

Production methods

Bare-root plants and stumps

Producing seedlings without containers seems like the easiest option for the nursery. Indeed, less soil is needed and the seedlings are easy to transport to the field. But although a containerless system has some benefits, the disadvantages almost always outweigh the advantages. Remember, the choice of procedures must always be based on what is best for seedling growth.

In temperate zones where the temperature drops to below freezing, bare-root beds work well with a variety of species because these become dormant — or stop growing — for several months. Hardwood species, for example, lose their leaves during the inactive period of dormancy. Plants are often stored in refrigerated warehouses and planted in the field before they start actively growing again. This greatly reduces the shock of lifting, transporting, and planting the trees.

In the humid tropics of Latin America, bare-root beds are commonly used for hardwoods like cedro (*Cedrela odorata*). While this species is not dormant during the planting season, it seems to store a lot of water and nutrients in its stem. The stem has sufficient reserves to continue growing even after losing roots during lifting and transport.

The two major problems with bare-root production are maintaining soil fertility in the beds, and proper handling of the plants. When plants are produced for several years in the same soil, nutrients are depleted and the trees become smaller each season. Lifting the trees from the beds in the nursery, transporting them, and planting, exposes the roots

advantages of bare-roots plants	disadvantages of bare-roots plants
<ul style="list-style-type: none"> • one person can carry several hundred seedlings to the field • smaller holes are dug than for plants in bags • lower production costs because containers are not purchased and less soil is needed 	<ul style="list-style-type: none"> • competition for light, nutrients and water when natural shade trees are used • depletion of soil nutrients in the nursery beds • slow initial growth in the field • high mortality in the field

Good nursery practices for bare-root production

- sow plants at a low plant density of 200 plants or less per square metre — this reduces competition for water, light and nutrients and improves seedling growth
- use a sharp wire to undercut the beds during the growth period so that cut roots heal naturally — this prunes the roots so they do not grow too deeply and promotes more lateral root growth
- use compost or fertilizer to replenish the soil nutrients throughout the growing season
- plant a leguminous cover crop or green manure such as *Canavalia* during the fallow season, then incorporate the organic material to replenish soil nutrients
- allow the bare-root beds to fallow or rest for one or more seasons to replenish the soil nutrients, and then incorporate the organic material into the soil
- dip the roots in a mud slurry after lifting seedlings from the bed
- wrap the plants in wet newspaper or jute bags
- keep plants in the shade and out of the wind at all times during transport
- plant in the field without any delay and only when the soil is very moist
- dig large holes and ensure that the roots point straight down when planted

Poor, but unfortunately common bare-root practices

- sowing seeds at a high density
- allowing the roots to grow deep into the bed
- producing seedlings in the same soil each year without replenishing soil fertility
- leaving the bed without vegetation when not used
- allowing the beds to become very weedy — weed seeds will contaminate the beds
- when lifting the seedlings, removing many roots from the plant or damaging them by stripping the outer protective layer
- allowing the roots and the leaves to dry out or become very hot during lifting
- planting in the field when the soil is dry
- digging shallow holes that do not cover the roots
- bending or twisting the roots when planting

to air and they die. Only when intensive nursery management maintains soil fertility in the beds and when the ideal lifting, transporting, and planting conditions are guaranteed, do we recommend producing bare-root plants.

Stumps or *pseudo-estacas* are bare-root plants that have been grown for, on average, 18 months in the nursery. They are often 1.5 to 2 m in height and have a diameter the size of your thumb. They are drastically cut back, ideally to about 15 cm root length and 3 cm shoot just before planting out. However, frequently, the shoots are left the same size as the root. The shoots should always be shorter than the roots. Stumps are common in Costa Rica for cordia (*Cordia alliodora*), a tree used to shade coffee, melina (*Gmelina arborea*) and teak (*Tectona grandis*). Because of the great setback in plant growth, it often takes over a year for the plants to regain their original height when cut. As this has to be added to the long time needed for their production (18 months instead of 3 or 4), their slow growth and high mortality in the field, we do not recommend producing stumps.

