CORF news

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FLORICULTURE EDUCATION FROM THE KEE KITAYAMA RESEARCH FOUNDATION

Irrigation Efficiency is the Key to Controlling Runoff

By Richard Evans, UC Cooperative Extension, Davis

California's greenhouse and nursery crop producers have been exposed to many management practices designed to promote stewardship of water quality. Growers can optimize the amounts of fertilizers and pesticides applied, control sediments in water, and treat runoff water. Perhaps the most important step a grower can take is to maximize irrigation efficiency. Nurseries that irrigate efficiently will have less runoff, and therefore less of a problem to manage.

Irrigation efficiency refers to the amount of water consumed by the crop relative to the total amount applied. An irrigator who wants to maximize irrigation efficiency must apply the proper amount of water uniformly over the target plants at the right time. This requires answers to the following three questions.

How Much Water do the Plants Need?

The main job of an irrigator is to satisfy the thirst of the crop, but few really know how much water is needed to do this. The quantity depends on plant size, environmental conditions, and spacing, so exact requirements will vary. Some typical values are given in Table 1. Note that few plants in 6-inch or gallon containers need more than a cup (8 oz.) of water per day, and most need even less.

Growers can easily refine this information for their own crops and conditions by measuring the change in weight of a pot containing the crop plant between irrigations. The difference in weight, in ounces or grams, represents

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Preventing Clogging in Microirrigation Systems

by Larry Schwankl, UC Cooperative Extension, Kearney Ag Center

Introduction

Clogging of the passageways in drip emitters and microsprinklers is a frustrating and difficult problem for microirrigation users. Because most drip emitters are a sealed unit, once plugged, replacement is the only alternative. This is time-consuming and costly, and if the clogged emitter(s) is not detected in time, the vegetation it was supposed to be watering may die. Clogging and maintenance issues are the most common concerns expressed by those who have tried drip irrigation and given it up.

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Weidner's Gardens Reflects on Impacts of Modifying Water Runoff Management Practices

by Karen L. Robb, UC Cooperative Extension, Mariposa

Oliver Storm, head grower of Weidner's Gardens, was responsible for evaluating the water runoff situation several years ago, when all greenhouses within the City of Encinitas were notified that they would have to eliminate any runoff leaving their property and entering a storm conveyance system. Oliver's first step was to determine where the runoff water was going, which was the San Elijo Lagoon. He also determined that a great deal of

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Editor's Note:

This issue of CORF News focuses on irrigation issues. A featured article by Larry Schwankl (UC Kearney Ag Center) addresses preventing clogging in drip irrigation systems. Richard Evans (UC Davis) addresses issues on improving irrigation efficiency. Karen Robb discusses changes in irrigation practices at a Southern California nursery made to nearly eliminate water runoff from the nursery. Each Advisor's regional report contains information on local irrigation matters.

- Steve Tjosvold, Editor, CORF News

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the amount of water used, in ounces or milliliters, respectively. It is best to weigh several pots distributed throughout the growing area, if possible.

How Much Water is Needed for Leaching?

Crops usually grow poorly if soil water is very salty. Problems can develop from high total salts, as indicated by elevated electrical conductivity values, or from specific ions, such as sodium, chloride, or boron. Salts can be removed from irrigation water by reverse osmosis or deionization, but treatment is expensive. A cheaper alternative is to leach salts, but this can increase runoff. Many short-term crops (3 months or less) can tolerate salt accumulation without obvious effects, but most crops require leaching. This is best achieved on ornamental crops by applying the proper leaching fraction. This is the ratio of the volume of water leached (for example, the water that runs out of the bottom of a pot) to the volume of water applied (for example, the total amount of water applied to a pot). The proper leaching fraction depends on the salinity of the irrigation water (including fertilizer, in a liquid feed program) and the salinity sensitivity of the crop. In general, ornamental crop producers in California should apply leaching fractions between 0.2 and 0.3. In other words, 20-30% of the irrigation water is applied just to leach out salts. For the 6-inch mum in Table 1 that requires 8 oz. of water each day, another 2-3 oz. would be needed daily to satisfy the leaching requirement.

Table 1. Typical daily water use of ornamental crops in California. Actual values will depend on plant size and environmental conditions.

CROP	WATER USE	
	ml per day	oz. per day
Acorus 'Ogon' (1 gallon, outdoor shade)	140	5
Aucuba japonica (1 gallon, outdoor shade)	100	3.5
Camellia 'Winter's Star' (1 gallon, outdoor shade)	100	3.5
Chrysanthemum (6-inch)	240	8
Dietes vegeta (1 gallon, outdoor)	130	4.5
Holly (1 gallon, outdoor shade)	140	5
Hydrangea (1 gallon, outdoor shade)	340	11.5
Hydrangea (6-inch, greenhouse)	175	6
Impatiens (4-inch, greenhouse)	100	3.5
Juniperus scopulorum 'Moonglow' (1 gallon, outdoor)	140	5
Lantana 'Pink Caprice' (1 gallon, outdoor)	200	7
Lavandula dentata (1 gallon, outdoor)	160	5.5
Magnolia grandiflora (5 gallon, outdoor)	340	11.5
Nandina domestica (1 gallon, outdoor shade)	120	4
Pelargonium (6-inch, greenhouse)	175	6
Penstemon 'Red Rocks' (6-inch, greenhouse)	150	5
Pistacia chinensis (5 gallon, outdoor)	580	20
Platanus racemosa (5 gallon, outdoor)	940	32
Prunus ilicifolia (5 gallon, outdoor)	250	8.5
Quercus agrifolia (5 gallon, outdoor)	260	9
Quercus lobata (5 gallon, outdoor)	335	11
Rhododendron (1 gallon, outdoor shade)	200	7
Rose (mature greenhouse plant for cut flowers)	400	14
Sequoia sempervirens (5 gallon, outdoor)	390	13
Weigela 'Variegata Nana' (1 gallon, outdoor shade)	160	5.5

How Uniform is Water Distribution?

