Operational Solutions to Water Management Problems in Ornamental Nurseries

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Abstract - State regulations to protect water quality have been established for Oregon container nurseries. These nurseries are presently drawing up plans, building water containment facilities and investigating water recycling, sub-irrigation systems and other water management practices to eliminate runoff. All of these systems provide opportunity for disease spread through the recirculating water. Methods for dealing with this problem are discussed.

INTRODUCTION

The Oregon Department of Agriculture (ODA) and Department of Environmental Quality (DEQ) have entered into an agreement for regulating irrigation runoff from container nursery facilities to assure minimal water quality degradation of Oregon waters.[1] By July 15, 1991, container nursery stock producers of Oregon must file with ODA a letter of intent regarding their nursery irrigation water management plan. They must select one of the following options:

(1) No discharges, no fees, no regulations;
(2) Discharge between May 1, 1991 and July 1, 1993 requires a fee;
(3) Discharge after June 1, 1993 requires a Water Pollution Control Facility (WPCF) permit.

As usual, this is both good news and bad news. The good news for all is the preservation of good quality water, both in streams and groundwater. The bad news for the nurseryman is the cost of establishing such a system and the potential problems which may result. Oregon is not the first state to have such regulations, (McGovern 1981, Arron 1989, Green 1989b, Dells 1990, Aglsworth 1991) but this is probably a foretaste of what will eventually be established in all states.

[1]Wolf,MJ. 1991. Personal Communication. Container Nursery Irrigation Water Management Plan. Copy available from natural resources Division, Oregon Department of Agriculture, Salem, Oregon.

There are a number of ways to eliminate discharge of irrigation waters and new ones are being continually developed. Careful monitoring of irrigation schedules, (Bartok 1989, Biernbaum 1990, Roberts 1990) pulsed water application, (Green 1989b, Biernbaum 1990) sub-irrigation (Neal 1989, Brandies 1990, Roberts 1990, Stockwin 1990, Richardson 1991), and recycling irrigation water (Green 1989a, Wells 1990, Aylsworth 1991) are some of the methods currently being evaluated. With any system which contains and recirculates irrigation water, there is danger of pathogen contamination and disease spread in the water (Baker & Matkin 1978, Daughtry 1989, Green 1989b, Atmatjidou et al 1991). My presentation will summarize methods used to control waterborne pathogens that may occur and spread in this manner, and I will give examples of approaches used in ornamental nurseries. Articles on this subject are becoming more frequent, and good reviews of sterilization techniques have been presented by Vestergard (1988) and Green (1989a, 1989b). Chemical contaminants in the water must also be evaluated and managed, but this subject is being addressed by other panel members.

IF IT AIN'T BROKE. . .

The old adage, “If it ain’t broke, don’t fix it” certainly seems redundantly wise; but I would like to amplify that with something which also seems redundant; “If it is broke, find out what’s wrong with it before you fix it”. This seems logical to most of us with the exception of garage mechanics and legislators. They seem to try all kinds of remedies without knowing the cause in the hope that they will miraculously stumble onto the solution without ever having to know exactly what was wrong. There is a better way.

Just because water is recycled does not mean there will necessarily be a disease problem. Each nursery seems to have a unique set of problems, and these must be carefully defined before attempting to set up a water purification system. Laboratory evaluations can determine the exact cause and extent of the problems and help in defining the purification system needed. Frequently, careful management and strict sanitation practices may be all that are necessary. Several studies have shown that with some new systems, such as the ebb and flow or nutrient film; pathogens may be present but due to excellent growing conditions, no disease develops. However if you are selling seedlings, such as conifers, that are infected, this is not acceptable.

SELECTING A WATER PURIFICATION SYSTEM

There are several criteria to be considered when selecting a water purification system. Determination by laboratory analysis of what pathogens are present and what degree of sterilization is necessary is the first consideration. Second, safety both to humans and the environment is an essential factor. Third, the system must be practical for the nursery system under consideration. Finally, the system must be economic both to set up and operate.

WATER PURIFICATION SYSTEMS

The various types of water purification systems can be categorized under five general headings; electrical, mechanical, heat, radiation, chemical. Examples of each of these will be discussed.

Electrical

Electrolytic production of pathogen-controlling ions such as copper are possible but have not been developed commercially. High concentrations of oxygen and ozone can be produced electrically, but this will be discussed more completely under the chemical heading.

Mechanical

Mechanical filtration has been used successfully to free water of pathogens. The type and size of filter or combination of filters necessary depends on the pathogen and amount of particulant matter in the water. Very fine mesh filters of 0.1-0.2 microns are necessary to filter out most pathogens. Large amounts of particulant matter in the water will quickly clog such filters and requires pre-filtering with coarse units such as sand filters. Frequently filters are used in conjunction with other purification methods.

