DISINFECTION OF NUTRIENT SOLUTION IN CLOSED SOILLESS SYSTEMS: RESULTS IN ITALY

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Introduction

The soilless cultivation system represents a viable alternative for reducing methyl bromide use (Garibaldi and Gullino, 1995; Van Os and Postma, 2000). Generally the crop management expenses are higher for soiless systems compared with a traditional soil cropping system, causing a reduced diffusion of this growing technique in Italy (Farina, 1995), generally applied for high value crops (i.e. rose, carnation, gerbera and tomato) (Serra, 1994; Tognoni and Serra, 1994). To reduce the environmental impact caused by the nutrient solution drained away, saving water, fertilisers and then economical resources, the closed soilless system seems to be a transferable technique, but not realistic without any preventive strategy to avoid the risk of dispersal of root-infecting pathogens with a recycled nutrient solution (Jarvis, 1992; Stanghellini and Rasmussen, 1994). Based on the above mentioned considerations, in Italy the future adoption of soilless cultivations could be limited by a realistic availability of an effective and easily transferable strategy permitting to disinfect the drained solution. With a support of EU project (FAIR6 CT98-4309) "PREVENTION OF ROOT DISEASES IN CLOSED SOILLESS GROWING SYSTEMS BY MICROBIAL OPTIMISATION, A REPLACEMENT FOR METHYL BROMIDE" starting in 1999, several disinfection methods were evaluated to recycle drained nutrient solutions (Garibaldi *et al.*, 2001).

Materials and methods

The experimental protocol adopted (table 1) compared active and passive disinfestation systems already available for floricultural Italian farms. The trials were carried out in a greenhouse, on gerbera plants cv "Goldie" kept on concrete benches and transplanted in plastic pots (5 l volume) using as growing media a steamed peat (20 % vol/vol) and pomice (80 % vol/vol) mixture. The pots were singularly provided with a drip emitter and irrigated with nutrient solution following the plant's needs. To simulate the soilborne pathogen spread effects, an isolate of *Phytophthora cryptogea* was artificially introduced into the closed soilless system when the plants were two months old. The artificial inoculation was carried out by infecting two plants per each plot, putting *P. cryptogea* infected wheat kernels at the base of each plant. To maintain a continuous presence of efficient inoculum, when completely collapsed, the infected plants were replaced with new ones previously inoculated with *P. cryptogea* infected wheat kernels.
The sand filtration system adopted (Figure 1) is commonly used to eliminate any type of material able to reduce the efficiency of irrigation systems (sands and other organic and inorganic particles) and is totally different from the slow

sand filtration described by Wohanka in 1995, but commonly used by Italian flower growers. The drained nutrient solution is discontinuously pumped into the sand filter only when the plants have to be irrigated. The nutrient solution flow rate influent into the sand bed (sand size 1.2-1.8 mm; % weight/weight <1.25 mm = 21%, >1.25 mm = 28%, >1.4 mm = 45%, >1.8 mm = 6%) is adjusted at 300 l/m^2h.
The UV system used (UV 403 SITA s.r.l., Genoa, UV-C rays 254 nm; 300 mj/cm^2 of irradiation per flow rate of 1 l/min) was adapted from an existing system employed for drinking water disinfection. Also in this case the nutrient solution is pumped into the UV system only when the plants are irrigated.
For chemical disinfection, a chlorogenic (sodium dichloroisocianurate [Na-DIC], applied at the dosage of 50 and 10 ppm) and non chlorogenic compound [metalaxyl, applied at the dosage of 20 ppm (Pasini *et al.*, 1984)] were applied separately, mixing the chemical in the tap water used to fill the tanks when necessary and generally done once a week.
The experimental design was organised randomising the different disinfection treatments into three blocks. The data collection was carried out periodically counting the number of infected plants and harvesting the produced flowers. The disease incidence (% of infected plants), the plant production (flowers/healthy plant) and the total production (flowers/m^2) were calculated. The data obtained were statistically analysed, according to Duncan's Multiple Range Test (P = 0.05).

Results
A reduced number of flowers/m^2 and flowers/plant harvested from the plants grown with recycled water treated with 50 ppm of Na-DIC was observed (table 2, figure 2). It is supposed that the reduction was due to the phytotoxicity of the chlorogenic chemical adopted rate (50 ppm), but the Na-DIC rate reduction from 50 to 10 ppm gave negative results too. The best control was obtained with the application of metalaxyl, followed by sand filtration and UV radiation (Table 1). Sand filtration showed interesting results even if the adopted system is completely different from the slow sand filtration described by Wohanka in 1995, first of all because the sand layer system can get dry between two following irrigations. This fact can seriously damage the resident microflora, recognised as an important factor for sand filtration (Metcalf and Eddy, 1979). The UV radiation strongly reduced the spread of *P. cryptogea* similarly to sand filtration.

