II. SEED SOURCES AND SEED PROCESSING

2.1 Seed sources

Indonesia is presently carrying out large scale afforestation and tree planting program. The demand for tree seed which is already high, is expected to further increase. Both the public and private sector are involved in the planting programs and the investments made are large in scale. The success of the plantings and the return on the investment will, to large extent, depend on the quality of the tree seed used.

The genetic quality of the tree seed depend on the categories of seed collection units or seed sources from which seeds are collected.

Projected activities of plantation forest establishment for PELITA (Indonesian Five Year Development) VII (year 1998 – 2002) cover area of 8.85 million ha, which consist of Industrial Plantation Forest establishment (HTI) as large as 1.25 million ha, rehabilitation of critical land as large as 2.5 million ha, rehabilitation of protection forest 1.0 million ha, development of private owned forest 0.5 million ha, and reforestation of natural forest 3.6 million ha. To carry out all those activities, the need for seeds amount to ± 150 tonnes per year on the average.

Most efforts to fulfill the need for such seeds, utilize seed from unidentified seed sources with poor physical, physiological, and genetical quality. Beside that, ecological suitability between seed sources and planting site is sometimes neglected, so that it is feared that stand quality produced is not in accordance with expectation. These phenomenon is due to the limited availability of existing seed sources. The following are present condition of seed sources in Indonesia.

2.1.1 Seed collection zones

Seed collection zones for a species is defined as the area or groups of areas subject to sufficiently uniform ecological conditions on which are found stands showing similar phenotypics or genetic characters.

A seed-zoning system should provide :

a. Information on seed sources available and on the ecological conditions prevailing in each zone.

b. Information on the maximum geographic limits for the zone and its sub-zoned or elevation belt.
c. Guidelines for transfer of seed and planting material.
d. Guidelines for sampling of seed and location of test areas for testing provenances or progenies (offspring from single trees).

2.1.2 Identified seed stands

An identified seed stands is any stands of average quality, natural forest or plantation, occasionally used for seed collection, and the location can be precisely described.

The area of identified seed stands in Indonesia is 23,661 ha, where nearly the whole of it is in the form of natural forest in all provinces outside Java, and is intended to produce seeds of some species, such as the following : meranti (*Shorea* spp.), keruing (*Dipterocarpus* spp.), kapur (*Dryobalanops* sp.), ramin (*Gonystylus bancanus*), sungkai (*Peronema canescens*), mahagony (*Swietenia macrophylla*), leda (*Eucalyptus deglupta*), dammar (*Agathis loranthifolia*), tusam (*Pinus merkusii*), ampupu (*Eucalyptus urpophylla*), gmelina (*Gmelina arborea*), merbau (*Instia bijuga*). An identified seed stand of tusam (*Pinus merkusii*) in Aceh Province is presented in Figure 2.1.

Figure 2.1 Identified seed stand of Tusam (*Pinus merkusii*) in Aceh Province

Condition of most identified seed stands are still at the stage of appointment (identification and allocation) and there have been no any proper maintenance, so that the quantity and quality of seeds produced are still poor.

2.1.3 Seed Production Areas (SPA)

A seed production area is a “plus” stand which is generally upgraded and treated with selective thinning, and cultivated for early and abundant seed production. An SPA is of higher phenotypics standard than normal selected stand, and the area must be free from contamination by foreign pollen. The objective of establishing SPA is to produce seeds with better genetical quality within a short period of time. SPA’s which have been established covered area of 6,175.08 ha, comprising 16 species and are located mostly in Java Island (Annex 2.1). SPA which has the largest area is that of teak (Figure 2.2) which is as large as 4,420.80 ha, followed by pine (*Pinus merkusii*) as large as 418.30 ha and mahogany (*Swietenia macrophylla*) as large as 349.70 ha.

Figure 2.2 Seed production area of teak (*Tectona grandis*) in Central Java

2.1.4 Seed orchads

A seed orchads is a plantation of selected clones or progenics (families), which is isolated and managed to avoid or reduce pollination from outside, managed to produce frequent, abundant and easily harvested crops of seed.

Seed orchards are stands planted especially for the production of abundant and genetically superior seeds. There are two main types of seed orchards, named according to the manner of their establishment :

1. Clonal seed orchard (CSO) : seed orchard raised from selected clones propagated by grafting, cutting, budding, air-layering or tissue culture.

2. Seedling seed orchard (SSO) : seed orchard raised from seedling produced from selected parents through natural or controlled pollination.

Seed orchards which have been established cover area of 2,064.93 ha which consist of CSO as large as 727.83 ha and SSO as large as 1,337.10 ha, comprising 13 tree species. CSO of teak (Figure 2.3) and SSO of pine (Figure 2.4).

