Greenhouse & Nursery Sanitation

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Greenhouse and Nursery Pathogens

• Pathogens are easy to find:
  – Root substrates
  – Containers
  – Under the bench
  – On the floor

• Easily introduced:
  – Plugs or transplants
  – Shoes
  – Guests
Public Water Supplies for Irrigation

- Irrigation water is often overlooked as a source of infection
- Public water sources are typically considered clean
  - Are they?
- Other irrigation sources:
  - Surface water
  - Agricultural wells
  - Re-circulated water
Identify the Pathogen

- Disease control is war!

- The art of war is simple enough. Find out where your enemy is. Get at him as soon as you can. Strike him as hard as you can, and keep moving.

  *Ulysses S. Grant*

- Use IPM
  - Manage the pest!!
Sanitation

• The formulation and application of measures designed to protect public health

The American Heritage Dictionary

references the disposal of sewage

• The formulation and application of measures designed to protect plant health

Steven E. Newman
Sanitation Practices

- Prevention
- Inspection
- Environmental control
- Eradication
Greenhouse Crops of Concern

- Geraniums
  - *Xanthomonas*
  - *Ralstonia (Pseudomonas)*
- Potted Color
  - Root rots
  - Mildews
  - White flies
  - Chrysanthemum White Rust
Greenhouse Crops of Concern

- Perennials and Bedding Plants
  - Viruses
  - Root rots
  - Foliar diseases
  - Insects and mites
Plant Disease

Susceptible Host

Causal Agent

Favorable Environment
Eradication

- Elimination of the pest
  - Modify environment conditions to a point that discourages insect and mite infestation
  - Periodic removal of all plant material in the greenhouse
  - Disinfectants
  - Pasteurization
Eradication

- Elimination of the pest
- Biological control
  - biological “pesticides”
  - predacious insects or mites

Special note: With biological control, a grower has to adjust their tolerances as to the presence of a pest.
Eradication

- Elimination of the pest
- Biological control
- Pesticides
  - Selective for target species
  - Formulation for penetration
  - Application zone
  - Timing
Exclusion

- Plant Inspection
  - Plant inspection
  - “Pet” plants
  - Screening
    - thrips screen
    - white fly screen
    - fly screen
  - Positive pressure
  - Double doors
Sanitation

In the Greenhouse

- Leaf litter and debris
- Trash cans
- Storage in the greenhouse
- Standing water
- Weeds (inside and outside)
Sanitation

In the Greenhouse

Employees
- Clothing and shoes
- Hands and tools
- Assignments and zoning
Sanitation

In the Greenhouse Employees
Production Practices
  – Tools
  – Water delivery
  – Containers
Plant pathogens have been found in irrigation water
  - *Fusarium*
  - *Pythium*
  - *Phytophthora*
  - *Erwinia*
  - Tobacco mosaic virus
  - Nematodes

*Pythium* spp. are the most common pathogens found in water
  - However not all are pathogenic
Pythium in Irrigation Water

- *P. dissotocum* and *P. rostratum* have been detected in Colorado irrigation water from holding ponds

  *Pottorff and Panter, 1997*
  *HortTechnology 7(2):153-155*

- *P. dissotocum* has shown the potential to be damaging to hydroponic spinach
- *P. rostratum* is not pathogenic or only weakly pathogenic
If water is your source of contamination, Gary Moorman of Penn State recommends that you first consider the following before choosing a control method:

- Will the method fit the overall design of the greenhouse?
- Do you or your employees have the expertise to use the method effectively and routinely?
- Is the method appropriate for the quality and volume of water that must be treated?
- How much can you afford to spend on a treatment?
Irrigation Water and Fungicides

- Fungicides are often considered by grower’s to be the first line of defense
- They are designed to apply to the substrate, not the irrigation water
- Many use irrigation systems to apply fungicides, ..... but
- Blending fungicides with irrigation are in violation of the label.
Fungicides and Irrigation Storage

- Irrigation water contaminated with a fungicide is a hazardous waste

- With fresh “make-up” water, the fungicide will become dilute
  - Dilute fungicides may not be effective in removing pathogens
  - Remaining pathogens may become resistant
Storage of Recirculated Water

• Recirculated water with fertilizer concentration is considered a point-source pollution risk in many states
• Secondary containment may be required
Water Sterilization for Greenhouses

