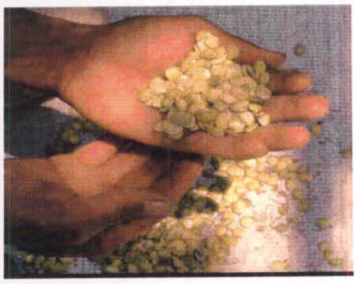
Kenya Forest Seed Centre



Seed Harvesting and Handling Training Manual

ICRAF

International Centre for Research in Agroforestry

FORWARD

Seed is the central input to all planting programmes. In this respect, an active seed industry; that which is submissive to demand is a pre-requisite to promoting tree planting activities not only at local or national, but also at regional levels. The ever sky - rocketing demand for tree and forestry products globally calls for effective seed procurement and distribution system..

A good seed source can only be used well if all the necessary operations for collecting seeds are done appropriately. More so, seed handling between collection and use should be apt otherwise past and future activities based on the seed could be unproductive and wasteful. Nevertheless, adoption of a more technical approach to production provides the basis of improved yields and availability of the products and services. Therefore, training becomes imperative as a tool in technology transfer to promote the procurement and handling of seeds.

Seed collectors need to be supplied with succinct information on how to collect, process, store and germinate seeds. Most of the information should be backed with applied research and complemented with local (farmer based) technology. However, careful and adequate documentation is an integral aspect of seed procurement. Any seed lot whose origin and physiological state is not known is worthless. This manual contains key issues behind principles of seed harvesting and handling to ensure procurement of high quality seeds in meeting set demands.

The manual ~~have~~ has been compiled with the inputs of several people with specific expertise in areas of seed harvesting and handling among them William Omondo Oloo, Bernard M. Kamondo, Joseph Oloo Ahenda and James Were with the logistic support of Barnabas Itambo Malombe

Contents

CHAPTER 1

SEED SOURCE INDENTIFICATION AND SEED SOURCE CATEGORIES

1.1 SEED PRODUCTION, OVERVIEW

Three basic points are important in provision of germplasm for any afforestation program, *Quality*, *Quantity* and *Time*. All must be correct for any system that aims at providing propagative materials to users. These materials must be of high quality, enough and provided when required.

The seed production process is wider than the mere seed collection, processing, storage and distribution.. The main stream seed production is supported and guided by tree breeders who avail improved germplasm to the seed producer for multiplication, silviculturist in advising on correct species and provenance, NGOs in sensitising on priority species and social economic surveys which establish the real needs of the people. With information from these supportive disciplines (there could be others), Seed Source Establishment is the most important undertaking and should all be geared to production of high quality seed.

1.2 GENESIS OF A SEED SOURCE

Seed sources arise from 2 avenues. Via selection from existing vegetation or from establishment.

1.2.1 SEED SOURCES VIA SELECTION FROM EXISTING VEGETATION

The general guide to selection is that the individuals to be selected are many enough to ensure interbreeding. Trees should be performing well phenotypically, healthy and free from diseases. Isolated trees should be avoided due to the risk of selfing, so should be tiny patches of trees and diseased ones.

(a) General Seed Sources:

Phenotypically better performing and healthy trees mostly from natural forests or in planted areas are picked out to be sources of tree seed. The input of the seed officer is only to identify and subsequent management of the seed source. To be such a seed source, it must:

- Be in an area of with a continuos vegetation cover of at least 2 ha.
- Area to have at least 100 individuals of desired species.

- Display better than average performance in growth, form and health.

(b) Selected seed stand

This is a stand of trees that has been chosen as a site for collection of seed as a secondary purpose. The primary purpose could have been for timber, fuel, soil conservation etc. It is distinguished from the General seed source by the fact that it has been selected from among many stands for its superior quality. There is contribution to tree improvement due to selection

(c) Selected Single Trees:

In a stand, individual trees can be of superior quality. This offers a good opportunity to use these trees as a source of seed. The trees are thereafter treated as seed trees and given silvicultural treatment to enable them bear as much seed as possible. To qualify as a Selected Single Tree seed source, seed must be obtained from ONLY this selected trees.

1.2.2 SEED SOURCES VIA ESTABLISHMENT

In the previous 3 categories, seed is an auxiliary purpose of the trees. But it is possible and in fact recommend to plant trees with the sole purpose of seed production. All the management decisions from the onset are geared to providing tree seed of acceptable quality. The planting material used in such a stand is called forest reproductive material or basic material. It could be raised from seed, cuttings, wildings or tissue cultured clones etc.

The seed sources that involve establishment by man are unfortunately prone to insidious omissions that can render an existing stand useless for quality seed production. At every moment, during the life history of an established seed source, one should be sure on the aspects of Documentation. Make sure you have answers for the following minimum documentation aspects.

- Species
- Year of planting
- Seed Origin
- Provenance
- Identity of Trees and Mapping of the Stand, i.e know the mother tree where their progeny are in the stand.
- Size of the seed source.

It is also very important that the Representation in terms of Provenance and Genotypes is kept clear throughout the life of the seed source. The best seed source should only have one provenance represented and as many genotypes (never below 30) represented in the seed source. The distribution of these genotypes should confer maximum cross pollination amongst them. The thinning regimes should be rationalised and designed in a way that the number of the different genotypes is not reduced below the thresh-hold and/or a particular genotype decimated to only a few individuals.

For the above details to be available and to be authentic, it is important to follow a scheme for establishing and managing a seed stand that allows for checks to avoid loss of information or ambiguity of the information contained there-in. From this avenue, 2 seed sources can be distinguished, the established seed stands and the seed orchards. For both of them

-Basic material should derive from selected single trees, or selected individuals in a general seed source,

- Basic material should be planted isolated from contamination by other provenances

- Basic material should be representative of the provenance (at least 30 mother trees) and the mother trees should be equally represented.

- The design should allow for maximum out crosses among the mother trees in the stand.

A seed orchard should be established with the advise of a tree breeder to maximise and access the gain emanating from the seed source.

1.3 GENERAL SUITABILITY CRITERIA FOR SEED SOURCE (RATING CRITERIA)

In general, the suitability of a seed source can be evaluated against the following:

- Is the seed source in the right ecological zone for seed production?
- Is the genetic integrity guaranteed?
- Is the health and performance above average?
- Is accessibility and Security of the source appropriate?
- Is the size of the seed source and its population adequate?

As much effort as possible should be put into seed source identification and establishment. It is the bedrock of high quality seed.

CHAPTER 2

SEED SOURCE EVALUATION AND SEED SOURCE MANAGEMENT

2.1 OBJECTIVES OF SEED SOURCE MANAGEMENT

The main goal of managing a seed source is to promote the seed source capacity to yield high quality seed. However, some management interventions although finally contributing to securing high quality seed have other immediate aims. Seed sources are managed to:

i) **Ensure the success in stand development and composition.**

The interventions necessary here are mostly the normal silvicultural activities that any tree stand require for establishment. They include proper staking and pitting, weeding and cleaning, beating up and in some cases fertilisation. However, it is in the composition of the stand special care should be taken. The most important intervention is to ensure the right isolation within the stand (at individuals within a mother tree level, individual mother trees and provenance levels).

ii) **Ensuring abundant, well distributed and regular flowering in the seed source.**

The management intervention that help in ensuring abundant flowering is mainly through manipulation of spacing of individual trees in the stand. Although different species require different spacing for abundant seeding, spacing of more than 5m by 5m is recommended for huge and shrubby trees. Some agroforestry species like *Leucaena* spps and *Calliandra*, as well as fencing species can still be managed as hedges for seed production. Even for such hedges, spacing between rows should be maintained at around 3m. Other possible interventions (depending on circumstances) to promote flowering include grafting with mature scions, and stressing the tree through various methods like digging up around the root system. Shocking the trees by driving in nails in the trunk has been known to work especially for horticultural trees.

iii) **Ease seed collection activity.**

By topping seed sources, seed collection is made easier as the apical dominance is arrested and lateral branching encouraged. Less labour is invested in climbing. Cleaning around the mother trees eases seed collection when collecting from the floor. Accessibility of the seed source through clearing of paths and cleaning around the mother tree sounds routine but helps a lot in easing seed collection. The cleaning of stands will also enable timely seed collection.

iv) **Protection of seed sources.**

As a manager, seed source protection should be a priority concern. Damage of seed sources could be from wild animals (especially when stand is young) or from human beings. When one has only the right for use but ownership rest with some other authority, protection arrangement must involve all parties with interests in the source. Prominent labeling of seed sources beside providing information on the seed source serve as an important protection tool.

v) **Use the seed source as a conservation unit.**

It is advisable to view seed sources conservation units and manage them for this ulterior motive. The management interventions especially of thinning should take cognisance of these fact and should therefore be undertaken in a way that the conservation value of the seed source is maintained. These is through adequate representation at individual tree level and at the provenance level. Proper mapping of the seed stand composition is vital if a seed source is to serve as a conservation stand.

