

Managing Disease Transmission into Production Nurseries

Pests and diseases are major causes of crop loss in production nurseries. They may increase crop management costs, increase time to produce a saleable product and may cause total crop failure. Furthermore, low level infestations can be spread in stock if management actions have been unsuccessful (or incorrectly implemented). Pests and diseases move into production nurseries easily, particularly if mitigating actions are not taken. Typically, they are carried or spread in plant material, water, growing media and soil. Many insects, and some diseases, are also spread in the air. The purpose of this fact sheet is to outline some vital management practices to prevent pests and diseases from entering the nursery and stop their spread, when they occur. No single strategy can prevent



pests or diseases from entering the nursery. However, when many management actions are combined they have a powerful effect on reducing the incidence of pests and diseases.

INTRODUCTION

The basic assumption taken is that all inputs (e.g. growing media, water, staff, visitors, etc.) have the potential to infest crops. Therefore, a holistic approach is taken with simple, effective recommendations that can be integrated into day-to-day

operations. They are based on sound biosecurity principles to reduce the risk of bringing pests and diseases into production nurseries. Review nursery processes regularly to ensure that best practice has been maintained. Management actions outlined here compliment those discussed in other production nursery resources, which are referenced where relevant.

Recommendations around the management of each nursery input are provided within a framework of preventing pests and diseases. This will assist nursery managers to understand how their actions prevent pests and diseases entering the nursery. A concise practical approach

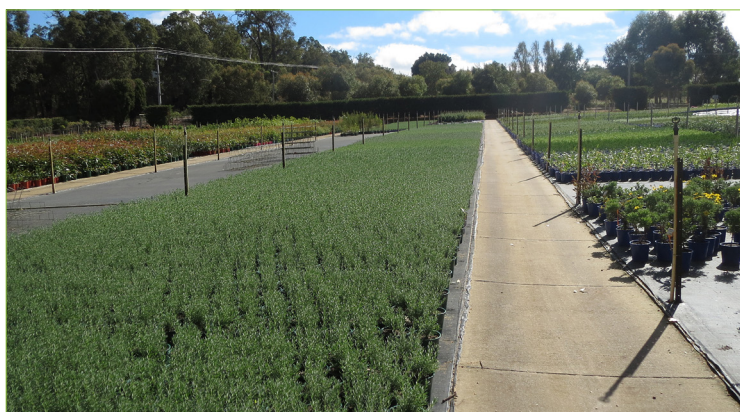
is also provided for managing a disease outbreak, to limit its spread and prevent healthy plants from becoming infested.

A great number of resources are available on the nursery production FMS website specifically created for the production nursery industry including [factsheets](#), [management plans](#) and [webinars](#) on a [wide range of topics](#) (the search function works!). These resources can be used as training material for staff so they understand why management practices are in place. Put in place a system that works for you and your staff to communicate potential problems proactively.

STAFF, VISITORS AND EQUIPMENT

Pests and diseases can be brought into nurseries by visitors and staff on hands, shoes, clothing, vehicles and equipment. They can be spread by people across nursery sites and between growing areas on the same site. It is important to train staff to be aware of where they may have come in contact with a pest or disease, so they can take appropriate action to mitigate the risk. For example, thoroughly wash hands in detergent, or suitable disinfectant product, after handling diseased plants. Consider if other areas were contaminated and disinfest as required. It may also be necessary to change clothes after handling or working with infested stock to avoid spread of the pest or disease through the nursery, e.g. severe infestations of spider mites, grey mould etc.

It is recommended to keep on-site roadways and parking lots sealed or free of soil, e.g. with a thick layer of weed-free road base or gravel. This reduces the risk of soil borne pathogens entering the nursery on shoes and reduces dust. Plants covered in dust may have reduced photosynthesis and pathogens may also be present in dust. Ideally, design the site so that staff parking is proximal to entry, i.e. vehicles do not have to drive through the growing area to get to the carpark.



