6

PLANTING MATERIAL IN AGROFORESTRY

When farmers plant trees, they use a variety of planting material (PLM), including seed, seedlings, rooted cuttings, grafted plants and branch stakes. Planners of agroforestry interventions need to ensure that farmers can get PLM that is apt for purpose and readily available. These two requirements are linked, because insufficient supply of PLM of acceptable quality may lead to use of poor-quality material. In this chapter, we provide answers to two important questions:

- What makes PLM apt for purpose?
- How can we ensure that farmers have access to it in sufficient quantity?

In this overview, we concentrate on seedlings, particularly bagged seedlings, and seed.

Quality of planting material and aptness for purpose

PLM that is apt for purpose has two characteristics. First, after it is planted or sown it survives and grows normally. Second, it yields products in the quantity and of the quality required. These two characteristics usually go together.

Nursery plants

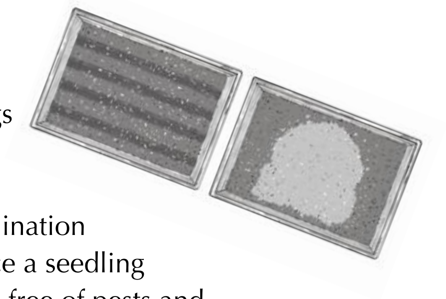
An apt-for-purpose nursery plant should have the following characteristics:

- a single stem, woody at the base and at least partially woody up to about three-quarters of its height
- dark green leaves, without any yellow patches and without signs of pests or disease
- new leaves at the tip
- roots that are not penetrating the base of the bag or other container.

Tree seedlings in containers, such as polyethylene bags, are generally ready to plant out when they are 30–40 centimetres tall, but – in some cases – farmers may have good reason to prefer larger plants. Plants need to be sturdy enough to withstand transport, handling and transplanting. The sturdiness coefficient is a useful measure of plant quality. It is calculated by dividing the plant height in centimetres by the basal diameter in millimetres. Its value should not exceed six. Farmers who regularly plant trees will learn by experience to avoid plants that are too straggly and to always plant sturdy seedlings.

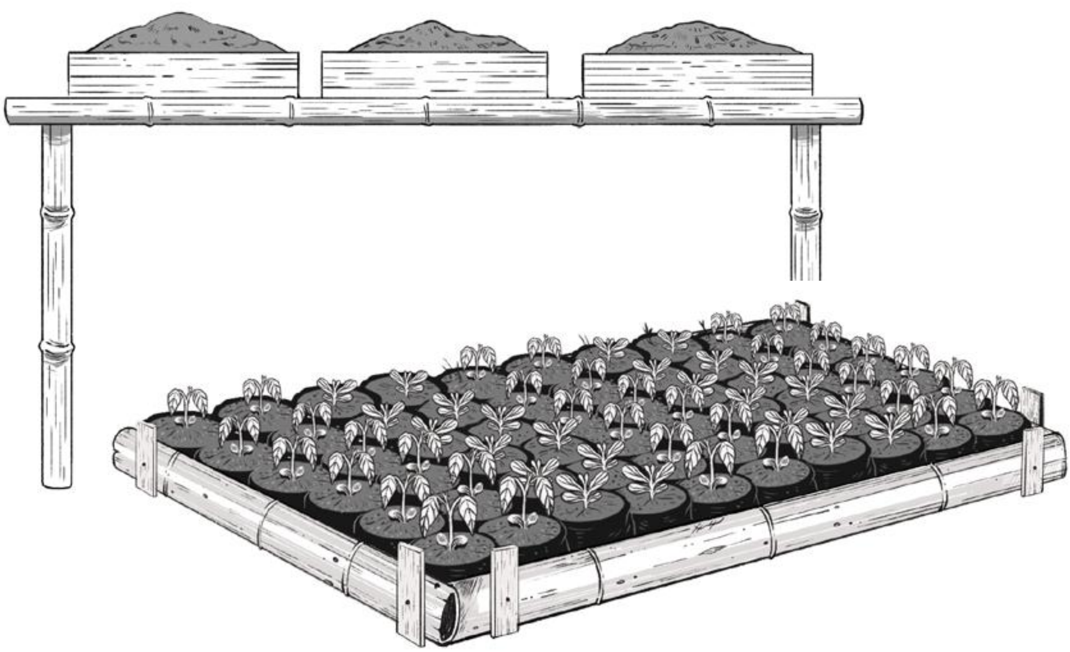
Plants can fail to be apt for purpose in various ways. Those that are too small may be smothered by weeds before the farmer has a chance to carry out the first weeding, or their root systems may be too small to withstand a snap drought after planting. Root systems can also be deformed: as a young tree grows, roots that were severely bent and twisted in the nursery usually get worse, not better, and end up strangling themselves. This leads to slow growth or death. Root spiralling, by contrast, can be corrected by pruning at the base and sides. However, it is better if farmers use plants with no defects.

