Final report: Vegetables under Glass - Aqua-Hort for Vegetables grown in inactive Media

This report is the translation from the report to the Danish government. The government supported the trials undertaken in 2003 outlined in this paper.

The nursery Nymarken has a production area of 16.000 m^2 with cucumbers. It employs 5 people. Nymarken had three owners, Peter Bjerregaard, Lars Kolling and Sigfred Rosendal Jensen, in 2003. They are all experienced cucumber growers. In 2004 was the nursery taken over by Lars Kolling.

Summary

Based on the observations made it must be concluded that Aqua-Hort can prevent the existence of water borne fungus of any importance by the growing of cucumbers on inactive mediums. The observed amounts of total Cu in the Grodan mats was higher than the typical "norms". This gave no cause for increased uptake of Cu in the plants, or any negative consequences hereof.

1. Project Description

Aim of the Project

The intention with this project was to develop methods by which Aqua-Hort can be used for vegetable growing in inactive media (Grodan slabs). Hereunder to show that Aqua-Hort can prevent diseases, specially those base don water borne fungus (Phytium and Phytophthora). It was also the aim to develop methods to secure that no destructive concentrations of copper ions build up during the cultivation.

Background for the Project

Vegetables cultivated under glass might suffer considerable damage from the water borne fungus Phytium and Phytopthera. The losses might take such dimensions, that they can threat the economics of the enterprice. Chemical treatment becomes more and more difficult as the number of allowed chemicals are dwindling. Application of chemicals also implies costs, handling and negative environmental influence.

For some time it has been known that a controlled dosing of copper ions can contribute very much to the control of fungus attacks, specially Pythium and Phytophthora. A controlled dosing of copper ions has hitherto been extreme difficult as copper ions applied chemically very quickly forms complex bindings, and then loose their lethal effect on zoospores.

Aqua-Hort is a machine for copper fertilization by means of electrolysis. By this method are the copper ions remaining free for several hours, which does not happen when copper salts are added to the nutrition mixture. The Aqua-Hort system also includes an electromagnetic treatment of the water. The electromagnetic forces removes hydrate layers from the nutrition ions allowing more easy passage throught he membranes. The electromagnetic forces pulls the bacteria clusters apart, causing many of them to die.

With Aqua-Hort a release of free copper ions is secured at the time of watering. The amount released is within the scope of nutrition levels. By cultivation in peat is the copper ions bound within a short time as complex copper. As the copper is dosed in small amounts, and get bound, there is no danger of toxic accumulations.

Aqua-Hort is today used by 200 nurseries. They mainly use peat as growth media. The production of vegetables under glass (tomato, cucumbers and peppers) is to a large extend cultivated on inactive media like Grodan, where the copper ions are not bound as with peat.

In some vegetable nurseries, like Nymarken, is recirculation employed. Here one might suspect that the copper would accumulate to unwanted levels in the recirculating water. This because of environmental and nutritional reasons.

The intention of this project is to develop methods to ensure that Aqua-Hort can be used for vegetable growing on inactive media like Grodan. The project also intends to show that Aqua-Hort can prevent diseases, specially those based on water borne fungus. For observation is also if the improved root building which can be observed in potplants, happens with vegetables.

The Innovational Value of the Project

The innovational value of the project lays in the need for developing a method for preventing Pythium and Phytophthora fungus problems in vegetables grown on inactive media by release of free copper ions and with no use of chemicals. For ornamentals grown in peat has the Aqua-hort method been applied with success since year 2000.

With the inactive media used for vegetables there was until now some fear that the copper ions could not be controlled sufficiently leading to some toxicity problems.

Project Implementation
The project was carried out the Nymarken nursery. The area being 16000 m^2 under glass. Production is cucumbers grown on Grodan mats. Recirculation of the nutriotion water takes place. The 2003 season is used as the project period.

The Aqua-Hort unit is installed near the fertilizer mixer, so the mixed water passes the Aqua-Hort on the way out to the plants. The system consist of a control unit, four copper treatment pipes and the pipe with the electromagnet. On the display is the desired copper level set. Actual flow, total water water accumulated and the amperes are also show non the display. Aqua-Hort starts operation automatically by registering flow. By means of an microprocessor it adjust itself when conductivity or flows are changing.

Through the trial period will the DEG Laboratory make the following analyses:

24 Water analyses
12 Leave analyses
12 Fungus analyses

Different levels of dosing will be applied. The reaction in plants, water and growing media will be observed. Dosing will never exceed 1,0 ppm Cu.

Expected Outcome of the Project
The desirable outcome is the ability to treat and prevent water borne diseases like Pythium og Phytopthera, which can attacks different vegetable crops.

