Factsheet 03/14 (a revision of 15/05)

Protected Ornamentals

Use of chemical disinfectants in protected ornamental plant production

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This factsheet examines the use of chemical disinfectants in protected ornamental production to prevent the spread of plant diseases. It is primarily a reference document, providing information on available products, their efficacy and important considerations affecting product choice. Legislation affecting use and disposal is summarised and the suppliers of some chemicals commonly used for disinfection are listed. It does not deal with chemicals used for water treatment or disinfectants used in food production to control micro-organisms that cause human diseases.

Action points

- Disinfection of structures, pot standing areas and equipment should be part of an integrated disease management strategy especially to aid control of root diseases and mechanically transmitted viruses.
- Before disinfecting a surface, remove peat, plant debris and any other organic matter as far as is reasonably practicable, as such contaminants are likely to reduce product efficacy.
- Do not use disinfectants on plants, soil or growing substrates – such use is illegal unless the chemical is registered as a pesticide or commodity substance for that particular use.
- Refer to the product label and Tables 3-8 in this factsheet for information on the spectrum of activity. Remember that concentration, contact time, the level of organic matter and other factors can markedly affect results.
- Always use the recommended personal protective clothing and equipment.
- Dispose of any waste disinfectant solution with due regard for the environment - obtain the necessary trade effluent discharge consent; or use a company authorised to handle waste or special waste; or follow the Code of Practice for Using Plant Protection Products (for disinfectants classified as pesticides or commodity substances).
- Note that new regulations, effective from 1 September 2013, will require all new and current disinfectants to be registered as authorised products before they can be marketed; however, transitional arrangements are in place while older products are assessed. The label of a registered disinfectant will specify exactly how and in what situations it can be used.

1. Standing area awaiting cleaning, sweeping and an end of season disinfection application

What is a disinfectant?

Disinfectants are products intended to control unwanted micro-organisms such as algae, bacteria, fungi, viruses and also nematodes. In horticulture, they are specifically used to control micro-organisms on inanimate surfaces and objects such as pot standing areas, structures and equipment rather than on living plants. They can also be useful in foot dips or mats, as a means of preventing disease transmission into high health status areas on the nursery.

Currently there is no register of authorised disinfectants. However, a list will be developed in coming years as new regulations are implemented.

Purpose of disinfection

Many plant pathogenic micro-organisms can survive on surfaces or in debris in the absence of a crop for several weeks or even months. When a new crop is introduced, there is a risk that infection will result. The aim of disinfection is to reduce the population of a damaging micro-organism to a level that no longer poses a threat to crop production. For some micro-organisms, such as highly infectious viruses, the aim will be to eliminate the virus from the nursery completely. For more common micro-organisms such as fungal root pathogens, the aim will be to reduce the inoculum to a level at which it no longer causes infection in a normal, well-grown crop. Disinfection should be considered:

- after a serious root disease problem;
- following an outbreak of an uncommon disease;
- between crops when a growing area is empty;
- before a long-season, high-value crop;
- as a barrier to pathogen spread into a high health status area.

For fungal root pathogens and mechanically transmitted viruses, particularly in the situations outlined above, nursery hygiene can be a key component of an integrated disease management strategy. However, disinfection alone is unlikely to provide effective, sustainable control of a disease. It is just one component of a nursery hygiene programme which should consider processes, procedures, health-testing of stock plants and potential transmission routes.

2. Disinfectant foot mat at the entrance to a high health status area

Please note the disinfectant products mentioned in this factsheet must not be used for cleaning hands. Products designed for disinfecting hands usually contain an alcohol and are formulated as a gel or foam. Experimental evidence indicates that the use of such products can reduce the transmission of bacterial, fungal, and viral pathogens of plants.

Areas of use

Disinfectants are most commonly used on propagation nurseries and in intensive protected plant production; they are also used in the production of hardy ornamentals for the treatment of gravel or standing beds for example. Areas and items that can be treated include:

- Glasshouse structures.
- Sand and gravel beds.
- Woven-type and capillary matting.
- Concrete pathways.
- Benches, trolleys and other equipment (secateurs, knives etc.).
- Pots and trays.
- Irrigation lines, drippers and pegs.

3. Cleaned and disinfected outdoor production beds awaiting the next crop

Disinfectants, although classified as biocides, are exempt from the 2011 Plant Protection Products Regulations (PPPR) providing they are not used on plants, soil, or substrates. Note that products used to control liverworts or moss are now considered to be plant protection products and not biocides; therefore products that are not registered as plant protection products can no longer be used to control liverworts or moss.

Some products have a label recommendation for use in water to control slime growth in pipework and prevent nozzle blockage. However, a disinfectant added to water to maintain a chemical residue around the roots of a crop for the purpose of controlling a root pathogen would probably be considered as a pesticide and is therefore not permitted unless approved as a pesticide for that use.

