

Section 2: Containers

Most agroforestry tree nurseries either produce bare-rooted seedlings or use polythene bags. We recommend that in a research nursery containers are used. However, polybags often restrict the root growth, and roots curl at the bottom or grow into the ground, resulting in weak or injured plants. We discuss root trainer systems as a modern alternative.

As a nursery manager, you have to decide whether to operate a bare-root nursery or a container nursery. Your decision depends mainly on the species and the environment. Economic considerations also play a role.

	bare-root nursery	container nursery
water	requires frequent watering	has moderate water requirements
soil conditions	needs excellent soil	soil quality is not critical
land requirements	needs large area of land because plants are grown at lower densities	can occupy a smaller area because of higher densities and lower culling rates
plant hygiene	soil-borne pests and diseases may become a problem	spread of disease can be better contained and controlled
symbionts	mycorrhiza and other symbionts may be present	specific mycorrhiza and other symbionts may need to be added to substrate
seedling handling	bare-root seedlings are relatively intolerant to physical abuse and mishandling	container seedlings are relatively tolerant to physical abuse and mishandling
root pruning	necessary and labour intensive	unnecessary if root trainers provide air pruning
outplanting	seedlings suffer outplanting stress; they are more suitable for better sites	seedlings are more tolerant to outplanting stress and are suitable for poorer sites

For a research nursery, always consider containerized systems unless you need bare-rooted systems for research.

Bare-root nurseries are often recommended for on-farm nurseries because of the smaller capital investment needed. For a research nursery, always consider containerized systems unless you need bare-rooted systems for research – for example when studying the suitability of a species or nursery practice for on-farm production. Always relate the costs of establishing a container nursery to the improved quality and value of the nursery stock. This is particularly relevant for nurseries in research projects where costs are less critical.

Types of containers

Containers for plant propagation come in various forms, sizes, and in different materials — polystyrene, polyethylene, fibre or paper. New forms and materials are constantly being developed and tested. The type of container selected depends on the plants to be raised, their purpose and size. For example, in India's Andhra Pradesh state, the forest departments prefer large (at least 500 ml) polybags for fruit trees (grafted tamarind, emblica, custard apple, etc.) but use smaller (90 and 150 ml) root trainers for pulp or timber species.

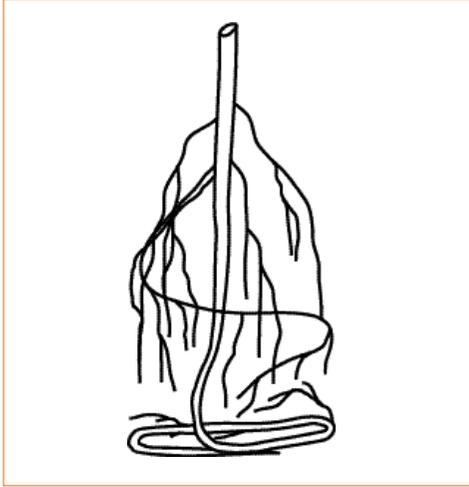
A common problem with all containers is the substrate — this is covered in the following section. However, it is important to note that in developing countries the most commonly used substrates are soil and sand-based mixtures which are unsuitable for the development of an extensive fibrous root system.

Polybags are the containers most commonly used in tree nurseries in developing countries. They are usually made of black polyethylene and have several drainage holes at the bottom (if they don't, holes can be made using a paper punch). **Polysleeves** made from the same material are cut from a continuous roll and have no bottom. Both types are often locally made and therefore cheap (the most common sizes cost about a fifth to a third of a US cent per bag), and readily obtained in most countries. They come in various gauges and volumes between 0.3 and 45 litres.

A common problem with polybags is that plant roots tend to grow in spirals once they hit the smooth inner surface. This will inevitably lead to plants with restricted growth, poor resistance to stress and wind-throw and even early dieback due to ensnarled root masses or pathogens. This is a major drawback in the use of the conventional polybags. Because of their open bottom,

Section 2

polysleeves allow for air pruning when placed on raised propagation beds, for example on a thick layer of gravel. But they are less resilient in transport, because the potting substrate can easily fall out and damage the roots. Polysleeves should never be placed straight onto soil because roots will grow into the ground and the main roots break off when you lift the plants.



Bags or sleeves are not very durable and can break prematurely. For plants with a long nursery cycle, this can be a problem. They are normally used only once. The discarded polybags and polysleeves are a problem for nursery waste management, as they do not decay and are often burned, producing serious air pollution.

