, Gene interactions, Sex determination, differentiation and sex-linkage, Sex-influenced and sex-limited traits; Linkage-detection, estimation; Recombination and genetic mapping in eukaryotes, Somatic cell genetics, Extra chromosomal inheritance.

Unit II

Mendelian population, Random mating population, Frequencies of genes and genotypes, Causes of change: Hardy-Weinberg equilibrium;

Unit III

Nature, structure and replication of the genetic material; Organization of DNA in chromosomes, Genetic code; Protein biosynthesis, Genetic fine structure analysis, Allelic complementation, Split genes, overlapping genes, Pseudogenes, Oncogenes, Gene families and clusters; Regulation of gene activity in prokaryotes and eukaryotes; Molecular mechanisms of mutation, repair and suppression; Bacterial plasmids, insertion (IS) and transposable (Tn) elements; Molecular chaperones and gene expression, RNA editing.

Unit IV

Gene isolation, synthesis and cloning, genomic and cDNA libraries, PCR based cloning, positional cloning; Nucleic acid hybridization and immunochemical detection; DNA sequencing; DNA restriction and modification, Anti-sense RNA and ribozymes; MicroRNAs (miRNAs).

Unit V

Genomics and proteomics; metagenomics; Transgenic bacteria and bioethics; Gene silencing; genetics of mitochondria and chloroplasts. Concepts of Eugenics, Epigenetics, Genetic disorders

Practical

- Laboratory exercises in probability and chi-square;
- Demonstration of genetic principles using laboratory organisms;
- Chromosome mapping using three-point test cross;
- Tetrad analysis; Induction and detection of mutations through genetic tests;
- DNA extraction and PCR amplification
- Electrophoresis: basic principles and running of amplified DNA ,
- Extraction of proteins and isozymes
- Use of Agrobacterium mediated method and Biolistic gun; practical demonstrations:
- Detection of transgenes in the exposed plant material;
- Visit to transgenic glasshouse and learning the practical considerations.

Teaching methods

- Power point presentation,
- Chalk and Board
- Smart board
- Lectures,
- Assignments, quiz,
- Group tasks, student's presentations

Learning outcome

After passing out this course the student will be able to know the difference between the genotype and phenotype, can carry study on inheritance and also know the role of DNA and RNA in genotypic manifestation of characters.

Suggested reading

- Daniel LH & Maryellen R. 2011. Genetics: "Analysis of Genes and Genomes". Daniel Hartl
- Gardner EJ & Snustad DP. 1991. Principles of Genetics. John Wiley & Sons. 8th ed. 2006
- Klug WS & Cummings MR. 2003. Concepts of Genetics. Peterson Edu. Pearson Education India; Tenth edition
- Lewin B. 2008. Genes XII. Jones & Bartlett Publ. (International Edition) Paperback, 2018
- Russell PJ. 1998. Genetics. The Benjamin/Cummings Publ. Co
- Snustad DP & Simmons MJ. 2006. Genetics. 4th Ed. John Wiley & Sons. 6th Edition International Student Version edition
- Singh B D. 2009. Genetics. Kalyani Publishers (2nd Revised Edition)
- Stansfield W.D. 1991. Genetics. Schaum Outline Series Mc Graw Hill
- Strickberger MW. 2005. Genetics (III Ed). Prentice Hall, New Delhi, India; 3rd ed., 2015
- Tamarin RH. 1999. Principles of Genetics. Wm. C. Brown Publs., McGraw Hill Education; 7 edition
- Uppal S, Yadav R, Singh S & Saharan RP. 2005. Practical Manual on Basic and Applied Genetics. Dept. of Genetics, CCS HAU Hisar.

Principles of Plant Breeding*

Course code: SAS/ST/M502

Credits :3(2+1)

Objective: Development of plant variety is the ultimate aim of any plant breeding program. A post graduate in the subject of agriculture must know what are the different selection methods, techniques and related crop improvement strategies. Further, knowledge of genetic resources, evolution and their role in development of noble varieties is the need of the hour.

Aim of the course: To impart theoretical knowledge and practical skills about plant breeding objectives, genetic consequences, breeding methods for crop improvement.

Theory

UNIT I

Early Plant Breeding; Accomplishments through plant breeding; Objectives of plant breeding; Patterns of Evolution in Crop Plants: Centre of Origin, Agro-biodiversity and its significance. Pre-breeding and plant introduction and role of plant genetic resources in plant breeding.

UNIT II

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.

UNIT III

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.

UNIT IV

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. Hybrid breeding: genetical and physiological basis of heterosis and inbreeding, production of inbreds, breeding approaches for improvement of inbreds, predicting hybrid performance; seed production of hybrid and their parent varieties/inbreds. Self-incompatibility, male sterility and apomixes in crop plants and their commercial exploitation.

