



Tree Seed Management

Seed Sources, Seed Collection and Seed Handling

Mulawarman, James M Roshetko, Singgih Mahari Sasongko dan Djoko Irianto

TREE SEED MANAGEMENT

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Seed Handling

A Field Manual
for Field Workers and Farmers

Mulawarman
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and Djoko Iriantono

Winrock International & ICRAF
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CONTENTS

List of Figures	iii
List of Tables	iv
Preface	v
Acknowledgment	vii
I. WHY IS THIS FIELD MANUAL NEEDED?	1
1. Why Is Tree Seed Important?	1
2. Practical Definitions for Common Tree Seed Terms	1
3. Seed Quality	2
4. What Affect Seed Quality?	3
5. How To Collect Quality Tree Seed?	3
II. WHERE SHOULD SEED BE COLLECTED?	5
1. Seed Sources	5
2. Seed Trees - the most common seed source for farmers and NGOs	7
2.1. Seed trees selection	7
2.2. Criteria for seed trees selection	9
2.3. Number of seed trees to select	9
2.4. Distance between seed trees	10
2.5. Importance of the stand in which seed trees are selected	10
III. HOW SHOULD SEED SOURCES BE ESTABLISHED AND MANAGED?	13
1. Establishment of Seed Trees on Farm	13
1.1. Site selection and tree planting	13
1.2. Managing genetic diversity on farm	14
1.3. Seed trees management	14
2. Establishment of Small-Scale Seed Orchard	15
2.1. Site selection for seed orchard	15
2.2. Germplasm selection for seed orchard	16
2.3. Seed orchard size	16
2.4. Seed orchard establishment	17
2.5. Seed orchard design	17
2.6. Seed orchard management	18
IV. HOW SHOULD TREE SEED BE COLLECTED?	21
1. Planning Seed Collection Activities	21
2. Things to Remember during Seed Collection	22

3. Seed Collection	22
3.1. Collecting seed from the forest floor	22
3.2. Seed collection directly from trees (without climbing)	23
3.3. Seed collection by climbing trees	25
3.4. General comments concerning seed collection	26
V. HOW SHOULD SEED BE PROCESSED?	29
1. Sorting Fruits	29
2. Seed Extraction	30
3. Cleaning and Grading	32
4. Seed Drying	33
5. Seed Storage	34
6. Transportation	36
VI. HOW TO ACCELERATE SEED GERMINATION?	37
1. Seed Dormancy	37
2. Seed Pre-sowing treatment	38
2.1. Soaking in cool water	38
2.2. Soaking in hot water	38
2.3. Mechanical (scarification) methods	38
2.4. Fire or heating methods	39
2.5. Soaking in chemicals	39
VII. HOW TO MEASURE SEED QUALITY?	41
1. Seed Quality and Sampling	41
2. Seed Testing	42
2.1. Purity test	42
2.2. Moisture content	42
2.3. The 1000 seed weight test	42
2.4. Germination/Viability test	42
VIII. HOW SHOULD SEED BE DOCUMENTED?	45
1. Seed Source Document	45
2. Seed Collection and Handling Document	45
3. Seed Quality Document	46
REFERENCES	47
APPENDICES	49
1. Collection dates, colors of mature seed, seed extraction and cleaning methods for some priority species	49
2. Seed pre-sowing treatment for some priority species	51
3. Glossary of terms	53

LIST OF FIGURES

1. Continuum of activities that influence seed quality and should be considered when planning seed collection and tree planting activities.	3
2. Comparison of seed quality from various sources.	6
3. Site for seed trees selection.	8
4. Selection of superior phenotypic seed tree.	8
5. When the seed (mother) tree is surrounded by other good quality trees, the progeny will demonstrate good quality.	11
6. When the seed (mother) tree is surrounded by primarily good to fair quality trees, most of the progeny will demonstrate good to fair quality.	11
7. When the seed (mother) tree is surrounded by many poor quality trees, the progeny will demonstrate poor quality.	11
8. Small-scale seed orchard on farm or community land.	17
9. Seed collection from the forest floor.	23
10. Seed collection directly from trees.	24
11. Seed collection from trees using pole tools.	24
12. Seed collection by climbing trees.	25
13. A sack of seed properly labeled.	27
14. Temporary seed storage.	27
15. Farmers sorting <i>Gliricidia sepium</i> pods.	29
16. Common seed extraction methods.	31
17. Cleaning seed by winnowing.	32
18. Orthodox seed should be dried under direct sunlight for 2-3 days.	33
19. Seed can be stored in various types of containers in a room dedicated for that purpose.	36

LIST OF TABLES

1	Characteristics of various seed sources.	6
2	Collection dates, colors of mature seed, seed extraction and cleaning methods for some priority species.	49
3	Seed pre-sowing treatment for some priority species.	51

Preface

Across the world smallholder farmers and non-government organizations (NGOs) actively plant trees on private farms and community land with the aim of enhancing local livelihoods. While individual plantings are small, in aggregate smallholder and NGO plantings can account for significant areas and are transforming degraded landscapes at the local level. Smallholder and NGO tree planting efforts are generally successful, more so than public or project attempts, because of smallholders' self-interest to benefit from the investment of their limited land, labor and monetary resources. These local tree-planting efforts are often undertaken without assistance from governments or other formal channels. Linkages are weak between the smallholder/NGO level and formal forestry sector - government agencies, forestry industries and tree seed supply enterprises. Smallholders and NGOs collect or produce most of the seed used in their tree planting programs. Unfortunately, experience shows that smallholders and NGOs have limited knowledge concerning proper tree seed collection and handling procedures. As a result, most of the seed collected by smallholders and NGOs is of questionable genetic and physical quality.

To assist smallholders and NGOs in Indonesia build the technical capacity required to properly collect and manage tree seed ICRAF and Winrock International, in collaboration with Indonesia Forest Seed Project (IFSP), developed this manual - *Tree Seed Management: Seed Sources, Seed Collection and Seed Handling*.

The manual was developed through an iterative process over a 20-month period with input from teams of foresters, tree seed specialists, development workers, NGOs and farmers. ICRAF and Winrock staff, based on their own experience and a review of technical documents, compiled the original draft manual to meet the specific needs of NGOs and farmers. The draft manual was then used in four 'seed source management and seed collection training courses' conducted for farmers and NGO field staff.

Those courses were held in:

- Mataram, Lombok 26-29 October 2000, in collaboration with LP3ES Mataram;
Kupang, Timor 12-18 January 2001, in collaboration with Yayasan Tananua Timor;
- Yogyakarta, Java 22-27 July 2001, in collaboration with USC Satu Nama Yogyakarta; and
Bandar Lampung, Sumatra 19-24 August 2001 in collaboration with the ICRAF Kota Bumi field office.

At the end of each course, farmer and NGO participants evaluated the manual and provided input on how to make it more relevant to farmers and NGO staff. After each course, this input was incorporated into the draft manual for use in subsequent training courses. After the fourth training course the manual was then reviewed for technical accuracy by a group of seed technology professionals. The last step in development was a review of the manual - text, diagrams, layout and design - by two teams of farmers who had not attend the previous training courses. These field reviews were conducted in Kupang, Timor and Mataram, Lombok January 14-18, 2002.

The Indonesian version of the manual was published in early 2002. The manual was then translated into English and expanded slightly to meet the needs of a broader global audience. The result of this participatory document development process is a technically-sound field manual that considers the unique land and socioeconomic conditions that confront farmers and NGOs. The manual's recommendations and guidelines are flexible and meant to be adapted to specific site conditions. The authors believe this manual is a valuable document, that will benefit individuals and organizations involved in tree farming and seed collection activities at the local level. We encourage all interested parties to use and share this document freely.

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- USAID/Indonesia for financial support to distribute this manual.

Authors

I. WHY IS THIS FIELD MANUAL NEEDED?

1. Why is Tree Seed Important?

Farmers commonly plant trees on farms or community lands to grow products' that satisfy household needs and market demands. Non-government organizations (NGOs) often support farmers' tree-planting efforts. Tree seed, a key input that determines the success of any tree planting activity, is often in short supply. As a result, farmers and NGOs use whatever seed is available, regardless of its quality. In most countries good quality tree seed is not readily available for a number of reasons, including:

- A lack of awareness concerning the importance of seed quality.
- Limited quantities of good quality seed are available; and government agencies, researchers and forest industry control access to this seed.
- Limited areas of forests and plantations exist that produce good quality seed (seed producing areas are called 'seed sources').
- The genetic quality of forests is often degraded because the best quality trees have been harvested, leaving only poorer quality trees available for seed collection.
- Collectors, dealers and other workers in the tree seed sector have limited training and inadequate facilities to produce, handle and store seed properly.
- A lack of cooperation between governmental agencies and the community-level to improve the availability and utilization of quality seed.
- No labeling or certification systems exist to provide adequate information (to the farmer- and NGO-level) concerning the origin and quality of the tree seed that is available.
- No premium is paid for better quality tree seed.

Enhancing the capacity of farmers and NGOs to properly collect, manage and evaluate their own tree seed sources is one way to address the problems listed above. This manual serves that goal.

2. Practical Definitions for Common Tree Seed Terms

To help the readers understand and use this manual it is appropriate to define some of the basic terms related to tree seed production and management. The definitions provided here are intended specifically for farmers and NGO field workers. They may differ from those used in the formal tree seed sector.

Beside those listed below, additional terms and definitions are found in the **Glossary** at the end of the manual.

- **Germplasm:** Seed or vegetative material used for the purpose of plant propagation; most commonly germplasm refers to seed.
- **Seed:** Reproductive material of flowering plants.
- **Seedling:** Plants propagated from any form of germplasm.
- **Seed source:** Individual trees or stands, natural or planted, from which seed is collected. This manual addresses four types of seed sources: seed trees, seed stands, seed production areas and seed orchards.
- **Seed trees:** Trees from which seed is collected.
- **Genotype:** Genetic constituents of an individual tree which, in interaction with the environment, largely controls tree performance and is inheritable by its progeny. Generally, trees with good genotype produce good progeny.
- **Phenotype:** The observed characteristics of a tree, which result from the interaction of the genotype and environment.
- **Plus trees (Selected trees):** Superior phenotypic trees from which seed is collected.

3. Seed Quality

Another important term is **seed quality**. Seed quality has a direct impact on tree growth and the success of tree planting activities. Seed quality is comprised of three components.

- **Physical quality:** Quality related to physical characteristics, such as size, color, age, seed coat condition, occurrence of cracks, pest and disease attacks, or other damage.
- **Physiological quality:** Quality related to physiological characteristics, such as maturity, moisture content, or germination ability.
- **Genetic quality:** Quality related to characteristics inherited from the parent trees.

Seed quality helps determine:

- The quantity of seed that should be sown to produce the required number of seedlings;
- The number, health and vigor of the resulting seedlings; and
- The characteristics of the resulting seedlings and mature trees, such as growth rate, biomass production (wood, leaves, etc), fruit and seed production, stem form (straightness, diameter, branchiness, merchantable length), general health and susceptibility to pests and diseases.

4. What Affects Seed Quality?

Tree seed quality is affected by any activity associated with: seed source selection and management; seed collection, cleaning, drying, packaging, and storage; and seedling production and tree planting. How these activities are linked is illustrated in Figure 1. Farmers and NGOs may not be involved in all of these activities. However, they should realize that these activities represent a continuum and that each individual activity impacts seed quality and the success of future tree planting efforts.

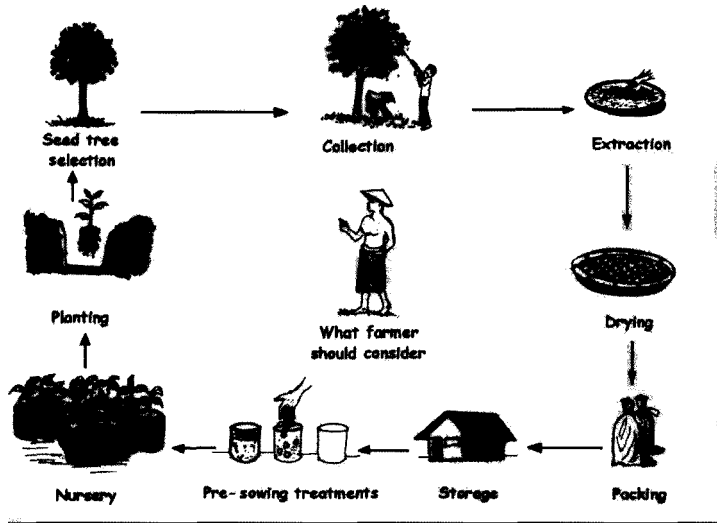


Figure 1. Continuum of activities that influence seed quality and should be considered when planning seed collection and tree planting activities (Adapted from IFSP, 2000).