2.2 MANAGEMENT INTERVENTIONS IN THE VARIOUS CATEGORIES OF THE SEED SOURCES.

The different categories of seed sources have their strong points that contribute to quality seed production. They also have weaknesses that tend to negate the seed quality. The practical approach is to maximize gains from the positive aspects of the seed source and mitigate the weaknesses by specific interventions. Table 1 in the next page discusses the possible approaches to mitigating weaknesses in respective seed sources.

Table 1: Mitigating weakness in seed sources

Seed source	Positive attributes	Negative attributes	Mitigating measures
General Seed Source	Allows for a wide genetic base Continued adaptations and evolution Non ambiguity over seed origin and provenance Low cost of establishment No time lag between establishment and collection No chance of errors during the establishment phase	Non uniformity of progenies and their products Harvesting costs high Accessibility problems High cost of protection	Selection of individuals during collection Thorough flower/seed survey Cleaning for accessibility and seed collection Protect in collaboration with other interested parties
Selected Seed Stand	Low cost of establishment No time lag between establishment and collection No chance of errors during establishment phase	Genetic integrity suspect Seed production suppressed	Collect equal quantities of seed from all parts of the stand Select individuals during the collection Open stand to encourage flowering and seed production Label with Billboard
Selected Single Trees	Uniformity of progenies and their products Favorable cost of establishment	High cost of seed collection Restricted genetic diversity Low quantities of seed yield	Thorough flower and seed surveys Select many single trees and collect as a general seed source if less than 25 are seeding

	Better chances of protection No time lag between establishment and collection No chance of errors during establishment phase		Ring mark with paint
Established Seed Stand and Seed Orchards	Uniformity of progenies and their products Better chances of protection Good accessibility Low cost of seed collection Sufficient quantity of seed and chance to tailor whole production system to meet demand	Restricted genetic diversity High cost of establishment and requirements of special skills (e.g. tree breeding and grafting) Time lag before seed production High chances of error in the establishment process	Take care to start with a wide genetic base > than 30 mother trees and thin out without compromising the genetic diversity. Follow the right establishment protocol and carry out thorough documentation of the whole stand establishment process Borrow from existing silvicultural knowledge for the particular species but remember the objective is seed production! Locate in areas favorable for seed production Label with bill board For the seed orchard, a breeder must be consulted!

CHAPTER 3

FLOWER AND SEED PHENOLOGY

3.1 INTRODUCTION

A sound knowledge of reproductive biology of plants is an essential prerequisite for planning effective programmes for their genetic improvement, seed multiplication and genetic conservation. The breeding system (whether a species is self-fertile or outcrossing) influences the partitioning of genetic variation within and between populations, and hence the choice sampling strategies for seed collection. Monitoring flowering pattern of plants is essential for timing and planning seed collection. The flowering intensity which tends to follow some seasonal pattern can be used as gauge for estimating the expected seed production levels in seed sources.

In outcrossing species, the mode of pollination (wind, insect, bat or bird), and the behaviour of the pollinators affect plant population structure and population differentiation through its influence on gene flow. Phenological differences (eg. in timing of flowering can create constraints to timing, either between populations or between individuals within a population thus reducing the effective size of the breeding population. The mode of seed dispersal also has an influence on pattern of seed distribution from the mother trees thus affecting the gene flow within and between plant populations.

3.2 FLOWERING IN PLANTS

This is the first stage in the life process of seeds. Flower initiation and its early development may extend over many months. Flower initials or primordia are formed months before the buds are fully developed. The rate of development is determined by environmental factors. In the early formative stages, there are no external indicators to distinguish flower buds from vegetative buds. However, as flower buds develop they are distinguished by their appearance and location. They enlarge greatly as the flowering season nears. Flowers of woody plants are of many different forms. They vary in colour, odour, arrangement, size, etc (Diagram 1). An angiosperm flower may have some of the following parts:

There are two types of seed producing plants:

- **Angiosperms**: These are plants whose seeds are enclosed in a case (ovary). They are further divided into two classes on the basis of their seed morphology.

(a) The monocotyledons which have seeds with only one seed leaf.

(b) The dicotyledons which have seeds with two seed leaves

- **Gymnosperms**: These are plants whose seeds are exposed i.e. not enclosed in any casing, e.g. conifers

Perfect flowers contains both male or female parts

Imperfect flowers contains male or female parts only

Most angiosperms are monoecious, i.e. both male and female flowers are produced on the same plant.. However, there are a few dioecious species where male and female flowers are produced on different plants. Examples: *Milicia excelsa* and *Hagenia abyssinica*.

Gymnosperms have separate male and female flowers. They can be monoecions, e.g., pines or dioecious, e.g., *Junipers*, *Araucaria*.

3.3 FLORAL MORPHOLOGY

Flowers are the reproductive units of gymnosperms and angiosperms. They differ greatly in size, shape and colour depending on the plant species under consideration.

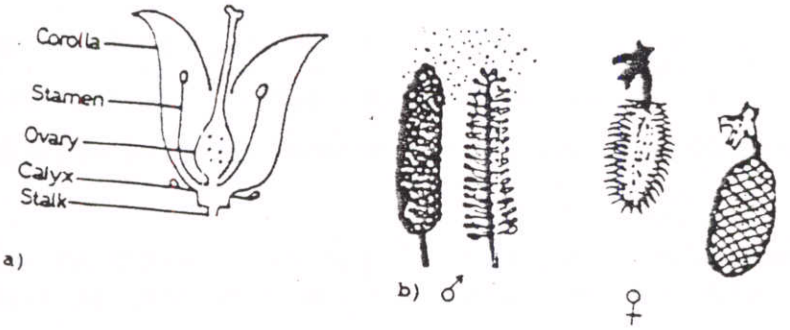
The flower has different parts performing various functions. The main parts of an flower are:

a) Protective and Supportive parts: stalk, penduncle, receptacle and calyx

b) Reproductive parts: Stamen (male part)-filament, anther (bears pollen grains) Pistil (female part)- style, stigma and ovary (bears ovules)

c) Advertisement (animal pollinated plant/flowers), Corolla, nectar

DIAGRAM 1: SCHEMATIC FLOWER OF AN ANGIOSPERM (a) AND GYMNOSPERM (b):



2.3.1 CLASSIFICATION OF FLOWERING PLANTS BY THEIR SEXUAL SYSTEMS

A) Spatial arrangement of male and female organs:

I) Individual plants

- Hermaphroditic: individual plants bear only bisexual flowers

- Monoecious: individual plants bear male and female organs (flowers bisexual or unisexual)
- Andromonoecious: individual plants bear bisexual and male flowers but male flowers are dominant.
- Gynomonoecious: individual plants bear bisexual and female flowers but female flowers are dominant.
- Polygamomonoecious: individual plants bear either bisexual, male or female flowers

II) Group of plants

- Dioecious: Individual plants bear either male or female flowers
- Androdioecious: Individual plants bear either bisexual or male flowers
- Gynodioecious: Individual plants bear either bisexual or female flowers
- Polygamodioecious (trioecious): Individual plants bear either bisexual, male or female flowers

B) Temporal or spatial isolation of male and female organs within a hermophroditic flowers or on the co-occuring unisexual flowers on a single individual plant (Monoecious species.

I) Protandry: Pollen released from anther before the stigma becomes mature (receptive)

II) Protogyny: Stigma becomes receptive before pollen grains are released from anther

III) Herkogamy: Male and female organs mature simultaneously but spatially isolated.

C) Biochemical recognition/rejection self-incompatibility alleles:

I) Self-incompatibility: Plants are polymorphic in respect to the presence of self incompatibility alleles. Pollination involving pollen and stigma sharing the same self-incompatibility alleles, including self-pollination do not result in fruit set.

II) Self-compatibility: All pollination, including self-pollination, result in fruit set.

D) Systems based on variation in style and stamen length or style dimorphisms (with or without self-incompatibility).

I) Heterostyly:

- Distyly: Plants with flowers having either long style and stamen (pin) or flowers with short style and long stamen (thrum)

- Tristyly: Plants having flowers with either short-, mid-, or long- styles in relation to the length of stamens.

II) Enantiomorphy (Enantiostyly): Plants having both flowers with the deflection of style either to the left or right of the floral axis.

The sexual systems in plants dictate the mode of pollination in the plant species. For instance selfing plant are normally hermaphroditic, monoecious and homogamous (self-compatible) among other adaptations.

3.4 POLLINATION AND FERTILISATION IN PLANTS

Pollen dispersal

Pollen release in both angiosperms and gymnosperms is spread over several days or more depending on humidity, temperature, and wind conditions.

Opening of mature flowers and pollen dispersal is normally followed by pollination which is a transfer of pollen grains by some means from stamens (male organs) to pistil (female organs). The union of male and female reproductive elements is the initiation of seed formation.

