CORF News

Floriculture Education from the Kee Kitayama Research Foundation

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Pathogen Control in Recycled Irrigation Water

By James D. MacDonald, Professor of Plant Pathology and Executive Associate Dean,, UC Davis

In many parts of California, nurseries have implemented a variety of technologies for recirculating irrigation water. Systems range from hydroponic culture, to flood-floor greenhouses, to drainwater capture and re-use in outdoor nurseries. While conserving water and minimizing off-site discharges (and associated TMDL issues), recycling introduces a real risk of spreading plant diseases. There is substantial evidence that pathogens (e.g., *Phytophthora*, *Pythium,* and *Colletotrichum*) are carried in the recirculated irrigation water applied to crops, and that contaminated water can result in plant infections. This has led to a need for data characterizing methods that can disinfect water. A number of common technologies, and points to consider about each, are described in the following sections.

Ultraviolet Radiation. UV radiation kills microorganisms by damaging nucleic acids (DNA, RNA) that are essential for normal growth, reproduction and metabolic activity. The most common sources of UV radiation are mercury-vapor lamps or xenon flashlamps. In water purifiers, lamps are encased in chambers through which water flows. The suspended microbes are exposed to radiation and killed as they pass through. Treatment dosage is determined by the

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Improving Water Quality With Buffers

By Darren Haver, Water Resources Management Specialist, UCCE Orange County

The term "buffer strip" often conjures up images of strips of land, hundreds of feet wide, planted with a single grass species next to a stream or a lake. The goal of these strips is to "buffer" an area from environmental impacts. Examples of buffers strips include riparian buffers, filter strips, grassed waterways, and contour grass strips. They have been shown to be effective at removing organics, pesticides, nutrients, and pathogens from wastewater generated and discharged from various types of industrial and agricultural production. The USDA Natural Resources Conservation Service (NRCS) states that a properly installed and maintained buffer has the capacity to remove up to 50% or more of the nutrients and pesticides, up to 60% or more of pathogens, and up to 75% or more of sediment. Buffer strips can also provide an area for wildlife habitat, stabilization of stream banks, and a beneficial interface between urban and agricultural land use.

Under most circumstances a nursery with runoff would benefit from the utilization of a filter strip and/or a combination grassed waterway/filter strip. In general, filter strips consist of an area of strategically located land established with permanent vegetation in order to intercept contaminated water in an effort to remove pollutants and improve water quality. The larger the filter strip the greater the capacity to mitigate large volumes of wastewater

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Evaluating Irrigation Water Quality

By Richard Y. Evans, Environmental Horticulture Specialist, UC Davis

Irrigation water quality has always been important to ornamental crop producers. That importance will be heightened considerably if growers must reduce or eliminate runoff from nurseries. Knowledge about water quality can help growers to maximize yields while minimizing pollution of water leaving the nursery.

For agriculture, salts in water are the main determinants of water quality. Most water, especially from wells, contains dissolved salts. Plants take up some salts, but most accumulate in the root zone. Over time, the accumulated salts reduce plant water uptake. High amounts of dissolved salts reduce crop yields and

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Editor's Note:

This issue of CORF News focuses on water recycling and management of effluent. Each farm advisor addresses this topic in their respective regional report.

—Steve Tjosvold
Editor, CORF News

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quality.

Water picks up salts from the geologic materials through which it passes. There are several common constituents of water in California, depending on the geologic materials through which the water passes (Table 1 at right). Laboratories usually report these in milligrams per liter (mg/L) or milliequivalents per liter (meq/L). Another unit, parts per million (ppm), is nearly equivalent to mg/L. Divide the value in ppm or mg/L by the equivalent weight (Table 1 at right) to convert to meq/L.

Water quality varies considerably in California, even over short distances (Table 2 at right), so even adjacent nurseries may have different water quality issues. Familiarity with irrigation water quality criteria (Table 3, see page 3) can help growers to define and address potential water quality problems.

Water salinity is usually measured in units of electrical conductivity (EC). Formerly reported as millimhos per centimeter (mmho/cm), the common unit now is decisiemens per meter (dS/m). Values are the same for both units. EC is related to total dissolved solids (TDS): EC (in dS/m) X 640 = TDS (in mg/L).

Irrigation water pH rarely is important, but water quality can affect soil pH. In most California nurseries, soil pH tends to increase due to bicarbonate. This is a greater problem on long-term crops than on bedding plants or most potted flowering plants. If the bicarbonate concentration is between 2-4 meq/L, soil pH can be managed by increasing the use of ammoniacal fertilizers. If the bicarbonate concentration is higher, it may be necessary to acidify the water. This should be done through consultation with a laboratory familiar with acid injection.

Some constituents of water are toxic to plants at high concentrations. Boron, chloride, and sodium are most likely to cause problems in California. Boron is absorbed by roots and transported to the leaves, where it accumulates and may cause burning of leaf margins. Some ornamentals are sensitive to concentrations in water as low as 0.5 mg/L.

Chloride ions also accumulate in leaves. Some crops tolerate chloride, but others (especially roses, camellias, azaleas, and rhododendrons) develop marginal leaf burning or leaf drop. Overhead irrigation with water high in chloride results in foliar uptake, which can also cause leaf scorch or leaf drop.

Plants irrigated with water high in sodium may develop symptoms similar to those from chloride. High sodium also causes soil problems. It destroys the structure of mineral soils, leading to poor

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Table 1. Common constituents of irrigation water.

Cations

Element	Symbol	Equivalent weight
major		
Calcium	Ca^{2+}	20
Magnesium	Mg^{2+}	12
Sodium	Na^{+}	23
minor		
Potassium	K^{+}	

Anions

Element	Ion	Symbol	Equivalent weight
major			
Chlorine	Chloride	Cl^{-}	35.5
Sulfur	Sulfate	SO_4^{2-}	48
Carbon	Bicarbonate	HCO_3^{-}	61
Carbon	Carbonate	CO_3^{2-}	30
minor			
Phosphorus	Phosphate	HPO_4^{2-}	
Nitrogen	Nitrate	NO_3^{-}	
Fluorine	Fluoride	F^{-}	
Boron	Borate	$B(OH)_3$	
Silicon	Silicate	$Si(OH)_4$	

Table 2. Characteristics of irrigation waters of 10 nurseries in the Salinas-Watsonville area.