In relation to cucumber it is interesting to observe the virus diseases: ”melon necrose spot virus” and ”tobacco necrose virus”. These might be prevented indirectly as they spead by the fungus Olpidium, which also might be destroyed by the Aqua-Hort system.

Consequences for the Environment, Work Conditions, Food Security and Nutrition.
By the use of Aqua-Hort is the application of chemical fungus control avoided. This has a positive effect on the environment, working conditions and food security. To develop the handling methods for use of Aqua-Hort in vegetable production on inactive media and with recirculating nutrition water, is part of the project. By the use of recirculation are different environmental benefits achieved. For example seepage of nitrogen and other components. Water consumption is reduced by the use of recirculation.

2. The Realized Working Program

The project was carried through by the following working programme.

a) **Daily Observations and Measurements**
The plants were observed daily, as well as the measurement of the free copper ions by the Merck test set. A separate document contains those data. The head grower Kaj Jensen was in charge of the measurements.

b) Laboratory Analyses of Water and Plants
During the project period were a number of analyses made at the DEG laboratory. Drip and mat water was tested. Plant analyses for spores of Phytium, Phytophthora, Fusarium and Trichoderma were made.
The last page of the report contains the test data.

c) Meetings and Evaluations
The project staff held frequent meetings. Contacts with external professionals were made.

d) Final Report with Contribution from DEG.
This report sums up the project. Plant Pathologist Lene Petersen DEG participated in the final project meeting, and submitted a trial report attached as the last page.

The data from the analyses are present in a separate paper.

3. Outcome of the Project.

The project brought the following results:

a) Occurance of water borne fungus diseases.

In the project period ther were no signs of attacks by Pythium and Phytopthera on the cucumbers.
The laboratory tests showed zoosporer of Pythium sp. Level one by some few of the tests. This level is very low and of no practical importance. The other tests for Phytophthora sp. Fusarium sp and Trichoderma sp were negative. Tests in earlier years showed considerable higher levels of zoospores. Lene Petersen from the DEG laboratory did the testing. Translation of her summary report is attached.
From these finding it can be concluded that the Aqua-Hort system keeps fungus down on a level where it has no practical importance any more.

b) Accumulation of Copper in Media and Plants

The tests of the nutrition water from drips, mats and the plants gave the following results:
The nutrition water in the drip showed most of the time a level of 1,0 ppm when measured as total copper in the laboratory. The level of free copper ions was measured to approx. 0,15-0,20 ppm with the Merck test. This level was regulated by the Aqua-Hort controls. A dose of 0,22 ppm copper was applied for the most of the season. The difference is the bound copper which via the recirculation is brought forward by the recirculation. The normal copper fertilization with coppersulphate did not take place during the project period. The Aqua-Hort dosing was stopped from the 7. to the 22. June, where coppersulphate was used. The tests showed that the free copper disappeared in this pepriod, while the bound copper was present to some degree. **These and other measurements shows that "normal" copper in nutrition water is only present in bound form.** It is impossible to generate free copper ions by adding coppersulphate to nutrition water, as the copper will get bound right away. The old Bordeaux mixtures probably had some free copper, but here we talk of copper in promilles and in ppm concentrations.With Aqua-Hort the dosing is with 1 ppm 1000 times less than with 1 promille.

The water in the mats showed a considerable higher amount of total copper. The DEG laboratory findings were often around1,5-2,0 ppm. This is much higher than what the traditional fertilizer "norms" says.

The plant analyses showed a Cu contend of 10 ppm. This is in line with the norm. The cucumber does not take more copper up in spite of the higher supply. The cucumber plant eats copper after demand irrelevant of the supply. For some other nutrients this is not the case, and the supply must be regulated. It is known that some crops react negatively when the copper supply is above certain levels. The plants showed no signs of nutritional unbalances, and were in strong growth throughout the season.

c) Precipitation

Some bluish-green slurry was formed in the main irrigation pipes. Earlier analyses had shown that the slurry contained a smaller portion of copper. It is assumed this is normal slurry from biofilm and fertilizers which is coloured by copper.
There has been no problems with stoppage of the drips.

d) Use of Fungicides

In the project period, season 2003, were no fungicides applied at all in the nursery.

e) CucumberYields

The yield of cucumber in numbers were in 2003 the highest ever recorded. The reason for that is not the topic of this report.

f) Increased Calcium uptake

The calcium uptake in the plants was 2-3 times higher than normal. Over 10 measurements 5,3% in the dry matter. It seems to stem from the presence of many fine root hairs which take up calcium. Increased calcium contend is beneficial for resistance and shelf life.

