Control of Oomycete Pathogens in Irrigation Water

Soft Fruit Information Day, SSCR

Thursday 19th Feb – The James Hutton Institute, Dundee, Scotland

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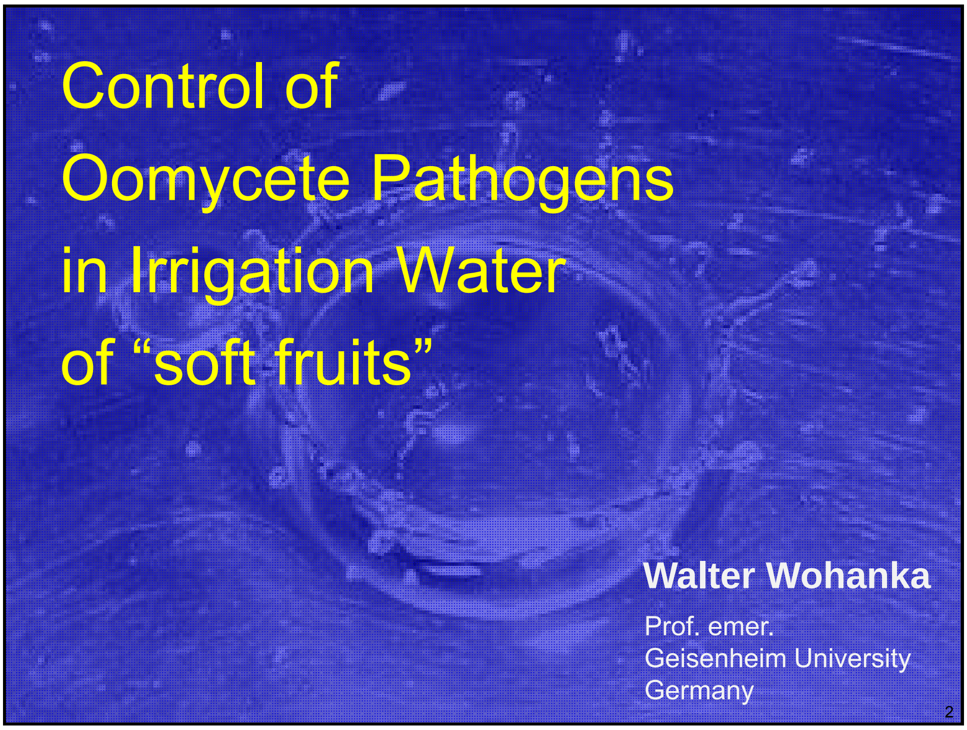


High Risk: Recycling Irrigation Water

Water Decontamination Recommended

High Risk: Contaminated Reservoirs

Water Decontamination Recommended

What treatment to control oomycetes?

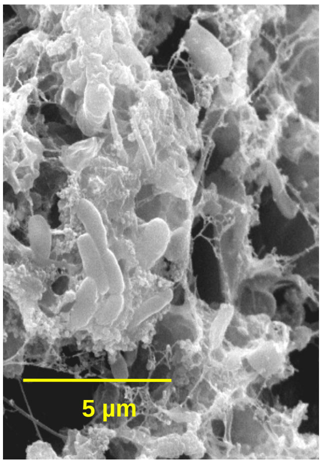
- Oomycetes are mainly disseminated by **zoospores**
- Zoospores are **highly sensitive** against all forms of water treatment technologies

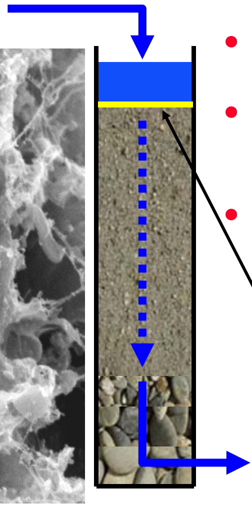
Water Treatment Technologies

- **Slow Sand Filtration**
- **Chemical Treatments**
  - **Chlorine dioxide**
  - **Chlorine**
  - **Cu-Ionisation**
- **Other** (e.g. UVc-Irradiation, heat treatment)

Low cost techniques

Slow- or Bio-Filtration





- water passes very slowly through the filter bed
- **10 to 30 cm/h** filtration rate: **100 - 300 L/m²h**
- mechanisms
  - mechanical
  - physico-chemical
  - **biological** “**Schmutzdecke**” (filter skin or biofilm)