Some disinfectants are highly toxic to plants by vapour activity or root uptake (including glutaraldehyde, hypochlorite etc.) and so can only be used between crops. Grower experience indicates that in some situations, and for a few disinfectants such as peroxyacetic acid (e.g. Jet 5), treatment can be made without harm to a crop remaining in another part of the same glasshouse, providing caution is taken to avoid drift onto that crop.

Considerations when choosing a disinfectant

Product label information

Chemical disinfectants specifically marketed for use in horticultural crop production usually carry detailed instructions on how the product should be used, covering a range of situations (as a spray, fog or dip treatment for example). These should be carefully followed. Disinfectants marketed primarily for prevention of animal or human diseases are unlikely to have specific recommendations for use in horticulture. It is suggested that intended users consult the distributor and/or manufacturer, or a BASIS-registered crop consultant for guidance. Read the product label carefully and check that use in protected horticulture is not precluded.

Under the Biocidal Products and Chemicals Regulations (BPCR), effective from 1 September 2013, it has become a legal requirement for all disinfectants to be registered. This registration aims to ensure that biocidal products are sufficiently effective against target species and that claims are valid. Newly registered biocides will be classed into one or more of 22 product-types which specify different areas where they may be used. Product-type 2 ('Disinfectants and algaecides not intended for direct application to humans or animals') is likely to be the product-type containing the main products available for use to prevent the spread of plant pathogens. Some products in product-type 12 ('Slimicides') may also be relevant and permitted for use in commercial horticulture.

The label on products registered under the BPCR will contain the following information:

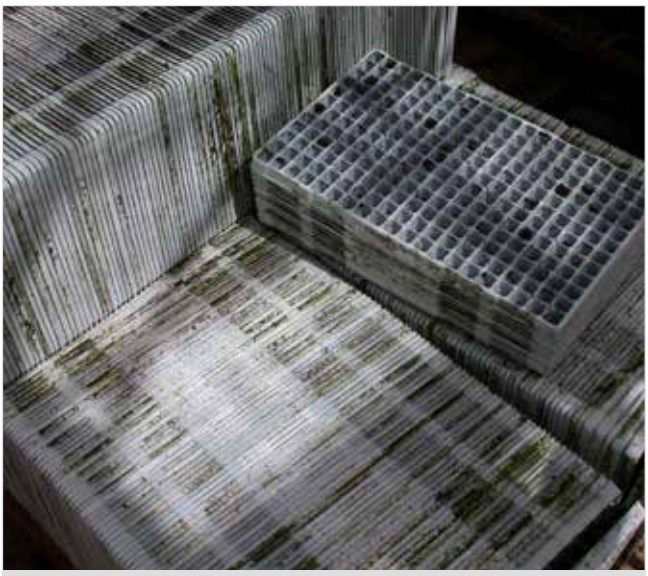
- An authorisation number e.g. HSE 1234.
- What the product is approved for; the product must not be used for any other purpose.
- Information about who is allowed to use it.
- Whether any protective clothing or equipment needs to be worn.
- How to use the disinfectant without harming yourself, other people or wildlife.
- Whether access to treated areas needs to be restricted.
- How to apply the biocide effectively.
- How to dispose of the product or empty container.

At present (March 2014), none of the disinfectants commonly used in horticulture have been listed under the BPCR. Current products can continue to be used pending their review for inclusion, and subject to relevant health and safety legislation.

Two active substances (dichlorophen and formaldehyde) have already been reviewed and were not approved for use in horticultural situations (i.e. were not listed for use as product-types 2 or 12 or other product-types applicable to ornamental horticulture).

Inactivation by organic matter

Most disinfectants are inherently reactive chemicals. Activity against a target pathogen will be reduced if the disinfectant reacts first with organic matter, such as peat or plant debris. Some disinfectants (including hypochlorite and quaternary ammonium compounds for example) are more susceptible than others to such loss of activity. Wherever disinfectants are used, it is strongly recommended that the surface to be treated is first cleaned of plant debris, peat or any other organic contamination as far as practicable, for example by sweeping, vacuuming or washing the surface.



4. Used trays awaiting washing and disinfection prior to re-use

Other factors influencing activity

Disinfectant concentration, contact time and the level of organic matter contamination are likely to be the main factors influencing the activity of a given disinfectant against a particular micro-organism. However, check the product label carefully as other factors, such as temperature, pH and water hardness, may also have a significant influence. Some disinfectants are combined with detergents which have good wetting powers and increase contact with surfaces.

Health and safety

As noted previously, most disinfectants are very reactive and some chemicals are caustic or damaging to mucous membranes or skin. Great care must therefore be exercised, particularly with the concentrated product. Follow the label instructions carefully and use the recommended personal protective clothing and equipment.

Measuring disinfectant concentration

On-site methods for measuring disinfectant concentration (such as test strips) are available for some products including hydrogen peroxide and chlorine (manufactured by Fisher Scientific). Monitoring of solution pH is recommended for Menno Florades (benzoic acid), topping up as required to keep the solution pH below 4.5.

