Seed Source Establishment and Management

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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 at the community level to improve the availability and utilization of quality seed.
- No labeling or certification systems exist to provide adequate information (to the farmers and NGOs) concerning the origin and quality of the tree seed that is available.
- No premium is paid for better quality tree seed.

Definitions for Common Tree Seed Terms

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.

- 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.

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.

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. To maximize the genetic base and productivity of on-farm tree sources, the following approach for establishing on-farm seed trees is recommended.

Site selection and tree planting

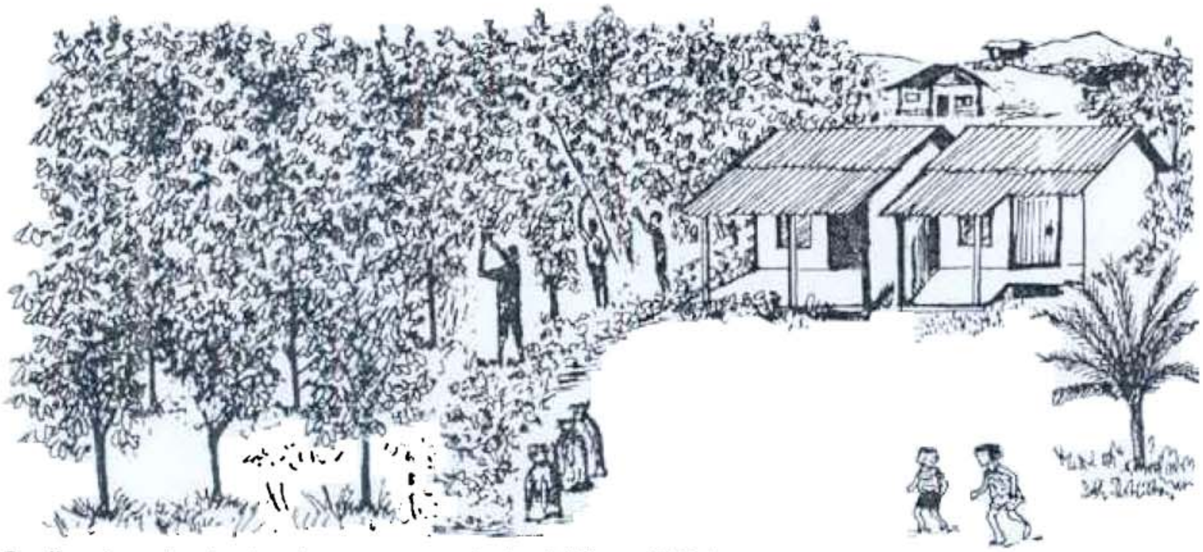
- First, environmental conditions of the site — rainfall, temperature, elevation, and soils — must be appropriate for the target species.
- To improve tree survival and growth thorough land preparation should precede seed tree establishment.
- Wider spacing between seed trees and other trees enhances 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 2 x 4 or 3 x 3 m. After these trees become large, thinning should be conducted to achieve wider spacing and remove the poorer quality trees. Additionally, seed trees should not be planted closer than 4 m 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.

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.
- 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. Multipurpose 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.

Establishment of a 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.



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

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.

Site selection for seed orchards

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.

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.

Seed orchard size

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. 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.

Seed Orchard Design

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 m. A hedgerow design is common for fast growing leguminous species, such as *Calliandra calothyrsus* (red calliandra), *Flemingia macrophylla* (flemingia), *Gliricidia sepium* (gliricidia) and *Leucaena* species (ipil ipil). Most other species will be established in a block design. Initial spacing may be 2 x 4 m, 3 x 3 m, or even wider. Narrow spacing such as 2 x 4 or 3 x 3 allows for intensive thinning, see details below under "Orchard spacing."

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.

Seed Orchard Management

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.

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 2 x 4 or 3 x 3 m. 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 then 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 8 x 8 to 10 x 10 m). 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 m height once or more per year. Every two m 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 m 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 practices 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. Cover crops may also be used to control weed growth and improve soil fertility. However, cover crops are often management intensive. Also, since cover crops 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!

References

IFSP. 2000. Demo room poster. Indonesian Forest Seed Project (IFSP). Bandung, Indonesia.

IFSP. 2000. Visual presentation of extension material. Indonesia Forest Seed Project (IFSP). Bandung, Indonesia.

Chamberlain, J.R. 2000. Improving seed production in Calliandra calothyrsus a field manual for researchers and extension workers. Oxford University Press, Oxford, UK.

