Sunseed Desert Technology
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A SIMPLE METHOD FOR MAKING YOUR OWN MYCORRHIZAL INOCULUM

This is a method of inoculating your plants with beneficial fungi. You can make your own from your own local soil. The soil that you make will be rich in beneficial fungi. This will be the 'inoculum'. It takes about an hour or less to set up and is very simple to maintain.

Contents:

INTRODUCTION

What are mycorrhiza?

Mycorrhizal fungi are a group of soil fungi that infect the roots of most plants. The fungi is not a pest or parasite as it supplies the plant with nutrients like phosphorus, copper and zinc, as well as increasing water availability. The plant supports the fungus with carbon in the form of sugars. This symbiotic relationship does not affect the plants, as they produce excess carbon. In fact, lack of water and nutrients is more often the limiting factor to plants' growth and establishment.

Mycorrhizal fungi are found in most environments, although their importance is greater in more extreme environments, where nutrients and water may be limited. There are very few plants that do not form mycorrhizal associations at all, although most can grow without it. In plants that have been infected by mycorrhizal fungi, the fungus is actually the chief method of nutrient uptake, not the roots.

There are two main types of mycorrhizal fungi. The type that we are interested in is by far the most common, and is called **arbuscular mycorrhizal fungi (AMF)**. These are invisible to the naked eye but form a fine mesh through the soil. The fungi enter the cells of the roots where they form branched arbuscles within these cells, this is where the exchange of nutrients and carbon occurs.

How do you know if a particular plant species can be a host to this type of fungus?

AMF form symbioses with 80% of plant species, including the majority of herbaceous and annual species, most arid and semi-arid woody species and tropical hardwoods. Many tree species of great economic value are AM hosts, e.g. citrus, grape, apple, peach, prunus, coffee, cocoa. AMF are quite promiscuous in their associations with host plants – this is the group that can be pot-cultured with maize, beans, onions etc and then applied as inoculum to a wide range of tree seedlings. In arid and semi-arid regions, most native trees share the same AMF as the wild grasses and other under-storey vegetation growing under the tree canopy.

The other main type is the Ectomycorrhizal fungi: these colonize the roots of most temperate and boreal tree species – conifers, oaks, beech etc. They are much more specific in their choice of host plants, and they have not as yet been successfully cultivated - they will not grow on the roots of garden plants such as maize, beans onions etc – but soil collected from the root zone of one of these tree species should contain propagules (spores etc) of suitable fungi, and can be applied direct as inoculum when sowing seed of the same tree species.

(The main Ectomycorrhizal families are: Pinaceae, Fagaceae, Betulaceae, Salicaceae, Dipterocarpaceae, some Cupressaceae and most Myrtaceae and Caesalpinoideae).

A few plant families do not form mycorrhizas, **notably the cabbage and beet families**. (The main non-mycorrhizal plant families are: Brassicaceae, Amaranthaceae, Caryophyllaceae and Chenopodiaceae (normally)).

Orchids and heathers have different types of mycorrhiza, and are not dealt with here.

Results that you can expect:

The most notable improvement should be an increase in survival rate. It has been shown that mycorrhizal plants cope better with stresses such as dry conditions and disease than non-mycorrhizal plants. Depending on your conditions and the species that you are using you may also notice an increase in growth. This is due to the plant accessing more phosphorus from the soil (this varies from just a few percent to double the normal growth).

There are other benefits that mycorrhiza can bring to the soil. Its fine structure helps stabilise the soil structure, slowing both sheet and subsurface erosion. Under the soil, invisible from above, a network of fungal hyphae will start to spread from your plant, gradually colonizing other plants and in effect starting to rebuild a healthy ecosystem. The underground structure is the key part of restoring the ecosystem. The plants then act as fertility islands with increased organic matter, better soil nutrient levels and with increased nutrient cycling.

If you are interested in producing your own inoculum for your own use and/or running some trials we have constructed this methods page, with a step-by-step guide to setting up your own experiment using a mixed mycorrhizal inoculum made from your own soil. This also instructs you on how to set up your own trial with different target species, be it trees or crops, seeds, seedlings or established plants.

