Mitigating Irrigation Pathogens Without Water Treatment©

Chuan Hong

Virginia Tech, Hampton Roads Agricultural Research and Extension Center, 1444 Diamond Springs Road, Virginia Beach, Virginia 23455

Email: chhong2@vt.edu

INTRODUCTION

Irrigation is where agricultural water security meets plant biosecurity. In light of global water scarcity, capture and reuse of runoff water for irrigation is of strategic importance to the sustainability of ornamental nursery and greenhouse industry. Without water no plant can be grown nor can existing plants survive. However, this practice could potentially recycle and spread destructive plant pathogens from isolated infections to an entire production facility and from a single facility to all sharing the same water resources, wiping out entire crops within weeks or even days.

Pathogen diversity in water and evidence of their economic significance has been mounting in recent years. According to a recent review (Hong and Morman, 2005), the diversity of plant pathogens found in water include 17 species of *Phytophthora*, 26 of *Pythium*, 27 genera of fungi, 8 species of bacteria, 10 viruses, and 13 species of nematodes. There is a growing body of evidence indicating that contaminated water is a primary, if not the sole, source of inoculum for a large number of destructive diseases on ornamental crops (Stewart-Wade, 2011).

The current approach to pathogens in irrigation water and their associated crop health risk focuses on chlorination (Hong et al., 2003b) and other water treatments (Fisher, 2011). Based on the latest research advancements, here I propose an improved version of a system approach for pathogen mitigation in irrigation water (Hong, 2008). Our ultimate goal is to move ornamental production towards a more sustainable industry.

A SYSTEM APPROACH TO PATHOGEN MITIGATION IN IRRIGATION WATER

A recycling irrigation system typically consists of three components: (1) production areas, (2) reservoirs including runoff water containment pond, and (3) pump house (Fig. 1). Runoff water from irrigation and rain events returns to the containment pond through ditches and/or underground drainage systems. Water is pumped out from reservoirs and treated in pump houses before being delivered to crops through PVC pipes.

Corresponding to the three components are three critical control points for plant pathogens in recycling irrigation systems (Fig. 1). Water treatment in the pump house is an important critical control point to prevent pathogens from reaching crops. The other two critical control points are to (1) prevent pathogens from reaching pump inlet, and (2) reduce pathogen entry into the irrigation system and negate its dissemination power. The following discussion will focus on potential mitigation strategies that may be implemented at each of these two critical control points.

PATHOGEN MITIGATION BY LOCATING PUMP HOUSE AWAY FROM RUNOFF ENTRANCE

Although aquatic biology of plant pathogens is largely unknown, there are several lines of evidence indicating that most pathogens including *Phytophthora* species,

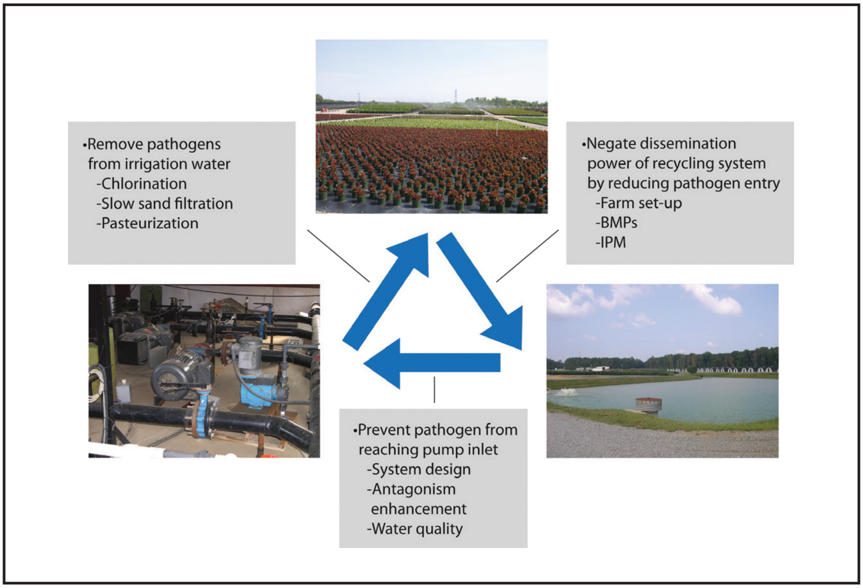

Figure 1. Illustration of three components of a nursery recycling irrigation system and three corresponding critical control points for pathogen mitigation.