Discussion
The adoption of chemical fungicides such as metalaxyl, even able to give good results, could be complicated when a completely nutrient solution wasting is requested and justified by unacceptable chemical parameters level (electric conductivity, pH) (Farina, 1995). In this case the environmentally negative risk could be due to the presence of chemical residues in a discharging nutrient solution. Moreover a not minor risk, caused by the use of specific mode of action chemicals, such as metalaxyl, is the increased risk of disease resistance onset. The chlorogenic compound adoption, such as chlorine (gas) or Na-DIC, recommended by few authors for the disinfection of nutrient solutions (Poncet *et al.*, 1999) did not seem a suitable opportunity. Chlorine gas is considered, in Italy, as a toxic gas and submitted to strict storage, handle and transportation

rules. Moreover using chlorine gas and chlorogenic compounds the risk of workers' exposure must be taken into the account. Finally, the obtained results point out the phytotoxicity risk caused by the application of a chlorogenic compound such as Na-DIC.

UV radiation or sand filtration seem to permit a non chemical management of recycled nutrient solutions. Moreover the results obtained using a sand filter suggest and confirm the complex mode of action of sand filtration: as mentioned, the sand size [one of the most important aspects involved in sand filtration (Metcalf and Eddy, 1979)] adopted was different from that indicated by other authors (Wohanka, 1995, Van Os and Postma, 2000), but the results were encouraging.

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Fig. 1. Sand filtration system (IMAGO s.r.l. Carasco –GE- Italy)
1: storage tank;
2: influent;
3: sand;
4: head space;
5: gerbera crop;
6: drain water.

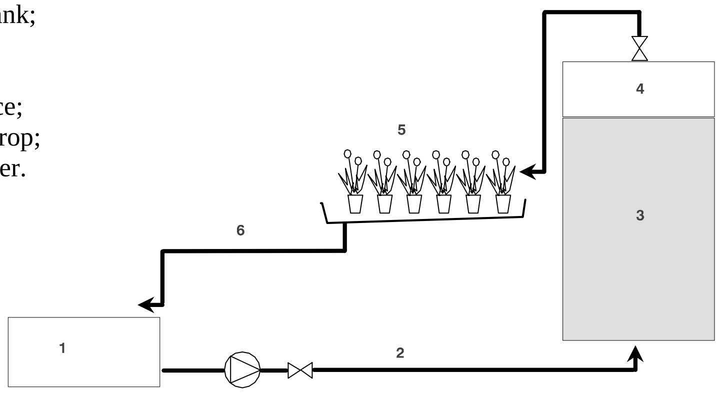

Table 1. Effect of active and passive water disinfection against *P. cryptogea* on gerbera (cv Goldie).

Treatment	% of infected plants on			
	03/13	05/05	05/12	05/18
Sand filtration	2.9 a°	4.5 a	4.5 a	5.4 ab
U.V. radiation	3.7 a	5.4 a	6.3 ab	8.1 ab
Na-DIC *	3.6 a	22.5 a	35.1 b	41.4 c
Metalaxyl	0.0 a	0.0 a	0.0 a	0.9 a
Control	9.1 a	19.8 a	25.3 ab	33.4 bc

* 50 ppm until 03/30 and 10 ppm later on; ° Means of the same column followed by the same letter do not statistically differ following Duncan's Multiple Range Test (P =0.05).

Table 2. Effect of active and passive water disinfection on gerbera flower production (cv Goldie)

Treatment	no. flowers/m^2			no. flowers/plant			flower stem length (cm)	
	03/29	04/26	05/29	03/29	04/26	05/29	01/11	03/29
Sand filtration	59.6 a	76.4 a	113.7 ab	6.8 a	8.6 a	12.9 a	41.7 a	48.1 a
U.V. radiation	57.7 a	72.3 a	108.5 ab	6.5 a	8.1 a	12.3 a	41.0 a	47.5 a
Na-DIC *	29.6 b	33.2 b	50.5 c	3.2 b	3.6 b	6.4 b	36.8 c	38.0 b
Metalaxyl	56.5 a	74.8 a	124.2 a	6.3 a	8.3 a	13.6 a	37.2 bc	46.8 a
Control	52.1 a	66.3 a	87.4 bc	6.1 a	7.8 a	11.3 ab	40.3 ab	47.5 a

*, ° see table 1

Fig. 2. Effect of active and passive water disinfection on gerbera flower production (cv Goldie)