In the process of fertilization, one sperm (male gamete) unites with the egg to form a zygote that develops into the embryo of the seed. Generally only one embryo develops, but in some species, multiple embryos occur. Example, *Gmellina arborea*

The other sperm unites with polar cells within the ovule (Figure) located near the centre of the embryo sac. The resulting fused nucleus develops into the endosperm, a nutritive tissue available for the growing embryo and the young seedling which arises from it.

In gymnosperms - pollen grains drift between the scales and get in direct contact with exposed, partly developed ovules. The fertilization process is the same as in angiosperms.

Sometimes when self pollination occurs, the embryo is not formed, resulting into empty seeds. Isolated trees can thus have a high percentage of empty seeds. However, this depends on the mode of pollen dispersal and the distances between the tree both factors determining the efficiency of pollen transport between the trees. Abundant flowering is therefore necessary for a good seed crop. This should be accompanied with sufficient number of pollen producing trees (to reduces the chances of self pollination).

Proper seed survey is therefore necessary to establish the extent of flowering and later the amount of sound seeds; (through cutting test) before carrying out any collections.

The flowers are adapted to promote different modes of breeding systems in plants. The wind pollinated flowers are generally dull and small, having exposed anthers with small, light abundant pollen grains and hairy stigma. Most of the conifers fall under this category. There the speed and direction of wind is very essential to their successful pollination. Flowers pollinated by insects and other animals are brightly coloured with sweet scent and nectar in some cases. Their pollen grains are normally sticky and less abundant. For these species the population of the pollinators is crucial to their pollination. The insect pollinated tree species include those in Moraceae, Leguminoseae, Myrtaceae and Verbenaceae among others.

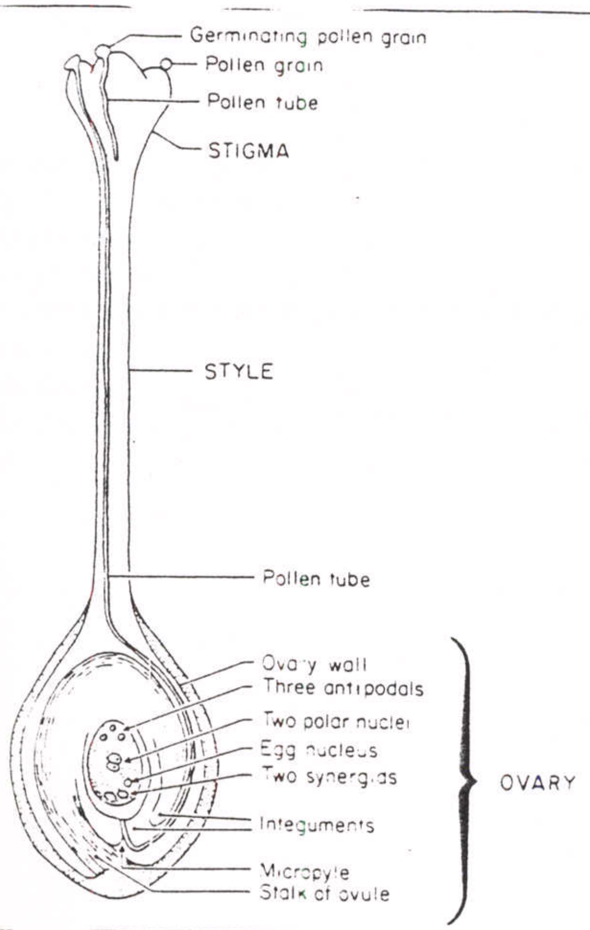
The process of pollination starts with the exposure and shedding of ripe pollen which carries the male gametes or their progenitor. The pollen grâin is normally exposed to a hostile environment and has to reach the proper receptive stigma while still viable.

Once pollen grains land on a receptive stigma (angiosperm) or close to micropyle (gymnosperm), they absorb nutritive secretions on the receptive stigma. The pollen grains germinate forming pollen tube. The pollen tube elongates and grows and enters the ovule (nucellus) through the micropyle.

2.5 FERTILISATION IN ANGIOSPERMS

Meiosis of a mother cell in the nucellus (ovary) folowed by mitotic cell division leads to the formation of embryo sac which is composed of a haploid eight-nucleate, seven-celled structure occupying the central space within the nucellus. When the elongating pollen tube the embryo sac it releases two male gametes. One male gamete unites with one of the nuclei in the embryo sac- egg cell forming a zygote which later develops into the diploid embryo plant. The second male gamete unites with two other female nuclei-the polar nuclei- to form a triploid cell which later develops into the endosperm, a tissue that later acts as food reserve to the resultant embryo. The remaining five nuclei of the embryo sac (2 synergids and 3 antipodal cells) play no further role in seed development. Successful fertilisation of the egg cell and successful triple fusion with the polar nuclei are both necessary for development of a viable seed.

DIAGRAM 2: AN ANGIOSPERM PISTIL JUST BEFORE FERTILISATION



C. FAO 1985

2.6 FERTILISATION IN GYMNOSPERMS

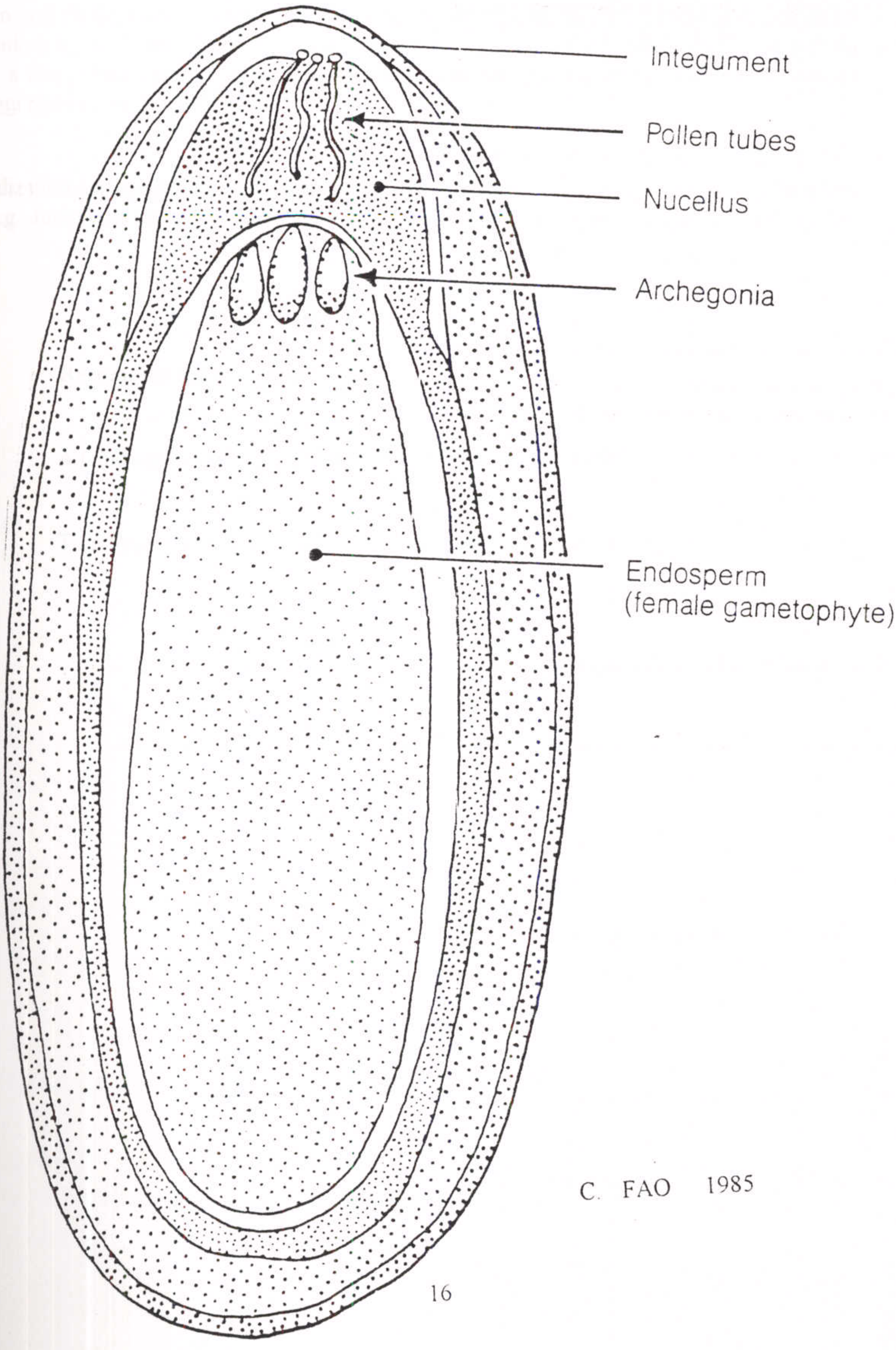
In gymnosperms ovules have certain characteristics in common with angiosperm ovules, but there are a number differences. There is normally a single protective integument which in a typical female cone is partially fused to the ovuliferous scale carrying the paired ovules. Meiosis in the nucellus, followed by mitotic cell division leads to the formation a multicellular haploid tissue-the female gametophyte. By the time of fertilisation, the female gametophyte is normally developed and is differentiated at micropylar end forming many archegonia, each containing large egg cell.

