



Credit: Marian Lechner

“ Germination is a critical stage in the life of a tree ”

Longman (2003)



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Introduction

Seed germination and seedling growth are both affected by a number of environmental factors including light, moisture, temperature and the availability of oxygen and CO₂. Although the management of these factors changes from one species to another there are a number of basic procedures that can be followed for most tree species. This brief provides general guidance for germinating and growing tree seedlings for restoration.

Who is this guidance for?

This brief is for individuals with limited horticultural experience but who nonetheless are tasked with the conservation and restoration of threatened tree species. Specialised training is not required but some basic skills (detailed on Page 2) should be present within your team.

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Before you start

Before you start, take the time to (1) research your target species; (2) ensure your team has the right skills; (3) set-up appropriate facilities with necessary equipment; (4) obtain a source of viable seed and (5) develop a seed sowing calendar.

STEP 1: Know your target species in advance

Different trees produce seeds with wide-ranging requirements for germination and seedling growth. For your target species, compile existing information from published literature, contact botanic gardens, seed banks or nurseries or consult specialists on the germination and growth of your species. Try to develop an understanding of the optimum growing medium, temperature, moisture and light requirements for your target species (or for closely related species).

Growing medium

Most species require a germination medium that is relatively open (for gas exchange) and water retentive.

However it is still worth investigating whether your target species has particular requirements. For example, some species require certain bacteria or fungi to be present in the soil.



Temperature

Temperature is a very important factor for germination but optimal temperature may vary greatly among different species. Most species have a maximum and minimum temperature, above or below which, germination will not take place.



Moisture

Most species require enough moisture to support growth of emerging seedlings but excessive watering reduces the amount of available oxygen in the substrate and promotes fungal growth. Species will vary in the amount of water required after they emerge from seed.



Light

Most tree seeds will germinate in the dark but a few species do require light to germinate. Managing light levels will be more critical **after** seedlings emerge. Find out whether your species is shade tolerant or not.



TOP TIP

When no existing information is available, you may need to set up your own experiments to discover optimal growing medium, moisture, temperature and light for a given species. For guidance on how to develop germination experiments, see [GTC Brief 8](#).

STEP 2: Make sure your team has the right skills

No specific technical skills are required for basic germination and seedling growth. However your team needs to be organised, have good time management and should have experience with record keeping.

For difficult to germinate species, you should have someone in your team with knowledge of horticulture and experience with carrying out experimental trials.

STEP 3: Establish facilities and acquire equipment

Advice on how to construct a nursery and a checklist of essential nursery equipment are provided in [GTC Brief 4](#). Here we provide examples of some of the essential equipment for germination and early seedling growth.

Your nursery facility

- Sufficient space for seed beds and pot beds
- Wind breaks and fencing
- Potting shed
- Sheltered area for workers
- Access to water
- Compost heap

Equipment and resources

- Growing medium
- Sieve (for removing large particles from soil)
- Materials for shading (e.g. bamboo)
- Polythene covers (to protect seedlings from frost)
- Seed trays, larger pots
- Trowel, Spade, Fork, Rake, Watering can
- Pruning knife, Secateurs
- Labels, Notebooks, Pencils, Pens

STEP 4: Obtain a source of seeds and prepare them for germination

Successful germination depends on a source of viable seed. For guidance on how to collect seed from threatened trees see [GTC Brief 5](#).

Seed from certain species may also require pre-treatment (e.g. scarifying seeds, soaking seeds in hot water or chemicals etc.) or stratification before germination can take place. For more guidance on preparing your seeds for germination see [GTC Brief 6](#).

STEP 5: Plan when you are going to sow seeds

Some species produce recalcitrant seeds that quickly lose viability and cannot be stored for long periods of time. Seeds from these species need to be sown as soon as they are collected and cleaned.

Other species produce orthodox seeds that can be stored over longer periods, therefore allowing you to select a sowing date that will favour later growth and planting of seedlings. Identify the optimal planting season for your species and calculate sowing dates based on the time it takes your species to germinate and grow to planting size.