In an imperfect irrigation system some sprinklers or emitters put out more water than others, so some plants receive more water than others at each irrigation. Measuring irrigation uniformity—distribution uniformity (DU) for overhead systems, emission uniformity (EU) for drip systems—gives irrigators two important pieces of information. First, it provides a measure of how good the system is. Second, the measured uniformity helps

Simple instructions for measuring DU and EU are widely available. The general concept is to measure the amount of water applied throughout the irrigation system, then divide the output of the places receiving the least water (usually the average of the lowest quarter of all values) by the overall average output. The resulting value tells how much the lowest quarter of plants receive compared to the average ones. In a perfect system, DU is 1.0. If DU is 0.6, then the lowest quarter of the plants get only 60% as much water as the average plants and, to irrigate properly those plants in the lowest quarter, the system must be run longer than is needed to irrigate the average plant. How much longer? Divide the application time needed for the average plant by the DU to get the answer. Figure 1 illustrates how irrigation uniformity affects the application time. A DU of 0.5—not unusual in nurseries—means that the system must run twice as long as a perfect system.

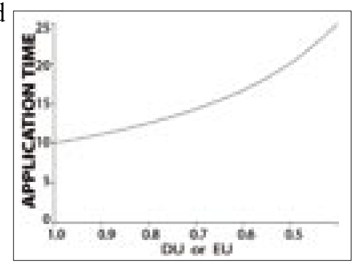

Figure 1. Effect of irrigation uniformity on required application time.

There are simple ways to improve irrigation uniformity. For example, using better nozzles (and making sure all are the same type), repairing leaks, and eliminating sources of large pressure drops can eliminate many problems in irrigation systems. Is it worth the effort? Look at Table 2, which compares the irrigation requirements of four hypothetical nurseries that differ in either water quality, distribution uniformity, or both. Even in most good systems, only about 75-80% of applied water is used by the crop. Poor water quality knocks that efficiency down a bit more because of the greater leaching requirement, but a low DU sends irrigation efficiency down to 40% or less. That means money down the drain—literally—and a management headache. Take the time to improve irrigation efficiency and your problems will evaporate.❖

Table 2. Hypothetical irrigation requirements (in ounces) for a 6-inch chrysanthemum plant in four different nurseries varying in water quality and irrigation uniformity. Irrigation efficiency is the percentage of applied water that is actually used by the plant.

	GOOD SYSTEM		POOR SYSTEM	
Water needed for:	Good water	Poor water	Good water	Poor water
Plant	8.0	8.0	8.0	8.0
Leaching	1.4	3.4	1.4	3.4
"Dry" spots	1.0	1.3	9.4	11.4
Total applied	10.4	12.7	18.8	22.8
Irrigation efficiency	77%	63%	42%	35%

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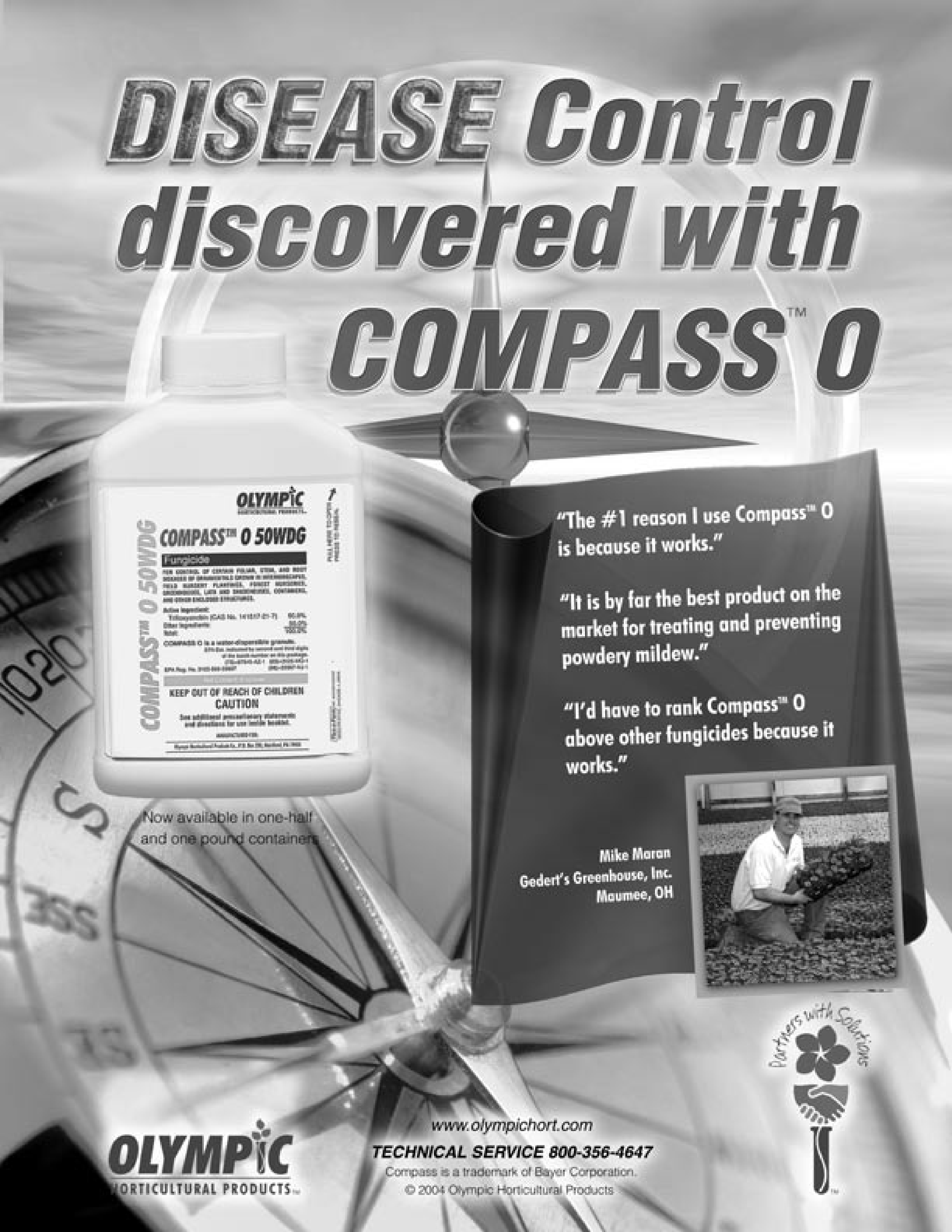

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Preventing Clogging cont. from page 1

Causes of Clogging

Clogging is often the result of a combination of factors but it is helpful to break the factors down and discuss the indicators to head off problems. Often, a water test can prepare you for problems and help diagnose a treatment. Three types of microirrigation clogging include: particulate clogging, biological clogging, and chemical precipitate clogging.