Dawson, I. and J. Were. 1997. Collecting germplasm from trees – some guidelines. Agroforestry Today 9: 6–9.

Schmidt, L. 2000. Guide to handling of tropical and subtropical forest seed. Danida Forest Seed Centre (DFSC). Humlebaek, Denmark.

Simons, A.J. 1997. Tree domestication – better trees for rural prosperity. Agroforestry Today 9: 4–6.

Stubsgaard, F. 1997. Tree climbing for seed collection. Technical Note. Danida Forest Seed Centre, Humlebaek, Denmark.

Willan, R.L. 1985. A guide to forest seed handling. FAO. Rome, Italy.

Yaacob, O. and S. Subhadrabandhu. 1995. The production of economic fruits in South-east Asia. Oxford University Press. Kuala Lumpur, Malaysia.

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Seed Sources

Lars Schmidt

Seed propagation is the principal mode of propagation for trees in temperate as well as in tropical regions. Seeds are unique in natural regeneration and propagation because:

1 Seeds constitute unique genetic compositions, resulting from mixing parental genetic material. The result is genetic variation of the offspring, which in turn enhances ecological adaptability.

2 Seeds are usually produced in large numbers and are readily available, each year or at longer intervals.

3 Seeds are (usually) small concentrated packages of plants-to-be, containing nutrients for the establishment of the plant and, except for recalcitrant (short-lived) seeds, usually resistant to damage and environmental stress.

4 Many seeds can be stored for long periods under cold dry conditions.

Considering that in a regenerational context only one successful seed (or two if the species is dioecious) is necessary to replace the parent tree(s), the production of seeds during the lifetime of a tree is exorbitant. A full grown *Eucalyptus camaldulensis* tree may produce a million or more seeds per year and may live and produce seeds for a century. Each year's production could afforest several hundred hectares. Although seed production is smaller in most other species, it is probably never a limiting factor in natural regeneration. Each seed contains the potential for becoming a full grown tree, but in nature most of the seed production will succumb to failed dispersal, predation, infestation, natural deterioration, germination failure, etc.

The objective of seed handling is to achieve a high survival and germination rate of the seed. Seed handling encompasses a series of procedures beginning with selection of the best quality seed source, collection, processing, storage, pretreatment, and germination. Each link of this chain implies a potential risk of losing seed, and any link in the process is of equal importance (though not necessarily equally sensitive). If a seed dies due to careless handling during collection or processing, even the best storage, pretreatment or germination conditions will not bring it back to life. If a seed dies during a handling procedure, the whole preceding effort is wasted.

The whole process of seed handling begins with collection of good-quality seeds, both physiologically and genetically. The genetic quality of seed will affect a plantation for years ahead, and since the operational cost of seed handling is almost the same regardless of genetic history, expensive handling will pay better when applied to good quality seed. Referring to the genetic quality of seeds, the Australian Tree Seed Centre has adopted the slogan: "Good seed does not cost—it pays" (Midgley 1996), meaning that the small investment in obtaining the best seed source is minor compared to the potentially better growth of the offspring.

Genetic Quality of Seeds

The term "seed source" applies to the stand of trees where seed is collected. A seed source can be a number of single trees, a natural stand, a plantation, and a seed-production area or seed orchard. Seed trees are the individual trees from which the seeds are collected. Potential seed sources are identified in the planning phase; actual seed trees are often only selected during the seed collection. "Phenotype," simply put, is the tree as we observe it, and "genotype" is the genetic constitution of the tree.

A seed source should yield an appropriate quantity of seed with a high physiological and genetic quality which matches the plantation site and purpose. In general the seed trees should be of good phenotype, neither juvenile nor over-mature and good seed producers (Morandini 1962). For special planting purposes, for example conservation or provenance seed stands, special consideration on sampling for the capture of genetic diversity may be included. For plantations not intended for future seed production, genetic diversity is usually of less importance, but collection should avoid inbred seed and inferior parent trees, which may affect the performance of the plantation. If, however, the plantation is envisaged to become a seed source itself some time in the future, appropriate measures should be taken to assure reasonable genetic diversity.

