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A HAND BOOK ON SEED TECHNOLOGY

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Punjab Forestry Research Institute
Faisalabad
August, 1996

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Donated to PFRI Faisalabad
by
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PREFACE

The quality of seed is a criterion for the quantity of output of a crop. Seed technology, therefore, is becoming increasingly an important field of research, training and extension. Successful plant production involves careful arrangement of seed production, cleaning, processing, testing, storage, seed treatment, certification and distribution to the end users. All these aspects have been covered in this handbook. Some other useful information regarding number of seed per kg, ripening and seed collecting season and germination percentage of the important trees have also been given. Good forestry depends upon good seed and vice versa. The pace of progress in wood production, therefore, will greatly depend upon the pace with which we are able to multiply and market good quality seeds of high yielding varieties.

This handbook of seed has been written as a guideline to the forestry students, nurserymen and seed dealers. It will really benefit all the seed growers, dealers, students, research personnels, government officials and others who are associated with forestry profession.

The authors are deeply indebted to Sahibzada Muhammad Hafeez, Director, P.F.R.I. Faisalabad for his continuous guidance, valuable suggestions and infinite assistance during the preparation of this handbook.

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FOREWORD

Tree planting activities on farmlands are going on fairly well for the last few years. This activity has further increased with the creation of well organized forestry extension wing in the Punjab Forest Department. Production of quality seedlings is a necessity for the success of any tree planting programme. Quality seedlings can be raised only from a quality seed. Production and supply of quality seed of various forest tree species has also received due attention and a Seed Supply System has been established at PFRI for the supply of quality seed to the farmers, field forest officers and other interested persons.

This hand book on SEED TECHNOLOGY has been compiled by the authors at a time when it was urgently needed by the staff of Seed Supply System and other users of seed. This hand book has tried to give information on all important aspects of seed technology like selection and demarcation of seed sources, seed collection, seed extraction and cleaning, seed storage, seed dormancy, seed testing, seed pests and seed certification etc. It will provide useful guidelines to the forest officials as well as tree farmers for use of quality seed for the production of quality seedlings.

August 14th, 1996

(Sahibzada M. Hafeez)
Director

C O N T E N T S

Para No.	Subject	Page No.
1.	THE SEED	..... 1
1.1	Definition	..... 1
1.2	Seed Structure	..... 1
1.3	Mature Seed	..... 2
1.4	Sound Seed	..... 2
2.	TREE SEED SELECTION	..... 5
2.1	Why to Collect Quality Seed?	..... 5
2.2	Plus Tree Selection	..... 6
2.3	Selection of Seed Stands	..... 7
2.4	Establishment of Seed Orchards	..... 7
3.	SEED COLLECTION	..... 9
3.1	Field Reconnaissance	..... 9
3.2	Seed Productivity and Seed Quantities	..... 9
3.3	Selection of Staff and Training	..... 10
3.4	Recording of Data	..... 10
3.5	Individual Tree Description	..... 10
3.6	Security and Labelling	..... 10
3.7	Collection Methods and Equipments	..... 11
3.7.1	Collection of Seed from Standing Trees	..... 11
3.7.1.1	Collection of Seed from Natural Fall	..... 11
3.7.1.2	Collection in the crown	..... 12
3.8	Bagging and Labelling	..... 18

Para No.	Subject	Page No.
3.9	Transportation	18
4.	SEED EXTRACTION AND CLEANING	19
4.1	Pre-cleaning	19
4.2	Drying	19
4.2.1	Natural Drying	21
4.2.2	Artificial Drying	21
4.3.	SEED EXTRACTION	21
4.3.1	Manual Threshing	22
4.3.2	Mechanical Threshing	22
4.4	Cleaning	22
4.4.1	Sieving	23
4.4.2	Winnowing	23
4.4.3	Flotation	23
4.5	Specific Seed Processing Methods	24
4.5.1	Bakain (<i>Melia azedarach</i>)	24
4.5.2	Chir pine (<i>Pinus roxburghii</i>)	25
4.5.3	Blue Pine (<i>Pinus wallichiana</i>)	26
4.5.4	Sufaida (<i>Eucalyptus camaldulensis</i>)	27
4.5.5	Jand (<i>Prosopis cineraria</i>)	27
4.5.6	Kikar (<i>Acacia nilotica</i>)	28
4.5.7	Mesquite (<i>Prosopis juliflora</i>)	28
4.5.8	Mulberry (<i>Morus alba</i>)	29
4.5.9	Shisham (<i>Dalbergia sissoo</i>)	29
4.5.10	Simal (<i>Bombax cieba</i>)	29
5.	SEED STORAGE	31
5.1	General Principles	31
5.2	Factors Affecting Seed Storage	31

Para No.	Subject	Page No.
5.3	Seed Prestorage Treatment	..... 32
5.4	Methods of Seed Storage	..... 33
5.4.1	Dry Storage	..... 33
5.4.2	Moist Storage	..... 34
5.4.3	Special Methods	..... 36
5.5	Kinds of Seed Containers:	..... 36
5.6	Care During Storage	..... 37
5.7	Seed Packing and Packing Materials	..... 40
6.	SEED DORMANCY	..... 41
6.1.	Definition	..... 41
6.2.	Types of Seed Dormancy	..... 41
6.2.1.	Physiological Dormancy	..... 41
6.2.2.	Physical Dormancy	..... 41
6.3.	Factors and Causes of Seed Dormancy	..... 42
6.4.	Factors Responsible for Seed Dormancy	..... 42
6.5.	Breaking Seed Dormancy	..... 42
6.5.1	Scarification	..... 43
6.5.1.1	Acid Scarification	..... 43
6.5.1.2	Physical Scarification	..... 43
6.5.1.3	Manual Scarification	..... 44
6.5.1.4	Mechanical Scarification	..... 44
6.6	Temperature Treatment	..... 44
6.7	Light Treatment	..... 45
6.8	Treatment with Growth Regulators	..... 45
6.9	Dry Heat	..... 45
6.10	Microwave Energy	..... 46
6.11	Specific Methods for Breaking Seed Dormancy	..... 46

Para No.	Subject	Page No.
7.	SEED TESTING	..... 49
7.1	Objectives	..... 49
7.2	Seed Purity Test	..... 49
7.3	Provenance Determination	..... 51
7.4	Moisture Determination	..... 52
7.5	Seed Weight	..... 53
7.6	Germination Test	..... 53
7.7	Calculation of Seed Rates	..... 54
8.	SEED PESTS	..... 57
8.1	Common Seed Pests	..... 57
8.2	Control of Pests During Seed Storage	..... 58
8.2.1	Sanitation	..... 58
8.2.2	Disinfection of Stores	..... 59
8.3	Treatment of Seeds	..... 59
8.4	Fumigation	..... 59
9.	SEED CERTIFICATION	..... 61
9.1	Objectives	..... 62
9.2	Seed Certification Agency	..... 62
9.3	Organization of A Seed Certification Agency	..... 63
9.4	Duties & Responsibilities of Seed Certification Officers	..... 63
9.5	Tags, Labels and Seals	..... 65
	Annexure I	..... 67
	Annexure II	..... 69
	Annexure III	..... 73
	Suggested Readings	..... 74

1. THE SEED

1.1 DEFINITION

It is a ripened ovule that consists of an embryo, its stored food supply and protective covering. The seed is also termed as dormant embryo.

1.2 Seed Structure

Generally, a seed has the following common parts (Fig. 1 & 2)

A: Each seed is enclosed by an outer hard coat called testa. Along one particular side of each seed, there is present a tiny opening called micropyle. The seed absorbs water through the micropyle.

B: A seed itself is a young dormant embryo which is internally made up of the following parts :

i. Plumule

It is an embryonic bud which on germination of seed develops into a young shoot of the plant.

ii. Radicle

It is the pointed end of the central axis of the embryo or hypocotyle which on germination of seed develops into the primary root of the plant that functions to absorb water for the seedling.

iii. One or Two Cotyledons

There are one or two structures found in each seed. If a seed has one cotyledon, it is called monocot e.g.

maize seed and the seed having two cotyledons is called dicot e.g. pea, gram, castor oil, etc. The cotyledons may be thick and bulky due to the storage of food in them e.g. pea and gram and they may be thin and papery if they do not store food in them e.g. castor oil seed.

C: Endosperm

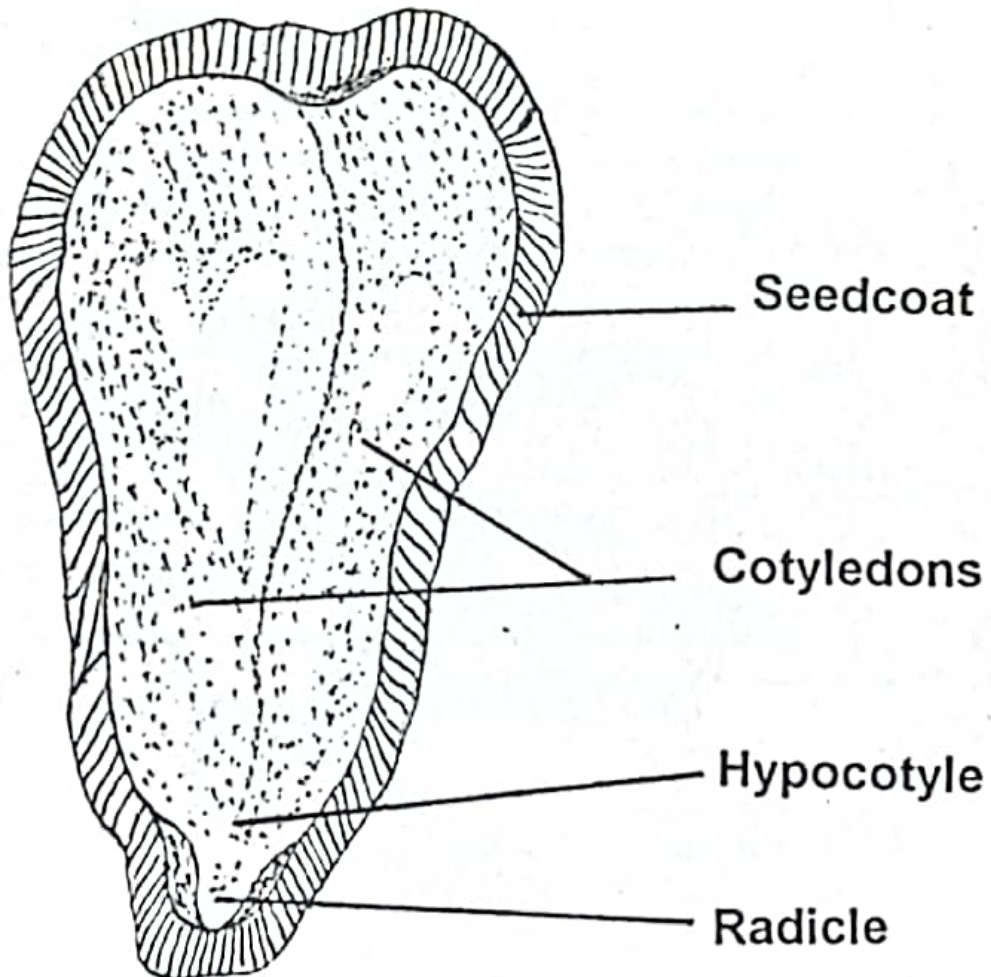
In some seeds there is present a special tissue which functions to store food for the future germination of the seed e.g. castor oil seed.

1.3 Mature Seed

A seed that has reached a stage at which it can be removed from the tree without impairing the seed's germination.

1.4 Sound Seed

A seed which contains all tissue necessary for germination.



STRUCTURE OF SEED, - EUCALYPTUS RUDIS

Figure 1: Eucalyptus rudis - Longitudinal section of the seed.