METHOD FOR MAKING A MYCORRHIZAL INOCULUM

Mycorrhizal inoculum can be produced either in pots or in a 'trap-trough'. The method is virtually the same for both.

1. Collecting your 'Starter Soil'

Where? Around 80% of vegetation forms mycorrhizal associations. The infected plant roots and the spores and hyphae of the beneficial fungi are in the soil and can colonize new plants. In arid and semi-arid regions you can be pretty sure of getting a good starter soil from any undisturbed area containing native vegetation including most grown trees (except pines and oaks), woody shrubs and perennial grasses.

In temperate regions, hedgerows, thickets and thriving perennial grasslands that have not been cultivated recently are good sources. If you plan to use the inoculum with tree seedlings, there can be special benefit in collecting some of the starter soil from under healthy trees of the same species.

Method: Clear away about 0.5m^2 of the vegetation underneath your target plant. Dig down to a depth of about 25cm collecting the soil and as many fine roots as possible. It is better, but not essential, to collect from under several different trees and shrubs. With stony soil, sieve it to get rid of large stones.

2. Multiplying the mycorrhiza

To multiply the mycorrhiza from your starter soil we use a 'trap-pot'. This method grows mycorrhizal dependent annuals in the collected soil. These plants, often called "bait plants", will become infected with the mycorrhizal fungus causing the fungal population to multiply. Often two bait plant species are grown together to encourage multiplication of different mycorrhizal fungal species.

A good combination would be a grassy species (eg maize, millet, sorghum, oats, wheat) or an allium (onion, leek), with a species of legume (beans, peas, lentils, alfalfa, clover). Combining maize and beans, for example, is a good choice as they grow well together. It depends, however, on what you know to grow well in your area and on what you have available.

Where? The best place is in a site that will not be needed for at least three months and where you can keep an eye on it. It will need regular watering, adequate light and protection from herbivores.

Method: Take your starter soil to the site you have chosen and then either fill one or several large (5 litre) plastic pots/basins (depending on how much inoculum you need). Alternatively, a trench can be dug intothe ground and lined with the plastic sacks or other material available. This is what we call a 'trap-trough'. The pit should be dug about 100cm x 50cm to a depth of 50cm and then lined with the plastic sacks. Plastic sheeting, bin liners or sugar sacks will be fine.

Perforate the plastic to allow for drainage. Make sure that it covers the whole basin with an overlap. Place stones on the overlap and fill the trough with the soil. Soak the seeds of your two chosen species overnight. Plant them closer than normal, alternating the species.

Note: the soil that you dig out of the trench can be used to fill in the holes where you extracted soil from under the local vegetation.

How much inoculum do you want to make? This depends on what size container you will be planting in, but estimate about 1/6 of each pot to be filled with the inoculum. If using on crops see 'inoculating crops' below.

Trap Trough

3. Maintaining your trap-pots or trough

Once you have set up your trap-pot or trough you can more or less forget about it. Just keep it regularly watered. In this time the roots of the bait plants will be developing and forming the association with the mycorrhiza. Depending on the season you might need to shade it or protect it from frost. If growing trap-pots then they can be moved into a more sheltered area.

4. Three months later…

Ten days before you are ready to use the inoculum, the bait plants should be cut down at the base of their stem and watering should be stopped. This kills the plant, and tricks the fungus into producing reproductive spores. Then, after the ten days, the inoculum is prepared by pulling up the roots of the bait plants which should be chopped into roughly 1cm pieces and then mixed back into the soil from the trap-pot or trough. This mixture of roots and soil is the inoculum.