Maintain clean and weed free paths.

SIGNAGE

It is necessary to have well designed signage to inform visitors and staff that biosecurity is a high priority for the nursery and that site induction is required (e.g. “Please respect nursery biosecurity, complete a site induction.”). Visitor site inductions can be short and highlight key points, e.g. informing visitors of prohibited areas, showing an example of prohibited area signage, how and when to use shoe and hand wash down facilities, etc.

Wherever possible, avoid contact with stock that has an infestation that can be moved on people, e.g. whiteflies, spider mites, grey mould etc. A flag system can be used as a visual sign for staff to restrict movement in certain areas or limit contact with stock until appropriate actions have been taken to remove the risk of spread.

FOOTBATHS AND FOOTWEAR EXCHANGE STATIONS

Footbaths should be used on entry to a nursery to prevent the introduction of soilborne pathogens on shoes. The effectiveness of a footbath depends on first removing most of the soil and plant material from footwear. Disinfectants will not penetrate clods of soil and therefore must be removed. Following the removal of soil, the footwear can be successfully disinfected in the footbath, killing remaining spores. The following footbath procedures are important and should be adhered to at all times.

- » Provide adequate procedures and tools to clean footwear prior to using the footbath. These include a firm bristle boot scrubbing brush, and a flathead screwdriver to remove mud from within the treads of the sole of the boot.
- » The footbath must be long enough for two steps and have a hard surface approach and exit. The footbath must be deep enough to allow the entire tread of footwear to become immersed in disinfectant.
- » It is best kept undercover to prevent dilution from heavy rain.
- » Fill with a registered disinfectant (e.g. quaternary ammonium-based products). Use at the recommended rate and specified contact time.
- » Routinely check the concentration of the quaternary ammonium-based product in the footbaths with test strips.
- » Change and clean footbaths regularly as a build-up of soil and plant material will reduce the efficacy of the disinfectant. Footbaths that drain to a removal container can be beneficial.

- » Dispose of the footbath contents in a hygienic manner, away from the production area and any water source.

Footwear exchange stations can also be used to prevent contaminated footwear from entering the nursery. As with footbaths, there must be a defined pathway at the entrance to the nursery. Shoes are exchanged for dedicated nursery boots. A footbath used in conjunction with the footwear exchange will further reduce the risk of contamination entering the nursery.



Fixed foot baths can be beneficial, particularly if they are built with a collection drain for easy and hygienic disposal of disinfectants.

HAND WASHING STATIONS

It is recommended that all visitors and staff disinfect their hands upon entry to the nursery. This reduces risk of plant and human pathogens entering the nursery. Hand soap and detergents are powerful sanitizers, active against a broad spectrum of microorganisms and are preferred over hand sanitizer. If using hand sanitizer, it is recommended to be ethanol based (>70% ethanol), and rubbed on the hands until dry. If hands are visibly dirty, soap and water should be used to remove material as the sanitizer is unlikely to penetrate organic matter. Disposable gloves can be used as an alternative in certain instances.

It is recommended to have wash stations in a number of locations in the nursery to encourage staff to disinfect their hands if they suspect they have come in contact with a plant disease.

VEHICLES AND EQUIPMENT

It is recommended to have dedicated vehicles, machinery and tools for the production area. If this is not the case, and vehicles and equipment have come in contact with soil or plant material, it is recommended to clean and decontaminate them before they enter the nursery.

- » Wash using adequate water pressure, and a detergent based cleaner, to remove all soil and plant material.
- » Rinse with clean water.
- » Decontaminate with an effective disinfecting product (e.g. quaternary ammonium-based products), at the recommended rate, and for the specified contact time.

Ensure containment and safe disposal of wastewater/soil/organic matter.

