The effect of disinfectants on fungal diseases of potato and vegetables

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Treatments of one and ten minutes were too short for all disinfectants against fungi in peat and plant debris. The best effect was achieved with a treatment of 90 min. Sodium hypochlorite (NaOCl) was the most effective and Korsolin and Virkon S were the least effective in the control of *Fusarium culmorum* and *F. oxysporum*. Virkon S (2%) was the most effective against *Mycocentrospora acerina* and *Phoma foveata*.

Soaking for 15 min and 60 min in a disinfection suspension eradicated *Botrytis cinerea* and *P. foveata* totally from the contaminated plastic pots. *Fusarium* spp. were the most difficult fungi to disinfect and these were best controlled with formaline, Iobac P, Menno-Ter-forte and sodium hypochlorite.

Iobac P, formaline, Menno-Ter-forte, Taloset and Virkon S were the most effective disinfectants against club rot (*Plasmodiophora brassicae*).Washing under running water was not sufficient to eradicate club rot. Against *Rhizoctonia* -induced damping-off of cauliflower the most effective disinfectants were formaline and Virkon S.

Key words: *Botrytis cinerea*, disinfection, *Fusarium culmorum, F. oxysporum, Mycocentrospora acerina, Phoma foveata, Plasmodiophora brassicae, Rhizoctonia solani*

Introduction

Many plant diseases, which cause a decrease of yield and yield quality, survive on plant debris, growth substrates, mull debris, and greenhouse and storage structures for long periods. Therefore it is essential to use disinfectants to prevent the spread of diseases by those routes. Disinfection of soil substrate is not at present topical, because new peat or other currently used substrates are free of diseases.

Grey mould (*Botrytis cinerea*) is a common disease in vegetables and ornamental plants grown in greenhouses as well as in vegetable storages (HEINZE 1974, DENNIS 1983). *Fusarium* spp. are also commonly encountered in vegetables. They cause *Fusarium* rot (*Fusarium avenaceum* and *F. solani* var. *coeruleum*) of potato (SEPPÄNEN 1983), wilt disease (*Fusarium oxysporum*) of tomato and cucumber, as well as damping-off and foot rot (*F. culmorum, F. avenaceum*). *Phoma* spp. cause damping-off, stem rot and various leaf spot diseases in greenhouses as well as *Phoma* rot (*Phoma foveata*) of potato. Club rot (*Plasmodiophora brassicae*) and damping-off (*Rhizoctonia solani*) are a major problem in cabbage cultivation, as soil-borne diseases also in seedling cultivation (HEINZE 1974). Liquorice rot (*Mycocentrospora acerina*) has become a common disease of carrots in storage (DENNIS 1983).

In order to prevent the spread of pathogens on a farm and from one farm to another, greenhouses,

seed storages, machines and tools must be disinfected. There are several disinfectants on the market, but little is known about their applicability in plant production against important and common diseases. In 1988-1990, studies were conducted to determine the effect of disinfectants against fungal diseases of vegetables and potato.

Material and methods

The effect of nine disinfectants (Table 1) in the control of potato and vegetable diseases was tested at the Institute of Plant Protection of the Agricultural Research Centre. Mostly the concentrations recommended by the manufacturers were used in the trials. The disinfectants were diluted in water.

The test fungi used were *Botrytis cinerea, Fusarium culmorum, F. oxysporum, Mycocentrospora acerina, Phoma foveata, Plasmodiophora brassicae* and *Rhizoctonia solani*. The names of the fungi are mainly according to DOMSCH et al. (1980). The fungal isolates included in the study were obtained from the collections of the Institute of Plant Protection of the Agricultural Research Centre. The fungi were cultivated on different media depending on the fungus (Table 2). The formulas for culture media of fungi are presented in BOOTH (1971).

The results were tested using the analysis of variance, and significances with Tukey's test.

Table 1. The disinfectants, their active ingredients and concentrations recommended by the manufacturers.

