Lecture 01

Importance of Seed in Present-day Forestry

In many countries of the world the number of trees planted increases each year. A recent survey (Lanly 1982) has estimated that the area of forest plantations in tropical countries will **increase from 11.5 to 17.0 million ha between 1980 and 1985**, an increase of 48 % in five years. Of the 11.5 million hectares at the end of 1980, 40 % had been planted in the previous five years. The average annual planting rate is expected to increase from 0.92 million ha in the period 1976 – 80 to 1.10 million ha in the period 1981–1985, an increase of 20 %. Large planting programmes are also in operation in many temperate countries. In addition to new planting, replanting of harvested plantations of non-coppicing species must be carried out on a considerable scale each year.

Large as these areas may appear, they amount to **only about a tenth of the area of natural forest being destroyed in the tropics** over the same period. A further increase in planting rates beyond 1985 will certainly be necessary.

- ✓ Forest plantations are a **powerful tool** to **increase productivity per unit area** - the only means of reconciling the increasing demands for forest products and services on the one hand with a decreasing area of land available for forestry on the other.
- ✓ A **combination of intensive site preparation with the use of uniform, well-grown nursery stock**, planted at uniform spacing, **increases growth and yield**, reduces rotation length, **facilitates tending and harvesting operations** and **improves the quality and uniformity of wood**, as compared with natural forest.
- ✓ Plantations also offer the means of using on a large scale the **genetically improved material** developed by tree breeders.
- ✓ Although there is no case for the indiscriminate replacement of all natural forest by plantations, their judicious use, **by providing an alternative source of forest products**, can itself **reduce pressure on the remaining natural forest** and so **help to conserve it as a habitat and a source of genetic diversity**.
- ✓ Not only do plantations have a **major role as producers of timber, pulpwood and wood-based panels for forest industries**, but **fuelwood and pole plantations and farm woodlots are locally important** in many countries.
- ✓ **Shelterbelts & dispersed planting** for soil stabilization, habitat improvement, urban and rural amenity or as part of an agrisilvicultural system all benefit the human environment.
- ✓ The current greatly **increased interest in agroforestry** opens up a whole new range of species for trial.
- ✓ Ability to grow in **symbiotic relationship with agricultural crops** will be the essential characteristic and will involve criteria such as rooting habit, ability to fix nitrogen and multipurpose uses (food, wood, shelter).
- ✓ Low stature may be beneficial and shrubs may become as important as trees.
- ✓ These new developments will **introduce new opportunities and new problems** in seed collection and handling.

With a few exceptions, notably among the poplars and willows and in some tropical species of Casuarina, trees are propagated from seed, and the **suitability and quality of the seeds have a big effect on the success of the plantations raised from them**. The use of sound seed from stands of high inherent quality is widely recognized as the best means of ensuring fast-grown and healthy plantations capable of yielding high quality wood. Seed quality comprises both genetic and physiological quality.

It must be stressed that "good seed" implies seed which is both of high viability and vigour and is genetically well suited to the site and to the purpose for which it is planted. **Physiologically good seed may lead to successful establishment of a plantation but this is of little value if it is slow-growing, ill adapted to the site or produces the wrong kind of wood because the provenance or genotype was incorrectly chosen.** On the other hand, there is little point in producing genetically improved seed at an increased cost if it is killed by poor handling techniques and has to be replaced or supplemented by inferior seed in order to achieve planting targets. Good seed handling is an essential complement to genetic improvement.

Quantity, as well as quality, of seed production is important. In natural stands variation in the quantity of seed produced affects the forester's decision as to the years in which to collect seed and the trees from which to collect it. More intensive management affords him the opportunity of stimulating heavy seed production in genetically superior crops through deliberate treatment, e.g. thinning in seed stands or a combination of initial spacing, irrigation, fertilization and thinning in seed orchards.

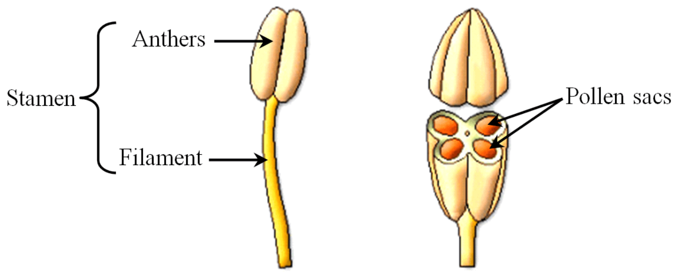
Lecture 02

Seed and Fruit Development

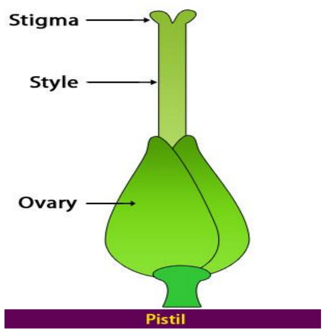
Flower Parts:

Most flowers have four main parts: sepals, petals, stamens, and carpels. The stamens are the male part whereas the carpels are the female part of the flower. Most flowers are hermaphrodite where they contain both male and female parts. Others may contain one of the two parts and may be male or female.

- **Peduncle:** This is the stalk of the flower.
- **Receptacle:** It is that part of the flower to which the stalk is attached to. It is small and found at the centre of the base of the flower.
- **Sepals:** These are the small, leaf-like parts growing at the base of the petals. They form the outermost whorl of the flower. Collectively, sepals are known as the calyx. The main function of the calyx and its sepals is to protect the flower before it blossoms (in the bud stage).
- **Petals:** This layer lies just above the sepal layer. They are often bright in colour as their main function is to attract pollinators such as insects, butterflies etc. to the flower. The petals are collectively known as the corolla.
- **Stamens:** These are the male parts of a flower. Many stamens are collectively known as the androecium. They are structurally divided into two parts:
  - **Filament:** the part that is long and slender and attached the anther to the flower.
  - **Anthers:** It is the head of the stamen and is responsible for producing the pollen which is transferred to the pistil or female parts of the same or another flower to bring about fertilization.



Structure of stamen



- **Pistil:** This forms the female parts of a flower. A collection of pistils is called the gynoecium. Pistil consists of four parts:

a. **Style** -is a long slender stalk that holds the stigma. Once the pollen reaches the stigma, the style starts to become hollow and forms a tube called the pollen tube which takes the pollen to the ovaries to enable fertilization.

b. **Stigma**– This is found at the tip of the style. It forms the head of the pistil. The stigma contains a sticky substance whose job is to catch pollen grains from different pollinators or those dispersed through the wind. They are responsible to begin the process of fertilization.

c. **Ovary** – They form the base of the pistil. The ovary holds the ovules.

d. **Ovules**– These are the egg cells of a flower. They are contained in the ovary. In the event of a favourable pollination where compatible pollen reaches the stigma and eventually reaches the ovary to fuse with the ovules, this fertilized product forms the fruit and the ovules become the seeds of the fruit.

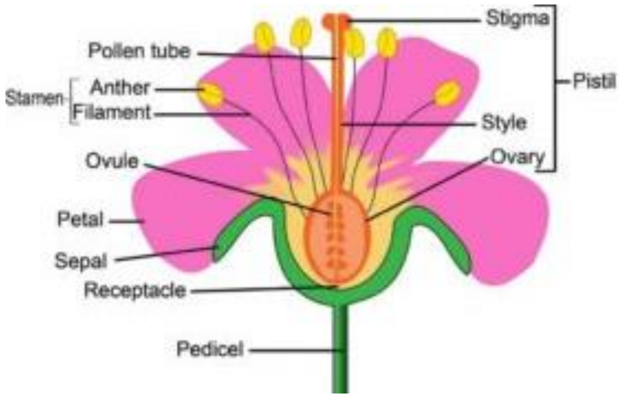


Fig. Typical Flower Parts

Seed and Fruit Development:

Introduction:

Some knowledge of the biology of seeds is essential to their proper handling. The use of seed for artificial regeneration makes possible a considerable degree of control over the conditions in which it is collected, processed, stored and treated, but the seed's inherent characteristics have been evolved as a result of millenia of adaptation to natural regeneration under local conditions. Knowledge of flowering phenology enables the collector to select the timing and methods of seed harvesting most appropriate to the species, while handling, storage and pretreatment of seed will benefit from knowledge of how seeds develop in nature. There are few detailed descriptions of seed development in tropical forest trees.

Pollination and Fertilization:

A seed is a reproductive unit which develops from an ovule, usually after fertilization. Ovules are borne by both the angiosperms (true flowering plants) and the gymnosperms (which include the conifers). In the angiosperms the ovules are totally enclosed within the ovary, while in the gymnosperms the ovules are “naked”, typically borne in pairs on the upper surface and near the base of each scale in a female cone. Since the cone scales remain tightly closed except at the time of pollination and later at seed shed, the term “naked” is a relative one.

Seed development is initiated by fertilization, the union of a haploid male nucleus from the pollen grain with a haploid female nucleus within the ovule to form a new diploid organism. Fertilization must be preceded by pollination, the arrival of a pollen grain on the stigma of the female flower in angiosperms or close to the micropyle of the gymnosperm ovule. It is important to distinguish the two separate processes of pollination and fertilization (Fritsch & Salisbury 1947).

In most angiosperms the elongation of the pollen tube is rapid and the interval between pollination and fertilization is only a few days or even hours. In a few angiosperms (e.g. *Liquidambar*, some species of *Quercus*) and many gymnosperms (e.g. *Pseudotsuga, Larix, Picea*) the interval is several weeks or months, while in other species of *Quercus* and in many *Pinus* it is a year to 14 months.