5. How To Collect Quality Tree Seed?

Collecting quality seed is not an easy task, particularly for farmers and NGOs who are busy with many types of activities and are not seed technology specialists. This manual is intended to serve as a seed collection guide for the non-specialist at the farmer- and NGO-level. Subsequent chapters of this manual address the following key questions that should be considered when collecting tree seed.

- **Where should seed be collected?**
- **How should seed sources be established and managed?**
- **How should seed be collected?**
- **How should seed be processed and stored?**
- **How to accelerate seed germination?**
- **How to measure seed quality?**
- **How to document tree seed?**

II. WHERE SHOULD SEED BE COLLECTED?

1. Seed Sources

Individual trees or stands from which seed is collected are called **seed sources**. At the farmer- and NGO-level, seed sources can be classified into four types according to the intensity by which they are managed and the quality of seed produced. These four types are:

- seed orchards,
- seed production areas,
- seed stands, and
- seed trees.

Seed orchards. Seed orchards (SOs) are stands established for the specific purpose of seed production. They usually consist of families of superior genetic quality and are planted at a regular spacing and specific design. Seed orchards should be established from a minimum of 30 families from seed (a seedling seed orchard) or vegetative material (a clonal seed orchard). The more families included the broader the genetic base of the germplasm produced. A seed orchard may produce seed or vegetative material. As the trees grow larger, selective thinning is conducted to maintain suitable spacing for optimal seed production and to remove poorer quality trees. This is best done through 2-4 successive thinnings, each following an assessment of the orchard and ranking of the trees to identify inferior trees for removal. In order to maintain the genetic superiority of the seed produced, seed orchards should be isolated from possible contamination by pollen of unimproved stands of the same species. Isolation is discussed in more detail below.

Seed production areas. Seed production areas (SPAs) are stands of trees in either natural forests or plantations that are improved for the specific purpose of seed production. Improvement consists of selective thinning to achieve optimal spacing for seed production and to remove poor quality trees, including those that have been attacked by pests and diseases. Thinning should be conducted so that the superior trees retained are approximately evenly spaced. Recommended spacing between seed trees will depend on species size and shape at reproductive age. The objective is for the crowns of seed trees to receive full exposure to sunlight. Like seed orchards, seed production areas should be isolated from contamination by pollen of unimproved stands of the same species. An appropriate isolation distance depends on the tree species and its pollination method. As a general rule, seed orchards and seed production areas should be isolated by a distance of at least 200-m.

Seed stands. Seed stands are groups of trees, in either natural forests or plantations, identified as having superior characteristics - such as straight stem form or rapid growth. Seed stands are managed for seed production, but only seldom benefit from selective thinning or other management intended to improve the quality of seed produced from the stand.

Seed trees. Seed trees are individual trees from which seed is collected. They should have superior characteristics - such as straight stem form or rapid growth. They may be in either natural forests or plantations.

Comparisons of the characteristics and seed quality of the four types of seed sources are provided in Table 1 and Figure 2. Seed orchards and seed production areas represent intensively managed areas where selection has been conducted to improve the genetic quality of the entire population. In contrast, the management of seed stands and seed trees focuses on increasing the seed production of individual trees. Seed orchards produce the best quality seed, followed by seed production areas, seed stands and then individual seed trees.

Table 1. Characteristics of various seed sources.

Characters	Seed sources				
	Seed orchards	Seed production areas	Seed stands	Seed trees	Unselected seed sources
Planting purpose	Seed production	Not for seed production	Not for seed production	Not for seed production	Not for seed production
Seed origin	Identified	Identified or Unidentified	Unidentified	Unidentified	Unidentified
Quality of mother trees	Selected and tested trees	Selected stands, thinned, untested	Selected stands, unthinned (or thinned), untested	Selected trees from unselected stands	Unselected trees from unselected stands
Seed quality	Very good	Good	Fairly good	Intermediate	Poor
Level of Management	Very Intensive	intensive	Intermediate	Some	None

Note: -This table is an illustrative comparison of various seed source types only.
 -Unselected seed sources are often of inferior quality as a result of poor management.

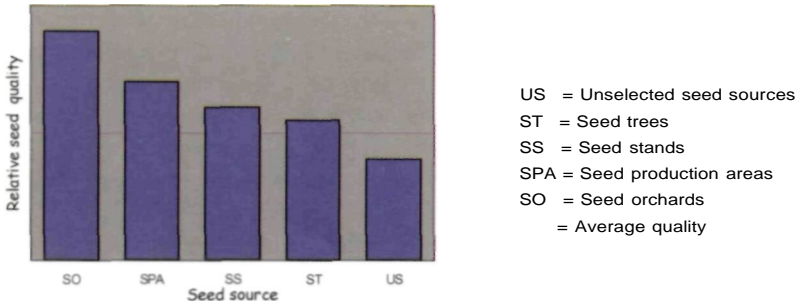


Figure 2. Comparison of seed quality of various sources.

2. Seed Trees - the most common seed source for farmers and NGOs

It takes time to identify, establish and improve seed sources. Seed orchards and seed production areas do exist for some species - such as *Tectona grandis* (teak), some *Acacia* species, some *Eucalyptus* species and *Gliricidia sepium* (gliricidia). The seed produced from these sources is of limited quantity and often owned by or reserved for government agencies, researchers or forest industry. Most other tree species are in early stages of improvement, families of superior quality have not yet been identified. Thus the development of seed orchards or seed production areas is not yet feasible. For most species the best seed sources available are seed trees, or possibly seed stands.

At the farmer- and NGO-level, seed trees are likely to be the main seed source available. It is also likely that the location of seed trees is in degraded forests, small-scale plantings on public lands or farms. The quality of the seed collected from these areas is questionable. In degraded forests the best quality trees have already been harvested. The origins of the seed used to establish trees on public lands and farms is usually unknown and often from a narrow genetic base. Furthermore most farms contain a small number of trees of any one species, often less than 10 trees. As a result of these conditions, the genetic quality of tree seed produced from degraded forests, small-scale plantings on public lands and farms is actually low. Since these are the primary areas available to farmers and NGOs, simple guidelines are required for selecting seed trees.

2.1. Seed tree selection

Proper seed tree selection will help maintain and improve the quality of the seed collected. Key guidelines are described below.

- Seed trees should be selected from the best stand available on a homogenous (uniform) site (Figure 3). As mentioned above, tree performance (phenotype) is determined by the genotype (genetic characters), the environment and their interaction. In brief, trees will grow well if: they have good genetic characters, grow in favorable environments, or have both good genetic characters and a favorable environment. However, the progenies of these trees will inherit only the genetic characters from their parents. The influence of the environment will not be transferred to the progenies. Thus it is important that seed trees be selected for good genetic characters, not for the favorable environmental conditions in which they are found. Thus, seed trees should be selected in a homogeneous environment (Figure 3a) where the environmental influence is fairly uniform and trees with superior genetic characters will perform better (demonstrate superior phenotype) and be easy to identify.

In a heterogeneous environment (Figure 3b), it is difficult to select genetically superior trees because of strong environmental effects (A = strong winds, B = shading, and C = flooding).

- Seed trees should be selected by comparing the trees with their neighbors. For instance, seed trees for timber species should be straight, tall and not effected by disease or insects. Small crooked trees with many branches should not be selected (Figure 4).
- Do not select isolated trees, those that are separated from other trees of the same species by a distance of 100 m or more. Isolated trees produce seed by inbreeding (selfing or self-pollination) which often results in growth depressions and susceptibility to pests and diseases in progeny.

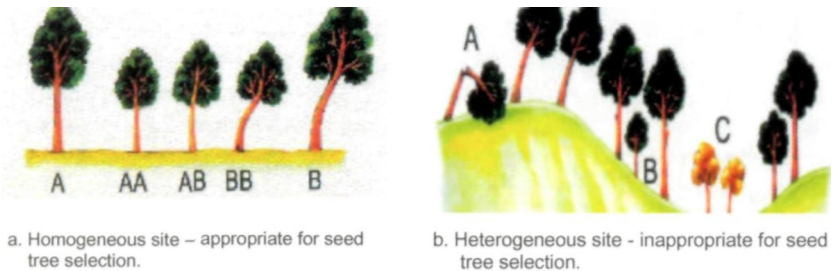


Figure 3. Sites for seed tree selection (IFSP, 2000).



Figure 4. Selection of superior phenotypic seed tree (Illustrated by Wiyono).

2.2. Criteria for seed trees selection

Seed tree selection criteria differ for various tree types.

- Timber tree criteria
 - > Above average tree height and stem diameter
 - > Straight stem form
 - > Long, clear merchantable bole
 - > Uniform crown, without heavy branches or double-stem
 - > Free of pests and diseases
 - > Good quality timber
 - > Mature tree that produces ample quantities of seed
- Fodder trees and living fences
 - > Rapid growth
 - > High leaf production
 - > High nutritive values of leaf
 - > Good coppicing ability
 - > Tree stature and shape that fits the intended planting system and site
 - > Free of pests and diseases
 - > Drought resistance
 - > Mature tree that produces ample quantities of seed
- Fruit trees¹
 - > Good growth
 - > Abundant, sweet, and big fruits
 - > Uniform crown with low branches
 - > Free of pests and diseases
 - > Mature tree that produces ample quantities of seed

2.3. Number of seed trees to select

Most tree species are preferentially outcrossing - female flowers of one tree are fertilized by pollen from the male flowers of a different tree. However, most tree species have a mixed mating system - they can produce seed by outcrossing or self pollination. In order to maintain genetic diversity, seed should be collected from a large number of trees - at least 30 **trees**. Outcrossing among a large number of trees maintains a broad genetic base, which will maintain adaptability to a wider range of environmental conditions. A broad genetic base reduces the possibility of inbreeding, which often causes growth depression and susceptibility to pests and diseases in the progeny. As mentioned previously, a common problem is that often **only small numbers of seed trees are available on farm or public lands, as few as 10 trees in some cases**. Seed should be collected only from the best of these trees.

To assure the desired characteristics, fruit trees are often propagated by vegetative methods. The criteria specified here are for the selection of scion (bud, graft, etc). For detailed information on vegetative propagation of fruit trees see, Yaacob and

When the number of trees available is limited, a farmer group approach to seed collection can help maintain genetic diversity. Using the criteria discussed above, individual farmers collect seed from the good quality seed trees accessible to them. The seed collected by individual farmer are placed in a common pile, thoroughly mixed together and then re-distributed. Each farmer receives the same quantity of seed they contributed to the common pile. This process will greatly increase the genetic diversity of the seed collected by the group. While an individual farmer in the group might be able to collect seed from only 5 to 10 trees, a group of 6 farmers can collect seed from 30 to 60 trees.

2.4. Distance between seed trees

Spacing between trees is an important consideration when selecting seed trees. Seed trees should be spaced at a distance greater than that associated with seed dispersal. Seed dispersal distances vary by tree species and environmental conditions of the site. In general, the distance between selected seed trees should be at least 50 m. Trees spaced closer than 50 m have a higher possibility of being closely related, i.e. share common parents or earlier ancestors. The genetic variation will be reduced when seed is collected from closely spaced trees. There is a risk of inbreeding in the next generation and consequentially the negative effects discussed above.

2.5. Importance of the stand in which seed trees are selected

It should be realized that the phenotypic characteristics of the seed tree represent only the maternal (mother tree) contribution to the seed collected. The phenotypic characteristics of the father tree can not be directly evaluated, because the father tree is unknown. However, a reasonable estimate of father tree characteristics can be determined by evaluating the trees (of the same species) that surround the seed tree (mother tree), because those trees are the likely source of pollen that pollinated the flowers of the seed tree.

To increase the possibility of collecting good quality seed, seed trees should be selected in stands that consists of good quality trees. When many good quality trees surround a seed tree, its progeny will demonstrate good characteristics (Figure 5). Even when a few poor quality trees are near a seed tree but most trees are of good to fair quality, most progeny will demonstrate good to intermediate characteristics (Figure 6). When possible, the poorer quality trees in the stand should be thinned from the stand. If a seed tree is selected in stands where most trees are of poor quality, the seed collected will very likely produce poor quality trees (Figure 7).