Particulate Clogging

Many irrigation waters, including those from groundwater, have small sand, silt, or clay particles suspended in them. The water may also be carrying small rust flakes or other contaminants from the conveyance pipeline. While these particles are often very small, they may still clog the drip passageways by themselves or in combination with other particles.

Biological Clogging

Biological contaminants – algae, bacterial slimes, etc. – can also clog microirrigation systems. They may also provide the "glue" to catch and bind particulate matter together; making the clogging hazard worse. Biological clogging problems are most often associated with surface waters (waters from rivers, ponds, reservoirs, etc.), but they can occur with groundwater sources. Some of the bacterial slimes do not need sunlight to flourish so growth may even occur in pipelines below ground. In addition to being in the water, the biological contaminants may grow in the microirrigation system where the heat and humidity are conducive.

Chemical Precipitate Clogging

Chemical precipitate clogging is often associated with groundwater sources. Under the right conditions, elements in solution in the water may precipitate and clog emitters. The most common chemical precipitate is calcium carbonate (lime) but other compounds such as iron, manganese, magnesium, and phosphate precipitates may also precipitate. A water analysis is very useful in heading off any potential chemical precipitate problems. Injection of chemicals, which add new sources of precipitates or change the water pH, may also result in chemical precipitate clogging so injections should be done cautiously.

Problem	What to Watch For	Treatment
Precipitate clogging	Small sand or other particles suspended in the water.	Good filtration using screen, disk, or sand media filters.
Pond or reservoir algae	Greenish tint to water or visible biological growth in the water.	Copper-based products added to the pond. Chlorine injection into microirrigation system at 1 ppm* continuously, or 5-20 ppm* periodically (every 2-4 weeks). Good filtration, often with sand media filters.
Bacterial slimes	Slimy coating inside pipe, tubing, and emitters. Water source is often surface water (river or stream, canals, reservoirs, etc.).	Chlorine injection into microirrigation system at 1 ppm* continuously, or 5-20 ppm* periodically (every 2-4 weeks). Good filtration, often with sand media filters.
Carbonate precipitation (most common with calcium forming lime)	White precipitate. HCO_3 (bicarbonate) levels of 2.0 meq/l or higher and pH of 7.5 or greater.	Continual acid injection to microirrigation system, maintaining pH = 5 to 7, for worst cases. Less severe cases may be mitigated injecting acid for the last 60-90 minutes of irrigation, maintaining a pH of approx. 5.
Iron precipitation	Reddish staining common. Iron concentrations of 0.5 ppm or greater in water. More severe problems when iron levels are above 1-2 ppm.	Aeration of the irrigation water followed by settling in a reservoir or pond. Use good filtration, often with sand media filters.

* Chlorine levels measured with a pool/spa test kit at the end of the last lateral line.

Common Problems and Solutions

The table lists some of the common microirrigation clogging problems, risk factors, and treatments.

Flushing

Flushing contaminants from sub-mains and especially from lateral lines, is extremely important in reducing clogging problems. Significant amount of particulate matter (silts and clays) which pass the filters because they are so small, precipitated chemicals, and biological contaminants may settle at the ends of lateral lines. These contaminants should be flushed out by opening the lateral lines, a few at a time, allowing them to flow until running clear. It should not take more than a minute or so for the lateral lines to flush clean. If it does take longer, flushing should be done more frequently. Start by flushing at a 2-3 week interval. If the lateral lines seem very dirty, flush more frequently. If they appear relatively clean, stretch out the interval between flushing.❖

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Improving Irrigation Systems is the Key to Water Conservation in Greenhouse Cut Flower Production

by Steve Tjosvold, UC Cooperative Extension, Santa Cruz and Monterey

This regional report consists of excerpts from a California Agriculture article I helped write several years ago. The findings are still applicable today.

Abstract

In our evaluation of 23 micro-irrigation systems used in greenhouse cut flower production, the systems' ability to apply water uniformly varied widely. The most common type of irrigation system, the perimeter system, generally applied water more poorly than other tested systems. Center riser systems generally were very uniform. Drip irrigation systems generally applied water most uniformly. Many perimeter irrigation systems could be retrofitted to improve water distribution, with 1-inch rather that 3/4-inch diameter laterals or with inlets in the middle rather than the end of the bed. All irrigation systems could be improved with a regular maintenance program consisting of clearing particulates and rust from the irrigation pipes. Other possibilities for retrofitting specific systems are described in this article.

Introduction

The Monterey and Santa Cruz County Cooperative Extension Service and Monterey County Water Resources Agency conducted a joint project to evaluate irrigation system effectiveness in applying water efficiently in greenhouse cut flower production. Growers received individualized reports that made specific recommendations to improve their irrigation systems and, with this report, some conclusions are made in regards to irrigation system design, retrofitting, and maintenance that influence the uniformity of those systems.

Results of Irrigation System Performance

Table 1. Uniformities of the irrigation systems, the typical ranges of pressures found in a typical lateral, and an estimate of plugging problems of greenhouse cut-flower irrigation systems.

SYSTEM TYPE	Distribution Uniformity (DU)	Pressure Range (psi)	Degree of Plugging
Drip	96%	35-35	Very Low
Drip	95%	34-38	Very Low
Perimeter Spray	90%	6.5-8.5	Medium
Drip	89%	34-37	Low
Perimeter Spray	88%	6.5-7	Medium
Center Riser	87%	26-33	Very Low
Center Riser	87%	26-39	Very Low
Perimeter Spray	84%	13.5-17	High
Center Riser	80%	9.5-14	Very Low
Perimeter Spray	76%	5-9	Very Low
Perimeter Spray	73%	2-4	Low
Perimeter Spray	72%	9-10	Medium
Perimeter Spray	72%	7-11	Low
Perimeter Spray	69%	3-12	Very Low
Perimeter Spray	69%	9.5-12	High
Perimeter Spray	69%	2-4	Low
Perimeter Spray	69%	4-14.5	Low
Perimeter Spray	64%	4-7	Medium
Drip	64%	4-7	High
Perimeter Spray	62%	4.5-13	High
Perimeter Spray	57%	14-35	High
Perimeter Spray	56%	16-26	High
Perimeter Spray	51%	8-15	High

Needed: Increased Awareness of Irrigation System Performance

On average, the greenhouse irrigation systems evaluated rated only "fair" and 10 of the 23 systems rated "poor." While most flower growers are very observant, irrigation system performance is not something that can easily be seen; it must be measured and quantified. Once the results of the evaluation were shown to the growers, they were quick to make improvements such as resetting pressure regulators, or adjusting automatic timers.

