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Seed Technology for Forestry in Hawaii

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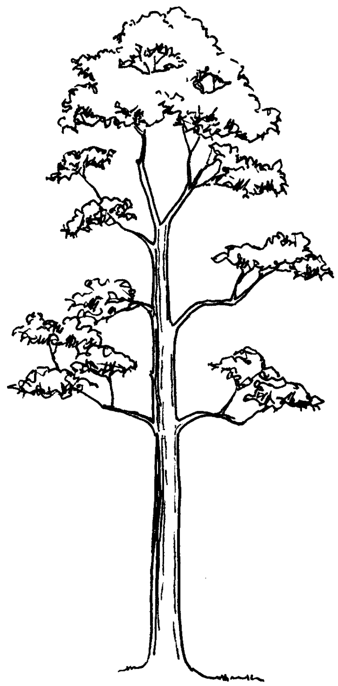
Good forestry projects start with good seeds. Lacking good genetic material to start with, investments in pruning, fertilizing, or other silvicultural treatments will have little result. In forestry as well as in agriculture, time and effort invested in procuring better quality seeds will pay back in higher rates of survival, higher yields, and better quality of wood and other products. This publication is a guide to help landowners and nursery operators in Hawaii obtain quality forest tree seeds.



To buy or collect?

The first question a grower faces is whether to order seeds from a commercial supplier or to collect from local trees. For species that are grown around the world and have been the subject of much tree improvement work, such as teak (*Tectona grandis*) and many species of *Eucalyptus*, it is almost always better to send away for improved seeds. Growers in many regions have been selecting varieties that grow faster, are more resistant to disease, and have better wood qualities. In addition, different seed sources of the same species are adapted to different sites. For example, trials in Hawaii comparing sources of *Eucalyptus grandis* found twice the diameter growth rate between the worst and the best seedlots (Skolmen 1986). If superior trees are available, the investment in obtaining their seeds almost always pays off. When species are being considered for a given site, it is a good idea to note what seed sources are available and whether the species has been genetically improved.

Seeds of some species may best be collected locally. Koa (*Acacia koa*) and other species native to Hawaii are seldom grown elsewhere anyway, and except for koa none have been the subject of tree improvement work. Even some exotic forest tree species important to Hawaii are not widely grown elsewhere. These include Queensland maple (*Flindersia brayleyana*) and toon (*Toona ciliata*). The ancient Hawaiians introduced a number of useful forest tree species, including milo (*Thespesia populnea*), kou (*Cordia subcordata*), kamani (*Calophyllum inophyllum*), and kukui (*Aleurites moluccana*), now the state tree of Hawaii. These trees, exotics which have long been established in Hawaii, have adapted to local conditions. More than a thousand different species of forest trees have been introduced to Hawaii, and part of planning any forestry project should include research on which species and genotypes have been successful here. For the grower, it is important to know whether a local population of trees grew from only a few casually introduced individuals (such as with kiawe [*Prosopis pallida*], all of which grew from a few seeds planted in 1828) or were the result of a deliberate introduction of a quality provenance selected for growing in Hawaii.

Importing seed

Seeds may be purchased either from American or foreign suppliers. While foreign suppliers may have better access to seeds of their local species of trees, importing seeds into the USA involves additional effort and paperwork. Both the Hawaii Department of Agriculture's Plant Quarantine Branch (HDOA-PQ) and the U.S. Department of Agriculture's Animal and Plant Health Inspection Service (USDA-APHIS) regulate importation of forest tree seeds into Hawaii. The State of Hawaii

Illustrations are by Penny Levin, Division of Forestry and Wildlife, Hawaii Department of Land and Natural Resources, except for the drawings of named plants, which are from Little and Skolmen (see References, p. 12). Helpful comments on the manuscript were received from Nicklos Dudley, Hawaii Agriculture Research Center; John Edson, Hawaii Reforestation Nursery; Penny Levin and Edwin Petteys, Hawaii Division of Forestry and Wildlife; and Alvin Yoshinaga, UH Center for Conservation Research and Training.

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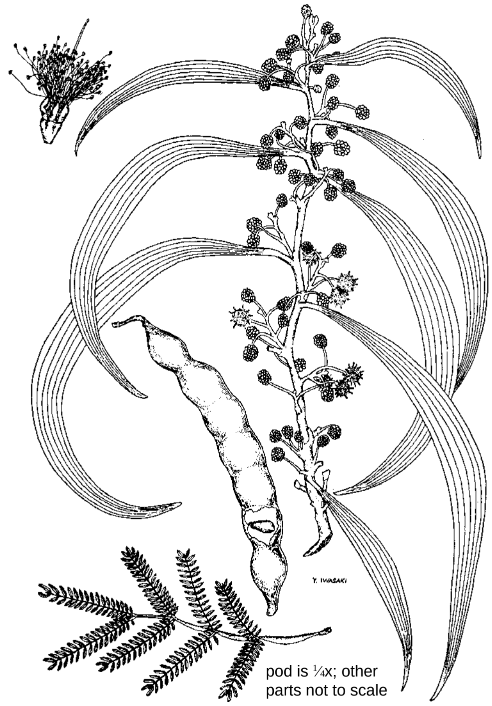
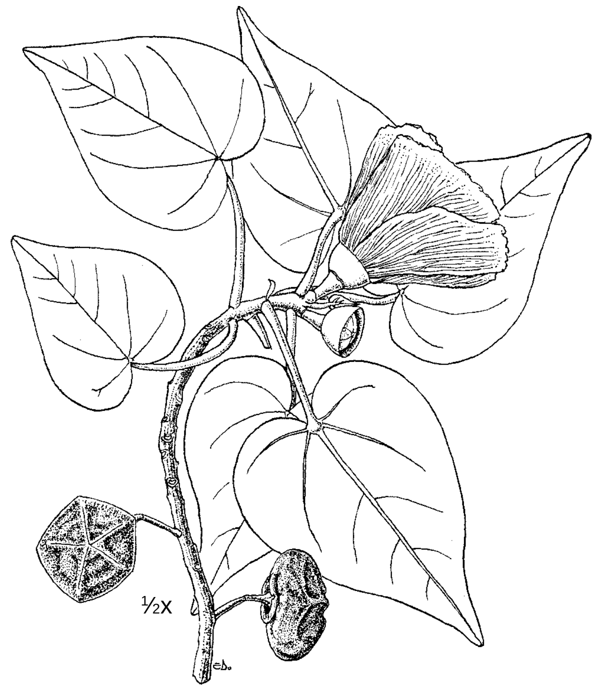
Koa (*Acacia koa*) grew in Hawaii before humans arrived and is one of our most prized and valuable timber trees.