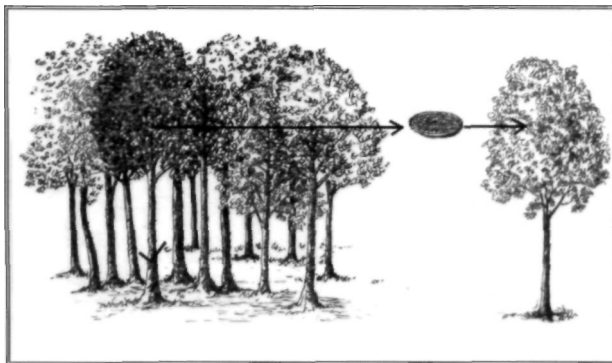


Figure 5. When the seed (mother) tree is surrounded by other good quality trees, the progeny will demonstrate good quality (Wiyono, 2002).

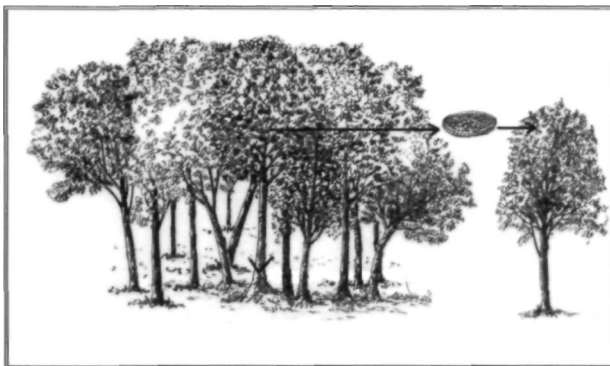


Figure 6. When the seed (mother) tree is surrounded by good to fair quality trees, most of the progeny will demonstrate good to fair quality (Wiyono, 2002).

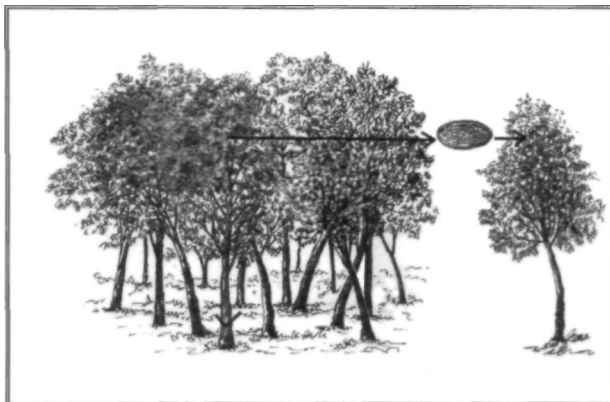


Figure 7. When the seed (mother) tree is surrounded by many poor quality trees, the progeny will demonstrate poor quality (Wiyono, 2002).

III. HOW SHOULD SEED SOURCES BE ESTABLISHED AND MANAGED?

1. Establishment of Seed Trees on Farm

Most farmers generally own, or have access to, only small areas of land and do not have the time or financial resources required to invest in intensive seed source management. In most cases, it is not feasible for the farmers to establish seed orchards or seed production areas. The best option for most farmers is to integrate seed trees into their existing farming systems, which often include pre-existing trees of many species. As mentioned previously, the main problem related to on-farm seed production is the limited number of trees available on individual farms. Collecting seed from a limited number of trees, results in a narrow genetic base and the negative effects discussed previously. To maximize the genetic base and productivity of on-farm tree sources, the following approach for establishing on-farm seed trees is recommended.

1.1. Site selection and tree planting

- First of all, environmental conditions of the site - rainfall, temperature, elevation, and soils - must be appropriate for the target species.
- To improve tree survival and growth thorough land preparation should precede seed tree establishment. Details regarding proper land preparation are provided later in this chapter under **Seed orchard establishment**.
- Wider spacing between seed trees and other trees enhances seed production by exposing more of the seed tree's crown to sunlight and pollination. Appropriate spacing will differ by species and site. A general recommendation is that seed trees be planted at 2x4 or 3x3 meters. After these trees become large thinnings should be conducted to achieve wider spacing and remove the poorer quality trees. Additionally, seed trees should not be planted closer than 4 meters to pre-existing trees, unless the pre-existing trees can be removed once they begin to impede the growth of the seed trees.
- If improved germplasm is used to establish seed trees, the seed trees should be isolated from stands of unimproved trees of the same species to avoid pollen contamination and maintain the genetic superiority of the seed produced. Because landholdings are small and farmers can not control the land management practices of their neighbors, maintaining effective isolation distances is often impossible. Therefore, farmers should realize that

the seed collected from on-farm trees results from both 'improved quality mother trees pollinated by improved quality father trees' and 'improved quality mother trees pollinated by average to below average quality father trees'. To improve the pollen source from their own land, farmers should remove poor quality trees.

1.2. Managing genetic diversity on farm

- Seed tree establishment should be planned and managed by groups of farmers who occupy adjacent lands. The greater the number of farmers involved the better.
- Each farmer in the group should plant as many trees as possible on their land. More trees mean more genetic diversity, and thus more variation in the seed produced and progeny. A greater number of trees of the target species is likely to make the area more attractive to appropriate pollinators². The more pollinators that visit the area the greater the occurrence of cross-pollination. If each of 6 to 10 farmers in the group plants 10 seed trees, a total of 60 to 100 seed trees would be available on the combined area of the farmer group. This is a good number of seed trees and will help maintain genetic diversity through cross-pollination between the seed trees.
- Seed collection should also be planned and managed through the farmer group as described under **Number of seed trees to select** in the previous chapter. This method will maintain a broader genetic base compared to seed collection and management by individual farmers. Farmer groups should collect seed from as many trees as possible - a minimum of 30 seed trees.

1.3. Seed trees management

- Active management of trees will improve on-farm seed production. Management options include: planting seed trees; weed control near seed trees; fertilizing seed trees; removing poor quality trees and trees that inhibit seed trees; pruning dead and non-productive branches from seed trees; maintaining a clean understory to facilitate seed collection (and reduce fire hazard); and implementing pest and disease protection measures. At the farm- and community-level these operations can be implemented in a cost-effective manner. However, labor is often a limiting factor for farmers. The potential positive impact of these management operations must be compared to the opportunity costs of individual farmers. The suitability of these operations will vary for each farm and situation. (Details concerning some management options are provided under **Seed orchard management** at the end of this chapter).

Attracting pollinators is important for tree species pollinated by insects, birds and bats; but not important for wind-pollinated tree species.

- Seed tree planting on farms should be developed for multiple products and services, not solely for seed production. Seed trees can serve as living fences, border trees, hedgerows, and shade trees or to enhance soil and water conservation. Under multiple-purpose management seed trees and other trees may produce fodder, fuelwood, timber, fruit, seed and other products. Multi-purpose management will increase the overall productivity of the stand, but decrease the productivity of each individual product. In other words, less seed but more products (and total value) for the farmer.

2. Establishment of Small-Scale Seed Orchard

Although farm-level seed production is primarily based on seed tree management, in some cases it may be possible for farmers to establish seed orchards. As mentioned earlier, seed orchards are seed sources established for the specific purpose of seed production. They are usually established from families of improved genetic quality of either seedling or clonal origin. Seed orchards are planted at a regular spacing with a specific design. Seed orchards are not intended to produce multiple products or services. Their main objective is to maximize the production of quality seed to meet long-term needs. Because of this strong emphasis on seed production, seed orchards are usually managed intensively. Isolation distances of 200 m from unimproved stands or trees of the same species are recommended and selective thinning is conducted purposely to increase spacing as trees become larger and to remove poorer quality trees. Fertilization, pruning and intensive pest and disease monitoring are also recommended.

In most cases it is difficult for individual farmers to establish seed orchards. But farmer groups or NGOs may establish seed orchards by utilizing the lands of adjacent individual farmers or communal land. Because of the intensive design and management associated with seed orchards, it is recommended that farmer groups and NGOs seek assistance from technical experts when establishing seed orchards. The remainder of this chapter provides information on seed orchard establishment and management.

f 2.1. Site selection for seed orchard

Site selection is important and the first step in seed orchard establishment. Seed orchards are long-term investments. Appropriate sites should meet all of the following criteria:

- . Environmental conditions - rainfall, temperatures, elevation, and soils - must be appropriate for the target species.
- Not vulnerable to natural disasters - floods, volcano, earthquake, landslide and frequent wildfires.

- Secure from wild and domestic animals.
- Isolated to avoid pollen contamination. The recommended isolation distance is 200m.
- Easy to access.
- Land tenure or land use rights are secure.

2.2. Germplasm selection for seed orchard

The seed used for seed orchard establishment should be collected from identified and improved seed sources. It may be seed from a large number of plus trees (30 or more) where the identity of the individual trees is recorded, or where the identity is not recorded (bulk seed). Seed from identified individual plus trees is good because the planting design can be developed to minimize inbreeding. However, if bulk seed is used seed orchard establishment and management is much simpler.

If the seed orchard design is intended to maintain the identity of individual mother trees, seed from each mother trees must be germinated separately in well-marked containers. The resulting seedlings must also be well marked in the nursery, during transportation and planting at the site. Before planting a detailed seed orchard map must be made that includes the identity of each tree. It is important that this map be followed during planting. If bulk seed is used to establish the seed orchard, seed can be germinated in any available and appropriate containers. The identification of individual seedlings is not necessary. The seed orchard map can be simple, showing the location of each tree, without specifying its identity.

2.3. Seed orchard size

As mentioned earlier, as the area of the seed orchard increases it should be more attractive to pollinators. Even though individual farmers have limited areas of land, a farmer group approach can be used to establish a large-scale seed orchard at the community-level. With this approach individual farmer would establish small-scale seed orchard units of 0.1 - 0.25 ha on their own land (Figure 8). At the community-level, these small units scattered across different adjacent farms will form a large-scale seed orchard. One hectare is the minimum 'target size' of a community-level seed orchard. This would require 4 to 10 farmers to establish small-scale seed orchard units of the size mentioned above. The more farmers involved the larger and better the community-level seed orchard. An appropriate role for NGOs in this process is to develop linkages with technical specialists and document/monitor each small-scale seed orchard unit. Each small-scale unit should contain at least 30 families/trees. The more families included the broader the genetic base of the seed produced from the community-level seed orchard.



Figure 8. Small-scale seed orchard on farm or community land (Wiyono, 2002).

2.4. Seed orchard establishment

As with any tree planting activity, thorough land preparation should precede seed orchard establishment. All competing vegetation should be cut to the soil surface and removed. At each position where a seedling will be planted, all vegetation within a 50-100 cm circle should be removed, this includes the removal of the below ground roots. If the seed orchard is to be established as a hedgerow, the vegetation should be moved from a meter-wide strip. To enhance seedling growth and survival the soil at each planting position should be finely tilled to a depth of 25-50 cm. To minimize the re-growth of weeds, site preparation should be conducted just prior to the rainy seasons. Seedlings should be planted immediately after the arrival of the rains.

Tree spacing will depend on tree species, site conditions, and orchard design. If the orchard is established as a hedgerow, in-row space may be 10-50 cm with spacing between hedgerows 4-10 meters. A hedgerow design is common for fast growing leguminous species, such as *Calliandra calothyrsus* (red calliandra), *Flemingia macrophylla* (flamingia), *Gliciridia sepium* (gliciridia) and *Leucaena* species (ipil ipil). Most other species will be established in a block design. Initial spacing may be 2x4 m, 3x3 m, or even wider. Narrow spacing such as 2x4 or 3x3 allows for intensive thinning, see details below under **Orchard spacing**.

2.5. Seed orchard design

If the genetic identity of each tree is to be maintained, a detailed orchard design should be developed prior to establishment. The seed orchards should be arranged so that no individuals of the same family are planted close to each other. This precaution will minimize inbreeding. Farmers and NGOs should develop the orchard designs with assistance from a tree geneticist or tree improvement specialist who is familiar with seed orchard establishment.

If the genetic identity of individual trees is not to be maintained, seed orchard establishment is easier, because there is no need to worry about the arrangement of individual trees or families. Trees can be planted in any arrangement. However, farmers and NGOs may still wish to seek assistance from a tree improvement specialist.