Angiosperm Seed Development:

At the time of fertilization a typical angiosperm ovule consists of one or two protective coats - the integuments - and a central tissue - the nucellus. Often the integuments and the nucellus are clearly differentiated only in the region of the micropyle - the minute pore in the integuments through which, in many species, the pollen tube enters the nucellus. The ovule is attached to the wall of the ovary by a stalk - the funicle.

Meiosis of a mother cell within the nucellus, followed by several mitotic cell divisions, leads to the formation of the embryo sac, a haploid eight-nucleate, seven-celled structure which occupies the central space within the nucellus. When the pollen tube reaches the embryo sac it releases two male gametes. One male gamete unites with one of the nuclei in the embryo sac -the egg cell - to form 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 which acts as a food reserve for the growing embryo. The remaining five nuclei of the embryo sac (2 synergids and 3 antipodal cells) play no further role in seed development. Successful fertilization of the egg cell and successful triple fusion with the polar nuclei are both necessary for development of a viable seed.

Development of the fertilized ovule into the mature seed involves several different parts. From the outside inwards these are as follows:

1. The integuments of the ovule become the seed coat of the mature seed. This sometimes consists of two distinct coverings, a typically firm outer seed coat, the testa, and a generally thin, membranous inner coat, the tegmen. The testa protects the seed contents from drying out, mechanical injury, or attacks by fungi, bacteria and insects, until it is split at germination. But there is great variation in seed coat among angiosperms.

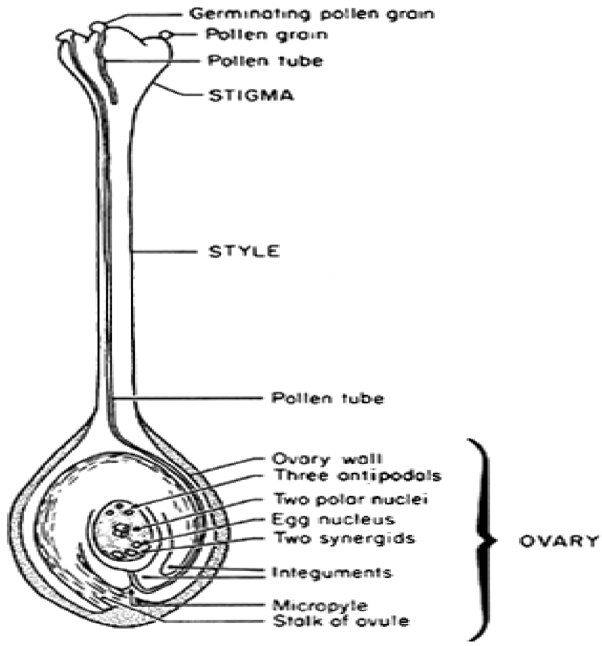


Fig. Longitudinal section through a typical pistil just before fertilization.

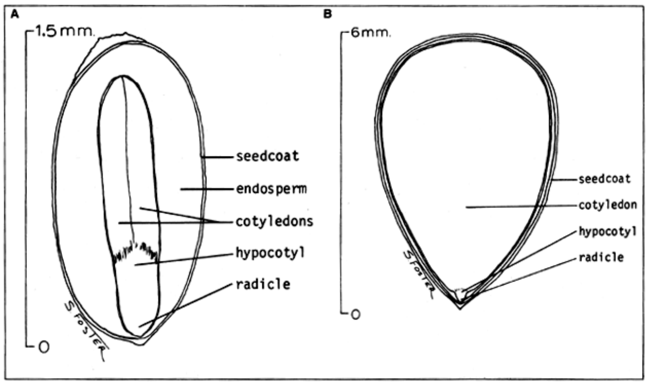
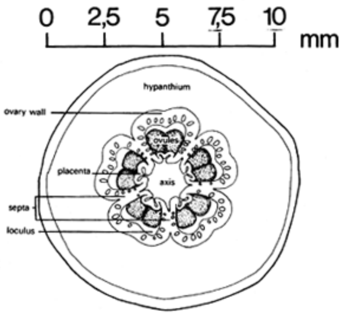
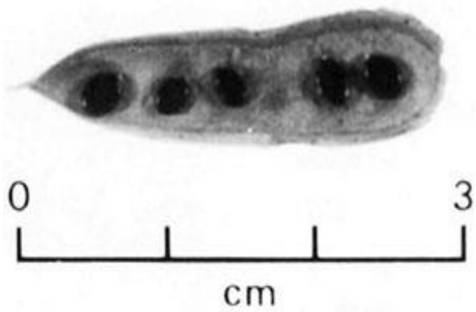


Fig. Longitudinal sections through ripe seeds of:- (A) *Paulownia tomentosa*. (B) *Tectona grandis*.

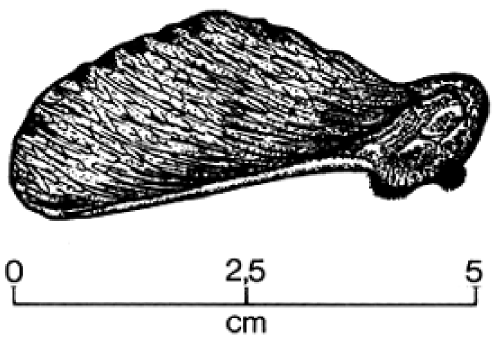
2.3 Examples of different types of fruits:



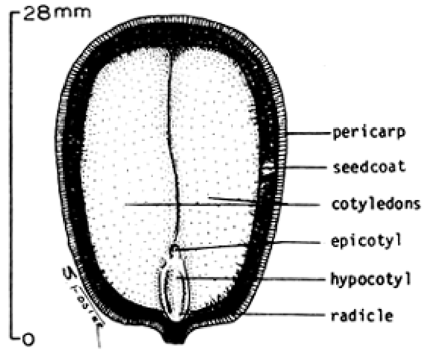
(A) Cross-section of capsule of *Eucalyptus preissiana* showing loculi, axis, placentae and ovules



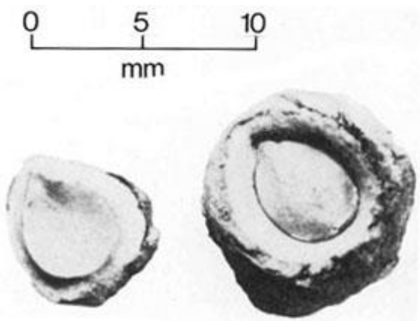
(B) Open pod with seeds of *Acacia aneura*.



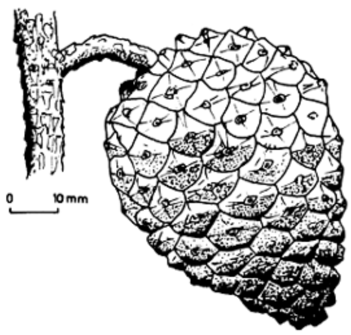
(C) Samara of *Triplochiton soleroxylon*.



(D) Nut (acorn) of *Quercus rubra*.



(E) Drupe of *Tectona grandis*.



(F) Cone of *Pinus oocarpa*.

2. The nucellus may persist in some genera as a thin layer - the perisperm -lying inside the seedcoat and supplying food reserves to the embryo. In most angiosperms, however, it soon disappears and its function is taken over by the endosperm.
3. The endosperm commonly grows more rapidly than the embryo during the period immediately after fertilization. It accumulates reserves of food and its fullest development is rich in carbohydrates, fats, proteins and growth hormones. In some species the endosperm remains conspicuous and still fills a greater part of the seed than the embryo even when the seed is ripe. In others, such as *Tectona*, the embryo absorbs food reserves from the endosperm during its later stages of development, until the endosperm disappears by the time the seed is mature.
4. The embryo occupies the central part of the seed. Its degree of development at the time the seed is ripe varies greatly according to species. In some it is possible to distinguish all parts of the rudimentary plant - the radicle which at germination will give rise to the primary root, the seed leaves or cotyledons, the plumule from which will develop the

primary shoot, and the hypocotyl which connects the cotyledons with the radicle. If the embryo absorbs all the food reserves from the endosperm, the thick fleshy cotyledons commonly become the main organs for food storage and occupy almost the whole of the seed cavity.

Although the storage function within the embryo is normally performed by the cotyledons, in *Anisophyllea, Barringtonia and Garcinia* it is completely taken over by the swollen hypocotyl which fills the seed cavity; the cotyledons are vestigial or absent. This is also the case in *Lecythis* and *Bertholletia*, hence the edible content of a Brazil nut (*Bertholletia excelsa*) is neither endosperm nor cotyledon but hypocotyl.

In some species the embryo is still small and undeveloped when the seed is ready for dispersal, and an additional period under suitable environmental conditions is needed for maturation of the embryo after seed shed, before the seed can become capable of germination, e.g. *Fraxinus excelsior*.

At its most complex the ripe seed may thus consist of diploid tissue from the mother tree (the seedcoat, including testa and tegmen, and the perisperm), triploid tissue in the endosperm, and diploid tissue of the new genetic combination in the embryo offspring. But both perisperm (nearly always) and endosperm (not infrequently) may be missing. The essential constituents of all seeds are the embryo, the protective covering of the seedcoat and a reserve of food substances which may be stored in the cotyledons, hypocotyl, endosperm or perisperm.

Occasionally more than one embryo may develop in a single seed and such polyembryony has been reported from several genera. It is, however, the exception.