Disinfectant	Active ingredient, %	Recommended concentration, %
Formaline	Formaldehyde, 37	5.0
Iobac P	Iodine, 1.8	
Ipasept	Quaternary ammonium compounds, 2.8	2.0
Korsolin	Glutaraldehyde, 10	
Menno-Ter-forte	Quaternary ammonium compounds, 32.5	1.0
Sanisept	Quaternary ammonium compounds, 2.5	2.0
Sodium hypochlorite (NaOCl)	Active chlorine, 10	
Taloset	Quaternary ammonium compounds, 3.5	2.0
Virkon S	Potassium peroxysulphate, 60	1.0

Table 2. The growth media used in the fungal cultures.

Fungus	Growth medium
Botrytis cinerea	Corn meal agar (Difco) + 100 ppm streptomycin sulphate
Fusarium culmorum	Nash and Snyder PCNB medium
F. oxysporum	Nash and Snyder PCNB medium
Mycocentrospora acerina	Corn meal agar (Difco) + 100 ppm streptomycin sulphate
Phoma foveata	Malt extract agar (Difco)
	Corn meal agar (Difco) + 100 ppm streptomycin sulphate
Rhizoctonia solani	Rhizoctonia agar (KO and HORA 1971)

The effect of disinfectants on the pathogens in peat and plant debris

The effect of disinfectants on the pathogens in peat and plant debris was investigated in laboratory trials. The inoculated peat was obtained by mixing one Petri dish culture of fungus (*F. culmorum* and *F. oxysporum*) and 100 ml of water in one litre of peat. The recommended concentrations (N) of disinfectants and a lower concentration (10^{-1} N) were used. Inoculated peat, 1.0 and 0.1 g, was mixed in 1 l of disinfection suspension. The preparation was allowed to act for 1, 10 and 100 min. Thereafter the suspension was filtered. The filter paper was washed with water (50 ml) and pieces of the filter paper were placed onto different agar plates depending on the test fungus (Table 2) (4 pieces/plate) to determine the viability of the fungi. The trial was made with three replicates.

The effect of disinfectants on fungi was tested on polyethene surfaces. The inner surfaces of the plastic pots were scratched with sandpaper and contaminated with fungus-peat inoculate. The inoculate used was obtained by mixing one plate of fungus (*F. culmorum, F. oxysporum* and *R. solani*) and

100 ml sterile water in one litre of peat, or by mixing five crushed pieces (4 cm long) of infected (*B.cinerea, M. acerina* and *P. foveata*) plant and 100 ml of sterile water in one litre of peat. The contaminated pots were allowed to dry for 1-2 days. Pieces (4x6 cm) cut from the plastic pots were soaked for 15 and 60 min in the disinfection solution (100 ml). They were rinsed with water and cut into pieces of 0.5 cm onto different agar plates as above. The plates were evaluated after one and three weeks. The results were calculated as efficiency percentages, i.e. the proportion of healthy pieces on agar plates of all pieces.

The effect of disinfectants on liquorice rot of carrot (*M. acerina*) and *P. foveata* of potato was investigated in a storage environment by inoculating carrots and potatoes with disinfected peat containing the respective fungus. One decilitre (30 g) of peat inoculated with *Mycocentrospora* or *Phoma* and 2 l of disinfection suspension were mixed. After 30 min (trial 1) or 60 min (trial 2) the peat was filtered and washed with water. The potatoes and carrots were washed and surface sterilized with 0.1% NaOCl solution for 2 min and thereafter washed with distilled water. Four holes (1 cm in diameter and 0.5 cm deep) were made in the potatoes and three holes in the carrots using a cork borer. The holes were filled with inoculated and disinfected peat.

The carrots were stored at +5°C and the potatoes at +10-+12°C for 4-6 weeks in the dark. Clean peat as well as water treated infected peat were used as controls. The trial was made with four replicates, ten treatments per replicate. The trial was repeated twice. The spread of the disease in the holes was evaluated in millimetres. The efficiency percentage of the disinfectants was calculated by comparing the treatments with the healthy controls and water treatments.

The effect of disinfectants on club rot *(Plasmodiophora brassicae)*

The club rot trials were carried out in the greenhouse. The containers (Vefi) were contaminated with *Plasmodiophora brassicae* infested soil (1.0 l soil/1 l water). The soil was taken from a club rot infected rape field. The containers were allowed to dry for one day before disinfection treatments.