Milo (*Thespesia populnea*) is one of the useful forest tree species introduced by ancient Hawaiian colonizers.

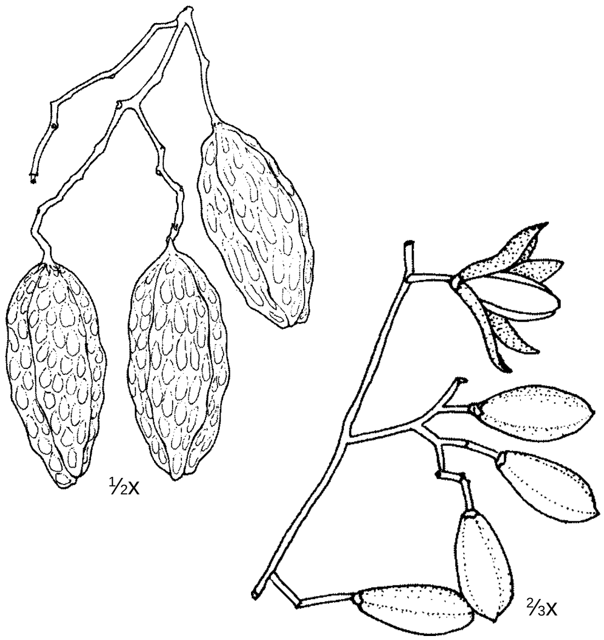


restricts imports of pines (*Pinus* spp.), palms (*Palmae*), and certain noxious weeds, the list of which includes the trees black wattle (*Acacia mearnsii*), kahili flower (*Grevillea banksii*), firetree (*Myrica faya*), kiawe (*Prosopis juliflora*), and various members of the family *Melastomataceae*, such as *Miconia*, *Melastoma*, and *Tibouchina* species. APHIS requires a permit for all woody plant seeds imported from other countries, even those brought back in personal baggage. Species on the U.S. endangered-species list, regulated by the Convention on Trade in Endangered Species (CITES), or considered by the USDA to be plant pests, are also subject to additional regulations. Except for sandalwoods (*Santalum* spp.), few forest trees are restricted. Permits should be obtained ahead of time, and a copy should be sent to the supplier with the seed order. Seeds must be clean and free of pests and pulp; all seeds need to be accompanied by a phytosanitary certificate from the supplier certifying that the seedlot is pest-free. Since regulations change over time, it is best to check with both HDOA and APHIS before ordering seed.

Seed suppliers should provide documentation of the origin and quality of the seed, including seedlot number, species and variety, type of seed source (seed zone, seed stand, etc.), location of seed source, origin of seed source if not a native species, viability, number of parent trees, and whether the seed has been treated with pesticides. The more documentation a supplier can provide, the more likely it is that the supplier is collecting carefully selected, superior seed. A supplier may be able to choose a superior provenance or variety if you specify the desired use and give environmental information on the planting site, including location, altitude, climate, and soil type. Suppliers should also be able to provide information on seed storage and pre-treatment and use of inoculants.

The quality of imported seeds may be variable, even from previously good sources. Local management, policies, or seed sources may have changed. Otherwise good seeds may be damaged in transit by heat, cold, or long delay. Seeds shipped by air freight and arriving in Honolulu from abroad must be picked up at U.S. Customs either personally by the grower or by a broker on the grower's behalf. Growers need to balance any savings in cost of imported seeds or the better availability of certain species against the additional cost and risk of importing seeds from abroad.

Queensland maple (*Flindersia brayleyana*, left) and toon (*Toona ciliata*) are useful forest trees imported recently to Hawaii and not widely grown elsewhere.



Silk-oak (*Grevillea robusta*) is a recent forest tree introduction that has become a weed of Hawaii's forests, invading native ecosystems after they are disturbed.

Collecting seed

A permit to collect seed from Hawaii's state forest reserves must be obtained from the Division of Forestry and Wildlife of the Hawaii Department of Land and Natural Resources (DLNR-DOFAW). While permits are free for growers collecting for personal use, there is no current mechanism for commercial seed collection from the state forests. If collection is to be done on private land, permission of the landowner should be obtained.

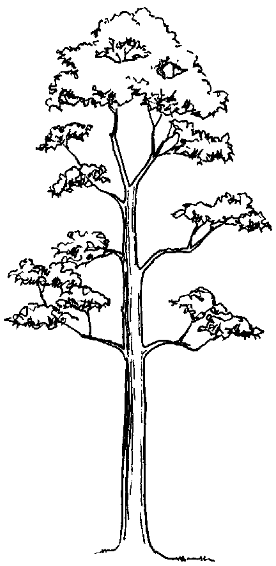
Weediness

Many useful plants that have been introduced to Hawaii have escaped cultivation and are now pests invading native ecosystems. Forest tree examples include *Albizia falcataria*, silk-oak (*Grevillea robusta*), and black wattle (*Acacia mearnsii*). No species that has a history of becoming weedy in new habitats should be introduced into Hawaii. Furthermore, species that are problems on only some islands in the state should not be introduced to other islands. Extra care should be taken in forestry projects adjacent to native forests or other natural areas. For more information on weedy species in Hawaii, consult the Hawaii Ecosystems at Risk web page at <http://www.hear.org>, or contact the Forest Health Project of the USDA-Forest Service's Institute of Pacific Islands Forestry (23 E. Kawili St., Hilo, HI 96720, 808-933-8121).

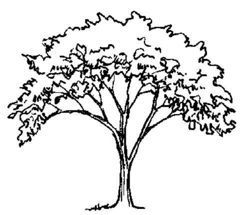
Selecting a seed source for collecting

Most growers are careful to select the species of tree that will best suit their needs. Many, however, do not realize that within a given species, *provenance* is also important. "Provenance" may be defined as an area in which trees grow under similar environmental conditions. Often it is important to choose as a seed source a provenance with an environment closely matched to that of the planting site. Matching seed source to the site helps ensure high survival and good growth of the trees planted. For example, in one experiment, koa from wet sites above Hilo showed much lower survival when planted on a dry site on Oahu than koa from dry sites on Oahu and Maui. Factors to consider in addition to rainfall include elevation, temperature range, and the soil type, including soil pH, texture, depth, and drainage. Native tree species in Hawaii have been shown to have genetically different populations at different elevations.