Angiosperm Fruit Development

Development of the fertilized seed is normally accompanied by development of the fruit. In the simplest case the ovary wall becomes thickened to form the pericarp. This may be:

a. Dehiscent, splitting open when ripe to release the enclosed seeds; examples are the capsule (e.g. *Eucalyptus*), a multilocular fruit derived from a syncarpous ovary, and the leguminous pod (e.g. Cassia), which is derived from a single carpel and spilts along two sutures. The pericarp may be dry, semi-fleshy or fleshy at the time of dehiscence. Semi-fleshy to fleshy capsules are common in the humid tropics (e.g. Baccaurea, Durio, Dysoxylum, Myristica) and are often associated with the development of variously coloured, tasty or smelly pulp (aril or sarcotesta) around the seed.

b. Indehiscent or dry, closely fused with the seed; examples are the achene, a small hard one-seeded fruit with membranous pericarp, the samara, similar to the achene but with pericarp extended to form a wing (e.g. Triplochiton) and the nut, a rather large one-seeded fruit with woody or leathery pericarp (e.g. Shorea, Quercus).

c. Indehiscent and fleshy, often distinguished by colour, smell and taste to attract fruit-eating birds and animals. Two types are distinguished. The berry has an outer skin and inner fleshy mass, containing seeds that have a hardened seedcoat (e.g. Diospyros, Pouteria). The drupe has the inner layer of the pericarp hardened to protect the seeds (e.g. Prunus, Gmelina, Azadirachta, Mangifera); the seedcoat, having no protective function in a drupe, is usually papery or membraneous. The different pericarp layers in a typical drupe are known as exocarp (the skin), mesocarp (the flesh) and endocarp (the stone). The stone may be actually stony as in Gmelina or leathery as in Mangifera.

In some species other parts of the flower, as well as the ovary wall, take part in fruit formation. An example is the pome, found in apples and pears, in which the enlarged fleshy receptacle forms the greater part of the fruit, while the pericarp forms the core. An additional partial or entire protective covering may be provided by fused bracts arising below the flower - the involucre. This may be papery, as in *Tectona*, or thicker and leathery as in the "acorn cup" of *Quercus*. Some fruits are formed by the coalescing of an entire inflorescence e.g. *Morus, Chlorophora, Anthocephalus, Artocarpus*.

At the opposite extreme, in several genera of the Sterculiacae (e.g *Fimiana, Pterocymbium and Scaphium*), fruit formation does not occur at all in the normal angiospermous manner. Soon after fertilization, the carpel (follicle) splits on one side and develops into a large membraneous scale-like or boat-shaped wing; the fertilized ovule develops in a naked position at or near the base of the open carpel, in a gymnospermous manner. Such fruits must be the most primitive of all angiosperm fruits. At maturity the seeds are dispersed, attached to their carpels which now behave as wings.

The interval between flowering and maturation of seeds and fruits varies greatly with species, even within the same genus. In *Eucalyptus* it varies from one month in *E. brachyandra* to 10 – 16 months in *E. diversicolor*. In most Malaysian Dipterocarps it is between two and five months. In *Tectona grandis* it takes 50 days from flowering for the green fruits to develop to full size but 120-200 days before they are fully ripe. In a study of rooted cuttings of *Gmelina arborea* in pots in Nigeria, individual flowers took 11 days from flower bud to opening and 45 days from flower bud to ripe fruits. In *Pterocarpus angolensis* the interval between flowering and fruit maturation is 8 months (Boaler 1966). The shortest interval on record between flowering and seed maturation for a tropical timber species is apparently 3 weeks, for *Pterocymbium javanicum*. In contrast, some species of temperate *Quercus* take about 18 months from flowering to production of mature seeds.

In most species fertilization of one or more ovules must precede fruit formation. In a few species, however, fruits are set and mature without seed development and without fertilization of an egg. Such fruits, called parthenocarpic fruits, occur in several genera of forest trees including *Acer, Ulmus, Fraxinus, Betula, Diospyros* and *Liriodendron*. Mature fruits do not invariably indicate mature seed, still less can the number of sound seeds be predicted from the number of fruits. In *Tectona* the number of sound seeds per fruit can vary between 0 and 4 and still greater variation is possible in other genera.

Gymnosperm Seed Development:

Gymnosperm ovules have certain characteristics in common with angiosperm ovules, but there are a number of 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. Within the integument is the nucellus which at fertilization, as in angiosperms, is clearly separated from the integument only in the region of the micropyle (Fritsch and Salisbury 1947). Meiosis within the nucellus, followed by mitotic cell divisions, leads to the formation of a multicellular haploid tissue - the female gametophyte. By the time of fertilization it has developed much further than the 8-nucleate embryo sac in the angiosperms and has largely displaced the nucellus. At its micropylar end it is differentiated into one to many archegonia, each of which contains a large egg cell.

At fertilization pollen tube releases two male nuclei into an archegonium, one of which unites with the egg nucleus. The resulting zygote later develops into the new diploid embryo. The second male nucleus aborts in Pinus but may fertilize a second archegonium in other genera e.g. *Cupressus*. It never unites with female polar nuclei to form a triploid tissue analogous to the endosperm of angiosperms; this type of tissue is unknown in gymnosperm seeds.

The mature seed consists of some or all of the following:

1. The seed coat or testa developed from the integument, diploid from the female parent.
2. The diploid perisperm, developed from the nucellus. In most species this is absorbed by the female gametophyte and has disappeared by the time the seed is ripe, but it is still recognisable as a distinct tissue in e.g. *Pinus pinea*.
3. The haploid female gametophytic tissue which serves as a food storage organ to nourish the embryo. Its function is the same as the endosperm in angiosperms and it is frequently called by that name, though this usage has been deprecated.
4. The embryo, with the same parts of radicle, cotyledons, plumule and hypocotyl as in angiosperms. The number of cotyledons varies between and within genera, being up to 18 in *Pinus*, compared with the constant two in the dicotyledons which comprise the great majority of angiosperm trees.

The essential constituents of embryo, protective covering and food storage tissue are present in all gymnosperm, as in all angiosperm, seeds.

More than one archegonium may be fertilized within a single ovule, but in the great majority of cases only one embryo per seed develops to maturity. Polyembryony does occur but is uncommon in most genera.

Gymnosperm Fruit Development:

After fertilization the female cone which is typical of several important gymnosperm genera e.g. *Pinus, Picea, Pseudotsuga, Araucaria* increases in size and weight, in moisture content and accumulated food reserves. As the cones approach maturity, the moisture content decreases again, accumulated food reserves move from cone to seed and the cone becomes more or less woody.

In *Pinus* a thin membranous flake becomes detached from the ovuliferous scale and adheres to the ripe seed, forming a wing. In *Juniperus* the cone scales grow together to form a fleshy berry-like fruit, while in *Podocarpus* and *Taxus* each singly borne seed becomes partly enclosed in a brightly coloured cup, the aril. The woody cone is, however, the most characteristic type of fruit in gymnosperms.

As in angiosperms, there is wide variation in the interval between flowering and seed maturity and dispersal. Because of the lengthy gap between pollination and fertilization in pines, the total period between pollination and cone maturity is usually about two years in this genus; among tropical pines, average periods are 23 months in *Pinus kesiya*, 18–21 months in *P. oocarpa*. In *Agathis robusta* it takes 16 months from pollination to cone maturity, in *Araucaria cunninghamii* up to 24 months, in *Araucaria hunsteinii* 21–24 months. In several temperate genera development is completed within a single season e.g. in 5 months in *Pseudotsuga menziesii*.

Development of unpollinated female cones with fully formed but usually empty seeds occur in a number of gymnosperm genera. Parthenocarpy is common in *Abies, Juniperus, Larix, Picea, Taxus* and *Thuja*. It is rare in pines.

Lecture 03

Seed Dispersal in Angiosperms and Gymnosperms

Survival and growth of young seedlings under the parent tree is often difficult, because of lack of light and intense root competition. Dispersal over a wide area can ensure that some seeds find conditions suitable for germination and survival, even though the vast majority will perish from the effects of harsh site conditions, competition or destruction by animals or disease.

What is Seed Dispersal?

Seed Dispersal is an **adaptive mechanism in all seed-bearing plants**, which is involved in the movement or transport of seeds away from their parent plant to ensure the germination and survival of some of the seeds to adult plants.

There are many vectors to transport the seed from one place to another.

Seed Dispersal in Angiosperms:

There are different ways in which seed from its parent plant is dispersed. These include:

1. **Seed Dispersal by Wind:**
   The wind is the natural and fundamental means of seed dispersal in the plant kingdom. Dispersal by wind is assisted when the seeds are very light and small e.g. *Eucalyptus*, or when either the seed coat (*Salix*, *Ceiba*, *Dyera*) or the pericarp (*Triplochiton, Pterocarpus*, *Koompassia*, *Casurarina*, *Fraxinus*) possesses wings or hairs which serve to prolong flight. Fruit may also be winged by the enlargement of persistent sepals (most Dipterocarps) or persistent petals (e.g. *Gluta, Swintonia*).
   The distance of seed or fruit dispersal by wind depends not only on the weight and type of dispersal unit but also on the local wind conditions and the exposure and isolation of the mother trees.
   The seeds of the orchid plant, dandelions, swan plants, cottonwood tree, hornbeam, ash, cattail, puya, willow herb, are all examples of plants whose seed are dispersed by the wind.
2. **Seed Dispersal by Water:**
   In this method of seed dispersal, **seeds float away** from their parent plant. These are mainly seen in those plant which **lives in water or nearby the water bodies** like beaches, lakes, ponds etc. Coconut, palm, mangroves, waterlily, water mint, are a few examples of plants whose seed are dispersed by the water.
3. **Seed Dispersal by Animal and Birds:**
   There are different ways in which animals and birds disperse the seeds. Few animals and birds are **attracted to bright colourful fleshy fruits and arillate seeds**. They eat the entire fruit and only the juicy part is digested by their system and the seed are excreted out in the form of their dropping, which forms into new plants. Blackberry, cherry, tomato and apple seeds are dispersed in this way.
   A few species of **squirrels collect nuts** from different plants like acorns and bury them under the soil as they store food for the winter season and often forget the place where they have previously buried them and the seeds grow into new trees.
   There are few plants which bear **seeds with hooks**. Burdock plant is an example of this type of plant species. The seed of these plants catch on the fur of animals and are carried away to different places, far from their parent plants. Dates, rambutan, sea grapes, sea

holly, tamarind, raspberry, sunflower, tomatoes are a few examples of plants whose seeds are dispersed by animals and birds.