- UV-C Sterilization
- Ozone Treatment
- Chlorination
- Hydrogen Peroxide
- Filtration
Ultraviolet (UV) Radiation

- UV radiation is electromagnetic energy with wavelengths between 200 and 400 nm
- Visible light is from about 400 to 700 nm
UV Radiation

- UV radiation is subdivided into three wavelength bands
  - UV-A (315-400 nm)
  - UV-B (290-315 nm)
  - UV-C (220-290 nm)
- UV-A generates photochemical smog and fades and damages plastics, paints and fabrics
- UV-C is absorbed by ozone
- 1% of solar radiation is UV-B
  - Responsible for human and animal health effects

The earth's ozone layer absorbs the UV-C radiation in solar energy, so it does not present any threat. UV-A and UV-B radiation does reach the earth's surface and is believed to have long- and short-term adverse effects on the eyes and vision.
UV-C Sterilization

- Water disinfection uses UV-C radiation at 254 nm
- Microorganisms absorb most of the energy at this wavelength
- Results in germicidal effect
  - Photochemical reaction
  - Alters essential molecular components (DNA & RNA)
- Eliminates fungi, bacteria and viruses
- Disinfection dependent on duration and intensity
UV Sterilizer for Greenhouse Application

- Vialux Disinfection System manufactured by Priva
- Operates on the principle of high pressure UV-C disinfection
- Allows for reuse of water
  - 20 - 50% of H₂O can be recirculated
  - Saves in water consumption and sewage costs
  - Reduce overall use of a limited resource
Vialux Disinfection System

SunBlest Farms
Fort Lupton, Colorado
Vialux Disinfection System

SunBlest Farms
Fort Lupton, Colorado
Vialux Disinfection System

- Multimedia filter
- Acid injection
- SunBlest Farms
  Fort Lupton, Colorado
Single pass / batch disinfection

(Rockwool/substrate systems)

Disinfected water

Vialux HP/UV

Drain water

UV-C dose 100 or 250 mJ/cm² for selective or total disinfection
UV-C Multi-pass Disinfection

(Hydroponics systems)

Vialux HP/UV

Drain water

UV-C dose and number of passes define the disinfection level
Issues With UV-C Disinfection

- UV-C is absorbed or reflected off any material in water
- Filtration important prior to UV-C unit
  - Requires sand or membrane filtration
  - Particles that increase turbidity reduce the disinfection
- Films may result on lamp
  - Mineral scale
  - Organic films
Ozone Treatment of Irrigation Water

- Widely used in water treatment since 1893 in The Netherlands
- Ozone
  - Colorless gas
  - Pungent odor
  - Highly corrosive
  - Toxic
  - Can cause severe respiratory tract damage
How Ozone is Produced

- Most ozone generators use corona discharge
  - Passing of $O_2$ through two electrodes separated by a dielectric discharge gap
  - Voltage to the electrodes causes electron flow across the discharge gap
  - This disassociates the $O_2$ molecules leading to $O_3$
  - Same as a lighting strike
How Ozone is Delivered

- Ozone is applied to the irrigation supply via an injector into a reservoir
- Injector line uses a pump that creates water flow
- Resulting venturi draws ozone into system
- Irrigation systems with high levels of suspended organic materials require a high level of ozone
Ozone Generator

- Air inlet
- Electrode chambers
- O₃ outlet
- Air pump
Benefits of Using Ozone Disinfection

- Ozone also oxidizes
  - Iron, Manganese and sulfides
  - May react with fertilizers
- No chemicals are added:
  - No corrosion
  - No residual contaminates
- Since no residual disinfectants are present:
  - May need to add a chemical treatment to maintain sanitation
Chlorine Treatment of Irrigation Water

- Municipal drinking water systems began chlorinating water in 1908
  - Prior to this, typhoid killed 25 out of every 100,000 people in the US
  - Chlorination has mostly eliminated typhoid and other water-borne diseases in the US
- Mechanism to kill or inactivate fungi and bacteria is not clearly understood
## Chlorine Reactions in Water

<table>
<thead>
<tr>
<th>Sources of chlorine</th>
<th>Chlorine reaction in water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorine gas</td>
<td>$\text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{HCl} + \text{HOCl}$</td>
</tr>
<tr>
<td>Sodium hypochlorite</td>
<td>$\text{NaOCl} + \text{H}_2\text{O} \rightarrow \text{NaOH} + \text{HOCl}$</td>
</tr>
<tr>
<td>Calcium hypochlorite</td>
<td>$\text{Ca(OCl)}_2 + 2 \text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 + 2 \text{HOCl}$</td>
</tr>
</tbody>
</table>
Sources of Chlorine