Unfortunately, one major cause of low DU in many systems was that the pipe sizes were too small for the application rates used, and this problem cannot be solved without some expensive retrofitting of the systems. Generally, in retrofitting or in new installations, lateral pipe diameter could be increased from 3/4-inch to 1-inch and the lateral inlet could be placed in the middle instead of at the end of the bed. Some systems could economize by using 1-inch lines in the first half of the bed and finish off the last half of the bed with 3/4-inch pipe. Another solution is to install drip irrigation, which, in our survey, can provide excellent irrigation uniformity without plugging. The lower operating costs resulting from higher uniformity, lower operating pressure, and reduced fertilizer needs could make retrofitting some systems economical. Growers need to have a better understanding of irrigation system design, and how it relates to total operating costs so that they can make informed decisions when deciding to retrofit their system or when selecting the design of a new irrigation system.

Although not quantified in this survey, it is apparent that timing devices rather than manual operation of solenoids could significantly improve uniformity. It was noted many times that a worker operating the solenoid valves was distracted and thus not keeping an eye on the timing of the irrigation.

Although not common, pressure compensating valves along water mains, when they are set properly, could significantly increase uniformity.

Plugging of the outlets was the other major cause of low uniformities. The mainlines in most of the systems were iron pipe and as a result often rust flakes were found plugging emmiters. Chemical precipitates and sand were often the cause of plugging in other systems. Only the drip systems utilized water filtration and the overall higher uniformity of these systems demonstrates the value of filtration. A regular maintenance program including chemical treatment and flushing of the laterals will also help keep systems clean and reduce plugging without the damage often caused by manual cleaning.

Uniform water application does not guarantee a high level of irrigation efficiency because it is still possible to apply too much water even if water is applied uniformly. The grower, in addition, must know the water use requirement of the crop and the irrigation system's application rate to estimate the correct amount of water to apply.❖

Excerpted from the following article: Schulbach, K., S. Tjosvold, D. Kasapligil. 1999. Improving Irrigation Systems Conserves Water in Greenhouse-grown Cut Flowers" California Agriculture, March-April. The full article available by contacting Steve Tjosvold.

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Irrigation Practices in Ventura County Nurseries

by Julie P. Newman, UC Cooperative Extension, Ventura and Santa Barbara

Ventura County nursery managers were asked to complete a 142-question survey, *Checklist for Assessing and Mitigating Runoff in Greenhouses and Nurseries,* compiled by the UCCE Clean Water Team (Julie Newman, Ben Faber, Kristine Gilbert, Michi Yamamoto, Eric Green, Laosheng Wu, Jay Gan, Don Merhaut, Richard Evans). There are approximately 140 wholesale production nursery operations in Ventura County and the returned surveys so far represent half.

In this report, I will summarize the results from the irrigation and leaching portions of the questionnaire, which represent a "snapshot" of the types of systems and management practices used by county flower and nursery growers.

Most nursery managers understand the value of testing the irrigation water before it is applied and use this information to help maintain good plant health, avoid problems associated with poor water quality, and to develop appropriate fertilizer management programs. Irrigation water quality is monitored by two-thirds of Ventura County nurseries, although only about half of the nurseries keep records.

Most nurseries regularly maintain their irrigation systems, including inspecting for leaks, flushing clogged lines and emitters, and cleaning filters. However, less than one-third of the nurseries periodically evaluate irrigation uniformity.

A uniformity evaluation measures the capability of an irrigation system to evenly deliver water. Systems with low uniformity will typically overwater some plants to provide adequate water to other plants. This is one area where improvements could be made. For example, in an earlier UC study of six Ventura County nurseries with overhead systems, only one nursery had a distribution uniformity over 80%.

In addition, pressure compensating emitters are only used in one-third of the nurseries; pressure differences at the top and bottom of the slope are compensated for in less than half of the nurseries with sloped terrain. Maintaining appropriate system pressure is an important step in increasing overall irrigation uniformity.

The majority of the nurseries who use overhead irrigation only do so in areas where pots or plants are spaced closely to minimize the potential of runoff and groundwater contamination from watering bare areas. However, one-third of the nurseries that use overhead systems are unable to deliver uniform irrigation without creating overspray on walkways and edges. Although many nurseries still rely on hand-watering, most do so with the use of an on-off mechanism to prevent runoff.

Most nursery managers properly correlate emitter use with plant type and pot size to avoid contributing to runoff. The majority of nurseries with spray-stakes and drippers use appropriate flow rate for each watering zone, use the same flow-rate in each watering zone, manage the area to make sure each stake/dripper is in a pot, and if it is not, make sure that it is turned off.

Most nurseries correlate irrigation schedule with plant moisture requirements but do not modify schedules based on evapotranspiration (ET), solar, or other collected environmental data. Measuring water use through pot weights or measuring soil moisture with tensiometers or other instruments is typically not used. Over 90% of the nurseries maintain staff that is specifically trained in irrigation scheduling and most rely solely on staff experience to judge when to water.

Half of the nurseries use time clocks, and most managers regularly adjust them to correlate irrigation schedules with environmental conditions and plant growth stage.

Automatic timers are useful in implementing more complicated irrigation schedules such as pulse irrigation, a practice that can reduce the applied water by irrigating in smaller increments that are more effectively used by plants. However, pulse irrigation is used in less than 10% of the nurseries.

Leaching is necessary to flush excess salts from the root zone, but excessive leaching or leaching too frequently will contribute to runoff and groundwater contamination. Only about half of the nurseries use EC of root media or leachates to determine leaching practices as part of the irrigation schedule. Less than half of them set irrigation schedules to perform leaching at specific irrigation events rather than every time they irrigate. Leaching only with fertilizer injectors turned off is not typically utilized. The optimum amount of leaching is 10-15%, but only one-fifth of nurseries report that they measure the leaching amounts.