Slow Sand Filtration in Practice

Foto: Ufer et al. 2008

Slow Sand Filtration in Practice

Cleaning after Clogging

- No back flush!
- Removal of the top layer (1 - 2 cm)
- Raking

New Cleaning Technique for water with high suspended load

- Layer of medium sub-angular gravel on top of the filter sand
- Water drained to about 10 cm from sand surface
- Agitation of the full gravel layer but not the filter sand with a rotivator
- Dirty water is drained off into a shallow channel with reeds

with courtesy of Tim Pettit 2014

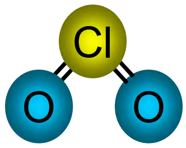
Slow- or Biofiltration

Pros & Cons

- Low cost
- Low energy
- Construction simple (considering site-specific requirements; conversion of existing reservoirs)
- "Bio"-Technique

- Not sufficient against viruses and nematodes
- **Area consumption**
- **Risk of clogging**

Chlorine Dioxide (ClO_2)



- **Chlorine dioxide is not "Chlorine"**
- Water soluble gas (not transformed to HOCl)
- Strong oxidant
- Effective concentration: < 1 ppm
  (bacteria and sensitive fungal spores)
- Short exposure time (<1min)
- Effective in a wide pH range (4 – 9)
- Usually produced and simultaneously injected on site; tablet/powder products available

Generation of Chlorine Dioxide

acid-chlorite reaction

sodium chlorite (7.5%) + hydrochloric acid (9 %)

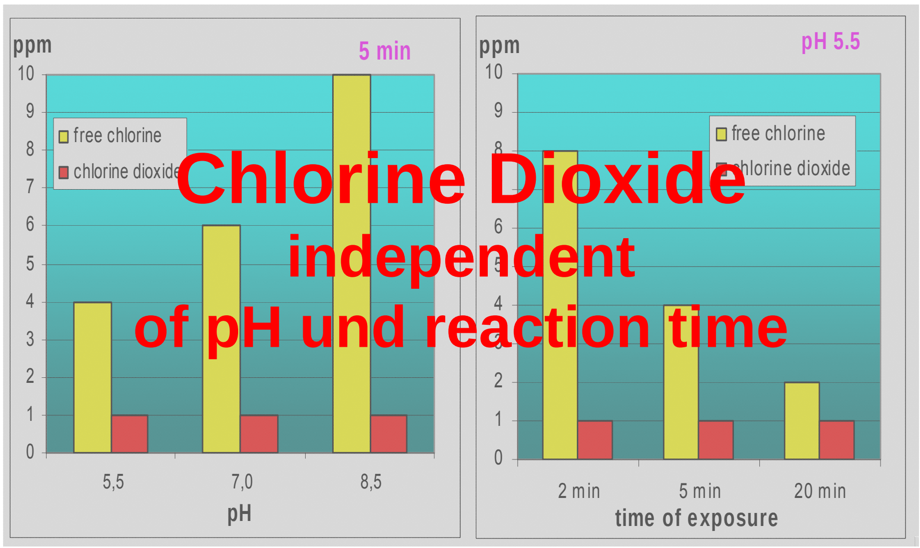
⬇

Chlorine Dioxide + salt + water

5 $NaClO_2$ + 4 HCl = 4 **ClO_2** + 5 NaCl + 2 H_2O

1L base + 1L acid
generate 40 g chlorine dioxide
sufficient for 10 – 40 m^3 (1-4 ppm)

Required Concentrations of Chlorine Dioxide and Chlorine to kill Chlamydospores of *Phytophthora cinnamomi*



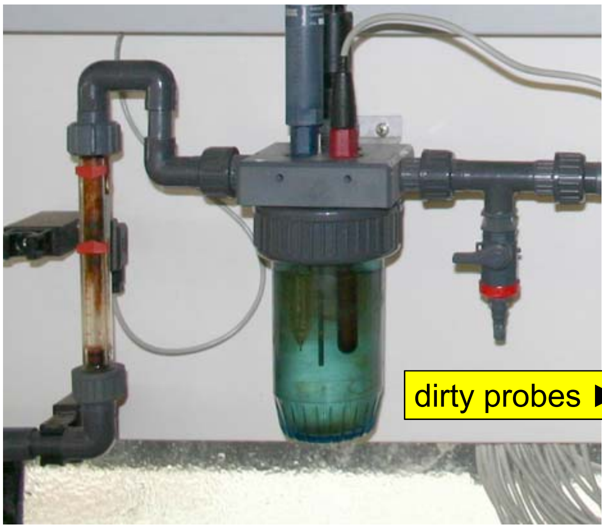
Armitage (1993)