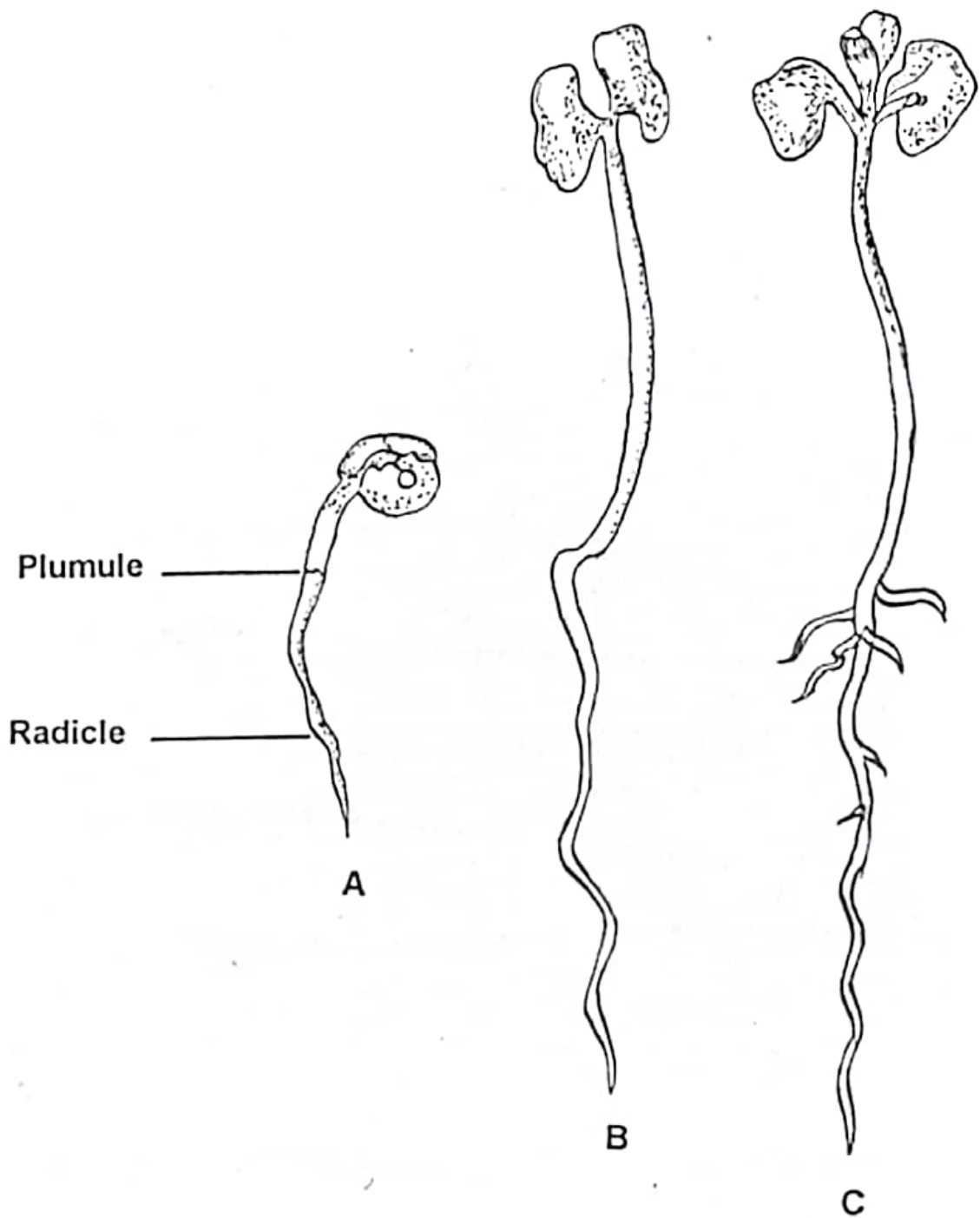


Figure 2 : - Eucalyptus seedling development :
A, at 1 day; B, at 8 days; C, at 42 days.

2. TREE SEED SELECTION

2.1 Why to Collect Quality Seed?

In agriculture, collecting seed from superior parent stock has been practiced for thousands of years. This technique results in higher yields and environmentally durable plants. The concept, however, has yet to gain widespread acceptance in forestry practice. To maximize yields and quality of trees for plantations, agro-forestry, and some other basic genetic principles for collecting seed should be observed.

In forestry, as in agriculture, the quality of offspring plants will be better if the seed used to produce them was collected from superior individuals, stands or orchards.

Seed quality is measured in two ways. One, by the physical quality of the seed and secondly, by the desired physical traits of the resultant mature tree.

The benefits of using better quality seeds, chosen from selected parent trees, are twofold: improved survival and greater economic returns.

Seeds from healthy, well-formed trees provide greater assurance that resulting stock will have good form, survival and better resist stressed conditions due to marginal sites, frequent cutting, or harsh climates. These adverse conditions typically weaken all the trees making them vulnerable to insects, fungi, parasitic plants, and diseases.

More important, because of the long-term resource investment and land and labour commitment in forestry, high survival rates of good quality trees is a must.

In agriculture, farmers can recoup their losses after a poor season, or even two. Trees, however, occupy a site for years,

therefore, any reduction in growth or quality from planting inferior stock represents a lost opportunity, which can be measured in time and capital, for as long as a tree occupies a particular site.

For the second benefit, economic return, the investment in seed selection will be more than compensated for by higher product yields over shorter rotations. Better yields result in more building materials, higher fruit production and quality, faster fuelwood growth, and quicker and more prolific growth after lopping.

2.2 Plus Tree Selection

Plus tree is generally a phenotypically superior tree. Sometimes the term "elite" is reserved for a tree or a stand that has been verified as superior by testing, for a specified environment and propagation system. Plus tree has some characteristics easy to recognize them depending upon the object of improvement and kind of tree species. They are:

- Superior tree should be young enough to produce good quality of seed.
- Should be better than an average with rapid growth and volume production.
- Stem form and shape should be straight, round and with desirable taper.
- Plus tree should have apical dominance characteristics.
- It should have no evidence of insect, pest, climatic damage and be diseased free.
- Tree selected should have well developed and good crown shape.
- Individuals that show evidence of good past and current wood production should be selected.
- Plus trees should have maximum branches equally well developed on all sides.
- Wood of selected tree should have desirable characteristics.

- ◆ Forking should be considered as defect while selecting plus trees.

2.3 Selection of Seed Stands

Seed stands also called "Seed production Areas" (S. P. A.) are groups of trees or stands that exhibit above average performance and are managed basically for seed production. The following criteria should be kept in mind while selecting seed stand or seed production area :

- ◆ Average or better than average in d. b. h. or height and in general appearance for the site.
- ◆ Middle aged stands are preferred. Stands that are too young or old often produce meager quantity/poor quality of seed.
- ◆ Majority of trees should exhibit desirable characteristics (phenotype) as outlined under plus tree selection.
- ◆ Stand should have no indication of disease, insect and pest incidence.
- ◆ Topography of stand should be relatively level to facilitate seed harvesting.
- ◆ Should be free from environmental damage.
- ◆ The area of seed stand should be at least 3 to 5 acres depending upon the site and species from economic point of view.

2.4 Establishment of Seed Orchards

Seed produced in seed orchards is often referred to as certified seed. It has high expectation of performance among the resulting progeny, provided that progeny records have been maintained long enough to:

- a) Ensure that progenies are better than average.
- b) Specify the conditions required to attain that performance.

Thus certified seed implies that the seed orchard has been progeny tested to determine the expected performance and the conditions. Seed orchards are essential to a tree improvement program designed to achieve maximum results. Their major objective is to produce mass quantity of genetically improved seed. Seed orchards are developed by assembling selected plus phenotypes into one or more orchards on carefully chosen sites. The phenotypes are planted in a prescribed design with replications within each orchard. The phenotypes may come from one ecotype (provenance) or they may come from several ecotypes. The former is probably the more common.

Seed orchards are plantations of seedlings or grafted plants from selected trees that are genetically superior i.e. proven superior are called seedling and clonal seed orchards respectively. From these plantations easily-harvested seed of higher-than-average quality is produced in the amount desired, as an end product.

Sometimes seed orchards are established before the genetic value (breeding value) of the parents is known or while it is still under investigation through progeny testingwhen the plantations are still test plantations. Then as the genotype (genetic quality) of the individuals is learned, the poor genotypes or progeny of them are roughed from the orchard. But the plantation does not really become a seed orchard until such roughing has occurred and the genetic superiority of the remaining numbers has been proven. When the seed orchards are initially established as test plantations, an estimate of tree breeding value is sought. The breeding value is estimated from the performance of the progeny of a given parent when combined with other parent (s). There are two types of combining abilities namely general combining ability and specific combining ability. General combining ability is the ability of a parent to give superior progeny in combination with several different males. On the other hand, specific combining ability is the ability of a specific individual to give superior progeny in combination with another specific individual.

3. SEED COLLECTION

Seed is the basic requirement for raising of nurseries. This important aspect is being ignored in forestry sector. A good seed is a guarantee for raising nurseries to meet the requirements of planting material in public and private sector. In the past the tree planting was confined to public sector but during recent years there is a great enthusiasm among the private land owners for raising trees in their farm lands. Hence, seed collection has become of vital importance. The following various steps are involved in seed collection and its storage :

3.1 Field Reconnaissance

Before collecting the seed, sufficient knowledge should be at hand with the seed collector for tree flowering, period of seed ripening, best time of collection, viability and dormancy of the seed desired to be collected. The site should be surveyed, plus trees marked and mapping done.

3.2 Seed Productivity and Seed Quantities

Every year is not a good seed year. Foresters must be cautious about their requirements before hand. Seed collected over and above the requirement is merely a wastage of time, money and labour coupled with problems of storage. The seed collection is directly related with our requirements. It should never be collected over and above the requirements. Seed productivity can be expressed as seed per Kg. per tree or seed produced per unit of land area. In legumes it may be expressed as seed per pod. It will facilitate the collection of seed. The number of seed produced per acre/hectare depends on the density, age and size of the trees.

Before collection of seed, the collector should have a vigilant eye over the tree habits such as flowering and seedling, etc. It may happen that the flowers fall down before formation of seed due to one or the other reason. If properly watched, it will facilitate to detect any disease, insect attack and natural calamities and to adopt preventive measures.

3.3 Selection of Staff and Training

Early selection of the seed collection team is recommended so that there is enough time for them to familiarize themselves with the task and species, and if necessary undertake training in the collection methods which they will be expected to use in the field. The team leaders should have sufficient experience in seed collection methods. The necessary labour force should be recruited in the area of operation. All the team members should be physically fit, adaptable to the task and able to make sound decisions on the spot when facing unforeseen problems.

3.4 Recording of Data

Necessary data regarding locality, latitude, longitude, altitude aspect, slope, climate and soil, etc. should be collected. The site of the seed collection should be accurately and concisely marked on the map. Distances from the nearest towns, villages, forest plantations with compartment No. or any other fact that will assist future field points should be recorded. The site features help build up a picture of the environment and ecology in which the trees grow and may assist in the interpretation of the experimental results. The seed collectors should always be on the look out for relevant comments from local people on the past history of the area and its climate.

3.5 Individual Tree Description

The main characteristics of each tree e. g. height, diameter, stem form, branching habit and number of trees in each species are of obvious importance in any future tree breeding work. Photographs are

a very useful adjunct to the written descriptions.

3.6 Security and Labelling

It is of paramount importance that fool-proof systems be adopted to maintain the identity and purity of each collection. System must be adopted to eliminate the possibility of any seed lot being mixed with seed of another through all steps from collection to registration in the seed store. Careful labelling through each and every process is of course very essential.

3.7 Collection Methods and Equipments

Before collecting the seed, arrangement for the equipment required should be made. A list of equipments required for seed collection is given at the end (Annexure-I).

The seed can be collected by any of the following methods:

3.7.1 Collection of Seed from Standing Trees

Seed collection from standing trees is very useful method of seed collection for research purposes. One of the main advantages over felling is that the trees are not immediately lost as a future seed source, and when warranted, the seed trees can be marked for future reference. The seed collected will be pure and well ripe. Almost seeds of all the tree species can be collected.

3.7.1.1 Collection of Seed from Natural Fall

This is the cheapest method that does not require skilled labour and ensures that only mature seed is collected. A rack, sieve and collection container are the only equipments required. Some refinements of the basic technique have proved useful in the collection of seed of species that mature and shed their seed over a short period. These can range from spreading the large sheets of plastic canvas,

hessian or like material around the base of the tree (Fig-3). Seed of toot, phulai beri etc. can be collected with this modified method.