The treatments were: 1= control, no washing, no disinfection; 2=washing under running water; 3=washing under running water, disinfection for 60 min.

After disinfection the containers were rinsed with water. On the next day about 130 rape seeds cv. 'Kova' were sown in fertilized peat (peat compound fertilizer 150 g and Dolomite lime 800 g/100 l peat). Additional light of 6000 lux was given to the plants. The trial was made with three replicates. The seedlings were grown for about 6 weeks, until the end of flowering. The severity of the infection was determined as the proportion of infected seedlings of all seedlings. The efficiency percentage was determined by comparing the effect of the preparation with the treatment of no washing.

The effect of disinfectants on damping-off *(Rhizoctonia solani)*

The inoculated peat used in the trials was obtained by mixing one Petri dish culture of *Rhizoctonia solani* and 100 ml of water in one litre of peat. One decilitre of inoculated peat + one decilitre of fresh peat and two litres of disinfection suspension were mixed. The disinfectant was allowed to affect for 60 min. The suspension was filtered and the peat was rinsed with water twice. The fresh peat was used as a growth medium in plastic pots (1 l). A layer of 1 cm of disinfected inoculated peat was placed on fresh peat. Thirty-six seeds of cauliflower cv. 'Tanskalainen suuri' were sown in the fresh peat and covered with a 0.5 cm layer of fresh peat. The number of replicates were five. The trial was repeated three times. The substrate, temperature and light conditions were as above in the club rot trial. The conditions of seedlings were checked 20 days after sowing. The results were calculated as the proportion of healthy seedlings of all seedlings.

Table 3. The effect of concentration and disinfection time on *Fusarium culmorum* in peat debris. Disinfectants and concentrations (N): 1 = formaline (5 %), 2=Iobac P (3 %), 3= Ipasept (2 %), 4 = Korsolin (1 %), 5 = Menno-Ter-forte (1 %), 6 = NaOCl (10 %), 7 = Virkon S (2 %).

Concentration of disinfectant	Peat g/l l disinfectant	Time min	Disinfectant 1	2	3	4	5	6	7
			Efficiency %						
Concentration (N)	1	1	0	50	93	5	95	93	0
		10	8	83	93	18	98	100	68
		100	93	93	93	5	95	100	100
	0.1	1	0	80	95	8	100	93	0
		10	93	88	93	45	100	100	0
		100	93	95	95	25	100	100	75
10^{-1} N	1	1	-	8	20	0	93	38	0
		10	-	0	13	0	93	75	0
		100	-	45	33	0	93	88	18
	0.1	1	-	33	83	0	95	0	0
		10	-	68	88	0	98	18	0
		100	-	95	93	0	98	83	8

Table 4. The effect of concentration and disinfection time on *Fusarium oxysporum* in peat debris. Disinfectants and concentrations (N): 1 = formaline (5 %), 2=Iobac P (3 %), 3= Ipasept (2 %), 4 = Korsolin (1 %), 5 = Menno-Ter-forte (1 %), 6 = NaOCl (10 %), 7 = Virkon S (2 %).

Concentration of disinfectant	Peat g/l l disinfectant	Time min	Disinfectant 1	2	3	4	5	6	7
			Efficiency %						
Concentration (N)	1	1	0	8	33	50	75	33	25
		10	17	30	55	50	93	75	0
		100	83	93	83	88	88	100	68
	0.1	1	0	70	80	0	95	93	0
		10	100	83	88	50	100	100	8
		100	100	93	93	50	100	100	100
10^{-1} N	1	1	-	0	0	8	0	8	0
		10	-	5	0	8	8	0	0
		100	-	55	0	50	45	0	0
	0.1	1	-	20	5	0	70	0	0
		10	-	85	5	0	80	0	0
		100	-	100	50	25	95	8	25

Results

The effect of disinfectants on pathogens in peat and plant debris

NaOCl was the most effective in the control of *Fusarium culmorum* when peat (1.0-0.1 g) was mixed in disinfectant. Also Menno-Ter-forte performed well. Korsolin was the weakest preparation (Table 3). NaOCl was effective also against *F. oxysporum*. The 100 min treatment time with Menno-Ter-forte, formaline and Virkon S was sufficient to disinfect the smallest amount of peat (0.1 g). Korsolin was the weakest preparation (Table

Table 5. The effect of disinfection against fungi on the surface of plastic pots contaminated with fungus-peat mixture.