2.6. Seed orchard management

Fertilizer application. The application of fertilizers in seed orchards has two objectives to: i) increase early tree growth and establishment; and ii) increase flower and seed production. To meet the first objective fertilizers should be applied during or immediately after orchard establishment. Fertilizers can be applied again in the second year immediately after the beginning of the rainy season. To increase flower and seed production the application of a phosphorous fertilizer is recommended just prior to the flowering season, which for most species corresponds with the rainy season. Depending on soil conditions, it may also be appropriate to apply boron or other trace elements to enhance flower and seed production. Fertilizer application rates should be based on soil analysis or farmer experience. An agronomist, silviculture specialist or tree improvement specialist can assist with fertilizer recommendations. Chemical fertilizers may be expensive and of unreliable quality in some rural areas. In many situations it may be easier for farmers and NGOs to use organic fertilizers. However, organic fertilizers that are high in nitrogen may encourage vegetative growth over reproductive growth. When possible, the use of organic fertilizers should be discussed with an agronomist. Additionally, testing and observation should be conducted to evaluate the impact of organic fertilizers.

Replacement planting. Seedlings or trees that die should be replaced as soon as possible. Delays in replanting may result in the new seedlings being undersized and suppressed by the older trees in the orchard.

Weed control. Weed control is an essential operation that will enhance seedling growth and survival in new orchards; and tree growth and seed production in mature orchards. A good general weeding regime for new orchards is to remove all vegetation within 50 cm of the trees whenever the competing vegetation begins to impede tree growth. Depending on site conditions weeding may be necessary every 2 weeks to 3 months. As trees gain size the frequency of weeding operations will decrease. Weed control should be maintained until trees achieve a dominant position and begin to suppress weeds. In mature orchards, the annual or biennial removal of understory weeds will improve tree growth and seed production. Understory weeding will also improve access and facilitate seed collection. Weed control includes the removal of overhead branches or even mature trees that are impeding the growth of seed orchard trees. This will be more important as orchard trees

increase in size. Weed control can be achieved by manual or chemical means. For farmers and NGOs, manual means are often the most practical as herbicides are expensive and not always available in rural areas.

Pest and disease control. Because seed orchards contain many trees of the same species they are more susceptible to pest and disease problems than individual trees scattered across a farm or community. Orchards should be closely monitored for evidence of pest and disease problems. If problems occur assistance should be sought from agriculture and forestry plant protection specialists.

Orchard spacing (the importance of thinning and pruning). Wider tree spacing enhances seed production by exposing more of the tree crown to direct sunlight and pollination. If tree crowns are allowed to grow together sunlight exposure, flowering, pollination, and seed production will all decrease. As mentioned above, most seed orchards should be established at 2x4 or 3x3 meters. As the trees grow, wider spacing is required. Wider tree spacing is achieved through 2-4 successive thinnings, each following an assessment of the orchard and ranking of the trees to identify inferior trees for removal. Poor quality trees may include those that are slow growing, attacked by pests or disease and produce low quantities of seed. Each thinning should remove no more than 30 to 40% of the trees. The subsequent thinning should occur when the crowns close and seed production declines. The recommended final density for a mature seed orchard of medium- to large-sized trees is 100 to 150 trees/ha (a tree spacing of approximately 8x8 to 10x10 meters). Caution: Thinning should be conducted so as not to reduce the number of families below 30 per seed orchard. Pruning should be conducted periodically to remove lower branches that have grown large or no longer produce flowers. The pruning of some branches from the upper crown may be warranted to maintain full sunlight exposure to the branches that are retained.

Spacing management is different for hedgerow orchards. Hedgerows should be pruned to a 1-meter height once or more per year. Every two meters one tree should be retained unpruned to serve as a seed tree. After the canopies of the hedgerow seed trees begin to close, probably after 2-4 years, in-row spacing of seed trees should be increased to 4 m. In hedgerow orchards, spacing between seed trees greater than 4 meters is probably not necessary. Once seed trees in the hedgerow become too large they can be cut down. Coppice growth from the seed tree, or other trees in the hedgerow, is then allowed to grow up and fill the place of the removed seed trees. To maintain high annual seed production, it is recommended that each year only a few large seed trees be removed. This will result in the hedgerow seed orchard containing seed trees of various sizes, with a relatively consistent annual seed production. The leaf and woody biomass harvested from hedgerows during pruning operations should be used as fodder, green manure or fuelwood.

Intercropping. Although seed orchards are intended for the sole purpose of seed production, it is possible to practice intercropping. Seed orchards can be intercropped with food crops - such as corn, upland rice, cassava, or vegetables - for 1 to 3 years after establishment. Intensive weed control and fertilizer application will benefit both the food crops and the orchard trees. Once the orchard trees become large shade-tolerant crops - such as ginger, turmeric or dwarf cardamom - may be cultivated in the understory. Covercrops may also be used to control weed growth and improve soil fertility. However, covercrops are often management intensive. Also, since covercrops do not provide a direct product, farmers and NGOs may prefer other crops.

A moderate amount of intercropping will not hinder seed orchard health and may enhance tree growth. However, intensive intercropping may damage trees and decrease seed production. All management practices should be implemented to favor the main objective of the orchard - *seed production!*

IV. HOW SHOULD TREE SEED BE COLLECTED?

Seed collection activities³ are as important as seed source management. All efforts to identify and manage quality seed sources will be wasted if seed is not collected properly. This chapter focuses on how to plan and conduct seed collection activities.

1. Planning Seed Collection Activities

- The **purpose** of collecting seed should be well defined. How much seed is needed? What type of planting will be established with the seed? How long will the seed be stored before use? Will the seed be used for internal needs or will it be sold or exchanged? This information will affect the intensity of tree seed collection activities and the amount of seed to be collected.
- **Where** should the tree seed be collected? Identify the best available seed source for the species in question. Local forestry officials and farmers may be very knowledgeable concerning the locations of various seed sources. (An alternative to collecting seed directly is to purchase seed from a dealer or government office of proven reliability. What to consider when purchasing seed is discussed in Chapter VII and VIII).
- **When** should seed be collected? A few tree species produce seed all year. Most species produces seed only during a certain period of the year. Some species produce seed only on cycles of multiple years. For many species information on flowering periods, seeding periods and the characteristics of mature fruits is available from books, forestry professionals and farmers (see Table 2 in the Appendix). This information should be validated through field visits to proposed seed sources when planning collection activities. *Warning! Upon maturity the fruit of many species burst open to disburse their seed. After dispersal, seed collection of some species is difficult or impossible. This is particularly true of species with tiny seeds like Eucalyptus. To avoid this problem, know the seed production characteristics of the species you want to collect and plan/conduct seed collection in a timely fashion. It should be noted that the seed of some species are commonly collected after dispersal. These situations are discussed below.*
- Prepare the required **seed collection tools** and **supplies** before leaving for the field. These items might include: pole pruners, hooks or saws; hand pruners or saws; ladders; ropes; seed baskets, sacks, bags or other containers; mats, tarps

³

For most tree species, seed collection is achieved by collecting the fruit in which the seed is contained. In this chapter the terms 'seed' and 'fruit' may be used interchangeably.

or plastic sheets; field books, notebooks, labels for seed containers and writing utensils. Tools and supplies should be stored in a specific place so they are easy to access and organize.

- Seek **permission** to collect seed from the landowner or land manager of the seed source. This is particularly important when collecting seed from private land, industrial forests, and government plantations or seed sources

2. Things To Remember During Seed Collection

- Collect only **mature seed!** This will maximize seed viability, seed storability and good quality seedlings.
- If **bulk seed** is collected, **mix** the seed from all trees **thoroughly** so that all containers or samples are representative of the bulk population.
- Once collected the seed should be properly **documented**. A seed collection form should be designed prior to seed collection. This and other seed documentation forms are discussed in Chapter VIII.

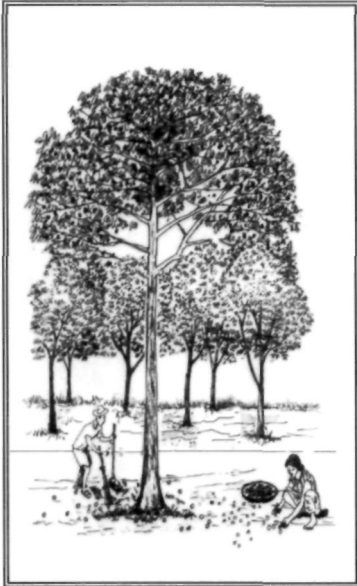
3. Seed Collection

3.1. Collecting seed from the forest floor (Figure 9)

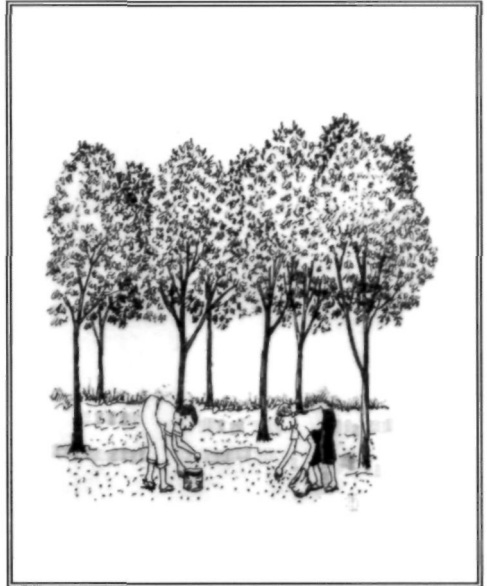
Collecting seed from the forest floor is easy, inexpensive and the only practical method to collect seed of some species. Seed of *Tectona grandis* (teak), *Gmelina arborea* (gmelina) and *Aleurites moluccana* (candlenut) are commonly collected by this method. The following points should be considered when collecting seed from the forest floor.

- Seed collected from the forest floor has been exposed to soil moisture and soil microorganisms. If the seed has been on the forest floor too long it may have imbibed moisture and possibly lost viability. To avoid this problem, be sure to collect seed frequently (1-2 times a week) during the peak seed maturation season. Additionally, the forest floor should be cleaned prior to the seed collection season and when feasible tarps placed under seed trees. *Note: Fire can be used to clean the forest floor by burning away debris and grass, this is common with Tectona grandis (teak). However, Fire can also damage the stand, its use must be closely monitored!*
- Since seed collected from the forest floor might be infected with soil pests or diseases, it should be stored in a separate container. It should not be mixed with seed collected directly from trees.
- The first fruits produced are often the first to fall. These early fruits are often not fully mature and may contain poor quality seed. Later in the season immature fruits frequently fall together with mature fruits. Care should be taken to collect only mature fruit or seed from the forest floor.

- Often, mature fruit can be dislodged and collected by shaking the tree. To facilitate collection a tarp should be placed below the tree before shaking.
- Mature fruit may also be collected from trees that are harvested for other purposes. However, *trees should not be cut down just to collect fruit! Such actions are inappropriate and decrease the productivity and quality of the seed source.*



a. Adapted from IFSP, 2000.



b. Adapted from Chamberlain, 2000.

Figure 9. Seed collection from the forest floor.

3.2. Seed collection directly from trees (without climbing)

Seed collection directly from trees without climbing is appropriate for small to medium sized trees. Seed of *Calliandra calothyrsus* (red calliandra), *Gliricidia sepium* (gliricidia) and *Leucaena* species (ipil ipil) are commonly harvested by this method. Mature fruit is harvested by hand directly from the ground (Figure 10) or with the aid of pole pruners or saws (Figure 11). Additionally, fruit bearing branches that are unreachable can be pulled towards the collector by using pole hooks or ropes. These lower branches might also be reached by using a stool, chair or foot-ladder. Spreading mats or plastic sheets below the trees will facilitate the gathering of seed that drops to the ground.