Figure 2.3 Clonal seed seed orchard of teak (*Tectona grandis*) in East Java

Figure 2.4 Seedling seed orchard of pine (*Pinus merkusii*) in East Java

Seed orchards mentioned in Annex 2.2 are the first generation seed orchards where some of them have produced superior seeds in limited amount.

2.1.5 Phenology

Flowering and fruiting season for each tree species varies. Even, within a species, there is a variation in such season between places.

Most tree species can flowering and fruiting every year, except for dipterocarps, which flowering and fruiting one every 2 – 5 years, or even for some species, one every 6 – 8 years. Dipterocarps which have the shortest period of flowering and fruiting season (2 – 3 years) are for instance meranti which include among other things *Shorea leprosula, S. parvifolia, S. macroptera, S. bracteolate, S. acuminata, S. smithiana, S. stenoptera* Burck and kapur (such as *Dryobalanops aromatica*). Dipterocarp which fruiting every year is *Shorea stenoptera* Forma which grows in research forest of Haurbentes, West Java, which belongs to Forest Research and Development Agency (FORDA), Ministry of Forestry.

Tree species such as dammar (*A. loranthifolia*), leda (*E. deglupta*), gmelina (*Gmelina arborea*), sengon (*Paraserianthes falcataria*), sungkai (*Peronema canescens*), tusam (*Pinus merkusii*) and puspa (*Schima wallichii*) can fruiting throughout the year. On the other hand, many other species flowering only at certain months such as mangium (*Acacia mangium*), manii (*Maesopsis eminii*) and teak (*Tectona grandis*).

Flowering and fruiting season and the number of seeds per kilogram for commercial tree species, is presented in Table 2.1.

Based on observation results in research forest of Haurbentes, West Java. Dipterocarps which flower on July – September, bear young fruit on October – December and bear mature fruit on December – March are *Shorea leprosula, S. pinanga, S. stenoptera, S. palembanica, S. multiflora, S. virescens, S. guisso, S. mecistopteryx, S. martiniana and S. chrysophylla*. Species which flower on July – August, bear young fruit on September – November and bear mature fruit on December – February are *Vatica wallichii* and *Dipterocarpus retusus*.

Table 2.1 Flowering and fruiting season and the number of seeds per kilogram for commercial tree species

No	Species	Flowering season	Fruiting season	Number of seed per kilogram
1	Mangium (*Acacia mangium*)	March – April	Sept – Oct	66,000 – 120,000
2	Dammar (*Agathis loranthifolia*)	Through out the year	Feb – April August – Oct	4,000 – 5,000
3	Leda (*Eucalyptus deglupta*)	Through out the year	Feb – April June – August	15,034,000
4	Gmelina/Jati Putih (*Gmelina arborea*)	Through out the year	April – July	2,500
5	Manii/Kayu Afrika (*Maesopsis eminii*)	Feb – May August - Sept	April – July Oct – Nov	700 – 1,000
6	Mindi (*Melia azedarach*)	West Java: March – May East Java: June – Nov West Nusa: June – Sept	June, August, September	3,400
7	Sengon (*Paraserianthes falcataria*)	Through out the year	June – Nov	38,000 – 40,000
8	Sungkai (*Peronema canescens*)	Through out the year	March – June	262,000
9	Tusam (*Pinus merkusii*)	Through out the year	July – Nov	50,000 – 60,000
10	Puspa (*Schima wallichii*)	Through out the year	August – Nov	1,300
11	Mahagony (*Swietenia macrophylla*)	Sept – Oct	June – August	1,800 – 2,500
12	Jati (*Tectona grandis*)	Oct – June	July – Dec	1,500
13	Suren (*Toona sureni*)	Central Java: June – Oct Sumatera: May – June	June – Oct	64,000

Tree species which flower on January – March, bear young fruit on April – June and bear mature fruit on July – September are *Hopea sangal, H. dryobalanoides, H. mengawaran* and *H. odorata*.

In Kalimantan, *Dryobalanops aromatica* and *D. lanceolata* are found to fruit on May – June, *Shorea gyberstiana* on March and June – August, *S. johorensis* on November – January, *S. selanica* on March, *S. smithiana* on March – May, *S. ovalis* on June – August and March – May, *S. parvifolia* on December – January, *S. platyclados* on January and March – June, *S. palembanica* on

January and March, *S. ovalis* on December – February, *S. javanica* on September and November – March, *S. acuminata* on June and October – December.

Time needed from the start of anthesis up to mature fruit for Dipterocarp species are presented in Table 2.2 and number of seeds/fruits for Dipterocarp species varies from 15 seeds/kg up to 17,000 seeds/kg and are listed in Table 2.3.

