

COURSE CODE:	FWM 316
COURSE TITLE:	SEED AND FOREST NURSERY TECHNOLOGY
NUMBER OF UNITS:	2 Units
COURSE DURATION:	Two hours per week

COURSE DETAILS:

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COURSE CONTENT:

Seed and its importance, seed collection and procurement, seed certification, records, seed storage, packaging and transport, seed testing, seed dormancy, pre-germination test. Nursery establishment; types of forest nurseries planning, forest nurseries, nursery site selection preparation, nursery layout; seed sowing; care, protection, conditioning of seedlings, quality control, pricking out and transplanting seedlings, raising non-seedling planting stock.

COURSE REQUIREMENTS:

This is a compulsory course for all students in the University. In view of this, students are expected to participate in all the activities and have minimum of 75% attendance to be able to write the final examination.

READING LIST:

SEED AND ITS IMPORTANCE

What is a Seed? – A seed is a matured ovule which contains an embryo and nutritive tissue and it's enclosed in protective layers of tissue (Seed coat).

Importance of Seed

1. The seed is the most practical, economical and commonly used planting material for propagation.
2. The production of seedlings for planting in afforestation, reforestation, agroforestry projects, forest plantation activities is largely dependent upon the germination of available seeds. Seed is of vital importance in silviculture since both artificial and natural regeneration programmes start with it. The need for forest tree seeds has continued to increase with the expanding afforestation and reforestation programmes in the tropics.
3. The use of good quality seed in any planting endeavour is imperative for its success. To raise high quality forest plantations, foresters require healthy seeds capable of producing plants which have ability to grow well on the chosen forest sites when given sound silvicultural treatments.
4. The seed is a very important element in the quality of seedlings produced in the nursery since the quality of the seedling is determined by the genotype of the seed from which it originates. Hence, to produce high quality trees one has to sow high quality seeds. All these underline the importance of seed in silviculture and the need to procure the right quality and quantity well in advance of any plantation scheme.
5. The quality of seed can only be maintained through appropriate seed technologies.

What is Seed Technology?

Seed technology refers to methods or techniques used to maintain the quality of seed from harvest till it is germinated.

Scope of Seed Technology

1. Seed technology encompasses all activities carried out to enhance storability, germinability, vigour and health of the seed.
2. Activities include harvesting, transporting, handling, storage, testing, grading, documentation, processing of seeds and germination of seeds.

SEED COLLECTION AND PROCUREMENT

Seed collection began as an art during the stone age. Later, it became a science when the need for improved seeds arose. The aim of seed collection is to obtain large quantities of seed of the best genetic quality. To minimize seedling variation, seeds should be collected from suitable sources. Thus seeds may be obtained from:

- a) Professional seed collectors or dealers,
- b) Through personal collection or supervision from
 - i) Native forests or plantation,
 - ii) Seed orchards.

To ensure a more certain collection as against the uncertainty of obtaining it from collectors or dealers and to minimize cost which should have been high if imported; it is advisable to collect for oneself or to supervise the collection.

One of the pre-requisites of any seed collector (be he a seed dealer or forestry labourer) should be the ability to identify the particular species of tree from which the seed is to be collected and to know when it should be harvested.

The general procedure, therefore, involves:

1. Determining the location of seed trees,
2. Determining the proper stage of maturity for harvesting the seed,
3. Harvesting or collecting the seed,
4. Extracting the seed from the fruit or plant,
5. Storage until required.

1. LOCATION OF SEED COLLECTION AREAS

Areas where seed crop is sufficiently heavy to make collection profitable should be chosen; and while making this choice, attention should be paid to the abundance and the quality of the seed. Every attempt should be made to collect seeds from suitable sources which go a long way to minimize seedling variation. To this end, **seed orchard** is the ideal place and in the absence of this, pure stands of desired species will also yield good result. It is however highly undesirable to collect seed from isolated trees/plants .e.g. arboretum. Arboretum trees are not ideal for collection of seeds because:

- a) Self-pollination which leads to reduction of seed quality may result,
- b) Cross-pollination which different species may take place.

When a good source has been discovered; trees of good form in the area which produce abundant seed of high quality should be selected and preserved as a future **Seed production area (Seed Stand)** from then on. Such stands are then thinned (rogued) to reduce phenotypic variation among the trees and to give the seed trees sufficient room for proper crown development. Such areas are managed on **Silvicultural rotation** basis. The ideal source of high quality seed in modern silviculture is the **Seed orchard**. This is a plantation of genetically superior trees, isolated to reduce pollination from genetically inferior outside sources and it is intensively managed to produce frequent, abundant and easily harvested seed crops.

* **Seed production areas (Seed Stands)** – are good stands, chosen by phenotypic characteristics, that are thinned or otherwise treated to stimulate seed production; sometimes poor phenotypes are removed.

** **Seed orchard** – is restricted to stands planted for seed production and composed of trees known to be of desirable genotypes from tests of their progeny. They are usually established by vegetative propagation from the chosen genotypes and must be isolated from sources of contaminating pollen.

2. TIME FOR SEED COLLECTION

Harvesting of seeds should take place after the seeds have accumulated sufficient reserve materials and should also be delayed until the state of ripeness is such that harvesting is facilitated. In other words we should not harvest under- and over-matured seeds. Seeds or fruits should usually be collected just as they reached full ripeness and before natural dispersal begins. Seed of broadleaves should be collected during the period between embryo maturation and seed dispersal. This period varies considerably in the different tree species; and with local climatic conditions. The ripeness of the seeds or fruits is often judged by the colour of fruits but the surest check of seed ripeness is to cut fruits into two length-wise with a sharp knife and examine the seeds which occur on the outer surface. By this method, the number of fully developed seeds per fruit can be counted at the same time. A ripe seed is normally known by its hardness and changes in colour. For example, ripe fruit of *Chrysophyllum albidum* is yellow and copiously milky while the immature fruit is greenish grey. Seeds of *Tectona grandis* L.f (Teak) are ready for collection when the lustrous green husks of the fruit turn brown. Green *Nauclea* fruit changes to orange while the pinkish unripe fruit of *Dacryodes edulis* becomes deep blue at maturity. The unripe fruits of *Terminalia ivorensis*, *Terminalia superba* and *Triplochiton scleroxylon* which are green turn grey to brown when ripe.