Rodents remove and store nuts or seeds; many are subsequently eaten but some may escape to germinate in the new situation.

4. **Seed Dispersal by Gravity:**

   Gravity is a force of attraction that exists among all the objects in the universe. As the **fruits from the tree fall on the ground** due to the force of attraction, they sometimes **roll down to some smaller distance, get buried in the soil** after few days and germinate into a new plant.

   In certain cases, fruits which do not have very hard **seed coat may crack and open after falling down from a height,** which leads to a better dispersion of seeds.

   In some cases, the **fallen fruit is carried by other agents like water, wind, birds or animal** and helps in the dispersion of seeds. Apples, Commelina, canna, coconuts, calabash and passion fruit are a few examples of plants whose seeds are dispersed by Gravity – A force of attraction.

5. **Seed Dispersal by Explosions:**

   Explosions in fruits literally refer to **bursting with all its energy**. In this case, as the fruits get ripened, it shoots out its seeds into the external environment. This type of seed dispersal is mainly seen in those plants having pods. Okra, Lupins, gorse, and broom are a few examples of plants whose seeds are dispersed by Explosions. Pea and bean plants also have pods and the seeds burst out when they ripen and pod has dried

Seed Dispersal in Gymnosperms:

- In the typical gymnosperm cone, ripening and drying of cone and seed causes the cone scales to open and release the seeds.
- Dispersal is by wind, assisted by the presence of seed wings in some genera e.g. *Pinus*.
- In some species of pine, the "closed-cone pines" e.g. *P. radiata*, there is usually an interval of months or years between ripening of cone and seed and the opening of the cone to release the seeds.
- In a few cases, such as the interior provenances of *Pinus contorta*, the cones open only when subjected to the heat of occasional fierce forest fires.
- On the other hand the cones of *Abies* and *Araucaria* disintegrate readily on the tree within a few weeks of ripening.
- Seed dispersal by animals is less common, but the "berries" of *Juniperus* and the fleshy fruits of *Podocarpus* are examples.
- In addition seeds of temperate conifers are collected and stored by rodents and some may germinate before being eaten.

Lecture 04

Planning of Seed Collection

Introduction:

Species which bear ripe seed in adequate quantities at all times present little problem to the experienced seed collector, but such species are few. In the majority of species the seeding season is concentrated within a few weeks and the collector's objective is to collect as much of the crop as possible within the short period while the seeds are mature but the fruits have not yet fallen or dehisced. Prior planning of collecting activities is therefore essential in order to ensure that operations are conducted as quickly and efficiently as possible in the limited time available. Collection in accessible and easily observable plantations or seed orchards reduces the need for careful preparation. On the other hand, collection in inaccessible, multispecific natural forests or sampling a number of different seed sources within a widely spread species calls for very careful planning if trained collecting teams are to operate with the right equipment in the right place at the right time.

1. Assembling Clear Information for Seed Collection:

A. Determining Species, Provenances and Stands:

Species

Selection of species for planting often presents no problem. In a simple afforestation project, which uses a proven well adapted species and provenance and obtains the seed from a local seed source, the choice is automatic. But not infrequently afforestation objectives change, e.g. emphasis may shift from sawlog to pulpwood or fuelwood production, or unexpected disease problems may arise.

For large-scale collections, data on seed demands 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.

Provenances

It is "The place in which any stand of trees is growing". For the purpose of seed collection, the ideal provenance would:

a. Be composed of a community of potentially interbreeding trees of similar genetic constitution (and of significantly different genetic constitution from other provenances).
b. Be sufficiently large for collection of reproductive material in quantities significant for forest practice.
c. Be defined by means of boundaries which can be identified in the field.

Stands

In contrast with provenances, the boundaries of individual stands are commonly well defined. In many cases the stands are being managed for seed production e.g. by thinning. Seed orchards are a special case, designed for seed production before they are planted and managed continuously for that purpose.

B. Determining Seed Quantities:

Seed users need to define the quantity of seed needed of each species, provenance or stand. For this it is necessary to know the area of plantation to be established annually and the initial spacing to be used, together with an estimate of losses and culls in the nursery, of replacements needed after planting to achieve full stocking, and of the number of germinated seedlings to be expected from each kg of seed sown.

By: Rajesh Kr Sharma, Assistant Professor (Seed Technology), CH&F, Jhalawar

C. Determining the Year for Seed Collection:

Effect of periodicity

Seed-bearing of many forest trees is rather irregular from year to year. One year with a heavy crop (a "seed year" or "mast year") may be followed by one or several years with a poor seed crop or none at all. This habit of periodicity in seeding is an important factor to consider when planning seed collecting operations.

Advantages of seed collection in a good seed year;

- High intensity of selection of seed bearers.
- Cost of collection is lower, due to the concentration of the crop.
- Seeds will usually be of higher germinative capacity.
- Seeds will retain their viability longer than those collected in a poor seed year.
- Damage from insects affects a smaller proportion of seeds.
- Conserves a higher proportion of the genetic diversity among male parents.

A heavy seed crop usually reflects a previous heavy production of pollen, to which all or most trees in the stand have contributed. Periodicity is well documented for many temperate conifers but less documented in tropical species. i.e. *Pinus sylvestris* bears an abundant crop every 2 – 3 years and *Pseudotsuga menziesii* every 4 – 6 years. Even in good years, flowering may vary substantially from one locality to another. Sometimes individual trees of a stand are on different cycles, some flowering abundantly one year, others in the next.

Counting the fruit crop

For those species which are known to exhibit periodicity in flowering and fruiting, it is highly desirable to visit the stands to be collected well in advance of the fruiting season, in order to assess in which of them the next seed crop promises to be heavy enough to justify the cost of collection. Estimation of the crop can be done by counting flowers or young fruits on a sample of the trees in the collection stand. Assessment of the abundance of flowering can give a preliminary estimate of the potential seed crop, but may be misleading if there are subsequent severe losses e.g. from insects, wind or poor pollination. Where it is necessary to count the fruits or cones, binoculars or telescopes are an essential aid.

Estimating full seed content by cutting test

The methods described above provide an estimate of the cone or fruit crop. It is necessary to relate this to seed production by examining the contents of a sample of the fruit crop. Fruits may develop normally to maturity whether one or one hundred of the contained ovules have been successfully fertilized and undergone normal development; in parthenocarpous 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.

The method generally recommended is to cut cones or fruits lengthwise and count the number of seeds which can be seen on one cut surface. Special cone-cutting knives have been designed for this purpose. One or two cone samples from each of 20 to 100 trees in an area are suggested.

D. Determining the Best Dates for Collection:

Some species in the tropics carry some ripe seed at all times of the year. Even in these there is a period of maximum seed production, when collection will be cheapest and seed quality highest. In other species, and especially in the temperate zone with its marked distinction between summer and winter, ripe seed is borne for a limited period, often during the autumn.

For many species there is good information on average dates of the seeding season, but these averages may not be sufficiently accurate for planning collection in a particular year.
The period between seed maturation and seed dispersal is often short, whereas the effects of climate in a given year may displace the dates of seeding by several weeks from the average.
In the temperate zone

- An early spring and dry summer can cause very early seed ripening, while strong, dry winds cause rapid dispersal of the ripe seeds. Cool, wet weather, on the other hand may delay ripening and dispersal by weeks or months.

In the dry tropics

- There are similar annual variations in the dates of the onset of the dry season and of the rains.

It is therefore necessary in each year to check the correct timing of collection by examination of the crop itself.
Several different methods have been used for the recognition of seed maturity.

Laboratory methods

a) Dry weight: The most generally accepted measure of maturity is the time when the seed has reached its maximum dry weight, a point called physiological maturity. This means that nutrients are no longer flowing into the seed from the mother tree.
b) Chemical analysis: Biochemical changes take place as seeds mature but relatively little is known for most species. e.g. content of crude fat and protein-nitrogen, which increase five and four times respectively from immaturity to physiological maturity.
c) X-ray radiography: The examination of the development of the embryo and endosperm of sample seeds by means of X-ray radiographs is a quick and relatively straight forward method of assessing seed maturity.
d) Moisture content of fruits: Water loss of maturing cones and fruits occurs in many species and is closely related to the maturity of the seed.

Field methods

a) Specific gravity of fruits: As moisture content of fruits and cones decreases with maturation, so does specific gravity or density, the ratio of unit weight to unit volume, decrease.
b) Examination of seed contents: Examination of seed contents exposed by cutting open fruits or cones lengthwise can be a reliable and simple method of assessing seed ripeness.
c) Colour of fruits or cones: Colour changes in fruit or cone provide a simple and, in some species, reliable criterion for judging seed maturity, but the operator must be experienced in the characteristics of the species concerned.
d) Abscission and shedding of fruits is usually a sign of fruit maturity and it might be assumed that it also indicates a high content of sound, mature seeds. This is not always the case.

