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Azadi Ka
Amrit Mahotsav

Agriculture and Allied Sciences

Restructured and Revised Syllabi of Post-graduate Programmes

- Plant Sciences
- Forestry
- Plant Protection
- Sericulture
- Horticultural Sciences



Education Division

Indian Council of Agricultural Research

New Delhi

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Course Title with Credit load

M.Sc. (Ag) in Seed Science and Technology (SST)

Course Code	Course Title	Credit Hours
SST 501*	Seed Developmental Biology	2 (1+1)
SST 502	Seed Dormancy and Germination	2 (1+1)
SST 503*	Seed Production Principles and Techniques in Field Crops	3 (2+1)
SST 504*	Seed Production Principles and Techniques in Vegetable Crops	3 (2+1)
SST 505	Seed Production Techniques in Fruits, Flowers, Spices, Plantation and Medicinal Crops	3 (2+1)
SST 506	Seed Production Techniques in Forage, Pasture and Green Manure Crops	2 (1+1)
SST 507*	Seed Legislation and Certification	3 (2+1)
SST 508*	Post Harvest Handling and Storage of Seeds	3 (2+1)
SST 509*	Seed Quality Testing and Enhancement	2 (1+1)
SST 510	Seed Technology of Tree Species	2 (1+1)
SST 511	Seed Industry and Marketing Management	2 (1+1)
SST 512	Seed Health Testing and Management	2 (1+1)
	Major Courses (minimum 20 credits from above courses including *marked Courses)	20
	Minor Courses	08
	Supporting Courses	06
	Common Courses	05
SST 591	Seminar	01
SST 599	Research	30
	Total Credits	70

*Compulsory Major Courses



Course Contents

M.Sc. (Ag) in Seed Science and Technology (SST)

I. Course Title : Seed Developmental Biology*

II. Course Code : SST 501

III. Credit Hours : 2 (1+1)

IV. Why this course?

Seed is the most complex and successful unit of reproduction in flowering plants. Seed contains genetic wisdom of the past and act as an agent of genetic transfer from generation to generation. Basic knowledge on seed developmental biology will enable the learners to understand the structure of seed to take up research in seed science and technology.

V. Aim of the course

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

VI. 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.

VII. 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.

VIII. Teaching methods

- Classroom lectures
- Slide shows
- Student assignments and presentation
- Group tasks
- Field and laboratory experiments
- Field visits

IX. 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.

X. Suggested Reading

- Adkins SW, Ashmore SE and Navi SC. 2007. *Seeds: Biology, Development and Ecology*. CAB International, Oxfordshire, UK.
- Bewley JD and Black M. 1994. *Seeds: 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.
- 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.



Kozłowski, TT. 2012. *Seed Biology: Importance, Development and Germination*. (Vol. I). Academic Press Inc., New York.

Maiti RK, Sarkar NC and Singh VP. 2006. *Principles of Post Harvest Seed Physiology and Technology*. Agrobios, Jodhpur, Rajasthan.

XI. Suggested e-books

<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_esc

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

XII. Suggested websites

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

<http://www.seedbiology.de/structure.asp>

<http://www.fao.org/3/ad232e/AD232E02.htm>

sbc.ucdavis.edu/Research_pages/Seed_physiology_and_technology/

<https://courses.lumenlearning.com/wm-biology2/chapter/development-seeds-fruit>

www.iari.res.in/index.php?option=com_content&view=article&id=449&Itemid=137

I. Course Title : Seed Dormancy and Germination

II. Course Code : SST 502

III. Credit Hours : 2 (1+1)

IV. Why this course?

Physiology and bio chemistry of dormancy and germination is basic science in the field of Seed Science and Technology. Complete understanding on the mechanisms of acquisition and release of dormancy and germination enable the students to take up research on advanced aspect which may helpful to design the seed for our requirement.

V. Aim of the course

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

VI. 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.

VII. 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 – α 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.

VIII. Teaching methods

- Classroom lectures
- Power point presentations
- Student assignments
- Laboratory experiments
- Group exercises on biochemical estimations

IX. 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.

X. 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.
- Kozłowski 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.

XI. Suggested e-books

- <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=18HeBwAAQBAJ&printsec=frontcover&source=kp_read_button&redir_esc=y#v=onepage&q&f=false

XII. Suggested websites

- <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>

- I. Course Title : Seed Production Principles and Techniques in Field Crops***
- II. Course Code : SST 503**
- III. Credit Hours : 3 (2+1)**
- IV. Why this course?**

Awareness about the use of quality seed among farmers enhances the seed demand and seed trade. To meet the seed demand, production should be carried out in large areas. Hence, it is essential to learn about the production principles and techniques of quality seed production.