Selecting the right type of tree as a source of seeds.



desirable timber form: tall and straight with few branches



short with many branches; good for fodder, not timber

trunk divides into several vertical branches; good for windbreak, not timber

poor bole form; not useful for timber

For koa, for example, it is best to collect seeds from a location that is no more than 1000 feet different in elevation than the planting site. Consideration must also be given to moving trees to different latitudes. If the seed collected is to be used in a number of different sites, it is best to collect from several different places within the native range of the species.

Extra care needs to be taken with seeds collected from plantations. The original seed source for the plantation may not have been a good one, in which case the seeds from that plantation will pass on the plantation's poor characteristics. The plantation itself may have been put in a place where the trees do not grow well, and planting seeds from that plantation in a similar environment would be a mistake. How well the trees in the plantation are growing, of course, indicates how well they are adapted to that site. Many plantations have historical records that indicate the seed source and growth rates. It should be assumed that most plantations are from single-seed sources or provenances unless documented otherwise. However, koa plantations in Hawaii were produced from bulked seed from many sources, so the quality of seeds collected from these plantings will be uneven.

Seed collection

Timing

Most trees flower at a certain time of year, often during the dry season, and they set seed sometime later. Successful growers plan ahead to collect and store seeds in advance so that they are available in the following planting season. Often, local knowledge is the best source of information. It is best to collect a crop's seed at the time when most of it is becoming ripe. The first and last fruits are often irregular, and their seeds will not produce healthy seedlings. Some trees do not set seed every year, and some do not set seed at all in some climates (for example, madre de cacao [*Gliricidia sepium*] does not set seed if there is no dry season). If seeds will be needed annually, it pays to collect extra in years when seeds are abundant to ensure an adequate supply in sparse years.

Selection of mother trees

Seeds should be selected from the best trees in a healthy stand. The trees should be growing vigorously and free of disease. For timber and pole production, the best trees are tall, straight, and fast growing, with few branches. For fodder production, the best trees are leafy and will grow back quickly when trimmed; they may be branchy and have several stems. Straightness is less important for windbreak trees than for timber trees. The observed character of a tree in the field—the phenotype—is a product of both the genetics of the tree and the environment in which it grows. The portion of the tree's characteristics that is inherited—the genotype—is the portion that will be passed on to the next generation. Growth rate is often largely determined by the environment (a particular tree may be growing in deep soil or in a sheltered position), but branchiness, forkedness, and wood quality are based on genotype and highly heritable. While stem form usually varies among individual trees, adaptation to a particular environment usually is common to a population. Thus, collectors should first select a site to match the planting site, then collect from the best trees in that site.

Unfortunately, the tendency is to collect from the most convenient trees, which may be the least desirable. For example, seeds are often collected from short, bushy trees with low branches that are easy to reach, but these seeds will probably not produce good timber trees. Workers collecting seeds may need to be closely supervised, but any extra effort in collecting usually pays back in much better results.

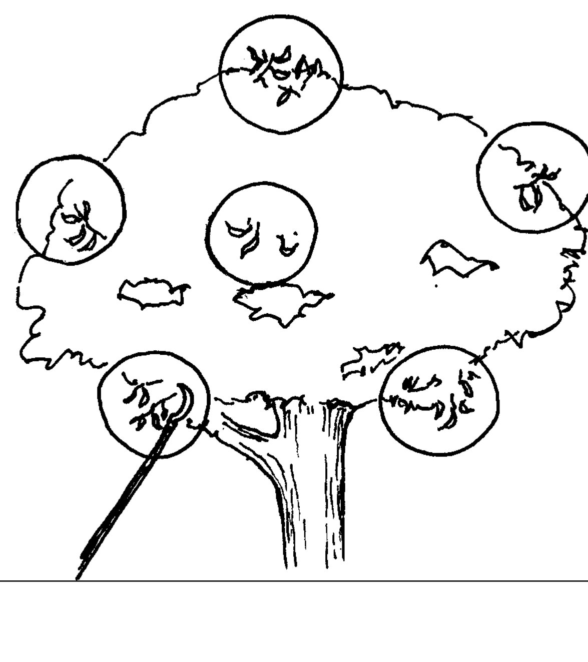
Seeds should be collected from mature or nearly mature trees so that the form of the parent can be observed. The first seeds borne on a tree usually have poor germination. Isolated trees of naturally cross-pollinating species (for example, low-elevation koa populations) should be avoided, because if these are self-pollinated the seedlings may be weak and deformed. Also avoid stands that contain numerous abnormal or diseased trees, as the tendency toward these undesirable characteristics may be carried by even the healthy trees in the stand.

As a rule of thumb, seeds should be collected from at least 25 individual trees to ensure that the seedlot will contain all the representative characteristics of the species at that site. Seeds collected from just a few parent trees, and thus genetically similar, will produce genetically similar trees that may be more susceptible to sudden disease and pest infestations. It is best to collect from as many individual trees as is practical. In cross-pollinating species, seeds should be collected from different locations in the tree's canopy to ensure maximum genetic diversity. Some species produce large, heavy seeds that fall directly under the mother trees. Adult trees in these stands are likely to have come from the same mother tree and thus be closely related to each other. To get a genetically diverse seedlot, collect seeds from trees that are separated by several times the width of one tree's crown. If plantations were grown from a genetically diverse seed collection, neighboring trees will not be related, so seeds may be collected from adjacent trees. Some plantations, however, have been established from the seeds of only a few individuals, and it would be best to collect only a small amount of seeds from them to be mixed with other seedlots.

Tree improvement programs

Traditionally, foresters have tried to collect seeds for plantations from natural trees with the best observed phenotype ("plus trees"). Many trees with good genes, however, do not live up to their potential in the wild because of a harsh environment. Tree-improvement programs grow trees from many different seed sources together in a plantation environment in order to select the best performing genotypes. For koa, seeds taken from some outstanding wild trees have produced only mediocre offspring, while seeds from wild trees with relatively poor appearance have produced outstanding offspring. When a species has been the subject of a tree-improvement program, the growth and production benefits of the selected seeds usually far outweighs the additional cost.

Collect seeds from various locations on the parent trees.