3.7.1.2 Collection in the crown

A widely used method of collection is simply to climb up into the crown of the tree and with the use of a saw or similar implement remove seed bearing twigs. Unaided climbing is not possible where

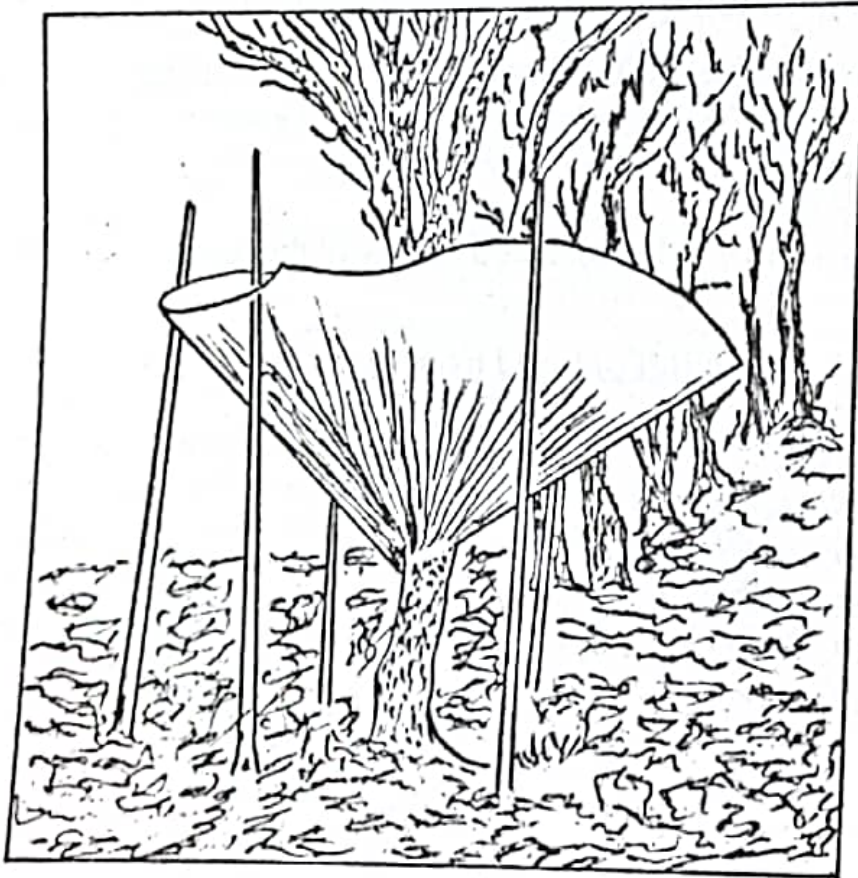


Figure 3 : Collecting seed from natural fall (funnel for trapping).



Figure 4 : Use of vehicle in seed collection.

trees stems are thorny or weak and there is always an element of danger. The use of safety belts is highly recommended. Items of equipment that may facilitate access to the crown of the small trees include :

Seed Vehicles

With strong roof carriers often provide a quick and easy means of gaining access to the crowns and fruits of small trees as shown in figure 4.

Portable Ladders

Well designed ladders provide a quick and safe means of reaching the live crowns of trees upto about 15m tall. There are many designs but the type selected should be compatible with tree habits and local conditions of topography and access. For small trees a light wooden, or aluminium single section or free standing ladder 6-8m long which will fit easily on a standard vehicle roof carrier will suffice. Seed of Eucalyptus and white siris can be easily collected.

Manual Collection

This may prove very effective where trees are small and their branches are low enough for the collector to reach them easily from the ground. In this case the branches may be bent over seed collection sheets spread on the ground and the pods stripped by hand (Fig - 5) where the crop is fully mature and near dehiscence or seed fall, sticks are often used for beating the branches to shake down seed or fruit. The use of pruning shears for cutting off thin branches are effective in collecting additional seed e.g. toot, shisham, beri, kikar etc.

Pole Implements

Where the crop is out of reach for hand picking, the use of various pole implements may be appropriate. Pole with shears, saws



Figure 5 : Manual collection of the seed.



Figure 6 : Use of pole Implement in seed collection.

Figure 5 : Manual collection of the seed.

or hooks of various designs attached to one end are commonly used for detaching the fruit or cutting the seed bearing twigs. Light and rigid bamboo, aluminium or plastic poles 4-6m in length are common. In order to reach beyond the 6-8m range of single pole, multistage telescopic poles with a shear on the end have been developed. These methods require careful location of the ground so that pods and seeds are not lost on impact (Fig:-6).e.g. pines eucalypts.

Throwing Rope with Weighted End

A 5mm diameter sash cord or nylon rope 25m in length with a 400 grams weighted end (e.g. a small bag of sand) can be thrown over small branches, which are then broken off by holding the two ends and pulling. Branches upto 12m from the ground can be reached by using this method. Skill is required to throw the rope over the selected branch and in the correct position for ease of breakage.

Flexible Saw

It is a recently developed device also called a "High limb chain saw". It is (1.2m) long and has a metal ring at each end for securing ropes; is similar in appearance and principle to the chain saw. A throwing rope is placed over the required branch and the saw with heavier rope tied at each end is then drawn up. Two operators working in unison then pull on the saw downwards and outwards. Branches upto 20 cm diameter can be brought down quickly and easily handed. The method is not applicable to trees with actually angled branches.

Rifle

The advantages of using a rifle in order to shoot down seed bearing limbs of tall Eucalypts is worth mentioning. This technique has also been approved useful for the collection of acacia pods from moist forest in Australia. This system, however, is not practicable in our country.

Collecting Seed from Felled Trees

This is also a cheap and commonly used method of seed collection. This method can be very safely practiced where fellings are in progress. But it is very ridiculous and unjustified to fell tree just for seed collection particularly in areas where trees are already scarce. The seed of kikar, shisham, siris & beri etc., can be collected from felled trees easily.

3.8 Bagging and Labelling

All the branches, twigs and other impurities be removed as far as possible before the seed is bagged. This is usually done by manual labour. The identity of each individual tree sample must be maintained from the sheet to the bag. Each bag should be clearly labelled both inside and out.

3.9 Transportation

The seed (or pods in case of legumes) should be carried to the storage site as early as possible. If the distances are long and the seeds or pods are fresh and packed in gunny bags, those should be arranged in the vehicle in such a way that circulation of air takes place in between them so that development of micro-organisms, fermentation or over-heating does not take place. The use of insecticidal and fungicidal dusts may arrest deterioration. It is advisable to despatch the seed in two different lots to reduce the chances of losing an entire collection through accidents enroute. When seedlots are split each bag must be labelled to indicate the number involved.

4.

SEED EXTRACTION AND CLEANING

Seed collected from the field is rarely fit for immediate storage. Drying, extraction from the pods (in case of legumes) and further cleaning are required. It is important to ensure that these operations do not harm the seed and the seed lots are not mixed.

Responsible staff should supervise the operation for final drying, extraction, cleaning and storage. The following steps are involved in extraction and cleaning of the seed:-

4.1 Pre-cleaning

After collection and before storage the seed collected must be inspected to determine its conditions. In case of pods it becomes more expeditious. Moist and fermenting pods must be spread out to dry and does require treatment with fungicide to avoid further fermentation. The removal of branches, twigs and other impurities will facilitate drying and further cleaning.

4.2 Drying

4.2.1 Natural Drying

The seeds are spread in a thin layer on sheets over the ground or over screens or platforms which improve air circulation. The layer of the seed is constantly disturbed so as to permit the lower layers to dry. The time required for natural drying depends on a number of factors including species, the degree of maturity of the seed and weather conditions (Fig: 7). Seeds having high moisture content are likely to ferment. In this case the seed should be dried at moderate temperature with good ventilation.

This method is ideally suited to hot, rain-free environment of the dry-zone. If there are heavy dews, material may have to be covered or bagged at night. Some-one must be on hand at all times to protect and to regularly turn the seed to permit the lower layers to dry.

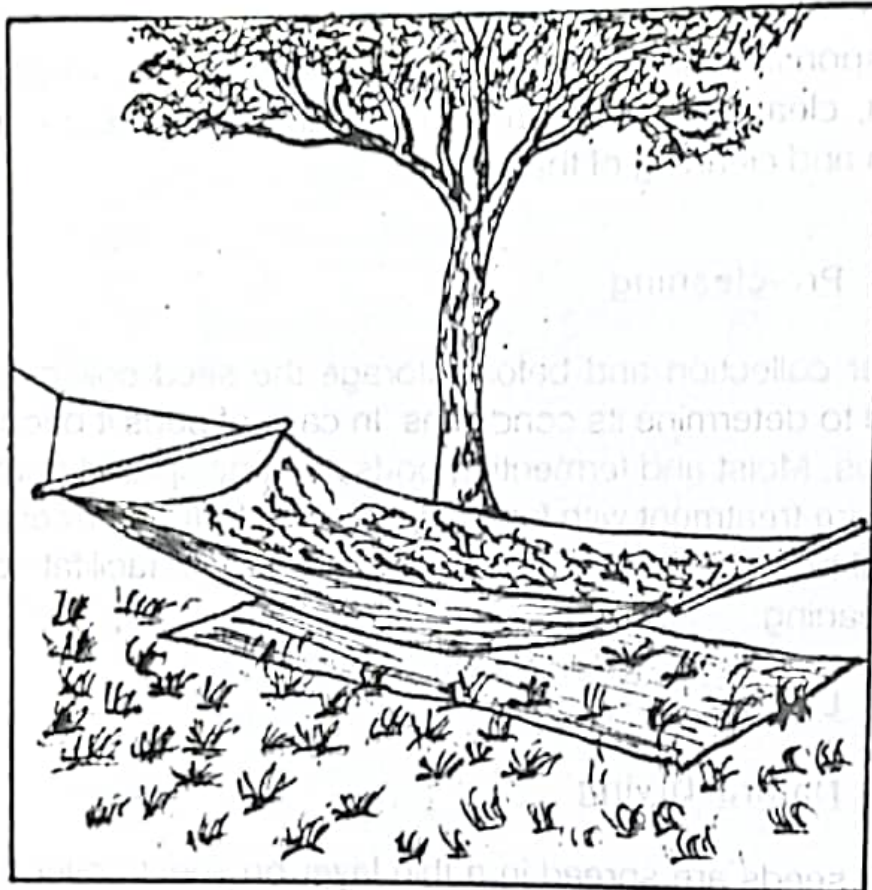


Figure 7: Natural drying on a temporary frame.

Where the climate is less reliable facilities such as rooted structures, glass houses or even specially designed drying rooms may be required.

4.2.2 Artificial Drying

The rapid, artificial drying of seed is especially useful during rainy or humid weather. A temperature treatment of 45°C for a maximum period of 48-72 hours is a common schedule. In species where a large proportion of seed remains either enclosed in the pods (e.g. *A. nilotica*, *A. aneura*) or firmly attached to it by the funical (e.g. *A. mangium*) even after lengthy periods of natural drying, a gentle artificial heat treatment at 40-45°C for 24 hours can promote a brittleness in the pod that assists in the extraction process.

There is a wide range of drying equipments available ranging from small ovens to large seed drying kilns. For small seedlots a forced draught oven can be used. Large kilns are expensive to establish and operate and are warranted only if very large amounts of seed are to be processed.

4.3. SEED EXTRACTION

After drying the seed must be removed from the pods, capsules and cones without affecting seed viability. The ease of extraction depends on the species, stage of maturity, and the available equipment. With some species, a mere shaking of the dried material will release all the seed from the pods. In other species the seeds remain locked in sections of the pods or remain attached to the pods so strongly that special efforts are needed to release them.

4.3.1 Manual Threshing

The seed of many acacias can be extracted from the dried pods by beating with a flail or slender pole, crushing the pods between canvas sheets by trampling underfoot or, with small samples, simply

by breaking up the pods by hand. More robust methods such as pounding the dried pods with a heavy wooden mallet may be necessary for very hard pods. e.g. siris, parkinsonia, prosopis, etc.

4.3.2 Mechanical Threshing

As manual threshing can be very time consuming and labour intensive, it is often advantageous to utilize either hand or power driven machinery to assist in this task. A wide range of equipments is available for threshing agricultural grain crops. Some can be adapted for the extraction of seed in forestry with some modifications. The tolerance of seed to threshing depends on species. Machinery must be carefully tested for harmful effects on each seedlot before the bulk of the seed is subjected to the treatment. Examples of machinery used to extract acacia, siris seed is a rotating drum or cement mixer with several large loose weights (e. g. stones, sand bags) which, when tumbled, break the pods and facilitate the release of seed. This technique is simple but slow and its effectiveness varies with species.