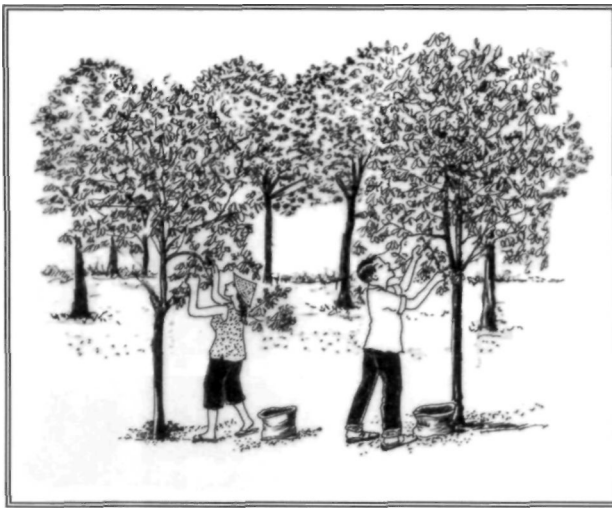


Figure 10. Seed collection directly from trees (Adapted from Chamberlain, 2000).

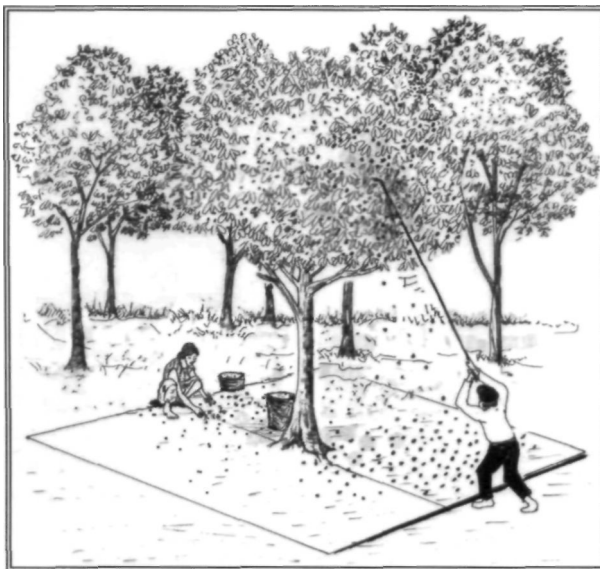


Figure 11. Seed collection from tree using pole tools (Adapted from IFSP, 2000).

3.3. Seed collection by climbing tree

Seed collection by climbing is appropriate for medium to large trees where the mature fruit can not be reached from the ground. This method is common with many species. Trees may be climbed by using ladders or without the use of equipment. Guidelines for these situations are discussed below. For safety, collectors should work in teams of two when climbing trees and receive some climbing training when possible.

Climbing trees by using ladders (Figure 12a) is a simple, safe, and quick seed collection method. This method is necessary when the lowest branch of a tree is high above the ground. Strong and light ladders made from wood and bamboo are widely available or easy to make. Aluminum ladders may be used if available. The disadvantage of using ladders is the necessity to transport them to the seed source and carry them between trees. This is particularly strenuous in steep areas. Ladders should be firmly in place and secured to the tree with straps or ropes before the collector climbs. Once the collector has reached an appropriate position the collection process is the same as described below.



a. Climbing a tree using a ladder (Wiyono, 2002).

Climbing trees without using equipment or tools (Figure 12b) is a common seed collection method throughout the world. Rural people usually have good tree climbing skills. After climbing to an appropriate position, the collector should select a strong branch on which to sit or stand. The collector then collects mature seed from nearby branches. The collector can access additional branches by using pole hooks, tying the branches to a main stem or branch and then collecting seed. After all mature seed is collected the branch is released and another branch hooked and tied. This process is repeated until all accessible mature seed is collected. The collector then moves to another position in the tree crown.



b. Climbing a tree without using tools or equipment (Wiyono, 2002).

Figure 12. Seed collection by climbing trees.

Some branches can be cut to ease climbing or seed collection But it is important to remember that if too many branches are cut future seed production will be reduced.

- Both climbing methods enable collectors to harvest mature seed (or fruit) conveniently. Harvested seed is placed in a bag carried by the collector. The bag should be strong, but light and flexible. Once full the bag can be passed down using a rope or dropped directly to the ground. Conversely, harvested seeds can be dropped directly to mats or plastic sheets spread below the tree. The use of mats or plastic sheets keep the seed clean and facilitate gathering.
- Many government agencies, forestry industries and commercial seed dealers use special tree climbing equipment to collect seed. Though expensive, this equipment greatly facilitates seed collection activities. A proper and thorough description of this equipment is beyond the scope of this manual. Interested readers should see Stubsgaard 1997.

3.4 General comments concerning seed collection

- Seed collected directly from trees is of high quality because: i) collectors have the ability to select mature and healthy seed, and ii) the seed has not been exposed to soil moisture or soil microorganisms. Additionally, by selecting seed from many parts of the crown, which may be pollinated by different father trees, the collector can encourage a broad genetic base of the seed collected.
- During field activities, seed that has been collected should be placed in a temporary storage area for initial processing. Seed processing is discussed in Chapter V.
- Sacks or any container (bamboo buckets, etc) used to store seed in the field should be labeled with accurate information concerning the seed's identity (Figure 13). This is important especially when collecting seed on an individual tree or family basis. Documentation is discussed in Chapter VIII.
- If seed extraction and processing can not be conducted immediately, place sacks or containers of seed in a dry and cool room with good air circulation. Place the sacks or containers on a shelf or rack to facilitate air movement (Figure 14). Sacks may also be hung from the ceiling. Do not place the sacks directly on the floor, otherwise the sacks and seed will absorb moisture and be more easily contaminated by insects and rodents. Seed placed directly on the floor deteriorates more quickly.

Note: Plastic bags lack air circulation and should not be used for temporary storage for more than 2 days.

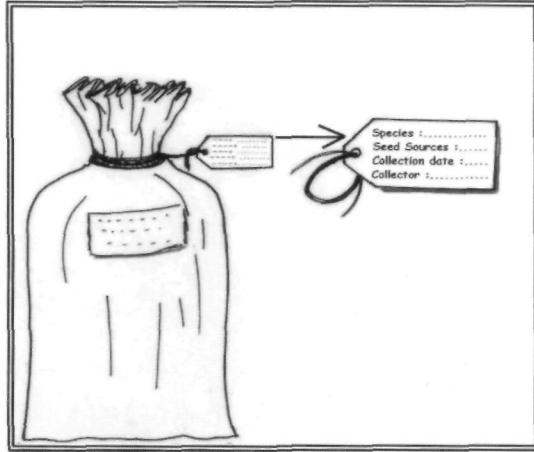


Figure 13. A sack of seed properly labeled (IFSP, 2000).

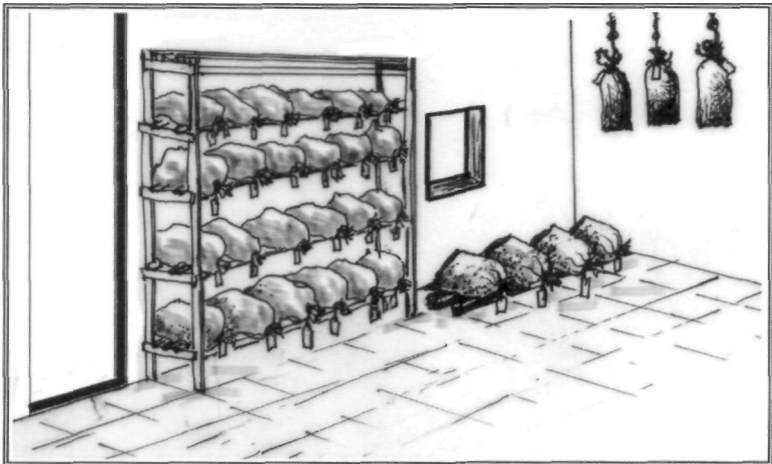


Figure 14. Temporary seed storage (Wiyono, 2002).

V. HOW SHOULD SEED BE PROCESSED?

The previous chapters have described how quality seed sources are selected and quality seed collected. In order to maintain seed quality, seed collection must be followed by proper seed processing and handling, which includes the following activities: sorting, extraction, cleaning, grading, drying, storage and transportation. Proper implementation of seed processing and handling activities is described in this chapter.

1. Sorting Fruits

Not all fruits collected in the field are mature or of good quality. Fruit should be sorted according to the following process. Mature fruits should be processed for seed extraction. Fruits that are undeveloped or infected with insects and disease should be discarded. Those fruits that are not fully mature should be separated (Figure 15) and allowed to after-ripen. They should be placed in a shaded place with good air circulation and examined every 2-3 days. Ripening may require 2 or more weeks. After-ripening is important, because extraction of seed from immature fruits can damage the seed.



Figure 15. Farmers sorting *Gliricidia sepium* pods (Photo, Mulawarman).

2. Seed Extraction

Extraction is the process of removing seed from fruits. Appropriate extraction methods vary by species and fruit type (Figure 16). The most common methods are discussed below. Additionally, seed extraction methods for some priority species are described in Table 2 of the Appendix.

- The dried fruit of some species open readily to release their seed. To facilitate seed gathering for processing, the fruit of these species should be dried on big plastic sheets or tarps under direct sunlight. Normally, 2-3 days of drying is enough. Rubbing and crushing the fruits will expedite seed extraction. Seed of *Leucaena* species (ipil ipil) and *Calliandra calothyrsus* (red calliandra) are extracted by this method.
- The dried fruit of other species open slowly over an extended period of time. To hasten seed extraction fruits of this type should be placed in sacks and lightly beaten with a stick (Figure 16a) or firmly crushed. Seed of *Glicicidia sepium* (glicicidia) and *Acacia mangium* (mangium) are extracted by this method.
- The fruit of some species need to be scraped with an abrasive material such as sand or ash to remove the fleshy outer layer (Figure 16b). Seed of *Santalum* species (sandalwood) are extracted by this method.
- Some fruits need to be scrubbed and washed with water to separate fleshy material from the seed (Figure 16c). Before washing, the fruit can be soaked in water overnight and, if necessary, crushed or lightly beaten to soften the flesh. It is important to scrub and wash away all the fleshy material and juice, otherwise insects and fungi may infest the seed. Seed of *Gmelina arborea* (gmelina), *Azadirachta indica* (neem) and *Tamarindus indica* (tamarind) are extracted by this method.
- The fruits of some species are simply broken open and the seeds removed (Figure 16d and 16e). Seed of *Swietenia macrophylla* (mahogany) are extracted by this method.
- The seed of some species do not require extraction. Rather the fruit are firmly rubbed together to remove the outer skin and other debris. While not truly extraction, this process serves the same purpose, preparing fruit for cleaning and grading. Fruit of *Tectona grandis* (teak) and *Calamus* species (rattans) are processed by this method.
- All extraction methods should be conducted carefully to avoid damaging seed. Some common tools used during extraction include sacks, tarps, trays, buckets, tanks and sandpaper (or other abrasive material).



a Beating fruits to facilitate seed extraction (IFSP, 2000).



b Scrapping fruits with abrasive material to facilitate seed extraction (IFSP, 2000).



c Scrubbing and washing fruits to remove fleshy material from seeds (IFSP, 2000).



d Breaking open fruit to extract seed (Photo, Mulawarman).



e Seed extracted from fruit (Photo, Mulawarman).

Figure 16. Common seed extraction methods.

3. Cleaning and Grading

After extraction from the fruit, the seed lot will contain seed and many types of debris, including sterile/empty seed and fragments of stems, leaves, fruit, wing, flesh, etc. In order to maintain high seed quality and viability during storage all debris must be discarded. *However, if the seed is to be sown within a short period, thorough cleaning is not necessary!*

- A number of simple cleaning methods can be used to remove debris. Winnowing and sieving are the most common and effective methods (Figure 17), which are used with the seed of most species.
- The seed of many species have wings that should be removed. Most wings can be detached by crushing or rubbing the seed. Large, firmly attached wings can be removed by hand and discarded. Once dewinged seed should be winnowed. The seeds of *Swietenia macrophylla* (mahogany) and many *Hopea* and *Shorea* species have wings.
- The cleaned seeds of some species may have wide variation in certain physiological or physical characteristics: maturity, viability, size, color, etc. These differences may affect seedling quality, the market demand for seed and the price of seed. In such situations, it is appropriate to grade seed according to relevant characteristics. Grading criteria will vary by species and local perceptions; and should be based on local experience and market specifications. During the grading process, any remaining empty seeds and other debris in the seed lot should be discarded.
- Cleaning and grading methods for some priority tree species are described in Table 2 of the Appendix.