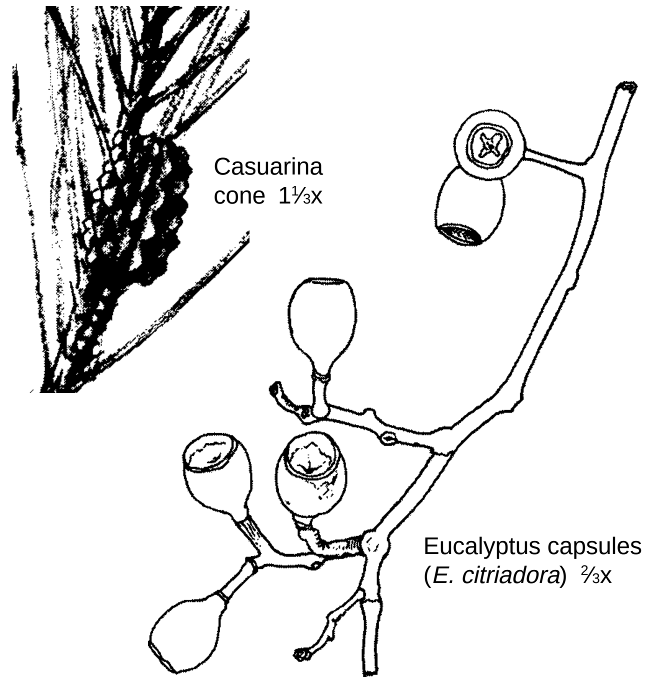
Selection of fruits and seeds

Only fully ripe seeds should be collected, because only these can be stored, even though green seeds may be viable. Most pods and fruits will change color when ripe, from green to red or brown. A few seed pods should be broken open to observe the ripeness of the seeds. Seeds usually are ripe when they become brown or tan and hard. Cones from pines (*Pinus*) and other conifers, alders (*Alnus*), and ironwoods (*Casuarina*) need to be collected after they begin to turn color but before they open and scatter the seeds. Seed capsules of many *Eucalyptus* species may remain closed and attached to the branches for over a year. Care must be taken to collect only ripe capsules and not immature or empty ones.

Methods of collecting

Pods, cones, fruits, or seeds ideally should be collected right off the tree as they ripen. Pods and cones can be broken off overhead branches with a forked stick or cut off with clippers, a pruning hook, or a pull saw attached to a pole and collected with a bag attached to another pole. Alternatively, entire branches can be cut off the trees, or seed collection can be done at the same time as the trees are harvested. Cutting branches will of course set back a tree's growth and could introduce rot into the tree. For koa trees, if branches greater than half an inch are cut, the branch may not bear seed for several years. If a branch is to be cut, an undercut should be made first so that the falling branch does not tear the bark from the stem of the tree. Another method is to spread tarps or mesh nets below the tree and shake or beat the seed-bearing branches. A rope with a weight tied around one end can be thrown up and wrapped around a branch to pull the branch down to within reach of the collectors. Although it is also common practice to climb trees to collect seeds, this method is dangerous without proper safety equipment and experience.

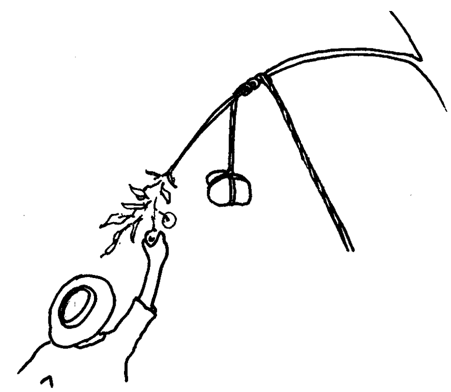
For some tree species, however, the pods shatter as soon as they are ripe, and it is very difficult to find ripe seeds on the trees. Other trees may be so tall as to make it impossible to collect seeds off the tree. For these, it may be necessary to collect seeds from the ground. One difficulty with this is that it may not be possible to identify the mother tree. While hard-coated seeds may not suffer too much from being in contact with the ground, there is an increased risk of damage by insects, fungi, and premature germination. Koa seed is particularly



Methods of removing seeds from branches

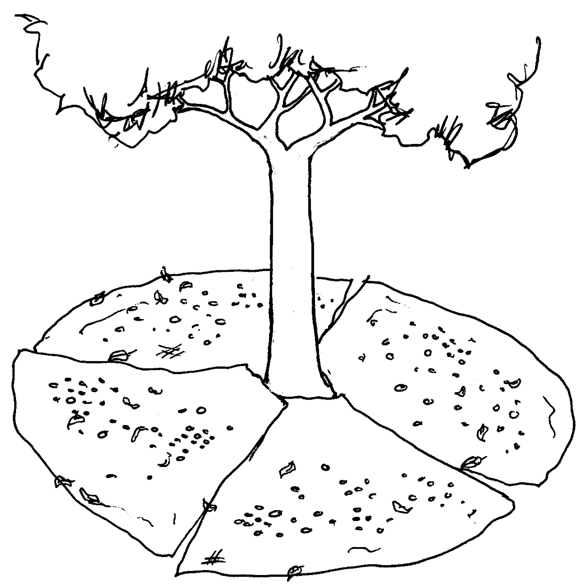
subject to insect infestation. In some areas in Hawaii, rats destroy most seeds of many native species, including the sandalwoods. One method of collecting seeds from the ground is to sweep or clean the area under a bearing tree of all old seeds, then collect only the fresh seeds that fall in subsequent days. Tarps laid under the trees can aid seed collection, or fine mesh netting can be suspended under trees to collect seeds as they fall. All such seeds must be carefully cleaned and inspected.

Some strategies for collecting seeds



A rope and weight can bring branches within reach.

Climbing trees to pick seeds can be dangerous.

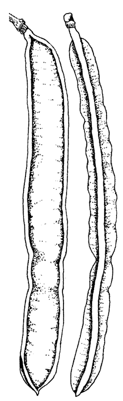


Tarps on the ground aid seed collection.

Seed handling and processing

Seed extraction and cleaning

Some trees bear their seeds in pods or capsules that are easily opened, especially when they are thoroughly dried. Sun-drying will cause pods of the mahoganies and eucalypts to crack and release the seeds. Pods of eucalypts need to be dried and then shaken to extract the seeds; aborted ovules will be extracted along with the viable seeds, and this “chaff” is difficult to separate. Pods from some trees may be placed in a sack and trammeled or flailed before winnowing the seeds from the broken pods. Screens also can be used to separate seeds.