Seed



Farmers and the agencies that support them use seed either to produce seedlings in a nursery, or to sow directly in the agroforestry system. To be apt for purpose, a seed must be capable of germination and, following germination, must produce a seedling that grows normally. Seed should also be free of pests and diseases that might spread to other seeds or plants. Such seed meets the requirements of the following dimensions of seed quality:

- **physical quality** (seed is undamaged, whole, within normal size ranges, clean, and free of soil, plant parts, etc.)
- **physiological quality** (seed is living and otherwise 'in full working order')
- **health** (seed is free of external and internal pests and diseases).



Genetics and aptness for purpose

PLM that meets all the requirements listed above can still fail to be apt for purpose if it is not genetically adapted to the planting site. In a nursery, it is easy to produce healthy, apparently high-quality plants that, however, are not well adapted to nearby planting sites. For example, seedlings of rainforest species can flourish in a nursery in a seasonally dry area because they are watered by the nursery staff, but they would be unlikely to survive a long dry season once planted out.

To be adapted means that the genetic makeup of the PLM equips it to withstand the range of environmental conditions that it will be subjected to when planted out. This includes variation due to climate, soil, competition and management practices. Well-adapted PLM survives and grows normally under this range of environmental conditions. Trees raised from material that is not locally adapted usually have lower growth rate; in extreme cases, poor adaptation leads to complete failure of a plantation.

'Well adapted' does not mean 'improved'. A productive agroforestry system can usually be established with unimproved PLM, **if** it is well adapted and has been produced using **best practices** – including those for seed collection. Fruit species can be an exception to this rule, for the following main reasons:

- Although an unimproved fruit tree may survive and grow well, it might not produce fruit for many years. Trees of grafted improved varieties will usually produce fruit within 2–5 years, depending on the species.

- Some markets might demand fruit of specific improved varieties, such as Hass avocado or Haden mango.

Access to planting material

Farmers have access to apt-for-purpose PLM if:

- best practices have been followed in seed collection and handling and in nursery management;
- appropriate supply systems for PLM are in place.

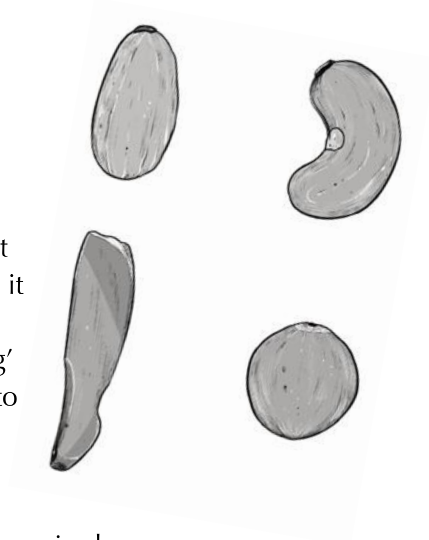
A full explanation of these conditions is outside the scope of this publication. However, we outline some important points below.

Best practices

Ensuring genetic adaptation
Plants will usually be well adapted if the seeds they were raised from were collected in an area that has a similar climate to where they will be planted. Therefore, to find out whether seedlings or seed are likely to be well adapted, it is necessary to know their provenance (where they come from). Exact information is best, but even approximate information may be enough to know whether the provenance has a similar climate to the planting zone.

Lack of genetic diversity may also lead to poor adaptation, even if the seed is local. Inbreeding depression is one problem: if a farmer collects all their seed from one tree, the resulting plants may all be healthy and well adapted, but if these interrelated trees eventually mate among themselves, then the seed they produce will be inbred, with slower growth and lower survival. A small sample (like the single tree just mentioned) is also a risky sample, as it could be highly unrepresentative, with a far-below-average genetic makeup. For this reason, seed should be sourced from at least 30 mother trees, which themselves should be part of a larger population.

