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Knowing the biology of waterborne pathogens can help you decide how to develop an overall sanitation program.

Water treatment series: Waterborne pathogens affect water treatment

YOUR GREENHOUSE CAN BE equipped with the best (and most expensive) water-treatment system available, but still run into disease issues. That is because water treatment is just one part of an overall sanitation program. Understanding the biology of waterborne pathogens can help you use preventive management and chemical disinfestants more effectively.

3 waterborne pathogens

Many plant pathogens are capable of spreading in greenhouse irrigation water. For example, foliar nematodes (tiny aquatic worms) can spread from plant to plant through leachate from containers. The three pathogenic genera most prevalent in greenhouses are *Pythium*, *Phytophthora* and *Fusarium*.

Pythium and Phytophthora are closely related aquatic, fungallike organisms. However, they are different in several ways. *Pythium* is widespread in nature, occurring in nearly all field soils. *Phytophthora* is only locally distributed in nature. *Pythium* is much more common in greenhouses. *Pythium* is weak compared to *Phytophthora*. However, in soilless growing media and water systems, *Pythium* has little competition and can cause widespread damage.

Fusarium is not an aquatic fungus but it has proven to be very successful at spreading from plant to plant in greenhouse irrigation systems.

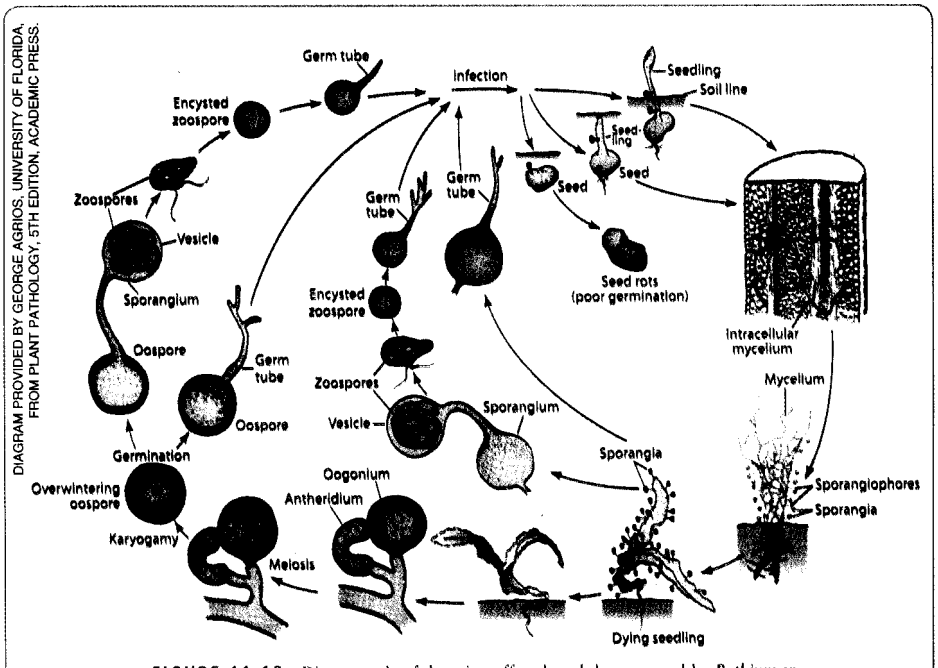

DIAGRAM PROVIDED BY GEORGE AGRIOS, UNIVERSITY OF FLORIDA, FROM PLANT PATHOLOGY, 5TH EDITION, ACADEMIC PRESS.

FIGURE 11-18 Disease cycle of damping-off and seed decay caused by *Pythium* sp.

A generalized life cycle of *Pythium* spp.

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Different pathogen life stages

The aquatic nature of *Pythium* and *Phytophthora* makes them particularly troublesome in recirculating water systems. Both require significant amounts of water to complete their lifecycle, and with few exceptions, produce swimming zoospores in large numbers.

Zoospores are released into the water and are disseminated in the water stream from plant to plant where they reinfect resulting in the release of more zoospores. As the zoospores come into close proximity to the roots, the spores can find the roots through a process known as chemotaxis.

