Section 5:
Nursery and plant hygiene

If you do not control pathogens and pests during propagation, your plants will be inferior, and field planting might be delayed. In this section we introduce ecologically sound concepts and ideas for improving the general level of hygiene in your nursery.

Healthy plants are the goal of every nursery manager. This is not restricted to research nurseries but applies to nurseries of all sizes and levels of sophistication. Nursery hygiene does not necessarily mean using expensive or toxic chemicals — you can achieve a healthy nursery with ecologically sound management.

Traditionally, there have been two basic approaches to nursery health: **preventive actions**, which include balanced fertilizers, use of resistant species or cultivars, timely hardening of plants, cleanliness in the whole nursery, and training of staff, and **curative actions**, which include the use of pesticides,

Factors that influence plant health	
abiotic ('non-biological')	- drought or waterlogging - excessively high or low - injury due to chemicals - physical damage, for example shearing off roots
biotic (biological)	all biological organisms (bacteria viruses, viroids, phytoplasms, fungi, insects, mites, nematodes, weeds, parasitic plants, birds and mammals) that interfere with plant production

There are two approaches to nursery health: preventive actions and curative actions.

heat, biological control or physical measures (e.g. cutting out of diseased parts). From these two approaches, **integrated pest management** has evolved, combining 'preventive' measures with 'curative' methods, and using chemical, biological and cultural control. It is neither practical nor wholly desirable to attempt total elimination of pests — many beneficial organisms are destroyed in such efforts, and a lack of beneficial organisms can lead to an explosive recolonization of the nursery beds with pests.

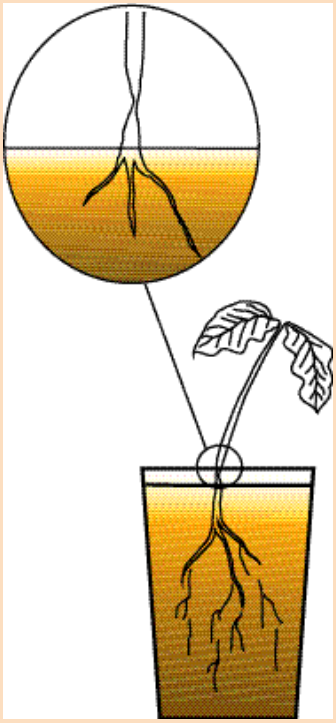
Actions to prevent nursery contamination

There are five main entry points for pathogens into the nursery:

- propagation facilities: containers, flats, knives, secateurs, working surface, boxes etc.

Damping-off

Probably the best-known nursery disease of all is ***damping-off***, which is caused by several species of fungi, particularly ***Pythium***, ***Rhizoctonia***, ***Phytophthora*** and ***Fusarium***.



Damping-off can occur on seed before germination, or on young seedlings.

When it happens, the stem of the seedling becomes constricted just above the surface of the germination substrate, and then the seedling falls over and dies. (Sometimes this can happen without any fungi present, for example, with high temperatures of the propagation medium.) There is often (but not always) damage to the plant beneath the soil surface as well. The reason for symptoms appearing at the soil surface are not well understood but might be related to the point where the plants start photosynthesizing or where aerobic/anaerobic conditions are conducive to the more virulent stages of the life cycle of the fungus.

Pathogens which cause damping-off, particularly ***Pythium***, ***Rhizoctonia*** and ***Phytophthora,*** can be spread in the irrigation water. High plant density, overwatering and heavy shade favour the spread of the disease and should be avoided.

- propagation substrates
- irrigation water
- planting stock: seeds, cuttings, scions and rootstocks
- shoes and clothing of nursery staff and visitors.

Plant hygiene begins before propagation, by paying attention to these five entry points.

Propagation facilities

- Keep the nursery area itself free of weeds. Many plant species can be alternate hosts of important nursery pests. This precaution includes a sensible selection of ornamentals, shade, hedge and windbreak plants in and around the nursery, as they too can be hosts for pests such as nematodes.