3. METHODS OF SEED COLLECTION

There is a great variety of methods and equipment available for collection of fruits and the choice depends on a number of factors which may be summarized as follows:

- a) Relative size and number of natural dispersal units and of the units which can be conveniently collected by man.

- b) Characteristics of the fruits: size, number, position and distribution of fruits, resistance of peduncles to shaking, pulling, breaking/cutting, interval between ripening and opening
- c) Characteristics of the tree: diameter, shape and length of bole, bark thickness, shape of crown, size, angle, density and resistance to breakage of branches, density of foliage and depth of crown.
- d) Characteristics of the stand: distribution and stocking of trees (e.g. isolated trees, open or dense stand) density of understorey and ground vegetation.
- e) Characteristics of the site: slope, accessibility.

The various seed collection methods could be classified in to the following:

1. Collection of fallen fruits/seeds from the forest floor.
2. Collection from the crowns of felled trees.
3. Collection from standing trees with access from the ground.
4. Collection from standing trees with access by climbing.
5. Collecting from standing trees with other means of access.

4. HANDLING COLLECTED SEEDS AND FRUITS AND SEED EXTRACTION

After collection, fruits are generally packed in sacks to facilitate transportation to places where they will be subjected to further treatments. Extent to which sacking can be done before deterioration sets in is dependent on the nature of the species. Generally however, immediate transportation after sacking is highly advocated. It is vital importance to label each container/sack thus:

- i) Kind of forest tree seed
- ii) Date of collection
- iii) Place/area in which the seed was collected
- iv) Name and address of collector.

If tree seeds cannot be transported at once to the storage point; provisional storage (emergency storage) should be arranged locally in huts under some kind of shelter which should be dry and airy.

In any case, sacks/containers should not be stored in large amount over a long period. Available means of transportation should be used to convey the harvested fruits and seeds to storage point as soon as it is found possible. Artificial drying should therefore follow as much as possible the natural process. Fruits or tree seeds should undergo progressive/gradual drying by continuous release of moisture from them. Air coming in contact with fruits or seeds should always be drier than the fruits and this is made possible by providing ample air circulation in any room where seeds are stored either naturally or artificially.

When fruits/seeds get to the processing point, the method of treatments will depend chiefly upon the character of the fruit. Examples

1. *Nauclea* and *Tectona grandis* storable in dry condition – so spread out in thin layer in the open sun/airy room until the pulpy exterior thoroughly dries over the seed, then store.
2. *Militia* and *Gmelina* – Macerate fruit in water, mash and stir in water, the seeds are then washed out. The pulp rises and seeds sink. Then spread out the seeds in thin layer to dry.

5. SEED EXTRACTION

In some species it is also the fruits which are sown in the nursery and they are often referred to loosely as 'seeds', e.g. *Tectona grandis* L. f. In the majority of species, however, fruits are collected but seeds are sown, therefore at some stage the seeds must be extracted from their covering of fruits. **The separation of the seed from other parts of the reproductive organ is called SEED EXTRACTION.** Extraction is sometimes done close to the site of collection, but is frequently carried out at a central processing and storage depot. The purpose of extraction and associated processes is the maximum production of clean seed having high viability. The processes involved include one or more of the following: maceration and depulping, drying, separation, tumbling and threshing, de-winging and cleaning.

Seed extraction machines should be centralized between point of collection and distribution to reduce cost of transportation most especially for the bulky fruits. For winged seeds or fruits, methods currently employed include:

1. In small scale – Rub seed through sieve in which mesh is sufficiently small to prevent the passage of seed with attached wings. Seeds could also be rubbed between hands or against a screen or roughened surface or by hand-rubbing in a cloth bag or by rolling them between two cloth sheets or in a cloth bag between a rubber surface below and a roller above.
2. For large quantities of seeds, special de-winging machines are used. De-winging machines range from those which are hand operated to large semi-automatic equipment which gives a continuous output.

Corn mixers and cement mixers are frequently used. Mechanical de-winging, if carelessly done, may cause damage to seeds by crushing, cracking or abrasion. Mechanical injury can be avoided in some cases by moist de-winging.

CLEANING- Seeds can be separated from chaffs by:

- i) Winnowing
- ii) Slowly pouring them from one basket to another through a current of air.
- iii) On large scale basis, mechanical treatments are employed.

SEED STORAGE

Why seed storage

Very often seed cannot be sown immediately after extraction and cleaning because of weather conditions. This is true for most species whose seeds are collected during the dry season. Such seeds must be stored until sowing time at the beginning of the raining season.

The main purpose of traditional seed storage is to secure the supply of good quality seed for a planting programme whenever needed. If sowing time follows immediately after seed collection and processing. Seeds can go directly from the processing unit to the nursery, and storage is not needed.

In seasonal climates with a relatively short planting season sowing time is normally determined by the wish to have palatable size seedlings at the beginning of the planting season. Hence seeds must often be stored during the period from harvest to sowing.

Many species produce seed (or good seeds crops) at long intervals, ranging (e. g. Triplochiton) from a few years to many years. To assure seed supply during the period between two good seed crops; a seed stock should be established (Wang 1975). Even when fruiting is regular and abundant every year, it may be more cost efficient to collect surplus seed to cover several years supply rather to undertake collection every year.

Hence seed storage serves the following purposes

1. Seed stores serve as a buffer between demand and production and has a regular turn over stores for conservation of genetic resources
2. To maintain the viability of the seed at the highest level possible after storage period

NATURAL LONGEVITY OF SEED

The period seeds will remain viable in store (their longevity whether long or short) is determined by their genetic and physiological storage potential and by any deteriorating events or damage prior to or during storage, as well as by the interaction between individual factors and also quality at the time of collection.