5. Using the inoculum

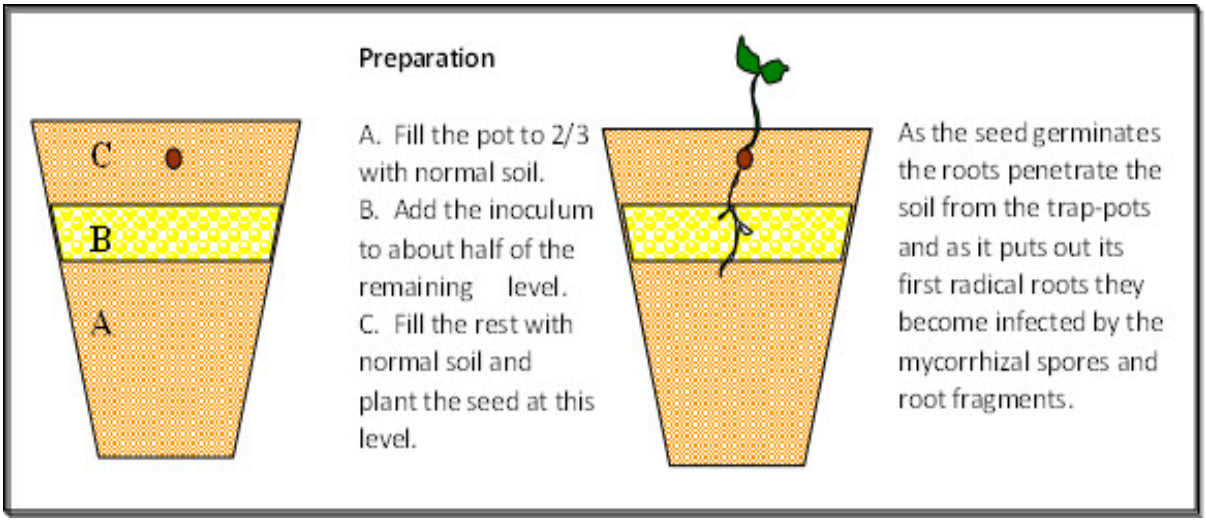
The inoculum can be used on a wide range of different trees, shrubs, crops and garden plants. In all cases the plants should be given the same care as normal. A small amount of compost will complement the addition of mycorrhiza but no artificial fertilizers or herbicides should be added.

THINGS TO CONSIDER WHEN SETTING UP A TRIAL:

Inoculating:

(a) Inoculating trees, growing them from seed:

Method: As shown in the diagram below, two thirds of the pot or growing tube should be filled with normal soil, with a little compost mixed in, if available. Then add a layer of inoculum and finally another layer of normal soil into which the seed is sown. The inoculum layer need only be a couple of centimetres deep. This means that when the roots grow down the tube they will come into contact with the fungus, and quickly become infected. The trees are then cared for as usual, and planted out at the same time as normal, to coincide with the growing season. The trees that have been infected with the fungus should be much better equipped to cope with shortages in rainfall, and will also improve the mycorrhizal potential of the surrounding soil.



(b) Inoculating pre-grown trees:

Method: dig the hole where you will plant your tree and throw in a spade-full of the inoculum. Place the sapling in the hole and sprinkle a little more of the inoculum around the edges as you fill it in. If you are adding compost then dig the hole slightly deeper, add the compost, cover over with normal soil and then add the spade-full of inoculum.

(c) Inoculating crops:

Method: Put a pinch of inoculum into any hole that you are about to sow or plant into. Or mix a couple of handfuls of the inoculum with seeds that you are about to sow and sow into a drill). If transplanting then soak the root ball in water and then dip in the inoculum. The root ball will then have a coating of inoculum. Plant as normal.

When you have used as much of the inoculum as you need, the trap-pot or trough can be topped up again with more starter soil, re-planted with bait plants and the cycle repeated. This ensures that there is a ready supply of inoculum all through the year.