UNIT V

Breeding methods in asexually/clonally propagated crops, clonal selection.

UNIT VI

Special breeding techniques: Mutation breeding, Breeding for abiotic and biotic stresses; Concept of plant ideotype and its role in crop improvement, concept of MAS, concept of polyploidy and wide hybridization, doubled haploidy.

UNIT VII

Cultivar development: testing, release and notification, maintenance breeding, Participatory Plant Breeding, Plant breeders' rights and regulations for plant variety protection and farmers rights.

Practical

- Floral biology in self and cross pollinated species,
- Selfing and crossing techniques.
- Selection methods in segregating populations and evaluation of breeding material;

- Analysis of variance (ANOVA);
- Estimation of heritability and genetic advance;
- Maintenance of experimental records;
- Learning techniques in hybrid seed production using male-sterility in field crops.
- Prediction of performance of double cross hybrid.

Teaching methods:

- Power point presentation,
- Chalk and Board
- Smart board
- Lectures,
- Assignments, quiz,
- Group tasks, student's presentations

Learning outcome

The knowledge of this course will enable the student to know breeding methods, different hybridization techniques for genomic reshuffling. The course will also acquaint the student with importance of floral biology, mutation breeding and participatory plant breeding, etc.

Resources

Allard RW. 1981. Principles of Plant Breeding. John Wiley & Sons.

Chahal GS and Gossal, SS.2002. Principles and Procedures of Plant Breeding Biotechnological and Conventional approaches. Narosa Publishing

Chopra VL .2004. Plant Breeding. Oxford & IBH.

George A .2012. Principles of Plant Genetics and Breeding. John Wiley & Sons.

Gupta SK.2005.Practical Plant Breeding. Agribios.

Jain HK and Kharakwal MC .2004. Plant Breeding and –Mendelian to Molecular Approach, Narosa Publications New Delhi

Roy D. 2003.Plant Breeding, Analysis and Exploitation of Variation. Narosa Publ. House.

Sharma JR. 2001. Principles and Practice of Plant Breeding. Tata McGraw-Hill.

Sharma JP.2010. Principles of Vegetable Breeding. Kalyani Publ, New Delhi.

Simmonds NW.1990. Principles of Crop Improvement. English Language Book Society.

Singh BD. 2006.Plant Breeding. Kalyani Publ.

Singh S & Pawar IS. 2006.Genetic Bases and Methods of Plant Breeding. CBS.

Common Courses

Course Title: Agricultural Research, Research Ethics and Rural Development Programmes

Course Code: SAS/ST/CC05

Credit Hours: 1+0

Objective: To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government.

Theory

UNIT I

History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

UNIT II

Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT III

Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co- operatives, Voluntary Agencies/ Non- Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Reading

- Bhalla GS and Singh G. 2001. Indian Agriculture - Four Decades of Development. Sage Publ.
Punia MS. Manual on International Research and Research Ethics.
CCS Haryana Agricultural University, Hisar.
Rao BSV. 2007. Rural Development Strategies and Role of Institutions
-Issues, Innovations and Initiatives. Mittal Publ.
Singh K. 1998. Rural Development - Principles, Policies and Management. Sage Publ.

Course Title: Basic Concepts in Laboratory Techniques

Course Code: SAS/ST/CC04

Credit Hours: 0+1

Objective: To acquaint the students about the basics of commonly used techniques in laboratory.

Practical

- Safety measures while in Lab
- Handling of chemical substances
- Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vascupets
- Washing, drying and sterilization of glassware
- Drying of solvents/ chemicals
- Weighing and preparation of solutions of different strengths and their dilution
- Handling techniques of solutions
- Preparation of different agro-chemical doses in field and pot applications
- Preparation of solutions of acids
- Neutralization of acid and bases
- Preparation of buffers of different strengths and pH values
- Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sand bath, water bath, oil bath
- Electric wiring and earthing
- Preparation of media and methods of sterilization
- Seed viability testing, testing of pollen viability
- Tissue culture of crop plants
- Description of flowering plants in botanical terms in relation to taxonomy

Suggested Reading

Furr AK. 2000. CRC Hand Book of Laboratory Safety. CRC Press.

Gabb MH and Latchem WE. 1968. A Handbook of Laboratory Solutions. Chemical Publ. Co.

Semester-III

Major courses

Course Title: Post Harvest Handling and Storage of Seeds*

Course Code: SAS/ST/C508*

Credit Hours: 2+1

Objective: To impart knowledge on principles, techniques and methods of seed processing, treatment, and storage.

Theory

UNIT I

Seed processing – objectives and principles; processing sequence – threshing, shelling, ginning, extraction methods; drying – principles and methods; seed cleaning, grading, upgrading – methods – machineries and equipment – scalper, pre-cleaner, cleaner cum grader, specific gravity separator, indented cylinder, disc separator, spiral separator, velvet separator, magnetic separator, electronic colour sorter – working principles and functions.