Treatment	*Botrytis cinerea*	*Fusarium culmorum*	*Fusarium oxysporum*	*Phoma foveata*	*Rhizoctonia solani*
	Minimum time min / efficiency %				
Water	60/83	60/0	60/25	60/8	60/42
Formaline	15/100	60/100	15/100	15/100	15/100
Iobac P	15/100	15/100	60/100	15/100	15/100
Ipasept	15/100	60/75	60/100	15/100	60/100
Korsolin	60/100	60/17	60/92	60/100	60/58
Menno-Ter-forte	15/100	15/100	15/100	15/100	15/100
NaOCl	15/100	15/100	60/100	15/100	15/100
Sanisept	15/100	60/50	60/92	60/100	60/100
Taloset	15/100	60/100	-	-	15/100
Virkon S, 2 %	15/100	60/100	60/92	15/100	60/75

Table 6. The effect of disinfection on *Mycocentrospora acerina* in peat debris. The tests were carried out on carrots.

Treatment	Spread of the disease, mm		Efficiency %
	Trial 1 30 min	Trial 2 60 min	Mean
Healthy control	0 a	0.2 a	
Water	16.5 c	17.8 d	
Formaline	2.4 ab	21.0 d	32
Iobac P	4.6 b	11.7 c	53
Ipasept	-	13.1 c	-
Menno-Ter-forte	1.4 a	6.0 b	79
NaOCl	6.6 b	10.3 c	51
Taloset	7.8 b	-	-
Virkon S 1 %	-	14.9 d	-
Virkon S 2 %	0.3 a	3.8 ab	88
F-values	56.59***	53.28***	

Values in columns marked with the same letter do not differ at P=0.05.
***= P0.001

Table 7. The effect of disinfection on *Phoma foveata* in peat debris. The tests were carried out on potato tubers.

Treatment	Spread of the disease, mm		Efficiency %
	Trial 1 30 min	Trial 2 60 min	Mean
Healthy control	0 a	0 a	
Water	19.2 d	15.3 c	
Formaline	1.9 ab	0.8 ab	92
Iobac P	6.3 bc	1.4 ab	77
Ipasept	-	2.8 b	-
Menno-Ter-forte	5.4 b	0.3 a	84
NaOCl	4.7 b	0.3 a	86
Taloset	10.0 c	-	-
Virkon S 1 %	-	0.7 ab	-
Virkon S 2 %	0.6 a	0.2 a	98
F-values	58.71***	107.44***	

Values in columns marked with the same letter do not differ at P=0.05.
***= P0.001

4). Lower than recommended concentrations were ineffective against *F. culmorum* and *F. oxysporum*.

Soaking of contaminated (fungus-peat suspension) plastic pots for 15 min in the disinfection suspension was sufficient to eradicate *Botrytis cinerea* and *P. foveata*. Formaline, Iobac P, Menno-Ter-forte and NaOCl were the most effective disinfectants against *F. culmorum, F. oxysporum* and *Rhizoctonia solani*. Ipasept, Korsolin and Sanisept were the weakest disinfectants on polyethene surfaces contaminated with fungus-peat mixture (Table 5).

In the trials where disinfected peat containing *Mycocentrospora acerina* was tested on the carrots, the most effective disinfectant was 2 % Virkon S. Menno-Ter-forte had a moderate effect. The effect of other disinfectants was weak (Table 6). In the potato trial on *Phoma foveata* Virkon S (2 %) was superior in efficacy to the other disinfectants. Taloset and Ipasept were the weakest preparations (Table 7).

Table 8. The effect of disinfection on club rot (*Plasmodiophora brassicae*) from contaminated plastic containers. The containers were washed with water before disinfection. Rape was used as test plant.