In other words, the period for seed to remain without viable germination is greatly affected by its quality at the time of collection, its treatment between collection and storage and the condition in which it is stored however seed longevity vary from species to species even if they given identical treatment and storage condition. Seeds are divided into 3 biological classes according to the time for which they are capable of retaining viability under good storage condition.

- (1) Microbiotic – seed life span not exceeding 3 years
- (2) Mesobiotic – seed life span from 3-15 years
- (3) Macrobiotic – seed life span from 15-over 100 years

FACTORS AFFECTING SEED LONGEVITY

- (1) **Genetic:** Storage potential is heritable species are sometimes general typically show an inherited storage behavior, which may be either orthodox and recalcitrant. Accordingly, each species is likely to respond identically to a given set of storage conditions (Bonner et al 1994). Robbert and Ellis (1977) suggest that within a species there may be at least a 7 fold genotypic variation in seed longevity. Genetic variation within species may occur on different levels, e.g. land races, provenances, individual and clones.

Genetic influence on storability may be directly related to progressive agency, or it may be indirect, ascribed to different susceptibility to factors, which may ultimately lead to loss of viability for e.g. inherited variation in seed coat morphology may cause variation in susceptibility to physical damage during processing which in turn may influence storability

(2) Development: Immature seeds generally have a shorter storability than seeds picked at full maturity (Seiber and Agpa 1976). However early collected seeds may be able to attain full maturity, including normal storability, if allowed to after ripen, possible reduction in storability thus depends on the stage of development at collection plus possible after ripening. The physiological cause of reduced storability may be described to failure of accomplishing essential stages of late maturation events e.g. incomplete embryo, inadequate protection from desiccation, or inadequate formation of storage proteins or chemical compounds necessary for storability. For example in *Taxus brevifolia* the embryo grows in size right up to the stage of full maturity and only full mature seeds tolerate desolation to a level necessary for storage (vertucci et al 1996).

Development stage is especially evident and important in recalcitrant seed. Firstly because dry weight continues to accumulate up to the time of seed maturity, so that seeds collected just before natural shedding may be under developed. Secondly because the process of maturation and germination are more or less continuous, if germination does not occur determination proceeds rapidly making late collection equally unsuitable.

Stage development interacts with environmental factors before and after storage for e.g. immature seeds tend to be more prone to processing damage (mechanical or heat) and be more susceptible to inflation.

- (3) **Environment:** For practical purposes, environmental factors can be grouped into those acting before and those acting during storage. Pre-storage deterioration is of paramount importance for seed longevity because of its influence. The initial viability never improves it e.g. if viability has been reduced from say 95% to 70% prior to storage even, the best storage conditions cannot bring it back to 95%. Seed deterioration may start already in the field and is influenced by handling from collection and transport through processing. Any damage which occurs during handling is an immediate loss in viability, but may affect long term storability. Pre storage may strongly influence the response to storage conditions e.g. vigorous, high quality seed of most species store surprisingly well even under relatively adverse conditions while badly deteriorated seeds store poorly even though conditions are quite favourable. On the other hand, the effect or degree of effect of pre-storage injuries is not always expressed but influenced by the storage environment e.g. minor damage to the seed coat that may serve as entry points for fungal attack is obviously only of importance under storage conditions where fungi are active (5-7% mc).

Temperature and humidity are the most important factors in seed storage. Non-dormant seeds may germinate if their mc is above 30%. Rapid deterioration by micro-organisms can occur if mc is 18-30%, and seeds with a moisture content above 18-20% respire and metabolize actively. Metabolizing seeds may be

damaged by accumulation of toxic metabolites or heat if improperly ventilated. Certain seeds insects are active at a mc of less than 10% and damage by fungi may occur down to 4-5%. This follows that the higher the storage mc, the more rapid the deterioration of the seed will be.

(4) Initial viability: Seed lots with high initial viability have a higher longevity in storage than seed with low initial viability. Loss of viability is initially slow, followed by a period of rapid decline. The higher the viability when the seed lot enters into storage, the longer the seed will keep viable under a given storage environment. For example a seed lot with an initial viability of 100% may take several years to loose 50% of its viability in storage, while the same seed lot having deteriorated during a few weeks of sub-optimal conditions to say 80%, may reach 50% viability in much shorter time. The different rate of loss of viability during the storage period emphasizes the importance of storage at the best conditions available as soon as possible after collection. That becomes especially important for species that rapidly lose viability at e.g. ambient temperature but respond greatly to improve (e.g. cold) storage conditions.

CLASSIFICATION OF SEED STORAGE POTENTIAL

Seed have traditionally been grouped into two main groups according to their physiological storage potentials viz recalcitrant and orthodox seed.

Orthodox seed: Seeds which can be dry to low (2-5%) mc successfully stored at low or sub freezing temperature for a long period. Viability is prolonged in a predictable manner by such moisture reduction and reduction in storage temperature.

Recalcitrant seed: This include a number of large seed that cannot with stand appreciable drying without injuring, they maintain high mc at maturity (often >30-50%) and are sensitive to desiccation below 12-30%, depending on species. They have a short storage potentials and rapidly lose viability under any kind of storage conditions. Some of the over whining majority of woody temperature species are with recalcitrant seeds.

FEATURES OF ORTHODOX AND RECALCITRANT SEED

Features	Orthodox	Recalcitrant
1. Natural occurrence	Dominating strategy in arid and semi arid emts, and pioneers in humid climates. Also prevent in temperate are tropical high altitude species	Prevalent in worm humid climate especially climax forest species of tropical rain forests and mangroves. Also some temperate and few dry zone species
2. Families and general where the particular storage behavior prevails	Myrtaceae, leguminosae, pina-cene, casuarinaceae	Dipterocarpaceae, Rhizophoraceae melia ceae, Arthocarpus, Aracicaria, Triplochiton, Agathis, syzygium, quercus
3. Seed mc and temperature during storage	Tolerant to desiccation and low temperatures. Conventional storing 5-7% mc and 0-5 ⁰ C	Intolerant to desiccation and low temperatures (except some temperature recalcitrant species). Tolerance level dependent on species, normally min 20-35% mc, 12-15 ⁰ c for tropical species
4. Potential storage period	With optimal storage conditions general years for most species. For some several decades	From a few days for extremely recalcitrant species. To several months for more tolerant ones.
5. Seed characteristics	Small to medium size seed, often with hard seed coat	Usually medium large size and heavy seeds; this partly attributed to a high mc
6. Maturation characteristics	Accumulation of dry weigh ceases before maturation. Decline of mc typically to 6-10% at mature little variation between individual	Accumulation of dry weight up to time of seed dispersal. Little or no maturation drying mc at maturity 30-70% with large variation between individual seeds
7. Dormancy	Dormancy often occurs	Dormancy absent or week maturation and germination often

		more or less continuous
8. Metabolism maturity	Not metabolically active when shed	Metabolic when shed