IRRIGATION WATER

All production nurseries need to irrigate with clean water. Highly destructive soilborne pathogens such as *Phytophthora*, *Pythium* and *Fusarium* can be carried downslope in surface water flow as spores, or in small pieces of infected plant tissue. Infected plant material can also be blown into water storage or moved by birds. Eventually, infective material will contaminate dam water. Some water sources are unlikely to become contaminated. These include bore water, and water from deep wells that have been protected from surface flow. These two water sources may require testing for salinity or treatment to remove or otherwise detoxify certain factors (e.g. iron). Rainwater collected from a clean roof, and stored directly in a clean tank, is also unlikely to be contaminated, as it has not come into contact with soil or plant material. But note, very few rooves are completely free of dirt, dust and plant matter. Town water is clean because it has been subjected to a purification and treatment processes to destroy organisms harmful to human health.



Maintain irrigation water to a high quality, free of algal blooms.

Water from dams, creeks and rivers has a very high risk of contaminating nursery stock and needs to be treated. The effectiveness of any treatment may depend on factors such as water chemistry, turbidity, pH and organic debris. It may be necessary to install a filter to remove debris and insoluble particles prior to treatment. Water sanitation can be achieved using [several methods](#) including chemicals, UV light, ozone or other systems. Inexpensive and simple options exist that may be suitable for your business. A great deal of information on water disinfection systems is available on the [nursery production FMS website](#).

GROWING MEDIA

Using pathogen free growing media can significantly reduce the risk of contamination. Growing media can be disinfested with steam (100°C for 30 minutes) or aerated steam (60°C for 30 minutes). It is important that new media be [stored](#) in an area free from contamination by soil, used growing media and sources of plant material (including wind-borne seed). Clean equipment is required when loading the media.

It is also important that the growing media provides for the basic requirements of the plant to facilitate optimal growth. The growing media must provide good aeration and drainage for root development. Respiration requires oxygen and produces carbon dioxide; air spaces in the media must be adequate to supply oxygen to the roots and remove carbon dioxide. The media must be well drained as intermittent waterlogging will predispose plants to infection because of low oxygen levels. A well-drained growing media is also necessary to minimise salinity injury to the roots. It must also supply adequate water and minerals for plant growth.

PLANTING MATERIAL

Never underestimate the danger of introducing pests or pathogens into your nursery with new planting material (e.g. seeds, grafting material, tube stock, mother stock). It is recommended to place all newly acquired plant material in an isolated area until freedom from high risk pests and diseases can be established. Remember many diseases are not detected upon initial inspection because of the incubation period between infection and symptom expression, or due to fungicide application. Unfortunately, some diseases ([latent pathogens](#)) can remain dormant for several years before showing symptoms.

MOTHER BLOCKS FOR CUTTINGS AND GRAFTING MATERIAL

Healthy, true-to-type mother stock should be grown in isolation from other stock plants and away from regular foot or vehicle traffic. Mother stock should be grown under optimal conditions to reduce plant stress. Seed, cuttings or other propagative material may be taken out of a mother block, but only devoted, healthy mother stock plants should be taken in. Monitor mother stock regularly for pests, diseases and disorders. Increase monitoring effort leading up to the period when cuttings will be taken. It is critical that mother stock plants are healthy, vigorous and free of pests and diseases. Propagating from infested plants multiplies the problem and should be avoided at all costs.

Avoid overhead watering of mother plants. Many fungi need prolonged wet conditions to produce spores and spores are often spread by water splash. Cuttings should be taken when leaves and stems are dry, away from areas that could be splashed with soil or growing media particles during rain (or irrigation events). This reduces the likelihood of taking cuttings that may be infested with soil borne pathogens. Disinfest secateurs and knives as they can transmit pathogens, especially viruses and bacteria. They should be sterilised with 1–2% bleach (by volume) for 30 seconds, or other suitable commercial products, before moving to the next mother plant.

For more information on the management of mother stock refer to the factsheet on [preventing disease in propagation](#) and the [high health grafting and budding factsheet](#).



Grow and maintain mother stock plants to a very high standard.