Chlorine Dioxide Demand

- Any **oxidisable material** consumes chlorine dioxide, organic load, biofilms and nitrite in particular.
- Due to this demand a **higher dosage** than the effective concentration is necessary.
  - e.g. a demand of 0.5 ppm ClO_2 requires to inject 1.5 ppm to achieve 1.0 ppm on the irrigation water outlet

Checking the actual concentration is essential!

Don‘t trust the probes alone!



dirty probes ► wrong values

Check the actual concentration manually!

Chlorine Dioxide

Pros & Cons

- Low cost technique
- Easy to fit into an existing irrigation system
- Particularly for big volumes
- Independent of pH and time
- No reaction with ammonium
- Residual effects
- Increased oxygen
- Overhead application possible
- No cancerogenic by-products

- Selective efficacy
- Affected by organics and other oxidisable compounds (chlorine dioxide demand)
- Outgassing possible
- Certain risk of phytotoxicity

Chlorination

Gaseous Chlorine (Cl_2)
Calcium Hypochlorite ($Ca(OCl)_2$)
Sodium Hypochlorite (NaOCl)
Electrolyzed Water (ECA)

WATER

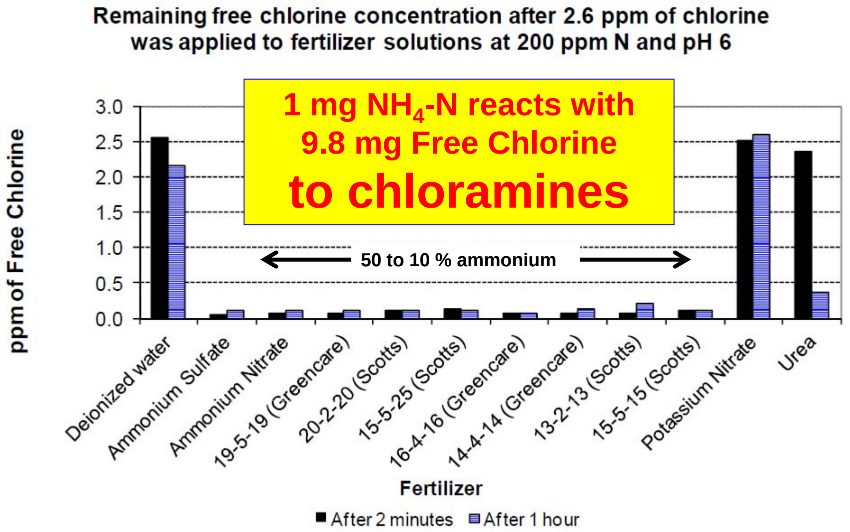
"active" or "free" chlorine

Cl^2 – **HOCl** – ClO^-

low ←— **pH** —→ high

Hypochlorous Acid
most effective

Conversion of free chlorine into less effective chloramines by Ammonium (NH_4)



Source: P. Fisher: Int. Symp. on Growing Media, Composting and Substrate Analysis, Barcelona, 17.-21.10.2012

Chlorine Demand

- Any **oxidisable material** consumes free chlorine, **NH_4,** organic load and biofilms in particular.
- Due to the chlorine demand a **higher dosage** than the effective concentration is necessary.
  - e.g. inject 5 ppm free chlorine to achieve 2 ppm on the irrigation water outlet.
- Accordingly the concentrations of **chloride** and **sodium** or potassium increase (especially relevant by using ECA)

Checking the actual concentration is essential!