- Treat all wooden supports with old engine oil or chemicals against termite attack. If possible, place propagation structures onto a slab of concrete.

- Keep tools, work surfaces and containers clean at all times. Take particular care with proper sterilization of containers, especially when these are reusable ones. Root diseases such as *Fusarium* root rot can be transmitted through diseased root segments grown into the wall of styrofoam containers. Some tools and containers can be autoclaved but the necessary equipment is not always available.

Keep the nursery area free of weeds and keep tools, work surfaces and containers clean at all times.

One of the most satisfactory and readily available chemicals for sterilizing nursery equipment is chlorine, the active ingredient of household bleach. Chlorine is a very irritating gas with a pungent odour. It evaporates easily and its smell can be detected in very low concentrations (0.2–0.4 ppm); in higher concentrations it irritates eyes, nose and throat. It is a strong oxidizing agent and kills organisms by chemically 'burning' their tissue. It is usually diluted in water. The usual form of chlorine in household bleach is as the sodium salt, sodium hypochlorite (NaOCl). Commercial household bleach contains 3.5% NaOCl in water. To use it as a sterilant, make a 10% solution (1 part bleach to 9 parts water) and soak instruments or containers in it for at least 30 minutes. The use of a few drops of washing up liquid helps prevent air bubbles next to the surface. Chlorine is deactivated by dirt particles. Therefore clean all material to be sterilized thoroughly before putting it into the solution. Make a fresh solution each time you need it, and replace when dirty.

Use 10% household bleach to sterilize tools and containers.

Chlorine is a contact sterilizer and has no systemic functions. It can only kill organisms that are exposed to it such as those suspended in the solution or on the surface of the equipment. Therefore, it is a good idea to soak containers and other equipment in water for 24 hours before sterilizing so that fungal spores, for example, can germinate which makes them more susceptible to the treatment. A 10% bleach solution is also used to sterilize bench surfaces and other work surfaces.

The disposal of used chlorine solutions may be a problem: the hypochlorite ion attaches to organic compounds in the soil, can be taken up in the food chain and can accumulate in the body fat of animals and humans. This can pose a serious problem when large amounts of chlorinated water needs to be disposed of. A practical solution for small amounts is to let a container with chlorinated water stand until it does not smell of chlorine any more.

Note: As with any other chemical disinfectants, chlorine is a hazardous substance and misuse can lead to serious injury or even death. Use only in well-ventilated areas.

A less hazardous alternative to chlorine is hydrogen peroxide (H_2O_2), which breaks down to water and oxygen. Use 1 part commercial H_2O_2 (35%) to 100 parts water. Other disinfectants frequently used, especially in the laboratory, are formalin, mercuric chloride and 70% alcohol. These are all more expensive than bleach, and in addition, formalin and mercuric chloride are extremely poisonous and are suspected carcinogens.

Propagation substrates

When substrates, in particular soil and organic material, are brought into a nursery, they provide easy ways for pests to come too. In bare-root nurseries or when practising open-ground propagation, pests may accumulate in the soil and make large-scale treatments or, in extreme cases, a move to a new location, necessary.

The standard treatments for substrates are either chemical fumigation or sterilization with hot steam or sunlight. Chemical fumigation with methyl bromide or related chemicals is very hazardous and expensive. Methyl bromide

is highly toxic to humans and it destroys the earth's ozone layer. It is scheduled to be banned worldwide, although this ban will not be effective in most countries until 2010. We therefore strongly discourage the use of methyl bromide. Environmentally safer options are sterilization (correctly called 'pasteurization' because it is not a complete process) with either hot steam or sunlight ('solarization'), or selective treatments with herbicides or fungicides if necessary.