Types of disinfectant

Disinfectants can be grouped according to the chemical structure and mode of action of their active ingredients (Table 1). The key features of each of the groups are summarised below. Note that some of the products contain active ingredients from more than one class.

Alkali – hydroxides

Alkali disinfectants such as sodium hydroxide are commodity chemicals rather than specific disinfectants. Although they do have biocidal properties, they are too caustic for general horticultural use.

Biguanide (or biguanidine) – chlorhexidine

Chlorhexidine, the only biguanide currently available, has potent activity against some bacteria but not against spores, fungi and most viruses. This spectrum of activity is not appropriate for use in horticulture. It is also inactivated by organic contamination.

Cationic surfactants – quaternary ammonium compounds

Quaternary ammonium compounds (QACs) are non-corrosive and non-irritating disinfectants. They have good penetrating activities when combined with a wetting agent. Their effects on micro-organisms are varied and selective, however, and they tend to foam and leave a residue, though some current products are less prone to this problem. They are usually more effective on bacteria and may have little or no effect on fungi. They may be less active in the presence of organic matter, oils, and waxes. They can be expensive.

Halogens and halogen-releasing compounds – chlorine based

These materials release chlorine when activated. Chlorine has broad-spectrum activity against viruses, bacteria, yeasts and moulds, though activity is slower against spores. Chlorine-bearing compounds are effective at cool temperatures and are unaffected by hard water scales. They have only a short residual effect, precipitate in iron-laden water and may be very corrosive.

Table 1. Types of disinfectant grouped according to the chemistry of the active ingredient

Class	Sub-class	Examples of actives and products
Alkali	Hydroxides	Sodium hydroxide
Biguanide	Chlorhexidine	e.g. Nolvasan, Virosan
Cationic surfactant	Quaternary ammonium compounds (QACs)	Benzalkonium chloride and other compounds (e.g. in Ambicide, Hortisept Pro, Menno Ter Forte, Vitafect)
Halogens and halogen-releasing compounds	Active chlorine	Sodium hypochlorite (bleach), organic chlorides (e.g. sodium dichloroisocyanurate)
	Iodophor	e.g. Antec Virudine, Deosan Iodel FD, Fam 30
Halogenated tertiary amine	Halogenated tertiary amine	In Ambicide, Avisafe, Trigene
Organic acid	Aliphatic acid	Citric acid
	Aromatic acid	Benzoic acid (e.g. Menno Florades)
Oxidising agents	Chlorine dioxide	e.g. Purogene
	Peroxides	Hydrogen peroxide (e.g. Hyperox, in GeoSIL), Peroxyacetic acid (e.g. Jet 5, Sanprox P)
	Peroxygen compounds	e.g. Virkon S
Phenols	Phenolics (high boiling tar phenols)	Carbolic acid, cresylic acid (e.g. Farm Fluid S, Longlife 250S)
	Synthetic phenol	Ortho-phenyl phenol (e.g. in Disolite)
Reducing agents	Aldehydes	Glutaraldehyde (e.g. in Horticide, Unifect-G)
Other	Alcohol	Industrial methylated spirits (IMS)
	Plant extracts	Essential oils, grapefruit seed extracts (e.g. Citrox P)

5. Poinsettia root rot can arise from contaminated capillary matting or floors

6. Poor growth of pansy due to black root rot - the causal fungus was found in sweepings on ornamental nurseries

7. *Phytophthora nicotianae* persisting in a sand bed was found to be the source of root rot in dieffenbachia

Halogens and halogen-releasing compounds – iodophor

Iodophor products consist of iodine in a phosphoric acid base, usually with surfactants. They are broad-spectrum disinfectants with activity against bacteria (except bacterial spores), viruses and fungi. They are quick acting and effective at ambient temperatures. They can be expensive, may stain porous metals and plastics and can corrode aluminium. They are usually brown in colour when active, becoming straw coloured as they lose their activity and are sometimes used in foot dips for this reason.

Halogenated tertiary amine

These are broad-spectrum compounds that kill bacteria, fungi, yeasts and viruses. They are relatively safe and tend to be used for general hygiene, as the compound is active for a long time in solution. They are non-corrosive and totally biodegradable.

Organic acids – aliphatic acid

Citric acid is the most commonly used organic acid. It is reportedly effective against some viruses, bacteria and fungi. It is a commodity chemical and therefore relatively inexpensive.

Organic acids – aromatic acid

Benzoic acid is the only disinfectant in this category. It has good activity against viruses, fungi and bacteria but does not control algae.

Oxidising agents – peroxides

Peroxides have broad-spectrum activity against viruses, bacteria and fungi, including spores. They are effective in cold conditions and in the presence of organic contamination. Hydrogen peroxide products (which are formulated with acetic acid and peracetic acid) and peroxyacetic acid, are both environmentally benign, breaking down into water, carbon dioxide and oxygen. Some products also contain silver which is claimed to provide some residual disinfectant activity on the treated surface.

