FOREST SEED MANAGEMENT

A Manual

Indian Council of Forestry Research & Education

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INDIAN COUNCIL OF FORESTRY RESEARCH AND EDUCATION
P.O. New Forest, Dehradun - 248 006

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Foreword

Dr. Suresh Gairola, IFS
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ICFRE with its Headquarters at Dehradun is an apex body in the national forestry research system that promotes and undertakes need based forestry research and extension. The Council that came into being in 1986 has a pan India presence with its 9 Regional Research Institutes and 5 Centers in different bio-geographical regions of the country. Since then research in different fields of forestry has been a major focus of ICFRE.

There is an earnest need of publication of its research to the stakeholders in a simple and lucid manner, to improve the visibility and relevance of ICFRE. Therefore it was decided that the information available on the technologies, processes, protocols and practices developed by ICFRE has to be published in the form of operational manuals/user manuals. It is also desirable that the manuals should be a comprehensive national level document depicting extent of knowledge in applicable form.

Accordingly, 18 scientists of ICFRE were nominated as National Subject Matter Coordinators (NSMCs) to carry out the task on the specified subject. These NSMCs were assigned the task to select and nominate nodal officers from other Institutes of ICFRE as well as other organizations if necessary, collect and collate the information on the subject from various sources in coordination with the nodal officers of ICFRE institutes.

In the light of above "A manual on forest seed management" is prepared for the various stakeholders of the forestry sector. It is in a simple and illustrative language to understand and follow the procedures and methods to be followed in seed collection, extraction, processing & handling, testing, storage, disease management, certification, etc. The figures, sketches and illustrations compliment the text which enhance the understanding and depiction of the methods to be followed to make this manual of much practical utility. This manual is useful for seed collectors, seed analysts, State Forest Department personnel - frontline staff, nursery and plantation managers, tree growers, farmers, teachers, students, researchers, scientists, technicians, other organizations engaged in nursery and afforestation activities like Ecotask Force, railways, NGOs, trainees of any course on seed and nursery technology of forestry, agroforestry, ornamental and medicinal species.

I hope that the manual will provide useful information to the diverse stakeholders and prove to be helpful literature for planning future programmes.

Dr. Suresh Gairola

Preface

Under the Paris agreement India has committed to create an additional 'carbon sink' of 2.5 to 3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030. Also Green India Mission/Scheme under India's National Action Plan on Climate Change, aims at protecting; restoring and enhancing India's diminishing forest cover and responding to climate change by a combination of adaptation and mitigation measures. These will be achieved through massive afforestation/reforestation programmes using multipurpose tree species suited to diverse agroclimatic zones. Currently and in future also a heavy demand for quality planting stock of various multipurpose species is foreseen for raising plantations. This has time and again highlighted the importance of selection of seed sources of forestry/multipurpose species for collecting their quality seeds, which have the quality to grow and adapt well to the planted sites. The growing realization of use of quality seeds for plantations has also raised the concern for having a trained and skilled manpower in seed, nursery and plantation technology through various hands-on training programmes, green skill development programmes for various stakeholders of the environment and forestry sector as well as allied sectors. The Director General, ICFRE stressed on the urgent need of developing user/óperational manuals on various subjects for such capacity building initiatives, that spell out the various technologies, processes standardized by ICFRE scientists through years of dedicated research. As a result one National Subject Matter Coordinator and Nodal officers were nominated in the institutes who were entrusted with task of compiling the information and knowledge generated on seed technology of forestry and other species into a manual on 'Forest Seed Technology'. Apart from an introductory chapter this manual comprises of chapters on seed collection, extraction, handling, seed quality evaluation, dormancy and pretreatments, seed storage, insect pest management of seeds, seed certification, seed testing and storage procedures of important forestry species. A chapter on instruments/equipments used in seed testing with their brief description has also been included to assist the users in establishing simple seed testing infrastructure and facilities. Besides this, formats for various seed quality test reports have been included as Annexures. An attempt has also been made to duly compliment the different processes with photographs, sketches and figures for better depiction of the methods aiding in effective understanding by the users. The authors sincerely hope that the manual on Forest Seed Technology will serve as a valuable resource material for training programmes on seed, nursery technology of forestry, agro-forestry, ornamental and medicinal species; forest certification, GSDP on Management of small botanical gardens, etc. for forest departments, farmers, Ecotask Force, seed collectors, seed analysts, nursery and plantation managers; tree growers, students, researchers, etc. All stakeholders are encouraged to use and share this document and offer their suggestions for its improvement in future.

Dr. Manisha Thapliyal
National Subject Matter Coordinator (NSMC)
Forest Seed Management

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Contents

1 INTRODUCTION

The current forest cover of the country is 23.34% (ISFR, 2017) and as per National Forest Policy it needs to be increased to 33% of the geographical area of the country while also addressing the productivity issues of forests in India which is low as compared to the world average. The productivity of our forests can be enhanced through raising forest plantations which are also a powerful tool for mitigating the climate change effects and global warming. Plantations not only have a major role as producers of timber, pulpwood and wood-based panels for forest industries, but fuelwood and pole plantations and farm woodlots are locally important as well. Shelterbelts and dispersed planting for soil stabilization, habitat improvement, urban and rural amenity or as part of an agrisilvicultural system, all benefit the human environment. With such a variety in planting purposes, it is not surprising that the scale of tree-planting and the variety of species planted continue to grow in so many ways. The greatly increased agroforestry plantations open up a whole new range of multipurpose species for trial (Willan, 1985). These new developments have introduced new opportunities and pose new challenges in seed collection, handling, quality evaluation of these wide spectrums of species.

To raise high quality forest plantations, foresters and plant growers require quality seeds capable of producing plants which have the ability to grow well on planted sites. The majority of afforestation and agroforestry programmes depend on quality seeds for planting. Seed quality has critical effect on the performance and productivity of trees established and on economics of planting them (Shukla *et al.,* 2017). At present, most of the genetic material (seed/planting stock material) used in forestry sector in India is obtained from unspecified sources, from stands, natural or planted, which are neither classified nor managed specifically for seed or planting stock material production. Thus, procuring seed and planting material will require conscientious efforts in the selection of species and strains for various types of planting sites ranging from wastelands to fertile soils, from drought prone areas to areas with well-distributed rainfall and from tropical to alpine climates (Piare Lal *et al.,* 2008).

Seed Technology is essentially an inter-disciplinary science which encompasses broad range of subjects. In its broadest sense, seed technology includes the development of superior plant varieties, their evaluation and release, seed production, seed processing, seed storage, seed testing, seed certification, seed quality control, seed marketing, distribution and sale, seed physiology, seed production and seed handling based on modern agricultural and forestry sciences. Knowledge of seed biology is crucial for proper management of seed sources as well as the handling of seed themselves (Thapliyal, 2014). Problems of seed procurement, handling, processing and lack of technology often limit the use of any species in the plantation programmes.

A user manual on seed technology for the various stakeholders of the forestry sector is required for making them understand and follow the procedures and methods to be followed in seed

collection, extraction, processing & handling, testing, storage, disease management, certification, etc. in simple illustrative language, that will be very helpful in using the right methods. The figures, sketches and illustrations would

compliment the text which will enhance the understanding and depiction of the methods to be followed to make this manual of much practical utility. This manual is intended to be useful for seed collectors, seed analysts, State Forest Department personnel - frontline staff, nursery and plantation managers; tree growers, farmers, teachers, students, researchers, scientists, technicians, other organizations engaged in nursery and afforestation activities like Ecotask Force, railways, NGOs; trainees of any course on seed and nursery technology of forestry, agroforestry, ornamental, and medicinal species.

2 SEED COLLECTION

PLANNING AND PREPARATION FOR SEED COLLECTION

Seed collection is the first step towards the plantation activities and success of each plantation activity is directly related to the quality of the seed. Quality of the seed should be maintained from seed collection stage but most of the times, adequate attention is generally not paid on seed collection whereas this should be planned well in advance and not left for last minute.

STRATEGY FOR SEED COLLECTION

Monitoring Visit

Field visits should be conducted before or at the time of flowering. This is the right time for site selection and GPS Coordinates of the selected site should be recorded for further monitoring visits. General information about the site should be recorded viz., habitat characteristics, species composition, volume and spacing, species density, age, health, status, etc.

The second phase of monitoring visit is the selection of seed trees. Trees should be assessed for their physical characteristics, including their form, branching, growth rate, dominance, crown cover, health, spacing preference of at least 100 meters between individuals of the same species.

SOURCE OF SEED

Source of seed is an important aspect which determines the early growth and survival, vigor, disease and pest resistance, productivity and quality of plantation. Most of the tree plantations in India have low productivity mainly due to the quality of the seed source. Generally, seeds are collected in bulk from the available region irrespective of considering the source of seed.

It is advisable to collect seeds from an adjacent source for raising plantation in the local site due to the similar suitable climate for the species and adaptability to disease and pests. Introduction of same species of the different geographical region may or may not have the resistance for pest and disease or adaptability to new climatic conditions.

From Forest/Natural Stand

Seed for the plantations should be collected from the natural stands. The stands should be of known parental seed origin, healthy, good growth rate, and have straight boles free of defects.

From Seed orchards

Seeds of superior genetic quality can be derived from seed orchards, where plants are improved by selection or plant breeding.

TIME OF SEED COLLECTION

The optimal time to harvest is when a large amount of viable, germinable seeds can be collected. Collection of mature and healthy seeds from disinfected, vigorous, healthy and disease-free mother plants is essential for raising good quality seedlings.

Seed collection can be prioritized based on the availability of seeds with respect to specific time or season. Some tree species are aseasonal, have more or less continuous reproduction throughout the year. Fruits and seeds of different age classes are present in the same tree due to which small number of mature seeds may be available during each collection. e.g: *Lagerstroemia* spp. Second category of trees have short seed maturation time and are highly season dependent so seeds should be collected within that period. A large number of seeds can be collected at one time but seeds are easily shed or dispersed within a limited period e.g. *Mesua ferrea, Diploknema butyracea, Acacia spp., Cassia spp*. The third category of the tree have definite maturation season but with prolonged persistence on the tree before dispersal. e.g. *Delonix regia, Schizolobium spp., Melia spp.,* etc.

Recalcitrant seeds usually begin to lose their viability soon after their maturity. So, it requires the collector to determine when seeds are mature and harvest them, accordingly. Recalcitrant seeds of *Diploknema butyracea* loose viability within two to three weeks after collection.

SELECTION OF PREFERABLE TREES

In order to maintain genetic diversity, seed should be collected from a large number of trees at least 15-25 trees. In general, the distance between selected seed trees should be at least 100 m. Seeds collected from the trees of close distance, have the higher possibility of similar genetic characters which may reduce the genetic variation in the subsequent generations through inbreeding and reduce the expected outputs. When many good quality trees surround a seed tree, its progeny will demonstrate good characteristics at the same time, if the seed tree is surrounded by many poor quality trees, the progeny will demonstrate poor quality.