V. Aim of the course

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



VI. 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.

VII. 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 roguing 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 insitu 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.



VIII. Teaching methods

- Classroom lectures
- Power point presentation
- Student assignment presentation and group tasks
- Field and laboratory experiments
- Field visits

IX. Learning outcome

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

X. 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.

XI. Suggested e-books

- <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/8BE3C99DFDCoF02D48E_CB53418504D10

XII. Suggested websites

- <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
- http://coin.fao.org/coinstatic/cms/media/16/13666518481740/seed_enterprises_enhancement_and_development_project_in_sierra_leone_mission_1_report_.pdf

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

II. Course Code : SST 504

III. Credit Hours : 3 (2+1)

IV. Why this course?

Seed trade is mainly based on high value low volume seeds. Area under vegetable cultivation is increasing day by day, which demands high area under seed production. The thorough knowledge on vegetable seed production will enable the students to take up seed production venture in low volume high value crops.



V. Aim of the course

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

VI. 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.

VII. 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 roguing 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.



VIII. Teaching methods

- Classroom lectures with power point
- Student assignment and presentations
- Field and laboratory experiments
- Demonstration
- Hands on training
- group tasks
- Field and industry visits

IX. Learning outcome

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

X. 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.

XI. Suggested e-books

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

<http://203.64.245.61/fulltext-pdf/EB/1900-2000/ebo021.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&--=1541066209_257&versionId=45008917+251246346

XII. Suggested websites

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

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

<http://www.jspuniversity.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>

I. Course Title : Seed Production Techniques in Fruits, Flowers, Spices, Plantation and Medicinal Crops

II. Course Code : SST 505

III. Credit Hours : 3 (2+1)

IV. Why this course?

At present seed industry is expanding towards the low volume and high value



seeds. Domestication of fruit, plantation and medicinal plants enable the farmers to cultivate commercially. The seed demands in these crops are increasing day by day. Hence, it is essential to learn the techniques of seed production in fruits, flowers and plantation crops.

V. Aim of the course

To impart comprehensive knowledge on seed production techniques in fruits, flowers, spices, plantation and medicinal crops.

VI. Theory

Unit I

Scope for seed production in fruits, flowers, spices, plantation and medicinal crops; factors influencing seed production and quality; propagation methods – seed and clonal propagation; seed and seedling standards; propagation and seed production techniques in major tropical, sub-tropical and temperate fruit crops; seed orchards – seed collection, extraction processing and storage techniques.

Unit II

Seed production techniques in commercially important flower crops – nursery management, clonal propagation, planting, seed crop management, post-harvest seed handling and storage techniques.

Unit III

Seed production techniques in commercially important seed spices and other spices – nursery management, sowing, seed crop management and post-harvest seed handling and storage techniques.

Unit IV

Seed production in commercially important plantation crops – mother tree selection – criteria – nursery management, elite seedling production, planting, plantation management, post-harvest handling and storage techniques.

Unit V

Methods of quality seed production in commercially important medicinal plants – nursery management, sowing, seed crop management, post-harvest handling and storage methods.

VII. Practical

- Study on the floral biology and pollination mechanism;
- Identification of seeds of fruits, flowers, spices, plantation and medicinal crops;
- Selection of mother plants and trees – phenotypic characters and genotypic characters;
- Study on different types of clonal and vegetative propagules;
- Seed and clonal standards of vegetatively propagating crops;
- Germination improvement treatments for seeds and vegetative propagules;
- Study on selection of planting materials and sowing methods;
- Nursery management practices for elite seedling production;
- Seed extraction methods – wet method and dry method;
- Post harvest seed handling – seed grading, upgrading techniques
- Study of seed storage techniques;
- Practicing seed germination enhancement techniques in fruits, spices and plantation crops;



- Practicing seed germination enhancement techniques in flowers and medicinal crops;
- Planning for seed production – economics of seed production in flower crops;
- Visit to mother tree orchard;
- Visit to plantation and orchard.

VIII. Teaching methods

- Classroom lectures
- Student assignment and presentation
- Group exercise
- Field visit

IX. Learning outcome

Successful completion of this course enables the students to take up elite seed and seedling production on commercial scale.