At fertilisation the pollen tube releases two male nuclei into an archegonium, one of which unites with the egg nucleus. This leads to formation of a diploid embryo. The second male nucleus aborts as in *Pinus* species or fertilises the second archegonium as in Cupressus species. The second male nucleus never unites with female nuclei to form a triploid tissue (endosperm) as it is in angiosperms.

Any failure of the pollen grain to germinate and later to fertilise the ovule leads unsuccessful pollination event. At times successful pollination may fail to lead to fruit/ seed development as a result of pollen competition, interactions with the style tissues, late incompatility process, or post-zygotic abortion.

After fertilisation, the embryo develops and various parts of fruit/seed are formed; the style/stigam, filament/anther, corolla and caly wither off and ovary form the fruit and ovules the seeds. However, in a few species fruits are set and mature without seed development and without fertilisation of an egg. Such fruits are called parthenocarpic fruits. They occur in a number of forest tree species such as *Betula*, *Fraxinus*, *Diospyros* and *Liriodendron*. Apomixis or uniparental reproduction is also common among some tropical tree species. This involves the production seed without fertilisation of the egg nucleus through sponteneous division of the ovary cells. The resultant embryo are normally identical to the parent plant genetically. Examples of apomictic plant species are *Mangifera* and Citrus.

DIAGRAM 3: A GYMNOSPERM OVULE DURING POLLEN TUBE DEVELOPMENT



3.7 SEED/ FRUIT DEVELOPMENT

Pollination and fertilization stimulates cell divisions and enlargements in the ovary and peripheral tissues leading to the formation of an ovule and the development of the enclosing or supporting structure, a fruit. Fruits take numerous forms - they may mature into fleshy or dry units and be simple, aggregate or multiple in structure.

After fertilization gymnosperms cones continue enlarging to form the familiar woody cone. In a few genera, e.g. Juniperus, the cone scales grow together to form a berry-like structure around the seeds.

Recommended Literature:

A Guide to Forest Seed Handling; FAO Forestry Paper 20/2.

Tree Seed Handbook of Kenya; GTZ Forestry Seed Centre, Muguga. Kenya.

CHAPTER 4

PRINCIPLES AND TECHNIQUES OF TREE SEED HARVESTING

4.1 SEED SURVEY

Every seed collection starts with a proper and regular seed survey in the region of the proposed collection covering one or several species. Their flowering and later fruit development and maturity are monitored by the collector. The survey is supposed to provide the following information:

4.2 FLOWER SURVEY

- The distribution of flowering in the seed source
- The flowering level of selected plus trees
- The number of male trees on flowers (for dioecious trees)
- The synchrony in the maturity of flowers in the different individual trees in the seed source.

4.3 SEED SURVEY

- The expected amount of seeds versus the demand
- The level of attack by pests and diseases
- The maturity level of the seeds
- The accessibility of the seed sources and the type of collection equipment needed.
- Ownership of the seed source and the neea for permission before seed collection.

4.4 ESTIMATING FRUIT SEED CONTENT BY CUTTING TEST

Examination of a sample of seeds in the fruit serves the purpose of indicating the state of development or maturity of the seeds and the incidence of damage by pest and diseases.

Fruits may develop normally to maturity whether one or one hundred on the contained ovules have been successfully fertilized and undergone normal development in pathernocarpous species fruits can mature without containing any sound seeds at all. The number of fruits is therefore not always a good guide to the number of seeds. So its important to ensure that enough trees are producing seeds in order to maintain genetic diversity and that the crop is healthy, i.e. free from pests and diseases and that the seeds are not empty.

4.5 PLANNING SEED COLLECTION

4.5.1 EQUIPMENT AND VEHICLES

One part of planning is the timely assembly of clear information on the nature of magnitude of the seed collection tasks - number of species and provenances, seed quantities, location of stands, best dates to collect, etc. The other part is to select and assemble the resources needed for the job.

(i) Organization of Collecting Teams

Known or estimated output of collecting teams needs to be related to the quantity of seed, number of stands and length of season, in order to determine the required and size of teams, i.e. mandays requirements.

(ii) Organization of Transport

Collection teams need to be cut to a minimum the time spent in moving between one site and the next. Transport must be available where and when it is needed. If necessary, extra vehicles may be temporarily hired. In roadless country, advance arrangements may be needed to employ extra unskilled workers to assist in carrying equipment, tents, etc.

(iii) Organization of Equipment

Choice of equipment will vary greatly according to local conditions. The steeper and less accessible the terrain, the simpler and lighter should be the equipment. Apart from collecting tools, safety clothing, first aid equipment and plenty of bags and sacks should be provided.

Materials needed for collection should be procured well in advance because collection needs proper timing. This is to avoid loss of viability, rotting of seeds and outcompete other seed eaters like monkeys, birds, insects, etc. The equipment need not be too sophisticated but this will depend on the species. For example, shrubs will allow direct hand picking while big trees have to be climbed.

4.6 PRINCIPLES OF SEED COLLECTION

6.6.1 MAINTAINING THE GENETIC BASE

One of the most crucial issues in seed collection is the collection from a sufficient number of trees. The less the trees from which seeds are collected from and the closer they grow to each other the higher is the risk of inbreeding in the future generations with considerable reductions in all important characteristics (growth rate, resistance to pests and diseases, lowered fruit and seed production, adaptability to site, etc.).

4.6.2 DETERMINING SPECIES AND PROVENANCES

Species

Selection of species for planting often presents no problems. In a simple afforestation project, which uses of proven well adapted species and provenance and obtains the seed from a local seed source, the choice if automatic. But sometimes, afforestation objectives change, e.g. emphasis may shift from sawlog to pulpwood or fuelwood productions or unexpected disease problems may arise, e.g. *Dothistroma pini* attacking *Pinus radiata* or *Cinara cupressi* attacking *Cupressus lusitanica*.

For large-scale collections, data on seed demand by species need to be assembled some months in advance. Most species need a year or more in the nursery. Estimates of seed demand must therefore be made about two years before planting in the field.

A centralized organization is needed to solicit demand estimates from the several planting agencies and to consolidate these by species and provenance.

Provenance

The word provenance in its simplest use means the place in which any stand of trees is growing. When applied to seeds, the meaning is frequently extended to mean the area where the mother-trees of the seeds were growing. In case where seeds are collected from an exotic plantation, one may talk of "derived provenance".

Evidence shows that within a botanical species, significant genetic variation in forest trees is frequently associated with geographic differences between the places where they are associated with soil or climatic changes.

Increasingly foresters recognize the vital importance of provenance and specify the precise provenance which they need to plant on a given site, not just the species. Even within a country distinct provenances or rates of a species others which look alike may differ in their adaptability to specific sites.

4.6.3 QUALITY AND SELECTION CRITERIA

Generally seeds can be collected from any tree of the species, if genetic diversity is maintained, the performance of which shows at least:

- better health than average

- average quality needed for the purpose the tree is used for, e.g. timber species should be selected for straightness of bole, fodder trees for large crown, fuelwood trees for high branchiness, etc.

There is a probability that the next generation shows the same good characteristics as the mother trees.

4.6.4 QUALITY OF CROP

In some countries a four class scale is used to estimate the nature of the crop. The classes are:

0 - <u>no seed crop:</u> Trees without flowers and fruits

1 - <u>weak seed crop:</u> Flowering and medium size seed crop on free growing trees and tree on free borders of stands

2 - <u>medium size seed crop:</u> Flowering and very good crop on most trees

4.7 SEED COLLECTION TECHNIQUES

There are various methods available for the actual operation of collecting seed from a given tree. However, it should be noted that almost invariably it is the fruits which are harvested from the trees and not the seeds. Only at a later stage in some species are the seeds extracted and the fruits discarded; in other species seed extraction is omitted and fruits are sown in the nursery with the one or more seeds which they contain.

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:

(i) Relative size and numbers of the natural dispersal units and of the units which can be conveniently collected

(ii) Characteristics of the fruit: size, number, position and distribution of fruits; resistance of peduncles to shaking, pulling, breaking or cutting; interval between ripening and opening.

(iii) Characteristics of the tree: diameter, shape and length of hole, bark thickness, shape of crown, size, angle, density and resistance to breakage of branches, density of foliage and depth of crown.

(iv) Characteristics of the stand: distribution and stocking of trees (e.g. isolated trees, open or dense stand), density of understorey and ground vegetation.