Treatment	Disease-% of seedlings				Efficiency%
	Trial 1	Trial 2	Trial 3	Mean	
No washing, control	73.1 a	61.4 a	91.5 a	75.3	
Water, control	5.8 b	7.1 b	46.2 b	19.7	73
Formaline	3.4 b	0.9 b	0.6 c	1.6	98
Iobac P	3.2 b	0.3 b	0.3 c	1.3	98
Menno-Ter-forte	1.1 b	0 b	0 c	0.4	99
NaOCl	3.4 b	2.2 b	0.8 c	2.0	98
Taloset	-	-	1.0 c	1.0	-
Virkon S, 2 %	3.3 b	0.3 b	0.3 c	1.4	98
F-values	39.05***	48.78***	184.52***		

Values in columns marked with the same letter do not differ at P=0.05.
***= P0.001

Table 9. The effect of disinfection on *Rhizoctonia solani* in peat debris. Cauliflower was used as test plant.

Treatment	Healthy seedlings, %				Efficiency %
	Trial 1	Trial 2	Trial 3	Mean	
Healthy control	100.0 a	98.9 a	98.8 a	99.2	
Water, control	36.8 ab	4.0 b	0 b	13.6	
Formaline	100.0 a	100.0 a	95.4 a	98.5	98
Iobac P	31.0 ab	61.3 ab	57.0 ab	49.8	42
Ipasept	5.1 b	24.2 b	20.2 b	16.5	3
Menno-Ter- forte	77.0 ab	91.5 a	72.4 ab	80.3	77
NaOCl	31.5 ab	44.3 ab	41.3 b	39.0	29
Taloset	79.5 ab	34.4 b	25.2 b	46.4	38
Virkon S, 2 %	100.0 a	96.0 a	81.4 a	92.5	91
F-values	3.73*	8.71***	7.87***		

Values in columns marked with the same letter do not differ at P=0.05.
* = P 0.05, ***= P0.001

The effect of disinfectants on club rot *(Plasmodiophora brassicae)*

Washing under running water without a brush, the plastic pots were not sufficiently free from club rot. All tested disinfectants were effective against club rot, but none of them eradicated it totally. The differences between the preparations were not significant (Table 8).

The effect of disinfectants on damping-off *(Rhizoctonia solani)*

Formaline and Virkon S were the most effective against *Rhizoctonia* induced damping-off. Menno-Ter-forte also performed well. Ipasept, Iobac P and NaOCl were the weakest disinfectants (Table 9).

Discussion

In the present trials, 100 % effect against *Fusarium oxysporum* mixed in peat was achieved only with NaOCl (10 %) after 100 min exposure time. These results are opposite to those of BÖHMER (1983) who showed that NaOCl (1 %) had no effect on *F.oxysporum*. This is due to the higher concentration of NaOCl used in the present study. Menno-Ter-forte, Virkon S and formaline were also effective against the fungus in a small amount of peat (0.1 g/l1 l disinfectant). Also BÖHMER (1985) showed that a small amount of peat (15-30 g/l) does not decrease the effect of Menno-Ter-forte on *F. oxysporum* but a large amount (60 g/l) decreases the effect of Menno-Ter-forte. Under clean conditions Menno-Ter-forte (0.5 %) has been shown to inhibit the growth of *F. oxysporum* conidia even after 5 and 10 min treatment time (BÖHMER 1983, BRIELMAIER 1985) but this and other studies (BÖHMER 1985) confirm that the peat in the disinfection solution decreases the effect of Menno-Ter-forte and a treatment time of 60 min at least should be used. According to BAANDRUP (1983), 2 % Korsolin inhibited the growth of *F. oxysporum*, but we used 1 % Korsolin and it was too weak against *F. oxysporum*. In this study, Iobac P did not inhibit totally the growth of *F. oxysporum* and the effect of Iobac P was decreased in the presence of peat.

NaOCl was the most effective against *F. culmorum* mixed in peat after 10 min treatment time. Menno-Ter-forte was moderately effective against *F. culmorum* mixed in peat when used at the recommended concentration. BRIELMAIER (1985), too, showed that Menno-Ter-forte prevents the germination of conidia of *F. culmorum* under clean conditions. When using a treatment time of 100 min, only Korsolin was ineffective against *F. culmorum*. Also this study showed that a treatment time of at least 60 min should be used.

According to BÅNG (1987a, b), formaline is effective against *Phoma foveata* and *F. solani*, but Iobac P is not. In the present trials, Iobac P was a weak disinfectant against *P. foveata* mixed in peat, but formaline was effective against *P. foveata*.