X. Suggested Reading

- Chadha KL. 1995. *Advances in Horticulture*. (Volume 1 to 13). Malhotra Publishing House, New Delhi.
- Hartman HT and Kester DE. 2000. *Plant Propagation: Principles and Practices*. Prentice Hall, New Jersey, USA.
- Singh SP. 2001. *Seed Production of Commercial Vegetables*. Agrotech, New Delhi.
- Vanangamudi K and Natarajan K. 2008. *Advances in Seed Science and Technology. Quality Seed Production in Spices, Plantation, Medicinal and Aromatic crops* (Vol. 5). Agrobios, Jodhpur.
- Vanangamudi KM Prabu and Lakshmi S. 2012. *Advances in Seed Science and Technology Vol. 7. Flower Seed Production*. Agrobios, Jodhpur.

XI. Suggested e-books

- <http://www.worldseed.org/wpcontent/uploads/2017/01/Seed-Production-Good-practice-10.01.17-final.pdf>
- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4233836/>
- https://www.academia.edu/35629702/Hybrid_Seed_Production_and_Flowers
- <http://www.agrimoon.com/horticulture-icar-ecourse-pdf-books/>
- <https://cbp.icar.gov.in/EBook.aspx>

XII. Suggested websites

- www.cimap.res.in/english/index.php
- www.dmapr.org.in/amprs.kau.in/basic-page/publications
- <http://ecoursesonline.iasri.res.in/course/view.php?id=153>
- <http://ecoursesonline.iasri.res.in/course/view.php?id=612>
- <http://www.celkau.in/Crops/Plantation%20Crops/Rubber/production.aspx>
- http://sbc.ucdavis.edu/Courses/Seed_Production/

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

II. Course Code : SST 506

III. Credits Hours : 2 (1+1)

IV. Why this course?

Agriculture and animal husbandry in India is interwoven and livestock is the source of income when crop failed. To feed the livestock population, cultivation and seed production of fodder and forage crops are much important. Likewise green manure crops maintain soil health, which created heavy demand for quality seed.



Hence, study of seed production techniques in these crops will help to produce quality seeds to meet the growing needs.

V. Aim of the course

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

VI. 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.

VII. 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.



VIII. Teaching Methods

- Classroom teaching
- Power point presentations
- Students assignment and presentation
- Field and laboratory experiments
- Hands on training
- Demonstration
- Field visit

IX. Learning outcome

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

X. 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.
- Gutteridge 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.

XI. Suggested e-books

- <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>

XII. Suggested websites

- 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>

I. Course Title : Seed Legislation and Certification*

II. Course Code : SST 507

III. Credit Hours : 3 (2+1)

IV. Why this course?

Awareness on usage of quality seeds among farmers increases the seed demand. To regulate the seed quality and to avoid the spurious seeds in the market, seed legislation and certification procedures should be known by all the stake holders. This course will provide comprehensive knowledge on seed policies, seed law enforcement and seed certification procedures to the learners.

V. Aim of the course

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



VI. 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.

VII. 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 crops – 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 (licence and renewal) of records in processing unit – float test, preparation of processing report and seed lot number construction;



- 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.

VIII. Teaching methods

- Classroom lectures
- Guest lectures
- Student assignments and presentations
- Demonstrations
- Field visits

IX. 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.

X. 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.
- Chakrabarathi 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.

XI. Suggested e-books

- <http://cms.tn.gov.in/sites/default/files/documents/seed-certification-o.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>

XII. Suggested websites

- 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



- I. Course Title : Post Harvest Handling and Storage of Seeds***
II. Course Code : SST 508
III. Credit Hours : 3 (2+1)

IV. Why this course?

Healthy seeds are the demanding enterprise of the recent era for the production of high yield in the next season. The seeds must be well processed and stored for the maintenance of high-yielding crop. During storage, major losses of seeds are caused by various biotic and abiotic factors. There is a need apply proper post harvest handling and storage techniques, which ultimately improve the market value and quality of the seed.

V. Aim of the course

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

VI. 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 behaviour 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.

VII. 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.

VIII. Teaching methods

- Classroom lectures
- Power point presentations
- Student assignment and presentation
- Processing experiments
- Demonstration
- Hands on training
- Exposure and field visits

IX. 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.

XI. 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.

XI. Suggested e-books

- 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/ebook021.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>



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

XII. Suggested websites

<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 Processingand StorageVer_1pt3.pdf

I. Course Title : Seed Quality Testing and Enhancement*

II. Course Code : SST 509

III. Credit Hours : 2 (1+1)

IV. Why this course?

Seed is the basic input in agriculture and the productivity is mainly depends on field population of plants. By sowing quality seeds, population can be maintained. Hence, it is necessary to know the quality parameters to be analyzed. Through seed treatments, the performance of seed can be improved. Especially to address the drought and climate change the knowledge on seed enhancement techniques is much essential.