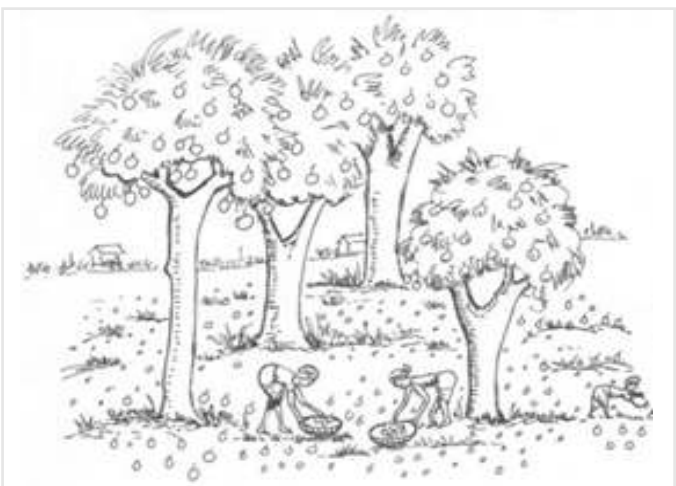
THE PURPOSE OF COLLECTION OF SEED

Purpose should be well defined before the collection of seeds. Criteria for selection of trees may differ based on the utility. Species having a straight stem, with fewer branches or no branches, long, clean and clear merchantable bole, without the fork and buttress free, uniform crown, free of disease and insect pest with superior quality timber and high volume are advisable for timber species. Trees which are fast-growing, nutritional, heavily branched and having high coppicing ability are suitable for fodder. Abundant and large sized fruits with good quality taste and large quantity, disease, and pest free trees are advisable for fruit trees.

COLLECTION METHODS

Collection from the Ground

Seeds of temperate species that are commonly collected from the ground are *Quercus, Fagus, Castanea*. Seeds of tropical species that are commonly collected from the ground are *Tectona, Gmelina, Triplochiton, Cassia, Acacia* and several Dipterocarps. Spreading plastic sheets or canvas under the tree during seed fall time is a good method for collection of seeds daily and it will minimise the inert materials and foreign particles in the seedlot.



Seed collection from the Ground

Collection from the Standing Trees

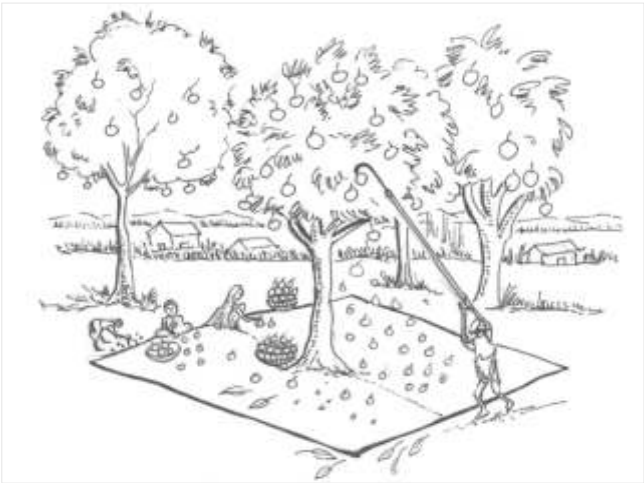
In the case of shrubs or low-branched trees, fruits can be picked directly from the branches by the collector while standing on the ground. e.g. *Fraxinus spp, Hardwickia binata, Pterocarpus spp*.

Collection using ladders, laggi

Ladders and laggi (a long hollow, metal pole with a sickle-like hook at one end) are most suitable for collecting seeds from trees of medium height. e.g. *Mallottus philippensis, Michelia champaca, Sapindus mukorossi, Enterolobium spp.,* etc.

Various tools and instruments are required during field visits for the collection of seeds. Some of the important items are safety harness, climbing accessories, first aid materials, pruners, rakes, tarpaulins, seed baskets, field books, pen, markers, plastic bags, ladders, rope, GPS, measuring tape, hammer, etc.

Seed Collection from tree using ladder



Seed Collection using laggi and tarpaulin Sheet

SEED COLLECTION TACTICS

- Collect seedlots from between 15 and 25 individuals that are spaced at least 100 meters apart from any other collection tree of the same species.
- Choose trees in vigorous health and avoid the ones that are diseased, suppressed, deformed, environmentally stressed, or in otherwise poor health.
- Collect seeds from trees that are well formed and either dominant or co-dominant in the canopy.
- Avoid collection of seed from trees that are isolated from others of the same species.
- Harvest only mature seed from ripened fruits.
- To ensure genetic variation, collect fruits equally from all parts of the crown-top, sides, and bottom-as these parts may have been pollinated at varying times from different sources.
- Man-made stands, including live fencing, plantations, or windbreaks, should be carefully reviewed as to their establishment before being selected as a seed source.

3 SEED EXTRACTION, PROCESSING AND HANDLING

SEED HANDLING

Appropriate handling of seeds after collection is crucial for the ultimate seed quality. Seeds with relatively high moisture content after collection can cause damage and deterioration. Rate of damage and deterioration mainly depend on the species, condition of seed at collection and external environment, etc. Handling of seeds at the field is mainly intended to reduce the bulk for efficient and economic transportation to the seed processing unit.

Generally seeds accompanied by impurities, foreign materials, soil particles, twigs, leaves and inert materials are detrimental to seed viability due to the presence of more moisture and seed pathogens. So it is essential to remove the harmful materials from the seeds.

Excessive drying and direct exposure to the sun should be avoided in recalcitrant seeds. Recalcitrant seeds must be dried carefully to the lowest possible levels for safe storage.

Harvested fruits can be stored for a short time before extraction if required. Fruits can be stored in sufficient air circulated containers such as trays, nylon net bags, etc. Soft fruits should be stored at 10^0-15^0C with adequate humidity and ventilation. Hard fruits can be stored in the shade in thin layers.

If collected seeds have high surface moisture, they should be first dried in shade or a well- ventilated room by spreading them on newspaper or blotting paper before transferring them to cloth or paper bags.

SEED EXTRACTION

Seed extraction is defined as the separation of seeds from their enclosing structures. Seed extraction should be done from the after ripened fruits and seed should be mature before extraction to avoid the rapid desiccation during extraction. If the fruits are not ripened to an adequate level they can be stored in cool, well aired containers such as nylon- net bags, wire- mesh bottoms and trays with holes. For Soft fruits, the temperature of the storage area/chamber should be maintained at 10^0C to 15^0C with sufficient humidity to prevent drying and hard or dry fruits are best stored in the shade in thin layers.

Procedure for seed extraction will differ accordingly based on the types and characteristics of fruit.

Extraction of Seed from Dry Dehiscent Fruits

Seeds from dry dehiscent fruits can be extracted by spreading the fruits on a tarpaulin under shade. Strong attachment of seeds with pods can be removed by threshing by hand, or beating the pods in the sack with sticks, or rubbing on a rough surface. Examples of dry dehiscent fruits are *Acacia spp, Bauhinia, Desmodium, Eucalyptus,* etc.

Dry dehiscent fruits of *Bixa orellana*

Extraction of Seed from Dry Indehiscent Fruits

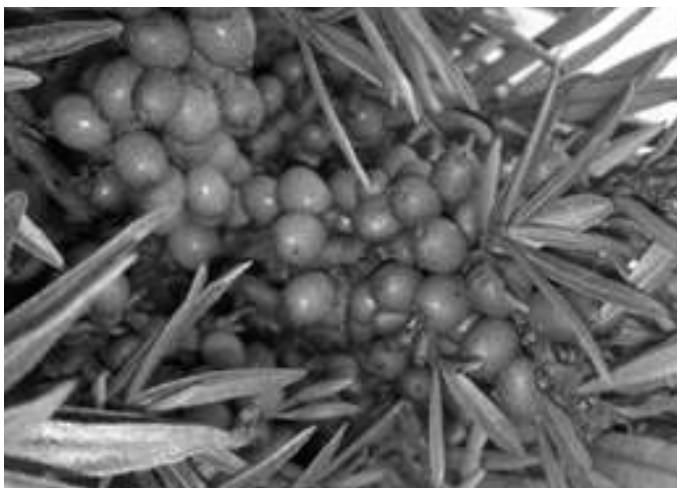
Smaller indehiscent fruits can be broken by threshing by hand, rubbing on a rough surface or by beating with sticks. Seeds from larger fruits can be extracted by splitting mechanically or by hand. Pods with gummy material e.g. *Cassia fistula* and *Prosopis cineraria* require several rounds of threshing and intermittent drying. Dry indehiscent fruits retain their seeds and do not crack open after ripening. e.g. *Acer, Fraxinus, Ulmus, Bamboos, Quercus, Corylus avellana*.

Dry indehiscent fruits of *Fraxinus* spp.

Extraction of Seed from Fleshy Fruits

Generally, seeds from fleshy fruits are removed by cutting the fruit in half or by cutting off the distal end and squeezing out the content into a container. Small seeds of pulpy fruits can be extracted by mashing the pulp, mixing it with water, allowing the seeds to settle and then detaching off the pulp. Large seeds from pulp can be extracted by hands/ forceps, or washing the seeds in sieves under running water, gently rubbing with wire mesh.

Examples of fleshy fruits are Neem, *Hippophae, Ficus, Putranjiva, Rubus, Cinnamomum camphora, Ilex, etc.*



Fleshy fruits of *Hippophae* spp.

Mucilaginous Seeds

Some seeds or fruits are remarkable for the abundance of mucilage. e.g. *Dillenia indica, Sterculia spp.* Mucilage in seed is not easy to remove by washing with water.

Some simple techniques to remove mucilage from seeds

- Rubbing the wet seeds on a wire mesh repeatedly with a gloved hand.
- Rubbing with clean and coarse sand followed by proper removal of sand with water.
- Dry the seeds first and then rub off the dry mucilage from the seeds.
- Acid treatment methods can also be used for removing mucilage adhering to the seed.

Pulpy Fruits

Soak the fruits in containers until they become soft and remove when they start to ferment. Wash the pulped seeds under running water and thoroughly clean and dry in thin layer on an absorbent sheet with circulating air. e.g. *Gmelina arborea*.

Stone Fruits

Stone fruits are de-pulped manually with a sharp knife and washed with running water to remove pulp. The seeds are then surface dried. e.g. *Prunus spp*.

Dewinging

De-winging is the removal of wings, hairs and spines from the seeds while seed of Dipterocarps and many recalcitrant seeds are not dewinged if sown immediately after collection. Dewinging helps to ease handling during storage, pretreatment and sowing and reduce the probability of getting fungal attacks due to moisture retention.