Both *Pythium* and *Phytophthora* produce oospores that allow them to survive for relatively long periods of time (years) in the absence of fresh plant material to infect. Indeed, a feeder root only 1 millimeter long could have 50-100 survival spores embedded in it. Despite their aquatic nature, these survival spores can live in a dried state on concrete floors

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Potential sources of pathogens in greenhouses

Source	Notes
Water source	Pathogen levels are usually low in unused municipal or well water. Recycled or surface water is more likely to require treatment. Test water for pathogens at both the source and at points in the irrigation system.
Water-holding tanks	Clean out residue between crops, followed by a shock treatment with a chemical disinfestant.
Biofilm in water pipes	This mix of benign, beneficial and pathogenic or problem algae, bacteria, fungi and other organisms can be chemically resistant. A chemical shock is needed if a water test at the hose end shows pathogens are present. Design plumbing with clean-out points for flushing lines.
Plant and soil residues	Remove residues before cleaning surfaces. Disinfestants are not effective at sterilizing organic residues. Install coarse and fine filters for irrigation water.
Greenhouses surfaces	Clean, then follow with an application of a labeled chemical disinfestant. Ensure there is sufficient contact time for control.
Plant material	Inspect new plant material. Regular pathogen testing is important, especially in young plant operations.
Reused containers and growing media	Compost and recycle rather than reuse. If reusing containers, ensure they are thoroughly cleaned and then disinfested.
Employees' hands, clothing, shoes and tools	Train greenhouse staff about overall sanitation. Foot baths are generally ineffective because of short contact time and high organic load. Sterilize tools between crops.

for months.

Fusarium also produces spores and mycelial fragments that travel in water. Fusarium also produces special survival spores that can survive in the absence of plant material. Like *Pythium* and *Phytophthora*, recirculating water systems contaminated with *Fusarium* are challenging to decontaminate.

Factors affecting treatment

It is important to remove plant and growing media residues and

PHOTO BY PAUL FISHER

Clean greenhouse surfaces that harbor organic residues and pathogens first, then disinfest.

spores through filtration and regular cleaning for chemical disinfestants, ultraviolet light or other technologies to treat water.

Pathogen life stages differ in their resistance to chemical controls. Researchers at Virginia Polytechnic University found that zoospores (the life stage that directly infects plants) of several *Phytophthora* and *Pythium* species were controlled by 2 parts per million chlorine at discharge (sprinklers/risers). However, other fungal structures such as chlamydospores, oospores and hyphae buried in plant and soil residues are unlikely to be controlled at this concentration. This is why it is difficult to provide exact guidelines on the required concentrations for chemical disinfestants.

Oxidants, including chlorine, activated peroxygen and ozone, have a short period of effective activity. Their primary action is to cleanse the water, rather than provide long-term protection. This is especially true for point treatments, such as ultraviolet light and heat. It is possible to provide a continuous dose of oxidizing material to a water-treatment system, but operating costs vary. Copper materials do not lose their activity like oxidants, but will bind to organic matter.

Duration of activity and overall efficacy of water-treatment technologies decrease when high levels of organic residues are in irrigation water. Oxidants work by chemically changing molecules in disease-causing spores, organic residues and fertilizers, and in the process the oxidants are used up. Ultraviolet light requires clear water for its light rays to penetrate spores.

All these interventions suffer from the same severe limitation. They are ineffective for treating infested organic material and soil that is inside containers, on plant root systems and in the corners of greenhouses. For this reason, it is essential to undertake a thorough cleaning and disinfesting process between crops. Clean surfaces first, and then disinfest. Dirty, soiled surfaces cannot be adequately disinfested and infested organic material cannot be penetrated.

The goal is not to sterilize the greenhouse, but to maintain plant health. Many microorganisms in biofilm, soil and water have a benign or beneficial role. Plants may be more susceptible to pathogens when these organisms are eliminated.

Take a holistic approach

The management of plant pathogens in recirculating water systems requires a holistic approach, because water is only one potential point of contamination. Well water coming into a greenhouse is probably free of pathogens. However, that is not the case if

the source is local surface water.

Ideally, plants coming into a greenhouse should be pathogen-free, but this is an unrealistic assumption. Visually inspect incoming plants to make sure they do not show symptoms of root diseases including random wilting, stunting or chlorosis. Isolate symptomatic plants to avoid disease spread. Use a university or commercial diagnostic laboratory to identify disease pathogens. Preventive fungicides targeted for root pathogens are optional but advisable if a greenhouse has a history of root diseases.

There are several places in greenhouses where disease-infected plant material can reside. The most obvious pathogen repositories are holding tanks for recirculating water. This is where organic material and growing media components, washed away from infected plants, come to rest. Perhaps less obvious are the corners, crevices and cracks on benches and concrete floors. Even less apparent are the corners and deadheads of pipes that recirculate the water and the biofilms that coat the inside of the pipes. Once a system is contaminated, every effort needs to be made to eliminate the organic deposits that collect in these areas.

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Chemical disinfestants can be phytotoxic to plants, are potential worker safety and environmental hazards, and tend to be corrosive to equipment. Always follow label instructions and maintain equipment.