UNIT II

Online seed processing – elevators and conveyers – processing plant – specifications, design and layout; mechanical injury – causes and detection – management.

UNIT III

Seed treatment – methods – pre and mid storage seed treatments, seed treating formulations and equipments; packaging materials – types – bagging and labeling; seed blending – principle and methods.

UNIT IV

Seed storage – purpose and importance – factors affecting storage, optimum condition for storage of different seeds; storage principles – Harrington's thumb rule – concepts and significance of moisture equilibrium – maintenance of safe seed moisture – physical, physiological, biochemical and molecular changes during seed storage – storage behavior of orthodox and recalcitrant seeds – prediction of viability – viability nomograph.

UNIT V

Methods of seed storage – modified atmospheric storage – ultra dry storage – vacuum storage – cryopreservation – germplasm storage – gene banks – NBPGR, IPGRI and National seed storage laboratory; seed storage godown – structure – maintenance – sanitation.

Practical

- Seed Extraction – wet and dry methods
- Seed processing sequence for different crops
- Design of processing plant – equipments – estimation of processing efficiency
- Seed drying methods – principle and methods
- Practicing seed grading – upgrading techniques
- Delinting methods – assessment of mechanical damage

- Visit to seed processing unit
- Seed packaging – effect of packaging materials on seed longevity
- Prediction of viability during storage – viability nomograph and accelerated ageing test;
- Assessing physical changes during seed storage
- Assessing physiological changes during seed storage
- Assessing biochemical changes during seed storage
- Storage behaviour of recalcitrant seeds
- Pre-storage seed treatments – protectants – antioxidants – halogens
- Practicing seed blending methods
- Seed storage godown – sanitation, fumigation – visit to seed storage godown and cold storage unit.

Teaching methods: Classroom teaching with AV aids, group discussion, assignment, class discussion and exposure and field visits

Learning outcome: The students will understand the principles and mechanism involved in seed processing, storage techniques and management practices to arrest the seed deterioration. Students will also acquire skill on seed handling and storage methods on commercial basis.

Suggested Reading

- Barton LV. 1961. *Seed Preservation and Longevity*, (Vol. 1). Leonard Hill, London.
- Gregg BR, Law AG, Viridi SS and Balis JS. 1970. *Seed Processing*. Avion printers, New Delhi.
- Gupta D. 2009. *Seeds: their conservation principles and practices*. Sathish serial publishing house. New Delhi.
- Justice OL and Bass LN. 1978. *Principles and Practices of Seed Storage*. Agriculture Hand Book No. 506, Castle House Publication Ltd., Washington.
- Kulkarni GN. 2011. *Principles of Seed Technology*. Kalyani Publishers, New Delhi.
- Maiti RK, Sarkar NC and Singh VP. 2006. *Principles of Post Harvest Seed Physiology and Technology*. Agrobios, Jodhpur, Rajasthan.
- Padmavathi S, Prakash M, Ezhil Kumar S, Sathiyarayanan G and Kamaraj A. 2012. *A Text book of Seed Science and Technology*, New India Publishing Agency, New Delhi.
- Sen S and Ghosh N. 2010. *Seed Science and Technology*. Kalyani Publishers, New Delhi.
- Singhal NC. 2010. *Seed Science and Technology*. Kalyani Publishers, New Delhi.

Suggested e-book

http://dfsc.dk/pdf/Handbook/chapter8_internet.pdf

<https://naldc.nal.usda.gov/download/CAT87208646/PDF>

<https://www.springer.com/in/book/9780792373223> <http://203.64.245.61/fulltext-pdf/EB/1900-2000/eb0021.pdf>
https://www.kopykitab.com/ebooks/2016/05/6997/sample/sample_6997.pdf
[https://trove.nla.gov.au/work/6862691?q&sort=holdings+desc&-1541066209257
&versionId=45008917+251246346](https://trove.nla.gov.au/work/6862691?q&sort=holdings+desc&-1541066209257&versionId=45008917+251246346)
<http://www.worldseed.org/wp-content/uploads/2017/01/Seed-Production-Good-practice-10.01.17-final.pdf>

Suggested Website

<http://www.fao.org/3/a-ah803e.pdf>
agritech.tnau.ac.in/seed_certification/seedtech_index.html
<http://ecoursesonline.iasri.res.in/mod/page/view.php?id=17806>
<http://www.bcseeds.org/wp-content/uploads/2015/01/Seed-Processing-2015-update.pdf>
https://www.carolinafarmstewards.org/wpcontent/uploads/2012/05/Seed Processing and StorageVer_1pt3.pdf

Course Title: Seed Quality Testing and Enhancement*

Course Code: SAS/ST/C509*

Credit Hours: 2+1

Objective: To impart knowledge on principles, techniques and methods of seed testing and seed quality enhancement.