(v) Characteristics of the site: slope, accessibility.

The various collection methods may be classified into the following:

- Collection of fallen fruits or seed from the forest floor
- Collection from the crowns of felled trees

- Collection from standing trees with access from the ground
- Collection from standing trees with access by climbing
- Collection from standing trees with other means of access.

4.7.1 COLLECTION OF FALLEN FRUITS OR SEEDS FROM THE FOREST FLOOR

(i) **Natural Seed Fall**

Collection from the forest floor of fruits which have fallen after natural ripening and abscission is common practice with a number of large-fruited genera. It is cheap and does not require as highly skilled labor as, for example, climbing; school children or casual labor may be used. Fruit size is very important as the larger the fruit, the easier it is to see and pick up by hand. Genera normally collected from the ground include *Tectona, Gmelina, Vitex, Podocarpus, Prunus*, etc.

The main disadvantage of collection from natural fruit shedding are the risks of collecting immature, empty or unsound seeds, and uncertainty in identifying the mother trees from which seed is collected. Seeds in the first fruits to fall naturally in the season are often of poor quality.

Clearing the forest floor of vegetation and debris, including old or prematurely fallen fruits, and/or spreading out sheeting of light canvas, calico, or plastic to catch the seed can greatly facilitate collecting efficiency. If carefully timed, this operation will also eliminate much of the risk of collecting empty or non-viable seed. Sound fruits should be gathered as soon as possible after they have fallen, to avoid damage or losses from insects, rodents of fungi and premature germination. Collection from the ground must, therefore be perfectly timed with seed fall.

(ii) **Manual Shaking**

If fruits are easily detached but natural fruit fall is insufficiently concentrated in time, fruit fall may be induced by artificial means. Trunks of small trees and low branches may be shaken by means of a long pole and hook or by a rope. This method has produced good results in *Cordia alliodora* as it facilitates rapid collection of seed with good viability as on as visual inspection shows that the fruits are mature.

(iii) Use of a rope involves an initial operation to pass the rope over the branch to be shaken. The same method is used to hoist a pulley into the crown. A line is attached to a weight which is projected over the branch by hand or by catapult. For higher branches the line may be attached to an arrow which is shot from a bow.

(iv) Collection of seed after dispersal

Although collection from the ground is most often used for fruits, it can also be used for seeds dispersed after the cones of fruits have opened. The use of sheeting spread on the ground in this case is very essential. Gathering of fruits on the ground is usually done manually but may be assisted by using a simple hand-tool, such as a long-handled rake.

4.7.2 COLLECTION FROM THE CROWNS OF FELLED TREES

One method of collecting large amounts of seed is to synchronize it with normal commercial felling carried out during the seed ripening season and to collect seeds or fruits from felled trees. If fruits are to be collected from throughout the felled crop, picking should for safety reasons be postponed until felling in the area is complete. If phenotypic quality of parent trees is more important than quantity of seed, it is preferably to select, mark and, if possible, fell and harvest fruit from superior mother trees in advance of the main felling. Collection from felled trees is only acceptable if the tree is due to be cut but the trees should not be cut for the mere purpose of obtaining seeds.

4.7.3 COLLECTION FROM STANDING TREES WITH ACCESS FROM THE GROUND

(i) **By hand**

In the case of shrubs or low-branched trees, fruits can be picked directly from the branches by the collector while standing on the ground. Example of genera which can be collected using this method are *Acacias, Zizyphus*, etc.

Smaller fruits are generally harvested directly into a basket, bag, bucket or other container held or worn by the picker.

(ii) **Cutting and breaking**

For branches out of arms' reach a variety of long-handled tools is available to enable the collector to reach the fruits from the ground. A pole and hook may be used to pull branches down within reach. Long-handled rakes, saws, chisels, hooks or pruning shears are used to pull off or sever individual fruits or fruit-bearing branchlet. Light rigid bamboo, aluminum or plastic poles 4-6 m in length are common. In order to reach beyond the 6-8 m range of single poles, multistage telescopic poles with a shear on the end have been developed.

However, it has been noted that in some species, fruits or cones on the lowest branches may yield little seed, because of lack of pollination in that position, and that it is preferable to collect fruits from at least halfway up the crown. Ability to use long-handled tools efficiently from the ground is much affected by the density and form of the crown in individual trees.

A rope can be thrown or pulled over a branch as already described, but used to break off the seed-bearing branch rather than to shake it. The method is however not recommended for general use as it damages the tree, allows access to pests and diseases and in the case of some species whose seeds take two years to mature, destroys the next year's seed crop while collecting the current year's.

4.7.4 COLLECTION FROM STANDING TREES WITH ACCESS BY CLIMBING

There is a limit of height to which long-handled tools can be used for collecting seeds or fruits from the ground. Near the limit the operation consumes much time and energy but produces little seed. For tall trees which cannot be felled, therefore, climbing is often the only practical method of collecting.

For convenience the operation may be described under the following subheads:

- Climbing into the crown by way of bole
- Climbing into the crown directly
- Climbing and picking of fruits within the crown.

Climbing into the crown by way of pole

Climbing with minimum equipment

Climbing without mechanical aids is practiced in a number of countries. However, climbing tall branchless boles with hands and feet involves a considerable safety hazard and the risks may tempt climbers to prefer collecting from the most easily climbable trees which are often silviculturally the least desirable. It is desirable to introduce one or other of the special climbing aids now available.

Climbing irons or spurs, which are attached to the climber's boots, offer a light and inexpensive means of safer and more efficient

climbing, if combined with safety belt, strap and line, safety helmet of glass fiber and heavy leather gloves. The lightness of the spurs (less than 1 kg a set) makes them particularly suitable for use in accessible stands in road-less country, where all equipment must be carried on foot.

There are a number of different types of climbing irons but basically they consist of a forged iron arm and connecting piece which terminates in a pointed spur. The iron must be fastened securely by a leather strap to the foot gear and sometimes to the leg length but is an advantage if the point does not extend beyond the sole of the boot, so that the climber can walk on the ground without difficulty.

The optimum length of spur depends on the size type of bark. The thicker the bark, the longer the desired spur length. Climbing irons are not safe on scaly bark. The main disadvantage of spurs is the damage they do to the bark, particularly of thin-barked species. If climbing is only occasional, this should not be excessive, but frequent climbing of the same tree is liable to cause an unacceptable degree of damage.

Ladders

For heights from about 8 to 40 meters, vertical scaling ladders in several sections provide a safe and convenient means of climbing the bole to the live crown. They can be made of a variety of materials including wood, aluminum, magnesium alloy, etc, but each ladder section must be light enough to be easily pulled up by the climber.

The bottom one or two sections of the ladder are set up parallel to the stem with the bracket at the top against the trunk. The climber ascends with his safety strap around both the trunk and the ladder until his shoulders are level with the top of the ladder and fastens it to the trunk by a rope or chain. Subsequent sections are pulled up by rope and fitted into the section below. Each section is climbed and fastened to the tree in turn. With lighter sectional ladders the climber can carry two sections, each 2 m long, attached to his safety belt.

Sectional ladders can be used without any risk of damage to the tree. They can be awkward to handle in stands with dense canopy or undergrowth and are much heavier to carry than climbing irons, especially if long clear boles impose the need for many ladder sections. They are therefore of limited use in inaccessible road-less country, but are ideal in seed orchards or plantations in flat to pography.

Climbing into the crown directly

Ladders

Access to stout lower branches in the crown may be obtained directly from the ground or by ladder, provided that the branches are not too high. Free standing domestic step-ladders or taller tripod ladders have the advantage that they do not need to be rested against the tree; they are awkward to handle in dense stands but are suitable for collection in seed orchards or where trees are widely spaced.

Ropes and hoisting equipment.

Access to the crown can be achieved by suspending a rope, rope ladder or hoisting equipment from a stout branch. The same methods for projecting a thin line over the branch (throwing, catapult, shooting arrow) are sued when using a rope to shake branch.

Climbing and picking fruits within the crown

Methods of climbing and picking fruits within the crown are independent of the method used to reach the crown, whether this is by ladder or climbing irons. In climbing on the branches of a tree as on the rungs of a ladder, handholds are used mainly for guidance and balance and the feet and legs are used for thrust. Only one limb - a hand or foot - is moved at a time, gripping or standing on branches where they are strongest, close to the main stem. Doubtful branches should be tested by being pulled sharply before being trusted to carry the weight of the climber. Confidence and muscular coordination are keys to safe climbing.

Safety belt and strap.

This serves to secure the climber to the stem of the tree. The safety belt and safety ropes together ensure the safety of a climber as he ascends the bole and while he picks fruits, even in the absence of a safety line.