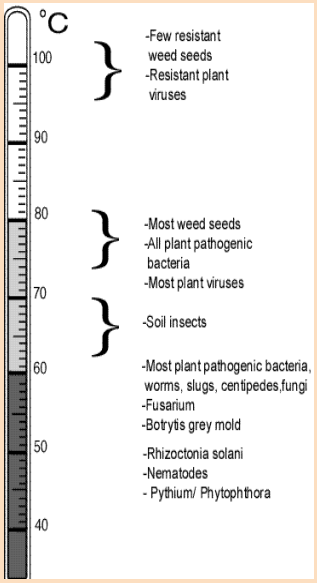
For storage of sterilized substrates, use only clean and disinfected containers.

Substrates that have been manufactured using high temperatures, such as vermiculite or perlite, do not need to be sterilized **unless they are recycled**. For storage of sterilized substrates, use only clean and disinfected containers.

Soil pasteurization treatments

steam pasteurization

Soil sterilization with aerated steam is preferred to fumigation with chemicals. However, steam is not selective and kills beneficial organisms as well as pathogens. Specialized equipment for steam pasteurization is not always available. A practical and simple alternative can be made using a clean oil drum: insert a strong mesh or grid at about 1/3 its height from the bottom, for example by welding iron rods at close spacing. Put the drum onto stone feet, fill with water up to the grid and place the substrate in sacks on top of the grid. Cover the drum, light a fire under the drum and keep burning for 2–4 hours. Ensure that the temperature of the substrate reaches 60°C for 30 minutes. This will kill most plant pathogenic fungi and bacteria, as well as nematodes, but only a few viruses, plant insects or weed seeds. If you need a more complete treatment, raise the temperature to 80°C and hold this for 30 minutes. However, at this temperature, so many beneficial organisms will be killed that this may lead to an explosive re-colonization of the substrate with pathogens.



solarization

Solarization can be carried out in any nursery. Cover moist soil with transparent polyethylene sheets and weigh them down with rocks. On sunny days, the temperature under the plastic sheet will reach 70°C or more. However, this pasteurization affects only the first few centimetres of soil and under cloudy conditions it can take several weeks for a successful treatment.

Irrigation water

A small amount of chlorine to provide a 1 ppm concentration for at least 30 minutes can be added to the irrigation water to control damping-off fungi.

Water for irrigating in nurseries often comes from a dam, a borehole or a tank filled with rain water. These stagnant reservoirs provide excellent conditions for water mould fungi — species of *Pythium* and *Phytophthora* — which are commonly associated with damping-off. A small amount of chlorine to provide a 1 ppm concentration for at least 30 minutes can be added to the irrigation water to control damping-off fungi. (Swimming pool water has a maximum concentration of 8 ppm available chlorine).

Disinfecting irrigation water

Household bleach usually has a strength of 3.5% or 35 000 ppm NaOCl. It contains 24 000 ppm chlorine (Cl_2). To make 1 L of a 1 ppm Cl_2 dilution, 0.042 ml (or 42µl) of household bleach is needed. For a 20 L bucket, 20 x 0.042 = 0.84 ml. A 10 000 litre water tank would need 420 ml. If the water contains a lot of sediment or other dirt particles, up to twice as much will be needed. In any case, the amount needed for treating irrigation water to check diseases like damping-off is very small, and this makes nursery hygiene affordable and simple.

Planting stock

Diseased plants in a nursery should be culled rigorously and burnt rather than composted.

Plant material from other nurseries (seed, cuttings, scion wood and rootstock) can harbour nursery pests. Wherever possible, accept propagation material from nurseries only if it has a plant inspection certificate. If in doubt, surface sterilization should be carried out on all new and unknown material.

Diseased plants in a nursery should be culled rigorously and burnt rather than composted. Composting diseased material can only be recommended if the compost temperatures are high enough to kill pests (above 60°C), and can be maintained at this level for several days.

Shoes and clothing

Quite often, diseases are brought into a nursery inadvertently on shoes (soil-borne diseases and nematodes) or clothing (weed seeds). This is very

difficult to control. The best way is probably to issue to staff boots and work clothes to wear during work in the nursery and to install a dip basin with 10% household bleach solution at the entrance of the nursery through which staff and visitors have to walk to disinfect their shoes, especially when they come from fields where soil-borne diseases or nematodes are present.