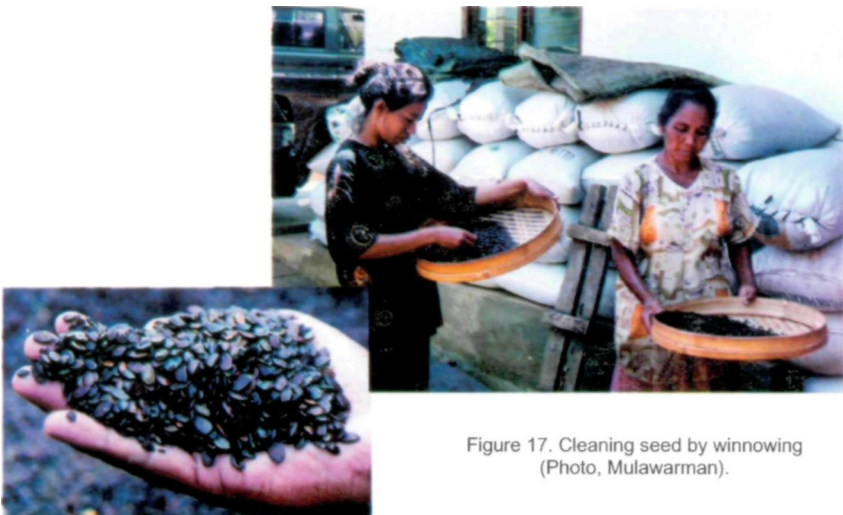


Figure 17. Cleaning seed by winnowing
(Photo, Mulawarman).

4. Seed Drying

If seed is to be sown immediately after extraction and cleaning, no further processing is required. However, if it will be stored, even for a short period, the seed of most species require drying in order to maintain viability during storage. Whether seed requires drying or not depends on its classification as recalcitrant or orthodox.

Recalcitrant seed must retain high moisture contents to remain viable and generally can be stored for only a few days or weeks. If stored under humid conditions, such as wrapped in a moist cloth or paper, recalcitrant seed may remain viable for a slightly longer period. However, once dried recalcitrant seed is dead. Thus, with recalcitrant seed the time from collection through extraction and sowing should be as short as possible. Species with recalcitrant seed include *Artocarpus heterophyllus* (jackfruit), *Azadirachta indica* (neem), *Calamus* species (rattans), *Durio zibethinus* (durian), *Eusideroxylon zwageri* (ulin), *Theobroma cacao* (cacao) and many dipterocarps (*Shorea*, *Hopea*, *Palaquium*, etc).

Orthodox seed must be dried to a low moisture content before they are stored. The drying process causes orthodox seed to enter a state of dormancy, which allows seed to maintain viability for long periods. The orthodox seed of many species can be stored for 1 year at room temperature or several years in cold storage with little loss of viability. Some orthodox seed can be stored for as many as 50 years. Once dormant, orthodox seed will begin to germinate only when conditions are favorable. Dormancy and germination is discussed in Chapter VI. Species with orthodox seed include *Acacia mangium* (mangium), *Eucalyptus* species, *Tectona grandis* (teak), *Paraserianthes falcataria* (falcata) and *Gliricidia sepium* (gliricidia).

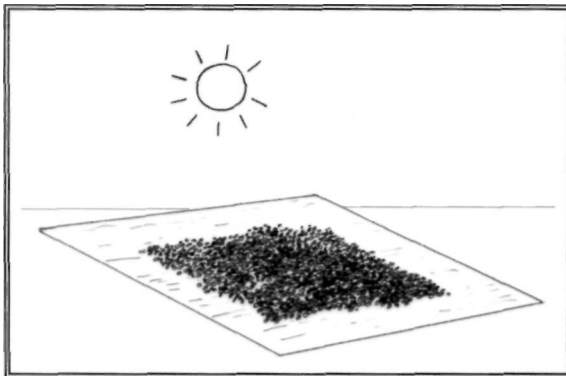


Figure 18. Orthodox seed should be dried under direct sunlight for 2-3 days (IFSP, 2000).

Orthodox seed stores best at moisture contents of 5-8%, but this can be achieved only by oven drying, which is not practical for most farmers or NGOs. Sun drying or air-drying can reduce moisture content to 8-12% (or less under arid conditions), which is sufficient for the needs of farmers and NGOs who commonly store seed for only a few months to 1-2 years. Orthodox seed can be dried by the following methods.

- Dry the seed under direct sunlight (Figure 18) for 2-3 days. Under humid conditions or periods of heavy rains, sun drying may require up to 5-7 days.
- Because relative humidity increases after sundown, seed should be placed in containers and moved indoors for the evening and night.
- When seed drying corresponds with rainy periods, workers must be ready to quickly move the seed to shelters.
- Seed may be air-dried under shelters or indoors, if necessary. Electric fans can be used to dry seed, if feasible.
- When the sun is extremely hot, seed should be dried under partial shade.
- Local methods used to dry rice, maize and other agricultural seed may be appropriate for orthodox tree seed and should be tested.

The following simple methods are used to determine if seed is sufficiently dry.

- Dry seed is easy to bite, crack or cut; and elicits a sharp snapping sound.
- When mixed or shaken, dry seed elicits a rustling or crackling sound.
- Weighing seed over consecutive days of drying reveals a constant weight.

5. Seed Storage

Seed storage is necessary for several reasons. Seed ripening and collection often does not correspond with the appropriate time for seedling production and tree planting. The location of the seed sources may be far from intended planting sites. Some species do not produce seed every year. Government agencies, forest industry companies and commercial seed dealers need to store seed before and while it is being shipped to field staff or consumers.

The length of time seed will remain viable varies greatly by species and storage conditions. Under fair to good conditions at the farmer- and NGO-level, orthodox seed of most species will remain viable when stored for 1 to 2 years. General guidelines for seed storage are consistent for all orthodox seed. The following are the key factors to consider when storing seed.

- **Temperature**

Seed will remain viable for a long time when stored at a consistent cool temperature. *The cooler the temperature the better!* However, a fluctuating temperature will cause a loss of seed viability.

- **Humidity**

Seed stores best under low air humidity. The lower the air humidity the better. High humidity conditions will cause seed to absorb moisture and lose viability. As with temperature, fluctuating levels of humidity accelerate a loss of seed viability.

- **Moisture content**

As mentioned earlier, seed stores best at consistent low moisture contents. Moisture contents of 8-12% can be achieved by sun drying or air-drying. Maintaining consistent low moisture content in seed is directly dependent on maintaining low levels of air humidity (as discussed above).

- **Light**

Exposure to direct sunlight deteriorates seeds' protective outer coat. Deterioration of the seedcoat facilitates moisture absorption and a loss of viability. Under high moisture conditions, exposure to light encourages germination. To avoid these problems seed should be stored in the dark or in covered non-transparent containers.

- **Insects and diseases**

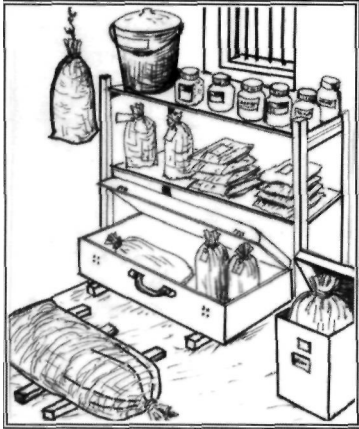
Exposure to pests and diseases during storage decreases seed viability and even kills seed. To avoid such problems seed should be thoroughly cleaned and stored in sealed containers. When available, chemical or organic pesticides can be applied to stored seed. Some organic pesticides include: neem oil or leaves, gliricidia leaves, and soap. Local methods used to protect agricultural seeds may be appropriate for tree seed and should be tested.

Of those mentioned above, **the two most important storage factors are temperature and humidity.** *It can not be over-emphasized that maintaining seed viability during storage is directly dependent on maintaining consistent low temperatures and low air humidity as mentioned above!*

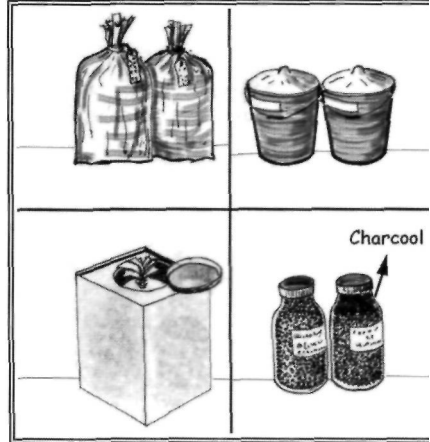
The best way to achieve optimal storage conditions for farmers and NGOs is to **store seed in containers in a room specifically dedicated for seed storage** (Figure 19). The seed storage room should be **cool, dry, dark, well ventilated and protected from insects and diseases.**

Containers appropriate for seed storage include sacks, bags, baskets, tins, and plastic or glass jars. Large quantities of seed can be stored in sacks, bags, baskets and tins. Small quantities of seed, high-value seed, and seed of species that produce seed infrequently should be stored in glass or plastic jars with air-tight lids. Air-tight lids make it easier to maintain seed storage conditions and thus seed viability. All seed storage containers should be clean and filled completely! Empty space in the containers allows air humidity to increase, resulting in a negative impact on seed viability. Bags and sacks should be tied tightly.

The empty space in baskets, tins and jars should be filled with material that absorb air moisture, such as charcoal, rice husks, or crumpled newspaper. All seed containers should be clearly labeled. Labeling is discussed in Chapter VIII.



a. A seed storage room
(Adapted from IFSP, 2000).



b. Various types of seed storage container
(Wiyono, 2002).

Figure 19. Seed can be stored in various types of containers in a room dedicated for that purpose.

6. Transportation

Appropriate storage conditions must be maintained while transporting or shipping seed to nurseries, field sites or customers. Otherwise seed viability might deteriorate quickly or be completely lost. The previous effort and money invested in seed source management, seed collection and seed handling will be wasted. During transportation, seed should always be: i) covered with waterproof material such as tarps or plastic sheets; and when possible ii) stored under permanent shelters. Seed containers should not be placed directly on the floor of shipping containers, trucks, ships, railroad cars, etc. Seed placed directly on the floor will absorb moisture, be more vulnerable to rats and insects, and deteriorate more quickly. Seed containers should be placed on racks or slates of wood as depicted in Figure 19.

Transportation and shipping of seed should be conducted as quickly as possible. Unnecessary delays and storage of seed under uncontrolled conditions will reduce seed viability. Tree seed is a high value commodity and should be treated as such. Seed should be shipped at the highest priority level that is economically justifiable. Packages of seed should be labeled as *fragile!*

VI. HOW TO ACCELERATE SEED GERMINATION?

1. Seed Dormancy

Dormancy is defined as the physiological state in which viable seed can not readily germinated, even when subjected to favorable conditions. Dormancy is a self-sustaining mechanism that maintains seed viability during adverse environmental conditions, such as annual dry-seasons, wildfires or exposure to insects and disease. These mechanisms hinder germination in the short-term by preventing moisture absorption or other physiological processes. The three most common types of dormancy found in tree seed are physical, mechanical and chemical dormancy.

- **Physical dormancy**

Physical dormancy is typified by a hard, thick or waxy impermeable seedcoat that prevents water from being absorbed by the seed. Without absorbing water seeds can not germinate. Seeds of the following species demonstrate physical dormancy: *Paraserianthes falcataria* (falcataria), *Acacia mangium* (mangium), *Sesbania grandiflora* (turi), *Calliandra calothyrsus* (red calliandra), and many more.

- **Mechanical dormancy**

Mechanical dormancy is caused by the presence of a hard encasing structure in the fruit that prevents the radical from expanding and exiting. Water may enter the fruit but embryo development is physically restricted. Fruits of the following species demonstrate mechanical dormancy: *Tectona grandis* (teak), *Gmelina arborea* (gmelina), *Aleurites moluccana* (candlenut), and *Canarium ovatum* (pilinut).

- **Chemical dormancy**

Chemical dormancy is caused by chemical compounds in the fruit, seed or embryo that prevent germination, even in the presence of water. This type of dormancy occurs in *Gmelina arborea* (gmelina), *Xanthoxylum rhetsa* (nyalin), and *Maesopsis eminii* (musizi or African wood).

Under natural conditions, dormancy may prevent seeds from germinating for days, weeks, months and even years. In order to operate efficient nursery and tree planting programs, methods are required that overcome seed dormancy and accelerate germination. These methods are called **seed pre-sowing treatments**.