STORAGE CONTAINERS

1. Transparent plastic bags

These are versatile containers for seed storage and suitable for many species and storage condition. Their main advantages are:

1. The material is reasonably air tight, at least thick material.
2. Transparency permits inspection of the contents without opening
3. The material is cheap.
4. They are available or can be made in almost any size.
5. They need no cleaning since the bags are discarded after use.
6. Bags can be closed with minimal air around the seed.

A thickness of 0.07-0.1mm is applicable; thinner material may permit some moisture to pass and is easily punctured during handling. Very thick material makes closing of the bags more difficult.

2. Glass jars and bottles

Several models are available volumes of 0.5-3litres are suitable. Jars and bottles should preferably have wide openings to facilitate efficient filling, emptying and clearing. Glass jars are convenient because they are transparent and the content hence directly visible. Their main disadvantage is their fragility. Particularly suitable for relatively small volumes of small to medium size seeds e.g. Eucalyptus species

3. Jerrycans

Metal and plastic models are available volumes normally 10-20 litres. Metal cans close with a clamp, plastic cans with a screw cap. Both types have an air tight rubber gasket.

Relatively large quantities of seed are easy to handle in jerry cans. However the containers are very difficult to clean and metal cans easily rust from inside.

4. Plastic drums and barrels

With cover volumes often 60-150 litres. A suitable type of drum is used for transport by chemical industries. It has a convert that can be closed airtight with a rubber gasket and clamp ring. Suitable for large seeds e.g. Termination, Khaya

STORAGE CONDITIONS

Storage conditions should be designed to prolong the viability of seeds by reducing or limiting any factor that impairs viability. The general storage conditions should therefore aim at

1. Reducing the metabolism of seeds
2. Keeping insects fungi and other pathogens away and
3. Reducing general seed ageing. The general prescription for seed storage are summarized below.
 - Store seeds with lowest temperature that will not damage the seed
 - Store seeds with lowest possible mc that will not damage the seed
 - Eliminate as many pathogens as possible before storage
 - Protect seeds from pathogens during storage
 - Store in the dark
 - Store orthodox and intermediates seeds with low mc in airtight containers
 - Store recalcitrant seeds in material permeable to gases but with retention of moisture.

METHODS OF STORAGE

Seed storage methods currently in use in the tropics vary with the characteristics of the seed, the length of storage envisaged and available storage facilities. They may broadly be grouped into

1. Dry storage
2. Cold storage
3. Cold moist storage

Dry storage

The simplest, oldest and currently the most widely used method of storage in the tropics. Suitably dried seeds are stored in sacks or heaps in well ventilated shades at ordinary room or air temperatures. This technique has proved successful for the storage of species like the Acacias, Albizia lebbek, Dalbergia Sisoo, Cedrela toona, tectonagradis, Melia azedarack and props juliflora which possess hard impervious seed coats. Seeds with more permeable testa tend to be less suitable. Their viability tends to decrease rapidly as they are subject to fluctuations in temperature and humidity of the storage room or shade. For such species where storage must be for a long period, storage in closed receptacles, metal boxes, bottles, and plastic are advisable. Closed containers are also essential for all seed types whenever the relative humidity of the atmosphere is high or the ravages of insects and rodents are serious enough to warrant control.

Cold dry storage

A generally more effective method though not yet widely found in the tropics is the cold dry storage technique in which suitably dried seeds are stored at temperatures around freezing point. Almost invariably all seeds keep longer and better under cold than warm dry storage. Low temperatures slows down the life processes within the seed and thus helps to keep the seeds in a state of dormancy. This technique has been found particularly suitable for seeds with high oil or fat contents.

Where cold storage is considered necessary, temperature is usually controlled at between zero and 2°C or below for longer periods of storage. The storage may be carried out in cold basements, refrigerators and refrigerated rooms fitted with temperature control gadgets. For long storage or for normally short lived seeds, storage should be in sealed containers or the entire storage facility must be kept at a proper relative humidity in order to guard against fluctuations in seed moisture.

Cold moist storage

This rarely used at present in the tropics, in this approach the seeds are kept in sealed containers thoroughly mixed with one to three times their volume of moisture retaining materials like peat, saw dust and ground charcoal. These materials help to maintain the seed moisture, provide them with oxygen while separating them from each other.

SEED TESTING

Seed testing is an analysis of some physical parameters and to physiological quality of a seed lot, based on a small representative sample. The quality (here strictly referring to physiological quality in contrast to the genetic quality) is the measure of potential performance of a seed lot under optimal conditions. Seed testing includes a number of parameters such as seed weight, purity, viability, germination and mc.

Purity and germination capacity form important attributes of seed lot as they influence not only the price a purchaser is prepared to pay but the amount of seeds to be sown per unit area of nursery seed and the number of healthy seedlings which can be expected. As a result tests for purity and viability are essential to efficient nursery operations. It is necessary to test for seed maturity and soundness before and during collection in the forest.

SAMPLING OF SEED FOR TESTING

Seed testing is carried out on a sample that is a small representative part of the seed lot.

Whether a sample is to be submitted for standard testing or is used for more simple tests, it must comply with the basic rule of being representative of the whole seed lot in any aspect to be tested. A sample should thus have the same average seed size, mc, viability e.t.c. as the whole seed lot.

The higher the degree to which a sample is representative of the seed lot from which it was taken, the better the test result can be valid for the whole lot.