Methods of surface sterilization	
heat	For seeds, tubers and roots, hot water soaks (40–55°C) are recommended. Temperature and duration depend on the species. You can find the best range with simple experimenting, for example by soaking material at two different temperatures for half an hour, two hours and four hours.
chlorine	Dipping cuttings into a 10% household bleach solution for 20 minutes is a practice recommended for some hardwoods but it should be tested for phytotoxicity on all species first.
fungicides	Seeds or cuttings can be coated with a dust or slurry of fungicides. Captan® and Benlate® are the most commonly used fungicides for seed treatment. Captan® is a contact fungicide which kills pathogens present on the seed coat; Benlate® is a systemic fungicide which penetrates into the seed and has an effect on the embryo during germination, giving the seed a longer-lasting protection. However, most fungicides have a high toxicity to seeds and they often act only on one of the number ofpathogens that are usually present. Recent work suggests that coating the seed with a bacterial formulation, esp. ***Trichoderma harzianum*** or ***Pseudomonas*** spp., would be helpful. However, for the time being, this technique is out of reach for most institutions in developing countries.

Actions to prevent nursery contamination	
plant health status	Healthy, well-fertilized and properly irrigated plants are better suited to withstand pest attacks. However, over-fertilizing should be avoided, especially excess nitrogen, which weakens plants and makes them more attractive to many sap-sucking insects, such as aphids and psyllids.
plant density	Avoid very dense spacing in germination and nursery beds, because diseases can spread easily. Close spacing can also lead to etiolated and weak plants which are susceptible to disease.
hardening	Timely hardening of seedlings will produce strong and healthy plants that are able to withstand a certain amount of pest or disease attack.
resistant species or cultivars	If possible, grow resistant types or cultivars, or avoid susceptible species altogether. For example, citrus should not be propagated in areas with high incidence of aphids, since aphids transmit citrus greening disease, and spraying against the aphids usually cannot check the problem to the necessary extent.
cleanliness in vegetative propagation	When harvesting scionwood and cuttings, take care that they come from healthy stock plants that are not depleted of nutrients or drought stressed, to enhance their resilience to diseases. Always sterilize knives and secateurs with alcohol to avoid spreading virus diseases, which are often transmitted on the tools.
staff training	To keep pest and disease levels low, all employees should be trained to recognize and report pests. Workers who are in daily close contact with the plants through watering, weeding etc., will probably more often encounter such problems than a nursery manager would.

Actions to cure infected plants

In instances of pest or disease attack, you will have to decide whether to use physical, biological or chemical pest management.

In areas where manual labour is readily available, and when the incidence is not very severe, collecting of pests or diseased leaves from the seedlings by hand and destroying them may be practical. Biological agents such as parasitic wasps can be used but they are not available everywhere. Successful studies with various agroforestry tree species, such as *Gliricida sepium*, *Erythrina* spp., *Calliandra calothyrsus* and *Leucaena leucocephala* have been carried out by the Institute of Biological Control, the International Centre for Insect Physiology and Ecology and other institutions which can provide more information.

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However desirable the use of biological methods, chemical sprays or drenches are still in most cases the methods of choice. These pesticides act quickly, and often they are selective so they do not destroy beneficial organisms. For important horticultural crops in temperate zones, pest occurrence thresholds have been published, below which the use of pesticides is not recommended. For tropical trees, notably agroforestry tree species, no such thresholds exist. We recommend that nursery managers develop them for their local conditions. For example, you could decide to spray with an insecticide against aphids only if these are detected on more than half of the stock, or to use a miticide against spider mites only if more than 10% of plants show symptoms. Of course these thresholds depend on the species and their susceptibility to the pests, and developing them requires intimate knowledge of the species.

Further reading

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