Species	Sowing date	Time to germinate	Time to grow to planting size	Planting date
Species 1	1st July 2014	2 months	6 months	1st March 2015
Species 2	1st Nov 2014	1 month	3 months	1st March 2015
Species 3	1st Sep 2014	1 month	3 months	1st January 2015

TOP TIP

Available staff, substrate, water and space in the nursery will limit the number of seedlings growing at any one time of year. If your optimal planting dates are flexible (e.g. over several weeks or months) try to stagger sowing to avoid over-stretching your nursery's capacity at any one time. If your nursery does not have regular access to water, you may want to avoid growing large amounts of seedlings during the dry season.

Carrying out germination

Germination is a critical stage in the life of a tree. As a tree seed moves from an inactive to an active stage, delicate seedling roots must emerge and establish in the soil before a young shoot emerges above ground.

Over the next two pages we provide a summary of the steps you can take to carry out germination. Remember that it is essential to provide a favourable environment for germination (as far as possible, optimising air flow, moisture, temperature and light for your target species).

Preparing a germination medium

In general, use a germination medium that:

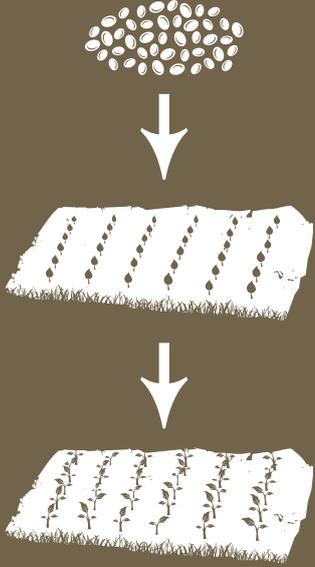
- Promotes adequate levels of moisture
- Promotes air flow (stale humid air promotes infection such as damping off)
- Has a texture that is firm enough to stop young seedlings from falling over but free enough to allow roots to penetrate it.

Your desired texture can be obtained by mixing sand with sieved organic materials or by using commercial substrate such as coir-sand with a ratio of 50:50.

Did you know?

Some tree species do not grow well if bacteria or fungi (such as mycorrhiza) are missing from the soil. To make sure they are present, consider collecting soil from under wild grown trees and adding it to your germination mixture.

When your germination medium is ready, sow your seeds using one of two main methods:

A) Direct sowing of seeds into pots	B) Scattering seeds into seed-beds
<p>When should you use this method?</p> <ul style="list-style-type: none"> • If seeds are large enough to be picked up • If you expect high and uniform germination rates • If you have a small number of seeds • If young seedlings have sensitive roots and will be unsuitable for being 'pricked out' into pots 	<p>When should you use this method?</p> <ul style="list-style-type: none"> • If seeds are very small • If you expect low and non-uniform germination rates • If you have a large number of seeds • If young seedlings are robust enough to handle being 'pricked out' into pots after emerging 

A) How to sow seeds directly into pots

B) How to sow seeds in a seedbed

STEP 1: Sow your seeds

- Fill containers with growing medium and firm it down gently leaving around 1cm space at the top
- Make small holes in the soil, not exceeding 2x the seed diameter. For species with high germination rates (>90%) place one seed in each container. For other species, consider inserting 2-3 seeds per container
- Cover seeds with a thin layer of growing medium

- Cover seed-beds with 6-8 cm of growing medium
- Scatter seeds thinly and evenly on the seed beds
- Cover seeds with a thin layer of growing medium (although you don't need to cover them if seeds are extremely small)

STEP 2: Apply light watering if the substrate is drying out

STEP 3: After germination discard unhealthy seedlings

- If more than one seedling emerges from each pot, consider moving surplus seedlings into separate pots or discarding any showing early signs of poor health.