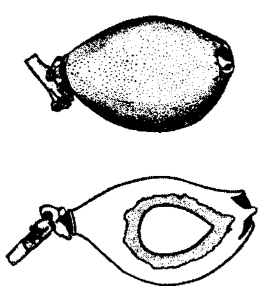


Monkeypod pod ¼x

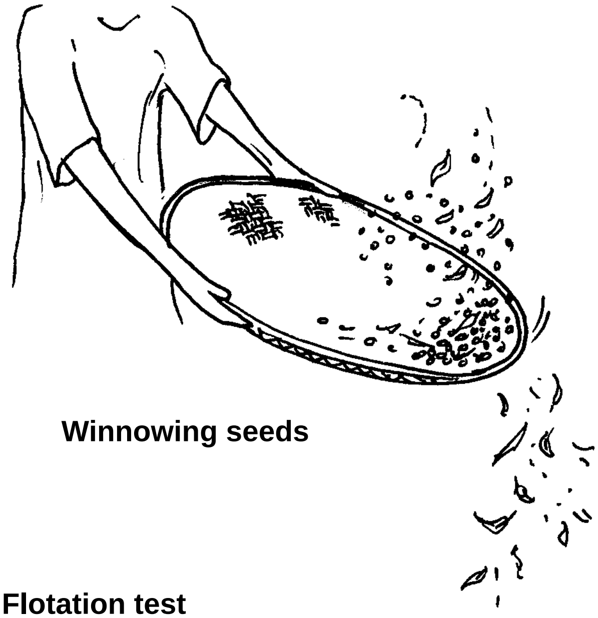
Some species such as monkeypod (*Albizia saman*) have seeds in hard-to-open pods or pods with a gum or sticky substance around the seeds. Hard seed pods may need to be opened with a machete or broken with a hammer. Usually, gummy material can be removed by a brief water soak.

After threshing and winnowing, seeds can be further cleaned by briefly immersing them in a bucket of water. Good seeds will sink, while pieces of pod, aborted seeds, and seeds damaged by insects will float to the top and can be thrown away. The seeds then should then be dried to prevent premature germination, unless they are to be sown immediately.

Some species, such as neem (*Azadirachta indica*) and the sandalwoods (*Santalum* spp.), have large seeds in a fleshy pulp. This pulp will quickly rot, which may kill the seeds, so it should be removed if the seeds are to be transported or stored. The fruits may be soaked in cool water a day or two to soften the pulp, then macerated and rinsed under running water or passed through a sieve. Fermentation usually should be avoided, as it may harm the seeds. Some fruits, such as those of chinaberry *(Melia azedarach)*, have a stone containing several seeds, which is usually sown whole. Others have individual seeds in the fruit, such as the mulberries (*Morus* spp.), and require greater care when handling.

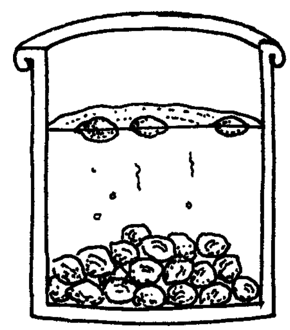


Sandalwood fruit (and cross-section showing seed) 2x

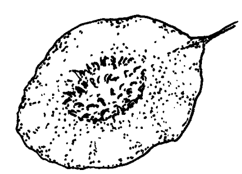


Winnowing seeds

Flotation test



Seeds in winged pods, such as those of narra *(Pterocarpus)*, cannot be easily removed from the pod. They are dried, then stored while still in the pod. Teak seeds also are usually not removed from their round fruits.



Nara seed pod ¼x

With conifers, the cones need to be dried for the seeds to fall out. Pine cones need to be dried slowly so that the resin on the cones does not harden and seal the cone shut. Ironwood (*Casuarina*) cones may be dried for three days under a cloth to avoid excessive heat, then tumbled in a container to remove the seeds. *Eucalyptus* capsules also must be dried in order to extract the seed. Tiny seeds such as these also should be treated with an insect repellent keep away ants.

Grading

After the seeds are cleaned, discard any that are clearly smaller or deformed, because these will not produce healthy seedlings. Undersized seeds may be separated with screens of appropriate sizes. Also, discard seeds that show holes or other insect damage or that have become moldy.

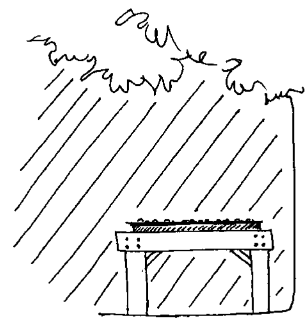
Drying

Seeds of most species of forest trees are best stored when dried. These are called *orthodox* seeds. Drying reduces the chances of the seeds being damaged by fungi or insects and prevents premature germination. When seeds are dry enough for general use, they will usually snap or crack, rather than bend, when pinched or bitten. Drying seeds to between 4 and 8 percent moisture content is recommended, but this is difficult to measure without special instruments. If the seeds are already reasonably dry when harvested, they can be satisfactorily dried in the sun for two to three days in humid areas or just one day in dry areas. If newly harvested seeds still are soft or moist, they should be first slowly dried in the shade to bring them to a lower moisture content before sun-drying them. Keep air circulating above the seeds with an electric fan. Sun-drying is best done in the morning or late afternoon, not at midday, and seeds should never be dried under glass or on top of tin sheeting, black plastic, or similar material, as excessive heat (greater than 100°F) may kill them. Seeds should be spread thinly on tarps, mats, or winnowing trays and turned or mixed four or five times during the course of the day. Sun-dried seeds should be allowed to cool off before being stored. If it is possible to dry seeds at cool temperatures in a controlled-humidity chamber, this gentler treatment will prolong storage life. One recommendation is to bring seeds into equilibrium with 20–30 percent atmospheric relative humidity at 50°F. Seeds may also be dried by sealing them in jars with silica gel (available from photography stores). Use a relative humidity card to monitor humidity in the jar and change the silica gel frequently until the humidity drops below 10 percent.

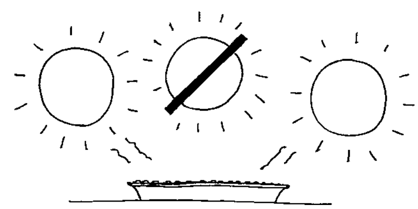
A few species of trees, such as cacao (*Theobroma cacao*) and Norfolk Island pine (*Araucaria* spp.) have seeds that will be killed by drying. Called *recalcitrant* seeds, these seeds have a high moisture content when harvested and do not develop a hard coat and go into dormancy as other seeds do. They are usually ripe when the seedcoat is dark. Since they are still respiring ("breathing"), they must be kept moist and treated similarly to mango or other fruit tree seeds. Even so, they will lose viability rapidly and must be planted soon after collection, usually within a few days or weeks.