E. Collection of Immature Seeds:

It is general practice to collect seeds when they are mature, because they have a higher germinative energy and a greater longevity in storage than immature seeds. An alternative method is to collect fruits prior to ripening and to store them in relatively cool, well ventilated conditions which permit after-ripening of the seeds within the fruit. It has shown promise on a research scale in a number of species.
Reasons for artificial ripening are: -

- **To extend the collection season**: The short period between seed maturity and dispersal may place an excessive demand on the availability of seasonal labour and in some areas unfavourable weather conditions in the collection period may aggravate this situation. Lengthening the period available for collection permits better organization of the collections and allows skilled personnel to pick more of the crop. It can be particularly valuable in research, where a large number of seed lots have to be collected from widely scattered localities.
- **To avoid damage to the seed crop by insects and other pests:** Insects, birds, rodents and other pests frequently damage or destroy seeds and fruits when they have reached maturity. Early collection may be one method of avoiding these losses and improve their subsequent viability and longevity in storage.
- **To salvage immature seed collected inadvertently:** Untrained collectors of seeds often begin picking fruits and cones too early in the year before they are fully mature. Artificial ripening provides a method for handling this material.

The development of techniques for after-ripening of immature seeds will require more research, before they can be applied to a wide range of species. However, where a problem of rapid dispersal or of seed pests exists and provided the earliest time for safe collection of immature fruits can be established, such techniques can be very beneficial.

F. Determining Which Trees to Collect From:

Identification of species presents no problems in monospecific plantations, but is essential and may be difficult in mixed natural forest, especially where very similar species of the same genus occur mixed together. Unless identification is certain, it is often advisable to collect herbarium specimens as well as seed.

Large-scale collections

In large-scale collections emphasis is on collecting as much seed as possible, as quickly and cheaply as possible, rather than on very careful selection of the parent trees. It is, nevertheless, essential to avoid collecting seeds from very poor phenotypes or seeds which prove to be empty or non-viable. Useful guidelines are listed by Stein et al. (1974), and form the basis of the following: -

1. Collect seed only from healthy vigorous trees of reasonably good form that are making average or better growth.
2. Where possible, collect from mature or nearly mature trees. Over mature trees should be avoided, since seeds from them may be of low viability.
3. Avoid isolated trees of naturally cross-pollinating species, since these are likely to be self-pollinated. Seeds are likely to be few, of low viability, and any seedlings produced are frequently weak or malformed.
4. Avoid collecting in stands containing numerous poorly formed, excessively limby, off-colour, abnormal or diseased trees.

Small-scale research collections

In small-scale collections for research, selection of trees will depend on the precise objective of the planned research.

1. Collect from not worse than dominant and co-dominant trees of average quality, within “normal” rather than “plus” stands. Collections from superior phenotypes should be kept separately.

2. Collect from a minimum of 10 trees, preferably from 25 to 50 in the stand. If the stand is very variable, increase the number of trees.
3. Seed trees to be at least seed fall distance apart from each other.
4. Individual seed trees to be marked.
5. Collect equal numbers of cones, fruits or seeds per tree.
6. In normal first stage provenance collections, seed from individual trees may be mixed together. If special studies on individual genotypes are to be done, seed from each tree should be kept separate.

Single tree collections

If progeny trials are the object of seed collection, it is essential to keep seed from individual trees separate at all stages of collection, transport, processing, nursery and field planting. The preservation of the identity of individual trees through the collection and extraction phase often requires considerably more effort than bulking the collections.

- It permits biosystematic study of genetic variation both within and between populations.
- It is possible to manipulate to equalize the amount of viable seed from each tree in the provenance mix if the seed must be bulked prior to sowing.
- It is not always possible to detect trees bearing hybrid seeds in the field (eucalypts). If seed lots are kept separate then, following the raising of small samples from each tree, any showing evidence of hybridization can be eliminated before the main trial is established.

Single clone collections

In seed collection in clonal seed orchards, the unit of identity to be kept separate is often the clone rather than the individual ramet. The advantages can be summarized as follows:

a. Maintaining individual clonal identities at all stages enables one to act with the minimum of delay on most information as it becomes available.
b. Seed lots can be made up and supplied to suit specific sites, making use of the most recent information on genotype/environment interaction from progeny test analyses.
c. Using the test results of each clone, composite seed lots can be made up in such a way as to give equal clonal representation in the final planting stock, avoiding the dominating effects that some clones frequently have in a bulked seed lot.
d. In general, it increases the options available to the user.

Collections for conservation

Collections are also made for the purpose of attempting to conserve the gene pool ex-situ either as seed in long-term storage or in planted conservation stands. Because exact knowledge of gene frequencies in the indigenous populations is largely lacking, collecting for gene conservation must be based mainly on common sense.

2. Assembling Resources for Seed Collection:

One part of planning is the timely assembly of clear information on the nature and magnitude of the seed collection tasks - number of species and provenances, seed quantities, location of stands, best dates to collect etc., as described above. The other part is to select and assemble the resources needed to do the job. Details of the various resources which may be useful are;

1. 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 number and size of teams. If planning can be done sufficiently in advance, it may give an opportunity to train additional climbers if they are needed. It is

desirable to have at least one tree-climber on the permanent staff, who can be responsible for looking after climbing equipment and for training new temporary climbers.

2. Organization of transport: Collecting teams need to 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.
3. 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. Whereas highly mechanised equipment such as tree shakers or mechanised platforms may be appropriate in large seed orchards on flat land. Apart from collecting tools, safety clothing, first aid equipment and plenty of bags and sacks should be provided.
4. Organization of records: Meticulous recording and labelling is essential to good collecting. Appropriate labels and forms need to be designed well in advance and printed in adequate numbers.
5. Organization of permits: These are not normally required for forest services collecting in government forest reserves, but may be needed when collecting on private land, in National Parks and special reserves, or in another country. Even if formal authority is not needed, it is often advisable to inform local communities of proposed operations in advance.
6. Organization of seed extraction: Arrangements for rapid movement of fruits from collection site to extractory may be needed, involving the advance organization of transport. The seed extractory staff must be advised when to expect the fruits. If some preliminary sun-drying of fruits in the forest is planned, polythene sheeting or tarpaulins will be needed.

Lecture 05
Methods of Seed Collection

Introduction:

Although the term "seed collection" is a convenient one in common use, it should be noted that almost invariably it is the fruits which are harvested from the trees. 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 complete 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:

1. Relative size and numbers of the natural dispersal units and of the units which can be conveniently collected by man. In the case of 1 – 3 large seeds inside a dehiscent or indehiscent fruit (e.g. *Aesculus, Tectona*), collection can be done most easily by awaiting natural fall of seed or fruit and collecting from the ground. At the other extreme collection from the tree of fruiting heads of *Adina cordifolia* at 200 per kg is the only practicable way to collect the seeds; at 11 million per kg, it would be impossible to collect them after dispersal.
2. 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.
3. 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.
4. Characteristics of the stand: distribution and stocking of trees (e.g. isolated trees, open or dense stand); density of understorey and ground vegetation).
5. Characteristics of the site: slope, accessibility.

The various collection methods may be classified into the following:

A. Collection of fallen fruits or seeds from the forest floor.
B. Collection from the crowns of felled trees.
C. Collection from standing trees with access from the ground.
D. Collection from standing trees with access by climbing.
E. Collection from standing trees with other means of access.

A. <u>Collection of Fallen Fruits or Seeds from the Forest Floor:</u>

1) 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 labour as, for example, climbing; school children or casual labour may be used. Fruit size is very important as the larger the fruit, the easier it is to see and pick Up by hand. Temperate genera commonly collected from the ground are *Quercus, Fagus, Castanea* and tropical genera include *Tectona, Gmelia, Triplochiton* and several genera among the dipterocarps.

Disadvantages of collection from natural fruit shedding are;

- Risks of collecting immature, empty or unsound seeds.
- Seed deterioration or premature germination if collection is delayed
- 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.

- Damage or losses from insects, rodents or fungi.
- Clearing the forest floor of vegetation and debris, including old or prematurely fallen fruits.

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. This is of particular importance in the moist tropical forest. Many of the seeds of the more important dipterocarps lose their viability within a few days of shedding. Collection from the ground must, therefore, be perfectly timed with seed fall.

Seeds of some hard-coated species may remain viable on the forest floor for years, especially in temperate conditions. A special machine screens the top 10 cm of soil and yields more seed per hectare. Even in the tropics viable hard-coated seeds may be obtained by screening the soil below the mother trees. Where the seeds are smaller e.g. in *Albizzia falcataria*, sieving with a wire mesh may be more practical.

Isolated trees present no problem in identifying of the mother tree (though they may be undesirable parents because of the risk of selfing), but much mixing of fruits can occur in dense monocultures with interlocking crowns. This is of no concern in collecting commercial quantities of seed, provided that the genetic quality of the stand is average or above average. For research and breeding purposes, it is often necessary to maintain the identity of the mother tree of each seed lot. In such cases it is advisable to clear the ground of already fallen fruits and to accelerate the fall of new fruits by shaking, beating or cutting off branches, or climbing and picking fruits in the crown. A compromise solution, suitable for commercial collections in unimproved stands containing a mixture of good and bad phenotypic trees, is to collect fruits only below the better seed bearers and within half the radius of projection of their crowns.

2) 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 directly by hand. Higher 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* and *Cedrela spp*., as it facilitates rapid collection of seed with good viability as soon as visual inspection shows that the fruits are mature. The cord should be positioned towards the end of the branch where it will have the maximum shaking effect and not close to the bole where the branch is thickest.