For a few tree species, genetically improved seed or plants may be available. Although not usually essential, improved PLM can increase productivity, quality and profitability. However, caution is advisable, because smallholder conditions may be very different from the conditions for which the improved sources have been developed. For example, improved eucalypts developed for highly fertilized and clean-weeded pulpwood plantations in, say, southern Brazil, may not be suitable for smallholder agroforestry systems in, say, Central America. There is no point in paying a premium for plants that are not improved for the site in question.



Seed handling and storage

Poor physiological and health quality have particularly serious effects on seed germination and subsequent growth. Often, these result from incorrect seed storage or other seed handling problems. If seed has not been stored in the right conditions, or has been stored for too long, then it will probably be of poor physiological or health quality. What 'the right conditions' and 'too long' mean depends on the species and, particularly, to which **seed storage category** it belongs (Box 5).

Most tropical tree species have recalcitrant seed. However, many of the commonly planted species have orthodox seed. Recalcitrant or intermediate seed should not be offered for sale if it has been stored for more than a few days – unless, in the case of intermediate seed, it is known from experience that it is likely to be viable.

The surest way to know whether seed is of good health and physiological quality is to test it. Seed merchants should carry out germination tests before offering the seed for sale. Unfortunately, while the legal sale of crop seeds is often strictly regulated, the sale of tree seeds is frequently poorly regulated, so merchants may not offer this information. For this reason, seed buyers may wish to carry out their own germination tests. For large purchases, seed merchants may be willing to supply a free sample from the same seedlot, or a small sample can be bought for testing. If the seed germinates to the buyer's satisfaction, then a larger quantity can be bought with confidence. A flotation test is a quicker but less accurate test. A sample of seed – ideally, about 100 – is placed in a container with water for 24 hours. Seed that is of high physiological quality will usually sink and will often begin to swell.

Box 5. Seed storage categories: Orthodox, recalcitrant and intermediate

Seed specialists categorize seeds by how they respond to drying. If drying is possible without killing the seed, seed can be stored for longer.

Orthodox seed can be dried so that it contains very little water. After drying, it can be stored at low temperature for many years or even decades without important decline in health or physiological quality. Orthodox seed dries out naturally before it is dispersed from the tree, but must be further dried prior to long-term storage.

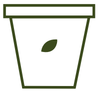
Recalcitrant seed dies when it is dried. In some cases, it can be stored for short periods (days to weeks) if kept in moist conditions that stop it from drying out. Recalcitrant seed does not dry out naturally before it is dispersed from the tree. Some people use the term 'recalcitrant' loosely, to mean any seed that is difficult to germinate. This is incorrect.

Intermediate seed is between orthodox and recalcitrant. It can be partially dried, but not as much as orthodox seed. Therefore, like recalcitrant seed, intermediate seed cannot be stored for long periods of time.

To find out what category a species belongs to, consult the databases of the international society for seed science: https://seedscisoc.org/.

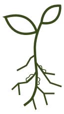
Nursery practices

Many manuals describing best nursery practices are available. Some commonly neglected elements of good practice are listed below:



Where possible, sow seed directly in the plant container, rather than in a germination bed: 'pricking out' is a common cause of root deformity.

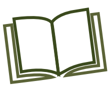
Use a soil mix with enough clay content to permit formation of a root-plug that, while not hard, remains intact during removal from the container.



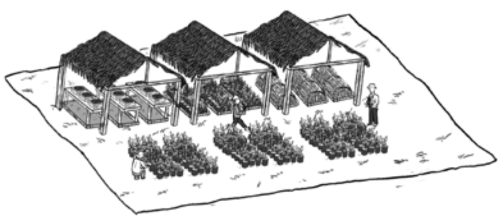
Include forest soil or humus to ensure development of mycorrhizae.

Harden off seedlings before planting or sale by reducing watering and increasing exposure to the sun.

Cull (throw away) poor quality seedlings, including those that are past their 'sell-by date' (sturdiness coefficient greater than six, or roots growing through base of container and into the soil).



Keep records to facilitate control and to allow accurate information to be given to PLM users.