Oxidising agents – peroxygen compounds

These products have a very similar spectrum of activity to the peroxides, since both work in the same way and are closely related chemically. However, peroxygen compounds tend to be safer to handle than peroxides. At least one product (Virkon S) has label uses in horticulture. This product is environmentally benign and leaves no residue.

Phenol – high boiling (point) tar acids (HBTA)

These products are derived from tar acids by distillation. They are acidic disinfectants with a low pH and a broad spectrum of activity against viruses, bacteria, fungi and mycoplasmas. They are effective at low temperatures and in the presence of organic matter. HBTA phenols are potent biocides, but they can have strong odours and may be corrosive to plastic and rubber. There is a risk of taint if used where edible crops are grown.

Phenol – synthetic phenols

Synthetic phenols avoid some of the odour and staining problems of HBTA phenols. They are also neutral rather than acid. However, they are not as broad spectrum in activity as HBTA phenols and there are some question marks about their environmental safety. There is a risk of taint if used where edible crops are grown.

Reducing agents – aldehydes

Glutaraldehyde is the most important reducing agent used as a disinfectant. It has a broad spectrum of activity, but needs a long contact time for disinfection. Its action is temperature dependent. There are potential health hazards to operators from exposure.

Other – plant extracts

Household disinfectants based on essential oils (including thyme, lemon and clove) or polyphenolic grapefruit seed extracts are becoming more widely available, particularly in North America. These have some action against bacteria and fungi and are considered harmless to users and the environment. However, they may prove too expensive for large-scale horticultural use and the level of their efficacy in practice, compared with synthetic disinfectants, remains to be determined.

Other – alcohols

Alcohols are usually the active ingredient of formulated gels and foams used to disinfect hands. More recently they have been used as sprays to disinfect clean (unsoiled) footwear. Evaporation of the alcohol after treatment means that there is no need to rinse with water.

Products used in horticultural crop production

Table 2 lists some products currently available (March 2014) and reported to be used in horticultural crop production. Product availability changes quite frequently with the introduction of new products and the withdrawal of others. The mention of a product name in this factsheet does not constitute a recommendation; the absence of a product name does not imply a criticism of that product.

Table 2. Some products used for disinfection

Product	Manufacturer/distributor	Active ingredient class(es)
Ambicide	DuPont Animal Health Solutions	Quaternary ammonium compound + tertiary amine
Boot	P.P. Products	Quaternary ammonium compound
Citric acid	Commodity chemical	Aliphatic acid
Citrox P	Agralan Ltd	Plant extract
Disolite	Progress Products	Phenolics
EndoSan	P.P. Products	Hydrogen peroxide + silver
Fam 30	Evans Vanodine	Iodophor
GeoSIL	GeoSIL Pacific Ltd	Hydrogen peroxide + silver
Horticide	CMW Horticulture Ltd	Quaternary ammonium compounds + aldehyde
Hortisept Pro	LQ Solutions	Quaternary ammonium compounds + inorganic acids
Hyperox	DuPont Animal Health Solutions	Peroxyacetic acid
Intra Hydrocare	Quill Productions	Hydrogen peroxide + silver
Jet 5	Certis UK	Peroxyacetic acid
Jeyes Fluid	Jeyes Group	Phenolics
Menno Florades	Brinkman UK	Aromatic acid
Menno Ter Forte	Brinkman UK	Quaternary ammonium compounds
Purogene	Tristel	Chlorine dioxide
Quatchem BC50	Quatchem	Quaternary ammonium compounds
Reciclean	Brinkman UK	Stabilised hydrogen peroxide and formic acid
Sanosil	Water Treatment Products	Hydrogen peroxide + silver
Sanprox P	Aromany	Peroxyacetic acid
Sorgene 5	BASF Ltd	Hydrogen peroxide + peracetic acid
Trigene	Medichem International	Halogenated tertiary amine
Unifect-G	Aromany	Quaternary ammonium compounds + aldehyde
Virkon S	DuPont Animal Health Solutions	Peroxygen compounds + organic acids
Vitafect	Vitax Ltd	Quaternary ammonium compounds + biguanidine salts

Spectrum of activity

Product activity as described in manufacturers' label claims and associated literature is shown in Table 3. The recommended dose rate for a product will often vary, depending, for example, upon the method of application and the pathogen that is the target organism. It should be noted that at present there is no concentration limit set for disinfectants and that almost any disinfectant will kill most organisms if the concentration used is sufficient. However, as products are registered under the BPCR a maximum concentration will be set for all disinfectants.