Safety line and safety ropes

These can be divided into classes: the short rope which the climber uses to attach himself to the tree while working in the crown and the long safety line which runs down to the ground and is controlled by an anchorman who remains on the ground. The length of the line must be at least twice the height of the tree, to allow a climber to be lowered to the ground. Apart from the additional safety factor it provides, the safety line can enable the climber to reach fruits in the outer crown which would otherwise be inaccessible.

Method of picking fruits.

With correct use of safety harness and safety line the climber should have both hands free to pick the fruits. Methods vary according to the size, number and distribution of fruits and the firmness of the peduncle, attachment. Numerous, small clustered and accessible fruits can be picked and deposited immediately in a bag attached to the climber's belt or slung from his shoulder and with his mouth braced open. Bigger and more scattered fruits may be detached, chopped and collected from the ground later. Fruits too inaccessible to be picked by hand may be detached by long-handled pole, hook, rake or shears. Gathering of fruits from the ground, when they have fallen after detachment by tools, is the same as described for natural seed fall. If fruits are small, numerous clustered, inaccessible for hand-picking or held firmly by the peduncle, it may be necessary to cut off whole fruit - bearing branchlet by long-handled shears or saw.

Climbers should wear boots with non-slip soles and overalls without belts or loops which could catch on branch snags. Anchormen must wear industrial safety helmets to protect them from objects falling from the trees.

4.8 SEED HANDLING DURING COLLECTION

During the period immediately after collection from the tree, seeds are particularly susceptible to damage. At the same time the environment in which they are placed, which is fairly easy to control in a seed processing depot, is difficult to control in the forest and during transport from the forest to seed depot. Fluctuations of climate cannot be predicted or prevented. During this period there are serious dangers of loss of the identity as well as of the viability of the material. If seeds have already lost some of their viability before storage, even the best storage treatment will give poor results. Careful advance planning is therefore essential.

4.9 MAINTAINING VIABILITY

Mostly it is fruits, not seeds, which are picked from the trees. Sun drying of fruits and extraction of seeds is carried out in the field in some places. In others it is considered preferable to transport the fruits as quickly as possible to the seed processing depot, where the conditions of extraction can be controlled much more closely than in the field.

If seeds are not extracted in the field, great care must be taken of the fruits both in the forest and during transport. Bulk quantities of fruits in high temperature and humidity are very susceptible to deterioration due to a high rate of respiration. Good ventilation to reduce these dangers is very important. If fruits are stored temporarily in separate containers, they should not be filled to the top. In particular, sacks containing fresh cones should only be half-filled; in this way space is left for expansion of scales as cones dry. Otherwise, scales may acquire a set which severely impairs subsequent seed extraction. Large open-mesh baskets are ideal for promoting free air circulation in cones and other large fruits and may be constructed from locally available materials, whether metal, willow, bamboo or rattan. Daily turning of loose-piled fruits or of sacks can do much to improve access of air to the less exposed fruits.

4.10 TRAINING AND SAFETY

Seed collection by climbing is arduous work and it is essential that climbers are carefully selected and well trained before they commence collecting operations. They need to be physically and mentally fit.

Safety precautions will vary according to local conditions and particularly the species of tree and the equipment and methods of collection used.

Some important rules need to be observed:

- All equipment should be carefully stored
- Clothes should be strong, well fitting and suited to the weather
- All equipment should be checked before use

- Do not climb in wet or windy weather, nor in poor light, e.g. at dusk nor when overtired
- Do not climb trees with stem rot, severe cankers or galls, split stems, double leaders or any other mechanical weakness
- The safety line should be coiled on the ground before the climber ascends to avoid tangling snagging the rope in the underbrush
- The anchorman should hold the safety line under one arm and over the other shoulder
- Never climb with anything tied or looped around the neck
- Safety helmets and if possible goggles should be worn to prevent injury to the head and eyes
- Stand on and grip branches close to the point of attachment to the main stem
- Watch for brittle branches, test doubtful ones before putting weight on them. Avoid branches with bark peeling on them - they are slippery
- The climber should have three points of support at all times (one hand and two feet or two hands and one foot)

- Do not carry tools when climbing the crown. If there is need for a pole pruner or cone rake, etc, use a light tool line to hoist the equipment to working level. Leave the tool line attached to large tools while working. Return tools to the ground on the line, do not drop them down
- Beware of sharp branch stubs, they can snag clothing and may cause painful cuts and bruises
- Climb spirally or in a ziz-zag manner
- The diameter of the main stem should not be less than 8 cm at waist level during climbing
- While attaching safety rope, keep one arm securely around tree until the rope is fastened securely to safety belt
- Before letting go of the tree with your hands, test your weight against the safety rope and footholds
- When picking near the top of the tree, keep your body close to the stem, so that your weight bears down, not outward
- The safety <u>strap</u> should always be attached around the tree stem except while one is climbing or changing position in the crown or one is suspended on the safety line
- Before dropping bags of cones or other material, be sure that the personnel on the ground are notified and are well clear
- When collecting fruits from a ladder, make fast the top of the ladder to the tree with a nylon <u>strap</u>. The ladder must be further steadied with two guy-lines

- Have a well-stocked first aid kit handy at the climbing site at all times.

Recommended Literature:

1). A guide to Forestry Seed Handling. FAO Forestry Paper 20/2

2. Tree Seed Handbook of Kenya. J. Albrecht (Ed.) GTZ Forestry Seed Centre Muguga, Kenya.

3) Tropical Forestry Handbook. Vol. 1 and 2. L. Pancel (Ed.) Springer-Verlag Berlin Heidelberg 1993.

CHAPTER 5

SEED PROCESSING TECHNIQUES

5.1 INTRODUCTION

Seed processing involves temporary storage, pre-cleaning, extraction, cleaning and drying (orthodox seeds). The seed processing operations are carried out to enhance the quality of the seed. They reduce storage space requirement, eliminate pests and diseases from the seeds and make sowing easier.

5.1.1 TEMPORARY STORAGE

If fruits cannot be transported at once to the processing depot, temporary field storage must be attached, in sheds or under some kind of shelter. Shelter is needed against too high in solation. Sheds should be well ventilated and sacks well spaced on racks or hung from hooks to allow free air circulation. Hanging from hooks has the advantage of giving protection against rodents. If storage is in the open, overhead shelter may be provided by canvas tarpaulins or polythene sheeting. If the collecting season coincides with a period of reliably dry but not too hot weather, no overhead shelter is necessary. Sacks should never be piled on top of each other in large heaps

For most orthodox seeds some degree of advance drying of the fruits in the field is desirable. Polythene bags are not suitable for temporary storage of fruits of these species, since they prevent drying and may encourage fungal mould and overheating.

5.1.2 SEED EXTRACTION TECHNIQUES

The methods of extracting seeds from fruits are determined mainly by characteristics of the fruits. Fleshy fruits are treated by a depulping process which usually involves a combination of soaking in water with pressure of gentle abrasion. Cones and other woody or leathery fruits are first dried until cone scales open or seeds become detached from the placenta of the fruit, and then treated manually or mechanically by tumbling or threshing in order to separate the dry seeds from the dry fruits.

Some indehiscent fruits, mainly nuts, achenes and winged samaras, do not require extraction but are stored or sown as fruits. Drying under cover with frequent turning of the fruits is appropriate.

5.1.3 DEPULPING

Depulping of fleshy fruits should be done soon after collection to avoid fermentation and heating. Small lots of seed are usually macerated by hand. Alternatively flesh may be macerated by rubbing it against or through a screen. The pulp and skins can usually be separated from the seed by washing through appropriate sieves or by differential floatation in a deep bowl through which a slow stream of water is flowing. The seeds sinks while the pulp rises to the surface.

For some other pulpy fruits like *Syzygium cumini, Azadirachta indica, Ocotea usambarensis, Gmelina arborea*, etc, are placed in barrels or cans with water. After a day or two the pulp becomes soft. The fruits are then mashed carefully without crashing the seeds. When plenty of water is added, the pulp will float while the seeds sink to the bottom.

After separation, orthodox seeds should be carefully air dried under cover, with frequent turning. Thereafter they can go to the nurseries or for further drying to a lower moisture content ideal for storage.

When large quantities of fruits have to be depulped, various designs of machines are available. They include feed grinders, concrete mixers, hammer mills and macerators. Most machines only free seeds from the flesh; a part of all of the residue must be removed in later cleaning.

5.1.4 DRYING AS A METHOD OF EXTRACTION

Drying must be used in the extraction of seeds of many important tree species and is always used for the cones of pines and other conifers and the capsules or eucalyptus.

a) Drying under cover

This is a slow method of drying fruits for seed extraction. Fruits must be in well ventilated rooms, spread thinly, stirred regularly if on a solid surface or, preferably, place on trays with a wire mesh on a solid surface or, preferably, placed on trays with a wire mesh bottom to allow all-round air circulation. Air-drying under cover is effective for species like *Maesopsis eminii* which can easily be damaged by heating in the sun.

b) Sun drying

This method is suitable for drying cones and fruits of species which will withstand high temperatures. It can be 100% effective in causing fruits to open.