2. Seed Pre-Sowing Treatments

Pre-sowing treatments are methods applied to overcome seed dormancy to ensure rapid, uniform and timely seed germination that facilitates seedling production. Pre-sowing treatments are applied to seeds immediately before sowing. Most methods require only a few minutes to 24 hours. However some pre-sowing methods require a few to several days. Appropriate pre-sowing treatment methods depend on the dormancy characteristics of the seed being treated. The most common pre-sowing treatment methods are discussed below. Table 3 in the appendix provides specific pre-sowing treatment recommendations for the seed of some priority tree species.

2.1. Soaking in cool water

Soaking in cool water is applied to overcome the physical, mechanical or chemical seed dormancy of some species. Most often seeds are soaked in water for 1 day, the seeds of a few species may require soaking for 2 days. This method is applied to the seed of *Sesbania grandiflora* (turi), *Tamarindus indica* (tamarind), *Gmelina arborea* (gmelina), *Gliricidia sepium* (gliricidia), and *Dalbergia* species (rosewoods).

2.2. Soaking in hot water

Soaking in hot water is applied to overcome the physical dormancy of seeds with hard, thick and waxy seedcoats. Water is boiled and removed from the source of heat. Seeds are soaked in hot water while being stirred for 2-5 minutes, and then soaked in cool water for 1 day. *Caution: if seed is soaked while the water is being boiled, the seed might be cooked and die.* This method is applied to the seed of *Paraserianthes falcataria* (falcata), *Acacia mangium* (mangium), *Calliandra calothyrsus* (red calliandra), and *Leucaena* species (ipil ipil).

2.3. Mechanical (scarification) methods

Mechanical, or scarification, methods are used to overcome the physical and mechanical dormancy of hard and thick seedcoats or fruit shells. Small holes are cut or scrapped in the seedcoat or fruit shell with a knife, metal file or abrasive material to allow water absorption. Mechanical machines are available for this purpose. After scarification, seeds are usually soaked in cool water for 1 day. These methods are used on the seed of the species mentioned under the hot water pre-treatment, as well as, *Eusideroxylon zwageri* (ulin or ironwood). The hard shells of some fruits are cracked with a hammer. The fruits are then soaked in water for 1 day!

2.4. Fire or heating methods

The fire and heating methods are used to overcome mechanical dormancy of fruits with thick shells. Fruits are spread on the ground and covered with a 2-cm layer of dry grass or straw, which is then burned. Alternatively, fruits may be heated in a pan over a fire. Further details concerning these methods are provided in Table 3 of the appendix, under the entries for *Tectona grandis* (teak) and *Aleurites moluccana* (candlenut).

2.5. Soaking in chemicals

Soaking seeds in sulfuric acid, hydrochloric acid, or hydrogen peroxide for a 10-20 minutes overcomes physical and mechanical dormancy. Seeds are removed from the chemical soak, rinsed with water for 2-5 minutes and then soaked in cool water for 24 hours. This method is not recommended because chemicals are dangerous and expensive.

VII. HOWTO MEASURE SEED QUALITY?

1. Seed Quality and Sampling

Seed quality refers to the purity, viability, vigor and health of a particular seed lot. Seed quality is measured by seed testing, which should be conducted shortly after seed is collected or bought. Testing should be repeated after a long period of storage, which may negatively impacted seed quality. Seed testing results are used to estimate the amount of seed required to produce the number of seedlings needed for field planting. It should be noted that most seed tests are destructive, and should not be conducted needlessly. Seed testing is conducted on a sample that is representation of the seed lot. Samples are drawn from the seed lot just prior to seed testing. The following are simple sampling criteria for seed testing that can be used by NGOs and farmers.

- Samples should be homogenous and representative of the entire seed lot.
- Samples should contain enough seeds to conduct all the tests required - simple planning and calculating is necessary (this chapter provides recommended sample size for each test).
- If the seed lot is large, sub-samples should be drawn from each container or from several parts of large containers to form a composite sample.
- If more than one seed lot is to be tested, sample and test them separately.
- However, if a few small-sized seed lots are to be used for seedling production, they can be mixed together thoroughly then sampled and tested as a single seed lot.

Once samples are drawn, seed testing should proceed immediately. Key seed tests are: purity, moisture content, 1000 seed weight, and germination/viability. Of these tests, the germination/viability test is the most important. It is simple to conduct and explained in detail below. The other three tests are summarized below. Access to an accurate scale is required to conduct most of the seed tests described here. A drying oven is required to determine seed moisture content.

For NGOs and farmers it may be inconvenient to conduct seed tests, because seed collection and management is just one of many activities in which they are involved. However, seed testing is needed to evaluate their seed stocks and plan tree planting activities. When possible, it may be easier and more accurate for NGOs and farmers to seek assistance with seed testing from local forestry agencies or universities.

2. Seed Testing

2.1. Purity test

In addition to seed of the specified species, seed lots contain debris including seeds of other species; pieces of fruits, twigs and leaves; and dirt. 'Pure seed' refers exclusively to the seed of the specified species - both viable and non-viable. The purity test calculates the percent of a seed lot composed of pure seed. Seed purity is determined by separating a sample into two components: i) pure seed; and ii) all other matter. The sample size should be approximately one handful. Purity is calculated as follows:

$$\text{Purity \%} = (\text{Weight of pure seed} / \text{Total weight of sample}) \times 100$$

2.2 Moisture content

This test determines the percentage of moisture contained in seed. The test results are primarily used to determine if seed is in the proper condition for storage. Moisture content is calculated by comparing the oven-dried weight of the seed sample with the weight of the sample before drying in the oven (pre-dried weight), as follows:

$$\text{Moisture Content \%} = \frac{(\text{Pre-dried weight} - \text{Oven-dried weight})}{\text{Pre-dried weight}} \times 100\%$$

The oven-dried weight is determined by drying the seed sample in an oven at 103°C for 17 hours. The sample size should be approximately one handful. As discussed, orthodox seed stores best at moisture contents of 5-7%. However, for short-term storage (a few months to 1-2 years) under local conditions moisture contents of 8-12% may be sufficient (see Chapter V for more details concerning moisture content and seed storage). If test results indicate moisture contents are too high, seed should be dried further before storage.

2.3. The 1000 seed weight test

This test is calculated by weighing 1000 pure seeds of the specified species. If seed is in short supply, 100 or 500 pure seed can be used to determine weight. The resulting value from this test can be recalculated and expressed in kilograms, pounds, any other unit of weight or as the average weight per seed.

2.4. Germination/Viability test

The germination/viability test is conducted to identify the capacity of a given seed lot to produce healthy and vigorous seedlings. This information is very valuable when estimating the amount of seed required to produce the target number of seedlings for field planting. There are two approaches, direct testing of germination and indirect testing of viability.

2.4.1. Direct (germination) test

Direct testing is appropriate for seed that is easy to germinate. For seed that is difficult to germinate or requires long periods to germinate indirect tests are more efficient. Simple procedures for conducting a germination test are as follows:

- Randomly select 100 seed⁴ from the sample and apply the pre-sowing treatment appropriate for that species (see Chapter VI and Table 2 in the Appendix).
- After applying the pre-sowing treatment, sow the seed in a tray containing a good quality germination medium (nursery soil).
- Maintain the medium under moisture conditions to promote germination.
- After 1 week, count the number of germinated seed. *Note: Some species and seed lot may require 3-4 weeks to achieve complete germination. The test should be monitored daily and continue until no additional seeds germinate.*
- Calculate the percentage of germination using the formula listed below.
- Also note the number of seed that are ungerminated but viable (see description of 'viable embryos' below under **cutting test**). Include this information on the germination form.

$$PG = (NGS/NSS) \times 100$$

PG = Percentage of germination

NGS = Number of germinated seeds

NSS = Number of seeds tested

2.4.2. Indirect (viability) tests

Indirect tests are appropriate for seed that is difficult to germinate or requires a long time to germinate; or when results are needed quickly. These tests do not measure percentage of germination but rather determine the percentage of seed that are alive and should be able to germinate. Seeds that are alive are called viable, thus these tests are called viability tests. Indirect tests always give a higher value than the germination test.

There are several methods of indirect testing. Some of these methods require sophisticated laboratory tools and equipment. Other methods are easy to conduct in the field or office with commonly available tools. Three of the easy to conduct methods are described below. It should be noted that the 'cutting test' is more accurate than the other two methods. The 'soaking test' and 'shape, size, and color observation test' are quick and simple tests to determine seed viability. They can be conducted during seed selection before sowing seed without destroying any seed. However, the results are very rough.

⁴For any germination/viability test (either direct or indirect methods), if seed is of limited supply the number of seeds tested can be 50, 40 or 20.

- **Cutting test**

- > Randomly select 100 seed from the sample.
- > Seed should be soaked in cool water for 12-24 hours prior to cutting.
- > Cut the seed with a sharp tool and observe the embryo. Viable embryos will be green or greenish white, moisture and fresh in appearance. Non-viable seeds will have unformed, deformed or discolored embryos. Magnifying glass can be used to enhance observation of the embryos.
- > Count the number of seed with viable embryos.
- > Calculate seed viability using the following formula:

$$PV = (NVS/NTS) \times 100$$

PV = Percentage of viable seeds

NVS = Number of viable seeds

NTS = Number of seeds tested

- **Soaking test**

- > Randomly select 100 seed from the sample.
- > Soak the 100 seed in cool water for 12-24 hours.
- > Visually examine the seed. Most viable seed will remain immersed in the water, some will have imbibed water and be visibly swollen. Non-viable seed may be floating and will not have imbibed water.
- > Count the number of viable seeds.
- > Calculate seed viability using the formula described under the 'cutting test'.

- **Shape, size, and color observation test**

- > Randomly select 100 seed from the sample.
- > Visually examine the seed. Viable seeds usually have a normal shape and size. The seedcoats of viable seed have a uniform, healthy, and often glossy appearance. Non-viable seeds are likely to be smaller, discolored, deformed and often empty (and comparatively light in weight). The seedcoats of non-viable seeds are often dull, vary in color and contain holes or cracks.
- > Count the number of viable seeds.
- > Calculate seed viability using the formula described under the 'cutting test'.

VIII. HOW SHOULD TREE SEED BE DOCUMENTED?

All tree seed should be documented to provide information regarding its origin, collection, handling and quality. Undocumented seed is dubious. It may be of good to adequate quality, but it is more likely of low viability and inferior genetic quality. Seed documents vary greatly depending on the needs of the collector/dealer, the requirements of user/consumer, and the purpose of documents. A complete set of seed documents provides detailed information of the whole seed procurement process from seed source identification through seed sowing in the nursery.

For the purpose of NGOs and farmers a simpler set of documents will suffice. Three types of documents are recommended and summarized below. The objective of these documents is to record and evaluate the seed sources and seed (both collected and procured elsewhere) used in local tree planting programs. This information will enable NGOs and farmers to focus seed collection activities on the best quality seed sources accessible to them.

1. Seed Source Document

- Botanical and local name of the species
- Location and site information of seed source (elevation, temperatures, rainfall, soil types, etc)
- Type of seed source (seed trees, seed stand, seed production area, seed orchard, other)
- Number of seed trees in the seed source
- Age of seed source

2. Seed Collection and Handling Document

- Botanical and local name of the species
- Date of seed collection
- Seed source from where the seed was collected
- Number of seed trees from which the seed was collected
- Average distance between seed trees
- Weight of fruit/seed collected
- Number of seed containers filled with the seed collected
- Name of collectors
- Seed lot number (a unique number to identify the seed collected on a specific date from a specific seed source)

3. Seed Quality Document

- Botanical and local name of the species
- Seed lot number
- Date of seed testing
- Seed purity
- 1000 seed weight test
- Moisture content
- Percentage of germination or viable seed

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APPENDICES

Table 2. Collection dates, colors of mature seed, seed extraction and cleaning methods for some priority species.