Table 3. Spectrum of activity summary of some products used for disinfection as described on product labels

Product	Bacteria	Bacterial spores	Fungi	Fungal spores	Viruses	Algae
Citric acid	+	+	+	+	+	
Citrox P	+		+		+	~
EndoSan	+	+	+	+		+
Fam 30			+	+		
Jet 5	+		+	+	+	+
Horticide	+		+		+	
Hortisept	+		+		+	
Jeyes Fluid	+		+			+
Menno Florades	+		+		+	
Menno Ter Forte	+		+		+	+
Quatchem BC50			+			+
Reciclean						+
Sanosil			+		+	
Sanprox P	+		+	+	+	+
Sorgene 5	+		+	+	+	
Unifect-G	+		+		+	
Virkon S	+		+	+	+	
Vitafect	+		+			

Key: + effective ~ inhibition only.

Efficacy against plant pathogenic fungi, oomycetes and bacteria

The ability of various disinfectants to prevent transmission of several important plant pathogens has been tested in a series of HDC-funded projects. Full details including method of application, rate used, surface treated and level of control achieved are given in the relevant HDC report and/or factsheet (Table 4). Results are summarised in Tables 5-8. Results presented are generally for 30 minutes exposure time. Note that some of the products listed in Tables 5-8 (shown in italics) are no longer marketed in the UK. Efficacy test results of such products have been retained in the tables so that useful information on the efficacy of active ingredients which may be present in other products is not lost.

Table 4. Target bacteria, fungi and oomycetes in HDC projects where disinfectants have been evaluated for activity

Target organism	Test method	HDC project number	Factsheet number
Bacteria	Knife treatment	HNS 179	15/13
	Laboratory tests	PE 149 and PC 291	26/12
Fusarium oxysporum	Bulb dip and laboratory tests	BOF 71 and 71a	10/13
Fusarium oxysporum	Laboratory tests	PC 213	08/07
Fusarium oxysporum	Spray to capillary matting	HNS 63	-
Phytophthora nicotianae	Spray to sand bed	PC 107	-
Phytophthora ramorum	Cellophane disc dip test	HNS 134	-
Phytophthora ramorum	Drench to gravel/sand/soil mix	HNS 123	-
Pythium species	Spray to woven matting	PC 97a	17/04 and 16/04
Pythium intermedium	Laboratory tests	HNS 147	-
Rhizoctonia solani	Laboratory tests	HNS 147	-
Thielaviopsis basicola	Plastic tray dip	PC 38c	19/02
Verticillium albo-atrum	Laboratory tests	PC 186a	15/01

Table 5. Summary of disinfectant efficacy against plant pathogenic fungi and oomycetes as determined in some HDC projects

Product	Class or sub-class	*Fusarium oxysporum* (PC 213)	*Fusarium oxysporum* (HNS 63)	*Phytophthora nicotianae* (PC 107)	*Pythium species* (PC 97)	*Pythium species* (HNS 147)	*Rhizoctonia solani* (HNS 147)	*Thielaviopsis basicola* (PC 38c)	*Verticillium albo-atrum* (PC 186a)
Citric acid	Aliphatic acid					–	–		–
Citrox P	Plant extract					–	+		
Clearsol	Phenol			+++				+	
Fam 30	Iodophor					+++++	+		
GeoSIL	Peroxide + silver					+++++	+		
Glu-cid	Aldehyde		+++	++++				+++	
Harvest Wash	Chlorine dioxide								+++++
Iodel FD	Iodophor	+++++	++++	++				++++	
Jet 5	Peroxide	+++++	+++	++	+++++			++++	+++++
Jeyes Fluid	Phenol		+						
Opticide H200	Aldehyde + QAC		++++					+++	
Purogene	Chlorine dioxide							+++	
Sodium hypochlorite	Chlorine	+++++		+++	+++++			+++	+++++
Ter Spezial	QAC		+++	++++	+++++			++++	
Trigene Advance	Halogenated tertiary amide					+++++	+		+++++
Unifect–G	Aldehyde + QAC	+++++							+++++
Virkon S	Peroxygen		+++	++		+++++	–	++	+++++
Vitafect	QAC	+++++							

Key: - no control; +1-25% control; ++ 26-50%; +++ 51-75%; ++++ 76-99%; +++++ not detected; blank box means product was not tested.

Products in italics not currently marketed in the UK.

The level of disinfectant activity in an experiment is affected by the concentration used, contact time, the level of organic matter contamination, the nature of the test procedure, and other factors. Please see the relevant HDC project reports for the full details behind these results.

Table 6. Summary of disinfectant efficacy against *Phytophthora ramorum* (HNS 123 and HNS 134)

Product	Class or sub-class	HNS 123	HNS 134		
			Cellophane square	Cellophane square + soil	Woven matting
Antec FFS	Phenolic	+++			
Hortisept	QAC	*	+++	–	–
IMS	Alcohol		+++	+++	+++
Jet 5	Peroxide	*	++	–	+++
Jeyes Fluid	Phenolic	+++			
Menno Florades	Organic acids		++	–	–
Sodium hypochlorite	Chlorine		+++	–	–
Unifect-G	Aldehyde + QAC		+++	+++	+++
Virkon S	Peroxygen	*			

Key: – no control; + 1-50% control; ++ 50-99% control; +++ not detected; * partial control (not quantified); blank box means product was not tested.