Net drum rotator used for separation of seeds of conifers

- Wings of conifers are removed by mechanical abrasion during tumbling.
- Delicate seeds are de-winged by tumbling in closed drums e.g. *Abies*.
- Mechanical de-wingers are used to de-wing seeds where wings are scraped away between the brushes.
- Papery wings, hairs and spines are removed by tumbling in mixers together with some abrasive materials like sand or gravel. e.g. *Casuarinas*.
- Abundant hairs in some seeds are removed by burning. e.g. Kapok

SEED CLEANING

Cleaning seed lots is the basic step. It is the removal of impure, inert, debris, foreign materials, damaged and infected seeds to improve the quality of the seeds. Seed should be cleaned immediately once it reaches at the seed processing site.

Seed Cleaning Procedure

- Separate seeds from debris and remove empty seeds and chaffs by gentle winnowing or by seed blower, aspirator, specific-gravity separators, flotation methods, absorption methods, etc.
- Inspect the insect and fungal damage in seeds. If infestation is suspected, store the seeds at sub-zero in a freezer for seven days to kill insects before removing infected seeds. Isolate the affected sample from the rest of the material and dry the seeds to low moisture content in sealed containers with silica gel to prevent further spread of fungi or insects.
- Removal of mechanically damaged and empty seeds manually.
- Verification and inspection of seeds finally for removal and inspect the diseased, damaged, empty and chaff seeds, color and shape of the seeds, etc.

Upgrading

Upgrading is the process of improving the potential performance of seed lot by removing empty, damaged, weak, immature or odd-sized seeds. Instruments used for upgrading will differentiate the inferior quality seeds from healthy seeds thereby reduce the storage space requirements, reduce the costs and improve uniformity in seeds and also reduce planting time in nursery. Some of the instruments used for upgrading the seeds are given in the chapter 10.

4 SEED QUALITY EVALUATION THROUGH SEED TESTING

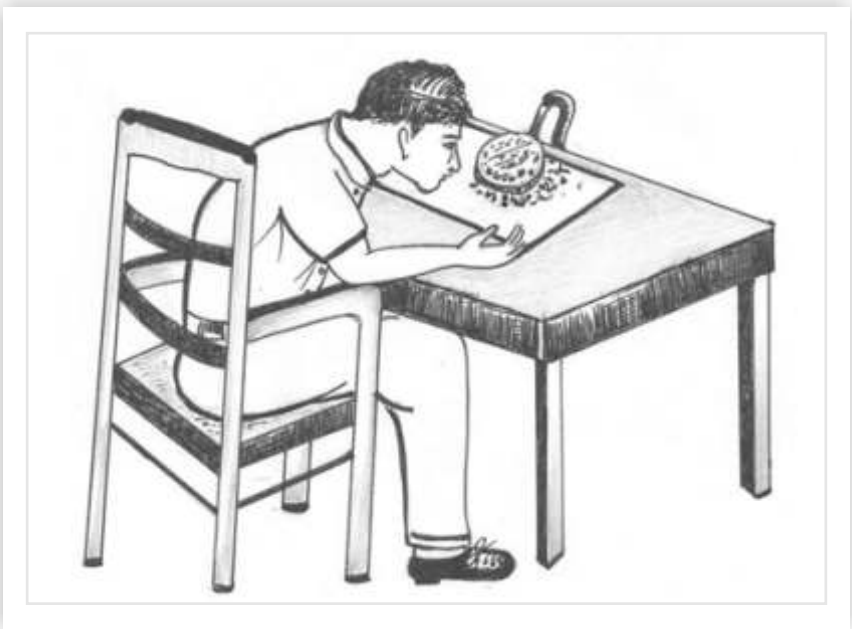
SEED LOT

A seed lot can be defined as a quantity of seed with every portion or every bag uniform within permitted tolerances as to percentage of pure seed, inert matter, other crop seed, germination and dormant seed, weed seed, and rate of occurrence of noxious weed seeds. A quantity of seed, which is not uniform within permitted representative tolerances, should not be classified as a seed lot.

PURITY ANALYSIS

The purity of a seedlot is the weight of pure seeds divided by the weight of pure seeds plus debris and is presented on a percentage basis.

$$\text{Purity (\%)} = \frac{\text{Pure seed weight}}{\text{Pure seed weight} + \text{Debris weight}} \times 100$$



SEED WEIGHT

It is a general term used to describe the relative size of seeds. The weight of 100 or 1000 seeds is the test used to quantify the weight of tree seeds.

The 1000 pure seed weight can be converted to seed per gram or per kilogram as follows:

$$\text{Number of seeds per gram} = \frac{1000}{\text{Weight (in gram) of 1000 seeds}}$$

$$\text{Number of seeds per Kilogram} = \frac{1000 \times 1000}{\text{Weight (in gram) of 1000 seeds}}$$

MOISTURE CONTENT

Seed moisture content is the amount of water in the seed. Moisture content is the most important factor determining the rate at which seeds deteriorate and has profound impact on storage longevity of seeds.

$$\text{Seed Moisture Content (\%)} = \frac{\text{Fresh weight} - \text{Oven dry weight}}{\text{Fresh weight}} \times 100$$

Seed moisture content can be determined by two different methods

- Oven drying method
- Moisture meters

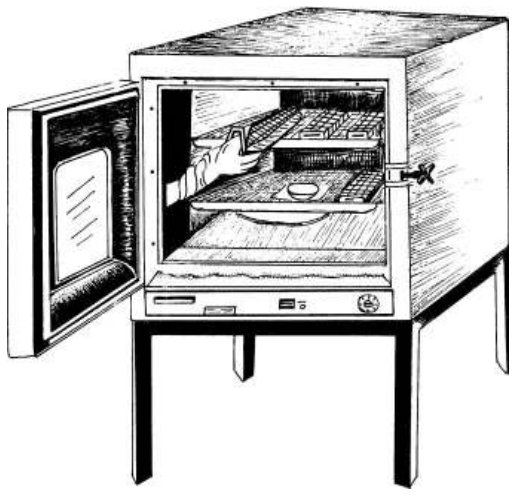
Oven Drying Method

The standard method for determining moisture content is the oven drying method. ISTA (2010) has prescribed two different oven-drying methods for determining moisture content, based on the chemical composition of seeds:

- The low constant temperature oven method for oily seeds; and
- The high constant temperature oven method for non-oily seeds.

Low Constant Temperature oven Method

This method has been recommended for seed of the species rich in oil content or volatile substances. In this method, the pre- weighed moisture bottles along with seed material are placed in an oven maintaining a temperature of 103°C. Seeds are dried at this temperature for 17 ± 1hr.The relative humidity of the ambient air in the laboratory must be less than 70 percent when the moisture determination is carried out.



Seed moisture content determination through oven dry method

High Constant Temperature oven Method

In this method, the pre- weighed moisture bottles along with seed material are placed in an oven maintaining a temperature of 130°C. Seeds are dried at this temperature for 1 to 4 hours depending on the species. In this method there is no special requirement pertaining to the relative humidity of the ambient air in the laboratory during moisture determination.

Moisture Meter

It estimates seed moisture content of seed quickly and gives a rough idea about the moisture content of a seed within minutes. But the estimation is not as precise as by the oven dry method.

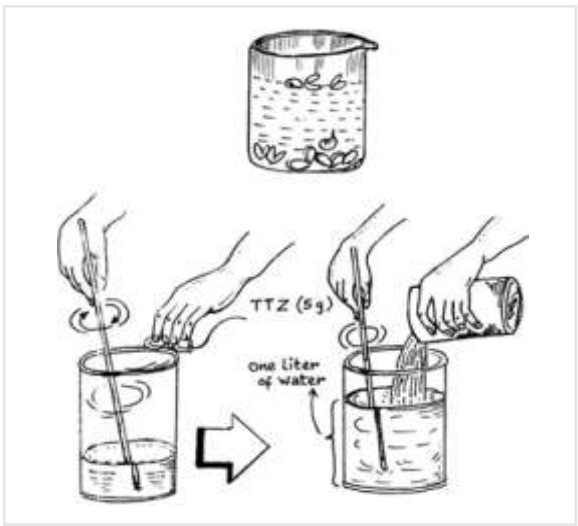
INDIRECT TESTS OF VIABILITY

The standard for judging seed quality is always a germination test under optimum conditions. Under certain circumstances, however, germination tests are not possible and so called rapid tests must be used to estimate seed quality.

Tetrazolium Test

This method determines the percentage of viable seed which may be expected to germinate. The chemical 2,3,5-triphenyl tetrazolium chloride is colourless but develops intense red colour when it is reduced by living cells. Split the seeds in to half by scalpel and soak the seed overnight.

Make 0.5% aqueous solution of tetrazolium chloride and soak the seed and immediately wrap with aluminium foil or dark polythene cover to avoid the direct light and keep the content in dark condition for 24 hours. Seeds are washed in tap water and the number of seeds which acquired red stain in the embryo is determined.



Seed viability testing using tetrazolium salt solution

$$\text{Viable Seed \%} = \frac{\text{Number of half seed stained red}}{\text{Total number of half seed taken}} \times 100$$

Indigo Carmine

It stains dead tissues blue. This method is common in Eastern Europe and was developed in Russia by Professor Nelyubon. As a viability stain, it will stain dead cells blue while living cells remain unstained.

Selenium or Tellurium Salt

Tests were developed in Japan by Dr. Hasegawa. This method was the first vital stain method with seeds, but it is not used now because of metal toxicity from the salts.

X - Ray Radiography

X-Ray radiography is the most expensive but not necessarily the best of the rapid tests. It is very effective for some situations, like other rapid tests, X-ray radiography offers a quick estimate of seed quality when there is no-time for a complete germination test.

Currently X-rays are used to test for

- Determining seed anatomy including embryo presence, size and shape. This process is good for empty seed counts before germination
- Determining insect damage including the location and extent of damage and the growth of insect larvae.
- Determining internal mechanical damage including seed coat cracks invisible to the naked eye.

Leachate Conductivity

As seeds deteriorate, cellular membranes are damaged and substances can be leached in proportion to the degree of deterioration. Measurements of these substances can be correlated with seed quality. Measurable materials are sugars, amino acids and electrolytes (the easiest to measure both in terms of time and expense).

VIGOUR TESTS

Standard germination tests do not adequately measure the ability of seeds to germinate and produce normal seedlings under field conditions because germination tests are conducted in the laboratory under optimum conditions. Therefore, a more sensitive measurement of seed quality has been sought by those concerned with the planting quality of a seed lot. This measurement of seed quality has been referred to as seed vigour. Seed vigour tests add supplemental information about the quality of seeds to information obtained through other tests. Seed vigour is most important under adverse field conditions and it can also indicate the storage potential of a seedlot.

Vigour Tests can be grouped into four categories:

- Seedling growth and evaluation
- Stress Tests
- Biochemical Tests
- Germination data.

Seedling Growth and Evaluation

a) Seedling Vigour Classification

Normal seedlings are further classified as strong or weak based on deficiencies of roots, shoots or cotyledons that are symptomatic of reduced quality.

b) Seedling Growth Rate

Similar to the standard germination test but at the end of germination period, seedling growth is measured as either linear growth or weight.