Plastic bags

Plastic bags are widely used for young plants in Latin America and throughout the tropics. This is principally because they are cheap and widely available, not because they result in the best plant growth. Bags come in many sizes, some with pleats so the bag stands upright, and some with no bottoms at all. Aeration holes are usually present — if not, they must be cut. The inherent problem with plastic bags is that when the roots reach the bottom of the bag they begin to spiral as described in chapter 2. Roots also grow into the soil below and later are damaged when the bags are moved.

A ***common, but poor nursery practice*** is to use large bags — 1 litre or more in volume — to improve plant quality. Plant development depends more on what is inside the bag — the quality of the substrate — than the size of the bag. In fact, as the substrate quality improves, bag size can be decreased. A ***good nursery practice*** is to use small bags with a rich substrate like compost. The only exception to the use of small bags and a rich substrate may be with trees that take longer to develop, such as grafted fruit trees.

Use small bags with a rich substrate like compost.

The use of small bags has advantages for the nursery and for the farmer:

- they require less substrate
- they are lighter and easier to carry to the field.

Large bags often weigh 1 kg or more, whereas small bags weigh $\frac{1}{2}$ kg or less when filled with compost. Thus if a person can carry 20 kg, he or she can only carry 20 large bags but 40 small bags. Making tree planting easier for the farmer is an important nursery objective.

Producing trees in small bags may require some nursery changes. A space should be left between rows of small bags in order to reduce the plant density. If the number of plants per square metre is high, the plants will grow tall and spindly. Plants grown in small bags may require more frequent watering than plants in large bags. Although it is always a **good nursery practice** to plant out trees on time, plants in small bags cannot stay in the nursery as long as plants in large bags.

Root trainers

For many years in both temperate and tropical forest regions, root trainers have been used to successfully grow high quality trees. They come in many shapes and sizes, but all have two characteristics in common:

- vertical ribs
- a big hole at the bottom.

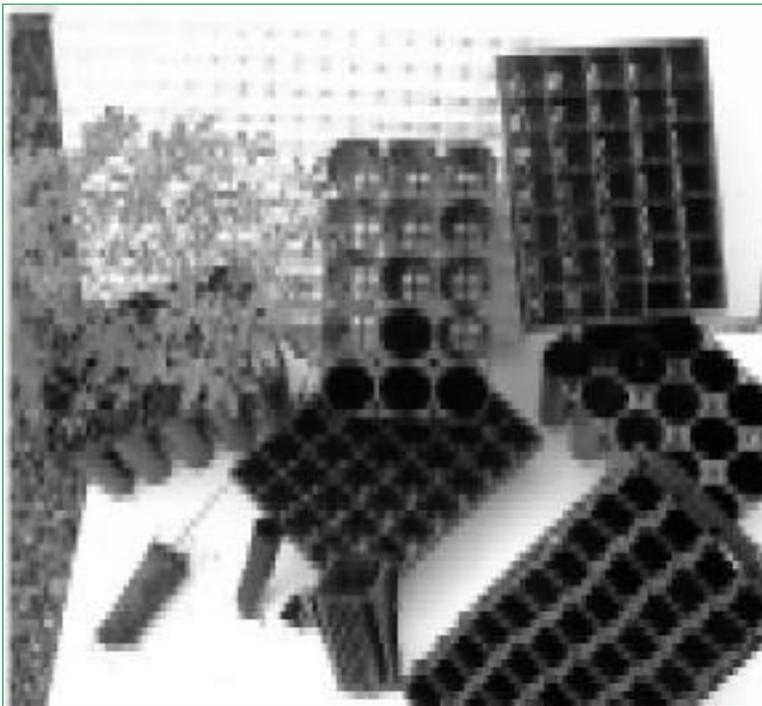
The vertical inner ribs direct the roots straight down as they grow, thus avoiding the root deformities caused by smooth plastic bags. The containers are set on frames above the ground, so that air circulates around the bottom hole. Roots are air-pruned as they emerge from the container. This natural pruning of the main roots encourages secondary root growth so that eventually the volume of the root trainer is filled with a 'plug' of fibrous roots. When the tree is planted in the field, the pruned roots continue to grow again.