Use care in drying seeds

Dry moist seeds slowly in the shade to reduce their moisture content before sun-drying.



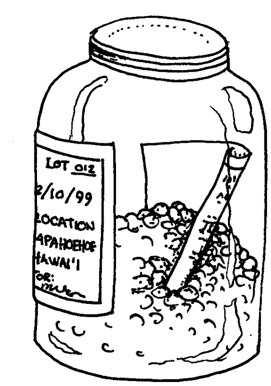
When sun-drying seeds, avoid direct sun during the hottest part of the day.



Seed storage

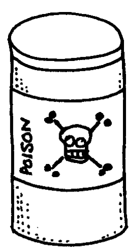
Orthodox seeds

Seed viability and longevity can be greatly affected by how seeds are stored. Since many tree-planting projects get off to a bad start because of poor seed viability, it is important to store seeds properly. Orthodox seeds behave like wood, absorbing moisture from the air when it is damp and releasing it when it is dry. They are best dried and then kept in tightly sealed containers so that they do not reabsorb moisture from the air. Jars, especially those with gaskets, or resealable tin cans make good containers. Plastic containers may not be airtight.



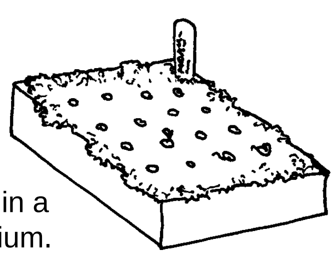
Silica gel, charcoal, sawdust, or other desiccants can be added to absorb any excess moisture. This is especially important if the container is to be opened frequently. Containers should be filled as full as possible to exclude air, so small containers are best for small seedlots. Foil-lined plastic bags that are heat-sealed are available for commercial applications. Regular plastic bags do not work as well as solid containers, because some moisture diffuses through them. Cloth or burlap sacks keep out neither pests nor moisture, and seeds stored in them must be periodically removed and re-dried.

Orthodox seeds also keep better if kept cool. This is because seeds are, after all, alive, and cooling them and reducing their contact with oxygen slows the rate of respiration and allows them to live longer. Most orthodox seeds will keep longer refrigerated than at outside temperatures—storage life approximately doubles for every 20°F decrease in temperature. Many seeds can also tolerate freezing and are best stored in a freezer, as long as they are properly dried. (Ice crystals forming in still-moist seeds will kill them). Properly dried and cleaned seeds should have no insect or fungus problems. Fungicides cannot be used with dry seeds, as they are made to work only when dissolved in water. If pesticides are added to a seedlot, the container needs to be carefully labeled to avoid accidental poisoning.



Recalcitrant seeds

Recalcitrant seeds need to be kept moist, just as though they were still in the fruit. If possible, they should be planted directly after extraction. For short-term storage, these seeds can be packed in a porous substance such as sawdust, peat moss, or vermiculite and kept well ventilated and moist. If recalcitrant seeds are packed too tightly, they will cease respiring and begin to ferment. They should be stored in a cool area, but not refrigerated. Washing the seeds and dipping them in a mild bleach or fungicide solution will retard the growth of fungus. Even under the best conditions, the period of viability for recalcitrant seeds will be only a few days or weeks.



Keep recalcitrant seeds in a moist, well aerated medium.

Labeling

All seeds need to be properly labeled and identified when stored or transported. Labels should include

- the species
- location seed was collected including latitude and longitude
- environmental factors such as rainfall, temperature range, and elevation
- number of trees collected from
- date
- collector's name
- seedlot number
- recommended scarification technique
- germination percentage if available
- the weight of seed in each container
- any insecticide or fungicide treatment.

Labels should be placed both on the inside and the outside of the containers.

Acme Seed Company
P.O. Box 000
Hilo, HI 96720 USA

Accession No.:	12345	Elev. (m):	260
Collected:	July 1998	Rainfall (mm):	1520
Species:	Gmelina arborea	Seed mother trees:	30
Provenance:	Muak Lek	Germination %:	45
Country:	Thailand	Gram seeds:	200
Lat., Long.:	14°00'N, 100°00'E	Viable seeds (no./g):	1
Collector:	J. Rock	Scarification:	None

Quality testing

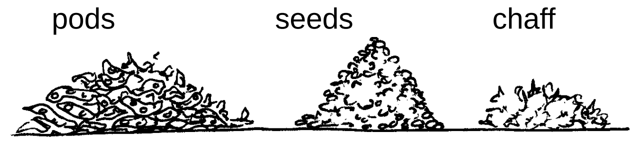
Before planting seeds, the quality should be tested so that the amount of seeds needed can be calculated. Seedlot quality includes both the purity of the seedlot and the viability. *Purity* is the measure of how much of the stored resource is the desired seed and how much is refuse such as broken pods, sticks, seeds of other plants, etc. *Viability*, usually expressed as a percentage, is how many of the seeds will germinate. Even under optimal storage conditions, different species' seeds have different shelf lives, so it is best to consult viability tables (for well characterized seeds) or do a viability test before planting.

Purity can be determined by taking a small amount of the seedlot, thoroughly cleaning it, then weighing the seeds and the refuse. From these data, the percentage of seed in the seedlot can be determined. Viability is most easily tested by doing a germination test. At least 100 seeds, randomly chosen from the seedlot, are tested for germination. This is enough to get a good estimate of seedlot viability and is used to determine the entire amount of seeds needed for a planting project. For a germination test, seeds do not necessarily have to be planted in pots but should be pre-treated in whatever manner necessary and sown closely together on moist sand, soil, or even between sheets of damp cloth or paper that are kept moist and well aerated. Germinating seeds should be counted daily (weekly for slower-germinating species) until germination stops. The number of seeds that germinated divided by the number sown, times 100, gives the percent viability. To determine the amount of seeds needed for a project, the number of seedlings needed should be divided by the percent purity, the percent viability, and the percent seedling survival in the nursery. For example, if 1000 seedlings are needed and the seedlot purity is 95 percent, the viability is 80 percent, and 15 percent of the seedlings are expected to die or be culled in the nursery, then 1000 / (0.95 x 0.80 x 0.85) = 1548 seeds needed. Project planning is easier if purity and viability are determined when the seed is stored and written on the label, but old seed should be re-tested before being used.

