Fungal Disinfection by Nanofiltration in Tomato Soilless Culture

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***Abstract*—**Principally, plants grown in soilless culture may be attacked by the same pests and diseases as cultivated traditionally in soil. The most destructive phytopathogens are fungi, such as *Phythium, Phytophthora* and *Fusarium,* followed by viruses, bacteria and nematodes. We investigated effect of carbon nanotube filters on disease management of soilless culture. Tomato seedlings transplant in plastic pots filled with a soilless media of vermiculite. The crop irrigated and fertilized using a hydroponic nutrient solution. We used carbon nanotube filters for nutrient solution disinfection. Our results show that carbon nanotube filtration significantly reduces pathogens on tomato plants. Fungal elimination (*Fusarium oxysporum* and *Pythium* spp.) was usually successful at about 96 to 99.9% all over the cultural season. It is seem that in tomato soilless culture, nanofiltration constitutes a reliable method that allows control of the development of diseases caused by pathogenic fungi

Keywords*—Fusarium oxysporum*, Nanofilteration, *Pythium* spp., Soilless culture, Tomato

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I. Introduction

THE each soilless cropping system requires a continuous supply of water and nutrients in open or closed circulation. There are quite a number of different technologies available with more or less risks to damaging plant's root system due to various pathogens.

In soilless cultures, water supply is one of the main sources for the introduction of pathogenic microorganisms since reservoir and surface waters like rivers are frequently contaminated by pathogens, *i.e. Pythium* spp., *Fusarium oxysporum* [20]. Moreover, the equipment of greenhouses with « closed » systems to minimise pollution by re-using the run-off solution makes them at risk of pathogen spread into the recycled nutrient solution [21]. Thus, preventing pathogenic infections through appropriate disinfection of nutrient solutions has become a major challenge.

There are several techniques applying heat or chemicals or radiation or filtration [8]. McPherson et al. (1995) investigated heat disinfection of nutrient solution. Heat exchangers work well at 95°C for 30 sec., e. g. to control *Phytophthora cryptogena* and *Pythium aphanidermatum* in tomato and cucumber. This system is well accepted by commercial growers.

The application of non-ionic surfactants works very well where mobile zoospores are the sole source of disease spread
Without phytotoxicity (Stanghellini and Rasmussen, 1996). While Cu and Zn in high concentration provide some promise to kill zoospores of *Olpidium* [22], other treatments e. g. with iodine [18], oxidants [5], ozone [23], hydrogen peroxide [19]) and chlorine [6] are either phytotoxic, ineffective, unpracticable or still in the developmental stage. Ultra-violet radiation has reached some commercial stage against *Pythium* rot in lettuce [2]

A method, widely adapted for closed soilless cultivation systems in the horticultural industry is slow sand filtration for the elimination of phytopathogens from reused irrigation water or nutrient solution [24]. But, according to Déniel et al. (2004) there is a limitation to the benefits of this disinfecting technique: indeed, full efficiency is often reached only after a variable period of time, which may extend to 6 months.

Nanomaterials with at least one dimension of 100 nm or less, are increasingly being used for commercial purposes such as filters, opacifiers, catalysts, semiconductors, cosmetics and drug carriers [3]. Particles in such as a size fall in the transitional zone between individual atoms or molecules and the corresponding bulk material, which can modify the physicochemical properties of material. Therefore such materials can generate biological effects in living cells [13]. Several researches showed negative effect on tested microorganisms [4], []. Recently nanofilters used for disinfection of refrigerators and washing machines. Therefore we think nanofiltration may be a reliable method for disinfection of nutrient solution in solless culture.

II.MATERIAL AND METHODS

Tomato seedlings in plastic pots filled with a soilless media of vermiculite substrate transplant to an experimental tomato-soilless greenhouse at room temperature. The crop irrigated and fertilized using a hydroponic nutrient solution. carbon nanotube filters were used for nutrient solution disinfection.