Conclusion:

Based on the research findings it must be concluded, that Aqua-Hort can prevent the appearance of water borne fungus to any significant degree. Cucumber cultivation on inactive media and Aqua-Hort works very well together.
The registered amount of copper in the Grodan slabs was above normal. This level gave no increased uptake in the plants, or any negative consequences.

Dr. Aksel de Lasson

Translated Summary Report by Lene Petersen, DEG Green Team, Plant Pathologist

AquaHort to Vegetables grown in inactive medias.

In the period May 2002 to Sept. 2003 was the recirculated water treated with Aqua-Hort tested frequently. The samples were 500 ml water.

The samples were tested for the water borne fungus of Pythium spp. and Phytophthora spp.by registering their zoospores. For Fusarium was the amount of micro- and macroconodies counted. The existence of the positive Tricoderma spp. was also registered. Trochoderma often occurs in recirculating systems for longer time after a single dosing.

For Phytium was 500 ml was 100 ml filtrated through a microporefilter to collect the zoospores. Afterwards was the porefilter placed on a selective growth media. After 3 days was the number of zoospores determined based on the colonies formed.

The same procedure was followed for Phytophthora. In addition to that was pieces of Rhododendron leaves placed in 100 ml water to "catch" possible zoospores of Phytophthora, as the amount of Phytophthora often is smaller than Pythium spores. After 4 days in the water are the leaves placed directly on a petri dish with a selective growing media, and cultivated for 3-4 days by 24℃. If zoospores of Phytophthora exist they will grow into the Rhododendron leaves. From the mycelia growth can it be determined by microscoping if zoospores of Phytophthora were preent in the water sample.

To register possible existence of micro- or macroconidia of Fusarium and conidiespores of Trichoderma, was further 100 ml put through a microporefilter, and afterwards cultivated on potatodextroseagar by 24℃ in 4 days. The mycelia growth in the Petri dish was determined by microscoping.

Laboratory Results of Samples from Gartneriet Nymarken:

Date	Pythium	Phytophthora	Fusarium	Trichoderma
21-05-02	0	0	0	2
17-06-02	0	0	1	0
05-05-03	1	0	0	0
21-05-03	0	0	0	2
12-06-03	1	0	0	0
23-06-03	0	0	0	0
11-07-03	0	0	0	0
04-08-03	1	0	0	0
03-09-03	1	0	0	0

Pythium 1-5, where 5 is the highest level
Phytophthora 0-1, where 1 is existence
Fusarium 0-1, where 1 is existence
Trichoderma 1-5, where 5 is the highest level.

In the examined samples are occasionally very small amounts of Phytium found. Phytium is the main cause of problems with fungus attacks in cucumbers. Most samples from this Aqua-Hort water are entirely free of fungus.

Conclusion: The use of Aqua-Hort by the cultivation of cucumbers in inactive media like Grodan prevents the propagation of water borne fungus like Pythium and Phytopthera, and decreases the amount of Fusarium and Trichoderma.

Yours sincerely

Lene Petersen

Table 1: Drip Nutrition Water Analyses Nymarken 2003

Dato			30-04-2003	15-05-2003	06-06-2003	18-06-2003	07-07-2003	30-07-2003	27-08-2003
Lab		**Norm**	DEG	DEG	DEG	DEG	DEG	DEG	DEG
pH 5,4-6,2	**pH**	**5.4-6,2**	6,1	6,3	6,2	5,6	5,6	6,7	6,3
EC 2,0-3,0 mS	**mS**	**2,0-3,0**	2,41	2,09	2,38	2,17	2,48	2,59	2,32
NO3-N 190-260	**ppm**	**190-260**	223	213	225	198	240	243	202
PO4-P 30-60 ppm	**ppm**	**30-60**	33	25	41	42	30	64	34
K 230-320 ppm	**ppm**	**230-320**	351	280	330	287	327	379	323
Mg 35-50 ppm	**ppm**	**35-50**	33	27	32	27	24	34	33
Ca 100-200 ppm	**ppm**	**100-200**	179	205	201	191	210	231	184
B 0,30-0,40 ppm	**ppm**	**0,30-0,40**	0,37	0,33	0,36	0,32	0,25	0,36	0,38
Mn 0,75-1,25 ppm	**ppm**	**0,75-1,25**	0,72	0,9	0,75	0,62	0,51	1,03	0,48
Fe 1,75-2,50 ppm	**ppm**	**1,75-2,50**	0,69	2,71	0,85	1,67	1,41	1,22	1,36
Zn 0,20-0,40 ppm	**ppm**	**0,20-0,40**	0,2	1,62	0,35	0,33	0,17	0,24	0,11
Cu total 0,15-0,20	**ppm**	**0,15-0,20**	1,92	0,99	1,35	0,61	0,92	0,88	0,83
Cu^{++} free ion	**ppm**		0,15	0,16	0,16	0	0,12	0,18	0,25
Na	**ppm**		18	18	16	17	19	17	25
Cl	**ppm**		9	9	13	14	18	11	15
SO4S	**ppm**		75	69	61	50	47	64	66
Bicar,pH3,9	**ppm**		42	48	48	33	26	46	45