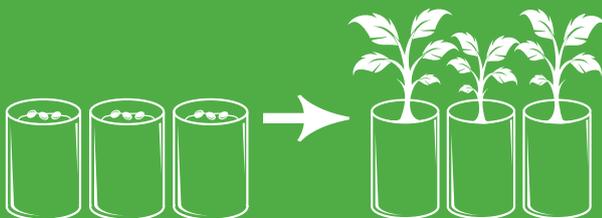


- Also consider discarding any unhealthy seedlings emerging in your seedbeds to reduce competition amongst healthy seedlings.

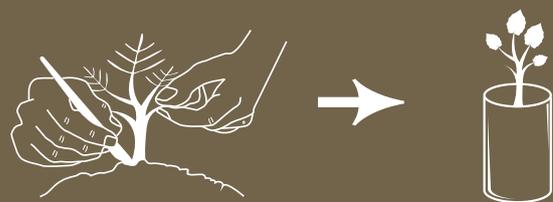


Note: Deciding which seedlings to keep and which to discard requires careful judgement. For example, if you are growing a small number of seedlings for an extremely rare species you may want to keep and care for as many seedlings as possible. However, if you are growing thousands of seedlings you might not want to waste resources on those seedlings that are unlikely to survive in the wild. See Page 7 for further guidance on seedling health.

STEP 4: Growing on your seedlings



After selection, young seedlings remain in their pots growing on until they are ready to be transplanted into larger pots.



After young seedlings emerge from seedbeds they need to be 'pricked out' and placed into pots.

Growing and caring for tree seedlings

When seedlings outgrow their first small pots, they will need to be **'potted up'** into larger individual containers (e.g. tubes, plastic bags, plastic bottles) in order to promote continued growth and survival.

When are seedlings ready for potting up?

Potting up should occur when a seedling's vegetative growth begins to slow. In general, seedlings are ready for transplantation when they have at least two pairs of leaves, a height between 3 and 5 cm and a root length of at least 5 cm.

How do you pot up seedlings?

Preferably transplantation should be performed on cloudy and wet days, without too much wind. Before starting, prepare containers filled with growing medium at the transplantation site. Next, carry out the following steps:

1 Carefully remove the young seedlings and place in containers with water to avoid roots drying out.

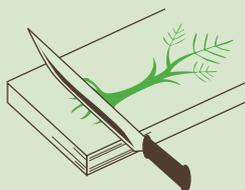
Handle seedlings by their leaves, never by their more sensitive roots or stems.



2 Discard defective or injured seedlings



3 Prune roots from each seedling to encourage root development (this is a key step for growing healthy seedlings).



4 Drill a hole in the centre of the growing medium and plant the seedling inside without folding or breaking roots



5 Ensure the growing medium just covers the root collar (the junction between the stem and root). The medium should fill the space between the fine roots.



6 Water the growing medium and leave the transplanted seedlings in an area protected from the sun and wind.



TOP TIP

Young seedlings are delicate and susceptible to damage and disease. After they emerge, water regularly and protect them from cold, wind and direct sun. Try to:

- Erect fences to protect seedlings from wind. Wind, especially in high temperature damages shoots, dries the leaves and wilts the seedlings.
- Cover seedlings at night with polythene if frost is expected.
- Avoid excess light or shade by using bamboos, palm leaves or other foliage to provide some cover. Seedlings can be gradually offered more light as they mature.
- Seedlings should be watered twice a day – depending on the climate and weather conditions – usually once in the early morning and late in the afternoon. However different species may have different irrigation requirements.

As your seedlings continue to grow in your nursery some of them may suffer from health problems. Left untreated, you may end up with low quality seedlings that will not survive in the wild or disease could spread within your nursery. Be aware of the following symptoms of poor seedling health and consider altering the management of your nursery when you come across them.