- Chlorine gas
  - 100% available
  - Cheapest source
  - Stores well without losing strength
  - Accurately delivered
  - Highly corrosive
  - Toxic to handlers
  - Hidden costs
    - Scrubbers
    - Alarms
    - Emergency Pre-Plan & associated fees
    - Labor and training
Sources of Chlorine

- Sodium hypochlorite
  (liquid soda bleach)
  - Not often used to disinfect irrigation water
  - Common use for disinfecting bench tops, floors, tools, etc.
  - Used at 10-15% strength
  - Corrosive – requires special pumps
  - Bulky to store and transport
Storage of Sodium Hypochlorite

- Sodium hypochlorite
  (liquid soda bleach)
  - Requires secondary containment
Sodium Hypochlorite Disinfection
Sodium Hypochlorite Injectors

- Chemical metering pumps
  - Must meet specifications for sodium hypochlorite
- Need not be an expensive set-up
  - Check with your favorite injector manufacturer for specifications
Decomposition of Bleach

Calcium Hypochlorite Feeders

- Provide accurate chlorine delivery
- No moving parts.
- Large orifices that avoid clogging
- Can run unattended for days at a time
Calcium Hypochlorite Feeders

System Water Flow

Accu-Tab Chlorinator
(Not Pressurized)

Untreated water
Adjust water flow to control chlorine delivery

Chlorinated water
Accu-Tab 3-inch Tablets treat water at a consistent rate

Flow

Accu-Tab 3-inch Tablets
Tablets in contact with water
Sieve plate with holes

Reservoir

No metering pumps...
No moving parts...
Calcium Hypochlorite Feeders

High volume system

Tablet reservoir

HOCl concentrate
Calcium Hypochlorite Feeders

Medium volume system

Tablet feeder

Water Storage
Chlorine Monitoring

- Chlorine levels must be monitored
  - 0.5 ppm free chlorine is standard for greenhouse needs
  - Measure free chlorine at the hose end

- Safety issues
  - Eye protection required while handling tablets
Safety and Handling of Chlorine

- Calcium hypochlorite must not be stored with acids
  - Mixing results in chlorine gas
- Calcium hypochlorite should not be stored with fertilizers
- Use appropriate eye protection
- Chlorine will damage reverse osmosis membranes
  - Filter with activated charcoal
Extra Benefits of Chlorine

- Clean cooling pads
- Lower fungus gnat levels
- Reduced fungicide needs
- Calcium hypochlorite
  - Some calcium fertility
  - No sodium risk
  - Easy to handle
Other Disinfectants

- **Hydrogen peroxide**
  - $\text{H}_2\text{O}_2$
  - Strong oxidizer
  - Sold from 3-90%
  - 3% as a wound cleaner
  - 90% for rocket fuel
- **ZeroTol (hydrogen dioxide)**
  - Contaminated water
    - 1:500 dilution
    - 540 ppm $\text{H}_2\text{O}_2$
  - Clean water
    - 1:10,000 dilution
    - 27 ppm $\text{H}_2\text{O}_2$
Filtration

- Water disinfection process is dependent on having water that is free of debris
- Organic substances reduce the efficacy of all disinfectant technologies
  - Peat moss
  - Plant refuse
  - Soil residue
- Filter return water prior to disinfection
Filtration Devices
Automatic Back Flush Filters
Bottom Line for Disinfection

- Water disinfection will save money
  - Reduce use of fungicides
  - Cleaner greenhouse
  - Cleaner crops
- Disinfection of recycled water is required
  - Recycled water reduces water and fertilizer expense
  - Often payback is quick
- Resistance to fungicides not an issue
Resources

• Antimicrobial Pesticides
  http://www.epa.gov/oppad001/

• Priva
  http://www.priva.nl/ or http://www.priva.ca/

• A Discussion on Ozone Chemistry Steven D. Kloos, Ph.D.
  http://www.osmonics.com/products/Page965.htm

• Calcium Hypochlorite
  http://www.ppg.com/chm_calhypo/default.htm

• Water Considerations for Container Production of Plants
  http://www.ces.ncsu.edu/depts/hort/hil/hil-557.html