Theory

UNIT I

Seed testing – history and development; seed testing in India; ISTA and its role in seed testing; seed lot and size, types of seed and size, samples – sampling – intensity and methods, sampling devices, receipt and registration of submitted samples in the laboratory and sub sampling; purity analysis – components and procedure – determination of other distinguishable varieties (ODV) and test weight determination – application of heterogeneity test – method of testing coated and pelleted seeds; seed moisture estimation – principles and methods, application of tolerances.

UNIT II

Seed germination test – requirements, media and methods – seedling evaluation, tolerance and reporting results; viability test (TZ test) – principle, procedure and evaluation; vigour tests – concept of seed vigour and vigour test – types of vigour tests – direct and indirect tests – physical, physiological and biochemical tests – principles and methods; seed health test – principles and methods.

UNIT III

Genetic purity assessment – laboratory methods – physical, chemical, biochemical and molecular tests – growth chamber and field testing (Grow Out Test) methods; testing of GM seeds; storage of guard sample – referral test; application of tolerance in seed testing; advanced nondestructive techniques of seed quality analysis – soft X-ray imaging – hyper spectral imaging, thermal imaging – spectroscopy – e-nose and machine vision techniques.

UNIT IV

Seed quality enhancement techniques – history and development; classification – physical,

physiological and protective seed treatments – special seed treatments; physical seed treatment – liquid floatation, specific gravity separation, irradiation, electric and electro-magnetic seed treatments – principles and methods – seed pelleting and coating principles, purpose and methods.

UNIT V

Physiological seed enhancement treatments – seed infusion, seed priming – principles and methods – physiological, biochemical and molecular mechanisms; pre-germination and fluid drilling techniques; biological seed treatments – microbial inoculation; organic seed treatment – integrated seed treatment – concept and methods of designer seed.

Practical

- Seed testing – sampling and dividing methods
- Determination of seed test weight and heterogeneity test
- Physical purity analysis – components, procedure, reporting results
- Seed moisture estimation – methods and equipments
- Conduct of seed germination test and seedling evaluation
- Conduct of quick viability (tetrazolium) test and evaluation
- Conduct of vigour tests – direct, indirect test and special tests
- Genetic purity assessment – laboratory and conventional methods – image analysis for seed quality
- Conducting different seed health tests to identify bacteria, fungi and insects
- Visit to seed testing laboratory
- Seed enhancement techniques – practicing physical treatments and water floatation techniques
- Seed coating and pelleting – uses of adhesives and filler materials
- Performing seed priming – hydro, halo and bio-priming – solid matrix priming
- Practicing seed infusion and microbial inoculation treatments
- Practicing pre-germination technique
- Studying integrated seed treatment/ designer seed treatment.

Teaching methods: Classroom teaching with AV aids, group discussion, assignment class discussion and field visit.

Learning outcome: Successful completion of this course by the students will be useful to acquire technical skill on seed quality analysis which leads to the development of human resource on seed quality analysis.

Suggested Reading

- Agrawal PK. 1993. *Hand book of Seed Testing*. Ministry of Agriculture, GOI, New Delhi
- Agrawal RL. 1997. *Seed Technology*. OXford & IBH.
- Agrawal PK and Dadlani M. 1992. *Techniques in Seed Science and Technology*. 2nd Ed. South Asian Publications.

- Chakrabarthy SK. 2010. *Seed Production and Quality Control*. Kalyani Publishers. New Delhi.
- Chalam GV Singh A and Douglas JE. 1967. *Seed Testing Manual*. ICAR and United States Agency for International Development, New Delhi.
- Copeland LO and McDonald MB. 2001. *Principles of Seed Science and Technology*. 4th Ed. Kluwer Academic publishers, USA.
- International Seed Testing Association. 2018. *Handbook on Seedling Evaluation*, 4th Edition, Published by ISTA, Zurichstr, Switzerland.
- International Seed Testing Association. 2019. *International Rules for Seed Testing* 2019. Published by ISTA, Zurichstr, Switzerland.
- ISTA. 1999. *Seed Science and Technology*, 27th supplement.
- Renugadevi J, Srimathi P, Renganayaki PR and Manonmani V. 2012. *A Handbook of Seed Testing*. Agrobios. Jodhpur, Rajasthan.
- Tridevi PC. 2011. *Seed Technology and Quality Control*. Pointer Publication. Jaipur, Rajasthan.
- Vasudevan SN, Doddagowder SR, Rakesh CM and Patil SB. 2013. *Seed Testing and Quality Control*. Agrotech Publications, Udaipur, Rajasthan.