Symptom	Possible Explanations
Yellow leaves	Low fertility, high temperatures, excessive light or rotten roots
Round or dying yellow leaves	Fungal, bacterial or viral infection
Death around leaf tips or margins	Excess fertilizers, drafts or hot winds
Slim leaves	Low light, excess water or root rot
Wilted leaves	Lack or an excess of water and root rot
Very slow growth	Small pots, compacted substrate, low fertility, root pests or pathogens

DID YOU KNOW?

It will not always be possible to grow your target species from seed. This may be because (a) you are unable to collect seeds from wild trees; (b) the seeds you collect have low viability or (c) germination protocols are unknown.

When seed propagation proves impossible consider these alternative methods for growing trees:

1) Collect wild grown seedlings (wildlings). Wildlings found under closed canopy often have low survival rates, so collecting a small proportion of these to grow on within the project nursery should have minimal impact on natural regeneration of wild populations. However, some species have highly sensitive roots and wildlings often suffer high mortality during and after transport to the nursery.

2) Vegetative propagation involves cloning new individuals from a part of the living tree (e.g. from leaves, buds, stems or roots). Vegetative propagation can offer a quicker and easier alternative to propagation by seed, but there are genetic issues related to introducing cloned plants back into the natural population. Take care not to cause lasting damage to the mother tree when using this method.

What next

If you intend to plant seedlings into their natural habitat they may need to be **hardened-off** before being removed from the nursery.

This involves preparing them for the physiological stress involved with transport, the act of planting and tougher field conditions. This process can last for several weeks and consists of a gradual decrease in irrigation and fertilization and – for species to be planted in open environments – increased exposure to sunlight.

Watch plants carefully over this period: you may need to re-adjust management if your seedlings begin to wilt or show signs of poor health.

Eventually seedlings will become harder and woodier with a well-developed root system. At this point they will be ready for planting. For further advice on tree planting, see [GTC Brief 9](#).

Selected references and further guidance

References and further guidance on some of the methods described in this brief are provided below.

Guidance on seed behaviour

Bradford, K. and Nonogaki, H. Annual Plant Reviews, Seed Development, Dormancy and Germination. (2008). Volume 27 of Annual Plant Reviews. Wiley.

Kew seed information database: http://bit.ly/gtc_ref_6e

Willan R.L. (1987). A Guide to Forest Seed Handling, with Special Reference to the Tropics. Rome, Food and Agriculture Organization of the United Nations: http://bit.ly/gtc_ref_4d

Examples of propagation guidelines for different tree species

Román, F., De Liones, R., Sautu, A., Deago, J. and Hall, J.S. (2012). Guía para la Propagación de 120 Especies de Árboles Nativos de Panamá y el Neotropico. Environmental Leadership and Training Initiative – ELTI, Yale School of Forestry & Environmental Studies. Available at: http://bit.ly/gtc_ref_7a1

Garry Oak Ecosystems Recovery Team: Native Tree Propagation Guidelines: http://bit.ly/gtc_ref_7b

Hawaiian Native Plant Propagation Database: http://bit.ly/gtc_ref_7c

Guidance on managing a tree nursery

United Nations Development Programme, Special Public Works Programme (1989). Tree Nurseries: An Illustrated Technical Guide and Training Manual, Booklet Number 6. International Labour Organisation. Available to order from: http://bit.ly/gtc_ref_7d

Guidance on raising trees from seed

Gosling, P. Raising trees and shrubs from seed. Forestry Commission Practice Guide. Forestry Commission, Edinburgh. Available at: http://bit.ly/gtc_ref_7e

Longman, K. A. (2003). Tropical Trees: Propagation and Planting Manuals. Volume 2 – Raising Seedlings of Tropical Trees. Commonwealth Science Council. Available at: http://bit.ly/gtc_ref_7f

Elliot, S., Blakesley, D. and Hardwick, K. (2013). Restoring Tropical Forests: a practical guide, Royal Botanic Gardens Kew; 344pp. Available at: http://bit.ly/gtc_ref_3i

For more information, or to download the other briefs in this series, visit
www.globaltrees.org/resources/practical-guidance

Acknowledgements

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