By maintaining a uniform irrigation system, proper scheduling and proper leaching, surface and groundwater pollution can be reduced. To help growers improve irrigation techniques we are conducting quarterly water quality educational meetings, many of which address irrigation management. Currently, CORF is conducting a series of six irrigation seminars, three in English and three in Spanish. The Clean Water Team is also providing irrigation information at on-site visits to local nurseries. Next year, at the end of the current program, nursery managers will again be asked to take the survey so that improvements in irrigation management can be documented.❖

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Ag Water Quality Research and Education Program

by Karen L. Robb, UC Cooperative Extension, Mariposa

Dave Shaw and Valerie Mellano are continuing the Ag Water Quality Research and Education Program to assist growers in complying with water regulations. Through this program, many tools have been developed to assist growers in developing their own site-appropriate water runoff management practices. For example, at the **http://cesandiego.ucdavis.edu** website, growers can download PDF versions of the following materials:

- Self-Assessments for Greenhouses and Nurseries
- Ag Water Quality Record Keeping materials
- Management Options for Non-Point Source Pollution for the Greenhouse and Container Crop Industries
- Employee Training Modules in English or Spanish (10 training modules each)

The Self-Assessment is a tool growers can use to assess the strengths and weaknesses of their current irrigation/runoff management strategies. This is also the first step when an individual consultation is conducted. This includes noting the type of equipment (all of it) on a location, and mapping the location. Identifying the crop(s) and where the roots are in the growing media is next. The following step is to turn on the irrigation system and look for leaks and obvious problems.

After several years of conducting the Ag Water Quality Research and Education Program, many trends have become apparent. Hardware maintenance, or more specifically, the lack of hardware maintenance is generally a major issue. A common problem is missing emitters/spaghetti tubing. The resulting holes produce a striking water show with each irrigation event, in addition to a significant loss of water. Another common problem with potted plants is that when a plant is removed from the bench, either due to spacing, plant death or harvest, the emitter is left to hang below the bench and below the pipe. As a result, when the irrigation is complete, water drains out of the system at this low point. Not only is water lost due to drainage, but the entire system has to recharge, so the emitters at the end of the system will deliver less water than emitters closer to the main. Addressing both of these situations involves educating the workers about the importance of repairing leaks as well as the need to keep emitters at or above the level of the pipe. Another option is to replace the current emitters with ones having low pressure check valves.

The next step in our program is to conduct an irrigation uniformity evaluation. What is irrigation uniformity? It is the term used to describe how evenly water is applied to a crop. It is an important consideration in this program because growers will water to the driest plant or pot. If the irrigation uniformity is poor, growers will overwater most of their plants in an effort to adequately water some of their plants.

Distribution uniformity is probably the most common uniformity statistic because it is easy to calculate. Distribution uniformity can be measured using catch cans or other volumetric containers. Twenty (or more) measurements are taken by: a) quantifying the time it takes each emitter to deliver a certain volume, or b) quantifying how much water is delivered by each sampled emitter for a given time. After making the measurements, the average is calculated by adding the measured amounts and dividing by the number of measurements. The average of the 'low quarter' is determined next by identifying the lowest 25% of the measurements. If 20 measurements were used, then the low quarter consists of the five smallest measurements. The Distribution Uniformity value (DU) is calculated as: DU=100 X (average of the 'Low Quarter'/Average of All Measurements).

Ideally, we would like to see irrigation uniformity ranges of 80-90%. Over the years, typical first time evaluations in greenhouses with a drip system were 40% or less.

In the next issue, I will discuss what growers can do to improve irrigation uniformity.❖

Field Observations:
Rattlesnake season is upon us…

Rattlesnakes are the only venomous snakes in California. Rattlesnakes are heavy-bodied with a broad triangular head, slender neck and vertically elliptical eye pupils. The rattle at the end of the tail is not present on any other snake species. When disturbed, rattlesnakes vibrate the rattle, but they do not always rattle before striking.

There are several precautions one can take to avoid being bitten by a rattlesnake. Most snake bites are on the lower leg or foot, so it's a good idea to wear heavy socks and high boots with pant legs outside the boots. Make it a habit to look carefully before stepping, jumping, sitting, or lying down. Look before stepping from bright areas into shade. Don't reach into rodent burrows, hollow logs, or other openings that might contain snakes. If you hear a rattlesnake, stand still until you are sure of its location. Avoid running or jumping blindly; snakes will usually retreat if given a chance.

Don't handle venomous snakes unnecessarily, even when a rattlesnake's head is severed from the body, the head can bite and inject venom by reflex action up to an hour or more after death. If you kill a rattlesnake, sever and bury the head to avoid this hazard.

*If you are bitten by a rattlesnake, **call 911 immediately.*** It is imperative that you receive medical attention as soon as possible. Do not waste time lancing the bite and attempting to remove the venom yourself, with or without the aid of a snake bite kit; do not use a tourniquet. These efforts are ineffective and actually increase the risk of secondary problems.

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Science to the Grower

Plant Canopies Affect Overhead Irrigation Efficiency

by Richard Y. Evans, UC Cooperative Extension, Davis

Most nurseries irrigate small container stock with overhead sprinklers. These simplify water delivery, but 80% or more of that water may miss the containers, resulting in low irrigation efficiency. It is no surprise that the percentage of irrigation water which lands in containers decreases as the spacing between containers increases. Horticultural science being what it is, though, researchers have examined some of the fine points of water capture by container-grown plants irrigated with overhead sprinklers. In this column I'll discuss two such studies, one old and one new.

The old study was part of a Master of Science project by T.W. Hawkins[1], who was directed by J.L. Paul at UC Davis. Hawkins evaluated the amount of water captured by escallonia, juniper, and privet grown in 1-gallon containers within an 8 X 48-foot bed in a container nursery. Plant spacing differed somewhat, depending on species. After irrigation the escallonia containers, which covered 31% of the bed surface, had captured only 18% of the applied water. Hawkins concluded that the canopy of escallonia plants acts like an umbrella, shedding water that would have fallen on an empty container. In contrast, the juniper and privet containers covered 25% or less of the bed area, but captured over 40% of the irrigation water. The canopy of these species acts like a funnel, intercepting water that would have fallen outside an empty pot and directing it down into the container. In other words, some crops can improve irrigation efficiency, while others may make it worse. Irrigation could be improved by separating umbrella crops from funnel crops.

The newer study is by two scientists at the University of Florida. Back in the 1990s, Beeson and Yeager had observed that irrigation efficiency decreases when plants are crowded together so that their canopies intertwine, and in the new study they sought the optimal spacing between container-grown nursery plants[2]. They found that the capture of overhead irrigation water by viburnum, privet, and azalea in 5-gallon containers decreased to some extent as their canopies overlapped, but overall irrigation efficiency was still highest when plants were spaced can-tight. They noted that can-tight spacing may make plants commercially unacceptable, so they recommend that growers use the minimum spacing required for commercial acceptability. This should allow for some contact between plant canopies. Their conclusion doesn't change recommended commercial practices. Since the same spacing is advised to maximize photosynthesis. Nevertheless, it's nice to have those recommendations confirmed.❖

[1] Hawkins, T. W. 1981. *Nitrogen leaching losses from two container-grown woody species*. M.S. thesis [Davis, Calif.].