Representative sampling is attained by very thorough mixing of the seed lot so that every single seed or particle of impurities in the whole lot has a good chance of being taken in the sample away of sampling needed.

All techniques applied in sampling aim at obtaining samples which are representative of the lot from which they were taken.

Two main pre-conditions help to assure homogeneity

- 1) Variations of seed characteristics within the seed lot should be as small as possible. Therefore, apparently different seed lots should be kept separate and tested individually. Variations typically occur between different provenance, growth site and degree of maturity.
- 2) Homogeneity within the seed lot should be assured by thorough mixing. For large seed lots, sub-samples should be taken from several locations within the seed lot where a large seed lot is stored in several individual containers, sub-samples are taken from each of these containers and according to their relative size, if their size varies. However for seed lots stored in more than six containers, special rules apply for sampling frequency, samples may be taken from a smaller number of containers than the total, but the containers from which the samples are taken should be selected in an unbiased way.

SIMPLE SEED TESTING

Seed weight-seeds orders are given by weight, seeding planted by numbers seed weight is therefore, together with purity and germination percentage. Number of seeds and their weight must be known to calculate number of seeds per kg. An electric digit scale is preferred. If such equipments is not available, weighing may be carried out on a balance.

There are two methods.

1. Put a known number of seeds on one side of the balance and weigh on the other until it balances.
2. Put a known weight on one sides and add seeds on the other until it balances.

There are two ways of indicating seed weight either in number of seeds per kg (or for small seeds occasionally per 100g), or in weight in grams for 1,000 seeds.

For example

- (i) 1,000 seed weight of *Eucalyptus camaldulensis* is 1.5g. Number of seeds per kg is
 $1000 \text{ seeds}/1.5\text{g} \times 1000\text{g} = 666,000 \text{ seeds}.$
- (ii) *Pinus caribaea* contains 3,500 pure seeds per kg. 1000 seed weight is $1000\text{g}/3.5\text{kg} = 285\text{g}.$

Seed weight varies both with seed size and density and there are reasons to be observant on factors that may influence these especially when comparing figures. For example, the term “seed” is in some cases subject to some confusion clear indications of what is the tested unit are sometimes necessary e.g. with or without wings, arils or pericarp. In *switetenia macrophylla*. Seed weight of winged seed is about 2100 seeds per kg, while for de-winged seeds it is about 2,300 seeds per kg mc influence density and thereby seed weight.

PURITY ANALYSIS

In common terms purity is an expression of how clean the seed lot is we are interested in knowing the fraction of pure seed not the composition of other matter. Therefore we weigh a sample of seeds with impurities, the separate the two fractions and weigh.

Purity of a seed lot indicates in percentage how large a fraction is made up of pure seeds of the species in question, and how much is made up of inert matter and other seeds.

Purity is expressed as the weight percentage of pure seed fraction over the total weight of the working sample

$$\text{Purity} = \frac{\text{weight of pure seed (g)} \times 100}{\text{Total weight of working sample (g)}}$$

Purity analysis is the 1st to be carried out because subsequent tests are carried out only with pure seed. Component purity is determined by careful inspection of a known weight of test sample, sorting out all those seeds that are true to the species and appear sufficiently normal and viable and re-weighing them. Generally seeds of larger-seeded species are usually of high purity while those of small seeded species such as Eucalyptus and pines may be relatively impure because of lines and other debris which are difficult to remove during the clearing process.

MOISTURE CONTENT

Mc is crucial in connection with storage and longevity. Since mc of seeds tends to vary with atmospheric humidity, it is important that exposure to varying humidity is minimized before testing. Therefore seeds should be packed in water proof material as quickly as possible after sampling. In order to avoid the possibility of water condensing on the seed when removed from cold store, seed should be allowed to reach ambient temperature before the container is opened.

Quick measurement of mc may be carried out with the aid of a moisture meter microwave dry is a quick method of moisture measurement for large seeds for which

moisture method are less applicable. The seeds are cut into small piece before drying in the micro oven 5-6min (ISTA 1991, Bonner et al 1994).

The sample is weighed before and after drying are mc calculated as after the oven drying method.

Under laboratory testing, seed moisture is measured by the oven drying method, which is the direct method, prescribed by ISTA and describe below. This method can also be used for calibrating moisture metres for indirect measurement of mc. The indirect methods provide a quick results, which can be used as a guide during seed handling, e.g. to determine the necessity for further drying mc of a sample is the loss of weight when it is dried in accordance with the prescribed rules. It is expressed as a percentage of the weight of the original sample (ISTA 1996). This is the fresh weight basis. Mc measurement contain the following component.

- 1) Container (heat resistant) including cover is weighed (m1)
- 2) Seeds are ground or cut into smaller fraction before drying to assure that moisture can escape from the inferior.
- 3) The seeds are placed in the containers and weighed together with the container (m2)
- 4) Seeds are placed in an oven at $103 \pm 3^{\circ}\text{C}$ for 17 ± 1 hr
- 5) After drying in the seeds are placed in a desiccation chamber while cooling (or avoid reabsorbing of moisture from the atmosphere)
- 6) After cooling, the seeds plus container are weighed again

The mc (fresh weight basis is calculated

$$\text{Mc} = \frac{M_2 - M_3}{M_2 - M_1} \times 100$$

Viability and germination test

A high germination percentage is obviously desirable for the nurseryman; anything other than pure germinable seed is waste.

Therefore a germination or viability test should indicate the potential germinability which with proper handling should reflect expected germination in the nursery.

Germination potential is most directly determined in a germination test.

Germination tests are widely used in both standard seed testing and more informal simple nursery tests. However, the tests have several limitations, some of which may either over-estimate or under estimate the actual germination tests are less applicable are the following:

- (1) Where seeds have a very short viability: Duration of a germination test is typically 3-5 weeks. For short lived recalcitrant seed significant loss of viability may take place during the test period. Hence, the germination percentage obtained by the test may not be valid for the seed lot from which it was taken because the viability of the seed lot has declined during the test period.
- (2) Where germination is delayed or suppressed by deep dormancy if pretreatment has been insufficient to overcome dormancy, germination may be low even if seed are viable.
- (3) Where fast test results are equipped: Especially for slow germinating species (some species takes several months to germinate) the duration of a germination test may be inconvenient. Where a seed lot is to be dispatched soon after collection, there is often not enough time for a germination test.