Stress Tests

a) Accelerated Aging

Developed at Mississippi State University on agricultural seeds, this test is now being used for tree seeds. In this test seeds are subjected to 40°C to 45°C and nearly 100 percent relative humidity for various periods.

b) Cold Tests

Seeds are placed in soil (high moisture and lower temperature 10°C) for a specified period then transferred to favourable temperature. It is probably the oldest vigor tests used in USA.

Germination Data

Another approach is to use germination test data, although more frequent counts than ISTA requires, may be needed to achieve the required sensitivity.

- As prescribed by ISTA, the first (early) count can be used as a vigour indicator.
- Time required to reach 50 percent, 75 percent, etc. of germination is calculated.

Mean Germination Time (MGT) can be useful in some cases. However, slow germination because of dormancy may inflate the value by giving equal weight to the very last seedlings to emerge.

Germination Value (GV) and Peak Value (PV) are used world-wide. Peak value is a good germination rate term to express vigor in temperate species.

Germination was expressed as percentage and as mean germination time (MGT) (Bonner, 2008). MGT is calculated by using the following equation:

$$MGT = \sum \text{(Daily germination percentage x days)/ number of seeds sown}$$

Tests for identification of mechanically damaged seeds

a) . Fast green test

The fast green test reveals physical fractures in the seeds .Seeds are soaked in a 0 1% fast green solution for only 15 30 seconds .During this period ,the fast green penetrates any area of the seed coat which has been fractured and stains the endosperm green .After the soaking period ,the seeds are washed and the fractures then become apparent (visible)in the seed coat .The stained seeds are counted and expressed in percentage .

b) . Ferric chloride test

Mechanically injured legume seeds turn black when placed in a solution of Ferric chloride .The seeds are immersed in 20% solution of Ferric chloride ($FeCl_3$) for 15 minutes ,the seeds are washed and all black stained seeds are separated and expressed in percentage .

5 SEED DORMANCY AND PRETREATMENTS

SEED DORMANCY

In a majority of forestry species, there exists a lag period between the attainment of seed maturity and the seed germination. Such seeds fail to germinate even if these are exposed to favorable environmental conditions, which are generally conducive to germination. This process is called seed dormancy. Seed dormancy is an important survival strategy of plants in their natural environments.

The extent of dormancy in seed depends on the genetics and on environmental factors, such as temperature, relative humidity and light duration.

AFTER RIPENING

After ripening process is required for seeds with moderate degree of embryo dormancy. Such seeds are kept in dry storage that causes certain physical and chemical changes in seeds. Biochemical changes like reduction of stored lipids, carbohydrates, and proteins will take place in seeds and also promote the production of gibberellins and hydrolysis of proteins during dry storage followed by an increase in the metabolic activity which causes initiation of germination in the seed.

Seeds of species like *Schleichera oleosa, Fraxinus* and *Ginkgo* require after ripening before germination due to immature embryo.

PRE-TREATMENTS

Cold Stratification

It is one of the most common methods to break dormancy. In this method, seeds are stored in a low temperature area in moistened condition and placed in layers of moisture-retaining media such as peat moss, vermiculite, sawdust, etc. The duration of moist stratification varies with the species e.g. *Acer caesium, Corylus jacquemontii, Junipers,* etc.

Scarification

- Acid Scarification

  Dormancy of seeds with hard and impermeable seed coats can be broken by soaking the seeds in concentrated sulphuric acid. The acid causes some kind of wet combustion on the seed-coat. This method is not applicable to seeds that easily become permeable because the acid penetrates and damages the embryo.

- Mechanical Scarification

  Permeability of hard coated seed can increase by puncturing the seed coats or scratching the seeds with the aid of knife, needle, file, hot wire burner, abrasion paper, etc. e.g. *Sapindus mukorossi*

- Growth Promoters/Chemicals

  Embryo dormancy of seeds can be broken by soaking the seeds in hydrogen peroxide which stimulates respiration and accelerate germination. Mild dormancy in seeds can be overcome by soaking the seeds in the solution of potassium nitrate, gibberellic acid and cytokinins for different period.

- Cold Water Soak

  In some hardseeded species, the seed coats are not completely impermeable to water. Soaking such seeds in water at room temperature for 24 to 48 hours may be sufficient for full imbibition and subsequent germination e.g. *Putranjiva roxburghii.*

- Boiling Water/Hot Water Soak

  Seeds are put into very hot or boiling water and left there till the water cools. The hot water softens the seedcoat or causes them to crack, and imbibition occurs as the water cools. Numerous leguminous species can be treated in this manner. e.g. *Acacia, Albizia,Cassia, Prosopis,* etc.

- Hot Wire

  This technique requires a heated needle or an electric wood burning tool to burn small holes through seedcoats. e.g. *Albizia*, chestnut, etc.

- Alternate Soaking and Drying

  Seed of some species is difficult to scarify by soaking. Teak (*Tectona grandis*) may require several cycles of soaking and drying. Alternate soaking and drying is also used for seeds of *Diospyros melanoxylon, Terminalia bellirica, Terminalia chebula, Terminalia citrina,* etc.

6 Seed Storage

Seed storage is the preservation of seeds under controlled environmental conditions which will prolong the viability of the seeds for long periods and supply when it is needed for regeneration. The objective of seed storage is to delay deterioration or decrease its rate until seeds are used.

Seed characteristics, seed handling before storage, genetics and the storage environment affect longevity in storage.

TYPES OF FOREST SEED

Orthodox Seed

Seed which can be dried to moisture content as low as 5% without injury and are able to tolerate freezing and stored at low temperature without losing their viability for long periods of time is known as orthodox seed. Most tropical tree pioneers, that are those typical of early forest succession, have small orthodox and dormant seeds. Species of *Acacia, Prosopis, Albizia, Cassia, Bauhinia, Terminalia, Tectona, Pinus, Picea, Eucalyptus,* etc.

Eucalyptus seed

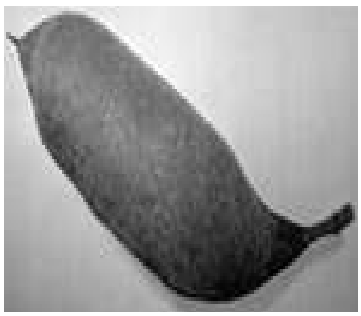
Teminalia spp.

Tectona grandis

Recalcitrant Seeds

Seeds of Recalcitrant species have high moisture content at maturity > 30-50% and are sensitive to desiccation below 12-30% depending on species. They have short storage potential and rapidly lose viability under any kind of storage conditions. Seeds cannot be stored under conventional seed-banking conditions of low water content and subzero temperatures

Disoxylum binectariferum



Castanospermum australe

Myristica fragrans

Species of *Dipterocarpaceae, Lauraceae, Quercus spp., Castanea spp, Castanospermum australe, Diploknema butyraceae, Mesua ferrea, Shorea robusta, Dysoxylum binectariferum. Cocos nucifera, Artocarpus heterophyllus,* etc.

Species producing seeds of this type typically occur in moist areas, particularly rainforests where the seeds are shed at high moisture content, in a metabolically active state. The seeds are often large and round, have thin coverings and a low seed coat ratio (SCR). High moisture contents of recalcitrant seeds make them sensitive to desiccation and chilling injury through the formation of ice crystals that disrupt cells when subjected to subzero temperatures.

Intermediate Seeds

Seeds are not fully orthodox or recalcitrant category. Some of these seeds may have a limited desiccation tolerance but are sensitive to freezing temperatures. Species are able to withstand desiccation between about 7-10% to 20% moisture content in an air-dried storage condition. e.g. certain *Citrus spp*.

Examples of intermediate Seeds are *Azardirachta indica, Bixa orellana, Citrus limon, Carica papaya, Araucaria columnaris, and Coffea arabica*.

SEED STORAGE CLASSES

Storage class	Storage period	Seed moisture	Temperature	Container type
	Years	%	^{0}C	
True orthodox	< 5	6-10	0-5	Airtight
	< 5	6-10	-18	Airtight
Sub-orthodox	< 5	6-10	0-5	Airtight
	< 5	6-10	-18	Airtight
Temperate Recalcitrant	< 3	30-45	-1 to –3	4-mil*plastic, unsealed
Tropical Recalcitrant	< 1	30-45	12-20	4-mil*plastic, unsealed

**mil = 1/1000 inch = 0.025 mm*

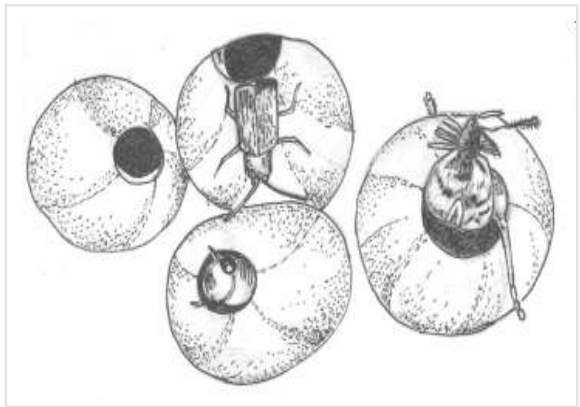
STORAGE PRINCIPLES

- Orthodox seeds at 5 to 10 percent moisture can be stored at most temperatures.
- The safe temperature range for recalcitrant seeds of temperate zone species is 1^{0}C to 3^{0}C while for tropical species it is usually above 12^{0}C to 15^{0}C, because of chilling injury.
- If the storage unit has humidity control (50 to 60 percent relative humidity), orthodox seeds need not to be sealed. Recalcitrant seeds cannot be sealed, so they cannot be stored in such a unit, the low humidity would desiccate the seeds.
- Without humidity control, relative humidity will be 95 percent or more, which is fine for recalcitrant seeds. Orthodox seeds must be dried and stored in sealed containers in such a unit.
- Humidity control is not recommended for the tropics because both orthodox and recalcitrant seeds will be stored in the same facility.
- Reduced oxygen slows metabolism and increases longevity but it is not usually practical to regulate oxygen level.
- Containers like fibre drums with capacity of 0.45 & 0.90 hl, plastic bottles and bags (0.1 to 0.2 mm thick) are very effective for seed storage.

7 INSECT PESTS OF SEEDS AND THEIR MANAGEMENT

INSECT PESTS OF FOREST SEEDS

One of the important causes of poor regeneration in Indian forests is heavy insect pests attack during flowering, fruiting, seed formation, and seed shedding. Insect pests attack has not limited and causes heavy loss and high mortality during storage and seedling stages. The cumulative actions of insect pests are significantly degrading the health of seed by damaging the seed and protective structures, consuming the reserve food in the endosperm or cotyledons and formation of bores, mines, and galls.