3) Mechanical shaking

Mechanical tree shakers were developed originally for fruit and nut orchards. The machines are expensive, need flat ground for efficient use, and experienced operators are essential to avoid excessive damage to the trees. Many cones are removed by a few seconds of shaking, but longer & repeated shaking of the more difficult trees can cause bark rupture and breakage of the leading shoot. Tree shakers have no role in diffuse collecting operations in natural forest, but will probably continue to be used in intensively managed seed orchards or seed stands of a limited range of species.

The American Shock Wave tree shaker is mounted on a short wheel base truck chassis, equipped with an automatic transmission. It has a padded clamping device mounted on the extreme end of a 6 metre boom capable of clamping the trunk of a tree up to 90 cm diameter.

In the case of species in which ripe cones can be easily detached, such as *P. elliottii* and *P. palustris*, trees are shaken in the period after cones have reached maturity but before they open, and the cones with their contained seeds are collected from the ground. In the case of species with persistent cones, such as *P. taeda* and *P. echinata*, shaking is deferred until the cones have opened and the objective is to shake out the seeds from the cones. They can then be collected from the ground by means of the net retrieval system.

4) 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 or fruits have opened. The seeds of some species, e.g. *Pinus elliottii* and *P. taeda* have a very short period between reaching maturity and being dispersed. In addition to the use of sheeting spread on the ground, including polypropylene netting round the crowns, funnel-shaped wooden frames covered with cloth or polyethylene and attached to a central hub surrounding the stem, and sheeting or nets raised on poles above the ground. If seed is borne mainly on or near the outside of the crown, much of it falls outside the spread of a single tree catching unit. If sheeting or netting must remain in place for an extended period of natural seed fall, it is liable to get damaged from weather and a proportion of the seeds are lost to birds and animals.

5) Animal caches

Squirrel caches are an important source of coniferous seed, but confined to limited areas. Typically, they are found in damp areas near springs, small creeks or marshes, on northern exposures, and in decayed wood or duff or around old fallen trees. A single cache may contain from a few cones to many bushels. Fresh cones on the ground are a sign of squirrel activity; piles of cone scales and cores may indicate a nearby cache. Caution should be exercised in collecting seeds or cones from caches, because of the danger of infestation by pathogenic fungi which may reduce germination.

Ants sometimes gather seeds together and in North Africa they have been observed to accumulate large piles of *Acacia* seeds. Any seeds collected from rodent or insect caches should be tested for soundness by cutting test or other means.

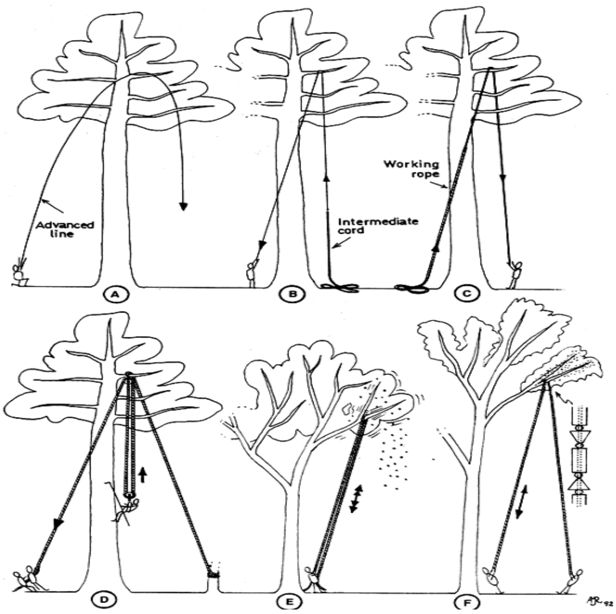


Fig. The Advanced Line Technique (A)-(C) show stages from shooting the advanced line to drawing

Fig. Funnel for trapping *Acacia aneura* seed up the working rope (D)-(F) show possible uses of the working rope, (D) with block and tackle to pull man into crown (E) for branch shaking (F) to sever branches by means of flexible saw.

Fig. Tree Shaker.

Fig. Net retrieval machine

B. Collection from the Crowns of Felled Trees:

One method of collecting large amounts of seed is to synchronise it with normal commercial fellings carried out during the seed ripening season. If fruits are to be collected from throughout the felled crop, picking should be postponed until felling in the area is complete.

If phenotypic quality of parent trees is more important than quantity of seed, it is preferable to select, mark and, if possible, fell and harvest fruits from superior mother trees in advance of the main felling. Collection of fruits from early thinnings should be avoided, since it is difficult to judge phenotypic quality correctly at that age. It is essential to confine collection to the season when seeds are mature; adjustment of felling dates to coincide with seed ripeness should be possible wherever the same authority is responsible for both the felling and the collecting activities. Hand picking of cones or fruits in the fallen crowns is common practice, assisted by rakes, hooks or machetes.

Collection in clear-felled areas has proved little cheaper than collecting from standing trees by a well-trained team of climbers. The tangle of fallen stems and crowns and the dispersal of some cones during felling greatly reduce productivity.

When relatively small quantities of seed from a few trees are needed for provenance testing or other research purposes, felling of selected individual trees may be necessary in areas where commercial fellings are not practised. Such special fellings should be avoided whenever possible, both because the bole is wasted and tree is lost as a future seed source, but they are sometimes inescapable in the case of tropical high forest species which are very difficult to climb and if a seed collecting expedition is severely limited in time.

The collection of fruits from wind-thrown trees is generally undesirable, as little selection can be applied and there may be a bias towards trees with characteristics which pre-dispose them to wind damage.

C. Collection from Standing Trees with Access from the Ground:

1) 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. Examples are *Crataegus, Sorbus* and *Ilex spp.* in temperate zones, the smaller acacias and mallee eucalypts in Australia and many of the small drought-resistant species of the arid and semi-arid zones. Smaller fruits are generally harvested directly into a basket, bag, bucket or other container held or worn by the picker.

2) Cutting, breaking and sawing

For branches out of arm's 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 branchlets. Light rigid bamboo, aluminium 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. The pruning saw is used for small branches <2 cm diameter, while the bow saw will cut through a 10 cm branch in 5 minutes' sawing.

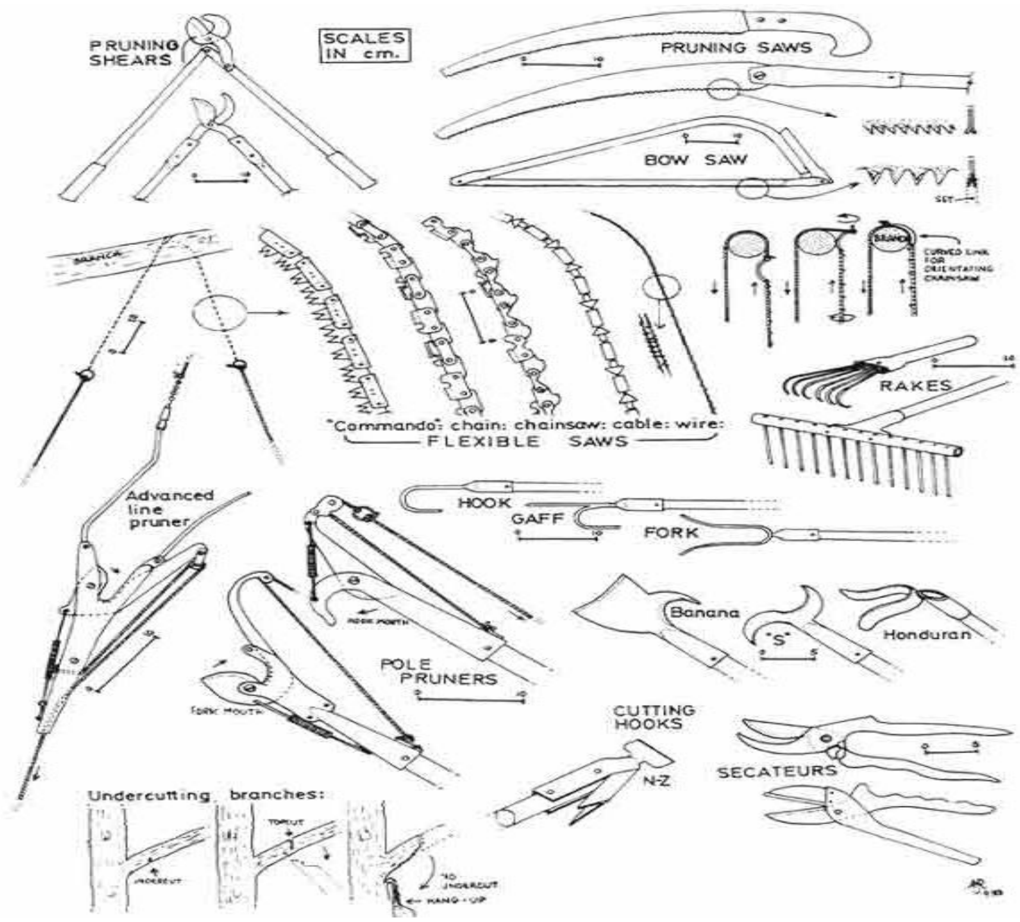


Fig. A selection of *Acacia* seed collecting equipment used in Australia.

3) Use of rifle

Another method of severing seed bearing branches is to shoot them down with a large calibre rifle. The method was successfully used to shoot out the tops of *Picea glauca* trees in seed production areas in north eastern USA. Not only was the topping of the trees found to be less expensive than climbing but the cones could also be collected at the best stage of development because of the short time in which the operation could be completed. More recently shooting off branches or tops from a helicopter has yielded promising results in Canada.