SEED TESTING CONTD

Where germination tests for some reasons are inconvenient or unreliable or where shortage of standard germination facilities limits the use of germination potential many be tested by indirect methods v12. Viability test. These tests do not prove that seeds are terminable only that they are (most likely) alive.

Viability tests are used as a supplement to terminative tests in order to examine the tar or quality of seeds that have not germinated during the stander test.

Several types of applicable to very small seeds such as Eucalypt, and for excised embryos the method is parochially impossibly (Balneal et al 1980)

Cutting test

Cutting test is never used as sole viability test in standard testing but rather to examine the conditions of non-germinated seeds in a germination test. The method is how ever, widely used in simple seed testing both during collect and processing. Cutting test are useful field and unseeing methods for determinedly sound and living seed. It is useful in chivvy the viability of seeds which are slow to germinate or the development of seeds and fruits in prop dive seed collection area

The seeds can be inspected through eyes for the purpose viability test cutting the seed opened with knife or scalpel and the cross-section is examined with a hand lens kernels which are firmly filed, plump and good colour are considered to be viable. It endosperm of the seeds must have a normal Coolum with a well developed embryos showing that the seed has a good chance of germinating. Although this test the seed has been found not to be liable , seeds with milky uniform, moldy decoyed, sterilized or smelling embryo and those with embryo can be taken as non-viable without must difficulty .it is not possible to

distinguished morbid (not trash) recently dieter recently injured seed which still the same as sound one. It is very useful tool in estimating the size and maturity of the seeds crop before collection and the ethereally of method use in processing .in cutting test viable and dead seeds are distinguished visually, which in practice means that seeds that are empty signs of damage are deemed non-viable and the removing portion viable (although actual life manifestation are not proven)

Tetrazolium test

The tetrazolium test is the most widely adopted biochemical method to examine seed viability. This is also called topographical tetra 30lium test (TT2). T2 test is especially useful as an alternative to germination test for spp. That require long of pretreatment to overcome dormancy but the test is also widely used as a quick test for species with less complex dormancy.

The principle of T2 test is as follows dehydrogenises are a group of metabolic enzymes in living cells. During the reduction processes in the metabolic active cells declhydrogeases release hydrogen. The hydrogen is able to reduce an applied pale yellow solution of 2, 3,5, trephine tetrazolium chloride or bromide (T2) to a stable, bright red trephine-Formosan. Hence the formation of red Formosan is an indication of dehydrogenate activity, which is in turn an indicator of viability, because staining of tissue is local, it is possible to distinguish living (red – colored) and dead (colorless) parts of the seed where dead (necrotic tissue occurs only superficially in cotyledons, while the radical stains normally, the seeds may still be viable.

On the other hand, even small patches of necrotic tissue in the vital part of the embryo normally mean that the seed would not be able to germinate.

Seed embryos are likely to stain whether they are dormant or not damaged but not necrotic tissue may stain normally. Therefore the result of the T2 test is likely to include the classes in the germination test. Normal seedlings, abnormal seedlings and live but not germinated seeds. A pre condition for application of the T2 test is that the seeds are mature i.e. physiologically terminable. Immature seeds normally because they contain live cells out would give poor results in a germination test. Another source of error is that seeds infected by fungi may stain because of the metabolic activity of the fungi and not the plant cells. However, such fungal cells generally stain dark brownish-red, not bright red as live sound plant cells do.

Since T2 measures the activity of metabolic enzymes (dehydrogenases) in living cells. It is necessary that seeds are imbibed and incubated at a temperature allowing active metabolism during the test.

For most species it is necessary to pre-moisten the seeds, either slowly or fast (soaking in water) until fully imbibed. Seeds with hard-coat must be scarified (punctured) to allow imbibitions seeds enclosed within a hard per carp must be scarified or extracted prior to imbibitions.

For most species a 1% t2 solution is used. The conc. Is achieved by dissolving 1g T2 salt in 1litre of water or buffer. The practical steps of the T2 test are as follows.

- 1) Prepare hard seeds for imbibitions by scarification, puncturing or extraction.
- 2) Pre-moisten seeds by soaking or between or on moist paper at approximately 20⁰C for 3-48hr (depending on species ISTA prescriptions).
- 3) Immerse seeds in the T2 solution. The seeds should be completely covered.

- 4) Incurable seeds in the T2 solution in darkness at 30 – 35⁰C for 1 – 24 hrs (dilution).
- 5) Wash seeds in distilled water and place and place them on moist filter paper until evaluation.
- 6) Evaluate staining

X – RADIOGRAPHY

X – Radiography is a quickest test to differentiate empty, under-developed, and insect of physically seeds from morphologically intact and healthy seeds by the aid of x – rays (ISTA 1996).

The seeds are places between the x – ray source and a photocytetive film or paper. When the seeds are exposed to x – ray of low energy (longer wavelength, approximately, 1 manometer), an image (radiography) into a visible picture since x-rays are non destructive, seeds examined by the x-radiography method may also be used in direct germinator tests.

Belong normal x-radiography is unable to distinguish aged or physical logically damage seeds from sound seeds, the best correlation of the x-ray and germination test is found where empty seeds, inset damage or other quality.

The method is especially useful where such damage or lacks of development are not apparent on the externs of the seeds e.g.

(1). Empty seeds in pines eucalypt and other where the seed development into full size even it contain no embryo.