4.4 Cleaning

Seed coming directly from the field or through the extraction process usually requires a final, thorough cleaning before storage. The aim of cleaning is to separate full seeds from impurities (including empty seeds) and thus obtain homogeneous seedlots of high viability. Complete cleaning of a seedlot is not always possible or necessary. The level of cleanliness adopted is usually a compromise between time, effort and loss of viable seed. It may also depends on plant quarantine requirements.

Mechanical cleaning usually depends on sieving, winnowing, flotation or a combination of these.

4.4.1 Sieving

A sequential sieving through a gradation of mesh size can produce a high level of cleanliness with many seeds. This process has

been mechanized by the vibrating screens of machines like the 'Vac-A-way Gravity Screen'. Problems arise when there are large proportions of impurities similar in size to the viable seed. In this case a combination of methods may be required to achieve acceptable results. e. g. eucalyptus, acacia, and other small seeds.

4.4.2 Winnowing

Winnowing is widely used for cleaning grain and other seeds in many parts of the world. Wind or an air stream is used to separate light material (chaff) from the heavier remainder (i.e. full seed). In its crude form, the uncleaned seed may simply be thrown into the air on a windy day. Various fractions of the seedlot separate out, and the desired ones are retained. This principle has been refined in seed cleaning machines commonly referred to as blowers. Many seed cleaning machines use a combination of winnowing and screening. The screens are used to remove the largest and finest fractions and the intermediate fractions containing the seed are winnowed. e. g. eucalyptus, siris, phulai.

4.4.3 Flotation

Flotation in water is an effective final treatment to remove small impurities. The method relies on differences in density with the seed sinking to the bottom of the water bath and the lighter material including water is drained off and the seed thoroughly dried before storage. This technique can be adopted for seeds of all the tree species.

4.5 Specific Seed Processing Methods

Capsules, fruits and cones are processed to extract and prepare their seeds for storage and final utilization. This may require getting rid of extraneous dirt and debris, freeing from physical or physiological

encumbrances, reducing bulk and weight, eliminating damaged and empty seeds, attaining and maintaining proper moisture content and applying needed protective treatment for subsequent storage. Seeds of some species need little processing while others need more intensive processing. Nevertheless, maximum production of clean seed having high viability is the end objective.

Processing methods have been designed for different species and the techniques for important species are given below:

4.5.1 Bakain (*Melia azedarach*)

The trees of *Melia azedarach* (Bakain) are usually leaf-less from December to March/April. The pretty lilac coloured flowers are born in axillary panicles and ripen in the cold season but remain on tree upto July. They turn yellow and wrinkled as they ripen.

Fruits which are drupe can be collected by hand after the leaves have fallen in late autumn or early winter. They may be either run wet through a macerator or the entire fruits may be planted immediately.

4.5.2 Chir pine (*Pinus roxburghii*)

Male flowers of chir pine are in catkins which are grouped in spirals on the new shoots. The catkins are yellowish during the ripening time and turning light reddish brown after pollens are shed. The male and female flowers ripen from February to April according to latitude and season. Female flowers are also in spirals in the form of young cones at the top of new shoots. They are pale green or slightly purplish.

Cones and seeds of *Pinus roxburghii* usually mature in winter and seed is ready for dispersal during April-May. Many cones may remain closed for several months or years. Cones should be collected

from trees superior in growth and form characteristics. Large cones generally contain more seeds, but usually all cones are collected except those with obvious disease and insect damage. Ripe cones can be collected from standing trees or from newly felled trees. Cones are usually hand picked, either with ladders or by climbing the trees. Hand cutters and cutting hooks are available to detach the cones and bringing the cones-laden branches to the picker. In advanced countries, mechanical shakers are used for rapid commercial seed harvesting. In this method large quantities of seed are collected by shaking the tree or beating the crown to extract the seeds, and then gathering them from cloth or plastic sheets spread on the ground under the tree.

Cones are dried under sun by spreading the cones on a dry surface. The cones should be dried slowly to prevent "case hardening". After the cones are opened they are shaken to remove the seeds. Seeds are usually cleaned by screening or fanning.

4.5.3 Blue Pine (*Pinus wallichiana*)

Male flowers of blue pine are found in catkins which are arranged on the base of the young shoots. They ripen and shed their pollens from the end of April to the beginning of June. Female flowers arranged in spirals in the form of young cones at the top of new shoots. They are completely developed and ready for pollination from the end of April to the beginning of June.

Immature cones are green in colour and turned to tanning yellow to light brown on ripening. Cones should be collected before seed dispersal during September-November. Ripe cones should be collected from trees having desirable characteristics. Cones are usually hand picked either by using ladder or climbing the tree. Mechanical shakers may also be used for rapid commercial seed collection. To extract seed from cones, same procedure can be followed as for chir pine.

4.5.4 Sufaida (*Eucalyptus camaldulensis*)

A striking feature of all eucalypts is the lid or operculum which seals the flower until, during the process of opening it is thrown off revealing the stamens underneath. The lower part of the flower bud from which the operculum detaches itself is the receptacle, which persists in the fruit, becoming hard and woody. The flowers are protandrous and are adapted for cross pollination by insects. *Eucalyptus camaldulensis* usually flowers during March to May, and capsules having viable seeds can be collected during September and October.

Collecting mature capsules of *E. camaldulensis* should present no serious problem, since there is relatively long interval between seed ripening and opening of the capsule. Care, however, should be taken to collect only well-developed, closed and healthy capsules because on a single branch capsules of different stages of maturity will be found as well as buds, flowers and empty capsules. The capsules are generally collected by climbing the tree. Collected capsules are spread over a sheet under sun for drying. The capsules should be spread in a thin layer to permit rapid drying and to prevent mold formation. The most common method is to air dry the capsules for a few hours to a few days, depending upon the maturity of the capsules. Once the capsules are open, they should be vigorously shaken to remove the seeds. Shaking is especially important if the capsules are somewhat immature, since the abscission of viable seed from the capsules placenta may not be complete. And if shaking is not done, only infertile seeds will be extracted. When examined, the immature capsules may appear empty after the aborted seeds are removed since the viable seeds are normally attached at the base of the capsule. Viable seeds are extracted with unfertilized or aborted ovules known collectively as "chaff". Large impurities such as the remains of twigs, capsules and leaves can be removed by specific gravity separators like that used in air column method. Viable seeds and chaff cannot be separated by usual methods and thus in commercial collections, fertile seeds are sold with chaff.

4.5.5 Jand (*Prosopis cineraria*)

It is a tree of small to medium size with an open crown. The trees remain leafless for a short period before flowering. The pods of *Prosopis cineraria* ripen from June to August. Pod collection can be made from standing trees or shaken from the trees and collected on to the sheet already spread under the tree.

Seeds can be extracted easily by drying the pods in the sun, crushing them by hand and then winnowing.

4.5.6 Kikar (*Acacia nilotica*)

The flowers of *Acacia nilotica* (Kikar) are yellow, regular, small and aggregated in spherical heads. The flowering season is somewhat irregular, varying not only according to locality but also in the same locality. Flowering is mostly in the rainy season, from January to September or October, but trees may be found in flowers as late as December or January. The young fruits develop rapidly, the time of ripening varies from April to June. In Sindh trees flower as a rule twice a year, once in June-July and again in November-December: the pods from the first flowering ripen in about October but are usually poor in quality and quantity.

Ripe *Acacia* pods are brown and can be picked from the trees or by falling onto sheet. Collection from the ground is generally discouraged mainly due to reason that seed is not of desired quality. Pods are dried under sun. Seeds can be extracted from them by trampling or placing the pods in a cloth bag and flailing it against the floor. A blower may be used to remove pod fragments and debris.

4.5.7 Mesquite (*Prosopis juliflora*)

Prosopis juliflora is now naturalized in the Punjab and it is already becoming a dangerous weed in irrigated plantations. This is a species to be tried only in problematic areas. Elsewhere, the problems

it causes may be immense.

The perfect flowers of mesquite open from March to April. The fruit is an indehiscent. Pod contains several seeds, usually ripen in May and June.

Ripe pods may be stripped from standing trees or collected after shaking on the sheet. Seed extraction is facilitated by allowing the pods to dry for several days at normal air temperature. Small lots of pods may be crushed manually to extract the seeds. Pods in large lots may be broken by running them through either a dry macerator or a hammer mill. If these equipment are not available, the dry pods can be broken by threshing. Sound seeds may then be separated by screening and fanning or winnowing.

4.5.8 Mulberry (*Morus alba*)

Flowers appear in catkins during April/May. The fruit is composed of many small, closely oppressed drupes. Fruits which are edible ripen and drop from the trees during the month of June to August and often dispersed by birds, animals and water.

Ripe mulberry fruits may be collected by stripping, shaking or flailing them from the trees on a ground on canvas or plastic sheet. Fruits should be collected as soon as most are ripe to avoid loss by birds and animals.

Fresh fruits are usually mashed immediately after collection. Fermentation at moderate indoor temperature for one to two days aids the extraction and cleaning process. Small samples may be cleaned by rubbing gently through a No. 6 screen and floating of the pulp. If the seed lot is big, after proper soaking, fruits are run with water through Dybvey seed cleaner or macerator. Clean seed should be air dried in shade before storage or use.

4.5.9 Shisham (*Dalbergia sissoo*)

The young flower buds appear with the new leaves and the yellowish flowers, in axillary panicles of short racemes, open in March or April. They may be as much as 2" long, pale green and hanging in masses all over the tree. By July they are full sized but remain unripe and yellowish green till November when they commence to turn brown, ripening toward the end of December or early January. Pods are blown off the trees from the time they ripen onwards and carried away some distance by winds.

Collection of Shisham pods can begin in late December or early January when the pods turn brown. Pods can be picked by hand from standing trees or dropped on the canvas or plastic sheet by shaking or flailing the branches of the tree. Pods are then placed in loosely woven sacks or spread to air dry.

If pods are not entirely dry when collected, they should be spread thinly and dried under sunlight for several days. Extraneous material and dirt can be separated by screening and fanning. It is difficult to extract seeds from pods. Seeds are, therefore, sown in the broken pods. After the pods are thoroughly airdried, they can be stored for 12-18 months or possibly more.

4.5.10 Simal (*Bombax cieba*)

The striking scarlet flowers of simal appear in January and February and sometimes continue till March. The fruits develop very rapidly while there are still flowers and ripen in April and May. The fruits open usually on the tree but sometimes after fall. The seeds which are numerous are surrounded by masses of white silky hairs (kapok), can be easily blown by wind.

The seeds can be picked from the standing trees while still in capsules or knocked off the tree and collected on sheet. The capsules are dried in the sun until they burst. A convenient method of separating

the seed from the cotton is to place both in a large open basket. A round stick about two feet (0.61m.) long and $\frac{1}{3}$ (0.85cm.) to $\frac{1}{2}$ inches (1.27cm.) diameter is prepared, and two inches (5.08cm.) from the one end of it, two pointed cross sticks about 5 inches (12.70cm.) long are tied firmly to the long stick and at right angle to it and to each other. This end of the long stick is then pushed into the cotton and the stick is revolved rapidly in alternate directions by rubbing.

5. SEED STORAGE

Maintenance of high seed germination and vigour from harvest till planting is of an utmost importance in a seed programme. Seeds are practically worthless if, upon sowing they fail to give adequate plant stands in addition to healthy and vigorous plants.

The expense and effort required to assemble a comprehensive range of provenances of widely distributed species makes it essential that the seed be safely and effectively stored until it is required for distribution and sowing. Good seed storage is, therefore, a basic requirement in seed production.

5.1 General Principles

In view of the various factors affecting seed viability in storage, the following principles emerge as necessary for good storage:

- ▶ Seed storage conditions should be dry and cool.
- ▶ Effective storage pest control.
- ▶ Proper sanitation in seed stores.
- ▶ Before placing seeds into storage they should be dried to safe moisture limits appropriate for the storage system.
- ▶ Storing of high quality seed only, i.e., well cleaned, treated as well as of high germination with vigour and good pre-storage history.