Table 2.2 Time needed from the start of anthesis up to mature fruit for Dipterocarp species (Al Rasyid *et al*., 1991)

No	Species	Time from anthesis to mature fruit (months)
1	*Shorea faguetiana*	5 – 6
2	*S. nigra*	6
3	*S. resinosa*	5
4	*S. singkawang*	4 – 5
5	*S. macrophylla*	5
6	*S. curtisii*	4 – 5
7	*S. sumatrana*	4 – 5
8	*Dryobalanops aromatica*	4
9	*D. oblongifolia*	3.5 – 4
10	*S. maxima*	4
11	*Dipterocarpus oblongifolia*	3 – 3.5
12	*S. martiniana*	3.5
13	*Hopea dyeri*	2.5 – 3
14	*H. odorata*	2.5
15	*S. bractelolata*	2.5
16	*S. macroptera*	2.5
17	*S. leprosula*	2.4 – 2.5
18	*S. ovalis*	2.5
19	*S. pauciflora*	2.5
20	*S. platyclados*	2.5
21	*S. gibbosa*	2.4
22	*S. wigtiana*	1 – 1.75

Table 2.3 Number of seeds/fruits per kilogram for Dipterocarp species (Al Rasyid *e al*., 1991)

No	Species	Number of seeds/fruits per kilogram
1	*Shorea stenoptera*	15
2	*S. gyberstiana*	36
3	*S. compressa*	33 – 48
4	*Dipterocarpus trinervis*	42
5	*S. pinanga*	42 – 65
6	*S. mecistopteryx*	91
7	*S. ovalis*	720
8	*S. johorensis*	372
9	*S. palembanica*	165 – 185
10	*Dipterocarpus gracilia*	353
11	*Dryobalanops lanceolata*	162 – 349
12	*D. aromatica*	88 – 584
13	*D. oblongifolia*	146
14	*S. javanica*	400 – 850
15	*Dipterocarpus crinitus*	660
16	*S. platyclados*	930 – 1,200
17	*S. koordersii*	950
18	*S. macroptera*	988
19	*S. assamica*	892
20	*S. pauciflora*	1,504
21	*S. leprosula*	1,900 – 2,268
22	*S. dasyphylla*	1,776
23	*S. parvifolia*	1,850 – 2,906
24	*S. bracteolata*	1,702
25	*Dryobalanops rappa*	2,500
26	*Hopea sangal*	2,950 – 4,950
27	*S. acuminata*	6,817
28	*H. mengarawan*	6,935 – 17,000

2.1.6 Seed collection

Before conducting seed collection, careful planning should be made. Planning of seed collection relates directly to the following questions:

a. Which species to collect (species selection)
b. How much seed to collect (quantity)
c. Where to collect (seed sources, seed trees)
d. When to collect (harvest time)
e. How to collect (collection method)

All available information on the species that are important to the collector, including data on phenology, maturity indices and detailed maps of seed source accurance, should be prepared thoroughly.

Basic principles in seed selection :

a. Colllect seeds which mature physiologically.
b. When fruits or pods fall to the ground, collect them before they deteriorate or germinate.
c. Collect seed during the regular fruiting season.

Type of fruit, maturity indices and method of fruit collection for commercial tree species is presented in Table 2.4.

Table 2.4 Type of fruit, maturity indices and method of fruit collection for commercial tree species

No	Species	Type of fruit	Maturity indices	Method of fruit collection
1	*Acacia mangium*	Dehiscens pod	Pods are brownish	Collection by climbing, ground collection or by placing sheets, net area under trees
2	*Swietenia macrophylla*	Capsule	Fruits are hard brownish and easy to split	Collection by climbing, or seed collected on the ground after fruit fall
3	*Pinus merkusii*	Cone	Cones are brownish scales are ready to open	Collection by climbing
4	*Agathis loranthifolia*	Cone	Cones become brownish – green	Collection by climbing, ground collection not recommended
5	*Tectona grandis*	Drupe	Drupes are brown colom	Ground collection after natural fruit fall
6	*Gmelina arborea*	Drupe	Fruits are yellowish and collected from the ground	Ground collection after natural fruit fall
7	*Maesopsis eminii*	Drupe	Fruits are yellowish and fleshy exocarp is easy to removed	Ground collection after natural fruit fall
8	*Paraserianthes falcataria*	Dehiscens pod	Pods are yellowish and become brownish as ready to open	Collection by climbing, cutting of fruit bearing branches
9	*Toona sureni*	Capsule	Capsules are brownish just before opening	Cutting of fruit bearing branches, collection after shaking
10	*Shorea* spp.	Nut	There are preliminary falls of fruit	Collection by climbing, ground collection after natural fruit fall

2.2 Seed processing of some commercial timbers in Indonesia

2.2.1 Introduction

Seed is the major vehicle by which genetic expression is transmitted to future forests and genetic improvement of seed is probably the cheapest way to increase growth and yield. Forest tree seed is collected to ensure the continuous short and long term supply of reproductive material for planting programs. The quantity of seed collected will be determined by both that required within country as well as other tropical countries which may not have reliable seed sources.