In this and other studies (SUNDHEIM 1991), formaline was effective against *Rhizoctonia solani* mixed in peat after a treatment of 60 min. Also Virkon S was effective against the fungus and it was equal to formaline in disinfecting *R. solani* from peat but in disinfecting plastic pots Virkon S was ineffective against *R. solani*. In the present trials, Iobac P was very effective against *R. solani* in disinfecting plastic pots, but in disinfecting *R. solani* from peat it performed poorly. The results are partly affected by the fact that Iobac P caused damage to the cauliflower seedlings, which were used as test plants. Damping-off of cauliflower could not always be distinguished from the phytotoxicity injuries caused by Iobac P. The use of cauliflower to indicate the efficacy of disinfectants is not the best choice because many disinfectants in peat cause phytotoxicity injuries to plants (AVIKAINEN et al. 1993).

F. oxysporum was effectively eradicated from plastic pots with formaline, Iobac P, Menno-Ter-forte, Ipasept and NaOCl. Fifteen minutes exposure time was enough for formaline and Menno-Ter-forte, but Iobac P, Ipasept and NaOCl needed 60 min. In these trials, Korsolin and Virkon S were effective against *F. oxysporum* although the effect was not perfect.

In the present study, all the tested disinfectants were effective against *Botrytis cinerea* when plastic pot surfaces were contaminated with a fungus and peat mixture. A treatment time of 15 min was sufficient for all disinfectants except Korsolin. In this and other studies, formaline was effective against *B. cinerea* (Hortica 1985, JOHANSSON 1985, SUNDHEIM 1989, 1991). Menno-Ter-forte has proved effective against grey mold growing on pieces of paper or on synthetic cloth, but not on pieces of wood (SUNDHEIM 1991, KOPONEN et al. 1992b). According to SUNDHEIM (1991), Virkon S (1 %) is not effective against grey mold, but this study showed that it is a very good compound in disinfecting plastic pots contaminated with fungus and peat.

In disinfecting plastic pots all disinfectants were effective against *P. foveata* after a treatment of 60 min. According to BÅNG (1987a, b), formaline is effective against *P. foveata*. The result is in accordance with this study.

In greenhouse trials imitating seedling production, 60 min treatment of plastic pots in disinfection

suspension against *Plasmodiophora brassicae* gave a good result although none of the disinfectants were capable of eradicating the fungus totally. Also in other studies Menno-Ter-forte (1.5 %) has been effective against *P. brassicae* when plastic pots were soaked in disinfection solution for 12 h (HADLER 1988). Whereas only washing with water or spraying of the disinfectant on the surface to be disinfested was not sufficient to eradicate club rot (HADLER 1988).

The present trials confirm the fact that dirt and organic material decrease the effect of disinfectants. The dirtier the surface to be cleaned, the longer disinfection time is needed. The disinfection time should always be at least 60 min. Although 15 min or less is sufficient in laboratory tests to eradicate the pathogen, it is not necessarily sufficient in practice.

Virkon S, Iobac P and NaOCl are effective disinfectants against many potato pathogens, e.g. *Rhizoctonia solani, Phoma foveata* and *Fusarium* spp. Iobac P can be used also for bacterial ring rot of potato (*Clavibacter michiganensis* subsp. *sepedonicus*) and black leg (*Erwinia carotovora* subsp. *atroseptica*) (KOPONEN et al. 1992a).

Iobac P, Menno-Ter-forte and Virkon S are good alternatives to those who want to avoid formaline in disinfection of plastic pots from *Plasmodiophora brassicae*.

Formaline and Virkon S are effective against *R. solani* when organic material is present, but plastic surfaces may be disinfected with Iobac P, Menno-Ter-forte, NaOCl and formaline.

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SELOSTUS

Desinfiointiaineiden teho perunan ja vihannesten sienitauteihin

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Yhdeksän markkinoilla olevan desinfiointiaineen tehoa vihannesten ja perunan tauteja aiheuttaviin sieniin tutkittiin Kasvinsuojelun tutkimuslaitoksella vuosina 1988-1990. Tutkittavat valmisteet olivat formaliini (formaldehydi), Iobac P (jodi), Ipasept, Menno-Ter-forte ja Sanisept ja Taloset (kvartaarisia ammoniumyhdisteitä), Korsolin (glutaraldehydi), natriumhypokloriitti (aktiivinen kloori) ja Virkon S (kaliumperoksisulfaatti).