It is important to select branches which will fall unobstructed to the ground. Horizontal branches are more readily detached than ascending branches. The shots should be positioned to take advantage of branch leverage. The method is best suited for collecting research quantities of seed from a heavy seed crop clustered on branches or tops too inaccessible to be conveniently reached by other means.

Disadvantage of the rifle method;

- Very strict safety precautions must be observed.
- Not used near roads or built-up areas.
- Crowns of some species such as *Araucaria* and *Picea* may be considerably damaged by this technique.
- It is usually necessary to steady the rifle on a tripod or to rest the stock against a tree or the side of a vehicle.
- A clear line of sight is required and this can be a limiting factor in dense forests.

D. Collection from Standing Trees with Access by Climbing:

There is a limit to the height to which long-handled tools can be used for collecting seeds or fruits from the ground. Near that 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. Some men are excellent natural climbers, while good training and good equipment can render collection by climbing an efficient and safe, albeit energetic, operation. For convenience the operation may be described under the following subheads: (a) Climbing into the crown by way of the bole, (b) Climbing into the crown directly, (c) Climbing and picking of fruits within the crown.

To use these methods, you must have skill in climbing trees and using some specialized equipment. This is the method normally used to collect from standing dry zone trees as they are of open form and relatively small.

1) Climbing into the crown by way of the bole

Climbing with minimum equipment. Some seed collectors climb barefooted or with the help of a rope which ties both feet together and presses them against the trunk of the tree. Other modifications are for the climber to cut successive notches in the bole with a hand-axe to support his feet, or to hammer in a series of iron spikes about 20 cm long which are later withdrawn for re-use as he descends. Both of these methods are physically exhausting, whether or not a safety belt is used, and do some damage to the tree.

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 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, e.g. for pollination and seed collection in seed orchards, is liable to cause an unacceptable degree of damage; other climbing methods should then be preferred.

Ladders. For heights from about 8 to 40 metres, vertical scaling well-designed portable ladders in several sections provide a quick and safe means of reaching the live crowns of trees. Ladders may be made of light wood, aluminium, magnesium alloy or bamboo 6–15 metres in length, but each section must be light enough to be easily pulled up by the climber. For small trees a light wooden or aluminium ladder 6–8 metres long is appropriate.

The tree bicycle or “Baumvelo” provides an extremely safe means of climbing tall straight branchless trees without damaging them and is lighter and more portable than sectional ladders but heavier than climbing irons. It is suitable for use on stems with diameters ranging from 30 – 80 cm. Its main disadvantages are the cost, the fact that its use is limited to a certain range of diameters and that, unlike ladders and climbing irons; it requires the bole to be pruned of branches all-round the circumference up to the living crown.

2) 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 heavily thinned plantations 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 are used as when using a rope to shake branches. A stronger and heavier rope is needed to support the climber's weight than to shake branches.

Hoisting equipment involves the use of a block and tackle which are hauled into position and secured by tying the rope firmly at the base of the tree. The collector is hoisted into the crown of the tree on a small bosun's chair or climbing saddle by one or two men on the ground or with the aid of a mechanical or electric winch. The method has an advantage over climbing irons or ladders because the ascent is less tiring and so reduces the risk of accidents.

Tree net. Devices such as the rope ladder and hoisting equipment give access to the interior of the crown. Some genera such as *Cupressus, Chamaecyparis, Tsuga* and *Thuja* bear a large number of small cones near the tips of the branches, where they are not strong enough to bear the weight of a climber. To collect these tree net provide one method to reach the exterior of the crown. The tree net was triangular in shape and suspended by special ropes and snatchblocks from a point near the top of the crown, covering part of the exterior crown and with the lower corners pulled taut and attached by guylines to nearby trees.

3) Climbing and picking fruits within the crown

Methods of climbing and picking fruits in the crown are independent of the method used to reach the crown, whether this is by ladder, tree bicycle or climbing irons. Modern climbing techniques and equipment are designed to ensure that, if a climber falls, he falls only a short distance before his fall is arrested.

Safety belt and strap

- The SAFETY BELT goes round the waist of the climber. It may be used alone or may form part of a more elaborate SAFETY HARNESS.
- The SAFETY STRAP goes round the bole of the tree and is secured at each end to the SAFETY BELT. It secures the climber to the bole until he climbs into the crown.

Safety line and safety ropes

- The (SHORT) SAFETY ROPE secures the climber or his (LONG) SAFETY LINE to the tree (either stem or stout branch) while he is working in the crown. It can also be used as a RESERVE SAFETY ROPE securing the climber when he is forced to disconnect his SAFETY STRAP in order to climb above a large isolated branch on the bole.
- The (LONG) SAFETY LINE connects the climber to his anchor-man on the ground. It provides safety while he is in the crown and a means of descent without having to climb down the bole.

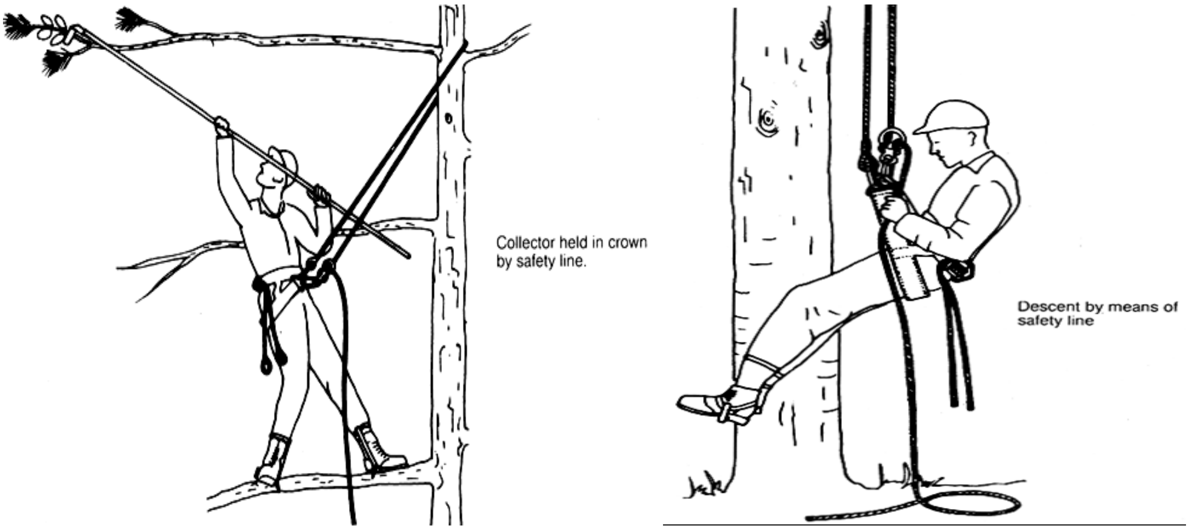


Fig. Use of hand tools and safety line locking method in picking fruits in the crown

E. Collection from Standing Trees with Other Means of Access:

Some types of equipment have been designed to raise the collector mechanically to a level where he can reach the fruit-bearing portion of the crown, without having to climb at all. Cable systems supporting a carriage can move pickers alongside tree crowns. Although access to several trees is obtained with one setting, the installation is time consuming. The system would prove most profitable in a stand where repeated collections are to be made.

The extension platform of a type used for the installation of overhead electric cables has been used for seed collection in many countries. There are a number of models available, including ones with telescopic raising gear and hydraulically operated articulated steel booms built on a turn-table.

A trailer-mounted platform attached to, and powered by, an agricultural tractor has been developed in Australia for seed collections from heights up to 10 metres above the ground. It is versatile and relatively low cost equipment. Hydraulic platforms are of most value when time and labour are short and fruits can be collected from accessible trees with good crops. Disadvantages of this equipment are the necessity for good access and the high capital cost.

Training and Safety Measures:

1. All equipment should be carefully stowed, both during transport in the field and while in store between collecting seasons.
2. Clothing should be strong, well fitting, and suited to the weather expected.
3. All equipment should be checked before it is used and, if there is doubt about its condition, it must not be used until repaired or replaced.
4. Do not climb in wet/very windy weather, nor in poor light as at dusk, nor when overtired.
5. Do not climb trees with obvious signs of stem rot, severe cankers or galls, split stems, double leaders, or other abnormalities indicative of mechanical weakness.
6. The safety line should be coiled on the ground before the climber ascends to avoid tangling or snagging the rope in the underbrush.
7. The anchor-man should hold the safety line under one arm and over the other shoulder. It is wise to make a half turn around a neighbouring tree. This gives control and prevents the safety line from being pulled from his hands. A sliding rope is difficult to control and can cause painful friction burns.
8. Never climb with anything tied or looped around the neck.

9. Safety helmets and goggles should be worn to prevent injury to the head and eyes in climbing rough, densely branched trees.
10. Stand on and grip branches close to the point of attachment to the main stem.
11. Watch for brittle branches; test doubtful branches before putting weight on them. Avoid branches with bark peeling from them - they are slippery. As far as possible, decide on the climbing route while still on the ground, especially for the branchy crown region.
12. The climber should have three points of support at all times (one hand and two feet or two hands and one foot), moving one limb at a time, except when attached to the tree by a safety strap or rope or when suspended on a safety line. Climb calmly with regular movements, taking short steps.
13. Do not carry tools while 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 the working level. Return tools to the ground on the line, do not drop them or throw them down.
14. Beware of sharp branch stubs: they can snag clothing and may cause painful cuts and bruises.
15. Climb spirally or in a zigzag manner, or fasten safety strops to the stem so that you cannot fall more than 2 m before your weight comes onto the safety line.
16. The diameter of the main stem should not be less than 8 cm at waist level during climbing. If in doubt concerning security, do not hesitate to tie a safety strop to the stem at a safe level before climbing within reach of the seed-bearing crown.
17. While attaching safety rope, keep one arm securely around tree until the rope is fastened to safety belt.
18. Before letting go of the tree with your hands, test your weight against the safety rope and footholds.
19. When picking near the top of a tree, keep your body close to the stem, so that your weight bears down, not outward.
20. The safety strap should always be attached around the tree stem except while you are climbing or changing position in the crown or are suspended on the safety line.
21. Before dropping bags of cones or other material, be sure that the personnel on the ground are notified and are well clear.
22. When collecting fruits from a ladder, make fast the top of the ladder to the tree with a nylon strop. The ladder must be further steadied with two guylines.
23. Have a well-stocked first aid kit handy at the climbing site at all times.