Suggested e-book

<http://odishaseedsportal.nic.in/SeedPortalData/Resource%20Material/INDIAN> MINIMUM SEED CERTIFICATION STANDARDS.pdf

www.kopykitab.com/Seed-Testing-and-Quality-Control-by-Vasudevan-SN

<https://www.jstor.org/stable/10.14321/j.ctt7zt51m>

https://link.springer.com/chapter/10.1007/978-1-4615-1619-4_13

https://www.researchgate.net/publication/269694458_QUALITY_SEED_PRODUCTION_ITS_TESTING_AND_CERTIFICATION_STANDARD

https://www.seedtest.org/upload/cms/user/ISTAMethodValidationforSeed_Testing-V1.01.pdf

<https://www.intechopen.com/books/new-challenges-in-seed-biology-basic-and-translational-research-driving-seed-technology/recent-advances-in-seed-enhancements>

Suggested Website

http://agritech.tnau.ac.in/seed/Seed_seedtesting.html

<https://core.ac.uk/download/pdf/85210907.pdf>

<https://www.betterseed.org/resources/seed-testing-accreditation-schemes/>

http://sbc.ucdavis.edu/About_US/Seed_Biotechnologies/Seed_Enhancement/

<https://www.seedtest.org/en/international-rules-for-seed-testing-content-1-1083.html>

Course Title: Seed Health Testing and Management

Course Code: SAS/ST/C512

Credit Hours: 2+1

Objective: To empower the students by imparting knowledge on seed testing management

Theory

UNIT I

History and economic importance of seed health in seed industry and plant quarantine important seed borne and seed transmitted pathogens – role of microorganisms in seed quality deterioration – storage and field fungi – effect of storage fungi on seeds – factors influencing storage fungi and management.

UNIT II

Transmission of pathogens – mode and mechanism – seed certification standards; mycotoxins – types and its impact on plant, animal and human health; seed health testing methods – direct examination, incubation, serological and molecular methods.

UNIT III

Production of disease-free seeds in agricultural and horticultural crops; management of seed borne pathogens – plant quarantine – Indian system and networking, post- entry quarantine and international systems – Pest Risk Analysis (PRA); Sanitary and Phytosanitary System (SPS) – certificates; International Seed Health Initiative (ISHI) on seed health standards.

UNIT IV

Storage pests – insects, mites, rodents and their development – economic importance; insect infestation – factors influencing, sources and kinds, biochemical changes in stored seeds due to insect infestation; detection methods and estimation of storage losses; types of seed storage structures – domestic and commercial.

UNIT V

Fumigation – principles and techniques – type of fumigants; preservatives and seed protectants on seed quality – non-chemical methods for managing seed storage pests – controlled and modified atmospheric storage – trapping devices – IPM for seed storage.

Practical

- Detection of seed borne pathogens – direct examination
- Detection of seed borne pathogens – incubation methods
- Detection of seed borne pathogens – serological methods
- Detection of seed borne pathogens – molecular methods
- Study on seed transmission of seed borne fungi, bacteria and viruses
- Identification of storage fungi
- Management of seed borne pathogens – seed treatment methods
- Identification of storage insects – internal and external feeders influencing insects
- Study on the effect of pre harvest spray on field carryover storage pests

- Estimation of storage losses due to pests
- Methods of detection of insect infestation
- Management of storage pests – pesticides, dose determination, preparation of solution and application
- Management of storage pests – non-chemical management methods
- Demonstration of controlled atmospheric storage
- Safe handling and use of fumigants and insecticides
- Visit to seed storage godowns.

Teaching methods: Classroom teaching with AV aids, group discussion, assignment class discussion laboratory experiments and hands on training.

Learning outcome: Successful completion of this course will provide knowledge on production of healthy seeds by timely detection and management of seed borne pathogens and storage pests to meet phyto-sanitary requirements.

Suggested Reading

Agarwal VK and Sinclair JB. 1996. *Principles of Seed Pathology*. Edition, CRC Press Inc. BocaRaton,FL.

Athanassiou CG and Arthur FH. 2018. *Recent advances in stored product protection*. Springer-Verlag, Germany

Cotton, RT. 2007. *Insect Pests of Stored grain and Grain products*. Burgess Publ. Co., Minneapolis, Minn., USA

Karuna V. 2007. *Seed Health Testing*. Kalyani Publishers, New Delhi. Karuna V. 2009. *Fundamentals of Seed Pathology*. Kalyani Publishers, New Delhi. Neergaard P. 1979. *Seed Pathology*. Vol. 1. The Macmillan Press Ltd.

Ranjeet K. 2017. *Insect Pests of Stored grain – Biology, Behaviour and Management Strategies*. Apple Academic Press, New York, USA.