Insect pests attack on seeds

In India's forest, Teak and Sal are the most economically important species attacked during inflorescence stage, seed formation and seed shedding. The inflorescence of teak is injured by the sap sucking bug, *Leptocentris vicaris* in South India, thus causing the destruction of much of the seed crops. High host density is also one of the key factor promoting pest outbreaks. Cones of various species of conifers in the Himalaya are attacked by *Dioryctria abietella*.

The intensity of seed damage depends on the parts of seeds damaged and also on the nature of insect pests. Insects of the orders *Hymenoptera, Diptera, Lepidoptera, Hemiptera, Coleoptera, Homoptera* and *Thysanoptera* cause the most damage to flowers, fruits, and seeds of woody plants. The most important among the insect pests damaging seed during storage is the species *Caryedon, Bruchus, Bruchidius, Callosobruchus* and *Sitophilus*.

CONTROL MEASURES

Monitoring and detection of insect pests in seeds are necessary at an earlier stage to reduce the heavy loss. Methods like traditional, natural, chemical, and biological measures can be used.

Parasites and Predators

Introduction of natural predators for the management of insect pests is found effective in many species. *Trichogramma evanescens* (Hymenoptera: Trychogrammatidae) has been used successfully against *Bambusa tulda* seed borer.

CHEMICAL MEASURES

Chemical insect control is effectively applicable in seed orchards or clonal seed orchards. Spraying of chemicals such as 0.25% of endosulfan or fenitrothion water emulsions, 0.05% of Monocrotophos dichlorvos water emulsions are reported to be effective for the control of pests.

Management of insects pests attacking seed on trees:

- High volume spray of Azinphos methyl 0.2%
- Fenvalerate and permethrin 0.025%
- Endosulfan 0.25%
- Tetrachlorvinphos 0.25%
- Monocrotophos and Dimecron 0.25%
- Thimet /phorate/ Furadon 0.5%
- Beauveria bassiana and Metarhizium amisopliae (100% mortality)

MANAGEMENT OF STORED SEEDS

Some of the methods should be followed before storage for ensuring the safety and quality of seeds for long-term are visual examination of seed, analysis of purity, inspection of moisture content, cutting test in representative samples, X-Ray techniques to detect any internal infestation, chemical treatment, etc.

Seeds should be treated with chemical fumigants such as carbon disulphide, ethylene bromide, and carbon tetrachloride. Chemically treated seeds can be stored in an air tight dry container, or disinfected gunny bags in properly aerated rooms. Gunny and jute bags used for seed storage can be treated with pyrethrine and malathion dusts for surface sterilization.

TRADITIONAL STORAGE PRACTICES USING PLANT AND ANIMAL PRODUCTS

Leaves of *Azardirachta indica, Pongamia glabra, Ocimum spp., Leucas zeylanica, Vitex negundo, Adathoda vasica,* stems of *Madhuca latifolia* and *Cactus spp.,* seeds of *Annona reticulata* and *Piper nigrum* are some of the natural extracts used for seed storage. Natural plant parts are safer as compared to toxic chemicals. Oil extracted from the seeds of *Ricinus communis* is a natural insect repellant.

Quality of seed production and viability of seed is highly influenced by the insect pest damage in natural populations and storage conditions. Healthy and insect pests free seeds can improve the survival rate of plantations and thereby increase their productivity. Regeneration failure in most of the forests is mainly due to pest and disease and can only be controlled by using specific control measures like chemical, biological, natural, etc.

Table 7.1
Insect pests of forest seed, fruit and conifers

Common Name	Scientific Name	Order	Family
SEED BORERS			
Oak acorn weevils	*Sitophilus glandium* (Marshall) *Curculio sikkimensis*	Coleoptera Coleoptera	Curculionidae Curculionidae
Pine shoot borer	*Dioryctria abietella* Denis & Schiff	Lepidoptera	Pyralidae
Pyralid moth	*Trachylepida fructicassiella* Ragnot	Lepidoptera	Pyralidae
Eucosmid moth	*Argyroploce illepida*	Lepidoptera	Eucosmidae
Ailanthus webworm	*Atteva fabriciella* Swedrus	Lepidoptera	Yponomeutidae
Albizia seed borers	*Bruchus bilineatopygus* Pic *B. spraspmaculatus* Pic *Caryedon gonagra* Fab	Coleoptera Coleoptera Coleoptera	Bruchidae Bruchidae Bruchidae
Sal Seed borer	*Sitophilus rugicollis* Casey	Coleoptera	Curculionidae
Weevil	*Mecobaris terminalae* Marshall	Coleoptera	Curculionidae
Beetle	*Araecerus fasciculatus*		
INFLORESCENCE FEEDER, SEED AND FRUIT BORERS			
Pyralid moths	*Dichocrosis punctiferalis* Guenee *Pagyda savalis* Walk	Lepidoptera Lepidoptera	Pyralidae Pyralidae
Teak seed borer	*Eutectona machaeralis* Walk	Lepidoptera	Pyralidae
Meliaceae fruit and shoot borer	*Hypsipyla robusta* Moore	Lepidoptera	Hypsipylidae

(Source: Sood, 2009)

8 SEED CERTIFICATION

SEED CERTIFICATION AND NEED OF SEED CERTIFICATION IN FORESTRY

Seed certification is the guarantee of seed character and quality by an officially recognized organization usually evidenced by a certificate, which includes such information as certification category, genuineness of species and variety, year of collection, origin, purity, soundness, and Germinative capacity.

Forest seed certification can be an effective way to improve the plantation practices in our country. With the aim of increasing the forest cover, Govt. of India has launched several initiatives like National Mission for Green India (GIM), CAMPA, National afforestation programme, etc. which aim to increase forest cover in India through rehabilitation of degraded forest, compensatory afforestation, reforestation and plantation and land restoration works.

The survival and success rate of most of the massive plantation work in India has not figured much in any literature but the results are comparatively lesser than the half of the expected level so we must give attention to some of the key factors to ensure success. In India, massive scale plantation programs always relied on seed and due to the length of forest tree cycles, the cost of plantations and long-term forest investment, it is essential to get proper information on the origin and on the genetic characteristics of the seed used in plantation programmes. In most of the plantation work, lots of funds have been primarily invested for nursery development, infrastructure, seedling supplement but adequate standards to measure the quality of seed should also get equal importance.

The origin, genetic characters of the seed significantly affect the growth, survival, productivity, long term viability, adaptive capacity and self sustainability of tree populations. Origin of seed will provide the details of climate, topography, edaphic characters, associates of the region and this information will be helpful when introducing the particular species in to other regions. If the seed is taken from a single tree or few trees or from limited site there must be high frequency of inbreeding this will cause low seed set and germination. In India, forest and plantations are facing the risk of inbreeding which cause reduced fitness, less survival and success rate of subsequent generations as compared to global average. Seed zone is the first step in seed certification which is a geographical area delineated by means of administrative and geographical boundaries and which may be based on the climate, topography, altitude, latitude, longitude, temperature, precipitation, etc. SSOs and CSOs should be developed to meet the immediate demand for forest seed for plantation work. These trees are genetically

superior and isolated from genetically inferior trees to reduce pollination and to get desired characteristics. The first experimental clonal seed orchard of teak was established at the New Forest campus of the Forest Research Institute, Dehra Dun. Following this, many states have established teak seed orchards on an area of nearly 1,000 hectares. More than 3000 hectares of seed stands and seed production areas have been identified in India and are managed for seed production.

Phenotypic characters of the tree must be highly relevant during utility-based tree seed collection. Phenotype is a product of both the genetics of the tree and the environment in which it grows. Growth rate is often largely determined by the environment, but branchiness, forkedness, and wood quality are based on genotype and is highly heritable. Thus, collectors should first select a site to match the planting site and then collect seeds from the best trees in that site.

INTERNATIONAL SEED CERTIFICATION SCHEMES

European Union (EU) and Organization for Economic Co-operation and Development (OECD) certification schemes are the two important seed certification schemes. Under the OECD Scheme, reproductive materials are classified into four categories. The rules of the OECD Scheme apply to forest reproductive material of "Identified", "Selected", "Qualified" and "Tested" categories, issued from forest basic material of "Seed-source", "Stand" and "Seed Orchard", "Parents of Family/ies, "Clone" and "Clonal Mixture".

Standards for Certification

- Categories of Reproductive Materials

Certification classes for forest reproductive material differ from classes for agricultural seeds. Forestry programs typically follow the OECD standards for forest reproductive material that includes "tested reproductive material," which is the equivalent of the "certified" category for agricultural seeds, and three additional classes of less rigid genetic control. The four classes and their requirements are:

Source - Identified Reproductive Material (Yellow Tag) comes from stands within an identified seed collection zone. It is required that:

- Seed source and/or provenance must be defined and registered with the designated authority.
- Seeds must be collected, processed, and stored under inspection by the designated authority.

Selected reproductive material (Green Tag) comes from phenotypically selected stands and cultivars. These stands and cultivars have not been tested for genetic quality, but they must;

- Be isolated by distance from poor stands.
- Show normal variation among trees within a stand.
- Be large enough for adequate cross-pollination.
- Be old enough and developed enough to allow evaluation of phenotypes.
- Exhibit phenotypic superiority in some desirable quality, such as volume, wood quality, form or growth habit, wood quality, resistance to disease, fodder production, or fruit production.

Reproductive Material from untested seed orchards (Pink Tag) comes from phenotypically selected parent trees in a seed orchard or from the progenies of such trees.

Tested reproductive material (Blue Tag) must come from seed orchards, stands, or cultivars whose genetic superiority in at least one desirable quality has been proven in tests approved by the designated authority. Superiority can only be certified in terms of the environment and the age of the test.

Forestry certification classes can be applied to parts of plants (cuttings) as well as seeds.

- Types of basic materials recognized in the scheme

There are six types of basic material from which reproductive material can be collected, namely: *Seed source, Stand, Seed Orchard, Parents of Family(ies), Clone* and *Clonal Mixture*.

Seed Source: Trees within an area from which seeds are collected.

Stand: A delineated population of trees possessing sufficient uniformity. These are of two types:

- Autochthonous Stand: Stand regenerated by natural regeneration. The stand may be regenerated artificially from reproductive material collected in the same stand or autochthonous stands within the close proximity.

- Indigenous Stand: An indigenous stand is an autochthonous stand or is a stand raised artificially from seed, the origin of which is situated in the same region of provenance.

Seed Orchard: A plantation of selected individuals where each one is identified by clone, family or provenance, which is isolated or managed to avoid or reduce pollination from outside sources, and managed to produce frequent, abundant and easily harvested crops of seed.

Parents of Family(ies): Trees used to obtain progeny by controlled or open pollination of one identified parent used as a female, with the pollen of one parent (full-sibling) or a number of identified or unidentified parents (half-sibling).

Clone: Group of individuals (ramets) derived originally from a single individual (ortet) by vegetative propagation (e.g. by cuttings, micropropagation, grafts, layers, etc).