5.2 Factors Affecting Seed Storage

Various factors like type of seed, stage of maturity, prestorage

treatment, viability and moisture content when stored, temperature, humidity and oxygen pressure of the air and degree of infection by rodents, fungi and bacteria affect during seed storage. Although the interrelationships among these factors are complex, a few generalizations, however, can be drawn as under:

- I. Fully ripened seeds retain viability longer than immature seeds.
- II. Seeds of high initial viability store better than those with low initial viability.
- III. Undamaged seeds retain viability better in storage than seeds physically damaged during collection or processing.
- IV. Seeds with hard, impermeable seed coats retain viability longer than those with soft, permeable seed coats.
- v. At low moisture content or low temperature, the harmful activities of insects and diseases are effectively slowed or altogether stopped.
- vi. Fluctuations in temperature and moisture are less favourable than constant conditions.
- vii. For many species, the lower the temperature and lower the moisture content of the seed, the longer the period of viability during storage.
- viii. The rule of thumb applied to agricultural seeds that conditions for long-term storage are good if the sum of the degrees F. and percent relative humidity is 100 or less-probably may also apply to tree and shrub seeds.

5.3 Seed Prestorage Treatment

Seeds of many tree species are ready for storage as soon as

they are cleaned. For others, preparatory steps such as drying or fumigation are often necessary.

Despite natural drying of that received during processing, seeds of many hardwoods and conifers require final drying prior to storage. Drying may be necessary to prevent heating and to attain recommended storage moisture levels. If seed with moisture content above 18-20 percent is stored in bulk at normal temperatures, multiplication of microorganisms and heating may occur in a few hours. Little or no growth of microorganisms occurs in seed with moisture content below 12 percent. Insects are usually killed during seed drying at temperature above 104°F and are prevented from reproduction in seed stored at moisture content below 9 percent.

Seeds can be harmed by over-drying. A measurement of moisture content before putting seed in storage is preferable to an empirical estimate. Seed moisture content can be determined quickly with an electronic moisture meter.

Insects and fungi are usually held in check by dry, near freezing or sub-freezing storage of seed, but in moist storage at cool temperatures, prestorage fumigation or other suitable treatment may be necessary. Chemicals such as formaldehyde, serafume, etc., are readily available in the market for fumigation. They should be used sparingly.

5.4 Methods of Seed Storage

Various methods are used for storing seeds of tree and shrub species. The brief description of important methods is given below:

5.4.1 Dry Storage

Dry seeds of many species can withstand a few weeks or months of storage at room temperature or a longer period at cool temperatures without adverse effects. Thus length of storage and level of temperature and humidity control needed are of prime

considerations among dry storage options. Temperatures are controlled by storage location or refrigeration. Seed moisture content is controlled by storing properly dried seed in tightly closed containers or by regulating humidity in the storage area. So far, control of moisture content in tree and shrub seed has been attained largely by putting dried seeds in closed containers whereas much agricultural seed is kept in dehumidified storage rooms.

Storing dry seeds in piles, sacks or open containers in a warehouse or a shed is one of the oldest, simplest and most economical storage methods. It works well in cool climate with naturally low humidity. Warehouse storage can also be used in humid climate by storing dry seed in air-tight containers or by regulating humidity in the storage facility. Adequate ventilation around seed container is required and usual precautions must be taken to protect stored seed from rodents and birds.

Dry seeds of numerous species store well at cool, above freezing temperature (32-41°F). Sub-freezing temperatures are, however, optimum for the long term dry storage. Temperature slightly below freezing may be sufficient but viability has generally been retained better when seeds are stored at 0°F. It has been recommended that dry tree seeds can tolerate extremely cold temperatures with injury down to -32°F but such low temperatures are not practical for storage.

Seeds are kept in both open and closed storage at sub-freezing temperatures. It has been demonstrated that viability of seeds which benefit from subfreezing storage will be reduced if placed in long-term at too high moisture content. But such seeds can tolerate higher moisture content in sub-freezing storage than in cool above-freezing storage.

5.4.2 Moist Storage

Seeds that require sustained high moisture content between time of ripening and germination are stored moist. Normally such

seeds are short-lived and are stored only for short periods or over-winter but techniques have been devised for extending the storage period to two years or more. The basic requirements for successful moist storage are good ventilation that prevent heating, maintenance of equable and high moisture content and moderately low temperature to control molds and premature germination. They can also be spread out uncovered in storage sheds or houses and turned at regular intervals. Techniques have also been developed for holding small-seeded species over-winter in moist storage. Seeds stored out-doors are kept moist by rain or snow but under cover, moistening at intervals may be necessary. For best and most uniform moisture conditions, the seeds are either mixed with a moist medium or enclosed in screen or cloth netting and placed in alternate layers with sand, peat or other moisture holding material. Such layers serve dual purposes i.e. storage and the preconditioning required for germination.

Storage at uncontrolled temperatures is cheap and simple but has several weather-related drawbacks. In a dry winter, moisture supply may prove scanty. If snow/rain is scarce, seed stored above ground may be subject to desiccation or extremely cold temperatures. Covering seeds with leaves, straw, soil or other materials can help moderate fluctuating weather conditions. An unseasonal warm spell, however, may trigger premature germination or rising temperatures near the end of storage period may bring on germination before seed can be sown.

The best storage conditions for high moisture content seeds are afforded by the controlled temperatures in the refrigerators, walk-in collars or air-conditioned buildings. Seed moisture content is maintained at high levels by storing the seed in a moist medium, by controlling relative humidity of the air in the storage chamber or by placing the seed in the moisture retaining containers. In open storage, seeds may require periodic watering. Drainage should be provided for any excess water which may accumulate in the storage container.

Recommended storage temperature for moist storage may vary with species in the range from 32oF to 50oF and has been proved the

best. Moisture requirement also vary from 11 to 40 percent. Moisture requiring seeds should not be stored in containers which limit oxygen supply. Seeds requiring moisture are sometimes stored expediently in running water. Stagnant water does not provide sufficient aeration. Moist seeds of a few species have been stored successfully at sub-freezing temperature.

5.4.3 Special Methods

Various other storage methods have been tested with promising results, but their cost, difficulty of application or other such problems, have precluded their widespread use. It is important, however, to recognize their availability and potential for solving storage problems of specific tree and shrub seeds. Of these the important ones are partial vacuum, storage in inert gases such as nitrogen, replacement of oxygen by carbon dioxide within the storage containers, sealing containers either wax or paraffin and coating seeds of especially large-seeds species with paraffin or latex to maintain their moisture content during storage and shipment. It should be noted, however, that these special methods can prove useful for certain species and under special conditions.

5.5 Kinds of Seed Containers:

Many kinds of containers are available to store tree and shrub seeds. They can be classified into the following types:

- ◆ Moisture-vapour permeable containers, e. g. jute bag, cloth bag, paper bag, multiple paper bag, etc.
- ◆ Moisture-vapour resistant containers like jute bag laminated with thin (200-300 gauge) polythene film.
- ◆ Moisture-vapour proof containers, e. g. fiber-boards, metal drums, metal or glass carboys, tin cans, polythene bags, aluminium-foil-lined packets, etc.

The choice of seed storing material and amount of seeds to be packed will depend upon several factors such as the kind of seeds, duration of storage, storage environment, the seed moisture content, the cost of packing material and geographical area where the seeds will be stored. In much of the seed literature degree of sealing determines the selection of storage container. The general guidelines for selecting the type of container can be listed as under:

- I. When seed requires further drying in storage, do not use a tight closing container because enclosing excess moisture is harmful to seed.
- II. Use a tight closing container if excess seed moisture can be damaging and the relative humidity in the storage facility is high.
- III. 4-10 mm. polythene bags will exclude or retain moisture, but still allow exchange of O₂ and CO₂ with air outside. Such exchange may be harmful or beneficial depending upon the species.
- IV. When seed moisture content or relative humidity is high, the container must be made of moisture resistant material. Plastic bags are often used as liners for rigid containers.
- V. Choose a container shape and stacking arrangement which facilitates uniform temperature and aeration throughout the storage facility.
- VI. Some containers may be made of substances that are harmful to tree seed. Unproven containers should be tested for toxicity before using.

5.6 Care During Storage

- I. Some seeds are attacked by a large number of insect

- species while other by a few. It is, therefore, advisable to store different types of seeds separately. This helps in better management of insect-pests.
- ii. Seed should be inspected at fortnightly intervals. In the event of detection of any insect infection, seed should be fumigated under air-tight condition with suitable fumigant.
 - iii. After fumigation seed godown should be aerated and thoroughly cleaned with brush or hard broom sticks to remove all dead, moribund insects.
 - iv. A container that is easy to open and close is desirable when quantities of seed are likely to be added or removed repeatedly. Open only when necessary to minimize temperature and relative humidity fluctuation. Alternately, store seed in small containers so that the entire contents can be stored or emptied at once to avoid temperature and humidity variation.
 - v. Fill containers completely to ensure minimum exchange of moisture between the seed and the entrapped air.
 - vi. When seed moisture content or relative humidity is high, the container must be made of moisture resistant material. When seeds are fragile and easily damaged, a rigid-walled container should be used. Moisture-proof plastic bags are often used as liners for rigid containers.
 - vii. Choose a container shape and stacking arrangement which facilitates uniform temperature and aeration throughout the storage facility.
 - viii. Some containers may be made of substances that are harmful to tree and shrub seeds. Unproven containers should be tested for toxicity.
 - ix. The method of storage selected provides the gross

storage conditions. A wise choice of container insures maximum benefit from those conditions where it counts most, immediately around the seed.

- x. For special purposes, moisture content within tightly closed seed container can be maintained with silica gel beads, charcoal, or various chemical solutions. Care is necessary in using any chemical for regulating humidity and seed moisture content since the material may directly affect the seeds or cause excessive reduction in moisture content.
- xi. Without proper care, vitality can easily be impaired or lost in the interval between storage and sowing. Maintenance of storage conditions during transit would be ideal, but often not be employed, however, to get seed to its destination in good condition.
- xii. High and fluctuating temperatures and adverse humidity are the chief causes of viability losses during shipment. Proper packaging can overcome most, if not all, moisture problems and will also help moderate exposure to temperature extremes. Moisture content of dry seeds can be maintained by sealing them in plastic, foil or moisture-resistant Kraft bags or in rigid containers such as vials, plastic bottles or tins. Seeds requiring high moisture should be well mixed in moistened fine sphagnum-moss, peat or sawdust and placed in water-resistant containers. A mixture of equal weights of dry packing material and water will provide adequate moisture.

For some species, a chemical germination inhibitor may be added to the moistened medium. Large, moist seeds can be sealed individually with paraffin or latex. During cool weather, some nuts can withstand surface drying and open shipment in boxes or sacks.

5.7 Seed Packing and Packing Materials

Seed should be packed in smaller units to avoid risk of physical gradients, particularly vapour pressure which arise in large bulks. Packing and storage in smaller units makes identification, transportation, handling and marketing easier.

Packaging selected for a seed shipment depends on the quantity to be shipped, time in transit, mode of transport, and expected weather conditions. Helpful practices include.

- i. Double-wrap the seed. Enclose the seed container in a sturdy, preferably rigid, outer container.
- ii. Small or moderate size containers generally withstand shipment better than large containers.
- iii. Fill containers completely to minimize air content and jostling of seed during shipment.
- iv. All packages should bear a good identifying label on the innermost covering and another one within the container.
- v. For long distances, shipment of sensitive seeds by air is desirable. Hermetically sealed containers may explode at high altitudes.
- vi. Seed packages should permit ready opening and reclosing if destined for export to a country requiring fumigation.
- vii. With adequate packaging and carefully planned shipment, most lots would arrive at their destination in good condition. It is wise to send adequate instructions on post shipment care with each lot.

6. SEED DORMANCY

6.1. Definition

Sound and uninjured seeds fail to germinate even placed under conditions considered adequate for germination. Such seeds are said to be dormant. Seed dormancy, therefore, can be defined as the state of inhibited growth due to internal factors.

6.2. Types of Seed Dormancy

Dormancy is a vague and relative term, because the mechanisms restricting germinations vary widely by species. Seed dormancy can be classified into.

6.2.1. Physiological Dormancy

Physiological dormancy, also known as endogenous or internal dormancy, is related to the physiological condition of anatomically mature seed which cannot grow until certain physiological changes are induced after seed disposal or collection. Physiological changes are often necessary in the embryo but for some species changes must occur in the cotyledons or endosperm. Physiological dormancy would also include those seeds where a germination inhibitor is present in the seed. The internal change taking place while alleviating physiological dormancy have been widely investigated but underlying causes are still little understood.