Spreading the fruits in layers on screens, platforms, canvas or other sheeting in the sun is one of the simplest methods of air drying and requires little investment in equipment.

Fruits can be laid on wire screens with meshes of suitable size to let seeds drop through onto canvas of polythene sheets. The main requirements are:

- Frequent stirring and turning to promote uniform drying and opening of cones and release of the seed
- Arrangements for immediate covering of fruits in the event of rain, either by moving them indoors or by erecting a temporary shelter over them

- Care to avoid overheating of the fruits while they still have a high moisture content

- Frequent removal of any seeds which have separated from the fruits, prevent their being exposed too long to intense direct sunlight

Protection against birds, rodents and insects which may pose a serious threat in open air drying than in drying inside a building.

5.1.5 SEPARATION

When fruit and cones open after drying, some seeds fall out easily as a result of manual stirring. But many seeds are left inside, especially in those drying techniques where the cones remain static. They must be removed as soon as possible after drying is complete.

In some species a thorough manual shaking is sufficient to extract the remaining seed. More vigorous treatments are however needed for some species, tumbling for conifers and threshing for hardwoods.

5.1.6 TUMBLING

A tumbler is a rectangular or round container or drum mounted horizontally on its long axis. As it turns, cones tumble about and seeds fall from open cones. It can be operated by hand or mechanically driven.

5.1.7 THRESHING

Extraction of seed from dry fruits of many hardwood species is accomplished by threshing. This is done by spreading the fruits on a platform of suitable material and beating them with a slender pole.

More robust methods, such as pounding the fruits with a wooded pestle or putting them through hammer mills, must sometimes be applied.

5.2 OPERATIONS AFTER EXTRACTION

When seeds have been extracted form their fruits, several operations are needed before they fit to go into storage. Sound seeds must be separated from empty and non-viable seeds and from inert fragments of fruits, winged seeds of some but not all species need to be dewinged; if seeds are to be stored, their moisture content must be tested and, if necessary, raised or lowered to the percentage most suitable for storage.

5.2.1 DEWINGING

Winged seeds or winged fruits are a feature of many forest trees and almost all conifer seeds have a wing which may vary from long and hard to very short and soft. In order to make seed processing and nursery sowing easier, the wing is usually removed whenever it is larger than the seed (or fruit).

For small quantities of seed dewinging may be done by hand, either by rubbing seeds between the hands or against a screen or roughened surface.

Mechanical injury can be avoided by moist dewinging. The seeds are moistened in water and left for 20-30 minutes before they are rubbed by hand to remove the wings. In other cases the wings absorb moisture and are shed.

57.2.2 SEED CLEANING METHODS

The main characteristics by which sound seeds may be distinguished from inert matter including sterile and empty seeds are size and shape, specific gravity, color and surface texture. The ease with which sound seeds can be differentiated depends on:

- The degree of difference which exists between the seeds and the matter to be separated from them
- The degree of uniformity among the seeds themselves.

Color, size and shape are useful criteria for visual separation, while most seed cleaning machines make use of seed size and specific gravity.

Screening or sieving methods separate by seed or particle thickness or diameter.

Liquid floatation and blowing, fanning and winnowing methods by specific gravity. Hand cleaning is also carried out for some species.

5.2.3 SEED DRYING

(a) Orthodox seeds

For medium or long-term storage of many species, a moisture content of 4-8% is recommended. This is considerably less than the MC of freshly collected seeds. Reduction of MC can be achieved in most species by placing the seeds in an ambient atmosphere of RH 15-20% for a period sufficiently long to allow the seeds to reach an MC in equilibrium with the RH.

The effectiveness of air-drying depends on local climatic conditions. In areas where insolation is high, many species can be successfully dried to 6-8% MC by exposing them to direct sunlight. Care must be taken to ensure that the seeds are as dry as possible before exposure and that they are moved frequently. Seeds should never be dried on polythene sheets, since temperature easily rises to 60 degrees centigrade.

(b) Recalcitrant seeds

Some species (particularly highland forest species) do not withstand drying at all or only moderate drying in the shade. Often they should not be dried down to a low moisture content like hard-coated species and the embryo only survives at a MC of 20-25 or even 40%. They should be sown immediately or stored under favourable conditions which keep the MC at a suitable level.

CHAPTER 6

SEED QUALITY TESTING AND SEED STORAGE

6.1 INTRODUCTION

Seed quality control is essential in providing consumer protection in regards to purity, germination capacity and freedom from diseases. Quality in seeds is a multiple concept with several components.

6.2 ANALYTICAL PURITY

In addition to entire seeds of a names species, a seedlot contains impurities such as broken seeds, chaffs, twigs, leaves and other inert matter. The presence of these materials within a seedlot could have adverse effects on the seeds eg.

- plant materials within a seedlot could be carriers of insect pest, pathogens and source of high moisture
- significant waste of resources occurs when handling, transporting, storing and using unclean seeds.

During seed collection, extraction and storage, it is therefore important to ensure that a high degree of purity is maintained at all levels. The purity analysis test in the laboratory provides information on the number of pure seeds by weight in a given sample. This result indicates the cleanliness of a seedlot and the type of impurities in it. Small seeded species like *Eucalyptus* are difficult to clean, but attempts should be made to obtain pure seedlot by using special cleaning techniques e.g. sieves.

6.3 SPECIES PURITY

It is always important to identify a tree species properly before actual collection is done. Wrong naming resulting from uncertainty of species identification can create serious problems to the users; particularly if the seeds are to be used for research purposes or production of specific tree products. Species which closely resemble one another e.g. *Casuarinas* and *Eucalyptus* create special problems. In addition, one could come across some rare tree species which he cannot identify with certainty. In such cases a seedlot should be accompanied with plant samples for taxonomic reference.

6.4 GENERIC PURITY

All aspects of plant improvements e.g. grafting, crossing and selection aim at providing users with species with advantageous qualities in terms of its genotypic and phenotypic characters. These qualities are inheritable and are passed on through generations by the seed. The seed thus contains all the genetic information for the future plant. The importance of mother tree selection can therefore not be ignored.

Seed collection from a large number of individuals ensures a widening of the genetic base to provide assurance against natural disasters. Collections from few or closely related individuals, provides a danger of artificial narrowing of the genetic base, which may lead to loss of advantageous genes, accumulation of recessive genes, reduce vigour and genetic instability. All these aspects should be borne in mind whenever collection activities are carried out.

6.5 GERMINATION CAPACITY

A high percentage of pure seeds by number which can germinate to produce robust seedlings is an ultimate goal in all seed production programmes. It would be pointless to waste a lot of time and resources to acquire seeds which cannot certify the expectations of the nurseryman in terms of seedling requirements. Every seedlot is to some extent a mixture of live and dead seeds. The higher the percentage of live seed portion, the better.

Germination capacity of a seedlot is determined through a germination test, the result of which provides the sowing value of a seedlot. It is ideal to ensure that only live seeds are collected; however because this is not practically possible, any factor which could indicate a negative physiological state of seeds must be taken into account before collection commences. At all levels of handling the seeds must be treated in such a manner that it retains its viability until that time that is sown. Seedlots of low germination capacity would be unfit for storage of low commercial value and must be sown with minimum storage.

6.6 VIGOUR AND SIZE

The germination capacity of a seedlot only indicates the ability of seeds to produce a seedling under a standard test. Seed vigour indicates the ability to germinate in unfavorable conditions. This concept is important because the fact that a seed can germinate under favorable conditions in the laboratory or glasshouse does not mean that it can germinate anywhere wherever it is sown. Differences in nurseries and their management creates circumstances whereby low vigour seeds would be disadvantages. Factors like soil type, water availability and soil temperatures greatly affects seedling emergence. Low vigour seeds could result in reduced and delayed emergence which could necessitate re-sowing. This operations can be both costly and time wasting.

Seed is usually at it highest potential when it attains physiological maturity i.e. maximum dry weight. At this stage the seed is at its maximum vigrour which denotes the vigour time for collection. Beyond this stage, aging and reduction of vigour commences and proceed at a rate which is determined by environmental conditions. Timely collections is therefore important to avoid premature, low vigour or aged deteriorating seeds.

Reduced seed vigour creates problems during routine seed testing because of differences in emergence rates, abnormal and weak seedlings and increasing duration of test periods. These factors make assessments difficult and could make results of such test unreliable. Likewise in plantation programmes seedlings should emerge and develop at the same rate to facilitate timely plantings and management.

6.7 SEED HEALTH

The health conditions of the seed is important in several ways

- Severely infected seed could loose viability and render them useless for sowing purposes
- Seeds could provide a means by which certain diseases are carried from one area to another
- Single infected seeds could contaminate other seed in store resulting into loss of large stock
- Some seed-transmitted plant pathogens would not harm the seed but would greatly affect seedlings and trees and reduce quality and quantity of the tree products of which the tree is expected to provide.