Clonal Mixture: A mixture of initially identified clones in defined proportions

- Origin of Reproductive Materials

For an autochthonous seed source or stand, the origin is the place in which the trees are growing. For a non-autochthonous seed source or stand, the origin is the place from which the seed or plants were originally introduced. The origin of a seed source or stand may be unknown.

Provenance: The place in which any seed source or stand of trees is growing.

Region of Provenance: For a species or sub-species, the Region of Provenance is the area or group of areas subject to sufficiently uniform ecological conditions in which stands showing similar phenotypic or genetic characters are found.

SEED CERTIFICATION IN INDIA

In India, seed certification was first started for agriculture crops with the establishment of National Seed Corporation (NSC) in 1963 and is also regulated in accordance with the Seed Act, 1966. In 2008, India became a member of OECD Seed Schemes followed by 109 varieties in 20 agricultural crops from India are enlisted in OECD list of varieties eligible for OECD Varietal certification.

However, an institutional framework along with adequate guidelines for certification of forest seed is not fully established in our country. Unlike agriculture crops, demands of forest seed certification has not reached a significant level due to many factors like long rotation period of trees, slower rate of breeding as compared to agricultural crops, very less demand for international trade, concept of secondary outputs from trees and forest, lack of proper standards in genetic/phenotype/environmental subject of tree seeds, etc.

In the 1970s, the Government of India had sanctioned a project known as Indo-Danish Project on “Seed Procurement and Tree Improvement” which issued a document “Certification of Forest Reproductive Material in India (Anon, 1979a)” and “Seed Zonation followed in India” (Gopal and Pattanath, 1979b) for forest seed certification by the States. This scheme was based on OECD standards and guidelines of ISTA, 1971 which framed a set of rules for the collection, transportation, processing, storage, sampling, labeling and sealing of seed for distribution.

The project formulated a set of minimum standards for seed collection.

- Source-identified Reproductive Materials: Seed from indigenous or non indigenous species collected from demarcated seed zones and approved by Designated Authority
- Selected Reproductive Materials: Derived from stands, cultivars with minimum standards mentioned in the scheme.

- Reproductive Materials from untested Seed Orchards: Derived from untested seed orchards, derived from single species seed orchards, collected from single region or provenance. Reproductive material derived from seed orchards established to produce species hybrids or provenance hybrids, can only be included in this category.
- Tested Reproductive Materials: Seed/reproductive materials originate from seed orchards, stands or cultivars whose genetic superiority to appropriate standards, in one or two characters important to forestry has been proved by comparative tests conducted in specified environments.

FOREST SEED CERTIFICATION ACTIVITIES AT THE STATE LEVEL

States such as Andhra Pradesh, Tamil Nadu, Uttarakhand, U.P., Gujarat, Haryana, Kerala, Madhya Pradesh, and Maharashtra have made considerable progress in the development of SPAs, SSOs and CSOs. In 1994, seed testing facility was established for quality seeds for plantation by Kerala Forest Department and later on Govt. of Kerala handed over this responsibility to Kerala Forest Research Institute (KFRI) which procures the seeds from SPAs and seed orchards and supplies the seeds to KFD after quality testing. In Kerala, seed certification of teak is done by the Seed centre of KFRI, Peechi. The seed centre has been set up in collaboration with the State Forest Department.

In 1992, Maharashtra Forest department established a Seed Centre at with the objective of ensuring supply of good quality seeds of forestry species for the planting programme by identifying and managing different seed sources such as seed stands, seed production areas, seed orchards etc, seed collection, treatment, certification and distribution. The unit is equipped with all infrastructural facilities necessary for seed processing, certification and storage

A few states also have the infrastructure to collect, process, grade and test seed, as well as a system of in house certification. However, in general, the progress in this respect is uneven and a majority of the States do not use (or have) enough source identified or certified material for plantations. So a Designated Authority with nationally recognized seed certification protocols should be adopted for all over the country which ensures the uniformity in seed certification practices.

S. No.	Scientific Name	Family	Flowering	Fruit maturity season	Seed processi	Seed Moist are content	Pretreatments for germination	No. of days/ months taken to germina	Germination percentage (%)	Seed storage behaviour
1.	*Abies spectabilis*	Pinaceae	April-May	October	Cones are dried in the shade for 2-3 weeks after collection from the field and seeds are separated from the cones manually and then dried for one week under room temperature.	8.73	No pre-treatment required, however poor germination is due to presence of large number of empty seeds (up to 60%)	1 month	42	Orthodox nature: Seeds stored in airtight moisture-proof polysac bottles placed in refrigerator at <50C retains more than 32% viability after 6 months, 27% viability after one year & 21 % viability even after one and half years of storage.
2.	*Acacia catechu*	Fabaceae	Feb-March	Jan-March	The dry pods were kept for drying in shade. When the pods started splitting, the seeds were separated manually.	12.96	Hot water for 24 hours	1-2	72-80	Orthodox

3.	*Aegle marmelos*	Rutaceae	March-May	May-June	The ripened fruits were macerated, de-pulped and washed with tap water. The seeds were separated with the help of sieve.	7-8	Not required	5-6 days	90-95	Orthodox
4.	*Albizia jullibrissin*	Fabaceae	April-June	Sep-Nov	The pods were kept for shade drying & followed by manual extraction.	9.86	Hot water for 24 hours	1-2 days	70-75	Orthodox
5.	*Bischofia javanica*	Euphobiac-eae	April-May	Dec-March	The ripened fruits were macerated, de-pulped and washed with tap water. The seeds were separated with the help of sieve.	13.02	Not required	12-18 days	65-78	Recalcitrant
6.	*Boswellia serrata*	Burseraceae	January-March	May-June	Seeds are extracted from the dry ripe fruits manually and wings are removed by rubbing between hands and then cleaning can be done either by winnowing or by a seed blower.	15-20	Seeds should be immersed in water before they are sown	6-15 days	20-90	Orthodox: In ambient conditions at 15-37°C upto one year; viability can be extended for more than three years, if stored at low temperature (-20°C to 15°C) with wide range of moisture content (4- 11%).

7.	*Buxus wallichiana*	Buxaceae	Mar - May	Sep-Oct	Seeds were extracted manually after splitting fruit.	10.61	GA_3(0.02, 0.05 % for 24, 48 and 72 hours) Moist stratification	30-40 days	40-45	Orthodox
8.	*Careya arborea*	Lecythidaceae	Mar-April	May-June		20.21	No	4-5 days	95-100	Recalcitrant
9.	*Carpinus viminea*	Betulaceae	Mar-April		Seeds were separated from the debris, empty seeds and chaffs by gentle winnowing.	6.4	GA_3(0.02, 0.05 % for 24 and 48 hours); Moist stratification	15-25 days	50-55	Orthodox
10.	*Chukrasia tabularis*	Meliaceae	April-June/July	Jan-March	Shade dried the capsules until they split open and then released the seeds by gentle tumbling or shaking		Not required	starts after 7 days and ends after 28 days	70-90	Orthodox
11.	*Dalbergia sissoo*	Fabaceae	March-May	Nov-Dec	Manual extraction method was adopted to separate the seeds from pods.	10.96	No	2-3 days	90-95	Orthodox
12.	*Desmodium oojeinense*	Fabaceae	March-April	May-June	Manual extraction method was adopted to separate the seeds from pods.	6.5	Not required	2 days	95-100	Orthodox

13.	*Dipterocarpus macrocarpus*	Dipterocar--paceae	June-November	Feb-March	Ripe fruits are sun dried, calyx and pedicel are removed and henceforth excised fruits is referred as seeds		Not required	10-12 days	25-80	Recalcitrant
14.	*Duabanga grandiflora*	Lythraceae	Mar-May	Sep-Oct	Fruits at maturity releases seeds during September and October		Not required	10-12 days	70	Recalcitrant
15.	*Elaeocarpus serratus*	Elaeocarp--acea	May-June	Sep-Oct	Chemical or mechanical scarification for removal of seed coat		Scarification	10-12 days	10	Recalcitrant
16.	*Emblica officinalis*	Euphorbi--ceae	March-May	Feb-April	Fruits are soaked in water for few days till the pulp softens, then macerated gently by pounding them in a mortar with a pestle to remove the pulp	20-25	Seed exposed to GA_3 500ppm for 24hours resulted better germination.	35 days	85	Orthodox type: >6years at low temperature (-20°C to 15°C, 4-12%). moisture content. Viability of seeds declines after two years of storage at ambient condition at any moisture content.
17.	*Euodia luna-ankenda*	Rutaceae	Sep-Feb	June-July	The fruits are manually depulped using water to extract the seeds.	18.3	Not required	28 days	56	Orthodox: Can be stored put to one year

18.	*Fraxinus micrantha*	Oleaceae	Aug-Sep	Sep-Oct	Fruits were separated from branches and seed extracted and removed all foreign materials manually.	6.07	No	5-6 days	85-90	Orthodox
19.	*Fraxinus xanthoxylodes*	Oleaceae	Mar-April	Sep-Oct	Fruits were separated from branches and seed extracted and removed all foreign materials manually.		GA_3(0.02, 0.05% for 24, 48 and 72 hours) Moist cold stratification, Warm stratification Warm+ cold stratification	60-65 days	25-30	Orthodox
20.	*Hardwickia binata Roxb.*	Fabaceae	July- Sep	April-May	The fully matured pods may be dried placing them under sun for extraction of seeds. Seeds are then cleaned by seed blower or by winnowing.	10-12	Nil	10-15 days in soil	80-100	Orthodox type: >5years at 0- -20°C. > 2years at ambient temperature (15-46°C) with 10% moisture content.
21.	*Hippophae salicifolia*	Elaeagna--eae	Feb-March	Nov-Feb	The ripened fruits were macerated, de-pulped and washed with tap water. The seeds were separated with the help of sieve.	10.4	Not required	5-6 days	85-90	Orthodox

22.	*Holoptelea integrifolia*	Ulmaceae	Feb-March	Jan-Feb	April-May	12-16	Nil	10 days	60	Orthodox : > 5years at 15^{0}C to - 20^{0}C and 3-5% moisture content. At room temperature viability of seed can be extended up to one year, if stored at 3-5% moisture content.
23.	*Hydnocarp-us alpina*	Flacourtiaceae	Feb-April	July-Aug	The mature hard fruits were broke open carefully using hammer to release the seeds	74.9	Not required	20 days	40	Recalcitrant: Can be kept viable only upto 20 days
24.	*Juniperus polycarpos*	Cupressac-eae	Nov-Dec (Male Cones)	November	Berries are dried in shade for a week after collection from field & then soaked in luke warm water containing 5% Lye solution (Na OH) for 3 days for easy seed extraction. Seeds are extracted from the berried by macerating the berries on wire mesh with the help oval or round shaped stone & then cleaned and dried in shade for 7-10 days.	9.20	Seeds are mixed with fresh cow dung and placed in open pits for 60 days duration during winter for cold moist stratification treatment.	10 month	70	Orthodox: seeds stored in airtight moisture-proof polysac bottles placed in refrigerator at <50C retains more than 70% viability after one year of storage and 55% viability even after two years of storage.