(2). Insect infested seed where no entry hole is visible, e.g. legume seeds infested by brooches or conifers or eucalypts infested with chalcids

(3.) Seeds enclosed by a hard fruit structure e.g. drupes or samaras where the pericarp or endocarp bears no sign of presence or condition of the enclosed seeds (s) .x radiography may reveal both no of seeds in such fruits and their condition

(4) Seeds where internal mechanical damage to the embryo may have occurred e.g. during processing

(5) Seeds with shrunken or underdeveloped embryo e.g. immature seeds x-radiography is especially useful for estimating viability of recalcitrant seeds because they short lived their germination potential has to be determined quickly

Application of specific contrast chemicals e.g. BaCl₂ AgNO₃ KBr to the seed before x-ray enhances possibility of evaluating viability of tissue,

Excised embryo test

This method is used where seeds germinate very slowly or where the seeds are deeply dormant and require long pretreatment. It may also be used where the nature of dormancy and hence pretreatment is not known. The principle of the test is that embryo is manually excised from the seed coat and possible endosperm under aseptic conditions placed on filter or blotting paper and incubated in germination cabinet at 20-25°C. The result of the excised embryo test is germination % age under inundation

Because the embryo is surgically excised from the seeds during the operation, it requires a certain minimum size of seeds and embryo before it is practically possible. The method is not applicable to very small seeds like eucalypts, pines, nuclear dicerid. The chief advantage of this method is that it makes possible within a few days or weeks, the

determinant of viability any seed which would normally require several months for germination in soil or other media .a viable embryo so traded a non-viable embryo would become discolored and deteriorate where given good condition for germination. The major shortcoming which some time out weighs the above advantages is the difficulty of extracting the embryos without injuring them.

Germination test

During the germination test, seed quality is measured directly as the ability of the seed to germinate under optimal germination conditions of temperature, moisture and light.

Germination is normally carried out in germination cabinets under controlled out. The conditions prescribed by ISTA include the following variables

- Temperature (level regime e.g. constant day and night or fluctuating)
- Light (+/- light or period of day night cycles)
- Substrate (sand(s), top of sand (is) top of paper (tp), between papers (nt) pleated paper

Germination is defined as emergence and development of the seedling to a stage where the aspects of its essential structures indicates where or not it able to develop further into a plant under favorable condition in the soil. (ISTA 1996). This means for tree seeds a root system shoot antis cotyledons and terminal bud .the exact criteria of evaluation very slightly btw spp e.g. in eucalyptus a seed is considered to have germinated when the radical has developed normally and the cotyledon have emerged from the seed coat have unfolded.

Germinated seeds are counted regularly during the preceded germination period from the indicated first count to final count.

Country once per week is usually sufficient. Renal of germination is done in order to facilitate subsequent countries and to avoid possible fungal spread. Both normal and abnormal germination are counted registered and removed during the period the final test result is grouped into the following classes

1. normal germinates : the cumulative no of seeds which have developed into seed line of normal and health appared with all essential structures of a seedling .this also includes seedlings where possible damage is caused by secondary in faction
2. abnormal germination : the cumulative no of seeds which have germination during the test period but in which the seedling show abnormal or unhealthy appearance e.g. lacking essential structure such as cotyledons or being discolored or infected by seed borne pathogens (primary infection)
3. ingemination seeds : seeds which have not germination by the end of the test period .these are grouped into the following sub-class
 - a. Hard seeds which are seeds that remain hard below they have not imbibed (normally bellows of insufficient pretreatment.
 - b. Fresh seeds which are seeds that have not germination although they appear from and healthy
 - c. Deon seeds which are seeds that are soft, or showing other sighs of decomposition
 - d. other seeds e.g. empty seeds

Seed dormancy \$ pretreatment

sometime seed known to be perfectly sound and unaired fail to germination in to presence of favorable metal conditions i.e. adequate moisture appropriate temper regime a normal atrophied and in some cases light such seeds are said to be dormant seeds dormancy is an

obstacle to success of the nursery man whose aim is to obtain the largest possible number of seeds sown germinating in the shortest possible time.

The cause of dormancy in seeds may be physical or physiological. Physical dormancy involves the presence of hard impervious seed coats which either prevent water and in some plants oxygen from reaching the embryo or prevent the embryo from enlarging and breaking the test even though water has been present by the presence of inhibitor or substance that of the fruit, in the seed coat or even in the endosperm of the seed.

Dormancy in seeds may be advantageous or problematic during seed handling. The advantage is that it prevents seeds from germination during storage and other handling procedures and induction of dormancy promotes storability on the hand where dormancy is complex and seeds need a very specific pretreatment failure to overcome those problems may result in poor germination.

Types of dormancy in seed

1. exogenous dormancy

Physical dormancy – when seed coat is hard and impermeable which prevents imbibitions and sometimes also gaseous exchange common to leguminous, myrtaceae (eucalyptus), cupressaceae, panacea, cabaña coca (teak) combat cease (terminal mechanical dormancy refers to the condition in which the embryo the elopement is physically restricted due to an enclosing structure. ambition many have place but raised is unable to split or penetrate its enclosure mechanical dormancy have some restriction to water uptake common to pterocarpus angiogenesis terminally superb a to mantissa eucalypti pavciflora delegate sis: where impermeability is complete it is retard to as combined mechanical & plaited dormancy

Chemical dormancy –when fruits and seeds contain chemical inhibitory compounds that prevent germination common in fluster fruit such as berries drupes and some dry seeds.

2. endogenous dormancy

Morphological dormancy: seeds with under developed embryo at the time of dispersal are unable to germination under normal germination condition physiological dormancy – when seeds contain immature embryo especially in early collected seeds e.g. ginkgo balboa

Double /combined dormancy

When two or more dormancy types occur in the same seed it is called double /combined dormancy. This is common in fleshy fruit with chemical inhibitors combined with e.g. hard coat (endocarp) physical dormancy or immature embryo combined with other types

Pre-treatment methods

Dormancy seeds germinate irregularly resulting in patching nursery stock of varying ages and sizes. To secure uniform and rapid germination of such seeds the cause of the dormancy must be identified and removed before the seed is sown. This is part important when magma of a relating valuable seed is available

Various methods of per-germination treatment have been advocated for hastening germination .some of those methods which have been found useful as discuss as following

