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Recycled Irrigation Water Chlorination and Pathogen Prevention©

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INTRODUCTION

During the past several years it has become increasingly important to utilize recycled irrigation water in nursery production. Many states within the southeastern United States experienced significant water shortages due to the drought of 2007. Local mandates and water restrictions will undoubtedly require nurseries to continue to conserve water. Increased dependence on recycled water has exacerbated the problem of crop losses due to outbreaks of waterborne pathogens, frequently *Phytophthora* or *Pythium* species. As a result, more nurseries are currently sanitizing or planning to sanitize their recycled water in an effort to minimize the risk of disease epidemics. It is important to follow relatively recently developed protocol to achieve the desired level of prevention.

ADVANTAGES OF CHLORINATION

With the current technology available, the most practical and cost-effective method for nursery production is chlorination. Several advantages make chlorine the preferred choice for sanitation.

From an economical standpoint, chlorine is very attractive from both establishment and operation standpoint compared to alternatives such as ozonation, slow sand filtration, or heat treatment. Three forms of chlorine are readily available for water sanitation. Chlorine gas (Cl_2), liquid chlorine (sodium hypochlorite), and a solid form (calcium hypochlorite). Of the three forms, gaseous chlorine is most cost effective when large volumes of water are treated. Using the current price average of $2.20/kg ($1.00 per pound), Cl_2 will provide 2 ppm concentration to 60,000 gal of water. To look at this from a different perspective, 1 lb of chlorine gas can provide 2 ppm concentration for 1 h at a flow rate of 1,000 gal per min. Gaseous chorine has the advantage of being the most concentrated form available. Less storage space is required and transportation costs are lower than liquid chorine. Unfortunately, it is also potentially the most hazardous to handlers. Chlorine gas systems should only be installed by professionals. And it is very important to provide training to nursery employees responsible for handling Cl_2 gas to ensure their safety. When considering Cl_2 gas as irrigation water sanitizer for your operation also check to make sure it is approved for use by the Environmental Protection Agency in your state. Under current pricing, liquid chorine is intermediate in material cost. Solid chorine is the most expensive form to apply.

In addition to the economical advantage of chlorination, it is usually the most practical choice over other options from the standpoint of reliable efficiency against waterborne pathogens. For example, ultraviolet radiation sanitation is usually not a practical option for recycling nursery irrigation water due to turbidity levels commonly encountered. To be most effective in eliminating waterborne pathogens utilizing UV radiation the water must have greater than 60%

UV transmission (Mebolds et al., 1996). This is generally not obtainable with recycling nursery water.

Chlorine also provides a fairly stable residual within the irrigation system to prevent the buildup of slime due to algae and iron forming bacteria. This helps assure a properly functioning system free of clogs especially when micro irrigation emitters are used. Chorine is also easy to measure using an inexpensive DPD (N, N-diethyl-p-phenylene-diamine) color indication test kit. These kits are also portable, which makes them very functional for field use.

HOW CHLORINE WORKS

Chlorine is a strong oxidizing agent. It will oxidize any organic matter upon contact in the water. This includes algae spores, peat moss, plant debris, and waterborne pathogens such as *Pythium* and *Phytophthora* species. Membranes, DNA, and enzymes of the pathogens are all subject to oxidation. When chlorine is added to water, hypochlorous acid (HOCL) and hypochlorite (OCL) are formed (Fig. 1).

IMPORTANT TERMS

"Chlorine demand" is the term used to describe the portion of the initial dose applied to the water that is either chemically bonded to minerals within the water or used to oxidize organic matter. The cleaner the water being treated the lower the chlorine demand. For example, water within a catch basin high in algae from nutrient runoff and high in turbidity from erosion would have a high chlorine demand. This portion of the initial dose is no longer available to actively sanitize (nonbiocidal).

"Free chlorine" is that portion of the initial dose remaining after chlorine demand is satisfied (residual concentration). This is the portion of the initial dose which is still available to actively sanitize (biocidal). When treating a relatively clean water sample, a greater percentage of the initial dose will be free chlorine.

PH SIGNIFICANCE

The pH of the water being treated with chlorine is very important because it has an impact upon the biocidal potential of the dosage introduced. No matter which forms of chlorine are utilized to sanitize, the biocidal potential of the dose is rendered less effective under high pH conditions (pH greater than 7.5). Hypochlorous acid (strong sanitizer) and hypochlorite (weaker sanitizer) are formed when chlorine is applied to water (Fig. 1). Acidification of water with a pH above 7.5 before chlorination will improve its efficiency. Simply to increase dosage in order to overcome a high pH water issue increases the potential for phytotoxicity to crops irrigated. A "free chlorine" level of 2.9 ppm concentration is generally considered safe for most crops (Skimina, 1992).