6.2.2. Physical Dormancy

Physical dormancy also called imposed or morphological dormancy is related to a morphological condition of the seed which

prevents germination. Such instances may be met with those seeds with an immature embryo, with hard and impermeable seed coat or other structure like endocarp which prevents germination.

6.3. Factors and Causes of Seed Dormancy

Non dormant seeds readily pass through three germination stages namely (a) imbibition of water, (b) activation of metabolic processes and (c) growth of embryo. A state of dormancy exists if any of these stages are blocked.

6.4. Factors Responsible for Seed Dormancy

Seed Coat Factors

- a. Seed coat impermeable to water.
- b. Seed coat impermeable to oxygen.
- c. Mechanically resistant seed coat.

Embryo Factors

- a. Dormant embryo
- b. Immature/rudimentary embryo.

Inhibitors/Regulators

- a. Presence of germination inhibitors.
- b. Absence of certain growth regulators/hormones

6.5. Breaking Seed Dormancy

Different methods have been devised by seed scientists and technologists to break the dormancy of seeds. Some of the simple and widely used methods are described below:

6.5.1 Scarification

Any treatment physical or chemical, that weakens the seed coat is called scarification. This method is applied when dormancy is imposed by hard seed coat. Various types of scarification are:

6.5.1.1 Acid Scarification

Soaking in concentrated sulphuric acid is the most common method of treating seeds like acacias, ipil ipil, etc. The effect on the seed coat is similar to that of prolonged boiling and the seed coat is left dull and shallowly pitted. It is an effective method than boiling water for many African acacias. This scarification technique requires a supply of commercial grade sulphuric acid (95%), resistant containers, wire containers and screens, and an abundant supply of water for rinsing the seeds after treatment.

Safety precautions require strict attentions as concentrated sulphuric acid is dangerous to people and materials. It should be handled at all times with great care. When mixed with water it produces a violent exothermic reaction. Water should never be added to the acid as it may boil explosively. If a dilute mixture is required the acid must be allowed to trickle slowly into stirred water. All operators should wear acid-resistant protective clothing, gloves and eye protection. A solution of sodium or potassium bicarbonate should be kept readily available as an antidote to accidental skin contact with the acid.

6.5.1.2 Physical Scarification

Scarification aims to abrade the seed coat so as to permit water absorption. Physical scarification may be performed by hand, especially for laboratory purposes, or by the specially designed machines.

6.5.1.3 Manual Scarification

Piercing, chipping, nicking or filing the testa of individual seeds with a mounted needle, knife, handfile or abrasive paper is a technique especially suitable for small quantities of seed. Scarification of the shoulder of the seed one quarter of the way round the circumference from the micropyle or the removal of one square millimeter of seed coat at the cotyledon end is sufficient. This is usually considered to be the most reliable method of pretreatment and the percentage germination capacity. Hand scarification is recommended as a method for pre-treating acacia seeds before germination tests. However, instances have been recorded when chipping the seed coat has proved detrimental to germination.

6.5.1.4 Mechanical Scarification

A number of commercial machines are available which operate on the principle of tumbling or blowing the seeds against an abrasive surface in a drum or mixer. The machines may be portable hand-operated models or large, less mobile machines driven by an electric motor. Various models e. g. the Forsberg scarifier, are advertised by seed equipment companies.

6.6 Temperature Treatment

When the dormancy is due to embryo factor, seeds are subjected to stratification, i.e. incubating seeds at low temperature (0-5°C) over a moist substratum for a specific period before placing them at optimum temperature required for germination.

Some seeds require a brief period of incubation (at 40°C to 50°C) before germinating at required temperature. Care should be taken that the moisture content of the seed is not more than 15 percent.

Hot water treatment is also an affective method for breaking hard seedness. For this purpose seeds are soaked in water. Care should be taken in deciding the treatment duration.

6.7 Light Treatment

Some seeds do not germinate in dark, thus providing continuous or periodic exposure to light is essential. In such cases seeds are either placed under red light initially and then germinated in dark or they may be germinated under continuous white light.

6.8 Treatment with Growth Regulators

Since endogenous dormancy may be due to the presence of germinating inhibitors, application of low levels of growth regulators and other chemicals may break the dormancy. Various groups of chemicals have been reported to break seed dormancy in agricultural crop seeds. Most widely, however, used chemicals are gibberellins and kinetins. Out of several gibberellins, gibberellic acid (GA_3) has been found to be the most effective in breaking seed dormancy. Seeds are either soaked in a solution of 100 ppm (GA_3) or 10-50 pp.m. kinetin before transferring to aqueous substrata or they are germinated in the substratum moistened with GA_3 or kinetin solution.

Among other chemicals, potassium nitrate (0.2%) and thiourea (0.5 to 3%) are used to break seed dormancy. Potassium nitrate ($KN^{\circ}3$) breaks dormancy of light requiring seeds in dark. Thiourea breaks dormancy of both light and chilling requiring seed.

6.9 Dry Heat

Hardcoat seeds especially acacias have been pretreated by applying dry heat, frequently by placing the seed in an oven maintained at the desired temperature. Dry heat has generally been less effective than hot water or scarification pretreatment but works well with agricultural legumes.

6.10 Microwave Energy

This is a recently developed technique in which the seeds are heated by microwave energy. Large quantities of seeds can be treated with exposure times from 20 seconds to 4 minutes. The technique has an effect similar to that of boiling water but the seeds remain dry.

6.11 Specific Methods for Breaking Seed Dormancy

Specific methods recommended for breaking the seed dormancy of important tree species seeds are illustrated in table on next page.

S.No.	Name of Tree	Pre-treatment
1.	<i>Acacia nilotica</i>	Soaking in hot water for 48 hours and allowed to cool for 24 hours prior to sowing. or Passing through alimentary canal of goats/sheep
2.	<i>Acacia catechu</i>	No special pre-sowing treatment is required.
3.	<i>Acacia modesta</i>	Soaking the seed in water for 24-48 hours.
4.	<i>Acacia saligna</i>	Seed can be immersed in boiling water and allowed to cool for 24-48 hours.
5.	<i>Acacia senegal</i>	To hasten germination soak the seed in water for 24-48 hours.
6.	<i>Albizzia lebbek</i>	The seeds should be soaked in boiling water and allowed to cool for 24-hours.
7.	<i>Albizzia procera</i>	The seeds should be soaked in boiling water and allowed to cool for 24 hours.
8.	<i>Azadirachta indica</i>	None
9.	<i>Cassia fistula</i>	Boil seed for 5 minutes before sowing.

S.No.	Name of Tree	Pre-treatment
10.	<i>Casuarina spp</i>	None
11.	<i>Bombax cieba</i>	None
12.	<i>Cedrus deodara</i>	Soak the seed for 2-3 hours in water..
13.	<i>Eucalyptus spp.</i>	None
14.	<i>Dalbergia sissoo</i>	Soaking in water for 24 hours hasten the germination.
15.	<i>Juglans regia</i>	Seeds of most juglans species have dormant embryo and a hard seed coat. Dormancy can be broken by stratifying the seed in plastic bags, moist peat or sand at 34-41°F for 90-120 days. Screening is always necessary to exclude rodents and a suitable fungicide is applied to prevent diseases during stratification.
16.	<i>Lucaena leucocephala</i>	Germination is delayed and reduced by the presence of very thick, tough, waxy layered waterproof seed coat. A satisfactory treatment is to put boiling water on the seeds; allow the seeds and water to cool and pour off the water. Mechanical (clipping the end of seed) and sulphuric acid treatment are also practical methods for handling large quantities of seed.
17.	<i>Melia azedarach</i>	Soaking in water for 12-15 days.
18.	<i>Morus alba</i>	For fall sowing a cold-water soak for 100 hours is beneficial. For spring sowing, stratification in moist sand at 33-41°F for 30-90 days improves germination.
19.	<i>Parkinsonia aculeata</i>	Scarification followed by soaking in hot water for one day.
20.	<i>Pinus roxburghii</i>	None
21.	<i>Pinus wallichiana</i>	None
22.	<i>Pongamia glabra</i>	Seed should be soaked in boiling water for 24 hours.

S.No.	Name of Tree	Pre-treatment
23.	<i>Prosopis cineraria</i>	Soaking in water for 24 hours.
24.	<i>Robinia pseudoacacia</i>	Scarification or by immersing the seed in concentrated sulphuric acid for 20 minutes Soaking of the seed in boiling water for 2 to 5 minutes and subsequent soaking in water at room temperature for 8-10 hours.
25.	<i>Zizyphus mauritiana</i>	Both stratification in moist sand for 60 to 90 days at 41°F and <u>scarification</u> for 6 hours or Soaking in water for 10-15 days.

7.

SEED TESTING

7.1 Objectives

The science of seed testing, that is, the science of evaluating the planting value of seeds has been developed to achieve the following objectives for minimizing the risks of planting low quality seeds:-

- i. To determine their quality, that is, their suitability for planting.
- ii. To identify seed quality problems and their probable cause.
- iii. To determine the need for drying and processing and specific procedures that should be used.
- iv. To determine if seed meets established quality standards or labelling specifications.
- v. To establish quality and provide a basis for price and consumer discrimination among lots in the market.

7.2 Seed Purity Test

When we buy seed, we expect to receive good seed and not a mixture of analytically pure seed with a high percentage of chaff, straw, weeds and other materials. In practice it is not possible to remove all these admixtures completely with the use of cleaning machines; some will always remain, and the purity analysis is the test to determine exactly how much, even if the percentage is very low.

Sub samples are taken from the submitted sample for the purity analysis. The object is to obtain a sub sample (working sample) that is of the same composition as the submitted sample but will take less time to analyze. Purity tests are carried out with the help of size screens, laboratory blowers and elevate working surfaces, commonly called "purity boards". For small seed such as those of Eucalyptus, willow etc. magnifying glass and binocular microscope are used. Balances intended for weighing samples, sub samples, fractions and components of working sample. Working sample is divided into four components as follow:-

- (a) Pure seed of test species.
- (b) Other species seeds
- (c) Weed seeds - not so important for tree and shrub seed, has potential value for nurseries.
- (d) Inert matter includes leaves, sand, soil, stones, pieces of bark and other non-seed materials. Each of the above component is expressed as percentage by weight of the original working sample and is calculated by using the following simple mathematical formula:

$$\text{purity \%} = \frac{\text{weight of component}}{\text{Total working sample weight}} \times 100$$

For example, a working sample of *Acacia nilotica* weighed 61.15 gms and the pure seed component weighed 56.36 gms. The purity of the lot will be:

$$\text{Purity \%} = \frac{56.37}{61.51} \times 100 = 91.6\%$$

The purity test is usually the first test the seed analyst performs and it provides pure seeds for other tests. Purity is often slow and meticulous. Large seeds such as those of kikar and oak are high in purity. Purity of small

seeds such as those of Eucalyptus on the other hand, are often low because the inert matter component is difficult to remove.

7.3 Provenance Determination

Some crops produced in a particular area have characteristics that are a result of the environment, as determined by temperature, rainfall and altitude. Certain varieties are often grown to the exclusion of other varieties, because of their adaptation to local conditions. In some cases, plants grown from seed produce in one region may be susceptible to disease that is prevalent in another region and conversely, certain areas may have diseases that would be harmful if introduced into another region. Because of these factors, it is important to know the origin of certain crop seed (i.e. the region where it was harvested from); the provenance.

Provenance is deduced from the evidence, taken as a whole, provided by the impurities in the sample and the characteristics of the pure seed.

- (a) Seeds of species with a known limited geographical distribution provide the most important clues, but an association of seeds of certain species having a wider distribution may be almost as important, even in the absence of seeds with a precise provenance.
- (b) Other impurities, such as stones, soil particles, snail shells and other animal matter may provide important clues.
- (c) Characteristics of the pure seed, such as colour and size may sometimes provide evidence, the following propositions are taken into account:-
 - I. The fact that a species is characteristics of a particular area does not necessarily mean that its seeds may not be found in seed lots harvested elsewhere.

- ii. Seed samples from same provenance area may contain different associations of impurities, depending on the kind of pure seed, season, date and method of harvesting, the method and efficacy of cleaning and on the particular locality within the provenance area where the seed was harvested.
- iii. The frequency of occurrence of the impurities may also vary due to these factors.

In a sample with a high degree of purity, the presence of certain species is often of greater significance than the actual number of seeds of these species.