Nursery	Ca+Mg meq/L	Na meq/L	HCO_3 meq/L	Cl meq/L	SO_4 meq/L	EC ds/mmg/L	B mg/L	SAR
A	7.2	4.8	7.6	2.0	2.4	1.10	0.61	2.5
B	4.3	0.9	3.6	0.4	1.2	0.44	0.24	0.6
C	5.7	3.5	3.1	4.3	1.6	0.94	0.12	2.1
D	4.5	1.7	2.6	5.8		0.64	0.12	1.1
E	16.3	8.3	7.4	10.0	7.2	2.04	0.32	2.9
F	3.3	4.1	4.8	2.7		0.74	0.01	3.2
G	2.7	1.1	2.1	0.9	0.8	0.39	0.12	0.9
H	3.2	2.0	3.0	2.5		0.62	0.08	1.6
I	18.8	4.3	8.6	13.1	1.4	2.15	Tr.	1.4
J	2.2	1.4	2.3	1.3		0.35	0.06	1.3

CORF
Floriculture education from the Kee Kitayama Research Foundation

California Disease Symposium

Tuesday, October 28, 2003; 8:00 am – 3:00 pm
Elks Lodge, 121 Martinelli Street, Watsonville CA

This full-day symposium will focus on major diseases and their control. 5.5 DPR CEUs and 3 CNN Pro CEU's have been requested. Lunch and a special Disease Symposium binder are included in your registration. Topics and speakers include:

- **"Downy Mildews" and "Rusts",** *Dr. Ann Chase, Chase Research Gardens, Mt. Aukum, CA*
- **"Tospoviruses and other Viruses", "Phytophthora and Pythium Diseases",** *Margery Daughtrey, Department of Plant Pathology, Cornell University*
- **"Management of cut flower diseases: fungicide testing for downy mildew on snapdragons, powdery milder on delphinium, and botrytis",** *Dr. Stephen Weguio, University of California, Riverside*
- **"Management of Fungicide Resistance",** *Dr. Frank Wong, University of California, Riverside*
- **"Nematode identification, biology and their control",** *Dr. Antoon Ploeg, University of California, Riverside*
- **"Postharvest Disease and Control",** *Dr. Michael Reid, University of California, Davis*
- **"New ornamental plant diseases in California and a growers' perspective for diagnostic techniques",** *Steve Koike, University of California Cooperative Extension, Monterey County*
- **"Phytophthora ramorum: an update on the pathogen and issues facing the ornamental nursery industry",** *Steve Tjosvold, University of California Cooperative Extension, Santa Cruz County*

Presentations from chemical companies on new and important products will be included.

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Registration Fees: $75 registration fee up to October 23, 2003. A confirmation will be faxed to registrants.

Late Registration: $100 for registration received after October 23, 2003 and for at-door registration. At-door registration will be accepted only if space is available.

Refund Policy: For refund requests received 10 days prior to the event, registration fees will be refunded minus a $10 processing fee. Refund requests must be received in writing (fax & email is acceptable)

For more information please call the CORF office at 831-724-1130 or email ccfc@ccfc.org.

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Irrigation Water Quality

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water infiltration. This is rarely a problem in container media that have large particle sizes. The sodium absorption ratio (SAR), a relationship between sodium and the combined calcium and magnesium content, is used to assess the potential for sodium problems.

Water can be a significant source of three elements that plants require in large amounts: calcium, magnesium, and sulfur. Some waters also contain significant amounts of nitrogen. Growers should consider the contribution of irrigation water to crop nutrition when developing fertilizer programs.

Growers can benefit from having their irrigation water analyzed, then monitoring EC regularly. New wells at an existing nursery should also be tested because groundwater quality can change over surprisingly short distances. By understanding water quality, growers can avoid costly problems and manage crop production effectively.

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Table 3. Some important irrigation water quality criteria for ornamental crops.

Electrical conductivity	
EC > 0.75 dS/m	Potential salinity problem
EC > 1.5 dS/m	High salinity hazard
pH	
Rarely under 7 in California; not usually a problem, even at values of 8	
Sodium	
SAR > 6	Permeability problems in mineral soil
SAR < 35	No permeability problem in potting mix
SAR > 8	Toxicity problems in mist propagation
Chloride	
> 5-10 meq/L	Leaf burn on woody species
> 3 meq/L	Leaf damage from overhead irrigation
Boron	
0.5 mg/L	Marginal leaf burn in some species
Bicarbonate	
< 2 meq/L	No potential pH problem
2-4 meq/L	Lower pH with ammoniacal fertilizer

Buffers

Continued from page 1

and its associated pollutants. However, the majority of nursery operations cannot afford to dedicate areas of production to a filter strip of considerable size. Research has shown that smaller filter strips can be effective at removing pollutants as long as the flow of wastewater does not exceed the capacity of the buffer. As a result, nurseries contemplating the utilization of a small-scale filter strip should perform a thorough audit of their irrigation system to determine if it is possible to reduce the amount of wastewater that requires treatment.

Figure 1 (at right) is an example of a modified waterway/filter strip installed at a commercial nursery. The waterway is a concrete channel that has been vegetated with canna lilies with the goal of reducing sediment, pesticides, and nutrients in surface runoff leaving the facility. Covering approximately 2,500 square feet, the buffer also provides the nursery with a significant area of saleable plants following the necessary regular removal of biomass.

The effectiveness of any buffer is also dependent on an understanding of the types and concentration of pollutants found in the wastewater. In order to reduce the erosion of sediment, nutrients, and other pollutants, the buffer must successfully reduce water runoff energy, stabilize soil particles, sequester nutrients, and trap and transform other pollutants such as pesticides. The design of a filter strip or grassed waterway (width and length) depends on which of these goals you are hoping to achieve. If the goal is to remove both sediment and soluble compounds such as nitrate, the buffer will have to be larger than if the goal is simply to remove sediment. Effective removal of nutrients and pesticides by adsorption, absorption, decomposition, and transformation requires more surface area and longer flow paths.

Figure 1. Modified waterway/filter strip installed at a commercial nursery.

The following steps should be taken in the design, installation and maintenance of a buffer, specifically a filter strip.

- Determine the purpose or goal(s) of the filter strip.
- Identify the location or locations of the strips.
- Measure the slope of the identified location to determine if it is too flat or steep. The ideal slope is between 2 and 6 percent.
- Select appropriate species for the climate and the conditions that the filter will be exposed to, such as occasional deep flows or constant shallow flows.
- Sediment should be removed from the system on a regular schedule in order to maintain even flow through the strip and to keep plant material from being smothered.
- If the filter strip is utilized for nutrient uptake, a harvesting schedule needs to be established to remove biomass, insuring the further efficient sequestering of nutrients by the vegetation.

The following NRCS link is an excellent resource for information on several different types of buffers including filter strips: http://www.nrcs.usda.gov/feature/buffers/.

The utilization of buffers can be a cost effective method to improve water quality if properly designed, installed, and maintained. Do not hesitate to seek professional assistance before establishing a buffer at your facility.