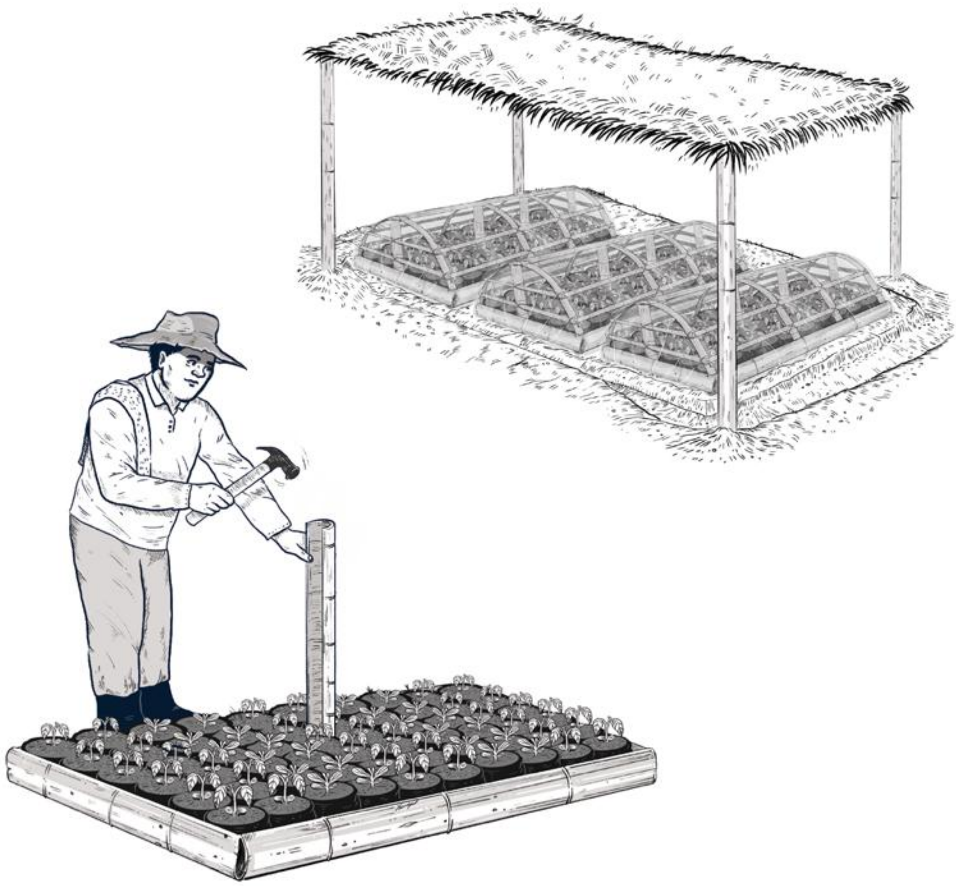


Nursery customers should be wary of nurseries that don't follow these practices.

Use of apt-for-purpose seed in nurseries is also an aspect of best practice. In the case of physical, sanitary and physiological quality, this is a matter of economics, efficiency and feasibility (plants can't be produced from seed that doesn't germinate). To secure genetic adaptation, nursery operators should obtain seed from seed sources that are located nearby, in similar climatic conditions, or that prior experience (including any formal provenance testing) has shown to be adapted.

Choosing a seed merchant or nursery

Several aspects of seed and plant quality cannot be evaluated simply by inspecting seed or seedlings. For example, seed of poor physiological quality can look normal, and poor adaptation of plants and seed may not be visible until the first years of growth in the field. Faced with this problem, farmers and those who support them have two alternatives. The first is to make their own seed collections and operate their own nurseries, in both cases following best practices. The second option is to ensure that the seed merchant or nursery operator is both trustworthy and competent. Trustworthiness can be verified by talking to other clients and by first-hand experience. Competence can be checked in various ways (such as by asking about the practices followed). In the case of gaps in competence and knowledge, supporting agencies may be able to provide training. Such training benefits both producers and consumers of PLM.



Planting material supply systems

A planting material supply system consists of the institutions, installations, policies, laws and value-chain actors that control and affect the access to PLM by users. A full account of approaches to developing context-appropriate supply systems is outside the scope of this publication. However, in the following sections we outline some important concepts and describe seven broad interventions that supporting agencies can make.

Access requires two conditions to be met:

- PLM must be available: this means that apt-for-purpose seed sources of the species must exist, and nurseries must stock plants produced from the seed.
- Farmers must be able to acquire the material (usually, plants), that is, they have the resources to travel to the nursery, buy the plants, and transport them to their farms – or an agency must either support them to do this, or provide the PLM directly.