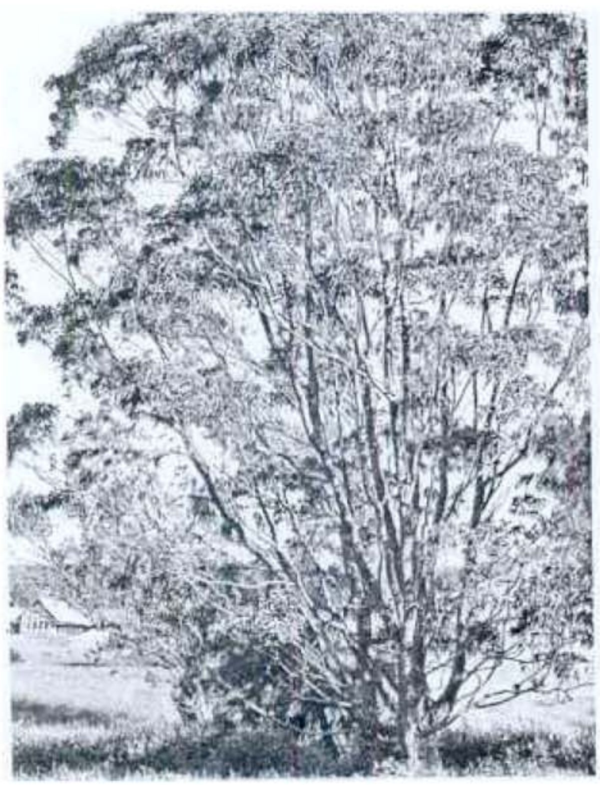
The genetic constitution or inheritance carried by the seeds makes up the potential performance of the progeny: if the genetic potential is poor, the performance will remain poor regardless of environment and silvicultural efforts; if the genetic potential is good, this potential may be expressed by appropriate silvicultural measures. Genetic quality can only be proven by genetic tests (e.g., progeny tests) which are outside the scope of this article. Yet, in the selection of seed sources and seed trees of unknown genetic constitution a few measures and precautions can and should be taken in order to avoid genetic inferiority, *viz.*

Avoid Seeds from Related Individuals and Inbred Populations

A narrow genetic base implies a risk of inbreeding. In a population of few flowering individuals the risk of self-pollination is high, and unless the species has a strong inbreeding barrier, many seeds of a small breeding population may be inbred. Isolated trees or trees flowering out of phase with the majority of the population are more likely to self-pollinate and consequently produce inbred seed. Therefore, such trees should be rejected as seed trees.

Neighbouring trees in natural stands are often half sibs or full sibs (Griffin 1990). Species with short-range pollination and dispersal are more likely to create groups of related individuals in the stand than species with long distance pollination and dispersal. This is especially to be considered in natural stands of a single dominant species, e.g., *Tectona grandis, Acacia senegal, Brachystegia* spp. and many pines and eucalypts. A distance of 100 meters between seed trees is usually considered a minimum in natural stands, but it depends on collection purpose (Gray 1990, Palmberg 1985). Genetic diversity is also assured by collecting from a large number of seed trees. Special sampling techniques are applied for special collections like trials or *ex situ* conservation (Eldridge *et al* 1992, Palmberg 1985).

The genetic history (e.g., the number of mother trees) of seed sources of planted material is important. Plantations raised from a narrow genetic base (i.e., few mother trees) should be rejected as seed sources. Obviously this is even worse in clonal plan-



tations, unless specifically designed for seed production.

Many exotic plantations are known to have originated from few mother trees during the first introduction. For example, mahoganies (*Swietenia* spp.) cultivated in many parts of Asia are believed to originate from a small number of seed trees in Honduras and Belize. Unless new material from a broader genetic base has been introduced later, plantations raised from seeds of such trees are likely to suffer from inbreeding depression. Other examples of exotic plantations based on a few mother trees are *Cupressus* in Kenya and *Gliricidia* in Sri Lanka.

Compared to natural stands, neighbouring trees in plantations are less likely to be related, provided the total genetic base is broad. This is because both seeds and plants are usually mixed during the establishment. Consequently, distance requirement for seed trees is less strict in plantations than in natural stands. However, as neighbouring trees are likely to be pollinated by the same pollen cloud, seeds collected from two adjacent trees may have a higher probability of being related on the paternal side than two distant trees.

Plantations raised from a broad genetic base and superior phenotypes are good seed sources. Since both seeds and plants have been mixed during establishment, the risk of neighbouring trees being related is not higher than for distant trees. Therefore distance requirement during sampling is less important.

Avoid Collecting from Trees that Appear Inferior

The phenotype (the tree as we see it) is a product of both genotype and environment. A poor phenotype can be caused by detrimental environment and the progeny may perform excellently when grown under favourable conditions in plantations. For example, Lake Albucutya provenance of *Eucalyptus camaldulensis* grows bent and crooked in its natural environment where it is heavily exposed to wind and sand flow. Grown in plantations (e.g., in Israel) the progeny grows fast and straight.