[2] Beeson, R. C., Jr. and T. H. Yeager. 2003. Plant canopy affects sprinkler irrigation application efficiency of container-grown

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2005 CORF Program Calendar

SEPTEMBER

22 ABC's of Horticulture

Escondido

(Spanish Only)

27 ABC's of Horticulture

Watsonville

(Spanish Only)

28 Impact/Overhead

Irrigation II

Santa Paula

OCTOBER

13 ABC's of Horticulture

Ventura

(Spanish Only)

NOVEMBER

15 Disease Symposium

Watsonville

DECEMBER

CORF Wishes you a

Happy Holiday Season!

Weidner's Gardens cont. from page 1

runoff was entering Weidner's property from surrounding greenhouses and residences.

The volume of water leaving the property daily was greater than he anticipated. Oliver's first thought was to establish a cooperative effort with their neighbors to donate the excess water to CalTrans for landscaping purposes. Unfortunately, the logistics proved to be too complicated.

Next Oliver looked at the existing irrigation system. He sought the assistance of Howard Mueller from the NRCS, Jim Brazzie from Hydroscape and Diane DeJong from the UCCE Agricultural Water Research and Education Program. Even though he had been making gradual upgrades and improvements, his system was only operating at 60% efficiency. Oliver, Jim and Howard considered many different systems. However, they ultimately decided that the best option was to upgrade Weidner's existing system. They corrected the irrigation system design and incorporated pressure regulators. These changes resulted in irrigation efficiency values in the high 80 percentile. Once they added pressure compensating emitters, irrigation efficiency increased to greater than 95%! Moreover, these emitters prevent drainage from the lines after the irrigation ceases, thus keeping the lines charged and ready for the next irrigation event. Oliver also changed the irrigation mist systems for propagation, installing pressure compensating valves in the mist house, which run for 5-7 seconds, as needed.

After reading the Management Options for Nonpoint Source Pollution for Greenhouse and Container Crop Industries, Oliver was interested in utilizing pulse irrigation to further reduce runoff. Weidner's Gardens applied for and received an EQIP grant to install better timers, which allow the irrigation systems to run for a set number of seconds rather than minutes. He increased the frequency of irrigations but still reduced overall time of application in half. Oliver changed the soil to add more peat moss and uses Aquatrol to help retain water in the media.

As a result of these changes, Weidner's has realized a 50% savings in water and fertilizer. Three out of five of the Weidner's Gardens growing operations are completely dry and total runoff has been reduced to less than 200 gal/day! This represents a huge reduction in runoff.

Now that the runoff was at a more manageable level, Oliver decided to install a 'low tech' collection system, consisting of an 1100 gallon septic tank, to capture the remaining runoff. This runoff was then pumped to a drip irrigation system and used to water the neighbors' landscape. The entire system cost less than $10,000.

When asked what the greatest challenges were in making this system effective, Oliver replied "The new timers are more difficult to operate, so it falls to me and one or two other irrigators to make all the adjustments. Irrigation is not a static system, it requires a lot of maintenance and adjustments."

Would he do it differently? What advice does he give to other growers? "Other than considering heavy rain years in siting the collection tank, I wouldn't do anything different. I recommend taking a step by step approach, first reducing overall water use and runoff, then dealing with whatever runoff remains. There are definite long term economic benefits for modifying irrigation systems to be more efficient," according to Oliver.❖

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Get Cultured

Ozonation of Recycled Irrigation Water and its Applications in the Nursery Industry

by Donald J. Merhaut, UC Cooperative Extension, Riverside

History. Ozone is a strong oxidizing agent, twice that of chlorine, and has been used since the beginning of the 20^{th} century to disinfect water. As environmental regulations become increasing restrictive for the use of chemical disinfectants, alternative methods must be developed which are effective, but do not produce harmful residues. In this article we will discuss the treatment of recycled irrigation water with ozone, presenting its attributes and limitations with regard to its specific use in the nursery industry.

Ozone, Free Radicals, and Oxidizing Agents – Oh My!

• **Ozone** = a chemically unstable gas molecule that consists of 3 oxygen atoms linked together. This molecule would like to have 2 more electrons to become more stable. Since an ozone molecule 'takes' electrons from another molecule, it is considered an oxidant.

• **Oxidant** = any chemical that is capable of taking electrons away from another chemical. These types of chemical reactions were originally termed 'oxidation' because it was believed that oxygen was the only chemical able to take electrons from another molecule. In the process, the oxygen bonded with the molecule it took electrons from. However, chemicals other than oxygen are now known to be oxidants, but the term 'oxidation' is still used in the literature. The ability of a specific chemical environment to cause oxidation is measured as 'redox potential' (REDOX) or 'oxidation reduction potential' (ORP). ORP values of 700 mv should provide complete disinfection.
OPR values less than 300 mv are usually considered safe for most aquatic life.

• **Free Radical** = any atom or molecule (group of atoms) that has at least one unpaired electron, but has an overall 0 charge (it is a particle that is neither positively or negatively charged). Even though this free radical has a charge of 0, it still needs to have the unpaired electron teamed up with another electron. All free radicals are oxidants since they have the ability to take electrons from other molecules. Ozone is not a free radical because all of its electrons are paired together. However, when ozone breaks down during oxidation reactions, oxygen free radicals (O·) and hydroxyl free radicals (HO·) can be produced.

• **Antioxidant** = any chemical that protects an organism from being oxidized or any chemical that inhibits the ability of oxidants to oxidize. Blueberries are good for you because they have a lot of antioxidants!

Note: In the world of oxidation reactions and free radicals, two general assumptions in chemistry must be understood: (1) most compounds are stable at an electrical charge of 0, and (2) electrons are only stable as pairs.

How Does Ozone Work in Disinfecting Irrigation Water?

Ozone disinfects water by oxidizing (adding oxygen/removing electrons) the membranes and key physiological reactions in living organisms and different types of chemicals suspended or dissolved in the water. In addition, as ozone breaks down, it produces free radicals (Equation 1). These free radicals also disrupt cell membranes and physiological processes by upsetting the electron balance of the cell wall structures and chemical pathways.