In supporting farmers' access to high-quality PLM, two perspectives must be considered. The first perspective is that of the project manager or project participant, who needs material for a specific intervention – usually, one identified in an agroforestry design process – to be carried out in a specific place in the near future. The second perspective is broader; it is concerned with the seed and nursery subsector in a specific geographical area, rather than with a specific project. Both perspectives are considered below.

The project perspective
Selection of species should consider the availability of PLM; even if farmers express strong preference for a given species, there is no point in selecting it if no material is available within the relevant time frame – which often means at the start of a project. This time frame also means that, from the project perspective, farmers' short-term access, rather than longer-term sustainability of access or availability, is the main concern.

There are many ways in which support agencies can ensure that farmers are able to access PLM, particularly plants. One way is by distributing plants for free. Two arguments against free distribution are sometimes made:

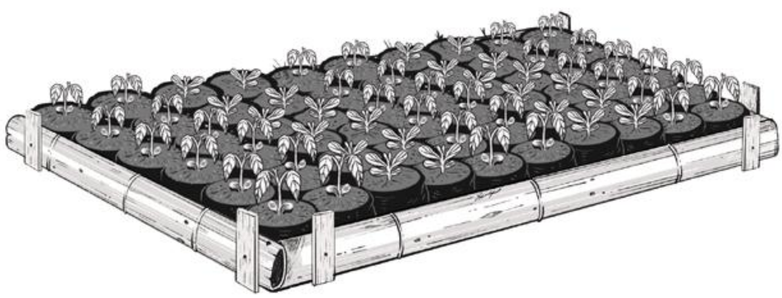
- Farmers will not value trees that they have not paid for.
- Free distribution of PLM undermines local private sector nurseries.

1

The first argument is true in some cases. However, if farmers do not value trees that they have planted on their land, then the fault is with the agroforestry design process, not the farmers. If this argument matches common experience, then it is because projects often have not truly met farmers' needs or aspirations.

2

The second argument is stronger. Free distribution of plants in a given region will unfairly affect local nurseries' sales of plants of the same or similar species. If this results in closure of nurseries, then it will also affect longer-term sustainability of plant supply. In most cases, the solution is not to stop free distribution of plants, but rather for the distributing agency to obtain them from local nurseries, at market prices. Such agencies can also provide training to local nurseries, where needed, so that they can fulfil this role.



The broader perspective: developing PLM supply systems
It is easy to design PLM supply systems on paper. However, if these don't reflect common realities, then they will remain 'castles in the air'. These realities include the following:

- There is a need, at least in large countries, for decentralized supply of PLM.
- Regulatory personnel, who often have an agricultural background, often have no expertise in agroforestry PLM quality.
- Regulating the whole supply chain, from seed source to planting site, is complex.
- Drafting, enacting and implementing effective seed laws is difficult, particularly for seed of multiple species with different collection and storage requirements.
- Tree planters and planting material producers often lack financial resources and technical capacity.

The strategic need is to identify farmers' needs and plan how to respond to them, rather than to attempt to construct perfect systems according to preconceived criteria.

In Table 4, we provide a 'menu' of seven broad areas in which supporting agencies may help enhance farmers' access to fit-for-purpose PLM. These are guided by four principles: farmer-centredness (as for agroforestry interventions in general); self-sufficiency (where possible, supply of PLM should be financed by sale of PLM); openness to intervention when markets fail; and a 'no harm' principle that intervention should not conflict with self-sufficiency.

Table 4. Menu of intervention options to enhance planting material supply systems

Intervention	Role
1. Implement a diagnostic study to guide interventions and actions	Ensures that substantive interventions and actions are appropriate and evidence based
2. Support the design, reform and application of laws and regulations	Supports other interventions
3. Promote or establish agroforestry nurseries	Appropriate when planting stock is unavailable due to lack of nurseries
4. Support the establishment and management of seed sources	Appropriate when seed sources are lacking or when they are unproductive
5. Support nursery operators' access to fit-for-purpose seed	Appropriate when nursery operators cannot obtain seed from existing seed sources
6. Support improvements in the quantity or quality of production by existing nurseries	Appropriate when nurseries do not produce sufficient apt-for-purpose plants of the species that farmers require
7. Support farmers' access to nursery plants	Appropriate when farmers are unable to acquire the planting stock that is available in nurseries