It is therefore important to consider the health of the mother trees and the manner of collection before engaging into large scale collections. Most plant diseases are caused by fungi which prefer warm moist conditions for survival and reproduction. Collection activities should therefore be done in dry weather. When the seeds are extracted using wet methods, then they should be dried immediately to safe MC levels to avoid invasion by fungi. Seed infection by pathogens occur in three ways:

1. on the mother plant, e.g. flowers, pods or fruits
2. contamination due to weathering on the ground or during extraction
3. contamination in store

All these infection channels can be avoided by careful observation of collection and handling rules. It is possible to detect and quantify seed pathogens in the laboratory through a health test. The results provide an indication of the infection level of a seedlot and decision for chemical treatment or disposal can be taken. Normally high infected seedlots would be suitable for storage.

6.8 MOISTURE CONTENT

This is the key factory in determining whether or not seed will retain its germination capacity from collection to sowing time. High moisture seeds increases physiological deterioration, provides environments conducive to fungal growth and are susceptible to mechanical damage. Seeds should therefore be collected and maintained at the lowed MC as possible. However when seeds are collected at relatively high MC then they should be dried as soon as possible to safer levels before storage.

Seeds of orthodox species e.g. *Acacias* are collected at a relatively low MC and do not require long drying periods. When handling recalcitrant seeds and pulpy fruits however, it is important to ensure that seeds/fruits are now exposed to high temperature after collection. Recalcitrant seeds should always be maintained at high MC levels due to their sensitivity to desiccation. Such seeds require constant free flowing air and should never be kept in airtight containers. Although such seed perform best when shown fresh, methods for temporary storage and special handling must be strictly observed.

6.9 MANAGING A SEED TESTING LABORATORY

There are several steps to be followed when managing a laboratory with routine or research work. Management is a practical occupation which can be perfected through experience.

Establishing a routine.

1. What is to be achieved
2. What information is necessary
3. In what order should steps be taken

Examples:

Samples are sent in from harvested seed lots. Some samples are received from research sources. The first step in routine seed testing is to record all the samples received. The records should contain date, species, source and registration/batch number. Every sample is given a test number. Once all the results have been recorded, the results are analysed, interpreted and documented.

Establishing the Cause

Several things have to be considered, what, when and where does the problem occur. How big is the problem? If there are low germinations, the cause could be listed out e.g.

- is the media used a good one
- is the temperature being used the optimum
- is there enough moisture in the substrate
- is the seedling assessment done properly
- was the seed dormancy sufficiently broken

Eliminate the unlikely reasons having come to a conclusion. Take the appropriate action. Do not dismiss all the unlikely reasons lightly because there may be a combination of reasons.

Communication

In the foregoing example, it is important that you are informed of what is going on. the information should flow up and down the staff. It is better if information is not passed through an intermediate every time but that you are approachable.

Staff need to know exactly what their job is. If there are any changes, what the changes are and where they fit into the change. If giving instructions, they should always be clear and prepared to discuss these with them. Instructions to more than one person should be in writing to avoid ambiguity.

Staff

The seed laboratory staff are an important assert. The results that they give must be accurate. The initial training of a seed analyst takes some time, it is therefore important they have good working conditions and that they have job satisfaction. Seed analysis could be seasonal in some laboratories, the staff can be deployed in other sectors during off peak season.

Accuracy

This is an important aspect of seed testing. Maintenance of equipment and high standards of organisation and cleanliness in the laboratory is necessary.

General cleanliness

The laboratory should be comfortable and clean. There should be adequate electric supply and water and good natural daylight. The laboratory and seed stores should be free from pests and rodents. Routine checks and cleaning operations should therefore be instituted The facilities in the laboratory should not be used for any other things.

Equipment

There doesn't have to expensive but can be good enough to serve the purpose. It is advisable to test a range of locally available materials, evaluate their costs and choose those which are easily available e.g

- an accurate balance
- expandable materials should be in good supply

Laboratory set-up

Depending on the volume of operations, there should be partitions within the laboratory, one for germination and the other for purity. There should be enough storage for samples and seeds.

1. purity testing
2. germination testing
3. healthy testing

Germination responsibilities:

Delegate work among analyst's. The senior analyst may check the work of other analysts. She/he should also be able to perform difficult analysis. The reports are also carefully checked before sending out. Monitoring of equipment and expandable to ensure they are in good working conditions and consumable e.g. sand, filter paper are in stock.

Purity responsibilities:

- organising order of priority of samples
- delegates work to analysts
- checking results to make sure they are correct and that all regulations are followed
- checking and identifying difficult portions within the seed lot may be classified wrongfully e.g. winged weeds.

Training of staff:

They must work for some time before they can be recommended for a course. A trainee will always work with an experiences analyst to gain experience.

Keeping test standards high:

1. At the beginning of each new seasons, samples with problems are given to new analysts for comparisons, discussions and agreement.
2. Check tests can be used because their problems are know. As problem are identified, they are noticed and overcome
3. There should be easy access to books i.e. ISTA rules and regulations for occasional references

Organisation:

- Should not be too streamlined as this may lead to job dissatisfaction
- Let one analyst be responsible for a whole test of a sample. Gives greater sense of responsibility

- People should be allowed to walk about the laboratory and talk to others
- Records should be initiated by analysts so that mistakes can easily be traced and corrected

6.10 SEED STORAGE

Tree seeds are stored for various reasons. After collection, some seeds may not be used immediately and must be stored in conditions that allow for future use. In some years, there is a lot seed produced by some tree species. If not all of it is used, there is need to store it so that in subsequent years even if production is low, then whatever is stored comes in handy.

Also it is very important to store tree seeds for conservation purposes. Short, medium or even long term storage are very effective methods of germplasm conservation.

The major aim of seed storage is to ensure safety of germplasm to retain its quality to support tree planting activities inn the near and distant future.

6.11 SEED LONGEVITY

Seed storage is governed by the concept of seed longevity. The length of time seed remains viable during storage varies within seed lots and its only through continuous germination testing over time that it can be determined. Longevity is influenced by initial germination, genetic attributes, and the way that the seed is handled as well as the containers in which it is stored.

Generally, seeds with high initial germination are expected to keep for longer times. This however is not true for recalcitrant seeds. In some legume species also, there may be high initial germination just after collection before the seed coats harden but have very low longevity.

The genetic attributes of seed also affects its longevity. The length of time seed remains of good quality while in storage may vary for individual seeds within a seedlot, for provenances of the same species, and between species.

The way seed is handled from harvesting, during extraction and the way it is dried all affect its longevity. Some handling methods are detrimental and lower seed longevity. For different species, proper handling and processing methods should be developed so that the resultant seed can keep for long.

The conditions in which the seed is stored also greatly affect its longevity. The major factors are temperature and moisture. In some cases, there is a wider range of tolerance to these factors but in some, seeds are very sensitive and longevity can drop considerably with small changes in these conditions.

6.12 HOW SHOULD TREE SEEDS BE STORED?

The way in which tree seed should be stored depends physiological considerations as well as the availability of resources. Ideally, tree seeds should be stored in a controlled environment.

In terms of storage physiology, tree seeds are divided into three different classes. The first is the type that can withstand desiccation. These are refereed to as **orthodox** tree seeds and can be dried and stored for a fairly long period of time before losing viability. The second class is that of **intermediate** tree seeds. These can withstand only a limited level of desiccation or drying and can not be stored for a very long period of time before losing viability. The last class is that of **recalcitrant** tree seeds. These are seeds that can not be desiccated at all. They have to retain a high level of moisture content in order to be viable. Such seeds pose a serious storage problem because they can be kept for a long in conventional seed storage containers and conditions.

6.13 SEED STORAGE CONTAINERS

Containers for tree seed storage vary greatly. Choice of these depends on various factors. Generally, and if funds are not a constraint, storage containers should be impermeable to gases, they should have good insulation properties, good mechanical properties, should provide adequate safety from rodents and insects and should be easy to handle.

For long term tree seed storage, tough plastic containers with screw tops or corks should be used while for short term storage, lighter gauge plastic bags or metal cans are suitable.

Unsuitable containers include paper bags, envelopes and cloth bags.

APPENDIX I

RESOURCE PERSONS

Chapter	Resource person(s)	Institution
1	Mr. B. M. Kamondo	KEFRI/ KFSC
2	Mr. B. M. Kamondo	KEFRI/ KFSC
3	Mr. B. M. Kamondo	KEFRI/ KFSC
4	Mr. Joseph Oloo.Ahenda	KEFRI/ KFSC
5	Mr. Joseph Oloo.Ahenda	KEFRI/ KFSC
6	Mr. William Omondi Oloo	KEFRI/ KFSC