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Regional Report

San Diego County

Now That You Have Captured The Runoff...

More and more San Diego producers are installing equipment or facilities to capture runoff from their growing operations. After assessing their current growing operations and practices, many producers realize that runoff water is not just excess irrigation water. It is likely to include water used in washing vehicles and equipment, cleaning walkways and eating areas, and in other non-production activities. Since quality of this water varies considerably, many have reservations about using it as part of their main growing operation. Runoff water may pick up dust, dirt, petroleum products, and shading compounds. It may also contain excess pesticides and fertilizer materials, not to mention pathogens and other things that should not be moved around the overall growing operation.

Providing additional irrigation water is not the main purpose of capturing runoff for many growers—the main goal is the elimination of runoff leaving their property. To accommodate the extra water, many growers have taken the liberty of adding an accessory crop to their operation that can use the captured runoff. One grower captures the runoff from his greenhouses in 1,200-gallon septic tanks, pumps it uphill into a storage tank, and then uses it to water a thriving vineyard. Prior to this time, he grew sunflowers with the runoff water. Another grower pumps his excess water into a pond, and then uses it to water lush, beautiful Sago palms that are planted around his greenhouses. The palms are grown for sale to the landscape industry.

Both of these growers have the outdoor space to add another very different type of plant to their growing operation for the specific purpose of using the captured water, and both have benefited from marketing what is grown with the runoff.

Other growers may not have adequate space to add another crop in this manner. One local grower we are currently working with is in this situation. The greenhouses at this operation are surrounded with parking areas and steep hillsides that lead to the nearby storm drain channel. He produces a few thousand gallons per day of salty water (the byproduct of a reverse osmosis system) that he must dispose of with very limited space to do so. He needs to avoid allowing this salty water to run into the storm channel. Along with the Salinity Lab at UC Riverside, we are assisting him in planting groups of plants that are salt tolerant and will grow well under his conditions. The purpose of these plantings is to use up the salty water, and also to minimize erosion that has been occurring on the hillsides surrounding his greenhouses due to lack of plant cover.

Other growers have chosen to use their water for other landscape purposes, such as eating areas for farmworkers and decorative plantings at the entrance of their growing facility.

Another alternative is to use a biofiltration system, where the water is passed through areas that include high water use plants (swampy areas, grassy swales etc.). These are not very common in California, but are used much more often in other parts of the country. This will "clean up" the water and use it up at the same time. However, there are justified concerns that this will increase the number of pests, including snails, mosquitoes, fungus gnats, etc. that thrive in moist conditions. Others have installed more technical mechanical systems to purify the water. Several companies are now installing custom systems that will clean runoff water and allow its reuse as if it is from the original source. These systems are usually the most costly option.

If you choose to reuse water, keep in mind that you may not need to add the same level of fertilizer to your growing operation. Analysis of captured runoff water by some local growers allowed them to cut their usual fertilizer application by as much as 30% when they took into consideration the levels found in their water. A periodic analysis of what is in your runoff water is beneficial.

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Regional Report

Ventura & Santa Barbara Counties

Growers Share Recycling Experiences

Recently I talked to three progressive growers who have implemented recycling systems: George Gutman, Bordier's Nursery (outdoor container nursery stock); Dudley Davis, DoRight Nursery (greenhouse potted color and bedding plants); and Ed Van Wingerden, EverBloom Nursery (greenhouse cut flowers in rockwool).

One reason these growers decided to capture and reuse water is to protect the environment. Recycling ensures that if runoff water contains contaminants, potential pollution will be prevented. In addition, recycling helps conserve water, an important consideration during a drought.

Another reason growers are recycling is increasing governmental regulations. In Carpinteria, for example, if growers have runoff and do not recycle, they must pay hefty fees for discharge permits.

Because runoff has been regulated in Holland for years, Ed Van Wingerden knew that California growers would eventually be regulated too. When he switched 12 acres of greenhouses from ground growing to hydroponics, Ed set it up so that he could later convert to recycling. It was fortunate that he made this decision before the increased regulations were mandated in Carpinteria. He now recycles about 35-40,000 gallons of water per day.

Dudley Davis also foresaw increasing regulations, and decided to put in a recycling system when he expanded and relocated his operation several years ago. As a result of numerous TMDLs that will be established and adopted soon, many Ventura County growers are contemplating following his example, but may have to retrofit, which is more expensive.

A third and very important reason growers are recycling is that it is economical. According to Ed, he is realizing savings of about 40% in fertilizer and water bills. The higher your cost of water, the more you can save.

The initial capital costs for the design and implementation of a recycling system can be high. Growers who are using hydroponic-type systems like Ed can get started for about $250,000. But for very large operations, such as Bordier's Nursery (about 842 acres), it can be significantly more expensive. Costs can be as high as several million dollars, even for small operations, if you are designing a very sophisticated system. Despite the capital outlay you can recoup your capital costs in 3-5 years, depending on the degree of sophistication of the system and the cost of water and fertilizer.

Pathogen control is a major issue because if a disease gets into the system it can do extensive damage. DoRights chlorinates filtered pond water, but a concern has been clay particles that attach to the chlorine molecules, rendering them useless. As a result, they are now planning to eliminate the use of their sediment pond, so that tail water won't be exposed to sunlight, which reacts with chlorine. A 50-micron filtering system will be used instead of the pond to screen clay particles. The filtered water will be pumped back directly to the return line.

Ed Van Wingerden invested in a heat treatment system for controlling pathogens. Pumps push water through a heat exchanger, which allows cold "dirty" water to pass next to "clean" water, previously heated to 207 ° F by a pool-sized boiler. The hot water heats up the cold water to 202° F, and only a few additional BTUs are required to heat it to 207° F for pathogen control. In the process, this water cools down the hot water to 75° F, rendering it ready for irrigation. This makes the sterilization process extremely efficient and cost effective.

George Gutman points out that you cannot rely on pathogen treatment alone. He feels that the best solution is good overall sanitation to prevent any inoculum sources.

In addition to pathogen control, it is important to manage salinity when using recycled water. Most growers do this by blending with fresh water. Bordier's found that many plants in the nursery tolerate EC levels of 2.5-3.5. They sample daily to keep recycled water in this range. Salt sensitive plants are irrigated with fresh water rather than with recycled water.

EverBloom Nursery's hydroponic system prevents salt buildup by maintaining a 40% over-drain. In other words, if a plant needs 600 ML in one day, 1000 ML is applied, of which 400 ML is recycled. This "over-irrigation" is possible because the rockwool mat is designed to retain a certain water to air ratio. Mat overdrain and irrigation water are sampled four times per week.