CURRENT PROTOCOL FOR PHYTOPHTHERA PREVENTION

Dr. Chuan Hong with Virginia Polytechnic Institute and State University is considered one of the leading authorities regarding plant pathogens in recycled irrigation water (Hong and Moorman, 2005). For the past 9 years he has been investigating what species of *Phytophthora* are present in irrigation water, how they may change at different locations and depths within each runoff retention pond, and developing science-based water treatments. Specifically, he and his associates have conducted a series of experiments determining the concentration required to kill vari-

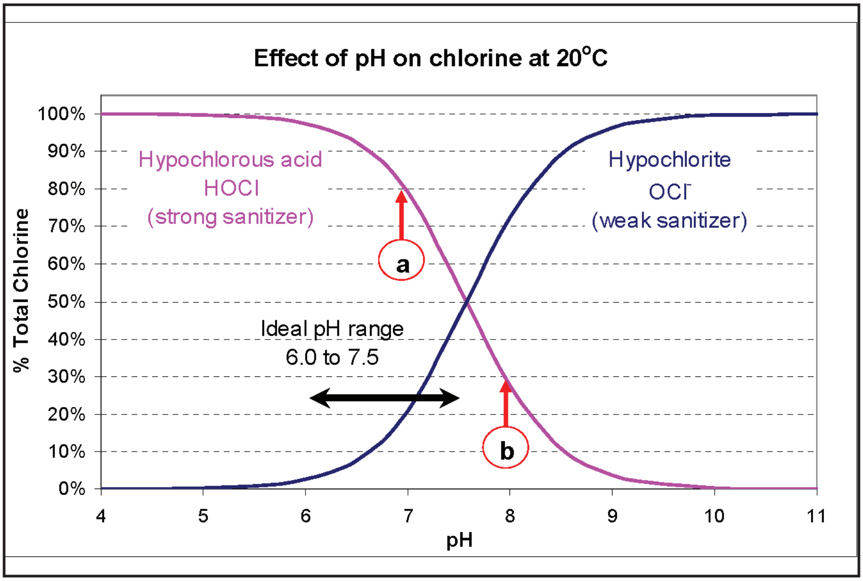

Figure 1. Effect of pH on chlorine. (Courtesy of Dr. Paul Fisher, University of Florida.)

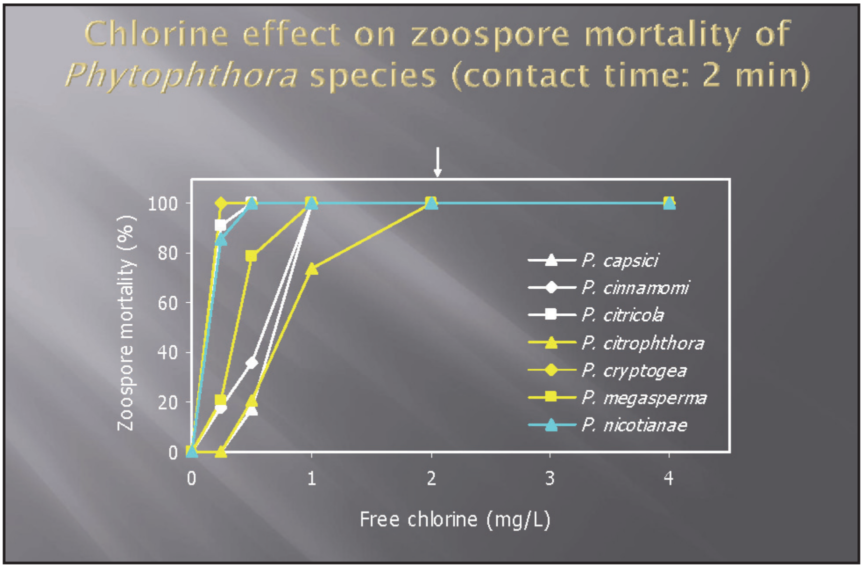

Figure 2. Chlorine effect on zoospore mortality of *Phytophora* species with a contact time of 2 minutes.

ous structures of different species of *Phytophthora* and *Pythium*. His research has clearly indicated that no zoospore (the primary dispersal and infective structure) of any species tested survived at 1 ppm free chlorine (Fig. 2).

Based on these results, Dr. Hong recommends maintaining 2 ppm free chlorine at the sprinklers for water decontamination in nursery production.

Hong's research group is looking into whether and how *Phytophthora* zoospore population may decline from runoff entrance in retention ponds, which their initial data shows happening in irrigation reservoirs. This new discovery raises the possibility of water decontamination simply by locating pump houses. In other words, water decontamination may be accomplished by designing new recycling irrigation systems or modifying existing systems. This could be a major breakthrough in pathogen biology and irrigation water treatment innovation. Currently they are sorting through the data and formulating protocols for minimal inoculum intake in the design and modification of recycling irrigation system design and modification.

CHLORINATION SYSTEM AT BENNETT CREEK NURSERY

Our irrigation water is supplied by computerized variable speed pumps in order to provide a wide flow rate up to 5678 L/min. (1,500 gpm) at 414 kPa (60 psi). A gas chlorination system provides continuous sanitation. The main components of the system are: flow meter with paddle wheel sensor, signal conditioning unit (SCU), Wallace and Tiernan S10K volumetric proportioner, Cl_2 cylinder and regulator, venture ejector, and booster pump. This system automatically adjusts to the desired initial dose. However, employees must still monitor periodic changes in chlorine demand, and make occasional dose adjustments to maintain 2 ppm free chlorine at the sprinklers.

SUMMARY

Use of continuous chlorination systems set to deliver 2 ppm free chlorine at the sprinklers are currently the most practical and cost effective protocol available to minimize the risk of a disease epidemic due to contaminated recycled water. Maximizing the distance in the catch basin between the return water entrance and the intake to the pump house will naturally decrease disease potential. The pH of the water chlorinated has a significant impact on the biocidal potential of the initial dose. Hence, a pH of 6.0 to 7.5 prior to treatment is recommended. Following BMP protocol to minimize catch basin nutrient loading and turbidity will reduce the amount of chlorine needed, as well as make the correct free chlorine dose easier to manage.

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