The main objective of the seed production program in Indonesia is to improve genetic, physiological and physical qualities through tree breeding, development of optimum methods for testing, storing and distributing seed. One of the greatest challenges for seed sectors in Indonesia is to ensure that processed seeds have the capacity to produce uniformly high quality seedlings required for plantation establishment or other purposes. Therefore, seed processing strategies need to be clearly defined and planning must include application of appropriate methodologies to fulfill the precise objectives.

Successful and safe trade in forest tree seed requires that seed is handled correctly from the time it is collected to when it is eventually sown. A well planned seed or fruit harvesting program should be an integral part of all tree improvement and plantation establishment programs. Hence sound prior knowledge of the seed crop to be collected is required if adequate collections are to be made. Meticulous records about the site, stand and seed collection at each site are essential. Equally important is accurate documentation and labeling to preserve the identity of every seed lot at all stages from seed source to seed store and nursery. Appropriate labels and forms need to be designed well in advance and printed in adequate numbers.

The success of all the operations involved depends very much on a sound understanding of the biological processes involved as well as on competent observation and organizational ability. In general, various steps in forest seed processing are outlined in Figure 3.1, which depend on the species. Usually, pre-sorting is carried out to separate between ripe and unripe seed before placing in proper seed sacks.

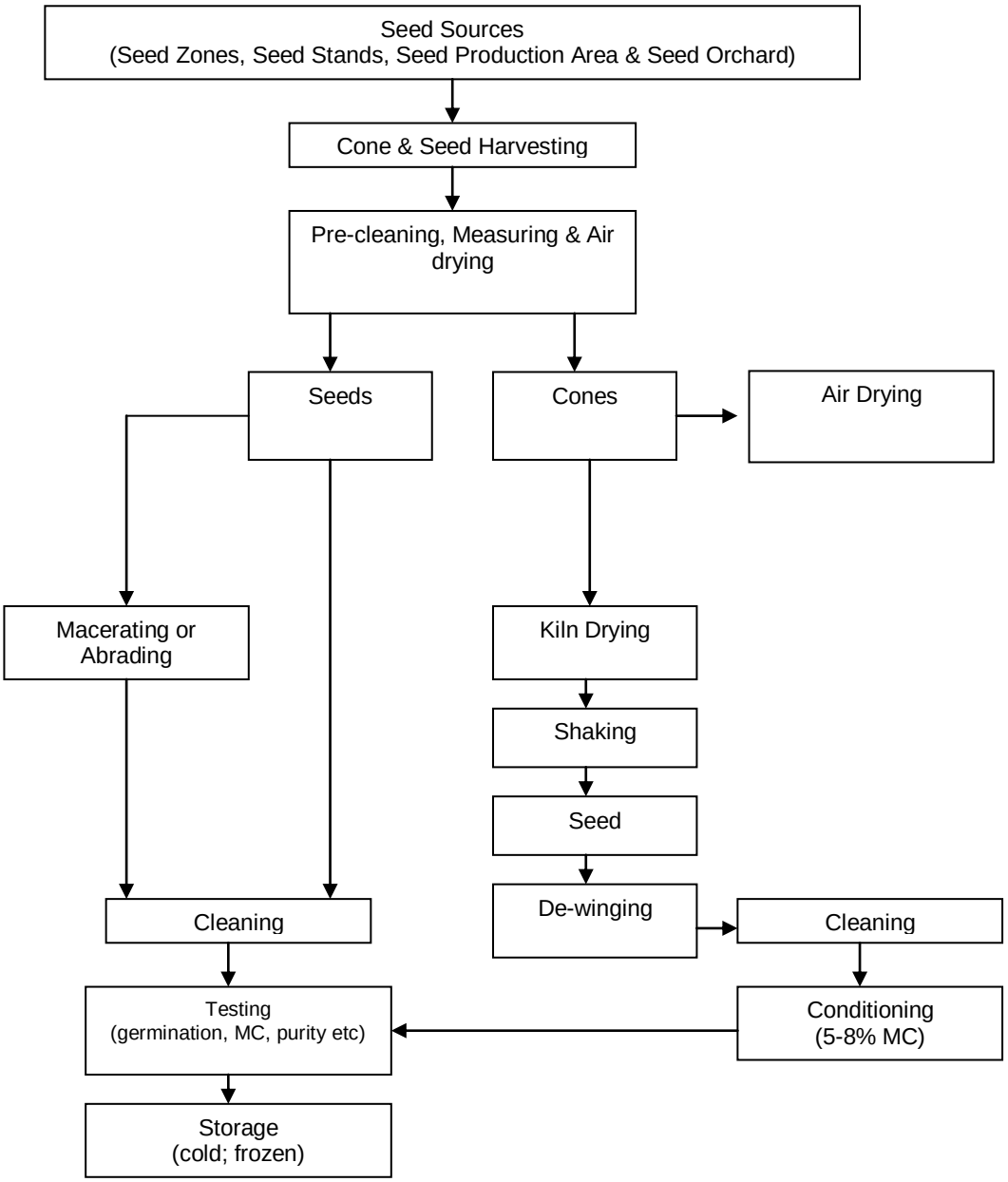

Figure 3.1 Steps in processing of forest seed

2.2.2 Current steps in seed processing

Extraction

Extraction is usually carried out at the Seed Processing Unit closest to the nursery site. The extraction work is done manually by labors. This process is usually completed within one week of collection to ensure high viability as well as to prevent possible loss of identity. Extraction is done using different techniques depending on the species. Extraction tools may be used with care in order to