Products in italics not currently marketed in the UK.

Table 7. Summary of disinfectant efficacy against some plant pathogenic bacteria as determined in three HDC projects (PC 149, PC 291 and HNS 179)

Product	Class or sub-class	PC 149	PC 291			HNS 179
		Agrobacterium species	*Pectobacterium carotovorum*	*Pseudomonas syringae*	*Xanthomonas campestris*	*Pseudomonas syringae* pv. *morsprunorum*
Fam 30	Iodophor		+++	++	+++	
Horticide	Aldehyde + QAC	+++				
Hortisept	QAC		++	++	++	
Iodel FD	Iodophor	+++				
Isopropanol	Alcohol					+++
Jet 5	Peroxide	+++				+++
Menno Florades	Organic acids		++	+++	++	
Sanprox P	Peroxide		+++	+++	+++	
Sodium hypochlorite	Chlorine	+++	+++	+++	+++	+++
Virkon S	Peroxygen		+++	+++	+++	

Key: – no control; +1-50% control; ++ 50-99%; +++ not detected; blank box means product was not tested.

The level of disinfectant activity in an experiment is affected by the concentration used, contact time, the level of organic matter contamination, the nature of the test procedure, and other factors. Please see the relevant HDC project reports for the full details behind these results.

Efficacy against nematodes and western flower thrips pupae

Although this factsheet is aimed at the use of disinfectants for preventing the spread of plant diseases, the following results on disinfectant efficacy against a few plant pests when present on inanimate objects (not for use on plants or substrates) may be useful for growers of protected ornamental crops.

The ability of disinfectants to control stem nematode (*Ditylenchus dipsaci*) on inanimate objects was tested in experiments carried out in 2001 (HDC project BOF 49). The disinfectants were tested in ambient temperature solutions, with and without added contaminants in the form of soil, and against both active, free-swimming nematodes and nematodes in the resting stage known as 'wool'.

Against active stem nematodes, the most effective disinfectants were the iodophor products (Antec Virudine and Fam 30), which caused 100% mortality in under five minutes, followed by Menno Florades and Farm Fluid S, both of which caused 100% mortality in under 20 minutes when applied at recommended concentrations (Table 8). None of the other materials caused 100% mortality in less than one hour. When contaminated with soil, the disinfectants were less effective than when in clean solution, the times taken to reach 100% mortality increasing by between two and five-fold. None of the disinfectants gave any control of nematodes in the 'wool' stage when immersed for 10 minutes.

The ability of chemical disinfectants to control leaf and bud nematode (*Aphelenchoides ritzemabosi*) and pupae of western flower thrips (*Frankliniella occidentalis*) was tested in 2007 (HDC project HNS 147). Leaf and bud nematode was partially controlled by an iodophor (Fam 30) and an amine (Trigene Advance) disinfectant under the test conditions used; western flower thrips pupae were completely controlled by the iodophor and partially controlled by the amine, a peroxygen (Virkon S) and a plant extract (Citrox P) disinfectant (Table 8). An organic acid (citric acid) and a peroxygen + silver product (GeoSIL) were ineffective under the test conditions used.

Table 8. Summary of disinfectant activity against some pests as determined in HDC projects (BOF 49 and HNS 147)

Product	Class or sub-class	Leaf and bud nematode (*Aphelenchoides ritzemabosi*)	Stem nematode (*Didylenchus dipsaci*)		Western flower thrips pupae (*Frankliniella occidentalis*)
			Active stage	'Wool'	
Ambicide	QAC		++	–	
Antec Virudine	Iodophor		+++	–	
Citric acid	Organic acid	–			–
Citrox P	Plant extract	–			+
Fam 30	Iodophor	+	+++	–	+++
Farm Fluid S	Tar acids		+++	–	
GeoSIL	Peroxide + silver	–			–
Jet 5	Peroxide		+++	–	
Menno Florades	Organic acid		+++	–	
Trigene Advance	Halogenated amine	++			++
Virkon S	Peroxygen	–	++	–	+

Key: – no control; + 1-50% control; ++ 50-99% control; +++ not detected; blank box means product was not tested. Results shown are for pests exposed to the disinfectant for 60 minutes.

Products in italics not currently marketed in the UK.

The level of disinfectant activity in an experiment is affected by the concentration used, contact time, the level of organic matter contamination, the nature of the test procedure, and other factors. Please see the relevant HDC project reports for the full details behind these results.

Legislation affecting use

Selection and use

Biocidal Products and Chemicals Regulations (BPCR)

The use of disinfectants in Great Britain from 1 September 2013 is now regulated by the Biocidal Products and Chemicals Regulations 2013; these are regulations which enforce the EU Biocides Regulation 528/2012.