Botanical name	Local name	Collection date (Geographic source of information)	Color of mature fruit (Related details)	Seed extraction and cleaning
<i>Acacia mangium</i>	Mangium	February-March August-September	Dark brown to black	Fruits are placed in a sack and lightly beaten. Seeds are winnowed.
<i>Aleurites moluccana</i>	Candlenut	November- December (Timor)	Yellowish-brown (and fallen)	Fruits are pressed or lightly beaten, and then washed and dried.
<i>Alstonia scholaris</i>	Pulai; Milkwood	May-June October-November	Brownish-yellow	Fruits are dried under shaded until they open and seeds are extracted. Seeds are winnowed.
<i>Anacardium occidentale</i>	Cashew	October-November	Reddish-yellow	Seeds are removed from fleshy fruits and dried.
<i>Azadirachta indica</i>	Neem	December- February	Yellowish-green	Fruits are hand-squeezed. Seeds are washed and then dried. *
<i>Calamus manan</i>	Rattan	July-August	Brownish-yellow	Fruits are rubbed together to remove the outer skin and then washed. *
<i>Calliandra calothyrsus</i>	Red calliandra	November	Dark-brown (and dry)	Pods are placed in a sack and lightly beaten. Seeds are winnowed.
<i>Canarium ovatum</i>	<i>Pilinut</i>	All year	Black (and fatten)	Fruits are pressed or lightly beaten, and then washed and dried.
<i>Dalbergia latifolia</i>	Indian rosewood	July-August	Dark-brown	Pods are crushed. Seeds are winnowed.
<i>Dyera costulata</i>	Jelutung	February-March, September-October	Brown (and easy to snap)	Fruits are dried until they open and seeds are extracted. Seeds are winnowed. "
<i>Enterolobium cyclocarpum</i>	Ear pod	March-August	Dark-brown	Pods are crushed and beaten until the seeds are extracted. Seeds are washed and then dried.
<i>Eucalyptus urophylla</i>	Timor white gum	July-September	Dark brownish-green	Fruits (capsules) are dried until they open and seeds are extracted. Seeds are sieved to separate chaff and other debris.
<i>Eusideroxylon zwageri</i>	Ulin; Ironwood	July-September	Yellow	Fruits are soaked and than rubbed to remove flesh. Seeds are washed and dried. *
<i>Fagraea fragrans</i>	Tembesu; Ironwood	April -May	Dark-brown	Fruits are rubbed over a sieve until seeds are separated. Seeds are sieved again and winnowed.

Table 2. Collection dates, colors of mature seed, seed extraction and cleaning methods for some priority species.

Botanical name	Local name	Collection date (Geographic source of information)	Color of mature fruit (Related details)	Seed extraction and cleaning
<i>Gliricidia sepium</i>	Gliricidia	November	Yellowish-brown	Pods are placed in a sack and lightly beaten. Seeds are winnowed.
<i>Gmelina arborea</i>	Gmelina; Melina	April-July (East Jawa) August-January (East Kalimantan)	Yellowish-green (and fallen)	Fruits are placed in sack and lightly beaten. Seeds are washed to remove the pulp and then dried.
<i>Hopea mengarawan</i>	Merawan	February-March	Light brown (and fallen)	Wings are removed from seed. *
<i>Intsia bijuga</i>	Merbau; Moluccan ironwood	September-October	Yellowish-green	Fruits are dried until they open and seeds are extracted. Seeds are winnowed.
<i>Leucaena leucocephala</i>	Ipil ipil	February-June	Yellowish-brown	Pods are crushed. Seeds are winnowed.
<i>Palaquium</i> sp	Nyatoh	November-December	Yellow	Fruits are hand-squeezed. Seeds are washed and then dried. *
<i>Paraserianthes falcataria</i>	Falcata; Falcataria	May-August	Yellow	After pods turn brown they are placed in sack and lightly beaten. Seeds are winnowed.
<i>Pinus merkusii</i>	Merkus pine; Mindoro pine; Sumatran pine	March—July July-September	Brownish green	Dried cones are placed in a sack and crushed or rubbed together until seeds are extracted. Seeds are gently rubbed to remove wings and then winnowed.
<i>Santalum album</i>	Sandalwood	May-June	Reddish-black	Fruits are crushed and squeezed by hand. Seeds are separated from the pulp, washed and dried.
<i>Sesbania grandiflora</i>	Turi	September-October (Timor)	Yellow	Pods are placed in a sack and lightly beaten. Seeds are winnowed.
<i>Shorea javanica</i>	Damar; Damar mata kucing	July-August (South Sumatra)	Brown (and fallen)	Wings are removed from the seed. *
<i>Swietenia macrophylla</i>	Mahogany	July-September	Brown (and easy to break open)	Fruits are broken open. Wings are removed from seeds. Seeds are winnowed.
<i>Tamarindus indica</i>	Tamarind	October-November (Timor)	Yellowish-brown	Fruits are crushed and squeezed by hand. Seeds are separated from the pulp, washed and dried.
<i>Tectona grandis</i>	Teak	July-September	Yellowish-brown (and fallen)	Fruits are rubbed together to remove the skin and then winnowed.

* Seed of these species are recalcitrant and should be sowed immediately after cleaning. They can not be stored for long periods.

Table 3. Seed pre-sowing treatments for some priority species. *

Botanical name	Local name	Pre-sowing treatment
<i>Acacia mangium</i>	Mangium	Soak seed in hot water for 2-5 minutes and then in cool water for 1 day.
<i>Aleurites moluccana</i>	Candenuit	Burning method. Spread fruits evenly on the soil surface or in a bed of sand and cover with a 2-cm layer of dry straw. Burn the straw. Pour cool water over the fruits immediately after the straw burns. Soak fruits in cool water for 1 day. Son dry method. Place wet fruits under direct, hot sunshine. When the fruits become hot spray them with cool water. Repeat this process until the skin of the fruits crack.
<i>Alstonia scholaris</i>	Pulai; Milkwood	No treatment.
<i>Anacardium occidentale</i> ®	Cashew	Soak seed in cool water for 1 day.
<i>Azadirachta Mica</i>	Neem	No treatment.
<i>Calamus manan</i>	Rattan	No treatment.
<i>Calliandra calothyrsus</i>	Red calliandra	Soak seed in hot water for 2-5 minutes and then in cool water for 1 day.
<i>Canarium ovatum</i>	Pilint	Place wet fruits under direct, hot sunshine. When the fruits become hot spray them with cool water. Repeat this process until the skin of the fruits crack.
<i>Dalbergia latifolia</i>	Indian rosewood	Soak seed in cool water for 1 day.
<i>Dyera costulata</i>	Jelutung	No treatment.
<i>Enterolobium cyclocarpum</i>	Ear pod	Soak seed in cool water for 1 day.
<i>Eucalyptus urophylla</i>	Timor white gum	No treatment.
<i>Eusideroxylon zwageri</i>	Ulin; Ironwood	Cut or scratch through the seed coat opposite the hilum.
<i>Fagraea fragrans</i>	Tembesu; Ironwood	No treatment.
<i>Gliricidia sepium</i>	Gliricidia	No treatment necessary, but soaking seed in cool water for 1 day will hasten and improve germination.
<i>Gmelina arborea</i>	Gmelina; Melina	Soak seed in cool water for 2 days.
<i>Hopea menqarawan</i>	Merawan	No treatment.
<i>Intsia bijuga</i>	Merbau; Moluccan ironwood	Cut or scratch through the seed coat opposite the hilum.
<i>Leucaena leucocephala</i>	Ipil ipil	Soak seed in hot water for 2-5 minutes and then in cool water for 12-24 hours.
<i>Palaquium</i> sp	Nyato	No treatment.
<i>Paraserianthes falcataria</i>	Falcata; Falcataria	Soak seed in hot water for 2-5 minutes and then in cool water for 1 day.
<i>Pinus merkusii</i>	Merkus pine; Mindoro pine; Sumatran pine	No treatment.
<i>Santalum album</i>	Sandalwood	Soak seed in cool water for 1 day.
<i>Sesbania grandiflora</i>	Turi	No treatment necessary, but soaking seed in cool water for 1 day will hasten and improve germination.
<i>Shorea javanica</i>	Damar; Damar mata kucing	No treatment.
<i>Swietenia macrophylla</i>	Mahogany	No treatment.
<i>Tamarindus indica</i>	Tamarind	Soak seed in cool water for 1 day.
<i>Tectona grandis</i>	Teak	Burning method. Spread fruits evenly on the soil surface or in a bed of sand and cover with a 2-cm layer of dry straw. Burn the straw. The surface of the fruits should be slightly burnt. Collect seeds and soak in cool water for 1 day. Roasting method. Place fruits in a pan and heat until the hair on the surface of the fruit is burnt off. Stir the fruit during the heating process. Soak fruits in cool water for 1 day. Soaking method. Soak fruits in water for 2 days. Then wrap the fruits in a moist cloth and store in a humid place for 5 days.

* The pre-sowing treatments listed here are those commonly used in Indonesia. Seed should be sown immediately after pre-sowing treatment.

Glossary of terms

- Clone:** A group of individual trees derived from the same parent tree by vegetative propagation.
- Family:** A group of individual trees that are more closely related compare to other individuals of the species. In the broadest sense all the trees in a specific location, within a species' range, constitute a family. Often family members may have a common male or female parent (half-siblings), the same male and female parents (full-siblings), or be regenerated from the same individual by vegetative propagation (clone).
- Fruit sorting:** The process of separating fruits base on their maturity or physiological/ physical quality. Mature fruits are processed for seed extraction, immature fruits are stored for further ripening, and poor quality fruits are discarded.
- Gene:** A unit of inheritance transferred from the parent to its progeny.
- Genetic base:** The amount of genetic variation in a species or population. It is expressed as the number of unrelated individual trees from which a seed lot was collected or a population of trees was generated.
- Genotype:** Genetic constituents of an individual tree which, in interaction with the environment, largely controls tree performance. Genotype is inheritable by its progeny. Generally, trees with good genotype produce good progeny.
- Germplasm:** Genetic materials - seed or vegetative material - used for the purpose of plant propagation.
- Isolation distance:** A spatial gap, usually measured in meters width, that isolates a seed source to prevent contamination from pollen of unimproved trees of the same species in adjacent stands.
- Orthodox seed:** A type of seed with a hard, impermeable coat that can be dried to a low moisture content and stored for long periods. Dormant when dried, orthodox seed will start to germinate only under favorable physical and physiological conditions.
- Outcrossing:** The production of progeny resulting from the transfer of pollen from a male flower of one individual to a female flower of another individual.
- Phenotype:** The observed characteristics of a tree, the sum of the attributes that result from interaction of the genotype and environment.
- Plus trees (Selected trees):** Superior phenotypic trees from which seed is collected.
- Pure seed:** The portion of a seed lot (or sample) that is composed of seed of the specified species, including both viable and non-viable seed. All debris and seeds of other species are excluded.
- Recalcitrant seed:** A type of seed, usually large and fleshy, that can not be dried to a low moisture content. Recalcitrant seed can not be stored for long periods and should be sown soon after ripening.

- Seed:** Generative/reproductive material of flowering plants that result from pollination of the female flower.
- Seed dormancy:** The physiological state when viable seed can not readily germinate when subjected to favorable environment.
- Seed extraction:** The process of removing seed from fruit.
- Seed grading:** The process of separating seeds based on their maturity, size, physical quality or other phenotypic characteristic.
- Seed lot:** Seed collected from a specific location during a single collection activity. The seed may have been collected from one tree, one family or a broader geographic location.
- Seed orchard:** A stand of trees specifically established for the purpose of seed production, usually from families of improved genetic quality.
- Seed pre-sowing treatments:** Methods or processes applied to seed to overcome dormancy or hasten/improve germination.
- Seed procurement:** All activities - collection, purchase, exchange, etc -conducted to secure supplies of tree seed.
- Seed production area:** A stand of trees in either a natural forest or plantation that is managed for the specific purpose of seed production. Stand improvement is conducted by selective thinning to remove poorer quality trees and retain trees of superior quality at optimal space for seed production.
- Seed source:** An individual tree or stand of trees, natural or planted, from which seed is collected.
- Seed stand:** A group of trees identified in a natural forest or plantation that have superior characters, such as straight stem or fast growth, and are managed as a seed source.
- Seed tree:** A tree from which seed is collected.
- Seed viability:** Term used to express the ability of seed to germinate or produce new plants
- Seedling:** A plant regenerated from any form of germplasm.
- Selfing (Self-pollination):** The production of progeny resulting from the transfer of pollen from a male flower to a female flower of the same individual.
- Tree domestication:** Accelerated, human-induced evolution to bring tree species into wider cultivation through a farmer-driven or market-led process. This iterative process includes a wide range of activities from the exploration of natural population, through tree improve, silviculture and product marketing.
- Vegetative propagation:** The production of new plants directly from vegetative material such as roots, stems, or leaves. The production of plants from material other than seed.