minimize seed damage. Extracted seed is placed in seed sacks, weight recorded on the sacks before being transported to the air-drying facility as soon as practical.

Air drying

The duration for air-drying of most seed is 1 – 2 weeks depending on weather. This is part of the process to reduce the moisture content (6 – 7%). It is important the seed are air dried under shade as exposure to direct sunlight has been observed to lower viability. Drying under shade ensures slow release of moisture from the seed.

Moisture content testing

Moisture content is a critical factor in determining storage life of seed, hence the seed moisture content before storage needs to be objectively analyzed. The required moisture content for storage of most ortodox seed is 3 – 7% as this ensures high viability for up to a year or more, while for recalcitrant seed requires much more moisture content ranging from 20 – 30%.

The samples taken are usually 3 lots (3 replicates). These are broken up and placed in glass or aluminum dishes and original weights recorded. After weighing the petri dishes are covered. The oven is switched on half an hour prior to testing to bring the temperature to constant 103^{o}C.

The dish covers are removed and petri dishes with seed samples are placed in the oven for 17 ± 1 hour. After 17 hours the petri dishes are removed from the oven and cooled for 30 minutes. The samples are then reweighed and the moisture content is calculated on a wet weight basis.

Winnowing

The final phase of the seed cleaning process is winnowing whereby all the unwanted material such as broken wings and injured seed which slip through the system, are hand picked and discarded. The cleaned seed is then stored in polythene bags prior to treatment with a fungicide.

Seed treatment

Seed may be dusted with fungicides as a preventative measure for fungi during storage and sowing. Seed is weighed and placed in polythene bags and fungicide dust is added to the seed. The polyethylene bag is lifted and held at both ends to ensure that the opening is closed. Using both hands, the bag is repeated turned up and down until the seed id thoroughly covered with the fungicide. It is very important that hand gloves and nose/mouth masks are worn at all times when working with fungicides.

Packaging

After fungicide application, seed samples are taken for use in germination tests. The rest of the bulk seed is packed. The seed lots are labeled correctly with 2 labels, one inside the bag and other tied on the sack. Information on the labels includes:

- species name
- seed lot number
- location of collection
- seed grade (dot, plus tree, seed stand)

Storage

Good seed storage facilities are vital in order to minimize loss of viability between time of collection and sowing. Also as a seed lot ages, its viability and germination energy will decline, making it less suitable for use in direct seeding. Hence, storage conditions need to be optimum in maintaining viability. Temporary storage is required for recalcitrant seeds, while long-term storage is usually applied for orthodox seeds.

Germination test

Germination test is most important in estimating the number of seeds which can germinate from a seed lot under optimum germination conditions. Provided the test result is representative of the total quantity available, this information can be used to determine the quantity required to be sent in order to achieve the planned annual planting target. It is of particular importance in direct seeding that seeds germinate rapidly and that early seedling growth is vigorous.

Distribution

Seed when distributed is accompanied with information or an advice slip so the Field Officers will know the origin and germination of the seed. Seed lots sent overseas are accompanied with a seed collection data form which also mentions the germination capacity of the seed lot.

2.2.3 General methods of seed processing of several tree species

Teak (Tectona grandis)

After collection, the fruits are cleaned for branches, leaves and rotten and damaged fruits and then dried in the sun for 2 – 3 days. After drying, the calyx is removed by squeezing and beating the seed in a bag. Finally the impurities are removed by winnowing.

Figure 3.2 Storage of teak seed

Teak seed stores well and may keep its germination capacity for several years provided the seed has low moisture content before storage and is protected against fluctuations in temperature and humidity during storage. If seeds are to be used in the same planting season, no special storage is needed. Seed can be piled in a convenient place near the nursery, preferably in a shed or in a storeroom, but not necessarily dried. Seed can be stored this way for maximum 3 – 4 months. Seed can be stored for up to two years at around 12% moisture content and stored in airtight containers (glass jars or sealed plastic bags) and kept in a dry, shaded and relatively cool place. If stored at low moisture content and in a cold store (0 – 4°C), the germination capacity of the seed can be maintained for 5 – 10 years.