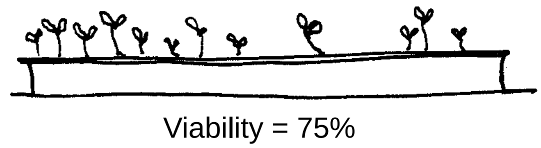
Pregermination treatments

Many forest tree seeds remain dormant for some time after they mature. Dormancy is a mechanism designed to allow a certain time interval between seed maturity and germination. Many tree seeds, including those of koa, are protected by a thick, waxy seedcoat. The coat protects them from attack by fungi and insects, and it keeps out moisture, thereby delaying germination. In order for the seed to germinate, moisture must pass through the coat and reach the seed embryo. Under natural conditions, seedcoat dormancy may be overcome by prolonged exposure to soil moisture or saprophytic soil organisms. It also may be overcome by exposure to digestive acids in the gut of a bird or other animal. The process of breaking down this dormancy mechanism is called *scarification*. Various seed treatment techniques accomplish seedcoat scarification and ensure rapid and uniform germination of the seeds planted.

Seed cleaning to obtain pure seeds

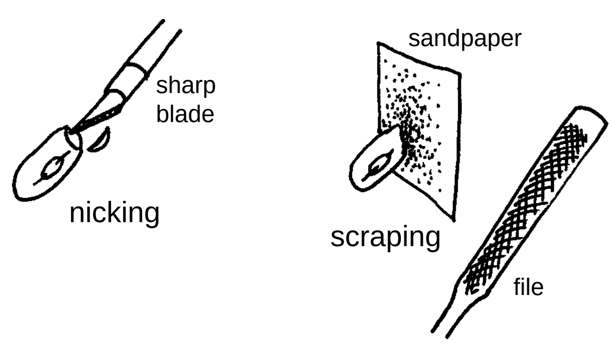


Seed testing to measure seed viability



Seed may be scarified by physically cutting or scraping away part of the seedcoat or by soaking the seed in water. Mechanical scarification works best with large seeds, such as those of *Intsia* or *Erythrina* species (including wili-wili), and it is most practical for small seedlots. Any disturbance to a small area of the seedcoat is likely to be effective, such as being nicked with a knife or nail clipper or scraped with sandpaper or a file. The object is not to remove the seedcoat altogether but to create a small breach in the seedcoat barrier, just enough to allow water to get in. Once the seed begins to soak up water and expand, it will burst out of the seedcoat by itself. The seed should be nicked on the side opposite the embryo so as not to injure it. The fleshy part of the cotyledon should not be damaged; even a small cut into the flesh of the cotyledon can lead to infection. The embryo in a large seed is usually found at the point where a seed was attached to the pod (near the hilum). A few seeds may be cut open to determine the location of the embryo before the entire batch is nicked. Small seeds

Mechanical scarification



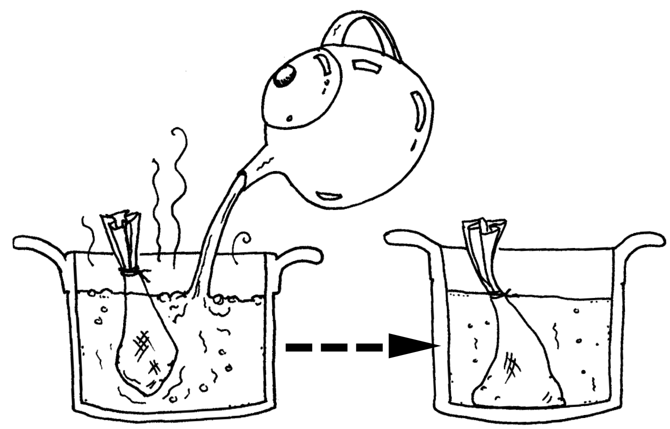
are hard to handle and thus difficult to nick. Spreading them on a hard surface and rubbing them gently with a sandpaper block may result in scarification.

The easiest method for scarifying a large quantity of seeds is by soaking. Some seeds will germinate after an overnight soak in cold water, but others can soak for many days without imbibing water and swelling. Using hot water in various ways can hasten the process. Water that has been brought to a boil and then removed from the heat to cool slightly may be poured over the seeds; after about 30 seconds to 2 minutes, dilute or replace the hot water with cold water. Heat about ten times the volume of water as the volume of seed to be treated, so that the water does not cool too quickly while the seeds are soaking. If a more extreme treatment proves to be necessary, prolong the soaking time, or briefly immerse the seeds in boiling water for 3–15 seconds, then transfer to cold water. Placing the seeds in a mesh bag makes these treatments easier to do.

Soaking seeds in concentrated sulfuric acid is an effective and precise method for small lots of seeds, but it requires training and laboratory facilities to be done safely. Bags made of nylon mesh and sown with nylon monofilament thread are convenient for handling the seeds as they are placed in the acid bath and then removed to a sink for rinsing.

Seed of some species is difficult to scarify by soaking. Teak (*Tectona grandis*) may require several cycles of soaking and drying. For sandalwood, cracking the seedcoat and soaking the seeds overnight in a 2% solution of gibberellic acid has been shown to stimulate germination. Pine and other conifers may require chilling for several weeks before sowing to overcome dormancy in a process called stratification. Among the scarification methods, the mildest treatment that is effective and convenient is usually the best. Experiment with small lots of seed to find the treatment that produces the most complete imbibition, and then observe germination and seedling development to be sure that the process has not damaged the seeds. Table 1 (page 15) gives suggested treatments for seeds of some tree species.

Hot-water scarification



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Germplasm collections at the Tropical Center for Agronomic Research and Teaching (CATIE), more international seed suppliers on a searchable directory, mostly in Spanish: <http://www.catie.ac.cr/germoplasma/>.

USDA Forest Service; Reforestation, Nurseries, and Genetic Resources; with online publications including *Tree Planter's Notes*, *Forest Nursery Notes*, and *Raising Forest Tree Seedlings at Home*: <http://willow.ncfes.umn.edu/snti/snti.htm>.

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USDA Animal and Plant Health Inspection Service (APHIS), for information about importing seed to the US: <http://www.aphis.usda.gov/>.

Seed storage for native Hawaiian plants: <http://www2.hawaii.edu/scb/scinativ.htm>.

Supplier

State Tree Nursery, Division of Forestry and Wildlife, Hawaii Department of Land and Natural Resources, Hilo office, 808 974 4221.

Glossary

Adaptation A genetic change in an individual or population of plants that results in better growth or survival.

Characteristic A recognizable trait or feature of a plant.

Cotyledon Fleshy, leaf-like structure in the seed; contains food reserves for the new plant.