Suggested e-book

<https://link.springer.com/book/10.1007/978-1-349-02842-9>

https://books.google.co.in/books/about/Seed_Pathology.html?id=lvVJAAAAYAA&redir_esc=y

<https://www.taylorfrancis.com/books/9781315365695> <https://www.ebooks.com/en-us/610606/insects-of-stored-products/david-rees/>

<https://www.elsevier.com/books/insects-and-seed-collection-storage-testing-and-certification/kozlowski/978-0-12-395605-7>

Suggested Website

www.tnagrisnet.tn.gov.in/

www.storedgrain.com.au/ https://openlibrary.org/subjects/seed_pathology

http://ciat-library.ciat.cgiar.org/articulos_ciat/2015/12620.pdf www.grainscanada.gc.ca/en/ <https://entomology.ca.uky.edu/ef145> <http://www.fao.org/3/t1838e/T1838E00.htm#Contents>

Course Title: Seed Industry and Marketing Management

Course Code: SAS/ST/C511

Credit Hours: 2+1

Objective: To empower the students to become seed entrepreneurs by imparting knowledge on seed industry management and marketing strategies.

Theory

UNIT I

Introduction to seed industry – genesis, growth and structure of seed industry – mission and objectives – present status of Indian and global seed industry – role of seed industry in Indian agriculture; government initiatives – seed hubs, seed villages and community seed production system.

UNIT II

Seed industry – organization set up and functions – public, private, MNC's, seed corporations; structure of small, medium and large seed industries, components of seed industry – public private partnership – custom seed production – risk management – human resource – infrastructure – processing UNIT – storage go down.

UNIT III

Seed production and distribution systems in state and central government; seed supply chain systems – seed production and distribution – planning, organization and coordination, staffing, assembling of resources; cost of seed production – overhead charges.

UNIT IV

Seed marketing – definition – importance – role of marketing; type of markets – domestic and global market – problems and perspectives; marketing policies – seed marketing schemes – marketing channels, responsibilities of dealers marketing mix.

UNIT V

Seed demand forecasting – purpose – methods and techniques; indenting and seed dispatch procedures and forms – seed store records – maintenance – missing link in seed supply chain; market intelligence – SWOT analysis; seed cost analysis; seed pricing – policy – components of seed pricing – factors – local market rate (LMR) – fixation of procurement and sale price of seed.

Practical

- Data collection on status of Indian and global seed industry
- Assessing the factors influencing farmers preference and assessment of seed demand and supply
- Planning for establishment of small, medium and large seed industry
- Planning for establishment of seed production and processing unit
- Economics of seed production – varieties and hybrids
- Seed pricings and cost analysis

- Exercise on fixing seed procurement and sale price
- Study of marketing channels – domestic and international
- Maintenance of carryover seeds – Assessing risk factors in seed industry and their management
- Survey and interaction with seed dealers and distributors
- Visit to state seed corporations
- Visit to MNCs and expert discussion
- Case studies and SWOT analysis
- Visit to modern seed processing unit and advanced seed storage complex
- Custom seed production, contract farming and procurement – procedures
- Planning and preparation of project proposal for setup of a seed industry

Teaching methods: Classroom teaching with AV aids, group discussion, assignment, class discussion, Swot analysis and seed industry visit and interaction sessions

Learning outcome: On completion of this course students will gain knowledge and confidence to manage seed industry and able to address the problems in seed industry and seed marketing.

Suggested Reading

Acharya SS and Agarwal NL. 2004. *Agricultural Marketing in India*. 4th Ed. Oxford and IBH.
Broadway AC and Broadway A. 2003. *A Text Book of Agri- business Management*.

Kalyani Singh AK and Pandey S. 2005. *Rural Marketing*. New Age Publications. Kugbei
S. 2008. *Seed Economics*. Scientific Publishers, Jodhpur, Rajasthan.

Sharma P. 2008. *Marketing of Seeds*, Green-Tech Book Publishers, New Delhi.

Singh G and Asokan SR. 1991. *Seed Industry in India: A Management Perspective*
Oxford & IBH Publishing Co Pvt. Ltd., New Delhi.

Singh S. 2004. *Rural Marketing – Focus on agricultural Inputs*. Vikas Publishing House.

Suggested e-book

<https://link.springer.com/chapter/10.1007/978-1-4615-1783-2-15>

<http://www.fao.org/3/V4450E/V4450E00.htm>

<https://books.google.co.in/books?id=vPVIbos4WkYC>

<http://download.nos.org/srsec319new/319EL19.pdf>

<https://isengewant.de/Marketing-of-Seeds-By-Premjit-Sharma.pdf>

<https://www.kopykitab.com/A-Handbook-of-Seed-Processing-and-Marketing-by-Gaur-SC>

Suggested Website

www.gov.mb.ca www.agricoop.nic.in www.agri.nic.in <https://sathguru.com/seed/>
<http://www.fao.org/3/V4450E/V4450E03.htm> <https://www.seednet.gov.in/smis/SMIS-User%20Manual.pdf>
<https://www.icrisat.org/seed-systems-models-lessons-learned/>
<https://www.bookdepository.com/Seed-Industry-India-Gurdev-Singh/>

Course Title: Seed Technology of Tree Species

Course Code: SAS/ST/C510

Credit Hours: 2+1

Objective: To make the students gain knowledge on seed production and handling techniques of various tree species.