Figure 3.3 Germination test of teak seed

Germination of teak is often poor and sporadic but the exact nature of dormancy is not known. The most common method of pre treatment is to soak the fruits during the night and dry them in the sun during the day, repeating this for 1 – 2 weeks. A better method is dry heat. The seeds are heated for 1 – 5 weeks at 50°C or 48 h at 80°C. This method is difficult to implement for large seed lots as it requires a large oven, but it can improve germination considerably.

Sowing is done directly in the field or in the nursery. If sown directly, normally 3 – 4 seeds are sown per hole to secure that at least one seedling will develop. This method is very demanding in terms of quantity of seed. Sowing in the nursery is done in a seedbed with soil or sand. The seed is covered with a thin layer of sand or soil not to be washed away by rain or be eaten by rodents and other animals. It is important that the seed is not sown too deep, as this will reduce germination rate drastically. Teak plants are very sensitive to shade, and when there is large variation in germination time, the later germinating seedlings can be shaded to death if they emerge under a large seedling. Germination generally starts 10 – 12 days after sowing, but spreads over a very long time, especially if no pre-treatment has been made.

Meranti (Shorea spp.)

Recommended processing of recalcitrant seeds is as follows: Remove wings for ease of handling and to reduce storage bulk for all species. Other processing apply to OLDA species. Seeds of this type will dry well in 20^{o}C or higher with a low relative humidity. Material should be transferred to the appropriate storage conditions as soon as the desired moisture content is reached. Retaining seeds in a monolayer in a flow of air will ensure rapid drying, thereby reducing the risk seed ageing. Careful removal of calyx can further reduce bulk for dry storage. However, this procedure is time consuming and may only be economic for longer-term (conservation storage).

Seed germination testing involves randomly counting four lots of 100 seeds each, from the working sample (ie. replicated 4 times). For each replicate of recalcitrant seed is placed in germinating beds. The medium used is zeolit which has proven to be reusable ideal for the germination of dipterocarps. Recommended procedures for germination are suggested by Krishnapillay and Tompsett (1998), as follows: Remove seed wings prior to sowing in order to ensure good contact with the germination medium and germinate at approximately 26^{o}C-31^{o}C. In the case of dry, decoated OLDA seeds (de-coating is recommended for conservation storage), slow imbibition is essential. This can be achieved by retaining the material in 100% humidity for 24 hours before sowing.

Recommended procedures for small and large quantities of recalcitrant seeds and for “orthodox with limited desiccation ability” (OLDA) seeds are as follows:

For larger quantity of recalcitrant seeds, material should be kept at near the harvest moisture content and in media such as sawdust and perlite. Seed moisture content should be checked at the start and then periodically during storage; any wide fluctuations observed should be counteracted by increasing or decreasing the moisture content of the medium. This careful moisture content monitoring and management can reduce the rate of pre-germination. Excess moisture in the medium causes the seeds to become anoxic, whilst too little moisture lowers seed moisture content and leads to desiccation damage. Suitable containers include open-wave sacks or bags. Storage in a high humidity room at 18^{o}C is recommended. Figure 3.4 shows the storage of seeds of *Shorea stenoptera* in open-wave sacks with sawdust medium.

Figure 3.4 *Shorea stenoptera* seeds in open-weave sacks with sawdust medium.

The optimal condition for storage smaller quantities of recalcitrant seed is retention within inflated polythene bags in a 99% relative incubator at 18^{o}C and at a moisture content near that of the seed at harvest. Polythene bags with rib-channel closure provide suitable packaging; alternatively. Loosely-tied, thin-gauge polythene bags may be employed. Insertion of rigid object helps to maintain an air space. Ventilation at least weekly is essential; use of air at a high relative humidity would be desirable for this purpose. Moisture content should be checked at the start and then periodically during storage; fluctuations should be counteracted by increasing or decreasing the relative humidity around the seed, if possible.

Different storage methods are required for OLDA species. Three following methods are to be effective:

a). Seed storage of OLDA species at about 40-50% moisture content is suitable over very short periods of about fifteen days. Moist storage avoids the risk of partial loss of viability on drying. Temperatures employed should be no lower than 18^{o}C. The seed containers described above in relation to recalcitrant species for smaller and larger seed lots are suitable.

b). In the case of longer-term storage any initial, partial loss on drying may be outweighed by the improved final longevity achieved. Storage for conservation is possible if seed is dried to approximately 12% moisture content; material should be sealed in suitable rigid containers (e.g. Kilner jars)

and retained at -20^{o}C. Further relevant information is given in the summarized processing method above.

c). For medium-term storage periods (between 2 weeks and 24 months), OLDA seed should be retained at 2^{o}C with other conditions as prescribed for longer-term storage.