Another problem can be sediment control. Bordier's Nursery uses gravel and vegetative biofilters in addition to a sediment pond and filtration. They are also working with Dr. Jay Gan at UC Riverside to investigate the use of flocculated polyacrylamide. In addition, they are examining the effect of charcoal to help scrub up pesticides.

Management of recycling systems is a full-time job, especially EC and pathogen control. Attention must also be paid to herbicide buildup and other contaminants, such as oil, that can get in the system. In spite of the extra effort required to manage these systems, all three growers were satisfied with their decision to recycle, and felt that the benefits were well worth it.

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Regional Report

San Mateo & San Francisco Counties

Off-Stream Ponds in San Mateo County & Water Recycling in Potted Plant Nurseries

Off-Stream Ponds in San Mateo County

The California Coastal Conservancy is funding a much-needed project which will facilitate and streamline the permit process to provide off-stream water storage ponds for coastal growers in San Mateo and northern Santa Cruz Counties. Many agricultural operations in this coastal area rely on summer diversion of water from perennial creeks and streams for irrigation. Summer in-stream flows can be limiting to Coho salmon (endangered species) and steelhead trout (threatened species) populations, so growers have been asked to reduce or eliminate their use of summer water to comply with Fish & Game requirements. Therefore, alternative water supplies are badly needed.

Spearheaded by Sustainable Conservation and Farm Bureau in the two counties, the project will develop a regional approach which will allow growers to reduce their use of summer flows by diverting and capturing excess water in winter, and developing off-stream storage for the water. Growers will be able to capture upland runoff, divert some of the winter stream flows, and store the water in off-stream storage ponds for summer use. The project will assist landowners with pond siting, construction, use, and maintenance, and will comply with permitting, environmental mandates, and watershed protection.

Currently, the process for acquiring the permits to construct each pond takes up to three years and several hundred thousand dollars for studies, plans, and negotiations with several local, state, and federal agencies. This regional streamlined approach is anticipated to reduce both the time and expense for permitting each pond. As off-stream ponds are constructed utilizing this cost-effective approach, there will be a cascading environmental benefit as more flow is left in the creeks during the critical summer period, and the project will help keep irrigated land in production.

This is very good news for growers in this county, because some have had to stop producing because of limitations in summer water supplies. Several hundred acres of agricultural lands have fallen out of irrigated production in recent years because of summer diversion issues. It is estimated that this project will irrigate 1,600 acres of production, or 40% of the agricultural acreage in production in the project area.

It is anticipated that the process for developing the regional environmental documents, the streamlined permit process, and the construction, management, and maintenance templates will take three years, and pond construction will begin in 2006. The Natural Resources Conservation Service (NRCS) and the Resource Conservation Districts (RCDs) in both counties are key participants in the project.

Water Recycling in Potted Plant Nurseries

With so much greenhouse potted plant production in San Mateo County, growers are looking at two main methods of recycling and reducing water use: (1) Zero runoff subirrigation (ebb-and-flow, and similar benches) in the greenhouse, and (2) Retention ponds to hold the runoff water from greenhouses for later use. Because potted plants are grown primarily on benches, growers are able to collect all runoff water. In summer months, some growers collect 100% of their runoff water and reuse it. Growers note that they get a more uniform crop with subirrigation, because fertility can be controlled more easily, and water uniformity is better from pot to pot.

The major concern with recycled and reused water is the buildup of salts. Growers therefore test for salinity and nutrients regularly, and then add clear water as necessary to reduce salinity to acceptable levels. Diseases have not been a major problem in the recycled water, but growers are continuing to look at different systems to sterilize the water, and to determine which are needed and cost-effective.

Subirrigation (ebb-and-flow benches, movable trays, etc.) works very well for potted plants, particularly shorter-term crops where salinity accumulation in individual pots is less of a concern. The labor savings with subirrigation are considerable (compared to hand-watering and spaghetti-watering), and subirrigation systems can be linked to other greenhouse environmental control systems for irrigation timing. Many growers are gradually increasing their area under subirrigation, but the high investment cost can be limiting. Growers estimate that payback of installation costs takes five to ten years.

What is driving growers to recycle and reduce water use here? Much the same as anywhere – water itself is becoming increasingly expensive, and in some places in this county, unavailable during summer months. By recycling, growers reduce the amount of water they use, its cost, labor costs, and the cost of fertilizers that they can recover and reuse in the recycled water. Growers also have taken a proactive environmental stance and are minimizing water and fertilizer runoff from their property. San Mateo County growers have a very good history of working with agencies such as the Regional Water Quality Control Board to comply with clean water regulations.

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Santa Cruz & Monterey Counties

Innovative Nursery Stock Growers Recycle Irrigation Water

Suncrest Nursery, Watsonville

In 1991, management initiated a water audit to evaluate irrigation water use at this 43-acre nursery in the Pajaro Valley. Water application, water runoff, drainage flow rate, and pump efficiency were examined. The results of the audit served as a basis of information to prioritize the needs of the nursery. First, the water distribution system needed improvement. The new system was built primarily below ground. At the same time the new system was being constructed, it was convenient to build an underground runoff collection system. Roads were graded so that irrigation runoff ran down the sealed roads to drop inlets in the underground collection system. The water collected in a holding pond. After construction, runoff water was monitored for salts and pH. Through some trials, it was determined that a 2:1 (fresh : recycled) blending ratio was optimum. Water-soluble herbicide use needed to be curtailed. The blended water was still not used on certain sensitive crops, such as ferns, and in liner and propagation areas.

The application efficiency of irrigation water was improved with more uniform water distribution. The installation of automatic timing devices was a key component of that. Automatically shutting down one local system and starting up another resulted in considerable savings of water over manual control.

When Suncrest bought a nearby 22-acre nursery in 1999, now called Sunspot, management planned for an even better water recovery system to be installed while the nursery was being rebuilt. A 6-mil tarp was placed below production beds in order to retain runoff and convey it down the naturally sloping nursery. Until recently, plans to build a collection pond were stalled in the county permitting process. The pond will be built and a gravel bed and aquatic plant filtration system will be installed to lower salts and improve water quality of the recycled water.

Twelve new production acres are being added this fall with the purchase of land across the street from the main nursery. New shade houses are being constructed with water conservation and water recycling in mind. A water recovery barrier and underground drainage system has been installed. It will connect to the water collection systems in the main nursery.