Root trainers must be placed in some kind of tray or frame at least 30 cm off the ground to allow for air-pruning. They are usually placed at least 1 m high for working comfort and efficiency. Trays can be made from chicken wire and placed on bricks with wooden supports, or can be made to slide between metal bars.

The right size of the container depends mostly upon seed size and some testing may be necessary for each species. Since the volume of root trainers, 75–250 ml, is usually much smaller than that of plastic bags (bags are usually $\frac{1}{2}$ –3 litres), only a rich organic substrate such as compost can be used. The compost must be tightly packed in each container and well-watered before inserting the seed or cutting. Another great advantage of root trainers is

that they are easy to fill which improves labour productivity. Depending on the size of the root trainers, several thousand can be filled in one hour, compared to a maximum of 200 bags per hour. Trainers are more expensive, but can be reused for many years, if properly maintained.

Root trainers are not simply a different container. They require a big change in nursery management — different substrates are used, different support systems are needed and watering regimes may increase. Their main advantage is in producing plants that are free of root deformities, with extremely fibrous root systems and a balanced root to shoot ratio. They are also easy to transport to the field.



Root trainers are available in a variety of styles and shapes. The container volume is small, so a rich substrate is needed.

New developments

Like root trainers, the following two products cost more than bags. They are available in Latin America, although only through large nursery suppliers. Nonetheless, we include them here because new developments that improve plant quality may be worth the added initial cost. They may be most appropriate for private nurseries that are integrated into a plantation operation or in research nurseries.



Three seedlings grown in root trainers. Notice the large quantity of roots growing downwards.

Spin-Out® is a copper hydroxide paint that can be applied to the inside of bags or any plastic container. The coating is toxic to root tips; when the roots reach the side and bottom of the bag, they stop growing before they become deformed. Secondary root growth is promoted which is important in absorbing water and nutrients.

Jiffy Pellets® are individual pellets that contain compressed peat surrounded by a biodegradable net. They are container and substrate in one. Jiffy pellets have been used successfully in industrial plantations around the world. The containers expand to a maximum height of 4 cm and 2 cm width. The peat is a lightweight, porous material that allows the roots to penetrate quickly. However, it contains no nutrients, so fertilizer must be added.

Like root trainers, Jiffy Pellets® require significant changes in nursery management. Support trays are needed; fertilizer regimes must be developed, and strictly applied. The quantities of fertilizers will probably vary for each species. The main advantage of this system is that the nursery does not have to acquire the substrate or fill containers. This saves labour and possibly material costs. The pellets use less space in the nursery and are easy to transport. They can also be used for vegetative propagation.

Summary of production methods

The most common production techniques may not always be the best. Bare-root plants and *pseudo estacas* are easy to transport to the field, but their survival and growth are usually very poor. Plastic bags are cheap and easily available, but they result in coiled roots and are heavy to carry to the field. Root trainers, copper coated containers, and Jiffy Pellets® are alternative systems which may have higher initial costs for the nursery. However, the farmer will receive the benefits of fast growth and high survival in the field.

Good nursery practices

- use bare-root production only if soil fertility is maintained in the nursery beds and ideal planting conditions are guaranteed
- use small bags with a rich substrate such as compost, instead of large ones
- invest in alternative containers such as root trainers to improve plant quality

Poor, but unfortunately common nursery practices

- using stump plants
- allowing bare-rooted plants to dry out during lifting, transport, and planting
- using large bags — over 1 litre in volume — to improve plant quality