Figure 3.5 Germination of *S. palembanica* (left) and *S. pinanga* (right)

Tusam (Pinus merkusii)

The cones require after-ripening before seed extraction as immediate sun-drying of freshly collected cones sometimes causes 'case-hardening'. The outer tissues dry too quickly before the inner tissues can lose moisture, and the cone scales fail to open properly. The period of after-ripening varies with the state of maturity of the cones. Mature, brown cones should be stored in the shade and with good ventilation in gunny bags or on racks for at least one or two days. Cones which are green-brown or green should be after-ripened until the colour is fully brown. This normally requires 5 – 10 days. Seed extraction is by drying the cones in the sun on trays or on canvas until they open. During sun-drying, the cones should be stirred to facilitate seed extraction from the cones. The common practice of seed extraction by splitting the unripe cone with knife or cone-cutter is not recommended. Many of the extracted seeds will be immature and will be damaged during storage leading to poor germination rate. To make further seed processing and sowing in the nursery easier, the wing should be removed from the seed. For small quantities of seed, dewinging can be done manually by rubbing the seed between the hands, or against a screen or roughened surface, or by rubbing in a cloth bag. Spraying the seed with water will facilitate the dewinging process. For large quantities of seed, mechanical dewinging may be used. The seed with wings is given 10-15 minutes dry dewinging (no water) in a

concrete mixer. This will loosen many wing parts. Then 5 - 10 % water is added gradually by spraying and the seed rotated for approx. 15 minutes. Then the seed is cleaned and dried.

Figure 3.6 Cones, wings and seed of *P. merkusii*

The seed is classified as orthodox, and can be stored at moisture content 6 – 8% (fresh weight basis) and temperature 3 – 4°C (dry cold storage) for at least 5 years without major decrease in germination percentage. If seed is well dried (MC 6 – 8%) and kept in an airtight container or plastic bag, the seed can be stored at room temperature (20 – 30°C) for at least one year without loss in viability.

The seed has no dormancy and no special treatment is needed to initiate germination. Soaking the seed in cold water for 24 hours before sowing is recommended to obtain even and fast germination.

Germination starts 7 days after sowing and often reaches 80% after 12 – 15 days. Seed can be sown directly in containers (1 – 2 seeds per container) or alternatively in sowing bed with later transfer to containers when the seedling is 3 – 4 cm tall. Mycorrhiza is required. The growth medium should be a mixture of sand and topsoil from a pine stand in the ratio 3:1. The growth of the seedling takes 9 – 10 months, i.e. rather slow compared to many other tropical species.

Damar (Agathis loranthifolia)

Mature cones are placed in porous gunny bags for 1 – 2 days. The seed will then be released from the cone and from inert matter. Seed cleaning to separate seed from other parts of cone (scales, twigs) is done manually, in a tumbler or in a seed blower.

The seed does not tolerate desiccation and cannot be stored for much more than 2 months in an air-conditioned room (temperature 18 – 20°C; RH 60%) at moisture content of 30%.

Figure 3.7 Cones and seed of *A. loranthifolia*

The seed has no dormancy and does not need pre treatment before sowing. Sowing is done with the wing part pointing upwards and ⅔ of the seed buried in the media. Soil or soil mixed with sand is used as germination medium in the green house. Germination starts 6 days after sowing, and germination percentage of 90 – 100% is reached within 10 days.

Mangium (Acacia mangium)

The pods should be processed as soon as possible after harvest. Pods and seeds should not be left long to dry in the sun, as temperatures over 43°C can reduce viability. Extraction with flailing thresher followed by winnowing is suitable for this species. The funicle can be removed manually by rubbing the seed over a sieve.

The seeds are orthodox and can retain viability for several years when stored in airtight containers in a dark, cool room. The recommended moisture content for storage is 5 – 7%.

Mature seeds are pre-treated by immersion in boiling water for 30 seconds followed by soaking in cold water for 24 hours; alternatively they can be manually scarified. Germination rate is high (75 – 90%) after suitable treatment.

Seeds can be sown in seedbeds, germination trays (wet towel method) or directly in containers.

Sengon (*Paraserianthes falcataria*)

Pods are placed in sacks and beaten with wood-stick until they open and release seeds. Cleaning is done to remove debris and then dry in the sun.

Figure 3.8 Pods and seed of *P. falcataria*

Recommended seed moisture content before storage is ± 8%, packed in airtight container. If stored at 4 – 8^{o} C can retain the viability up to 18 months with germination rate of 70 – 90%.

Due to seed coat hardness, pre-treatment is done to obtain uniform germination. Seed germinates after 5 – 10 days. Before sowing seed is poured with boiling water as much as 4 times seed volume. Other way is to immerse seed in boiling water for 1-3 minutes, lifted up and finally soaked in cold water for 24 hours.