Jiffy® pots are made from compressed peat and need to be filled with a growth substrate. Roots can easily penetrate the container walls, so root curling does not occur. The seedling is planted together with the pot which is biodegradable. **Jiffy® pellets** are made from compressed peat and held together with a biodegradable net. They are pot and growth substrate in one. Upon use, they are irrigated and expand to approximately 5–10 cm height. Seeds or cuttings can be directly planted into them. Roots will grow through the walls and the seedling is planted with the surrounding pellet in place.

Root trainers are usually rigid containers with internal vertical ribs, which direct roots straight down to prevent spiral growth. The containers are set on frames or beds above the ground to allow air-pruning of roots as they emerge from the containers. The latest developments also encourage lateral air root pruning through vertical slits.

Seedlings grown in root trainers have more vigorous and rapid root growth than seedlings grown in polybags. Outplanting survival and, more importantly, long-term survival are much better. Plants grown in root trainer systems are often ready for planting out when they are substantially smaller than those from conventional polybags. This helps to reduce space requirements in the nursery and transport costs to the field.

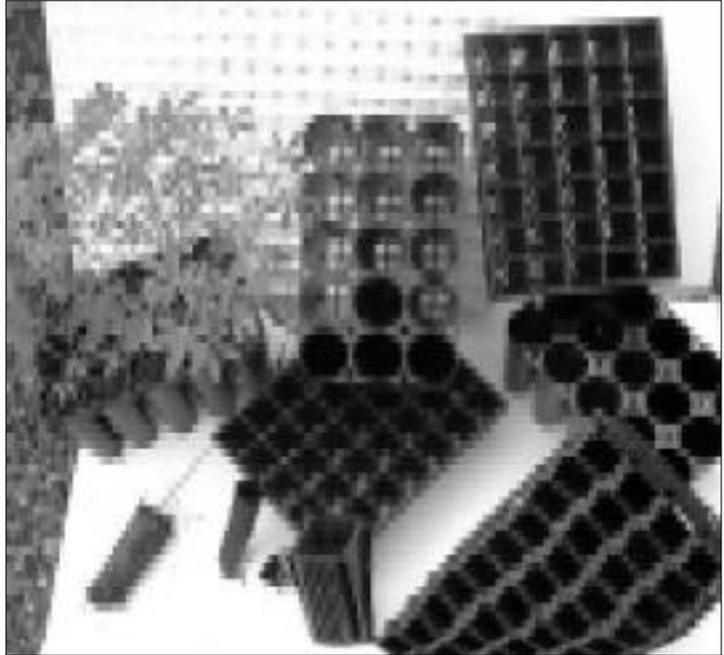
type	description	cost per unit	comments
polybag	black or clear polyethylene; 0.3–45 L volume	US\$ 0.002–0.003 for the commonly used 0.5–1.5 L sizes	often made locally; usually used only once; can cause spiralled roots; root system can be crushed during handling.
polysleeve	black or clear polyethylene; 0.3–1.5 L volume, cut from an endless roll; open at both ends	as for polybag	allow air root pruning through the open bottom; substrate can fall out, therefore of limited usefulness when transporting seedlings to the field; usually used only once; root system can be crushed during handling.
jiffy pots and pellets	pots made from compressed peat	US\$ 0.03–0.06	roots penetrate the container easily; can only be used once as the containers are planted with the seedling; easy planting but danger of root system drying out if planted too shallowly (wick effect).
root trainer	rigid containers with internal vertical ribs	US\$ 0.04–0.10	big holes in bottom allow air root pruning; can be used 4–6 times; vertical ribs force roots to grow straight; some types open like a book to allow easy extraction of seedlings; require raised nursery frames; root damage during handling is negligible.

There may be some confusion in different countries concerning the term ‘root trainer’. It was chosen because the internal ridges direct (i.e. ‘train’) roots to grow vertically downwards. Many companies produce root trainers of different types. The original container marketed was patented under the name Rootrainer®.

The classic Rootrainers®, first manufactured in Canada, have a special feature in that they consist of ‘books’ of four or five cells (one cell is used for each seedling) that can be opened for easy inspection and to remove seedlings for planting. Several of these books are packed into trays manufactured to fit the size of books. Bread trays or other home-made trays with a perforated

Section 2

bottom that allows air root pruning can be improvised too. These containers are ideal for research studies as they can be opened and closed during plant growth to observe actual root development of the species or substrate tested without damaging the seedlings. Roottrainers are made of rigid polyethylene and when stored open, do not require a lot of storage space. They can be used



A variety of root trainer systems

two to four times before the plastic wears out from repeated opening and closing, as well as the high UV radiation in tropical countries. Current prices for roottrainers (1998, excluding shipment) are US\$ 0.04–0.10 per cell including the costs for the tray.