To make a provenance determination, the sample submitted as a whole is examined, unless a firm opinion can be formed after examination of only a part of it

Impurities are separated, identified and counted. The characteristics of the pure seed are noted and, if relevant, measured. On the evidence so found, an opinion is formed as to the provenance of the sample.

7.4 Moisture Determination

The moisture content of seeds is one of the important factors influencing the period of time seeds will maintain their viability. High moisture content at harvest can increase the liability of the seed to threshing damage and later, in storage. Viability decreases more rapidly at high moisture content because of mold growth, heating damage aging and increased insect damage. Therefore, it is of great value to know the moisture content of the seed directly after harvest and when necessary also after artificial drying. In the seed trade a certain moisture percentage is allowed, depending upon the kind of seed. The object of a analysis is to find out the moisture content of a seed lot at the time it was sampled. The samples must be handled in such a way that its initial moisture content is retained. To that end it

should be packed in a moisture proof container (metal or plastic), be submitted to the seed testing station without delay and analysed promptly upon arrival. During the determination, exposure of the seed to the laboratory atmosphere shall be reduced to the absolute minimum. For species which do not require grinding not more than 2 minutes may elapse from the time the sample is removed from the container or the plastic package in which it was received until the working sample is enclosed in the drying container.

7.5 Seed Weight

Seed weight is very useful in calculating sowing rates for nursery beds and direct seeding. It is affected by size, moisture content and the proportion of filled seeds in the lot. Weight is normally expressed as the weight of 1000 pure seeds. Although weight can be determined simply by counting out 1000 seeds and weight them. ISTA (International Seed Testing Association) specifies 8 random samples of 100 seeds each from the pure seed component. Some laboratories use two or more sample of 500 seeds each. More samples should be taken from the more variable seed lots. When replicates vary more than 10% of their mean, additional, samples should be weighed. All weights should be accurate to three significant digits.

The counting of samples can be done by hand or with counting boards. While using counting boards seeds are spread over the top board to place one seed in each hole. The spring holding top board is then moved to the right until its holes line up with an other set in the bottom, the seeds then drop through. Some laboratories use vacuum counters or automatic electronic counters for more rapid work. 100 seeds overcrowd the test substratum, the replicates may be broken up into smaller replicates of 50 or 25 seeds each.

7.6 Germination Test

When a viable, non-dormant seed is provided with a wetted substratum, oxygen and suitable temperature, water is imbibed,

respiration and metabolic events increase and after a certain period of time the radicle emerges from the seed. Thus, moisture, temperature and oxygen are considered as essential factors for seed germination.

In relation to seed quality control programmes, germination is taken as the emergence and development to the seedling to a stage where the presence, absence and formation of essential structures can be assessed, thus indicating whether or not the seedling is able to develop further into a satisfactory plant under favourable conditions in soil. Not all germinable seeds necessarily produce normal seedlings only.

The germination percentage can be calculated at the end of test by using the following formula:

$$\text{Germination percent} = \frac{\text{No. of seeds germinated}}{\text{Total No. of seeds}} \times 100$$

Seeds that germinate abnormally are not included in the germination count. Some laboratories, however, report the percent of abnormal germination and it should always be reported by using the following formula:

$$\text{Abnormal Germination percent} = \frac{\text{No. of abnormal seeds}}{\text{Total No. of seeds}} \times 100$$

7.7 Calculation of Seed Rates

The nurseryman can take laboratory test results; plug in his desired seedling density and use expected tree percent to arrive at the amount of seed to sow per unit of nursery bed area. Several methods of calculating of seed rate can be used, but the commonly used formula is given below:

$$W = \frac{(A) (d)}{(n) (p) (q) (t)}$$

Whereas:

W = Wt. of seed in Kg required for the bed unit.

A = Area of bed unit in sqm.

d = Desired final seedling density in No./sq.m.

n = No. of seeds per Kg determined at sowing time.

P = Percent purity divided by 100.

q = Percent germination divided by 100.

t = Expected tree percent divided by 100.

(In the above formula pure live seed (PLS/100) may be substituted for (p) (q).

EXAMPLE

Calculate the amount of seed (W) required to sow in 400 square meter bed (A) to get a density (d) of 20 seedlings per square meter with 8000 per Kg (n), 96% purity (p), 88% germination (q) and an estimated tree percent (t) of 70%.

SOLUTION

$$W = \frac{(A) (d)}{(n) (p) (q) (t)}$$

$$= \frac{400 \times 20}{8000 \times 0.96 \times 0.88 \times 0.70}$$

$$= \frac{8000}{4731} = 1.7 \text{ Kg}$$

Two possible sources of error should be pointed out.

First, the number of seeds per Kg must be based on the seed moisture content at the time of sowing. For stratified seed this number will be much less than for dry seed. The nurserymen may have to take a new determination of seed per unit weight on the spot. A second source of error could be poor mixing of the seed lot. Uneven bed density could result if some parts or containers of a given lot differ in viability, purity or size. Very thorough mixing of the entire lot prior to sowing is required. If two small lots with differing characteristics are to be combined for some reasons, they must be thoroughly blended to obtain even bed density. Calculation of seeding operations are complicated by many other factors.

Seed test results can have other applications for nurserymen or seedmen. Low vigour or quality indicates that the storage potential of the lot is probably low. It should be sown or sold immediately before it deteriorates further. Lots of higher vigour may be stored for future seed stocks. Similar action may be desirable if the report shows considerable processing damage. Low germination percentage may also be due to greater dormancy than usual, so longer stratification time may be required.

8.

SEED PESTS

8.1 Common Seed Pests

During storage seed pests are one of the most important biotic factors which adversely affect the seeds. The seed pests have also negative effect on seed production, forest regeneration and raising of nurseries on large scale. Most of the pests destroy immature, unripened and moist seed. Some pests also destroy the seeds when these are in cones, pods or even in fruits on standing trees. Some of the important pests of common forest tree species are:

Pest	Damage
<i>Coccotrypes carpophagus</i>	Fruit of <i>Acacia catechu</i>
<i>Baris cordinae</i>	Fruit of <i>Cordia myxa</i>
<i>Calandra glandium</i>	Acorns of <i>Quercus ditatata</i> Acorns of <i>Q. incana</i> Acorns of <i>Q. glauca</i>
<i>Bruchus bilineatopygus</i>	Seed of <i>Albizzia procera</i>
<i>Pisorum</i>	Seed of <i>Albizzia lebbek</i> Seed of <i>Cassia fistula</i> Seed of <i>Dalbergia sissoo</i>
<i>Sparsemaculatus</i>	Seed of <i>Dalbergia sissoo</i>

Pest	Damage
Pachymerus gonagra	Seed of <i>Acacia nilotica</i> Seed of <i>Albizzia lebbek</i> Seed of <i>Cassia fistula</i>
Dioryetria abietella	Seed of <i>Pinus gerardiana</i> Seed of <i>P. wallichiana</i> Seed of <i>P. roxburghii</i> Seed of <i>Abies pindrow</i> Seed of <i>Cedrus deodara</i>
Euzophera cedrella	Seed of <i>Pinus gerardiana</i>
Hypsiphyla robusta	Seed of <i>Cedrella toona</i>
Sitotroga cereallela	Bomboo seed

8.2 Control of Pests During Seed Storage

Following are preventive and curative measures for seed pests:-

8.2.1 Sanitation

Sanitation is one of the most effective ways of preventing attacks of seed pests. The following sanitation measures should be taken before storage of seeds.

- ◆ Collected seeds should be cleaned and dried in the sun as moisture contents of 15 to 20% are very favourable for the existence of seed weevils.
- ◆ Store room/receptacles/bins should be thoroughly cleaned.
- ◆ Doors and windows should be screened to avoid entry of seed pests.

- ◆ Crevices free receptacles/bins aids in sanitation.

8.2.2 Disinfection of Stores

Disinfection of store room is very important before storage. Disinfection can be done as follows:

- ☆ Spray with BHC or Malathion
- ☆ Fumigation with EDCT/Carbon disulphide
- ☆ Heating with charcoal.

8.3 Treatment of Seeds

If any attack of seed pests is observed the following control methods should be applied:

- ◆ Usually seeds are spread in the sun outside the store room. Adults fly away and larvae go down clearing the seeds.
- ◆ If room temperature is raised upto 125-130°F for 3 to 6 hours most insects are killed without affecting the viability of seeds.
- ◆ Cooling of room upto 40°F makes all insect inactive, avoiding damage in the stored seeds.

8.4 Fumigation

For fumigation store room/receptacle/bin is made air tight. Fumigants are applied with great care. Storage is kept closed for 72 hours. The following fumigants can be used:-

a) Phosphine

It is available in the form of tablets in air tight tubes with brand name phostoxin. When exposed to air phosphine gas

is released which kills all sorts of insects instantly, 20-25 tablets per 1000 cft space.

b) EDCT-Ethylene Dichloride Carbon Tetrachloride is available in the form of a mixture. It is poured into a shallow vessel and allowed to evaporate. EDCT is used in a dose of 1-4 lbs. per 1000 cft space.

c) Carbon disulphide

It is also available in a mixture. The mixture is poured into a shallow vessel and allowed to evaporate. It is used in a dose of 2 lbs. per 1000 cft space.

d) Contact spray

For contact poisoning, seeds are sprayed with any one of the following insecticides and doses:-

- ◆ BHC 12.5% WP, 0.05-0.1% dose (4-8gm per litre of water)
- ◆ Malathion 57% EC 0.05-0.1% dose (10 ml per 5-10 litres of water)
- ◆ Diazinon 60% EC, 0.05-0.1% dose (10ml per 6-12 litres of water)
- ◆ DDVP 50% EC, 0.05-1-0.1% dose (10ml per 5-10 litres of water)

9.

SEED CERTIFICATION

Seed certification is a legally sanctioned system for quality control of seed multiplication and production which consists of the following control measures:

- ◆ An administrative check on the origin of propagating material for the purposes of determining trueness to varietal purity (genetic purity).
- ◆ Field inspection - An evaluation of the growing crop for obtaining data on trueness to varietal purity, isolation of seed crop to prevent cross pollination, mechanical admixtures, and disease dissemination; and crop conditions as regards diseases, objectionable weeds and admixtures.
- ◆ Supervision of silvicultural and commercial operations of harvesting, storage, transport and processing with a view to preserving the identity and quality of the lots.
- ◆ Sample inspection - An evaluation of the planting quality by a laboratory test of a representative sample drawn by the certification agency that aims at determining the percentage of germination, moisture content, weed-seed content, admixture and purity.
- ◆ Bulk inspection - An evaluation of the lot for the purpose of checking homogeneity of the bulk as compared with the sample inspected.
- ◆ Control plot testing - Samples drawn both from the source seed and the final seed produced can be grown in the field alongwith standard samples of the variety in

question. By comparison, it can be determined whether the varietal purity and health of the produced seed are equal to results based on inspection.

9.1 Objectives

- ☆ The systematic increase of superior varieties.
- ☆ The Identification of new varieties and their rapid increase under appropriate and generally accepted names.
- ☆ Provision of a continuing supply of comparable material by careful maintenance.

9.2 Seed Certification Agency

A seed certification agency should not be involved in production and marketing of seeds.

- ◆ A seed certification agency should have autonomy.
- ◆ The seed certification standards and procedures adapted by seed certification agency should be uniform, that is the same standards and procedures should be adopted throughout the country.
- ◆ A seed certification agency should be closely associated with the technical institutes. Its relationship with other institutes should be clearly defined.
- ◆ Its long-term objective should be to operate on a no-profit no-loss basis
- ◆ Adequate staff trained in seed certification should be maintained by the certification agency.
- ◆ It should have provision for creating adequate facilities for ensuring timely and thorough inspection.

- ▶ It should serve the interests of seed producers and buyers.

9.3 Organization of A Seed Certification Agency

A skeleton staff pattern may be as given below:

Board of Directors	
Technical staff	Other staff
:	(Ministerial)
Chief Seed Certification Officer	:
:	Accounts Officer
Regional seed Certification Officer	:
:	Accountant
Seed Certification Officer	:
:	Clerks
Seed Certification Inspector	:
	Peons, Drivers etc

9.4 Duties & Responsibilities of Seed Certification Officers

- ☆ To arrange for suitable application, inspection and report forms.
- ☆ To identify sources of authentic breeder's seed that can be used as the basis for further multiplication.
- ☆ To ensure that all basic certified seed production has originated from acceptable sources of breeder's seed.
- ☆ To ensure, through field inspection, that the prescribed minimum standard for isolation, planting ratio, rouging

and other requirements, as specified in the seed certification standards, are met.