Filtering systems have been designed which are very effective in purifying the water, are safe to operate, and may be practical and economic if water requirements are not large. Installation costs may be high as large capacity pumps may be necessary to move water through the filters and several filters may be required.

Reverse osmosis is another type of filtering system that has been used successfully in some nurseries (Hughes 1977, Green 1978). Osmosis is the spontaneous passage of a liquid from a dilute to a more concentrated solution across a semi-permeable membrane. In reverse-osmosis, the concentrate solution is artificially pressurized, which causes the liquid to flow from the concentrated to the dilute solution. In this process, approximately 90% of the solutes contained in the water can be removed, allowing only minimal contamination. It will not only control pathogens but also mitigate chemical problems such as high iron or zinc levels in the water (Arron 1978). The system is safe, practical for some situations and economic to operate but may be expensive to install.

Ultrasound is another mechanical type purification system that is very effective but only on a small scale. Because of the high frequency sound, protection is required for workers in the vicinity.

Heat

Pasteurization, heating water to 60 C for 30 minutes, has been a widely used system of water purification over the years. However, some organisms are able to withstand short periods of this temperature or even to 100°C,requiring either longer times or repeated heating to this temperature. It is best to heat water in smaller amounts and store treated water in a larger reservoir to allow for cooling. In nursery situations where hot water is a natural byproduct or must be produced for other purposes, this may be a safe, practical and economic solution. However, it may be too expensive where the heat would have to be generated just for this purpose.

Radiation

Several types of radiation have been demonstrated to successfully purify water; gamma radiation, x-ray, and ultraviolet (UV) radiation (Vestergard 1988). All of these methods have some safety concerns. Of all of the methods, only UV systems have been developed commercially. UV sterilization systems have been successfully used in some greenhouses. However, because of the number of factors which must be taken into consideration such as water temperature, radiation time, radiation depth, salinity, water color, particulant matter, the system can be quite complex and costly. Also, 100% kill of pathogens is rarely achieved.

Chemical

This category can be further subdivided into five groups: pesticides, chlorination, bromination, ozonation, oxygenation.

While several pesticides have been approved for application to irrigation systems (Green 1989a), they are generally more effective in controlling pathogens at the plant level rather than in the water. Etridiazole, furalaxyl, metalaxyl and oxime-copper have been tested for control of Pythium and Phytophthora. Zoospore formation was prevented by all, but mycelial growth was only retarded (Spencer 1979). Introducing another chemical into the system however may only further complicate the use of recycled water.

Chlorination has been used very effectively in controlling such pathogens as Pythium and Phytophthora in water systems (Baker & Matkin 1978, Daughtry 1989, Green 1989a). The use of sodium hypochlorite (bleach) is generally safer than chlorine gas (Green 1978, Daughtry 1989). The activity spectrum of chlorine is limited to certain pathogens primarily Pythium and Phytophthora. Time/temperature consideration is important to obtain adequate control. Fungus spores have been killed by a concentration of 2ppm of free chlorine for one minute at a pH below 7.5. High temperatures reduce the efficacy of chlorine (Daughtry 1989, Yeager et al 1990). Chlorine can also be phytotoxic to some plants, so careful monitoring is essential. A chlorination system is relatively inexpensive to set up and maintain.

Bromination is a more recent water purification system and has many advantages over chlorination (Tayama 1986, Green 1989a, Austin 1990, Arron 1991). It operates on a similar principle but has a wider activity spectrum, active over a wide range of pH, is non-phytotoxic and leaves no residuals. It is also effective in controlling algae at concentrations of 5-10 ppm. The system is fairly inexpensive to set up and operate.

Ozonation is presently undergoing commercialization as a wastewater treatment for nurseries, although its effectiveness as a sterilizing procedure has been known for many years (Rice and Browning, 1981). This approach has the advantage in that it is a potent sterilizing agent with a broad activity spectrum, leaves no residuals and has a beneficial byproduct of oxygen. Presently the systems are expensive to set up but should be economic and safe to operate.

Oxygenation is also based on an old principle but is also just now being developed commercially (McWhirter and Prober, 1980, Krofta and Wang 1986). It is very similar to ozonation in the spectrum of activity and beneficial production of a byproduct of oxygen. In this process, hyperoxygenation (generation of 200% oxygen) not only kills pathogens but causes water contaminant agglomeration which can be easily filtered out. This system also will be expensive to set up but should be safe and economical to operate.

All nurseries will eventually be faced with establishing some type of water containment system. At that point, remember to determine what problems you are facing before you attempt to correct them. This will help you to design a system which is effective, practical, safe and economic.

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