Pathogen Recycling Risk Mitigation through System Design and Best Management Practices

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The Issues:

1. Water Availability
2. The Dilemma for the Industry
3. A Clear and Imminent Threat
4. Best Management (Mitigation) Practices
Basic Principles – Pathogen Management:

1. Clean Stock
2. Substrate Formulation
3. Good Site Design – Production areas; Conveyance and Capture Systems (Pond Design)
4. Precision Water Management
5. Monitoring; Applying Knowledge
Water Availability

- More “crops per drop”
- Drought; Competition from other water users
- Water efficiency
  - Plant species and varieties
  - Cultural practices
  - Capture and reuse of runoff water for irrigation
Water Recycling: A Dilemma for the Green Industry

“The potential for economic disaster from the spreading of waterborne pathogens is greatly increased.”

“We are in the position where we could potentially destroy our crops through our efforts to be good citizens.”

(Chuan Hong, National Water Conference, 2010)
**Phytophthora Species in Virginia Water**

<table>
<thead>
<tr>
<th>Well known (10)</th>
<th>Recently named (7)</th>
<th>New Species (5+)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>P. cactorum</em></td>
<td><em>P. insolita</em></td>
<td>➢ <em>P. aquatilis</em></td>
</tr>
<tr>
<td><em>P. cambivora</em></td>
<td><em>P. inundata</em></td>
<td>➢ <em>P. aquimorbida</em></td>
</tr>
<tr>
<td><em>P. cinnamomi</em></td>
<td><em>P. parsiana</em></td>
<td>➢ <em>P. hydropathica</em></td>
</tr>
<tr>
<td><em>P. drechsleri</em></td>
<td><em>P. plurivora</em></td>
<td>➢ <em>P. irrigata</em></td>
</tr>
<tr>
<td><em>P. gonapodyides</em></td>
<td><em>P. polonica</em></td>
<td>➢ <em>P. pini</em></td>
</tr>
<tr>
<td><em>P. citrophthora</em></td>
<td><em>P. sansomeana</em></td>
<td>➢ Another (TBN)</td>
</tr>
<tr>
<td><em>P. megasperma</em></td>
<td><em>P. tropicalis</em></td>
<td></td>
</tr>
<tr>
<td><em>P. nicotianae</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>P. palmivora</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>P. syringae</em></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Chuan Hong, National Water Conference, 2010)
Focused Systems Approach

Plant response

Water and Nutrient Uptake

Fertilizer

Surface runoff

Substrate components

Nutrient leaching

Water application

Pathogens / water

Desorption, dissolution, mineralization

Adsorption, precipitation, immobilization

Weathering

(Ground Water)
Basic Principles – Pathogen Management

1. **Clean Stock:**

   → **Reduce initial infection by using pathogen-free:**

   ✓ Propagating material
   ✓ Imported nursery stock
   ✓ Growing media, production areas
   ✓ Volunteer host carriers
Basic Principles – Pathogen Management

2. **Substrate Formulation:**

   → **Provide an antagonistic environment for pathogens:**

   ✓ Formulate substrates from pathogen-free materials

   ✓ Have appropriate particle size distribution to ensure good drainage (aeration)

   ✓ Provide adequate water holding capacity, so not to induce plant stress

   ✓ Have appropriate nutrient-holding capacity (CEC) for the plant species being grown
3. **Good Production Site Design:**

   → **Provide an antagonistic environment for pathogens:**

   - Production areas should drain freely after irrigation
   - Production areas should be weed-free
   - Conveyance systems pathways should slow water, drop sediments and expose water to natural UV
Good Production Area Design:
Good Production Area Design:
3. **Good Recycling Pond Design:**

→ **Provide an antagonistic environment for pathogens:**

- Containment ponds should be designed for maximum path-length from inlets areas to the pump take-out point
- Pump intake should be raised off the pond floor
- Containment ponds should be aerated
Good Recycling Pond Design

- Pond Inlet
- Long path-length
- Rip-rap slows water, drops sediment
Water Quality

- Pond water quality is affected by:
  - Poor practices in the production area
  - Poor pond design and maintenance
Basic Principles – Pathogen Management

4. Irrigation Management:

→ Provide an antagonistic environment for pathogens:

✓ Irrigation systems should be adequately *designed*

✓ Irrigation systems should be adequately *maintained*
Irrigation Management Issues

- Irrigation System Efficiency:
  - Design
  - Maintenance
Basic Principles – Pathogen Management

4. **Irrigation Management:**

   → Provide an antagonistic environment for pathogens:

   ✓ Irrigation systems should be adequately *designed*

   ✓ Irrigation systems should be adequately *maintained*

   ✓ Irrigation scheduling should be an active (thoughtful) process
Irrigation Management Issues

- Management:
  - Species Water Requirements
  - Precision Scheduling (Timing)

(Kim and van Iersel, 2009)
Basic Principles – Pathogen Management

5. Monitoring Tools:

→ We need to provide cost-effective monitoring tools to growers, so they are convinced to change practice:

✓ Real-time monitoring systems
Sensor Networks

Local Irrigation Control

Sensors
Solenoid

Global Irrigation Control
Crop Models
Irrigation Scheduler
Graphic User Interface
Database

Production Area / Irrigation Zone

DATA STATION

Local Computer
Grower Input

(Via Secure Internet Connection)

Remote Server
Smartphone or Handheld Device
Acer rubrum Transplants – Soil Moisture / Irrigation events (2010)

Total Irrigation = 124 L per tree
5. Monitoring; Application of Knowledge:

→ We need to provide insightful tools to growers:

✓ Real-time monitoring systems

✓ Expand those systems to pond management, provide forecasting tools for growers
Pitch Kettle: Weather Station
Real-time Environmental Data

![Graph showing real-time environmental data](image)
Pond Node Deployment

Inlet

Decagon Sensors

YSI Sensors
Real-time Temperature and EC Pond Data
Pond Temp vs. EC Data

July 2011

EC (mS/cm)

0.25
0.30
0.35
0.40

Temp (°F)

80
85
90
95
100

Mon 04  Mon 11  Mon 18  Mon 25  Mon 01
Pond Temp vs. pH Data

July 2011

pH
6
7
8
9
10
11

Temp (°F)
80
85
90
95
100

Mon 04  Mon 11  Mon 18  Mon 25  Mon 01
Agricultural Risk Management

Precision Farming is more than just GPS controlled harvesters. It also helps keeping track of pathogen development, optimize treatments to hit a disease dead on, warn of frost, and to produce as environmentally friendly as possible.

Disease Models

For Adcon's data visualization platform addVANTAGE Pro we provide a series of disease and pest models for a great variety of different crops. These models were either developed by leading plant and disease specialists, like Prof. Gubier of UC-Davis, California, or Prof. Kast from Weinsberg, Germany, or they are based on publicly available algorithms, like the Mills Table or the Ullrich-Schroeder algorithm. They support interpretation of disease risk indices, growing degree-day calculation, chilling hours, evapotranspiration and soil moisture data. Reduce chemical usage during low pest pressure periods and optimize your spraying intervals during high-pressure periods - accurate information for precise management decisions.

Every model will inform you very clearly about the progress in the calculation of the disease index, treatment recommendations and the washout of chemicals. Messages like treatment recommendations are visible as alarms even if the respective window is not open.

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>19/05/07 00:00:00</td>
<td>Grape Downy Mildew</td>
<td>Preventive treatment recommended</td>
</tr>
<tr>
<td>01/05/07 00:00:00</td>
<td>Crop Service</td>
<td>Grapevine - 3 Leaves Unfolded</td>
</tr>
<tr>
<td>24/04/07 07:00:00</td>
<td>Grape Downy Mildew</td>
<td>Infections possible</td>
</tr>
<tr>
<td>21/04/07 00:00:00</td>
<td>Crop Service</td>
<td>Grapevine - Bud Burst</td>
</tr>
</tbody>
</table>

Each user can create his own database of chemicals. When entering a new chemical, the user needs to tell the model if the substance is systemic or preventive, how many days it controls the disease, the waiting time in days and the washout limit. By also telling the system which diseases this chemical can be used for it facilitates the selection of the proper chemical when entering a treatment.
Knowledge Center: http://waternut.org/moodle
Welcome to the Irrigation Pathogens site, home of a collaborative research and extension project: Integrated management of zoosporic pathogens and irrigation water quality for a sustainable green industry. This project is sponsored through the Specialty Crop Research Initiative (SCRI) of USDA-National Institute of Food and Agriculture (NIFA). It is a partnership between seven institutions and the ornamental horticultural industry, in a quest for better plant quality and productivity while promoting containment and recycling of irrigation water to protect and conserve natural water resources.

Our Vision

Crop health, productivity, and horticultural product quality does not have to be compromised at nurseries and greenhouses where irrigation runoff water is contained and recycled.

Our Mission

This project aims to enable farmers to recycle irrigation water without recycling plant pathogens through the integration of research and extension activities that take system-based, trans-disciplinary approaches. Our ultimate goals are to move the horticultural production and distribution towards becoming sustainable industries and enable them to better compete in global markets.