EQUATION 1

$$O_3 + H_2O \rightarrow O_2 + 2OH\cdot$$

Ozone + water → oxygen + 2 free radical hydroxyls

Procedures for Ozonation of Irrigation Water

(1) Provide a relatively pure oxygen source. The use of regular air will not work since it is only 21% oxygen.

(2) Electrically charge the oxygen (O_2), which forms ozone (O_3). This is often performed through corona discharge or plasma discharge units. Over 80% of the energy is wasted in the form of heat, which must be removed from the ozone generator, since heat will decompose ozone.

(3) Bubble the ozone through the water source. An injection **rate of 1 oz per 1,000 gallons of water with a one hour exposure time** is target rate, but may vary according to different water sources. Treated water should be maintained in a closed pressurized system to prevent off-gassing of the ozone.

(4) Ultraviolet light can be used to increase the rate of breakdown of ozone, which causes the rapid increase in free radical hydroxyl (·OH) groups. This acts as a better disinfectant. This technique is called 'Advanced Photo Oxidation'.

(5) Deactivate excess ozone by venting through an activated charcoal filter.

ADVANTAGES

+ Powerful disinfectant with no chemical residues: Ozone breaks down to oxygen. So there are no chemical residues directly from ozone.

+ No additional chemicals: Proper ozonation will require no other chemical control.

+ No chemical storage: Ozone is made on-site.

+ Easy monitoring: Efficacy of system easily monitored by measuring the ORP (redox potential).

+ Maintenance: Low maintenance unless oxygen source is not clean, then electrodes must be cleaned.

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Get Cultured cont. from page 12

+ Pathogen control: Most pathogens will be killed.

+ Algae control: The system will kill algae.

+ Pesticide breakdown: Many pesticides will be oxidized.

DISADVANTAGES

— Lengthy treatment period: Depending on the amount of organic matter in water, ozone exposure may require up to 20 minutes to 1 hour to achieve 100% mortality of pathogens.

— Space allocation: Since the efficacy of ozone is related to its concentration and exposure time, collection tanks for treated ozone water will be needed so that ozonated water can be stored long enough for effective disinfection.

— High operation cost: For electrical source.

— Increased water pH: Ozone will increase water pH, so water acidification may be necessary.

— Effectiveness reduced with dirty water: Organic matter will react with ozone, decreasing the amount of ozone available to kill pathogens.

— Floating debris removal: Does not break down or remove floating debris.

— Pathogen resistance: The chlamydospores and microsclerotia of some pathogens are more difficult to kill with ozone.

— Clay and silt removal: Clays and other soil particles are not removed or broken down.

— Chelates destroyed: If chelates for iron or other nutrients are used, ozonation may react with the chelates, precipitating the nutrient out of solution.

— Element precipitation: Ozone may oxidize and precipitate out of solution some essential nutrients such as iron, even if chelates are not being used.

— Plant toxicity: Ozone is toxic to plants, so ozone levels should below toxicity levels before applying to water.

Conclusions. When used properly, ozonation can be an effective method to disinfect irrigation water in some nursery systems. One of the main limitations to ozone use is the space and cost for holding tanks for treated water. Since ozone is also dangerous to humans, proper safety procedures should be followed.

When treating recycled waters, always check for effective control of pathogens, regardless of the treatment process being used.❖

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Campus News & Research Updates

Compiled by Julie Newman, Farm Advisor, UCCE

Research Updates

UC RIVERSIDE

Pesticide Isomers Pose Uncalculated Toxic Risks

Jay Gan, professor of environmental chemistry, in cooperation with a team of UCR colleagues including ***Daniel Schlenk***, professor of aquatic ecotoxicology; Soil Physics Professor, ***William Jury***; and visiting professor ***Weiping Liu***, recently completed a pesticide toxicity study which may have significant implications for risk assessment and development directions of new products. They demonstrated that isomers – or the mirror-image structures – of some pesticides, although chemically identical, have very different biological and environmental impacts between the two sides.

The environmental risks of pesticides have been traditionally evaluated on the basis of their specific chemical structure, according to Gan. He found, however, that this group, known as chiral pesticides, including many widely used organophosphates and synthetic pyrethroids, pose previously uncalculated toxic risks due to the differing biological reactions of the isomers in the environment.

A characteristic of chiral compounds is that they occur as isomers with two (or more) identical but mirror-image structures that, as Gan's research indicates, while chemically identical, may behave biologically differently. These mirror-image molecules are known as enantiomers. Currently about 25 percent of pesticides fall into this classification and this ratio is expected to increase as new products are being introduced into the market.

Gan's findings add weight to the argument that regulators should consider whether a product is a chiral compound when assessing its risk, and that the chemical industry should pursue the value of producing single isomer products instead of mixed isomer products.

By using pesticides with just the active isomer, growers will likely achieve the same degree of pest control at a much-reduced rate of chemical use. This will have environmental benefits as much less chemical is introduced into the environment.

The findings were published in a paper titled *Enantioselectivity in Environmental Safety of Current Chiral Insecticides* in the Proceedings of the National Academy of Sciences. Gan and his colleagues at UC Riverside examined chiral insecticides that are widely used today, including the organophosphates, such as profenofos, and synthetic pyrethroids, such as permethrin. For all these compounds, one of the optical isomers, or enantiomers, was consistently over 10 times more toxic than the other to Ceriodaphia, a small crustacean often used to assess water toxicity.

The researchers also found that a specific enantiomer lingered longer in the environment than the other enantiomers, making one enantiomer of permethrin almost twice as prevalent in sediment or runoff water. This means that the environmental impact of these pesticides may depend on the behavior of a particular enantiomer instead of the whole compound, the team concluded.

Regulators currently examine the safety of the pesticide straight from the factory, in which both enantiomers are normally present in an equal ratio. On the other hand, knowing about such selectivity would be valuable for the chemical industry. For instance, if only one enantiomer is known to contribute to the pest control efficacy, it would be environmentally advantageous to manufacture products containing just the active component. The rate of use may be cut in half, and the chemical load into the environment will also be halved.

"The difference in terms of pesticide regulation and future R&D directions could be pretty drastic for chiral pesticides," said Gan.
(Adapted from University of California Newsroom, http://www.newsroom.ucr.edu)

Pesticides in Nursery Runoff: Sources and Transport Mechanisms

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Commercial nurseries are intensive users of pesticides. Due to heavy and sometimes inefficient irrigation, many nurseries generate large amounts of surface runoff that contains relatively high levels of pesticides. Pesticide runoff can also occur after a rainstorm. If not controlled, nursery runoff may enter adjacent urban streams and contribute to acute or chronic toxicity to aquatic organisms in sensitive surface water bodies such as coastal estuaries.