GROW HEALTHY PLANTS

Healthy plants are less susceptible to diseases and can tolerate greater pest damage. Stressed plants are more prone to pest damage and have increased risk of disease infection and non-pathogenic disorders. Maintaining proper irrigation practices, balanced nutrition programs and appropriate growing conditions will produce healthier plants. Furthermore, some factors can have both direct and indirect effects on disease development. For example, any factor that devitalises the top of a plant (climatic extremes, insects, a toxicity or deficiency of nutrients, incorrect growing media pH or EC) can make the root system more vulnerable to soilborne pathogens.

It is recommended to monitor the growing media and irrigation water pH and EC on a regular basis to ensure conditions are within the optimal range. These factors can affect uptake of water and nutrients but, perhaps more importantly, affect root growth and root regeneration. Inappropriate pH and EC also can cause disorders that appear as nutrient deficiency, pest or disease damage, including root rot, leaf spots and unusual foliar growth.

Monitor plant health regularly, recording the incidence of any pests, diseases and disorders electronically (e.g. in a searchable database or spreadsheet). Electronic platforms provide a history of pest and disease incidence that can be searched easily and may assist in establishing patterns that can be used in the proactive management of the problem. This is particularly important for pests that only occur sporadically or after particular environmental conditions. It is also recommended to record successful and unsuccessful management actions, which can be used to [build a management plan](#) if the pest/disease increases in importance. Without electronic records to consult, such patterns are not normally recalled years down the track (or may not be passed down from one production manager to the next).

INSECTS AS DISEASE VECTORS

A large number of insects can vector plant viral, bacterial and fungal diseases. The most important groups of insects that vector plant viruses are aphids, thrips and whitefly. Other groups also transmit viruses including leafhoppers, mealybugs, some mite species and other organisms. The lifecycle of insect-vectored viruses can be very complicated. Therefore, if you are managing an insect-vectored virus it is recommended to investigate the system in detail and put in place management actions that break

the life cycle and eradicate the problem from the nursery. This may include growing resistant varieties or cultivars, managing weeds (which can be asymptomatic hosts for the virus), removing all infected plants promptly from the site and other actions. For more information refer to the factsheet on [managing viruses in production nurseries](#).

Some insects can transmit bacteria or phytoplasmas, e.g. leafhoppers. Furthermore, feeding damage caused by insects cause wounds that can lead to secondary infection by fungal and bacterial plant pathogens. Insects may also physically move bacteria and fungi on their bodies from plant to plant, potentially increasing the spread of the problem significantly. Therefore, management of insects and mites is important from the perspective of disease management.

In particular, [fungus gnats](#) and shore flies can spread spores of plant pathogens. Fungus gnat larvae feed on fine roots, root hairs and lower stems of plants and reduce plant growth. They also wound root tissue, making roots more susceptible to soilborne pathogens. Shore fly larvae feed mainly on algae and also spread fungal spores. Managing algae includes removing all infested growing media and plant debris, and not overwatering, as this encourages algal growth. Refer to the [weeds management plan](#) for more information.

MANAGING CONTAMINANTS – WEEDS AND WASTE

There are many sources of contaminants in the nursery that must be managed on a regular, proactive basis to reduce risk of disease. This includes organic matter in the growing area, weeds, old stock and keeping working areas and tools clean. All waste material (plant and spilled growing media) should be regularly removed and disposed of appropriately. This includes old stock and ‘pet’ plants. Any vehicle or trolley used to remove waste must be cleaned and disinfested prior to use within clean areas.

Removal of old stock is particularly important as it can serve as a link from the old stock to new stock, potentially infecting new stock. As container stock ages a number of disorders can become increasingly important (e.g. nutrient deficiency), plants can become pot bound and low oxygen can lead to root rot if media breaks down too much. These factors can lead to plant stress that increases the risk of infection or may reduce the lifespan or vigour of stock, post-sale.

