Prof. Dr. Walter Wohanka
State Research Institute Geisenheim, Dpt. Phytomedicine
D-65366 Geisenheim, Germany

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REPORT

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Efficacy of Water Treatment with the AquaHort®-System against *Xanthomonas hortorum* pv. *pelargonii*

(W. Wohanka, H. Fehres)

Client:
Aqua-Hort® Danmark ApS, Aksel de Lasson
Engdalsvej 26, DK-8220 Brabrand, Denmark

Introduction

Aqua-Hort® is an utility for a controlled electrolytic supply of copper and an electromagnetic water treatment to irrigation water. It shows an approved efficacy against zoospores of oomycetic pathogens such as *Pythium* spp. and *Phytophthora* spp. However, the effectiveness of the Aqua-Hort®-system to eliminate phytopathogenic bacteria is unknown so far.

Objectives

To test the efficacy of the Aqua-Hort®-System against *Xanthomonas hortorum* pv. *pelargonii* in a range of 0 to 4 ppm Cu at various exposure times (5 min to 24 hrs).

Material and Methods

Aqua-Hort® Danmark ApS installed a Aqua-Hort®-unit at the experimental greenhouse of the department of phytomedicine. The unit has been put into operation and tested for its functional capability by Mr. De Lasson. He trained the personal involved into the project to handle and maintain the Aqua-Hort®-equipment.

From a 1000 L reservoir a nutrient solution contaminated with *Xanthomonas hortorum* pv. *pelargonii* was pumped with about 1 m^3/h through the Aqua-Hort®-unit. After passage through the unit the solution was dumped.

800 L nutrient solution were prepared by 0.5 g/L of the complete fertiliser FERTY® 3 MEGA (ingredients see table 1). The solution ready for use had a electric conductivity of about 1 mS/cm and a pH of about 7.2. On demand of the client, for the supplemental test (see below) the pH was adjusted to 6.5 by adding sulphuric acid. Preparation took place one day in advance to achieve a adaptation to the ambient temperature of about 19 °C.

Immediately before the first treatment the nutrient solution was contaminated with a rifamycin-resistant pathogen *Xanthomonas hortorum* pv. *pelargonii* (strain B047Gshm). From a 48 h plate culture (YDC agar) a bacterial suspension (Ringer solution) was prepared (OD 51-52 %) and an aliquot added to the 800 L nutrient solution to achieve a density of about 10^3 to 10^4 cfu/ml. The nominal Cu-concentrations (displayed on the unit) were 0,5, 2,0 und 4,0 ppm Cu. Additionally, in a separate trial conducted 4 weeks later, the concentration of 1 ppm at exposure times from 60 to 1440 min was tested. Table 2 shows the realised (photometrically determined) Cu-concentrations of the various treatments.

Samples were taken 1 min after adjusting the respective concentration at the display (pump continuously working). The samples were immediately transferred to the lab and there stored at room temperature. To realise the various exposure times three sub-samples each were plated onto YDC-agar plates 5, 15, 30, 60 min, (2), 4 and 24 hr after the samples were taken (spiral plate; Meintrup DWS Laborgeräte GMBH, Lähden – Holte, Germany). At start and end of each treatment beside the Cu-concentration (Kupfer-Test Aquaquant®; range 0.3 – 5.0 mg/l; Merck KGaA, Darmstadt), the electric conductivity, pH and temperature of the nutrient solution were determined.

Each treatment was repeated four times. The bacterial counts (cfu/ml) were statistically analysed by ANOVA and significant differences to the control were determined by the Dunnett-test (STATISTICA for Windows version 7.1)

table 1: nutrient contents of the complete fertiliser FERTY® 3 MEGA (Planta Düngemittel GmbH, Regenstauf, Germany)

Plant Nutrients	**Content (%)**
nitrogen	18
potassium	12
phosphorus	18
calcium	2
boron	0.02
copper	0.04
iron *)	0.10
manganese	0.05
molybdenum	0.01
zinc	0.01
*) partially as chelate (EDDHA)	

table 2: Cu-concentrations (ppm) of the treated fertiliser solution at the various repetitions (rpt.1 – rpt. 4)

set value (displayed)	**rpt. 1**	**rpt. 2**	**rpt. 3**	**rpt. 4**
0.0	0.5	0.0	0.0	0.0
0.5	0.3	0.3	0.3	0.3
1.0 *)	0.8	0.6	0.8	0.3
2.0	1.5	2.0	1.5	2.0
4.0	4.0	4.0	4.0	3.5
*) tested at a separate trial				

Results and Discussion

The AquaHort® treatments with 0.5 ppm or 1.0 Cu (nominal values) had no significant effect on the bacterial concentration, even not at the longest exposure time of 24 h (1440 min).

At least 2 ppm Cu were necessary to affect the bacterial concentration, dependent on the exposure time (see table 3). Up to 60 min no significant differences to the control treatment could be seen. Only at exposure times from 240 min on and Cu-concentrations of 2 and 4 ppm a clear impact onto the pathogens could be detected, but no complete elimination. The corresponding efficiency rates for 2 ppm Cu were 96.5 % and for 4 ppm Cu 99.5 %. A complete elimination (efficiency rate 100 %) of the pathogens was only to be seen after an exposure time of 24 hrs (1440 min) and Cu doses of 2 and 4 ppm.

table 3: Means of bacterial counts (cfu/ml) of *Xanthomonas hortorum* pv. *pelargonii* in a fertiliser solution after treatment at different Cu-concentrations and exposure times

treatment	**exposure time (min)**						
	5	**15**	**30**	**60**	**120**	**240**	**1440**
control (trial 1)	6576	5650	5820	5684	--	4343	7541
control (trial 2)	--	--	--	3889	2929	2822	14215
0.5 ppm Cu	6145	6192	5854	12335	--	4980	12335
1.0 ppm Cu	--	--	--	2089	1256	987	4491
2.0 ppm Cu	6104	5915	5827	5501	--	150	0
4.0 ppm Cu	6416	4654	5271	4959	--	20	0

The results clearly show the potential of the AquaHort®-system to eliminate phytopathogenic bacteria such as *Xanthomonas hortorum* pv. *pelargonii* under practical conditions. However, it requires a minimum Cu-concentration of 2 ppm and exposure times of at least 4 hrs.

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(Prof. Dr. Walter Wohanka)