Mahogany (Swietenia macrophylla)

Mature dry fruits or dry seeds collected from the forest floor can be stored for some days in sacks without significant deterioration. However, in order to reduce bulk it is often preferable to initiate processing in the field. The fruits will split open when dried for 1 – 4 days, depending on maturity, after which the seeds are easily released by gentle shaking of the fruits. Fruit parts (valves and columella) are removed by hand. Further reduction of bulk by manual dewinging maybe desired.

Seed is orthodox and if stored at 3 – 7% moisture content at low temperatures (1 – 5 °C), it will retain high viability for several years. If the seed is stored in paper bags at room temperature, 7 – 8 months storage can be expected without loss in viability. Initial moisture content in mature seeds is 9 – 12%. Germination percentage of fresh seeds is 60 – 90 %.

Pre-treatment is generally not necessary but germination of seeds with low moisture content may be enhanced by soaking in water for 12 hours.

Under test conditions seeds are germinated in sand at fluctuating 35 – 30°C or constant 30°C and 12/12 for 8/16 hours light/dark. In the nursery, seeds are sown in a bed of light sand in 3 – 7 cm deep furrows or holes or directly in containers. Germinating seeds should be kept moist and under shade. Seeds will germinate in 10 – 21 days. The seedlings are kept under shade until out-planting, which can take place when they are about 50 – 100 cm tall.

Kayu Afrika (Maesopsis eminii)

As soon as possible after collection the fleshy exocarp is removed. For small quantities the pulp is removed using a knife or by rubbing the fruits over a wire mesh. For large quantities the fruits are soaked in water for 24 hours, then mixed with gravel in the proportion 1 kg of gravel to 2 kg of fruits and depulped in a cement mixer with large quantities of water for about 30 minutes. The clean

pyrenes are dried on a wire mesh in the sun for several days during which they are frequently stirred and kept well aerated, 5 kg fruits yield about 1 kg of extracted pyrenes.

There are conflicting reports on the storage behaviour of this species. Germination is normally very high for freshly collected seeds but after a few months' storage it is low and erratic. It is likely that this is caused by dormancy not because the seeds are recalcitrant. Kenya Forest Seed Centre and others recommend storage at 4 – 9% moisture content. When stored at this mc and at 3°C the seed can retain viability for up to 3 years.

The most common pre treatment is to soak the pyrenes in cold water for 3 days, changing the water every day. Some recommend scarification while other trials show this treatment has no effect.

The unit for sowing is the pyrene. Germination is slow even after pre treatment and may last up to 4 months. The final germination will typically reach 65-80%. Because of the strong development of the taproot it is normally recommended to sow directly in polybags. Some, however, prefer broadcast sowing in seedbeds because of the slow and erratic germination. If sown in seedbeds, the seedlings should be pricked out in the cotyledonous state before the roots develop. After 2 – 4 months the seedlings are ready for transplanting into the field. Stands can also be established by natural regeneration, direct sowing or planting stock raised from stump plants.

Gmelina (Gmelina arborea)

Transport of fruits to the processing site should be in open baskets or nets, not in plastic bags. In order to avoid fermentation, fruits should be brought to the cleaning area within 24 hours. This is especially important for fully ripe – i.e. yellow and brown – fruits. As much care as possible should be taken to avoid damage to the fruits, since fermentation is more likely to start among damaged fruits. At the processing site, the fruits should be sorted into those that are ready for immediate processing (yellow and brown colour) and green and green-yellow fruits, which will benefit from after-ripening. After-ripening is done in the shade by spreading the fruits in a 10 – 15 cm thick layer until they have turned yellow. This may take up to one week.

Depulping of small quantities of fruits can be done manually by mashing the fruits until the pulp is loose from the stone, and rinsing with water. For larger quantities of fruits depulping is normally done in a coffee-depulper. Soaking the fruits in water for 24 hours before depulping will facilitate the process. After depulping, the fruits are spread out on a wire mesh tray and rinsed with water to remove juice and pulp. Normally traces of pulp will remain on the stones after depulping and further cleaning or polishing of the stones is required. This can be done either manually by rubbing the stones with sand and water or mechanically (also with sand) in a concrete mixer. Finally the stones are washed and dried well in the sun.

Fruits, which have been dried down to a moisture content of 5 – 8% and kept below this moisture content in cold storage (4 – 5^{o}C), can be stored for several years without reduction in viability. It is however difficult to sun dry the stones below 10 % moisture content, so additional drying in an oven (35 – 50^{o}C) may be required for long term storage. If seeds are sown within a year from processing, sun drying and storage in airtight containers is sufficient. Rodents may cause severe losses in stored stones. Storing in metal containers prevents such losses.

The seeds have no dormancy, and no pre treatment is required. Soaking of the seed in cold water for 24 – 48 hours before sowing is recommended.

The seeds (stones) are sown in a seedbed of soil or sand, covered by a thin layer of sand or soil. The germination of gmelina seed is epigeous with the radicle emerging first and the cotyledons shortly after. Depending on the position of the first germinating seed.