Cross-pollination Pollination by a genetically different plant.

Dormancy A state where visible growth and development are suspended; a resting stage.

Embryo The tiny, developing plant inside the seed.

Exotic Introduced to an area outside the natural range.

Genetically diverse Containing a range of different inherited traits.

Genotype The genetic characteristics of a tree.

Germination percentage The percentage of seeds in a seedlot expected to germinate.

Inoculant Culture of a microorganism (e.g., rhizobium bacterium, mycorrhizal fungus) applied to seeds to ensure symbiotic infection of the plant by the organism.

Nicking Cutting or chipping away part of the seed coat with a tool (e.g., knife, fingernail clipper).

Orthodox seeds Seeds with a long life span (months or years), which can be stored dry and cold.

Phenotype The characteristics of a tree, both those caused by genetics and by the environment.

Plus tree A wild tree selected to be outstanding in certain characteristics, i.e., phenotypically superior.

Provenance A geographical area of origin in which trees grow under similar environmental conditions.

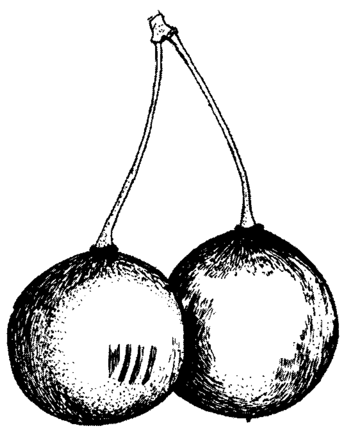
Purity The measure of how much of the stored seed resource is actually seeds of the desired species, as opposed to plant debris, seeds of other plants, etc.

Recalcitrant seeds Seeds with a short life span, which usually must be kept moist and warm.

Scarification Opening or softening the seed coat so that water can penetrate into the seed, or any other technique of breaking seed dormancy.

Stratification Exposing seed to a cold, moist treatment to overcome dormancy.

Viability The percentage of seeds in a seedlot that will germinate.



Kamani fruit ⅔x

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Characteristics of the seeds of some common forestry trees in Hawaii.

Species	Scarification method (key below)	Number of seeds per pound (or ounce)	Seed type[z]	Germination time (days)
Acacia auriculiformis	A, 30 sec.; B	15,000–40,000	O	6–60
Acacia koa, koa	A	2400–7500	O	11–24
Acacia mangium	A, 30 sec; B	20,000–50,000	O	3–6
Albizia lebbeck	A; B; C	3,000–8,000	O	4–5
Albizia (syn. *Samanea*) *saman*, monkeypod	A; B	2000–4000	O	9–18
Alnus nepalensis, Nepal alder	N	5000–50,000/oz	O	7
Aleurites moluccana, kukui	B	45	O	10
Araucaria columnaris, Norfolk Island pine	N	900–1200	R	10
Azadirachta indica, neem	N	2000–5000	R	4–35
Calliandra calothyrsus	A; B; C	9000–10,000	O	4–10
Calophyllum inophyllum, kamani	B; C	60	R	30–100
Casuarina cunninghamiana, small-cone ironwood	N	43,000–46,000/oz	O	28–42
Cedrela odorata, Spanish cedar	N	10,000–25,000	O	7–28
Cordia subcordata, kou	B; C	500–600		20–90
Cryptomeria japonica, Sugi pine	C; D, 34°F, 60–90 d	145,000–150,000	O	14
Cupressus lusitanica, Mexican cypress	D, 34°F, 30 d	119,000	O	14
Dalbergia latifolia, Indian rosewood	C, 1–2 d	10,000 cleaned	O	7–21
Dalbergia sissoo, sissoo, rosewood	C, 1–2 d	20,000 cleaned	O	7–21
Erythrina sandwicensis, wili-wili, coral tree	B; C	1000–2500	O	3–14
Eucalyptus deglupta, rainbow gum, kamarere, Mindanao gum	N	650,000/oz, [28,000–56,000][y]	O	7–10
Eucalyptus grandis, rose gum	N	350,000/oz [5600–34,000][y]	O	14–29
Eucalyptus microcorys, tallowwood	N	[1500–25,600][y]	O	24–28
Eucalyptus robusta	N	200,000/oz [5700–20,000][y]	O	18–28
Eucalyptus saligna	N	30,000/oz [2400–26,000][y]	O	28
Flindersia brayleyana, Queensland maple	N	4450–5300	O	7–20
Gliricidia sepium, madre de cacao	N	3000–6000	O	3–14
Intsia bijuga, merbau, ipil	B	80–100	O	11
Khaya spp., African mahogany	N	1300–3000	R	18–21
Leucaena leucocephala, koa haole	A; B	10,000–15,000	O	2–30
Lophostemon (syn. *Tristania*) *conferta*, brushbox	N	140,000/oz [3000][x]	O	10–14
Metrosideros polymorpha, ohia	N	many thousands/oz	R	30–90
Pinus radiata, Monterey pine	D, 40°F, 21 d	13,000	O	7–28
Pterocarpus indicus, narra	C; N	500–1000	O	14–28
Santalum ellipticum, coast sandalwood	B; see text	2700–3000	R	21
Senna (syn. *Cassia*) *siamea*, pheasantwood	A; C	12,000–18,000	O	4–40
Sesbania sesban	B; C	40,000–50,000	O	3–10
Swietenia macrophylla, big leaf mahogany, Honduras mahogany	N	600–900	O	15–30
Swietenia mahogani, West Indies mahogany	N	3000	O	18–30
Tectona grandis, teak	C, 6 wet-dry cycles	400–1,000 for whole fruits	O	10–100
Thespesia populnea, milo	N	1600–3000	O	14–28
Toona ciliata, toon	C	133,000–174,000	O	1–14

Scarification method:

A = Pour boiling water over seeds; allow to soak for 2 minutes or time specified; pour off hot water; replace with cool water; soak overnight.
B = Nick, crack, or cut open the seedcoat with a file or knife; do not damage cotyledon.
C = Soak in cool water for 24 hours or time specified.
D = Pre-chill at temperature and for time specified.
N = No treatment needed.

[z]O = orthodox, R = recalcitrant.
[y]Number of viable seeds per ounce of seeds plus chaff.
[x]Number of viable seeds per ounce, uncleaned.

Main references: Forest, Farm, and Community Tree Network; International Plant Genetic Resources Institute; Seeber and Agpaoa 1976; USDA Forest Service 1974; Young and Young 1992.