25.	*Litsea wightiana*	Lauraceae	Sep-Feb	June-July	Fruits are soaked in water for 12 hours and the pulp removed manually to extract the seeds.	52.19	Not required	28 days	63	Recalcitrant: Seeds are short lived and are viable upto 20 days.
26.	*Madhuca indica*	Sapotaceae	Mar-April	June-Aug	Seeds are separated from the seeds by rubbing the fruits manually and thorough washing.	40-45	Nil	17 days	80-100	Recalcitrant: Viability up to 5 months at 28°C in sealed polythene bags with shedding moisture content of 40-41%.
27.	*Magnolia champaca*	Magnoliace-ae	June-Sep	Aug-Sep	Remove seed from dried fruit, rub seeds with sand papers or press seed edge with sharp knife and immerse overnight in hot water before sowing		Stratification	7 to 28 days	70-80	Orthodox Low temperature
28.	*Meliosoma wightii*	Sabiaceae	Sep-Oct	June	Soak fruits for 12 hours in water and manually remove the pulp. The extracted seeds are sown.	33.27	Not required	27 days	77	Orthodox : Seeds can be stored at 15°C upto one year

29.	*Mesua ferrea*	Calophylla--ceae	April-June	July-Sep	Soaking in cold water for 24 hrs to hasten the germination		Not needed	11-24 days	90	Orthodox
30.	*Michelia champaca*	Magnoliace-ae	Jan-Feb	Sep-Nov	The mature fruits are spread on tarpaulin for about 4 days and allowed to split open to release the seeds.	28.63	Soaking seeds in water for 24 hours slighty improves the germination.	25 days	26.25	Intermediate: Seeds are viable upto 2 months at room temperature.
31.	*Michelia nilagirica*	Magnoliace-ae	Sep-Oct	May-June	The mature fruits are spread on tarpaulin for about 4 days and allowed to split open to release the seeds.	20.11	Soaking seeds in water for 24 hours slighty improves the germination.	25 days	25	Intermediate: Seeds are viable upto 2 months at room temperature
32.	*Morus laevigata*	Moraceae	Jan-Feb	April-June	Pre-treatment with hormones like GA_3 enhance germination		Stratification	30 to 60 days	50-80	Orthodox
33.	*Neolitsea zeylanica*	Lauraceae	Jan-Feb	May-June	Fruits are washed in water to remove the pulp and seeds extracted	24.13	Not required	45 days	25	Recalcitrant. Seeds remain viable only upto 20 days
34.	*Nothapodyt--es nimmoniana*	Icacinaceae	Oct-Feb	June-July	Fruits are washed in water to remove the pulp and seeds extracted.	24.13	Not required	30 days	51	Recalcitrant. Seeds remain viable only upto 45 days

35.	*Phoebe goalparensis*	Lauraceae	April-May	Oct-Nov	Manual removal or 2-4 longitudinal incisions on the seed coat helps in water absorption and subsequent seed germination		Stratification	35 days to 4 months	65	Recalcitrant
36.	*Pinus kesiya*	Pinaceae	April-June	Dec-Jan	Cones dried in the sun, Seeds are extracted by shaking or raking and de-winged before storage		Not needed	6-20 days	70-90	Orthodox
37.	*Pinus merkusii*	Pinaceae	March-June	Oct-Nov	Seed extraction is by sun drying the cones until they open and then stirred the cones for seed		Not needed	7-15 days	40	Orthodox:Kept upto 6 months beyond which thegermination capacity declines.
38.	*Pinus wallichiana*	Pinaceae	April-May	Sep-Nov	The dry cones of *Pinuswallichiana* were placed in a drum rotator machine to separate the seeds from cones and de-winging was done.	11.69	Hot water for 24 hours	10 days	75-85	Orthodox
39.	*Pongamia pinnata*	Fabaceae		March-May	Seeds are extracted from pods by light hammering or pressing a knife along the sutures to break them open.	14.32	Nil	30 days	80	Orthodox: > 5years at ambient temperature (15-35oC) and moisture content of 4-5%.

40.	*Pterocarpus marsupium*	Fabaceae	June-Nov	Dec-March	The seed wings are clipped off the fruits with the help of scissor to facilitate sowing operation.	20-25	Nil	69 days	60-95	1 year viability at ambient temperature (15-35^{0}C). > 3 years at 15^{0}C to -10^{0}C and 4-5% moisture content.
41.	*Pyrus pashia*	Rosaceae	Feb-March	Sep-Dec	The ripened fruits were macerated, de-pulped and washed with tap water. The seeds were separated with the help of sieve.	10.97	Not required	4-6 days	70-75	Orthodox
42.	*Rhododen--dron arboreum*	Ulmaceae	Feb-March	Oct-Dec	Manual extraction method was adopted to separate the seeds from capsules		Not required	8-10 days	7680/g (weight basis)	Orthodox
43.	*Sapindus laurifolius*	Sapindaceae	Oct-Dec	Feb-May	Fruits are spread and dried in Sun. Seeds are then separated by gentle cracking of the fruits	10	Soaking in cold water for overnight	10-15 days	60-70	Orthodox: High Viability at 0 to -200C, 3-5% moisture content.
44.	*Schima wallichi*	Theaceae	April-May	Oct-Nov	Seed - germinates freely when sown as soon as it is ripe		Not needed	12-30 days	10-20	Recalcitrant

45.	*Shorea asamica*	Dipterocar--pac eae	Aug-Oct	Jan-April	Not required but Recommended to soak the seed for 12 hours prior to sowing		Not needed	15-30 days	50-60	Recalcitrant
46.	*Shorea robusta*	Dipterocar--pac eae	Feb-April	May-June	Not required		Not needed	15-28 days	75-90	Recalcitrant
47.	*Symplocos cochinchin-enis*	Symplocac-eae	Nov-Feb	July-Aug	The fruits are soaked in water for 24 hours and then the pulp is removed by scrubbing with sand.	29.32	Seeds require after ripening. Pack seeds and allow it to remain at 20°C for about 9 months. Then soak seeds in water for 24 hours and sow in the nursery bed.	25 days	90	Orthodox: Stores well even upto 2 years at room temperature
48.	*Syzygium arnottianum*	Myrtaceae	Oct-April	July-Aug	The seeds can extracted by soaking the fruits in water for an hour followed by manual depulping and washing. The cleaned seeds need to be surface dried under shade (28-30 °C) for half an hour.	30.94	Seeds can extracted by soaking the fruits in water for an hour followed by manual depulping and washing. The cleaned seeds need to be surface dried under shade (28-30°C) for half an hour.	19 days	23.8	Recalcitrant: Fresh seeds can remain viable only upto one month.

49.	*Syzygium cumini*	Myrtaceae	Dec-Feb	June-Aug	The seeds can extracted by soaking the fruits in water for an hour followed by manual depulping & washing. The cleaned seeds need to be surface dried under shade (28 -30 °C) for half an hour.	44.0	Not required	18 days	86.3	Recalcitrant: Fresh seeds can remain viable only upto one month.
50.	*Terminalia arjuna*	Combretac -eae	April-July	Feb- May	Fruits are dried in the shade.	30-40	Seeds are soaked in Indole-3 acidic acid (IAA) at the dose of 500 ppm induce better germination capacity	50-75 days	50-75	Orthodox type: >5 years at 0 to -20°C with low moisture content. Even hermetic storage at room temperature (15-35°C) with 5% moisture content retains their viability up to 2 years.
51.	*Terminalia chebula*	Combretac -eae	Feb-March	May- Nov	The fruits are soaked 24-48 hrs in water and the pulp is removed by macerating the fruits and washing thoroughly under water, clean seeds are then dried under shade.	10	Soaking and drying for 5-7days	86 days	66.7	Orthodox type: > 5 years at 0 to -20°C with low moisture content. Even hermetic storage at room temperature (15-35°C) with 5% moisture content retains their viability up to 2 years.

52.	*Toona ciliata*	Meliaceae	March-April	April-June	Manual extraction method was adopted to separate the seeds from capsules.	5.96	Not required	4-5 days	85-95	Orthodox
53.	*Uncaria pilosa*	Rubiaceae	April-May	Sep-Oct	Minute seeds were extracted manually.	10.7	Dry after ripening for four months	10-12 days	1701/g (weight basis	Orthodox
54.	*Viburnum erubescens*	Adoxaceae	Jan-Feb	July-June	Seed extraction not required. Fruits can be sown directly.	6.4	Not required	40 days	39.5	Intermediate: Seeds can store upto one month.

10 INSTRUMENTS/EQUIPMENTS USED IN SEED TESTING LABORATORY

SAMPLING EQUIPMENTS

Seed Trier: It is used for drawing seed samples from the seed lot.

- Nobbe Trier

It is used for sampling seed from bag but not in bulk. It is inserted pointing upwards at an angle of about 30° to the horizontal, with the hole facing downwards until it reaches the centre of the bag, then revolved through 180°, bringing the hole face upwards, and is withdrawn with decreasing speed so that the quantity of seed obtained from successive locations increases progressively from centre to side of the bag.

- Sleeve Trier

This is used for drawing seed samples from the seed lots packed in bags or in containers.

SAMPLE DIVIDERS/SPLITTERS

- Boerner Divider

It is used for dividing seed/grain sample into two equal halves.

- Gamet Divider

It is used for dividing and mixing of seed/grain which do accurate division and reduction to working size of samples exactly representative of the original sample.

- Rotary Cone Sample Divider

It splits seeds of fine or coarse texture into representative sub-samples with high accuracy of 99.9%, and assures reproducibility of analysis.

- Riffle Sample Splitters

It is precisely designed to reduce the bulk of material to a convenient representative size for laboratory analysis. A homogenous, dry, free- flowing sample is poured evenly into the hopper/funnel. The material flows through the alternately arranged passages in the opposite direction (chutes/riffle bank) into the two collecting pans under the dividing head outlets. With every operation the feed sample is divided in two representative subsamples. The operation can be repeated as many times as necessary, until the required dividing quantity has been obtained.

SEED PURITY & GRADING INSTRUMENTS /EQUIPMENTS

- Illuminated Purity Work Board/ Diaphanoscope

It is the instrument used for separating the inert matters from the seed samples. Inert matters can be anything other than the seeds like parts of leaves, stems, chaff, twigs, soil material, discolor and 1other foreign materials.

- Winnower

The winnower is used to separate seeds and other parts based on specific weight. A rough air separation separates the seeds from the husks. It is very suitable for cleaning small seed lots.

- Seed Blower

The seed blower serves for quick and easy separation of light and heavy fractions of a great variety of seeds. The blower is equipped with a synchronous motor to ensure uniform RPM and air flow is regulated with a calibrated vernier gate.