1. Scarification: this could be manual or mechanical. This involves any process of breaking, scratching, chipping, filling, piercing or burning with the aid of knife, needle, file, hot wire burner, abrasion paper or mechanically altering the seed coat to make it permeable to water or gases. Iyamabo (1967) reported that chipping the

fruit of *Pterocarpus angotensis* at one edge was sufficient to hasten its germination. Manual scarification is effective at any site of the seed coat, but the micropylar region should be avoided as it is the most sensitive part of the seed where the radical is located. The main problem of manual scarification is its labour intensiveness. However for treatment of large quantities of seeds, mechanical scarification is more suitable seed may be tumbled in a concrete mixer drum lined with abrasive materials such as sand paper, bricks or cement mixed with sand or gravel or incorporation abrasive disk. If gravel or sand is used, it should be sieved to ensure that it can be readily separated from the seed smaller seed lots may be scarified by gently shirring them in a mortar with sharp sand. The scarified seed should, all the same be quickly dried and stored away in sealed containers or planted immediately as scarification renders them highly susceptible to pathogenic attacks.

2. Soaking in water: This is the most widely used pre germination treatment. It is used to tackle all the different types of dormancy; in other words to modify hard seed in water from 12 to 24 hours in running or stagnant water renewed daily is effective for most species prolonged soaking in running water for one to several days also serves both to leach inhibitors and soften fruit or seed-coat. Modification of this approach include keeping the seed in running water for two weeks and then spreading them out thinly to dry or pouring them into pits dug near the nurseries watering and shirring them for about two weeks.

Generally soaking alone is a very slow procedure to overcome physical dormancy as there is a great risk that imbibed seed will die if left in the water until the remaining seeds become permeable.

Hot water treatment

Hot water overcomes physical dormancy in some seeds especially leguminosae by breaking tension which consequently causes cracking of the macro sclera layer. The method is most effective when seeds are submerged into the hot water, accompanied by quick withdrawal of the source of heat and allowing the seed to soak in the gradually cooling water for a period of time that varies with the seeds. A quick dip is also better to avoid heat damage to the embryo. E.g. species of *Cassia Siamea* when soaked for 1-2min in 85°C warm water or submersion at 85°C with subsequent cooling in the water for 12-36 hours gave a germination percentage of 82-89

Dry heat burning

Forest or plantation fire is an important powerful natural factor in the removal of seed dormancy. A fierce fire will kill the seeds but a light to moderate fire such as those associated with controlled burning will reduce seed coat impermeability and stimulate germination. Dry heat has a similar effect on seed-coat of dry fruits as boiling water, tension in the outer cells causes formation of cracks through which gas and water can penetrate. The effectiveness of dry heat and burning is normally enhanced by rapid temperature change e.g. by rapidly pouring the seeds to cold water after heat pretreatment. This also reduces the risk of heat damage to the embryo. Kiln drying for

extraction of e.g. *Acacia mangium* may serve as an incidental pretreatment oven drying at 100°C for 10 minutes followed by cold water immersion was found to be effective 83% of the seeds germinated after this treatment as compared to 3% for untreated.

Acid pre treatment

Concentrated H₂SO₄ acid is mostly used to break seed coat dormancy. The acid causes some kind of wet combustion of the seed-coat and works equally in legumes and non-legumes. Seed kept in the store for a long period require a large period of treatment in acid than fresh seed which are prone to damage if treated for a longer period. The method is not applicable to seeds that easily become permeable because the acid penetrates and damage the embryo.

The practical application of acid pretreatment is as follows:

A container type that is not corroded by the acid should be used e.g. glass baker for small lots under laboratory condition (testing) or thick plastic bucket or bowl for large quantities soaking in acid should be at ambient temperature (15-25°C). Duration of treatment varies according to the following factors

1. Seed coat thickness (depending on species maturity, age)
2. Temperature (longer treatment is required at low temperature)
3. Strength of the acid (new acid is stronger than re-used)
4. Stirring (stirring during treatment reduces duration of treatment)
5. Relative volume of acid (a relatively large volume of acid as related to volume of seed is likely to reduce time required for pretreatment).

After soaking, the seed is removed from the acid and rinsed under running water for at least 10 minutes. The seeds can be sown (possibly after soaking in water to enhance inhibition) or re-dried and stored for a period.

Acacia albidia., A Senegal and A nitotica seeds require soaking in ions H_2SO_4 for 20, 40 and 80 minutes respectively. Albijia lebbeck (40 minutes), cassia fistula (45 minutes), delonix regia (3-6hrs). Leucaenn lencocephala (30 minutes). One hour pre treatment of A nogeissus lei ocarpus seed reduced germination period from 15-30days to days.

Acid pretreatment has several advantages in overcoming physical dormancy:

1. It is applicable to many species not only leguminous
2. It is the most effective method of buck treatment for very hard coated seeds.
3. It required no special equipment
4. Seeds can be stored for a period after treatment.

However, below are some of its major problems

1. It implies a serious safety hazard to workers
2. Seed are in risk of being damaged by over-treatments
3. It can be difficult to safety dispose of waste acid
4. It can be expensive in some places.

BIOLOGICAL METHOD

Germination of seed is found to improve if pass through the digestive tract of some animals e.g. cattle. In mature animal's micro organism are found as important factor in the break down of seed, Coat impermeability. Although it is very difficult to make use of these organism as a control pre treatment of seed, but successful result have seen reported

about those organism, for instance, seed of Acacia Senegal which pass through the digestive tract of goats germinate readily when placed under favourable condition because of the strong digestive chemical in the goat. It is therefore suggested that if the pods of seeds are fed to penned goats and seeds are collected from the dropping at goats, it provides a pre treatment for the seeds of A Senegal and those of other species like Ginnelona. But if the seeds pass through the digestive tract in cattle, as a result of pure grinding, the seed will not be collected. Termites are also good agent for breaking down seed coat dormancy especially in the part of tropics for advantages:

1. Seeds are extracted and pre-treated during the same process
2. Seeds are efficiently cleaned from infestation by infecting organisms e.g. brunched and seed borne pathogens.
3. Adhering during serves as fertilizer for the seedling
4. The pods serve as food for the animal eating them.