Yet, phenotypic selection does have a justification: if the phenotypic quality is good, then we know that the tree has the genetic potential for good performance; if the phenotype is poor, then we do not know the cause. Hence, in environments with moderate environmental stress a certain selection of seed trees is appropriate. Trees with exceptionally poor phenotypes (multiple stems, forking, attack by diseases, etc.) should be avoided.

To avoid detrimental genetic effects in seed collection the following practical measures are recommended (For. Com. 1994):

1 Avoid seed collection from sites where seed crops are sparse or heavy crops restricted to isolated trees, i.e., give preference to stands with heavily fruiting trees in close proximity to each other.
2 Within the preferred stand, spread each collection over the largest possibly number of widely dispersed trees; collect from at least 15 trees which are preferably at least 100 m apart.
3 Collect from vigorous trees of good form; some defects due to physical damage (e.g., from fire or falling trees) can be ignored.

Species and Provenance

Within a species (or other taxonomic sub-unit) a large variation exists in terms of ecological adaptation and growth forms. In botanical ecology the term ecotype designates a special growth site (habitat), e.g., dry zone, humid zone or high altitude. In forestry the term provenance has come into common use as the place of origin of the planting material because it designates both the ecotype and the growth habit (e.g., fast growth, straightness of stem or other desired traits). For example, *Eucalyptus camaldulensis* grows over most of the Australian continent.

Despite its morphological similarity, various ecotypes occur according to different ecological conditions. Variations of growth habits have been revealed through provenance trials, i.e., trials of comparative performance of different seed sources grown under similar conditions. Provenance names such as Petford and Lake Albucutya are known sources of seeds of the species whose progeny has proven superior growth habit in many areas of the world with climate and soil similar to the original site.

The provenance name normally designates the distinct location of origin of the seed source, for example named from the nearest town, lake, river or hill. An ideal provenance is characterized by (after Barner 1975):

1 It is composed of a community of potentially interbreeding trees of similar genetic constitution (and significantly different from the genetic constitution of other provenances).

2 It is sufficiently large for the collection of reproductive material in quantities significant for forest practice.

3 It can be defined by means of boundaries that can be identified in the field.

Although boundaries of gene flow (interbreeding) may be difficult to define in areas with more or less continuous population, the provenance concept is practical in forestry and should be included in seed documentation.

Holistic Planning

Planning of activities based on biological systems must necessarily be flexible and adjustable since these systems are often unpredictable or things can change rapidly. A crop failure of one species or seed source may be compensated for by a larger collection of another species or seed source. A sudden abundant fruiting of a rarely fruiting species should be taken advantage of by a large collection of that species. In some species, processing can be delayed without detrimental consequences, e.g., for dry orthodox seeds; in other species lack of preparation or shortage of capacity of the processing unit may ruin an otherwise successful seed collection. In some cases seed availability may influence the planting programme, especially for those species where a storage buffer is lacking, e.g., for recalcitrant seeds. Hence, planning and management of seed collection involves the whole seed-handling process.

References

Barner, H. 1975. Identification of sources for procurement of reproductive materials. In: Report on FAG/DAN IDA Training Course on Forest Seed Collection and Handling. Vol. 2: 42–64, FAO Rome.

Eldridge, K., Davidson, J., Harwood, C. and Wyk, G. van. 1992. Eucalypt domestication and breeding. Oxford Science Publication.

For. Com. 1994. Seed manual. Procedures for seed collection, handling, storage, purchase and accounting. Forestry Commission, Hobart, Tasmania.

Gray, R. 1990. Professional seed collection. In: Conference Proceedings: Sowing the seeds, direct seeding and natural regeneration conference. Greening Australia.

Griffin, A.R. 1990. Effects of inbreeding on growth of forest trees and implications for management of seed supplies for plantation programmes. In: Reproductive ecology of tropical forest plants. (Bawa. KS. and Hadley, M., eds.). Man and the Biosphere Series, Vol. 7. pp 355–374.

Midgley, S. 1996. Seed collection strategies in a changing world. In: IUFRO: Innovations in tropical tree seed technology. Proceedings of the IUFRO Symposium of the Project Group P.2.04.00, "Seed Problems", Arusha, Tanzania. 1995.

Morandini, R. 1962. Forest seed handling, equipment and procedures, I: Seed production, collection and extraction. Unasylva 15:4, 1–15.

Palmberg, C. 1985. Sampling in seed collection. In: Forest tree improvement. FAO Forestry Paper No. 20: 41–45. FAO Rome.

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