Monterey Bay Nursery, Watsonville

More than 13 years ago, a collection system was built to catch runoff on this nursery of 30 acres on rolling hills. Runoff water from 5 production valleys is moved by gravity, siphon, or pumping to a collection pond. Management estimates that nearly 50% of the applied water is recovered. No water blending is done, but the recycled water is used only on tolerant plants. The water is not sterilized but is sediment filtered through a coarse sand filter. Recycled water is not applied to plants susceptible to *Phytophthora* or sensitive to salts, such as greenhouse crops or those in propagation houses. Monterey Bay Nurseries has not detected any increase in root diseases or fungicide application associated with crops irrigated with recycled water. Water-soluble herbicide use was discontinued.

Phytophthora ramorum Discovered in Pacific Northwest and British Columbia Nursery Stock

Until this spring, infestations in North America of *Phytophthora ramorum*—the causal agent of Sudden Oak Death—were limited to wildland and urban interface situations in 12 counties in California, one county in Oregon, and a single nursery in Santa Cruz Co. However, this spring, *P. ramorum* was discovered in nursery stock at new sites in California, Oregon, Washington, and British Columbia, Canada. An abbreviated timeline follows:

In April, an infected rhododendron was shipped from a Santa Cruz County nursery to an Alameda County nursery. At a second Santa Cruz County nursery, *Camellia sasanqua* 'Bonanza' tested positive. The infected camellia had been shipped from a nursery in Stanislaus County. The first report of *P. ramorum* on *Camellia japonica* and *Viburnum tinus* in the U.S. was confirmed at a nursery in Marin County. The infected plants were adjacent to a stand of *P. ramorum*-infected California bay laurel trees.

In May, two samples of *Camellia sasanqua* 'Bonanza' from a Stanislaus County nursery tested positive for *P. ramorum*. There are no known wild infestations in the county. *P. ramorum* was detected on *Viburnum bodnantense*, *Pieris japonica*, and *Pieris japonica* x *formosa* plants at a nursery in Clackamas County, Oregon. This was the first finding of the European, or A1 mating type of the pathogen in North America, which is genetically distinct from the A2 mating type found in wildland infestations and all previous nursery infestations. As a result of the trace forwards, some infected rhododendrons were also found at a nursery in King County, Washington owned by the same company as the Oregon nursery.

In June, an infected rhododendron plant was discovered in a nursery in British Columbia. The infection at this site was also the A1, European mating type.

More information on *Phytophthora ramorum* can be found by visiting the following links:

www.suddenoakdeath.org

For European information:

www.eppo.org/QUARANTINE/Alert_List/Fungi/oak_death.html.

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Get Cultured – Slow Sand Filtration

By Donald Merhaut, Extension Specialist, Nursery and Floriculture, UC Riverside

In this article and the following series of articles, we are going to stay in the water, so put your wetsuit on! We will discuss the various methods of filtering and sanitizing recycled water, such as sand, chlorination, ozonation, etc. Hopefully, through this series of articles, you will be able to decide which type of water treatment process is right for your production facilities.

Slow Sand Filtration (SSF)

What is SSF? Slow sand filtration (SSF) is a method of filtering water through fine sand (0.15-0.35 mm). Unlike coarse sand (1.0-2.0 mm), finer sands trap some pathogens and also allow beneficial microorganisms to develop on the sand surface, which kill pathogenic bacteria, fungi and certain viruses, thus eliminating the need for chemical control methods such as chlorination.

Introduction. Slow sand filtration for horticultural purposes has been used in Australia and Europe since the early 1990s and for the filtration of drinking water since the 1800s. Research has shown that this type of system, in addition to filtering organic matter and fine debris from the water, also reduces or eliminates pathogens. Filter efficiency is based on 1) sand particle size, and 2) the beneficial microorganisms that develop on the sand surface ('Schmutzdecke'), which actively breakdown pathogens via chemical, physical, and biological means.

Pathogen control. Pathogens can be physically trapped in the fine sand of the filter. The biological/chemical effect is through the beneficial organisms that develop on the surface of the sand. This living matrix has been shown to eliminate pathogens such as *Phytophthora*, *Pythium*, *Cylindrocladium*, *Fusarium*, *Verticillium dahliae*, *Thielaviopsis*, and *Xanthomonas*. For example, in one study with greenhouse-grown tomatoes growing in rockwool, the control of *Phytophthora cinnamomi* in recycled water was 100%, when fine (0.15-0.35 mm) and medium (0.20-0.80) grade sands, rather than coarse sands (0.5-1.60 mm) were used and the flow rates were low (10 cm/h compared to 30 cm/h). Based on this and other studies, flow rates of 100 to 300 liter/hour/meter^2 are recommended. The slower the flow rates, the more effective the system is in trapping and killing pathogens.

SSF Advantages

- Operation costs–low energy costs since the system works through gravity.
- Installation costs–low. Financial outputs are primarily for retention basins.
- Chemicals–no chemicals are required to kill pathogens (most organisms.)
- Technical components–no technical components or control systems.
- Maintenance–low maintenance requirements.
- Adaptability–adaptable to wide range of production systems.
- Pathogen removal–An established SSF, where a biological active film has formed on top of the sand, will remove and/or breakdown pathogens.
- Chemical control–Properly maintained SSFs do not alter the pH of the effluent water.

Disadvantages

- Filtration Time –longer filtration time (0.05-0.55 gpm/ft^2) than rapid sand filtration (2.0-20 gpm/ft^2).
- Labor–occasional cleaning maintenance requires labor.
- Space–requires approximately four times more surface area than rapid sand filtration.
- Herbicide and Pesticide removal–ability to filter or breakdown herbicides and pesticides does not occur. *Note:* Placement of a layer of granular-activated carbon (charcoal) can adsorb certain organic herbicides and pesticides.
- Floating debris removal–larger suspended debris should be removed, so that intervals between cleaning filters is extended.
- Dissolved organic matter–Coloration due to dissolved organic matter and acids is not always removed through SSF.

Structure and Operational Considerations

Housing

The sand filter can be housed in a cement tanks, plastic, or fiberglass drums or containers. *Note:* It is recommended to have two smaller units rather than one large unit, so that one system can be shut off for cleaning, while still having the other unit operating.

Filtration components

Inlet structure. The inlet for untreated runoff water should be constructed so that the sand surface is not disturbed by incoming water.

Water. A constant depth of approximately 1 meter of supernatant water should be on top, the weight of which allows percolation through the sand below.

Stability. The water level should not fluctuate, so that flow rates through the sand column do not change. Variable flow rates decrease filtering performance.

Level. The water level should never go below the level of the sand filter. The water column protects the beneficial biologically active film/filter that develops on the sand surface. High temperatures and drying will kill or impede the activity of the biological filter.

Flow rates. The flow rate should be continuous. Biological filters will die through oxygen starvation in stagnant water.

