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Hygiene in the nursery - Disinfecting production surfaces; cement, gravel, capillary mats and sand beds

by Gordon Stovold, NSW Agriculture, Tropical Fruit Research Station, Alstonville

If you thought all disinfectants were the same and worked instantly, you had better read this!
This paper details the advantages and limitations of some commonly used disinfectants on various surfaces such as cement sheet/concrete, gravel, capillary mat, and sand beds. The rough and porous surfaces used for paths and placement of pots, such as concrete, gravel, capillary mats and sand beds require different disinfectants and treatment times for fungi, bacteria and nematodes. However none of the tested treatments were effective on the highly resistant spores of *Chalara elegans*, which could not be eliminated from gravel and cement sheet and was only partially controlled on capillary mat. Further research is required to develop effective means of controlling *Chalara elegans* contamination of nursery surfaces.

This is the second part of the new hygiene and sanitation protocols developed for the nursery industry and comes out of a research project commissioned at the request of the National Accreditation Committee (NIASA). The previous Nursery Paper 2000/03, defined the sanitation procedures for working surfaces such as stainless steel benches.

Always clean thoroughly before treatment and give it time to work

The successful disinfection of porous surfaces will depend on prior and thorough removal of growing media, plant debris and organic matter that can both harbour plant pathogens and neutralise the disinfectants by absorbing or reacting with them. The washing process will remove most of the fungal, bacterial and nematode contaminants from surfaces. Special attention should be paid to clean media out of cracks and joints. Bacteria however, often form a chemically resistant biofilm that is difficult to detect and remove.

No disinfectant can cope with a mess like this one

Production surfaces require more time in contact with the disinfectant (at least 1 hour in most cases) than the hard, non-porous working

surfaces such as steel and plastic. Chlorine and the QAT (quaternary ammonium compound) were relatively quick acting and degrade quickly whereas copper required more time to react but persists on surfaces. Copper therefore has a place in nursery hygiene practices where it is used as a long-term surface treatment. However, care should be taken to ensure that the copper-based chemical dries onto the surfaces and isn't washed from treated surfaces to enter dams or waterways.

Using chemicals to eradicate disease (Table 1)

In situations where observation or disease testing indicates the presence of disease we need to know how to completely kill off the problem. Otherwise it is highly likely that future crops will become infected. Opinions vary on the use of such treatments on a regular basis to ensure good hygiene.

*Phytophthora cinnamom*i, the root rotting fungus, was killed in all surfaces tested, usually after one hour, however, in gravel, a 20 minute treatment time with 4000ppm chlorine or a five hour treatment with 20,000 ppm copper was required.

The black rot bacterium *Xanthomonas campestris* and the root knot nematode *Meloidogyne* sp. were killed within one hour on most surfaces with chlorine or QAT. Copper did not kill the nematodes completely within that time. However observations of the nematodes indicated that, after one hour exposure to 1066 ppm copper, the remaining live nematodes were severely affected and probably died.

Chalara elegans (also called *Theilaviopsis basicola*) was more difficult to control, requiring 4,000ppm chlorine or QAT for one hour to suppress but not kill the fungus on capillary mat. On sand beds, 2,000 ppm chlorine for 1 hour or 40,000 ppm copper for 24 hours was required to suppress of *C. elegans*. None of the treatments tested were effective for *C. elegans* contaminated gravel or cement.

Table 1 Effective treatments for disinfection of common nursery surfaces from a range of plant pathogens. All treatments applied as spray (160ml/m^2). Concentrations are in ppm active ingredient (a.i.)

Surface	Fungi	Fungi	Bacteria	Nematodes
	Phytophthora cinnamomi	*Chalara elegans*	*Xanthomonas campestris*	*Meloidogyne* spp+
Capillary mat	2,000ppm Cl for 1h* 2,000ppm QAT for 1h*	None of the tested treatments were effective	2,000ppm Cl for 20min 2,000ppm QAT for 20min	4,000ppm QAT for 1h 20,000ppm Cu for 1h
Sand bed	2,000ppm Cl for 1h* 2,000ppm QAT for 1h* 20,000ppm Cu for 1h*	2,000ppmCl for 24h	2,000ppm Cl for 20min 4,000ppm Cl for 5min	4,000ppm QAT for 20min
Gravel	4,000ppm Cl for 20 min 20,000ppm Cu for >5h*	None of the tested treatments were effective	4,000ppm Cl for 20min	4,000ppm Cl for 1 h 2,000ppm QAT for 1 h
Cement/ Cement sheet	4,000ppm QAT for 1h 20,000ppm Cu for >5h*	None of the tested treatments were effective	4,000ppm Cl for 1 h	Not tested