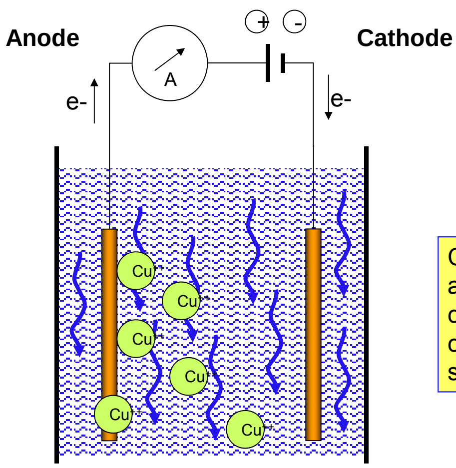
Chlorination

Pros & Cons

- Low cost
- Suitable for small and big volumes
- Easy to fit into an existing irrigation system
- Residual effects

- Selective efficacy
- Chlorine demand by organics and **ammonium**
- pH dependent
- Time dependent
- Risk of phytotoxicity
- Risk of toxic by-products
  (trihalomethanes; e.g. chloroform)

Copper Ionization



Copper ions are released by an electrical charge between copper electrodes and carried away by the water stream.

concentration of Cu^{2+} in the irrigation water depends on flow rate, EC and voltage

Ionizators

Aqua-Hort® - Copper Bars in PVC Pipes

The AquaHort-system is the only one **automatically adjusting the copper concentration** at varying water flow or at varying electric conductivity.

Other Constructions

Aqua-Hort® - Tank Model

Aqua-Hort® - Raft with Copper-Plates

Efficacy of Cu-Ionisation against *Phytophthora cinnamomi* on Hedera

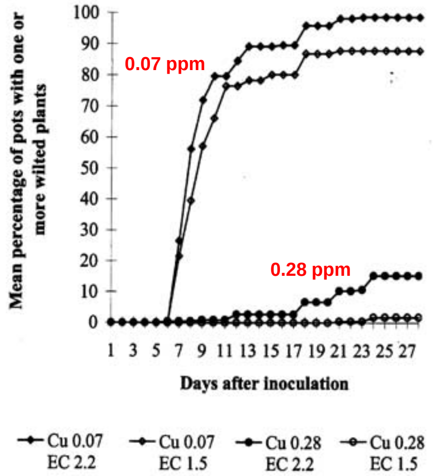
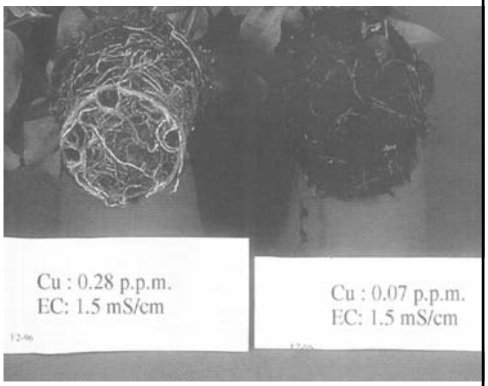


Fig. 2 Mean percentage of pots in experiment 2 with one or more wilted plants with symptoms of *Phytophthora cinnamomi* in *Hedera helix*, recorded in days after inoculation. Mean of inoculation level 5 and 50 zoospores/ml nutrient solution, each with three replicates of 40 pots for each treatment



Source: Toppe & Thinggaard, 2000

In practice: 1 to 4 ppm Cu^{2+}

Cu-Ionisation

Pros & Cons

- Low cost technique
- Easy to install, handle and maintain
- Small and very big volumes possible
- Residual effects

- Selective efficacy
- Long reaction times
- **Limited scientific proof in practical use**
- Phytotoxicity at higher concentrations and long term application unclear

The Best Treatment ?
10 relevant points to consider

1) What pathogens do you expect?
2) What infection risk (no, low, medium) will you accept?
3) What irrigation system (sub-irrigation, overhead, „hydroponics“)?
4) What water volumes and water flows (peak values) will you expect?
5) Check the irrigation water quality and its fluctuations (impurities, Fe-, Mn- and NH_4-content)!
6) Check the phytotoxicity on your crops!
7) Check the integratability in existing irrigation systems!
8) Is the technology easy to control (special skills) and to maintain?
9) Be aware of environmental and health hazards!
10) Calculate the investment and maintenance cost with special respect to flow volumes and water quality (see §4 and §5)!

There is no "Best Treatment", however a "Best Solution" for a certain Production Site

Control of Oomycete Pathogens in Irrigation Water of “soft fruits”

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