Organic film – This organic film, called 'Schmutzdecke', is a layer of beneficial microorganisms and organic matter that naturally develop on top of the sand filter bed. This is the key component that filters and/or kills many pathogens.

Sand – A layer of sand 80-150 cm (32-60 inches) deep.

Particle size. Particle size of 0.15 to 0.35 mm is recommended.

Uniformity coefficient. The uniformity coefficient (UC) of the sand should be less than 5, but recommended to be less than 2. The UC = d_{60}/d_{10}, where d_{60} is the sieve size, in mm, that allows passage through the sieve of 60% of the sand (by weight), and d_{10} is the sieve size, in mm, that allows passage through the sieve of 10% of the sand (by weight).

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Get Cultured

Continued from page 10

Granular activated charcoal – optional. This adsorbs most organic chemicals such as pesticides and herbicides. This can be placed in between the sand column. Placed new the surface, the activated charcoal should be replaced when the top layer of sand is replaced.

Gravel bed – a layer of gravel prevents sand from blocking the treated water outlet. In more sophisticated systems, three different graded layers of gravel are used: 2-8 mm, 8-16 mm, and 16-32 mm.

Drainpipe – A perforated drainage pipe is placed in the bottom layer of gravel. Additional filtering can be accomplished with a textile fabric placed over or around the drainage pipe.

Flow meter and control valve – For optimal performance, flow rates should be consistently maintained with the installation of a control valve at the end of the drainpipe.

Operational settings

Filtration rate – 10-30 cm/hr (2.5-7.5 inches/hr). Low flow rates (10 cm/hr) are recommended when control of pathogens such as *Fusarium* are required, while higher flow rates of 30 cm/hr) are suitable for the control of pathogens such as *Phytophthora* and *Pythium*, which are commonly found in nurseries producing containerized woody ornamentals.

Filter capacity – 100-300 L/m²/hr (25-75 gal/yd²/hr).

Maintenance

When flow rates diminish, the upper 1-4 cm of sand are removed along with the biological 'schmutzdecke' layer that developed on the surface. The frequency of this maintenance is based on the cleanliness of the runoff water, water temperature, and amount of water being filtered in a given time period. Cleaning frequency intervals may range from every several weeks to every several months.

Note: With this system and any collection and filtration system that is described, a small pilot system should be fabricated to test the feasibility of use at each nursery site.

Science to the Grower–The Slow Growth of Potted Orchids and Orchid Research

Despite their beauty and high value, potted orchids have never been a dominant component of potted flowering plant production. That may be a mark of our impatient society—orchids grow slowly and require special attention. Likewise, research on orchid cultivation has grown more slowly than that for crops such as chrysanthemums and lilies. Now, however, things may be changing. Potted orchid sales are growing rapidly. The wholesale value of U.S. sales is up 63% since 1998, and orchids now represent 13% of potted flowering plant sales, compared to only 9% in 1998.[1] Research is not keeping pace, but some scientists are trying. Let's review some research on the nutrition of *Phalaenopsis* orchids.

A lot has changed since 1894, when H.A. Burberry asserted that orchids acquire their nutrients from vapors and recommended occasional sprinkling of guano and liquid manure on the greenhouse floor. Still, it took another 99 years for someone to measure uptake of nitrogen fertilizer by orchids. Hew and others found that both terrestrial and epiphytic orchids take up ammonium more rapidly than nitrate. Among their interesting findings was this: Terrestrial orchids take up nitrate-nitrogen at a steady pace of about 50 micrograms per gram fresh weight per day.[2] That's about 0.0001 oz. of nitrogen per day for a big orchid, ten times less than a pot mum's typical diet requires. In a commercial greenhouse, that would add up to an annual fertilizer requirement of about 45 lb. of nitrogen per acre.

According to Yin-Tung Wang's group at Texas A&M, *Phalaenopsis* orchids grow best when fertilized at a rate of 200 ppm nitrogen at each irrigation.[3] Highest yields occurred when plants were fertilized with either a 20-5-19 or 20-20-20 water-soluble fertilizer containing urea and grown in a mix of 70% fine fir bark and 30% peat moss.[4] The peat moss increases water holding capacity enough to retain nutrients for uptake by roots. In earlier work[5], Wang reported that high levels of phosphorus fertilizer are not beneficial, and he recommends a rate of 22 ppm phosphorus in the liquid feed. However, the high concentration of phosphorus in the leachate from the pots is an indication that even 22 ppm phosphorus may be excessive. Since nitrogen and phosphorus fertilizer leaching losses can affect downstream water quality, it will be important to learn more about the nutrition of this increasingly important crop.

[1] Floriculture and Nursery Crops Situation and Outlook Yearbook. Market and Trade Economics Division, Economic Research Service, U.S. Department of Agriculture, FLO-2003, June 2003. (www.ers.usda.gov).

[2] Hew CS, Lim LY, Low CM. 1993. Nitrogen uptake by tropical orchids. *Environmental and Experimental Botany* 33:273-281.

[3] Wang YT, Gregg LL. 1994. Medium and fertilizer affect the performance of *Phalaenopsis* orchids during two flowering cycles. *HortScience* 29:269-271.

[4] Wang YT, Konow EA. 2002. Fertilizer source and medium composition affect vegetative growth and mineral nutrition of a hybrid moth orchid. *Journal of the American Society for Horticultural Science* 127:442-447.

[5] Wang YT. 2000. Impact of a high phosphorus fertilizer and timing of termination of fertilization on flowering of a hybrid moth orchid. *HortScience* 35:60-62.

By Richard Y. Evans, Department of Environmental Horticulture, UC Davis

$2.5 Million Grant Awarded to Flower and Nursery Industry

By Julie Newman, UCCE Farm Advisor, Ventura and Santa Barbara Cos.

The University of California Cooperative Extension will receive a state Proposition 13 grant of over $2,678,000 to address water quality issues in the floriculture and nursery industry. Ben Faber and I (UCCE, Ventura County) are among a team of researchers participating in the project, which includes Don Merhaut, Laosheng Wu, and Jay Gan (UC Riverside); Richard Evans (UC Davis); and Farm Advisor Don Hodel (UCCE Los Angeles County).

The grant will assist Ventura County floriculture and nursery growers in preparing for the soon-to-be implemented regulation of pollution TMDL levels in the Santa Clara River and Calleguas Creek. Other California ornamental producers will also benefit from the grant program through the development of Best Management Practices (BMPs) for specific ornamental crops, as well as through educational training meetings open to growers statewide.