* Complete kill at lowest rate and time tested.
\+ *Meloidogyne* spp were free-swimming juveniles. The adult female forms a more chemically resistant cyst which will be harder to kill with the listed treatments.
Cl = Chlorine solution (Sodium hypochlorite)
QAT = quaternary ammonium compound. The test product was PHYTOCLEAN ™ which contains 100g/litre benzalkonium chloride.
Cu = copper either as copper oxychloride (used on *Phytophthora* and *Chalara*) or copper ethanolamine complex

*Table 2 Treatments which will reduce **but not eliminate** plant pathogens from common nursery surfaces. All treatments applied as spray (160ml/m^2). Concentrations are in ppm active ingredient (a.i.)*

Surface	Fungi	Fungi	Nematodes
	Phytophthora cinnamomi	*Chalara elegans*	*Meloidogyne* spp+
Capillary mat	2,000ppm Cl for 1h* 2,000ppm QAT for 1h* 20,000ppm Cu for 1h*	4,000ppm Cl for 1h 4,000ppm QAT for 24h 2,000ppm Cl for 24h	4,000ppm Cl for 1h 4,000ppm QAT for 20 min
Sand bed	2,000ppm Cl for 1h* 2,000ppm QAT for 1h* 20,000ppm Cu for 1h*	2,000ppm Cl for 1h 40,000ppm Cu for 24h	4,000ppm Cl for 1h 4,000ppm QAT for 20 min
Gravel	2,000ppm Cl for 20 min 20,000ppm Cu for >5h*	None of the tested treatments were effective	4,000ppm Cl for 20min 2,000ppm QAT for 20min
Cement/ Cement sheet	4,000ppm Cl for 20 min 4,000ppm QAT for 1 min 20,000ppm Cu for >5h*	None of the tested treatments were effective	Not tested

* Complete kill achieved at lowest dose and time tested.
+ *Meloidogyne* spp were free-swimming juveniles. The adult female forms a more chemically resistant cyst which will be harder to kill with the listed treatments.
Cl = Chlorine solution (Sodium hypochlorite)
QAT = quaternary ammonium compound. The test product was PHYTOCLEAN ™ which contains 100g/litre benzalkonium chlozride.
Cu = copper either as copper oxychloride (used on *Phytophthor*a and *Chalara*) or copper ethanolamine complex

Are these treatments practical?

Many of the eradication treatments require high concentrations with extended treatment periods and may be impractical to use regularly in commercial nursery situations. Table 2 therefore presents information on treatments that will lower pathogen populations but not eliminate them. Such treatments may reduce but certainly will not eliminate the potential for disease spread . For example fungi can produce vast numbers of spores very quickly (within 24 hrs) under the right conditions if not all are killed.

Alternative treatments such as steaming, solarisation and fumigation may also be employed to disinfest production surfaces however, protocols for these treatments have not been developed.

Gravel provides an excellent production surface but can still become contaminated with pathogens

Correction

The Nursery Papers issue 2000/03 'Hygiene and Sanitation of Working Surfaces in the Nursery' contains a major error in the bottom part of Table 2. Below are the correct rules and calculations. Thanks to David Cliffe of Narromine Transplants for spotting the error.

Correction to table 2, The Nursery Papers 2000/03.

How to convert active ingredient (a.i.) g a.i./L to ppm (mg/L) and how to calculate the dilution of product to the required strength

Product strength (units)	**What is the product strength in ppm? Multiply by the figure below to convert to ppm**	**To make up 1L of X ppm active ingredient add Y ml of *product* to Z ml of water**	
		Rule to find Y	Rule to find Z
g/L	1,000	$\frac{X}{g/L \text{ a.i.}}$ = Y ml product	Z = 1,000 - Y
Example 125g available chlorine /L	125 x 1,000 = 125,000 ppm available chlorine in undiluted product	*Example, you need a 4,000ppm solution* $\frac{4,000}{125}$ = 32 ml product	Z = 1,000 - 32 = 968 ml water

So in this example you would put 32ml of the product into a measuring container and then add water until you have one litre of solution.

Capillary mats should be cleaned before disinfectant is used

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