- Aspirator

It is used for separation of light chaffy material from grains and bamboo species.

- Gravity Separator

It is used to separate seeds based on their specific weight. The purpose is to separate empty seeds, insect damaged seeds, stones and other lighter or heavier materials from the seed lot. The principle of floatation applies here when the seeds are transferred through a hopper/funnel into the platform surface. Air circulation through porous deck surface and the bed of seeds by a fan, stratifies the seeds in layers according to density with the lightest seeds

and particles of inert matter at the top and the heaviest at the bottom. An oscillating movement of the table causes the seeds to move at different rates across the deck. The lightest seeds float down under gravity and are discharged at the lower end, while the heaviest ones are kicked up the slope by contact with the oscillating deck and are discharged at the upper end.

- Density Separator

This seed density separation unit is used for accurate seed density grading using liquids (water or liquids with certain osmotic pressures). During separation the seeds should maintain the same moisture level content.

- Magnetic seed Separators

These machines use a magnetic force to separate damaged seeds or other particles from the good seeds.

- Colour Separator

The colour separator is used to separate discoloured seed, greatly of lower quality. Separation based on colour is necessary because the density and dimensions of discoloured seed are the same as those of sound seed; Seed that differs in colour is detected by the photo cells, which generate an electric impulse. The impulse activates an air jet to blow away the discoloured seed into reject bin while the rest of the seed passes through to another bin.

OTHER INSTRUMENTS/EQUIPMENTS USED IN SEED TESTING LABORATORY

- Seed Counter

It is designed to count number of seeds automatically and also make it easier to determine the number of seeds per kilogram.

- Vacuum Seed Counter

It is used for seed counting and also placing the seed in petridish or germination tray in the course of seed germination. It has a suction tube and suction head with control button to control the suction power according to seed size.

- Seed Scarifier

Species with a hard or waxy seed coat require scarification. Scarification is a technique that simulates the natural disintegration (such as weathering, abrasion, or partial digestion) of the seed coat to allow water uptake for timely germination.

- Seed Moisture Meter

It is a quick and easy method to determine the moisture content in seed.

- Oil Seed Analyzer

It is used in the determination of oil & moisture content and Solid Fat Content of oil seed.

- Seed Analyser

It is a compact steel box bearing a weighing machine, backlit unit and a set of cameras. The versatile setup enables necessary adjustments for accommodating seeds of varying sizes. The unique combination of strategically placed cameras and the LED light source generate images of the seeds for analysis. The software captures seed images and analyses the physical properties of the seeds.

- Seed Germinator

It is basically a growth chamber that creates an artificial environment of temperature, humidity and light to provide optimum conditions for the germination of seeds. Temperature of the chamber can be altered to constant high or low temperature for different time periods.The germination chamber, improves uniformity, decreases the lead time and increases the numbers of germinating seeds.

- Plant Incubator

In plant incubator, heating, cooling and humidity are provided to reproduce certain environmental conditions for the growth and maintenance of plant. This is also used for germination studies in seed/plants.

- Seed Storage Chamber

The Seed Storage Chambers are basically enclosed spaces with a controlled environment, designed to maintain specific temperature and relative humidity conditions for short term or long term storage of seeds. Seeds with reduced moisture content (desiccated) are stored at desired low temperature for enhancing the shelf life.

- Desiccator:

Desiccators protect seed from humidity and remove moisture from the seed samples. Desiccant like Silica gel or Calcium Chlorite are filled below the platform in the desiccators, which remove traces of water from the seed samples. The glass lid of the desiccator is sealed with grease or other lubricant to ensure an airtight seal.

- Seed Dryer

It removes excess moisture from the seeds under low temperature and low humidity conditions and enhances the storage life of seed.

- Hot-air oven

It is used for determination of percent of moisture content in seed samples.

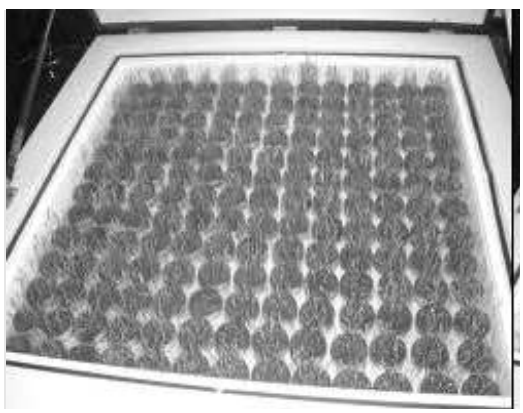
- Accelerated Ageing Chamber

It is designed to simulate environmental conditions to test the vigor and long term effects on seeds under stressed environment by adjusting the light, temperature and humidity at different time periods.

- Seed Herbarium

Seed herbarium is designed for the identification of various seeds and placed in alphabetic order of scientific name or family.

- Thermogradient Plate:



Thermogradient plates are set up in different ranges of temperature and this determines the exact temperature required for the germination of seeds. The gradient variation in temperature in sections is 0.5°C or 1°C.

IMPORTANT CHEMICALS USED IN SEED TESTING LABORATORY

- Tetrazolium Chloride

2,3,5-Triphenyl Tetrazolium Chloride is used to check the viability of seed. Viable seeds appear in red/pink color and non viable seeds do not take any stain.

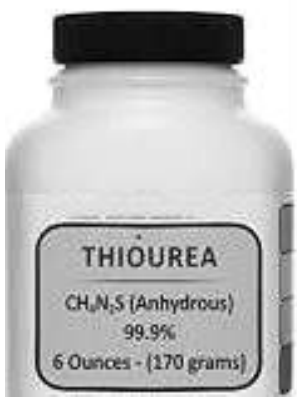
- Benzyladenine: Seed Pretreatment

- Kinetin : Seed Pretreatment

- Gibberllic Acid: Seed Pretreatment

- Potassium Nitrate: Seed Pretreatment

- Thiourea: Seed Pretreatment



- Hydrogen peroxide: Seed Pretreatment

- Sulphuric Acid: Seed Pretreatment

- Mercuric chloride: Seed sterilization

- Sodium hypochlorite: Seed sterilization

11 FORMATS FOR VARIOUS SEED QUALITY TEST REPORTS

Annexure I

PURITY TEST

Date	Replicate				
	A	B	C	D	
Composition of Sample	Weight Grams %	Weight Grams %	Weight Grams %	Weight Grams %	Pure Seed %
Pure Seed					
Other Crop Seed					
Inert Matter					
Total Weight of Sample					Total
Original Weight of Sample					Av.

Summary

Pure Seed %:

Other crop seed %

Inert matter%

Moisture content%:

1000 pure seed wt……..g

No. of pure seeds per kg ……..

No. of pure seeds per kg.. ……..unsorted sample

No. of germinable seeds per kg……..unsorted sample

Annexure II

SEED MOISTURE CONTENT TEST (Fresh Wt. basis)

Date	Replicate			
	A	B	C	D
CWt. Container + fresh seed				
Wt. Container + dried seed				
Wt. Container				
Fresh Wt. of seed				
Dried Wt. of seed				
Wt. of moisture removed				
% moisture content				
Average % m.c.				

Summary

1000 pure seed wt……g

Drying Oven Temp ^{0} C: …….

Hours in drying oven : …….

Seed crushed/uncrushed: …….

Weight of unsorted sample containing 1000 pure seeds……g

Annexure III

GERMINATION TEST

Study ……..…….

Species ……..…….

Seeds/Rep. ……..…….

Test Period ……..…….

Temp. Regime ……..…….

Pretreatment ……..…….

	Date										Mouldy Removed	Insect Damage	Empty	Fresh	Total No. Seeds
	Days														
Replicates	A														
	B														
	C														
	D														
	Total														
	Av.														
	%														

Seed pre-treatment	Germination Test	
Method:	Method:	Germination:
Time:	Temp^{0}C:	Variation:
Temp0C:	Time:	Tolerance:
	No. of seeds:	Germ capacity

Annexure IV

SUMMARY OF TEST RESULTS

Species……..

Official Identity No……

Test No.	Date	Purity %	Germination %	No. of pure Seed per Kg	No. of viable Seed per Kg	Empty Seed %	Conversion Factor	Seed Moisture Content %	Remarks

Annexure V

Price List of Seeds, Silviculture and Forest Management Division, FRI, Dehradun (As on May 2019)

Sl. No.	Name of Species	Price (Rs/Kg)
1.	*Emblica officinalis (Amla)*	1500
2.	*Mesua ferrea (Nagkesar)*	500
3.	*Podocarpus gracilior*	1000
4.	*Elaeocarpus sphericus (rudarksh)*	700
5.	*Melia dubia/composita*	300
6.	*Peltophorum africanum*	300
7.	*Taxodium spp.*	600
8.	*Cascabela thevetia (kaner)*	700
9.	*Cinnamomum camphor (kapoor)*	500
10.	*Acer oblongum (Himalayan maple, pharjanj)*	400
11.	*Adenanthera microsperma (rakta chandan)*	400
12.	*Aesculus assamica (Indian horse chest nut)*	300
13.	*Albizia julibrissin (siris, silk tree)*	400
14.	*Anthocephalus chinensis (kadamb)*	400
15.	*Callistemon viminalis (bottle brush)*	500
16.	*Cassia fistula (amaltas)*	500
17.	*Cassia glauca (pila amaltas)*	500
18.	*Cassia javanica (pink shower, java cassia)*	500
19.	*Cassia nodosa*	500
20.	*Chukrassaia tabularis (Indian redwood, Chikrasi)*	500
21.	*Cupressus cashmeriana (weeping cypress, Kashmir cypress)*	600

22.	*Dalbergia sissoo (Indian rosewood, shisham)*	200
23.	*Delonix regia (gulmohar)*	400
24.	*Desmodium oojeinense (sandan)*	250
25.	*Eucalyptus citriodora - lemon-scented gum*	2000
26.	*Enterolobium contortisiliquum (earpod tree)*	400
27.	*Eucalyptus hybrid*	2000
28.	*Ficus benjamina (weeping fig, pukar) (Lokeh)*	600
29.	*Gmelina arborea (gamhar)*	400
30.	*Jacaranda mimosaefolia (neeli gulmohar)*	1000
31.	*Lagerstroemia speciosa (jarul)*	400
32.	*Michelia champaca*	500
33.	*Putranjiva roxburghii (putranjiva)*	300
34.	*Sapindus mukorossii (soap-nut tree, ritha)*	300
35.	*Schizolobium parahyba*	400
36.	*Strychnos nux-vomica (kucchla)*	400
37.	*Tecoma stans (piliya, sonapati)*	1000
38.	*Tectona grandis (teak, sagwan)*	600
39.	*Terminalia arjuna (arjun)*	400
40.	*Terminalia bellirica (baheda)*	400
41.	*Terminalia chebula (harad)*	400
42.	*Trewia nudiflora (false white teak, gutel)*	200

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