Theory

UNIT I

Importance of tree seeds – seed quality in plantation establishment – scope of seed production in tree species; seed structure and its significance in natural regeneration of forest species.

UNIT II

Reproductive biology – angiosperms and gymnosperms – reproductive age – seasonal influence on flowering – reproductive efficiency; factors influencing seed set – pollination – pollinating agents – self incompatibility – seed dispersal – mode and mechanism of dispersal.

UNIT III

Seed stand – selection and delineation – seed production area – seed zone – selection criteria for candidate, plus and elite tree; seed orchards – definition – types – seedling and clonal seed orchard – pollen dilution zone – seed orchard establishment and management; OECD certification programs for forest reproductive materials and seeds – ISTA certification standards for tree species.

UNIT IV

Physiological maturity – maturity indices – determining optimum harvestable maturity; seed collection – methods – factors influencing seed collection – precautions in collection of recalcitrant seeds; seed extraction – methods – wet, dry and cone extraction; drying – critical moisture content – seed processing; dormancy – types of dormancy in tropical, sub-tropical and temperate tree seeds – dormancy breaking treatments; recalcitrant seeds – mechanism.

UNIT V

Seed production and handling techniques in important tree borne oil seeds (*Madhuca*, *Pongamia*, *Azadirachta*, *Simaruba*, *Callophyllum*), timber (teak, sandal, pine, cedar, red sanders, shisham), fuel wood (*Acacias*), pulp wood (*Bambusa*, *Ailanthus*, *Casuarina*, *Melia*, *Eucalyptus*), fodder (*Leucaena*, *Albizzia*) and ornamental (*Cassia*, *Delonix*) tree species.

Practical

- Study of tree seed structure – internal and external structures
- Study on phenology of different tree species
- Selection procedure of candidate and plus trees
- Assessment of seed set, physiological and harvestable maturity
- Assessing natural regeneration in different tree species
- Study on seed dispersal methods and dispersal distance in different species
- Seed collection techniques in important tree species – seed collection – Orthodox and recalcitrant seeds – safety measures during collection
- Seed extraction methods – wet and dry extractions – fruits, pods, cones, etc.

- Study on different seed drying methods and precautions
- Practicing seed grading and upgrading techniques
- Practicing seed dormancy breaking methods
- Germination improvement treatments for elite seedling production
- Study on storage of recalcitrant seed
- Estimation of critical moisture content for safe storage
- Visit to seed production area and seed orchard
- Visit to tree seed processing unit.

Teaching methods: Classroom teaching with AV aids, group discussion, assignment, class discussion and field visit to seed orchard.

Learning outcome: Knowledge of the seed biology of a tree species enable to produce good quality seeds, handling and prevent loss of seeds. The knowledge on sexual life cycle enables them to plan for genetic improvement, production, collection, conditioning, storage, and planting of the seeds.

Suggested Reading

- Dennis AJ, Schepp EN, Green RJ and West cott DA. 2007. *Seed Dispersal*. Agrobios, Jodhpur.
- Khanna LS. 1993. *Principles and Practices of Silviculture*. Khanna Bandhu, Dehradun, India.
- Lars Schmidt 2000. *Guide to Handling of Tropical and Sub Tropical Forest Seed*. Danida Forest Seed Centre, Denmark.
- Negi SS. 1998. *Forest Tree Seed*. International Book Distributors, Dehradun, India.
- Ram Prasad and Khandya AK. 1992. *Handling of Forestry Seeds in India*. Associated Publishers, New Delhi.
- Sivasubramaniam K, Raja K and Geetha R. 2012. *Recalcitrant Seeds – Causes and Effects*. Sathish Serial Publishing House. Azadpur, New Delhi.
- Umarani R and Vanangamudi K. 2004. *An Introduction to Tree Seed Technology*. International Book Distributors, Dehradun.
- Vanangamudi K, Natarajan K, Saravanan J, Natarajan N, Umarani R, Bharathi A and Srimathi P. 2007. *Advances in Seed Science and Technology: Forest Tree Seed Production* (Vol. 4). Agrobios, Jodhpur
- Willan RL. 1985. *A guide to Forest Seed Handling*. FAO, Rome
- Zobel B and Talbert TT. 1984. *Applied forest tree improvement*. Joh willeyand Sons, New York.