The grant also will establish a cost-share program for improved technologies to reduce runoff, to be managed by the California Cut Flower Commission through a sub award agreement. One million dollars will be earmarked for upgrades of equipment in Ventura and Los Angeles County nurseries by growers who are willing to share the costs. The purpose of the cost sharing is to improve irrigation and sanitation practices, which will both become the focus of regulatory scrutiny after pollutant levels are announced.

Our goal is to assess every nursery in Ventura County that chooses to participate. The initial confidential assessment with a UC Cooperative Extension representative will involve a tour of the facility, a questionnaire about runoff management practices, and a preliminary plan of action to improve efficiency. The assessment takes approximately an hour. The grower may then choose to apply for the cost-sharing program and develop a proposal with assistance by the UC representative.

Program funding can contribute up to 80% of the cost of the improvement project. A committee spearheaded by the CCFC, consisting of ornamental growers from outside Ventura and Los Angeles Counties, and of UC Cooperative Extension farm advisors, will review the proposals and make decisions concerning individual project funding. The UC research team will document improvements after the projects are implemented, and use the data to develop BMPs for specific crops. The new BMPs will be reviewed by a team of grower-stakeholders before inclusion in UC recommendations or in publications.

Growers who are interested in participating in the program should contact Julie Newman promptly, as a goal is to determine which nursery projects will receive funding from the cost-share program before the grant is awarded. Currently, it appears that the State Water Resources Control Board and the University of California will have an executed contract by January 2004.

The Los Angeles Regional Water Quality Control Board is giving Ventura County ornamental growers a chance to self-evaluate and self-regulate. If enough growers cooperate in the project, the industry may avoid "one-size-fits-all" regulations, such as those imposed last year on the greenhouse industry in Carpinteria. Data collected by the researchers will be pooled and used to document the fact that growers are using appropriate BMPs to limit runoff.

Ben Faber, Don Merhaut, Richard Evans, and I previously worked on a grant funded by the Hansen Trust, that examined potential runoff from greenhouses and nurseries in Ventura County. We found only a few nurseries contributing to surface runoff in a preliminary survey. The Proposition 13 project will benefit these growers by providing an opportunity to implement recycling systems—systems that growers may not be able to afford otherwise.

Though many growers are contributing little to surface runoff, they still may be contributing to potential groundwater contamination, an issue that will soon come under scrutiny by regulators. The Proposition 13 project provides an opportunity for these growers to prepare for increasing regulations, by allowing them to implement systems and practices that can tighten their irrigation distribution systems, and concentrate on greater efficiency.

This grant is one of the largest ever awarded to the agriculture industry. Assistance of money and technical support is targeted to ornamental producers because of the intensive nature of flower and plant production. The tools of the ornamental industry are water, plant nutrients, and chemicals— all of which must be employed to meet the demand for plants that are of high aesthetic quality, yet competitively priced.

For more information or to request an assessment, contact me at 805/645-1459 or at jpnewman@ucdavis.edu.

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Compiled by Ann King

***Labor Management in Agriculture: Cultivating Personnel Productivity*, second edition**; from the UC Agricultural Issues Center; suggests ways agricultural employers can cultivate greater productivity and reduce employee turnover. It covers the use of practical tests in hiring, incentive pay, different pay structures, performance evaluations, interpersonal conflicts, and employee discipline. The book focuses on management techniques rather than on legal requirements. The publication is available in English (2nd Edition, 248 pp.) and Spanish (International Edition, 262 pp.). The book can be viewed on the Internet at http://www.cnr.berkeley.edu/ucce50/ag-labor/. It costs $12.50 plus tax and shipping, and can be ordered through the UC Cooperative Extension office in Stanislaus County at 209-525-6800 or eresendez@ucdavis.edu.

Aquatic and Riparian Weeds of the West, publication number 3421 is now available from the University of California. The authors are Joseph M. DiTomaso and Evelyn A. Healy. Price is $40, 442 pages. Call the ANR Publications office at 800-994-8849, or http://anrcatalog.ucdavis.edu

A Guide to Agricultural Heat Stress, from UC Cooperative Extension, is available at http://ucce.ucdavis.edu/files/filelibrary/742/10181.pdf

So You Want to Start a Nursery is a new book from Plant Delights Nursery founder Tony Avent. The 340-page, hardcover book is a realistic explanation of what it takes to start a nursery, administrative concerns like insurance and taxes, and the merits and disadvantages of retail, wholesale, mail-order and liner operations. The $24.95 book has 105 black and white photos, and includes a subject index, bibliography, metric-and-back conversion chart, U.S. ports of entry for plants, state and regional nursery associations, and Helpful Sources of Information. mail@timberpress.com; http://www.timberpress.com

***Specialty Cut Flowers*, second edition**, by Allan Armitage. This revised and enlarged edition offers an improved A-Z format, updated information to fit the times, and "real world" comments from the growers themselves. Judy Laushman, executive director of the Association of Specialty Cut Flower Growers, is coauthor.

UNH FloraTrack for Poinsettia; a new version of the Excel-based software is provided for free by Paul Ecke Ranch at http://www.ecke.com/new1/poin/points_tech_graph_track.asp. The program is for graphical tracking of poinsettia.

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Postharvest Update–*Alstroemeria* Cultivars Show Differences in Leaf Yellowing & Flower Longevity

Michael S. Reid, Professor Dept. of Environmental Horticulture, UC Davis

Alstroemeria have become a staple flower for bouquet arrangements because of their range of colors and long-lived flowers. One frustrating aspect of using *Alstroemeria* is that the leaves often turn yellow many days before flower senescence rendering the stems unsightly or requiring stripping of the leaves. Dr. Reid and EH's professor emeritus, Wes Hackett, combined forces with Dr. Antonio Ferrante of Italy's Scuola Superiore di Studi Universitari e di Perfezionamento, and Dr. Donald Hunter of the New Zealand Institute for Crop and Food Research, to determine the patterns of leaf and flower senescence on cut stems of a large number of Alstroemeria cultivars provided by Mellano Wholesale Florists.

They found wide variation in the rate of leaf yellowing and petal fall among the 20 cultivars tested. Leaf yellowing was visible within 5 days for cultivars such as 'Cuba,' 'Saba,' 'Petra,' and 'Tamara.' In contrast, no leaf yellowing was seen in the cultivar 'Rio' until the flowers had been in the vase for 18 days. The time to first petal fall varied from 10 days for 'Cuba,' 'Tamara,' 'Petra,' and 'Rio,' to 17 days for 'Tiara' and 'Jubilee.' No relationship was found between the time to leaf yellowing and petal fall for the cultivars tested.

Over half of the *Alstroemeria* cultivars tested showed yellowing of the leaves before the start of floral senescence. Future breeding programs could greatly improve the postharvest performance of these flowers by selecting for both flower and leaf longevity.