Table 2: Mat Nutrition Water Analyses Nymarken 2003

	05-02-2003	24-02-2003	10-03-2003	26-03-2003	30-04-2003	15-05-2003	06-06-2003	18-06-2003	07-07-2003	30-07-2003	27-08-2003
	DEG	DEG	DEG	DEG	DEG	DEG	DEG	DEG	DEG	DEG	DEG
pH 5,4-6,2	6,1	5,5	5,9	5,8	6,3	6,4	5,7	5,2	5,6	4,6	6,2
EC 2,0-3,0 mS	2,99	3,14	2,92	3,05	2,78	2,58	2,93	3,81	3,05	3,12	3,57
NO3-N 190-260 ppm	277	246	288	332	235	248	296	396	316	303	328
PO4-P 30-60 ppm	96	102	61	41	22	18	37	59	17	85	34
K 230-320 ppm	403	401	353	341	399	325	367	444	326	464	522
Mg 35-50 ppm	67	51	47	51	43	44	44	58	37	48	59
Ca 100-200 ppm	275	302	308	341	220	319	281	191	313	298	279
B 0,30-0,40 ppm	0,72	0,61	0,6	0,59	0,55	0,5	0,51	0,68	0,39	0,51	0,65
Mn 0,75-1,25 ppm	2,98	1,88	1,45	1,03	0,67	0,32	0,79	0,97	0,52	1,03	0,37
Fe 1,75-2,50 ppm	1,01	1,49	2,17	2,68	1,83	1,78	1,83	3,68	2,73	1,92	2,36
Zn 0,20-0,40 ppm	0,47	0,39	0,28	0,76	0,22	0,19	0,34	0,48	0,22	0,24	0,08
Cu total 0,15-0,20	0,28	0,99	1,04	1,45	1,47	1,72	1,78	1,88	2,04	1,44	1,62
Cu^{++} free ion				0,09	0,08	0,08	0,05	0,05	0,05	0,06	0,08
Na	20	28	29	35	32	36	31	47	42	34	59
Cl	21	30	21	5	17	13	22	35	34	22	25

Table 3: Plant Analyses Nymarken 2003

Dato			13-06-02	02-07-02	27-03-03	28-04-03	14-05-03	06-06-03	18-06-03	07-07-03	29-07-03	27-08-03
Tørstof	**%**	**Norm**	5,4	11,2	11,6	16,6	13,4	12,1	13,6	12,4	10,5	10,6
N 4,75-5,25 %	**%**	**4,75-5,25**	4,5	4,64	4,34	4,76	4,25	4,14	4,08	5,02	4,69	5,02
P 0,40-0,60 %	**%**	**0,40-0,60**	0,32	0,37	0,53	0,4	0,36	0,47	0,41	0,41	0,41	0,47
K 4,00-5,00 %	**%**	**4,00-5,00**	3,03	2,49	2,85	1,79	3,52	3,3	3,53	3,05	3,07	2,88
Mg 0,35-0,50 %	**%**	**0,35-0,50**	0,73	0,46	0,47	0,6	0,62	0,55	0,52	0,5	0,48	0,47
Ca 1,65-2,15 %	**%**	**1,65-2,15**	4,99	3,22	4,94	5,26	6,61	5,51	5,8	5,6	6,35	4,68
Na			0,05	0,01	0,04	0,01	0,03	0,03	0,02	0,04	0,04	0,04
Cl			0,03	0,02	0,26	0,04	0,05	0,1	0,03	0,05	0,04	0,09
SO4S			0,72	0,41	0,55	0,15	0,38	0,488	0,488	0,494	0,616	0,439
Fe 100-150 ppm	**ppm**	**100-150**	157	69	116	153	112	113	153	183	92	120
Mn 40-80 ppm	**ppm**	**40-80**	275	211	252	278	311	259	281	206	203	187
B 25-35 ppm	**ppm**	**25-35**	48	45	34	54	42	42	46	34	48	46
Cu 10-25 ppm	**ppm**	**"10-25"**	9	6	7	11	12	8	8	10	11	10
Zn 30-60 ppm	**ppm**	**30-60**	22	29	27	44	38	37	40	33	36	35