Previously the EU Biocidal Products Directive (BPD) 98/8/EC, which came into effect in May 2000, laid down harmonised rules for placing biocidal products on the market. Relatively few disinfectants were assessed and registered under this legislation. The EU Biocides Regulation 528/2012 repeals and updates the BPD. The same basic framework applies with actives approved at EU level and products approved at national level. Its main purpose is to improve the free movement of biocidal products within the EU while maintaining the high level of protection of human and animal health and the environment established in the BPD. Transitional arrangements are provided for existing biocidal products.

Biocidal products are approved for use by HSE as one of 22 product-types specified in Annex 1/1A (before 1 September 2013) or in the Union list maintained by the European Chemicals Agency (from 1 September 2013). Product-type 2 biocides are due to be listed in the Union list from 1 January 2017. Each biocidal product approved by the HSE is given a unique reference number, beginning HSE or BPR, which is listed within the product label.

There are 22 types of biocidal products. Disinfectants used in commercial ornamental horticulture are likely to fall into:

- Product-type 2: 'Disinfectants and algaecides not intended for direct application to humans or animals'.
- Product-type 12: 'Slimicides, products used for prevention of slime growth on materials, equipment and structures used in industrial processes'.
- Product-type 18: 'Insecticides, acaricides and products to control arthropods, by means other than repulsion or attraction'.

For a full list of product-types, see www.hse.gov.uk and follow the link to the EU BPR pages.

A few disinfectants are registered as pesticides (e.g. benzoic acid) or commodity substances (e.g. sodium hypochlorite). Pending review for inclusion in Annex 1/1A/Union list, such products will continue to be approved until they have been reviewed.

Most disinfectants currently marketed are classified as biocidal products not within the scope of pesticides legislation. They can continue to be sold and used pending review of the active substance under the EU Biocides Regulation, subject to other relevant health and safety regulations, such as the Control of Substances Hazardous to Health Regulations (COSHH).

COSHH

The Control of Substances Hazardous to Health (COSHH) Regulations are now well established to reduce the risk of substances to human health at work. The fifth edition of the Code of Practice was updated in 2005 and can be downloaded from: http://books.hse.gov.uk/hse/public/saleproduct.jsf?catalogueCode=9780717629817.

All the disinfectants mentioned in this factsheet and others which may also be used on nurseries will be controlled by these regulations. Keep on file and read:

- The product label.
- The product material safety data sheet (sometimes called the material safety data sheet).

These are available as downloads from the manufacturer and give essential guidance on protective clothing and possible use in horticultural applications. The acquisition of safety data sheets is a requirement of a COSHH assessment.

Disposal of waste disinfectant solution

Waste disposal is tightly regulated. Reduce or eliminate the need for disposal by only making the quantity of disinfectant solution needed. It may be possible to re-use diluted disinfectant for a lower-grade purpose such as non-critical rinsing.

Disinfectants carry an environmental threat at disposal and are classed as trade effluent which may need a licence (from the Environment Agency) for discharge from the premises (www.environment-agency.gov.uk/business/topics/water/default.aspx). The product label will identify safe methods for disposing of surplus disinfectant and the empty container.

For disinfectants currently registered as pesticides, of which there are very few, The Plant Protection Products (Sustainable Use) Regulations 2012 replaced the previous UK legislation governing the use of pesticides. There are a few changes, but following the disposal guidelines in the present Code of Practice for Using Plant Protection Products (www.pesticides.gov.uk/Resources/CRD/Migrated-Resources/Documents/C/Code_of_Practice_for_using_Plant_Protection_Products_-_Complete20Code.pdf) covers the necessary requirements. Take 'reasonable precautions' by identifying and mitigating any risks; and follow good filling, storage and disposal practice such as that detailed in the Code of Practice. To determine if a product is registered as a pesticide visit the HSE Pesticides Register of UK Authorised Products at https://secure.pesticides.gov.uk/PestReg/default.asp.

Further information

HDC Factsheets and publications

- HDC Factsheet 20/08. 'Wet heat treatment to sterilise pots for re-use'.
- HDC Factsheet 06/08. 'A guide to best practice in handling bought-in plants'.
- HDC Factsheet 10/07. 'Guidelines on nursery hygiene for outdoor and protected ornamental crops'.

HDC Grower summaries and reports

See the HDC website (www.hdc.org.uk) for copies of PC 291, 213, 186a, 149, 107, 97a, 97, 38c; HNS 179, 147, 134, 123, 63; BOF 71a, 71, 49 and PE 142.

Other publications

- Code of Practice for Using Plant Protection Products.
- Defra Pesticide Safety Directorate. Website: www.pesticides.gov.uk/home.asp.
- Health and Safety Executive 'blue book'. Website: www.hse.gov.uk/pesticides/bluebook.
- Health and Safety Executive COSHH – A brief guide to the Regulations (reference code INDG136rev2). Order online at www.hsebooks.co.uk.
- The UK Pesticide Guide 2014 (CABI).