Setting up a trial:

Labelling your plants

1. Keep a careful note of where each plant was planted and what treatment if any it was given. It is useful to give each plant a number.
2. Label each plant in a way that will not be destroyed by the elements. You are unlikely to remember which plants are where months later. We usually label the plants either mycorrhizal (M) or control (C) (= non-mycorrhizal)

Layout of M and C plants

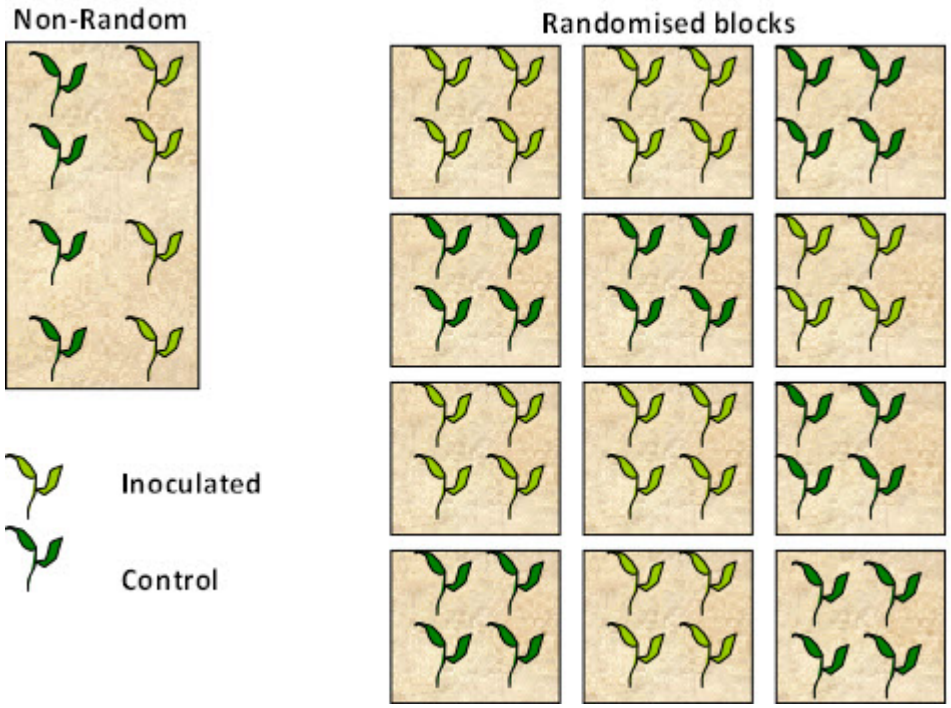
1. Do not plant too close together. Spacing them will reduce the chance of the fungi spreading to non-inoculated plants.
2. It is preferable but not essential that the treated and non-treated plants are laid out randomly. This reduces environmental factors that might affect the results. One way of doing this is a randomised block design (see below).

Designing the trial:

It is worth spending some time considering where and when you want to set up the trial. How much space you have as well as the amount of care that you can give the plants. The trap-pot or trough needs to be set up three months in advance of your scheduled planting in order for the mycorrhizal population to fully mature.

For whatever planting you are doing try incorporating the mycorrhizal method. But if you have a blank area and would like to set up a more rigorous test of the method then below are a couple of examples of how you might lay out a trial. The first is non random (see diagram below), this has the advantage of giving a direct and easy to see comparison.

However, with this layout external factors might well influence your results. For example, factors such as wind direction, shade, and soil variability could induce better growth in one side regardless of the treatment. Using a randomised block design is a fairly simple way of reducing the risk of these factors influencing your results. An example of a randomised block design is shown below:



HOW TO RECORD PROGRESS:

How to record the progress of your inoculated and non-inoculated plants

You will need to keep a regular check on the plants that you are growing. Survival is simply a matter of recording the number of inoculated and control plants surviving. This is less time consuming than taking height measurements.

We would only expect height measurements to be taken if you are growing small numbers of plants, or if you feel you have sufficient time and labour. The system for measuring the plants needs to be consistent, using the same unit of measurement (preferably millimetres), the same instrument and if at all possible, by the same person.

The frequency of measurements is up to you, the more regular the better. Here, we measure height and survival in the nursery every two weeks, and decrease that to once a month after the plants have been transplanted into the field. It is recommended that the measurements be taken with an interval of not more than a month.

In addition to measurements, we would encourage additional comments on the data pages, to record information relevant to specific plants (e.g. eaten by insects, broken by children etc) and any other information about the trial and external factors in general (e.g. bad rains, widespread diseases etc).