Suggested e-book

- <http://www.fao.org/3/a-ah803e.pdf>
- <http://www.fao.org/3/ad232e/AD232E01.htm>
- <https://www.springer.com/gp/book/9783540490289>
- <http://www.fao.org/docrep/006/ad232e/ad232e00.htm>
- <http://envis.nic.in/ifgtb/pdfs/Tree%20Seed%20Management.pdf>

[https://www.forestry.gov.uk/PDF/FCBU054.pdf/\\$FILE/FCBU054.pdf](https://www.forestry.gov.uk/PDF/FCBU054.pdf/$FILE/FCBU054.pdf)
[https://www.forestry.gov.uk/PDF/FCBU059.pdf/\\$FILE/FCBU059.pdf](https://www.forestry.gov.uk/PDF/FCBU059.pdf/$FILE/FCBU059.pdf)

Suggested Website

www.ista.org.in ifgtb.icfre.org/indeX.php <http://www.kfri.res.in/research.asp>
<http://www.fao.org/3/ad232e/AD232E21.htm>
https://www.srs.fs.usda.gov/pubs/gtr/gtr_so107.pdf
http://www.sfri.nic.in/pdf_files/Seed%20Technology.pdf

Minor course

Germplasm Characterization and Evaluation

Course code: SAS/ST/M517

Credits: 3(2+1)

Why this course: Students need to learn about morphological and quality agronomic traits of accessions as well as their reaction to biotic and abiotic stresses. This will increase the importance of the germplasm.

Aim of the course: Students will gain knowledge on germplasm characterisation, evaluation and documentation of information. Recording of morphological and agronomic traits, including quality, as well as those for resilience to biotic and abiotic stresses that will promote utilisation. Exposure to development of web-based tools for systematic description for efficient use of germplasm.

Theory

UNIT I

Understanding genetic diversity in crop plants; Crop descriptors, descriptor states; germplasm characterization/ evaluation procedures; evaluation of germplasm for specific traits; Measuring diversity using agro-morphological data, statistical procedures to measure population genetic variation, markers and their use in PGR, evaluation of biotic and abiotic stresses, Principles and methods for formulating core and mini core collections and their validation, Web based tools for management of data

UNIT II

Principles and practices of germplasm regeneration and maintenance, breeding systems and mode of reproduction; maintaining sufficiently large populations for effective conservation of farmer landraces, evaluation and maintenance of wild relatives of crop plants. Genetic enhancement, Use of CWRs genetic resources for crop improvement.

UNIT III

High throughput phenotyping systems- imaging & image processing concepts for automated germplasm characterization (phenotyping) – evaluation for nutritional traits, resistance traits - Biochemical and molecular markers for characterization.

Practical

- Field layout and experimental designs;
- recording field data on germplasm evaluation in different agri-horticultural crops,

- post harvest handling;
- evaluating quality traits, biochemical and phyto-chemical evaluation of crop germplasm, data processing;
- documentation, analysis of diversity and cataloguing, data analysis, viability equations, sampling strategies, data documentation, cataloguing, biochemical analyses of samples.

Teaching methods

- Lectures,
- Power point presentations,
- assignments, quiz,
- Group tasks, student's presentations

Learning Outcome

To educate students about science of managing genetic resources including principles involved in maintaining genetic integrity during regeneration, germplasm characterization and evaluation. X.

Resources

Tripathi K, Bhardwaj R, Bhalla S, Kaur V, Bansal R, Yadav R, Gangopadhyay KK, Kumar A and Chaudhury R. 2018. Plant Genetic Resources Evaluation: Principles and Procedures, Indian Council of Agricultural Research - National Bureau of Plant Genetic Resources (ICAR-NBPGR), New Delhi. vi+50 p.

Brown, AHD, Clegg, MT, Kahler, AL, Weir, BS (eds.) 1990. Plant Population Genetics, Breeding, and Genetic Resources, Sinauer Associates, USA.

Frankel, R and Galun, E 1977. Pollination Mechanisms, Reproduction and Plant Breeding. Monographs on Theoretical and Applied Genetics, Springer-Verlag, Berlin, Heidelberg.

Hayward, MD, Bosemak, NO and Romagosa, I. 1993. Plant Breeding: Principles & Practices, Chapman & Hall.

Holden, JHN and Williams, JT 1984. Crop genetic resources: conservation and evaluation, IBPGR. Stoskopf, NC 1993. Plant Breeding: Theory & Practice, Westview Press.

Puzone, L and Th. Hazekamp 1996. Characterization and Documentation of Genetic Resources Utilizing Multimedia Database. NBPGR, New Delhi.

Rana, RS, Sapra, RL, Agrawal, RC and Gambhir, R 1991. Plant Genetic Resources, Documentation and Information Management. NBPGR, New Delhi.

Sundeeep Kumar, et al 2016. Evaluation of 19,460 wheat accessions conserved in the Indian national Gene bank to identify new sources of resistance to rust and spot blotch diseases. PloS One Vol 11,

pages 0167702.

Semester-IV
Master's Research thesis

Course code: SAS/ST/CT599

Credits: 18