Lecture 06

Fruit and Seed Handling Between Collection and Processing

Introduction:

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 the seed centre or seed processing depot, is difficult to control in the forest and during transport from forest to seed depot. Fluctuations of climate cannot be predicted or prevented and transport may involve persons who do not have the same personal interest in the welfare of the seeds as the collector, processor or user. During this period there are serious dangers of loss of the identity as well as of the viability of the material. The risks are especially high in many tropical countries, where temperature and humidity are high and where transport may be difficult, slow and uncertain. 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 in order to provide the closest possible control over the identity and health of the seed at all stages in its movement.

Maintaining Viability Between Collection and Processing:

Almost invariably it is fruits, not seeds, which are picked from trees. Sun drying of fruits and extraction of seeds is carried out in the field in some countries where the climate is suitable. 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 through the action of moulds and other fungi and through overheating due to a high rate of respiration. The importance of good ventilation in reducing these dangers cannot be overemphasized.

If fruits are stored temporarily in separate containers, they should not be filled to the top. In particular, sacks containing fresh cones should be only 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. To facilitate air circulation within sacks, as well as for easy handling during transport, it is advisable to put only 10 – 20 kg of fruits in each sack.

Loose-weave hessian sacks or nylon-mesh laundry bags allow good air circulation through the side of the container. In the case of eucalypt capsules and fruits of other species with very small seeds, however, close-weave cotton bags should be used if there is any chance of the fruits opening during transit.

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.

Aeration in loose-piled fruits can be improved by inserting loosely-constructed “chimneys” of wooden slats in the middle of the piles. Daily turning of loose-piled fruits or of sacks can do much to improve access of air to the less exposed fruits.

If fruits cannot be transported at once to the seed processing depot, temporary field storage must be arranged, in sheds or under some kind of shelter. Shelter is needed against rain and too high insolation. Sheds should be open-sided or otherwise well ventilated and sacks well-spaced on racks or hung from hooks to allow free air circulation. Hanging from hooks has the added advantage of giving protection against rodents.

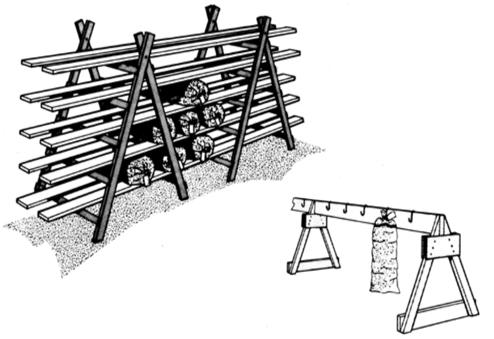


Fig. Interim cone storage racks.

Fig. Wire baskets for temporary storage of cones

Fig. Temporary frame for field drying

If storage is in the open, overhead shelter may be provided by canvas tarpaulins or polyethylene 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 of orthodox seeds some degree of advance drying of the fruits in the field is a good thing. Drying of orthodox seeds less than 12 % before shipment by air has been recommended by IBPGR. Drying can be facilitated by the use of open-weave sacks. Polyethylene bags are not suitable for temporary storage of fruits of these species, since they prevent drying and may encourage fungal moulds and overheating. However, fruits of recalcitrant species must be kept cool and moist to maintain viability of their seeds. Polyethylene bags, which prevent drying, are suitable as containers for species of this type.

For large collections, large wire bound pallet boxes, with a capacity of 7.3 hectolitres, are much more efficient for the physical handling of cones prior to processing. These boxes, used as a single container for handling, shipping and storing, are delivered as components which can be assembled in less than three minutes as needed. But, because of their weight of around half a ton when filled, they need the use of a forklift truck for loading and unloading and are therefore only suitable for large and highly mechanized operations.

Special measures may be needed to prevent damage from pests and diseases. The use of insecticidal or fungicidal dusts may be advisable in some circumstances, if there is a high risk of severe damage, but great care is needed in treating fresh and relatively moist seed, to avoid damage from the chemicals themselves. Maintaining fruit hygiene, particularly through good ventilation, is usually preferable to reliance on chemicals. Storage of sacks off the ground will itself give some protection against rodents. The incidence of pests and diseases is often worst on the forest floor and prompt collection of fallen fruits can do much to minimize subsequent losses.

Maintaining Identity Between Collection and Processing:

To ensure maintenance of seed lot identity, each container of fruit must be labelled correctly when it is filled. As an additional insurance against accidental loss of the exterior label, identical labels should be placed both inside and outside the container.

Weather proof labels should be used and the minimum information recorded should include species, seed lot number, geographic location or name of seed source and weight of seed contained, date of collection and collector's name. Information on seed lot number and species is the key for seed documentation. If detailed information is given on seed collection data sheets the information given on the labels can be limited to seed lot number, species, seed source and weight of seed contained. A copy of the seed collection data sheet or certificate of origin with reference to seed lot number must be attached to the documents accompanying the seed - or preferably be mailed before the seed is despatched.

When one seed lot is divided between several containers for despatch, each label should state also the number of containers involved (e.g. 1 of 4).

In large-scale operations, information may be coded. In the case of small collections for research purposes, e.g. provenance collections or single-tree collections for progeny trials, additional information is recorded on a separate certificate of seed origin or collection data sheet.

Reference to seed lot number is important. Labelling is more time-consuming, but also it is even more important, in numerous small research seed lots than in bulk collection, since it is essential to keep each seed lot separate and clearly identified at all stages between collection and sowing in the nursery.

Small nylon bags are ideal containers for small lots of cones and seeds which need to be kept separate. They allow good ventilation and many of the stages of seed handling (transport, sun or kiln drying manual dewinging) can be carried out without removal of the cones or seeds from the bag.

Additional information, apart from that on the label, often needs to be recorded, especially for research seed collections. There are three main purposes for documentation of seed;

1. To record the location of the collection, so that good sources can be revisited if necessary at any time in the future and, equally important, bad sources avoided.
2. To provide information on the ecological conditions, the actual populations sampled and the methods of collection and handling of the seed, to assist with interpretation of research results or the planning and conduct of other collections.
3. To comply with requirements for safe and rapid transport and acceptance of the seed.

Special documentation which may need to accompany seeds in transit, especially if movement is between countries, includes collecting licences, seed movement orders, export and import permits, phytosanitary certificates and certificates of origin or of genetic value under national or international schemes of seed certification.

Special Precautions for Recalcitrant Seeds in the Humid Tropics:

Most of the problems in maintaining seed viability are accentuated in the case of recalcitrant species in the humid tropics. They have short life spans, and can neither tolerate low temperatures (not much below 20°C) nor reduction in their moisture content below a relatively high value. The majority of seeds in the humid tropics are recalcitrant, and as a result of high rates of seed spoilage in transit, such species are seldom used in reforestation except within their countries of origin. Even for seeds collected and used locally, deterioration can be serious within a matter of days unless special precautions are taken. Collectors have to work within relatively narrow limits of tolerance. The main precautions to note are as follows:

a) **Ventilation:** Recalcitrant seeds (and their fruits) respire actively, hence require good ventilation. If large quantities are closely packed, suffocation, physiological breakdown, fungal growth, and overheating will occur resulting in rapid death of the seeds. If plastic bags are used as containers, their tops should be left open or small holes should be made in their sides. Baskets or cloth bags are suitable although usually more bulky or expensive. It is not easy to strike the right balance between adequate ventilation and adequate moisture conservation.

b) **Temperature:** Temperatures below 20°C or above 35°C should be avoided. Low temperatures are likely to be experienced in air transportation unless the seeds are kept in the pressurized cabin. High temperatures may be due to respiration or to direct heating by the sun. Good ventilation will reduce heat build-up from respiration. Recalcitrant seeds should be kept shaded from direct sun at all times.

c) **Moisture content:** Recalcitrant seeds deteriorate if their moisture content is reduced too much or too rapidly. This is likely to happen during transportation in open vehicles because of air movement. The size and number of ventilation holes in the containers should be reduced under such circumstances. Open containers should be covered with newsprint or cloth to reduce the desiccating effect of air movement.

d) **Organization of nursery:** Before the collection is made, the recipient nurseries should be forewarned to have their germination beds ready. Recalcitrant seeds should be sown as soon as possible after collection.

e) **Long trips:** Collection trips for recalcitrant seed should not exceed a few days in duration. If a long trip cannot be avoided, a lot of extra work has to be done in daily inspection and processing of the collections already made. If decay and fungal growth set in, the seeds will have to be spread out for better ventilation. Decaying pulpy fruits will have to be separated from the healthy fruits and depulped immediately. Capsules must be discarded as soon as they have opened sufficiently for their seeds to be extracted. If seeds begin to germinate during the trip, the germinants may be saved by storing in rigid containers or baskets lined with newsprint or other absorbent material and kept moist. Some seeds deteriorate so rapidly that the best way to transport them may be in a germinating condition in a moist medium.