Laboratoriotesteissä tutkittiin valmisteiden suositeltujen käyttöväkevyyksien tehoa turpeessa tai kasvijätteessä oleviin *Bortrytis cinerea-, Fusarium culmorum-, Fusarium oxysporum-, Mycocentrospora acerina-* ja *Phoma foveata-* sieniin. Lisäksi testattiin käsitelyajan vaikutusta valmisteiden tehoon. Sienten elävyys testattiin agarmaljoilla. Porkkananmustamätä (*M. acerina*) ja perunan Phoma-mätä (*P. foveata*) testattiin laittamalla saastutettu ja desinfioitu turve porkkanoihin ja perunoihin ja säilyttämällä juureksia varasto-olosuhteissa. Turve- ja kasvijätteessä olevien taudinaiheuttajien desinfiointia muovipinnalta tutkittiin liottamalla liattuja muoviruukun paloja eri aikoja desinfiointiaineissa. Sienten elävyys testattiin agarmaljoilla.

Yhden ja kymmenen minuutin vaikutusajat olivat kaikilla valmisteilla liian lyhyitä turpeessa ja kasvijätteissä oleviin sieniin. Paras teho saatiin 1,5 tunnin käsittelyllä. *F. culmorum-* ja *F. oxysporum-* sieniin paras teho oli natriumhypokloriitilla, huonoin Korsolinilla ja Virkon S:llä. *M. acerina-* sieneen tehosi parhaiten Virkon S (2 %). Formaliini, natriumhypokloriitti, Iobac P ja Taloset olivat teholtaan huonoja. Virkon S (2 %) tehosi parhaiten myös *P. foveata-* sieneen.

Viidentoista minuutin ja tunnin liotus desinfiointiaineliuoksessa puhdisti liatut muoviruukut hyvin *B. cinerea-* ja *P. foveata-* sienistä. *Fusarium* spp.-sienet olivat vaikeimpia puhdistaa. Paras teho niihin oli Formaliini-, Iobac P-, Menno-Ter-forte- ja natriumhypokloriitti- valmisteilla. Korsolin, Ipasept ja Sanisept olivat teholtaan huonoja valmisteita.

Desinfioinnin vaikutusta möhöjuureen (*Plasmodiophora brassicae*) ja *Rhizoctonia solani-* taimipoltteeseen testattiin kasvihuoneessa taimikasvatuskokeissa. Möhöjuurella liattuja muovisia lokerikkoja liotettiin desinfiointiainelaimennoksissa yhden tunnin ajan. Lokerikoissa kasvatettiin rypsin taimia noin kuusi viikkoa. Taimista analysoitiin juurten tautisuus. *Rhizoctonia solani* taimipolte kokeessa testikasvina oli kukkakaali. Kaikki tutkitut desinfiointiaineet tehosivat hyvin möhöjuureen. Huuhtelu juoksevalla vedellä ei riittänyt möhöjuuren puhdistamiseen. Kukkakaalin *Rhizoctonia*-taimipoltteeseen tehosivat parhaiten formaliini ja Virkon S. Huonoimpia valmisteita olivat Ipasept, Iobac P ja natriumhypokloriitti.

Desinfiointiaika tulisi olla vähintään tunti. Vaikka viisitoista minuuttia ja lyhyempikin aika riitti joidenkin taudinaiheuttajien puhdistamiseen laboratoriokokeissa, se ei välttämättä riitä käytännön olosuhteissa.

Porkkanavarastojen desinfiointiin soveltuvat parhaiten Virkon S (2 %) ja Menno-Ter-forte, perunavarastojen Iobac P, Virkon S ja NaOCl. Möhöjuuren desinfiointiin soveltuvat hyvin Iobac P, Menno-Ter-forte, Virkon S ja formaliini. *Rhizoctonia*-taimipoltteen saa parhaiten puhdistettua formaliini- ja Virkon S-valmisteilla.