Care should be taken to ensure that weeds are not allowed to grow in the nursery or immediate surrounds. They can act as alternative hosts for many pests and plant pathogens, especially virus diseases. Some viruses have a wide host range and some weed hosts do not show symptoms when

infected. A good example is *Tomato spotted wilt virus* which is transmitted by several species of thrips, including western flower thrips. It is recommended to manage weeds proactively, as per the [liverwort](#) and [weed management plans](#).

After a growing area has been cleared, and prior to introducing new plants, [decontaminate](#) all structures including benches, pathways etc. to reduce the inoculum load of any pathogens, algae, liverworts and other weeds that may be present. First remove all organic matter (plant material, soil, algae etc.) then wash, rinse and decontaminate as recommended for vehicles and equipment and the '[Keep it CLEAN](#)' guide. It is also recommended to have hooks available to hang hose nozzles so that they do not rest on the ground. Work benches should be nonporous to aid in effective cleaning and disinfection.

MANAGING AN OUTBREAK

Proactive handling of disease infestations will limit spread and prevent healthy plants from becoming infested. Monitoring plants regularly (e.g. weekly checks) to catch outbreaks early is of critical importance. This limits spread of the infestation in the nursery and reduces costs associated with managing it. It also builds knowledge of when certain disease pressures are at their highest (e.g. seasonal high-risk periods) and establishes whether preventative management actions have been effective. If diseased plants are found it is important to act quickly to reduce spread to healthy plants. Correctly identifying the pathogen is important as management may differ for different pathogens. Therefore, this section is necessarily general to those actions that are relevant to most infestations; more specific recommendations can be found in fact sheets and management plans on specific pathogens.

It is recommended to send plants to a diagnostic service to identify the problem (or to provide evidence that a pathogen is not present). Each state has a diagnostic service for plant pests and diseases. However, the production nursery industry has a levy funded project that provides 6 free pest or disease diagnostic samples per year for all production nursery businesses (between 2021 and 2026). For more information refer to the [Grow Help Australia website](#).

For foliar pathogens it is important to identify the source and remove or quarantine infected plants, debris and containers to prevent further spread. Hygienically discard unsaleable plants and disinfest all equipment and structures they contacted. Space the remaining healthy plants sufficiently to reduce relative humidity and prevent cross contamination from irrigation splash. Irrigate in the morning to give leaves time to dry and subsequently reduce leaf wetness. Identify the pathogen so you can apply the appropriate management actions required to break the disease cycle. Grow susceptible plants in the season less conducive to disease. If appropriate, apply fungicides to protect healthy plants from infection. Grow resistant varieties where possible. For more information refer to the [leaf spot management plan](#) and [fungicide resistance management factsheet](#) (which includes details of the mode of action of many leaf spot fungicides).

For root rots and vascular wilts, again identify the cause and source. Find the most likely entry point and take action to reduce further risk of introduction (e.g. contaminated water, growing media, plants). Hygienically remove and discard all diseased plants off site. While fungicides may temporarily suppress disease expression, once a plant has had a root or vascular wilt disease it cannot be cured. Therefore, it is not recommended to sell plants that have had a root rot or vascular disease as this will spread the disease. Consider discarding an entire consignment if a high proportion of plants have shown symptoms. Quarantine remaining susceptible healthy plants and monitor for symptom development until you are sure they are disease free. Disinfest the affected growing areas and equipment with a suitable disinfectant. For more information refer to the [soil borne disease management plan](#).



Growing areas have had a disinfectant applied between growing cycles. The product used caused rocks to become pink.

This document was prepared by Ken Pegg and Andrew Manners (Agri-science Queensland, Department of Agriculture and Fisheries, Ecosciences Precinct, GPO Box 267, Brisbane QLD 4001) as part of the nursery levy and Hort Innovation funded project Building the resilience and on-farm biosecurity capacity of the Australian production nursery industry (NY15002) in 2020. All photos by DAF.