Other manufacturers produce square or round pots within rigid trays. Cost per cell is similar to the example above; separate trays are not needed and often, the plastic material used is more rigid and durable than for root trainers. A disadvantage is that it might be more difficult to extract the seedlings from the containers, which is a serious problem when the substrate has a large mineral (i.e. soil or sand) content. Single pots are also available which have the advantage that plants can be rearranged within a tray, for example after culling or for an experiment.

If you choose the root trainer system, you may need to adapt other nursery practices to the special requirements of the system. It is important to choose a potting substrate that is fibrous so that it does not fall through the bottom holes of the containers. Sand and soil or mixtures that contain a lot of sand or soil are not suitable. You need to construct raised frames so that the base of the root trainers is at least 30 cm above the ground to allow for air pruning. Because the root trainer cells often have a smaller volume than polybags, you may need to increase the watering schedule.

Changes in management also include the outplanting step. The 'plugs' from root trainers can be transported into the field like bare-rooted seedlings, provided there is a strong fibrous root system binding the plug. This reduces transport costs. Of course you will need to take the same precautions concerning desiccation of the plants as you do for bare-rooted seedlings:

- the seedlings have to be planted on the same day you take them out of their containers
- never let the root system dry out
- keep the seedlings in the shade at all times
- special care has to be taken to avoid crushing the root system.

Did you know?

Seedlings produced in a project nursery in Indonesia using root trainers and a peat-based potting substrate cost about 20% more than seedlings produced in a conventional nursery in the neighbourhood which used polybags and topsoil. But reduced transport costs to the field and better seedling survival and growth eliminated this difference completely.

Similarly, the profitability of a forestry plantation is high enough to handle a 50% increase in investment without suffering more than a 2–3% loss in income. This loss can be recovered with marginal yield increases.

Section 2

And more...

Researchers are testing other methods of increasing fine root system development. Coating the inner surface of a container with copper hydroxide has been found to efficiently stop root growth once the roots touch the surface, and to increase the development of lateral roots. Once outplanted, the roots start growing again, thus giving the seedling a good start in the field. The commercially available product (SpinOut® from Griffin Co. – see Annex 1) can be applied to plastic containers, polybags, cloth and cement.

In a research setting the products are not usually sold. However, the slightly higher cost of producing better seedlings is a good investment — and seedling cost is marginal compared with the overall expenses of a research project.

Further reading

- Davidson J. 1996. Off site and out of sight! How bad cultural practices are offsetting genetic gains in forestry. In: Dieters MJ, Matheson AC, Nikles DG, Harwood CE and Walker SM. (eds). Tree improvement for sustainable tropical forestry. Proceedings, Queensland Forest Research Institute Conference, Caloundra, Queensland, Australia. 288–294.
- Dunn GM, Huth JR and Lewty MJ. 1997. Coating nursery containers with copper carbonate improves root morphology of five native Australian tree species used in agroforestry systems. *Agroforestry Systems* 37: 143–155.
- Gera M, Sharma S, Bhandari AS and Srivastava RL. 1996. A trial on improved polybag seedling production system. *Indian Forester* 122(11): 992–998.
- Josiah SJ and Jones N. 1992. Root trainers in seedling production systems for tropical forestry and agroforestry. Washington, DC, USA: World Bank. Asia Technical Department. Agriculture Division. 54 pp.
- Jones N. 1993. Essentials of good planting stock. Forests and Forestry Technical Bulletin Number 2. Washington, DC, USA: World Bank/AGRNR. 7 pp.
- Landis TD, Tinus RW, McDonald SE and Barnett JP. 1990. Containers and growing media. vol. 2, The container tree nursery manual. *Agriculture Handbook* 674. Washington, DC, USA: US Department of Agriculture, Forest Service. 88 pp.

- Rabeendran N and Jeyasingam. 1996. The effect of pot size and mulch on planting stock of exotic and indigenous species in Sri Lanka. In: Yapa AC (ed.). Proceedings of the International Symposium on Recent Advances in Tropical Tree Seed Technology and Planting Stock Production. Muak-Lek, Saraburi, Thailand: ASEAN Forest Tree Seed Centre. 119–125.
- Struve D, Arnold M, Beeson R, Ruter J, Svenson S and Witte W. 1994. The copper connection. *American Nurseryman*. 52–56.
- Valli I. 1996. Production of high quality seedlings in central nurseries in Indonesia. In: Yapa AC (ed.). Proceedings of the International Symposium on Recent Advances in Tropical Tree Seed Technology and Planting Stock Production. Muak-Lek, Saraburi, Thailand: ASEAN Forest Tree Seed Centre. 130–135.