- ☆ To assist seed growers and producers in obtaining suitable planting seed, and in planting their seed properly. This is especially true in the case of hybrid seed production.
- ☆ To assist the seed producer at the time of harvesting, drying and processing, to ensure that these are done correctly. This is particularly true for new producers who are just gaining experience. It should not be necessary to supervise every step of the operation once the seedsmen have had adequate experience in the programme.
- ☆ To sample and inspect seed lots and submit such samples to the seed testing laboratory in order to ensure that the prescribed seed standards are met.
- ☆ To issue appropriate seed certification tags for seed lots which pass inspection. Ultimately, more responsibility of this kind should be borne by the seedsman himself.
- ☆ To carry out educational programmes designed to promote the use of certified seed and to encourage seedsmen to develop their own promotional programmes.
- ☆ To maintain adequate records so that the eligibility of specific lots can be determined in subsequent years.
- ☆ To operate in such a way as to ensure a close working relationship between certified seed growers, dealers, research personnel, government officials, and others with an interest in certified seed.
- ☆ To investigate vigorously any violation of prescribed

standards, or complaints from users of certified seed and subsequently to take appropriate corrective actions.

9.5 Tags, Labels and Seals

- (a) All seed stocks when sold as certified shall have an official tag, to be supplied by the certification agency, properly affixed to each container. The certification tag shall contain the following particulars:-
- ◆ Name and address of the certification agency.
 - ◆ Kind and variety of the seed.
 - ◆ Statement to the effect that the seed of the variety/kind is genetically pure.
 - ◆ Lot number, or other identifying mark of the seed.
 - ◆ Name and address of the certified seed procedure.
 - ◆ Date of issue of the certificate and of its validity, including the period during which the seed shall be used for sowing.
 - ◆ An appropriate sign to designate certified seed.
 - ◆ An appropriate word denoting the certified class designation of the seed.
 - ◆ A statement indicating that certified seed sold after the expiry of the validity period shall not be considered as certified seed and the risk of using such seed shall be on the purchaser of the seed if the seal, or the certification tag, has been tampered with.
- (b) The container of the certified seed shall carry a seal of such material and in such form as the certification agency may

determine, and no container carrying a certification tag shall be sold as certified seed, if the tag or seal has either been tampered with or removed.

- (c) All official certification tags must be obtained from the certification agency and must be affixed to seed containers by either the producer and/or a representative of the certification agency as may be prescribed. The seed container shall be sealed as prescribed by the certification agency.

ANNEXURE - I

EQUIPMENT REQUIRED FOR SEED COLLECTION

- ◆ Stationery e.g. note books, recording forms, pens and pencils.
- ◆ Binoculars.
- ◆ Camera and accessories.
- ◆ Markers (of different colour), coloured plastic ribbons.
- ◆ Tree measuring instruments e.g. diameter tape, height measuring instruments and length measuring tape.
- ◆ Soil chart, pH testing kit.
- ◆ Compass.
- ◆ Altimeter.
- ◆ Hand lens.
- ◆ Seed bags.
- ◆ Seed collecting instruments, saws, strings, ropes, ladders etc.
- ◆ Safety gear e.g. steel capped boots, leather gloves, safety helmet, safety belt.

- ◆ Water proof tags for labelling each seed lot.
- ◆ Tags for botanical specimens.
- ◆ Plant press for botanical specimens.

ANNEXURE-II

**List of tree seeds their seeding period,
viability and No. of seeds per Kg.**

Sr. No	Species.	Seeding period	Viability	No.of Seeds per Kg.
1.	<i>Acacia nilotica</i>	May-June	upto one year	6600-11000
2.	<i>Acacia catechu</i>	Dec-Feb.	upto one year	32000-35000
3.	<i>Acacia modesta</i>	Jan-Feb.	upto one year	21160 approx.
4.	<i>Albizzia lebbek</i>	Jan -March	upto one year	4940-12430
5.	<i>Albizzia procera</i>	Feb-May	upto one year	17640-29980
6.	<i>Azadirachta indica</i>	June-August	only when fresh	2880-4400
7.	<i>Bambusa arundinacea</i>	Feb-April	upto one year	71000-105000
8.	<i>Bambusa polymorpha</i>	March	upto one year	49000-58000
9.	<i>Bauhinia alba</i>	Feb-March	upto one year	3530 approx.
10.	<i>Bauhinia purpurea</i>	Feb-March	Best upto one year	3600 approx.
11.	<i>Bauhinia variegata</i>	May-June	-do-	2470-3520
12.	<i>Bischofia javanica</i>	Dec-January	only when fresh	91710 approx.
13.	<i>Butea frundosa</i>	May-June	-do-	1023 approx.

Sr. No	Species.	Seeding period	Viability	No. of Seeds per Kg.
14.	<i>Callistemon lanceol-atus</i>	June-July	-do-	Minute seed.
15.	<i>Casuarina equisetifolia</i>	June-Dec.	3 to 4 months	660000-990000
16.	<i>Cassia fistula</i>	Jun-April	Best upto 2 years.	5500-6070
17.	<i>Cassia glauca</i>	April - May	upto one year	31750-35270
18.	<i>Cedrela toona</i>	May June	Only when fresh	282000-423000
19.	<i>Cedrus deodara</i>	Sept - Nov.	-do-	7050 - 9170
20.	<i>Cordia myxa</i>	June August	upto one year	4230 - 5460
21.	<i>Cupressus sempervirens</i>	Nov - Dec.	upto 2 years	110000-154000
22.	<i>Cupressus torulosa</i>	May Sept.	Best when fresh	165000-396000
23.	<i>Dalbergia Latifolia</i>	Dec - April	upto one year	20000
24.	<i>Dalbergia sissoo</i>	Dec January	upto one year	13220 - 15870
25.	<i>Dondonea viscosa</i>	May - June	upto one year	70400 -105600
26.	<i>Ehretia acuminata</i>	Nov - Dec.	Only when fresh	46000 approx.
27.	<i>Eucalyptus camaldulensis</i>	Oct - Feb.	upto 2 years	330000-660000
28.	<i>Eucalyptus citriodora</i>	May - June	upto one year	57000 - 99000
29.	<i>Eucalyptus crebra</i>	Oct - Dec.	upto one year	330000approx.
30.	<i>Eucalyptus tereticornis</i>	Sep - Oct.	upto one year	367400approx.
31.	<i>Syzygium comuni</i>	Jul - Aug.	Only when fresh	1166 approx.

Sr. No	Species.	Seeding period	Viability	No. of Seeds per Kg.
32.	<i>Ficus infectoria</i>	Mar - May	Only when fresh	Minute seed.
33.	<i>Ficus religiosa</i>	Mar - June	Only when fresh	Minute seed.
34.	<i>Ficus bengalensis</i>	Mar - May	Only when fresh	Minute seed.
35.	<i>Gmelina arborea</i>	May - June	Only when fresh	1410 - 2640
36.	<i>Jacoranda ovalifolia</i>	Feb - Mar.	Upto one year	38800 approx.
37.	<i>Lagerstroemia indica</i>	Nov - Dec.	Upto one year.	17630 approx.
38.	<i>Leucaena glauca</i>	May - Dec.	Upto 2 years.	39930
39.	<i>Leucaena Leococephala</i>	May - Dec.	Upto 2 years.	28570 approx.
40.	<i>Melia azedarach</i>	Jan - Feb.	Upto one year	1440 approx.
41.	<i>Morus alba</i>	Mar - May	Best when fresh	42300 - 45800
42.	<i>Nyctanthes arbortristis</i>	Apr - May	Only when fresh	7190 approx.
43.	<i>Olea cuspidata</i>	Sep - Dec.	Upto 2 years.	5820 - 11780
44.	<i>Parkinsonia aculeata</i>	May July	Upto 2 years	12320 approx.
45.	<i>Pinus halepensis</i>	Oct - Nov.	Upto 2 years	48400 - 88000
46.	<i>Pinus wallichiana</i>	Sep - Nov.	Upto 18 months.	12340 approx.
47.	<i>Pongamia glabra</i>	Apr - June	Upto one year.	1540 - 1650
48.	<i>Prosopis cineraria</i>	May - June	Upto 18 months	27160 - 28600
49.	<i>Prosopis Cineraria</i>	June - Aug.	Best upto one year	27160 - 28600

Sr. No	Species.	Seeding period	Viability	No.of Seeds per Kg.
50.	<i>Bombax cieba</i>	Apr - May	Upto one year	26000 - 32000
51.	<i>Tamarix aphylla</i>	Sep - Dec.	Very low even when fresh	481000 approx.
52.	<i>Tecoma stans</i>	Nov & Mar (Twice)	Only one year	136000 approx.
53.	<i>Tecoma undulata</i>	May - July	Upto one year	85000 approx.
54.	<i>Terminalia arjuna</i>	Feb - May	Only when fresh	520 approx.
55.	<i>Terminalia belerica</i>	Nov - Feb.	Only when fresh	1760242approx.
56.	<i>Zizyphus mauri-tiana</i>	Mar - Apr.	Upto 2 years	1020 (Dry) approx.
57.	<i>Zizyphus nummularia</i>	Oct - Nov.	Upto 2 years	2360 (Dry depulped) approx.

ANNEXURE - III

GERMINATION %AGE OF SOME IMPORTANT FOREST TREE SPECIES

S.No.	Scientific name of the species	Local name	Germination %age	Seeding age (year)
1.	<i>Acacia nilotica</i>	Kikar, babul	50 - 90	5 - 7
2.	<i>Acacia catechu</i>	Kutch, Khair	70 - 75	very early
3.	<i>A. modesta</i>	Phulai	60 - 90	early
4.	<i>Albizia lebbek</i>	Black siris	30 - 90	early
5.	<i>Azadirachta indica</i>	Neem	70 - 75	early
6.	<i>Casurina equisetifolia</i>	Jao	40 - 50	4 - 5
7.	<i>C. glauca</i>	Jao	40 - 50	4 - 5
8.	<i>Cedrus deodara</i>	Deodar	50 - 60	30 - 45
9.	<i>Dalbergia sissoo</i>	Shisham	70	3 - 5
10.	<i>Euc. camaldulensis</i>	Sufaida	50 - 90	30 - 45
11.	<i>Euc. citriodora</i>	Lemon sufaida	45 - 50	5 - 15
12.	<i>Euc. tereticornis</i>	Sufaida	upto 92	5 - 15
13.	<i>Melia azedarach</i>	Dhrek/ Bakain	65	early
14.	<i>Parkinsonia aculeata</i>	Parkinsonia	85 - 90	2 - 4
15.	<i>Pinus roxburghii</i>	Chir	75 - 85	35 - 40
16.	<i>Pinus wallichiana</i>	Kail	70 - 75	35 - 40
17.	<i>Pongamia glabra</i>	Sukh chain	75	early
18.	<i>Prosopis juliflora</i>	Mesquite	65 - 90	3 - 4
19.	<i>Prosopis cineraria</i>	Jand	46 - 66	5 - 11
20.	<i>Robinia pseudoacacia</i>	Robinia	65 - 75	6
21.	<i>Zizyphus mauritiana</i>	Beri	35 - 90	5 - 6

Source, Magini, E & N.P. Tulstrup (1955). Tree Seed Notes F.A.O. Rome.

Suggested Readings

1. Agrawal, R.L. (1982) Seed Technology - Oxford and IBH Publishing Co, India.
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3. Doran, J.C. et al. (1983) Hand Book on Seeds of dry Zone Acacias. FAO Rome.
4. Iqbal, Z. (1994) A Manual for Seed Technologists. P.F.R.I, Publication No. 119; P.F.R.I, Faisalabad.
5. Ismail, M and Wali-ur-Rehman. Seed pests of Forest Tree Species and their Control (Unpublished paper) P.F.I. Peshawar.
6. Magini, E and N.P. Tulstrup (1955). Tree Seed Notes F.A.O. Rome.
7. Schopmeyer, C.S. (1974). Seeds of Woody Plants in the United States. Agriculture Hand Book No. 450. Forest Service, U.S. Deptt. of Agriculture Washington, D.C.