V. Aim of the course

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

VI. 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 non destructive 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.

VII. 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.

VIII. Teaching methods

- Classroom lectures
- Student assignment and presentations
- Laboratory experiments
- Demonstration
- Hands on training
- Exposure visits

IX. 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.

X. 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.



- Chakrabarthi 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 Hand book 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.

XI. Suggested e-books

- [http://odishaseedsportal.nic.in/SeedPortalData/Resource%20Material/INDIAN MINIMUM SEED CERTIFICATION STANDARDS.pdf](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.seedtest.org/upload/cms/user/ISTAMethodValidationforSeedTesting-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>

XII. Suggested websites

- 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>

I. Course Title : Seed Technology of Tree Species

II. Course Code : SST 510

III. Credit Hours : 2 (1+1)

IV. Why this course?

Tree seed production is an important primary niche for carrying forward sustainable agriculture and forest resource management. Knowledge of the seed biology of a tree species is essential to successful seed production and handling of tree crops. The sexual life cycle must be known to plan for genetic improvement, production, collection, conditioning, storage and planting of the seeds for propagation of trees.

V. Aim of the course

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

VI. 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 programmes 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*, *Albizia*) and ornamental (*Cassia*, *Delonix*) tree species.

VII. 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.

VIII. Teaching methods

- Classroom lectures



- Power point presentations
- Student assignments and presentation
- Group exercise
- Laboratory experiments
- Field visit to seed orchard

IX. 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.

X. 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 Technlogy*. 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
- Zoebel B and Talbert TT. 1984. *Applied forest tree improvement*. Joh willey and Sons, New York.

XI. Suggested e-books

- <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)

XII. Suggested websites

- 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

- I. Course Title : Seed Industry and Marketing Management**
- II. Course Code : SST 511**
- III. Credit Hours : 2 (1+1)**
- IV. Why this course?**

India has a vibrant seed market. Over the years, the seed industry has evolved



side by side with Indian agriculture. Indian seed industry is the fifth largest seed market in the world. This course will provide insights in seed industry development and better management of seed industry and seed marketing.

V. Aim of the course

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

VI. 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.

VII. 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;
- Final practical examination.

VIII. Teaching methods

- Classroom lectures
- Survey
- Student assignment and presentation
- Economic analysis
- Group discussion
- Swot analysis
- Seed industry visit and interaction sessions

IX. 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.

X. 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.

XI. Suggested e-books

- <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>

XII. Suggested websites

- 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/>

- I. Course Title : Seed Health Testing and Management**
II. Course Code : SST 512
III. Credit Hours : 2 (1+1)



IV. Why this course?

Seeds are the foundation for crop production and seed health is related to food production in many ways. Healthy seeds, free from seed transmitted pathogens, are a prerequisite for sustainable food production. Seeds are routinely tested to prevent and control plant pests and pathogens that may affect seed quality, seed movement when introduced into new territories. A seed health test is also frequently a phyto-sanitary requirement imposed by national plant protection authorities. This course aids in timely detection and management of seed borne pest and diseases and supply of pest and disease free seeds in market.

V. Aim of the course

To acquaint the students with principle and practices of seed health testing and management of seed borne pathogens and storage insects.

VI. 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.

VII. 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.

VIII. Teaching methods

- Classroom lectures
- Power point presentations
- Student assignment and presentation
- Laboratory experiments
- Hands on training.

IX. 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.

X. Suggested Reading

- Agarwal VK and Sinclair JB. 1996. *Principles of Seed Pathology*. Edition, CRC Press Inc. Boca Raton, 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.

XI. Suggested e-books

- <https://link.springer.com/book/10.1007/978-1-349-02842-9> <https://www.crcpress.com/Principles-of-Seed-Pathology/Agarwal-Sinclair/p/book/9780429152856>
- https://books.google.co.in/books/about/Seed_Pathology.html?id=lvVJAAAAYAAJ&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/kozłowski/978-0-12-395605-7>

XII. Suggested websites

- 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>
- <https://www.agric.wa.gov.au/pest-insects/insect-pests-stored-grain>