commonly known as water molds, are not as adapt to agricultural water environments as previously perceived. First, the population of *Phytophthora* species consistently declined with increasing distance from runoff entrance in two containment ponds (Ghimire et al., 2011; Hong et al., 2003a). Specifically, in the pond with a single runoff entrance at one end and a pump inlet and an outlet at the opposite end, *Phytophthora* recovery at 100 m away from the runoff entrance decreased by 92% (Ghimire et al., 2011). Second, irrigation reservoirs are considered rather harsh environments for wildlife including plant pathogens. Water quality in this aquatic system periodically undergoes dramatic changes (Hong et al., 2009). For instance, water pH fluctuated from 4.5 to 10.5 in one of the ponds monitored and it was mostly above 7. Third, in a recent study evaluating the impact of water pH with Hoagland's solution as base medium, the vast majority of zoospores from five of the seven *Phytophthora* species died off within the first day (Kong et al., 2009). The only exception was *P. megasperma* which survived a broad range of pH from 3 to 11 for the entire experiment period of 7 days. It is anticipated that many other water quality parameters also could limit the survival of plant pathogens in irrigation reservoirs. These latest studies suggested that the risk of pathogen recycling through irrigation systems is inversely related to the runoff water turnover time.

Any considerations that prolong runoff water turnover time will contribute to pathogen mitigation. For single pond recycling systems, these may include (1) digging a curve-shaped reservoir with "speed bumps" in the bottom to slow water movement, (2) channeling runoff water from all production areas to a single runoff entrance at one end, and (3) locating the pump house as far away from the runoff entrance as possible. The bottom line is to settle pathogens out along the water path (Hong and Kong, 2003). This settling effect may be enhanced by adding a second or more ponds to existing recycling systems. To maximize this benefit, these new ponds and the existing pond should be built with a stepwise water flow to capture runoff from all production areas in the top pond and water for irrigation pumped out from the bottom pond (Hong, 2002).

PATHOGEN MITIGATION BY DESIGNING GOOD DRAINAGE AND CONVEYANCE SYSTEMS

The sharp decline of *Phytophthora* populations along the water path from runoff entrance (Ghimire et al., 2011) indicates that most pathogens in that irrigation pond originated in production areas. These pathogens could have been from direct wash-off from diseased plants or leachate from infested potting mixes and containers on the production beds. They also could have entered runoff when it runs through contaminated sidewalks, roads, and open ditches.

One mitigation strategy is to reduce pathogen movement from production areas to the containment pond by building good drainage and conveyance systems. By functionality, such systems should be set to (1) mitigate direct contact of runoff water with diseased plants, contaminated substrate, containers and areas, or (2) settle pathogens out before reaching containment ponds.

Mitigating direct contact of runoff water with diseased plants, contaminated substrate, containers and areas may be accomplished making the right choices during the design of production beds and drainage systems. For instance, a variety of materials are used for production bed surfaces. These include gravel, seashells, and porous polypropylene ground cloth. Those that enhance infiltration and drainage reduce direct contact of runoff water with diseased plants and infested substrate/containers. Similarly, production beds could drain water to one, two, or four sides. Assumingly, those with a four-sided drainage dry most quickly, reducing pathogen growth and minimizing direct contact of runoff water with diseased plants and infested substrate/containers. Runoff water is commonly channeled through open ditches along sidewalks and roads. This drainage system is prone to cross contamination as discussed above. An alternative for risk mitigation is use of an underground drainage system with large diameter pipes that traverse underneath production areas. Such a drainage system not only reduces the risk of runoff water picking up pathogens along its path but also provides a foundation for a clean and dry production environment. An underground drainage system also opens an additional possibility for effectively draining water within the production bed. Runoff water may be directed to the center of production beds connected to a underground drainage system, so that no runoff water leaves the production beds, thus, completely eliminating pathogen entry from contaminated sidewalks and roads.

As an extension of open ditch or/underground drainage systems, the conveyance system delivers runoff water to containment ponds. Any conveyance system design that slows water movement, promotes sedimentation, and prolongs runoff water turnover time will reduce the diversity and level of pathogens returning to containment ponds. Examples include (1) use a J-shaped system to route water along the side of the reservoir to the opposite end from the pump house, and (2) add gravel with "speed bumps" along the water path.

PATHOGEN MITIGATION THROUGH BEST MANAGEMENT PRACTICES

An irrigation system is a powerful means by which pathogens spread to an entire nursery or greenhouse from isolated infections. However, this dissemination power may be further negated through best management practices to reduce the sources of inoculum for water dispersal. These practices may prevent pathogens from entering production systems or create suppressive environments. One example is to schedule irrigation events during daytime instead of night hours where *Phytophthora* and *Pythium* pathogens are of primary concern. It has been demonstrated that this practice alone reduced spread of these pathogens by more than 80% (Nielsen et al., 2006). This is due to the nocturnal nature of their production of zoospores, the principal dispersal structures and infective propagules. Zoospore populations began to increase at the start of the dark cycle and peaked sharply at Hour 4 (Nielsen et al., 2006). Additional examples include, but are not limited to, use of clean propagating and planting materials and sanitation practices. Some of these best management practices have been recently compiled (Griesbach et al., 2011).