Pesticides used at nurseries vary greatly in their ability to move with surface runoff. Depending on properties such as water solubility and adsorption, pesticides may move in runoff differently. Water soluble and weakly adsorbing pesticides such as some herbicides and diazinon will move in the dissolved form along with the runoff water, and the transport can be long-range. For pesticides that are hydrophobic and strongly adsorbing, such as most synthetic pyrethroids and to some degree chlorpyrifos, movement can occur as attachment to loose soil/sediment particles. Such transport is typically short-range. However, if the pesticide happens to be persistent, long-range transport can also occur.

Pesticides may also enter the runoff water differently. Water-soluble and weakly adsorbing pesticides may leach through potting mix during irrigation and enter the runoff water. For hydrophobic and strongly adsorbing compounds, it is likely that spilling and consequent washing away of potting mix may lead to introduction of pesticides into the runoff water. Such pesticides may be strongly attached to the potting mix particles, and when runoff water flows over the spilled potting mix, pesticides are carried along in the runoff water.

We have carried out a series of studies on a 100-acre commercial nursery located near Irvine, CA, to understand pesticide fate and transport in nursery runoff. Our studies showed that synthetic pyrethroids entered runoff when spilled planting media (containing pesticides) was mixed into the runoff water by surface erosion, traffic, and other physical forces. In the runoff flow, pesticides such as bifenthrin and permethrin were predominantly associated with suspended solids because of their strong sorption capacity. Due to their association to the suspended solids, these compounds partitioned quickly into the sediment layer along the runoff path when the suspended solids settled out. This particular transport pattern suggests that any practice to promote sedimentation would also decrease the pesticide load in the runoff. Therefore, controlling potting mix spill during operation and off-site export of sediment will be critical for mitigating pesticide runoff from nurseries.

UC DAVIS

Plant Viruses as Useful Tools

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For many years, the postharvest research group at Davis has been studying the basic biology of floral aging, in the hope of identifying ways to improve the life of flowers, particularly those, like Iris, Gladiolus, and Daffodil, where Ethylbloc has no effect. As part of that research, we have identified many genes that may have a role in the control or execution of the petal aging process. We recently have adapted a technique called Virus Induced Gene Silencing (VIGS), to help us in these studies. It turns out that during evolution, plants have developed a strategy to moderate the effects of viral infection so that many plants show few or no symptoms when they are infected with some viruses. The plant recognizes the invading virus, and degrades its genetic material so that it cannot reproduce. VIGS uses this mechanism by including plant genes in the infecting virus. The plant turns those genes 'off' as well, and we can thus observe the effects of 'silencing' a specific plant gene. For example, we know that chalcone synthase (CHS) is a key enzyme in the production

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of red, blue, and purple pigments. When we infect a young leaf of a purple-flowered petunia with a virus containing a portion of the plant's CHS gene, we can see where the virus has moved because the flowers turn white. If we add another 'unknown' gene to the virus, we know that the unknown gene is also turned off where the petals are white, and we can examine the effect of the gene by comparing the aging pattern in the white and purple sectors. VIGS is a tool that will allow a rapid screening of many genes in which we are interested, and should accelerate progress towards developing chemical or genetic tools to increase the life of iris and many other short-lived flowers.

Semi-closed Irrigation Systems to Reduce Runoff in Nurseries

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Semi-closed irrigations systems differ from open irrigation systems, where water is applied and runoff is allowed to move away from the pots. They also differ from closed irrigation systems, where water is recycled back to the containers, in that water is applied to the containers and is not recycled, yet limited from running off. In the systems presented here, each pot has its own individual well or a group of pots have another type of reservoir that is used by only the pots in that section.

Both of these systems use subirrigation to irrigate the crops. Subirrigation has been more widely adopted in greenhouse production and usually as a closed system such as ebb and flow or using capillary mats. While plants may grow well in those systems, care must be taken that pathogens are not spread from an infected plant or contaminated media to the rest of the plants watered from the same reservoir. The difficulty in using subirrigation in outdoor nurseries lies in the production process. Plants are constantly being moved around, workers are pruning, selecting plants for sale, and otherwise working among the pots. Watering tubes are kicked out of the pots easily or the reservoir mats are dirtied. These systems need to be adapted in order to work most effectively on outdoor nurseries. Nevertheless, these semi-closed systems offer the benefits of little to no water runoff and consequently little or no pesticide and fertilizer runoff. In my studies, weed growth was significantly reduced in subirrigated pots due to reduced wetting of the soil surface. Additionally, plants grew faster in the subirrigated treatments than in the conventional treatments. Unfortunately we did not measure water use between the two treatments to determine whether there was any water savings. Results of this study can be found at: **http://ucce.ucdavis.edu/files/filelibrary/2017/7634.pdf** and a slide show at: **http://ucce.ucdavis.edu/files/filelibrary/5025/5477.**

Future studies are planned to examine the utility of the subirrigation mats for reducing pesticide use and runoff. These offer great potential if water savings and improved production outweighs the cost. One place where their utility may be realized is in the retail side of nursery sales. Most watering in retail nurseries is by hand and plants are often overwatered to the point of runoff or underwatered resulting in significant plant loss. Use of these mats may significantly reduce these problems as well as runoff from the nursery with little or no modification of pots or benches.

Campus News

Jack Kelly Clark Retires. World-renowned photographer Jack Clark, who built a distinguished 38-year career with UC, retired on June 1. Clark's photos have been particularly helpful in illustrating UC ANR IPM manuals and publications. More than 80,000 of Clark's images are part of the UC IPM photo collection.

Horticultural Research tour of Germany. Heiner Lieth took a group of students on a research tour of Germany last year. Recently a report was written on the trip by Lieth and students. The report can be accessed at Lieth's web site: **http://lieth.ucdavis.edu/tmp/DAAD/GermanHortTour.pdf.**

Please note that there are lots of pictures and the file is huge (7 megabytes, 25 pages). If you are not using a high-speed Internet connection, the complete download will take a long time.❖

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CORF

FLORICULTURE EDUCATION FROM THE
KEE KITAYAMA RESEARCH FOUNDATION

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