Manufacturers and distributors

- **Agralan Ltd,** The Old Brickyard, Ashton Keynes, Swindon, Wiltshire SN6 6QR. Tel: 01285 860015. Website: http://www.agralan.co.uk/.
- **Aromany Environmental Hygiene Specialists,** Queenswood House, 70 Durleigh Road, Bridgwater, Somerset TA6 7JE. Tel: 01278 429800. E-mail: Sales@aromany.co.uk. Website: http://www.aromany.co.uk/.
- **BASF Pest Control Solutions,** PO Box 4, Earl Road, Cheadle Hulme, Cheshire SK8 6PG. Tel: 0161 4860891. E-mail: pestinfo@basf.com. Website: http://www.pestcontrol.basf.co.uk/agroportal/pc_uk/en/pest-control-home.html.
- **Bio Natura Ltd,** 25 The Grove Promenade, Ilkley, West Yorkshire LS29 6AF. Tel: 01942 816816.
- **Boothmans (Agriculture),** Kellington House, South Fen Business Park, South Fen Road, Bourne, Lincolnshire PE10 0DN. Tel: 07860 215869. E-mail: robert@boothman.co.uk. Website: http://boothmans.co.uk/4707/home.
- **Brinkman (Horticultural Service) UK Ltd,** Tudor Building, Dunswell Road, Cottingham, E. Yorkshire HU16 4JT. Tel: 01482 842123. Website: http://www.brinkmanuk.co.uk/.

- **Certis UK,** 1b Mills Way, Boscombe Down Business Park, Amesbury, Wiltshire SP4 7RX. Tel: 01980 676500. Website: http://www.certiseurope.co.uk/.
- **CMW Horticulture Ltd,** Stonepit Road, South Cave, Brough, East Yorkshire HU15 2BZ. Tel: 01430 422222. Website: http://www.cmwhorticulture.co.uk/.
- **DuPont Animal Health Solutions,** Chilton Industrial Estate, Sudbury, Suffolk CO10 2XD. Tel: 01787 377305. Website: http://www2.dupont.com/DAHS_EMEA/en_GB/index.html.
- **Evans Vanodine Plc,** Brierley Road, Walton Summit, Lancashire PR5 8AH. Tel: 01772 322200. Website: http://www.evansvanodine.co.uk/index.html.
- **Fargro Ltd,** Toddington Lane, Littlehampton, West Sussex BN17 7PP. Tel: 01903 721591. E-mail: info@fargro.com. Website: http://www.fargro.co.uk/.
- **Fisher Scientific UK,** Bishop Meadow Road, Loughborough, Leicestershire LE11 5RG. Tel: 01509 555178. Website: http://www.fisher.co.uk/.
- **GeoSIL Pacific Ltd,** PO Box 513, Shortland Street, Auckland 1140, New Zealand. Tel: +64 9 443 6745. E-mail: sales@geosil.co.nz. Website: http://www.geosil.co.nz.
- **Jeyes Group,** Brunel Way, Thetford Norfolk IP24 1HF. Tel: 01842 754567. Website: http://jeyesgroup.com/default.htm.
- **LQ Solutions,** Spring Garden Mill, Green Road, Colne, Lancashire BB8 8EJ. Tel: 01282 869850. E-mail: info@lq-solutions.com. Website: http://www.lq-solutions.co.uk.
- **Medichem International,** PO Box 237, Sevenoaks TN15 0ZJ. Tel: 01732 763555. E-mail: info@medichem.co.uk. Website: http://www.medi-chem.com.
- **P.P. Products,** Hoveton, Norwich NR12 8QN. Tel: 01603 784367. E-mail: mail@ppproducts.co.uk.
- **Progress Products,** Queenswood House, 70 Durleigh Road, Bridgwater, Somerset TA6 7JE. Tel: 01278 429800. E-mail: sales@aromany.co.uk. Website: http://www.progressproducts.co.uk/.
- **Quat-Chem Ltd,** 4 Dodgson Street, Rochdale, Greater Manchester OL16 5SJ. Tel: 01706 344797. E-mail: sales@quatchem.co.uk.
- **Quill Productions,** Manor Farm, Pulham, Dorchester, Dorset DT2 7EE. Tel: 01258 818239. E-mail: sales@quillprod.com. Website: http://www.quillproductions.co.uk/.
- **Sorex Ltd,** St Michaels Industrial Estate, Widnes, Cheshire WA8 8TJ. Tel: 0151 4244238.
- **Tristel,** Lynx Business Park, Fordham Road, Snailwell, Cambridgeshire CB8 7NY. Tel: 01638 721500. E-mail: mail@tristel.com. Website: http://www.tristel.com.
- **Vitax Ltd,** Owen Street, Coalville, Leicestershire LE67 3DE. Tel: 01530 510060. Website: http://www.vitax.co.uk/.
- **Water Treatment Products Ltd,** Unit 5, Gilchrist Thomas Court, Blaenavon, Pontypool, Torfaen NP4 9RJ. Tel: 01495 792790. Email: sales@watertreatmentproducts.co.uk. Website: http://www.watertreatmentproducts.co.uk/.

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