SUMMARY

Plant pathogens in irrigation water present a growing threat to ornamental crop health as the horticultural industry increasingly depends on recycled water for irrigation. To counteract this emerging crop health issue, a system approach was proposed along with three critical control points and several pathogen mitigation strategies. These strategies are based upon good system design from production beds to drainage, conveyance, containment and recycling systems, and upon best management practices. Building new production facilities with good system design and implementing best practices is a matter of making informed choices. Such choices may not necessarily cost even an extra dime but surely their pathogen mitigation benefits will be ever-lasting, giving growers an competitive edge in the global market. Some of these designs prevent infective propagules from reaching pump inlets. Other designs and practices mitigate pathogen entry into recycling irrigation systems by reducing the source of inoculum in production areas and curbing movement to containment ponds. Altogether they provide long-term solutions to pathogens in recycling irrigation systems. The major principles of these designs and practices are to reduce inoculum source and contact with runoff water, and prolong turnover time. Examples used in this work were to illustrate these principles. Growers are encouraged to apply the same principles, make informed choices and build new production facilities with designs and practices that deter pathogen entry, reducing the risk of recycling and disseminating through an irrigation system. As our understanding of water quality dynamics in irrigation reservoirs and pathogen aquatic biology advances, growers should not have to choose between agricultural water security and plant biosecurity. Together we can and will build a more sustainable ornamental horticultural industry.

Acknowledgements. This work was supported in part by grants from USDA: CSREES Risk Avoidance and Mitigation (Agreement #: 2005-51101-02337) and NIFA Specialty Crop Research Initiative (Agreement #: 2010-51181-21140), Virginia Nursery and Landscape Association, and a number of nurseries in Alabama, Maryland, Mississippi, North Carolina, Pennsylvania, and Virginia.

LITERATURE CITED

Fisher, P. 2011. Water treatment: A grower's guide for nursery and greenhouse irrigation. University of Florida, < http://www.irrigation-pathogens.info>.

Ghimire, S.R., P.A. Richardson, P. Kong, J.H. Hu, J.D. Lea-Cox, D.S. Ross, G.W. Moorman, and **C.X Hong.** 2011. Diversity and distribution of *Phytophthora* species in the irrigation runoff containment basin of an ornamental plant nursery during winter months. J. Phytopath. 159:713–719.

Griesbach, J.A., J.L. Parke, G.A. Chastagner, N.J. Grunwald, and **J. Aguirre.** 2011. Safe procurement and production manual — A system approach for the production of healthy nursery stock. Oregon Assoc. of Nursery.

Hong, C.X. 2002. Considerations in adding water reservoirs to minimize pathogen accumulation in recycling irrigation systems. Virginia Nursery & Landscape Association Newsl. 72:75–76.

Hong, C.X. 2008. Management of pathogens in irrigation water. Green Industry Knowledge Center, University of Maryland, College Park, Maryland, <http://www.waternut.org/moodle/course/view.php?id=56>.

Hong, C.X., and **P. Kong.** 2003. Settling of infective *Phytophthora* propagules in runoff retention pond. Virginia Nursery and Landscape Association Newsletter. 73:41–43.

Hong, C.X., J.D. Lea-Cox, D.S. Ross, G.W. Moorman, P.A. Richardson, S.R. Ghimire, and **P. Kong.** 2009. Containment basin water quality fluctuation and implications for crop health management. Irrigat. Sci. 29: 485–96.

Hong, C.X., and **G.W. Moorman.** 2005. Plant pathogens in irrigation water: Challenges and opportunities. Critical Rev. Plant Sci. 24:189–208.

Hong, C.X., P.A. Richardson, and **P. Kong.** 2003a. Decline in *Phytophthora* spp. with increasing distance from runoff water entrance in a retention pond. Phytopathol. 93:S36.

Hong, C.X., P.A. Richardson, P. Kong, and **E.A. Bush.** 2003b. Efficacy of chlorine on multiple species of *Phytophthora* in recycled nursery irrigation water. Plant Dis. 87:1183–89.

Kong, P., G.W. Moorman, J.D. Lea-Cox, D.S. Ross, P.A. Richardson, and **C.X. Hong.** 2009. Zoosporic tolerance to pH stress and its implications for *Phytophthora* species in aquatic ecosystems. Appl. Envir. Microbiol. 75: 4307–14.

Nielsen, C.J., D.M. Ferrin, and **M.E. Stanghellini.** 2006. Cyclic production of sporangia and zoospores by *Phytophthora capsici* on pepper roots in hydroponic culture. Can. J. Plant Pathol. 28:461–66.

Stewart-Wade, S.M. 2011. Plant pathogens in recycled irrigation water in commercial plant nurseries and greenhouses: Their detection and management. Irrig. Sci. 29:267–97.