TDZ (thidiazuron) prolongs green leaves in *Alstroemeria* and other ornamentals

Dr. Reid and Dr. Hackett teamed up again with Dr. Ferrante and Dr. Hunter for further study of *Alstroemeria* to determine the effect of various chemical treatments on delaying leaf yellowing in cut stems. It is widely known that treatment with such plant hormones as gibberellins and cytokinins can delay leaf senescence and commercial products containing these compounds are available for use with *Alstroemeria*.

Thidiazuron (TDZ) is registered as a herbicide and defoliant and has high cytokinin-like activity. Dr. Reid's group showed that a vase solution containing 1 μM TDZ delayed leaf yellowing for over 70 days on cut *Alstroemeria* stems but had no effect on flower longevity. More useful in a wholesale setting, the group found that a 24-hour pulse treatment in a solution of 10 μM or greater TDZ also afforded protection from leaf yellowing for as long as 60 days.

Research with TDZ in Dr. Reid's lab on other ornamental crops has shown this compound to be highly effective in preventing premature yellowing of leaves of other cut flowers such as lilies, stock, tulip and iris. Potted flowering plants such as poinsettia and miniature roses also benefited from treatment with TDZ as a foliar spray. Since TDZ is already registered in the US as an agricultural chemical (for defoliation of cotton under the name "Dropp") its extraordinary efficacy at low concentrations makes it a potentially less expensive commercial treatment for delaying leaf senescence in many species. ❖

Pathogen Control

Continued from page 1

number and power of the lamps within the chamber (which affects radiation intensity) and water flow rate through the chamber (which affects exposure time). It is important to know that the UV radiation intensity decreases sharply with increasing distance from the lamp. This is why large chambers have multiple lamps inside. This is also why it is important that water flow through the chamber be rapid enough to create turbulence that will carry microbes close to the lamps.

UV lamps can be very effective, killing fungal spores in a matter of seconds. The disadvantages of UV are:

1. There is no residual activity that continues to act against microbes as water moves out into the irrigation system (as occurs with chlorine or ozone treatments). All treatment action is confined to the UV lamp chamber.

2. Dissolved organic matter (which often gives irrigation drain water an amber coloration) or sediments block UV, thereby shielding microbes and degrading treatment efficacy.

3. UV light will break down iron chelates in hydroponic nutrient solutions.

Chlorination. Chlorine is one of the best known of the oxidizing biocides (which also includes chloramine, chlorine dioxide, ozone, bromine, bromamine, and some bromine-containing compounds). These chemicals act, in part, by degrading proteins needed for cell membrane function or physiological activity by microbes. Experiments have shown that fungal spores can be killed following 10- to 15- minute exposure to a 2 ppm solution of chlorox (NaOCl).

While chlorination has been used to effectively treat recycled irrigation water, chlorination systems have not been widely adopted as a treatment technology because chlorine gas (the cheapest form) is extremely hazardous. While there are safer forms of chlorine available (tablets and liquid) they are more expensive than gas. Chlorine also reacts with (oxidizes) organic residues in water, forming products with reduced microbicidal activity (e.g. chloramines). Thus, water must either be partially purified (to remove organic contaminants) or additional chlorine must be added to compensate for the "chlorine demand" of the water. Also, with prolonged usage on long-term crops, there is risk of phytotoxicity and a need for managing the build-up of chloride salts.

Ozonation. Like chlorine, ozone is a strong oxidizing agent that essentially degrades protein activity required for membrane function and physiological processes. Ozone is typically produced by passing air (or oxygen) through a corona discharge generator to produce O_3 from O_2. Ozone is then bubbled into the water so that it can dissolve and disperse. Experiments have shown that fungal spores in irrigation water are killed by exposure to 0.5 ppm ozone for 20 minutes.

While highly efficacious, the oxidizing power of ozone is degraded by organic residues and other contaminates in water that react with ozone, leaving less available to kill microbes. Thus, greater amounts of ozone may need to be produced to compensate for the "ozone demand" of the water. Also, to achieve the needed exposure times, it is necessary to install large holding tanks that the treated water passes through before moving out into the irrigation system. The size or number of tanks is determined by peak pumping demand.

Heat treatment. Heat is a well-known method for killing microorganisms—it coagulates proteins and fatally disrupts metabolic processes. In the Netherlands, heat has been used to disinfect water recirculated in some hydroponic systems. All living organisms are sensitive to heat, so this is an efficacious method, but one that involves a different set of technical challenges.

One challenge is the cost of energy to heat water. This can be mitigated to a certain extent by use of heat exchangers that cool treated water before it goes out to the crop, and heats incoming water before it goes to the boiler. It also may be necessary to partially purify irrigation water before treatment, since soluble impurities could precipitate or coagulate at the requisite temperatures, fouling the heating systems.

Filtration. Microfiltration has been used to eliminate fungal propagules from nutrient solutions in hydroponic systems. However, this method is not feasible for nursery use since the filters that would effectively remove zoospores, microconidia, or bacteria from water would foul quickly and require a high level of maintenance. Slow filtration of water (by percolation through deep columns of sand) however, has been used effectively in some greenhouse operations because they can effectively remove small propagules without plugging. However, the volumes of water delivered by such systems are relatively small, limiting their application to small-scale operations. *(Editors note: See Don Merhaut article, pg. 10.)*

Summary. There is no single solution that can be applied to the many different growing systems used in ornamental production. Each technology has distinct advantages and disadvantages, and careful consideration must be given to them. It also is critical to have effective water monitoring methods to continually assess the efficacy of a treatment against pathogens of concern. That is the only way to assure quality.

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CORF

Floriculture education from the Kee Kitayama Research Foundation

CORF News is the quarterly publication of CORF, the California Ornamental Research Federation, a statewide partnership of growers, floriculture associations, allied industry and researchers/educators whose mission is to identify and meet the research and educational needs of the California floriculture industry.

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Calendar of Industry Events

October
5 .... CSFA Annual Event & Top Ten Competition, Newport Beach, 916/448-5266
9 .... CORF ABCs of Horticulture (Spanish only), Half Moon Bay, 831/724-1130
23–25 . WF&FSA Floral Expo, Atlanta, GA, 410/573-0400
28 .... CORF Disease Symposium, Watsonville, 831/724-1130

November

December

January
28 .... CORF Hands On Irrigation Training, Somis, 831/724-1130

February
20–22 . SAF Pest Management Conference, San Jose, 703/836-8700

March
15-16 .. SAF Congressional Action Days, Washington, DC, 703/836-8700
31 .... CORF Hands On Irrigation Training, Oxnard, 831/724-1130

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