To test the effectiveness of nano filtration, samples of the nutrient solution were collected in triplicate from April to September just before it flew through the filter; each time, three other samples were also taken after nanofiltration of solutions. Detection of potential fungi focused on *Pythium* spp. and *Fusarium oxysporum* because both are key-components of roots and nutrient solution microflora in soilless greenhouses. The concentration of *Pythium* spp. and *Fusarium oxysporum* was determined on nutrient solution samples filtered through a 0.45-µm membrane. Filters were plated on selective media named CMA-PARP for *Pythium* spp. and Komada for *F. oxysporum*. *Pythium* thalles were counted after incubation of the plates for 48 h at 25°C in the dark, whereas *F. oxysporum* propagules were counted 5 and 7 days after incubation under the same conditions. Results were expressed in percent of eliminated micro-organisms.

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III.RESULTS

The re-circulating nutrient solutions used in the greenhouse of concern here were regularly invaded by different fungi, in particular *Pythium* spp. and *F. oxysporum*. and nanofiltration eliminated them excellently (Tables I). Fungal elimination was completely successful with mean of 98.6 for *Pythium* spp and at about 98.6% for *Fusarium oxysporum* over our 6-month experiment (April - September).

TABLE I
EFFICIENCY OF NANOFILTERS TO ELTMINATE *PYTHIUM* SPP. AND *FUSARIUM OXYSPORUM*

	April	May	June	July	August	September
***Pythium* spp.**						
Before nanofiltration	122	98	87	106	98	117
After nanofiltration	0	0	2	0	3	2
% elimination	99.9	99.9	97.7	99.9	96.9	97.7
Fusarium oxysporum						
Before nanofiltration	1753	2785	1997	3005	2796	4015
After nanofiltration	0	0	25	16	28	35
% elimination	99.9	99.9	98.7	99.4	98.9	99.1

1 *Pythium* spp. thalles were counted on selective media coded CMA-PARP and
F. oxysporum thalles were counted on selective media coded Komada
after a 48-h incubation of the plates at 25°C in the dark.
Results are expressed in percent of eliminated micro-organisms.

IV.DISCUSSION

It is obvious that soilless culture is no guarantee for pest and disease free cultivation. But there are a number of ways to minimize infestations. The biggest problems can arise from phytopathogenic fungi such as *Pythium*, *Phytophthora* , well adaped to the aquatic surrounding and able to produce zoospores [1]. *Pythium aphanidermatum* [14] on cucumber, lettuce and various ornamentals and *Phytophthora cryptogea* [12] which often attacks gerberas, but also tomatoes, lettuces and other crops, seems to find favourable conditions to infest plants in soilless cultures. *P. nicotianae* var. *nicotianae* is mainly found on young tomato plants [21].

Among the fungi without zoospores, *Fusarium oxysporum* f.sp. *lycopersici* [17] will cause wilting. Danger comes when already infected plants are introduced into the soilless system. *Fusarium* crown and root rot of tomato seems to be established in the plant at the seedling or transplant stage but remains symptom less until the crop is stressed by its first fruit load [9].

Large operations with monocrops may choose sterilization of the irrigation water. There are a numbers of practical options ranging from various chemicals (ozone, hydrogen peroxide, chlorine, iodine), UVc irradiation, heating, membrane and slow- or biofiltration but all of them have some problems [8].

The present study demonstrated that nanofiltration resulted in a very high elimination (generally about 98 to 99.9%) of fungi such as *F. oxysporum* and *Pythium* spp. all over the cultural season.

Some researchers have shown the toxicity of nanoparticles, such as fullerene, carbon nanotubes and metal oxids to human cells,bacteria and rodents [4], [10], [11], [16]. Therefore high effect of nanofiltration against fungal phytopathogens is exceptive and reasonable.

However, how nanomaterials affect living organisms remain unknown, though reactive oxygen species generation and oxidative stress are proposed to explain the toxicity of inhaled nanoparticles [13].

I think this paper is first suggestion for nanofiltration of nutrient solution for soilless culture disinfection. It is seem that in tomato soilless culture, nanofiltration constitutes a reliable and highly effective method that allows control of the development of diseases caused by pathogenic fungi. This method requires low energy input and ease of construction and operation. However a great deal of research needs still to be conducted to better understand advantage or disadvantages of this method.

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