

BULLETIN

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pH and Micronutrient Management in Container Grown Crops

by Bill Argo and Paul R. Fisher

Why is pH important?

The most common nutritional problems occur in greenhouses and nurseries when the pH of the growing medium is outside the acceptable range for the crop. Media pH is a measure of the acidity (low pH = acid) or basicity (high pH = basic, also called alkaline) of the growing medium. The pH of a growing medium is important because it affects plant health.

Plants take up dissolved nutrients through their roots. Media pH drives the chemical reactions that determine whether nutrients are soluble and therefore available for root uptake, or

insoluble, and therefore unavailable for uptake (Figure 1 page 9). Several nutrients are affected by media pH, but the most important are phosphorus and most micronutrients, especially iron, manganese, copper, zinc, and boron (which decrease in solubility at high pH), and molybdenum (which increases in solubility at high pH).

The optimum range for many crops growing in soilless media is 5.8 to 6.4, because in this range micronutrients are soluble enough to satisfy plant needs without becoming so soluble as to be toxic.

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Implementing a Customer Loyalty Program

by Kathleen M. Kelley

I ncreasing market share is a retailer's primary business goal. The more often customers shop at their store, the more likely sales and profits will increase. Consumers, however, have many choices as to whom they purchase from, how they purchase (i.e. Internet, catalog, retail store), and where they purchase goods. Differentiating themselves from the competition is necessary for retailers to become and remain foremost in their customers' minds.

Over the past couple of years, smaller, independent retailers have begun to develop and implement "customer loyalty" or "reward" programs as a means to increase their customer base. This promotional tool essentially allows customers who enroll

in the program, and who are "loyal" in the form of repeat purchases, to receive benefits (coupons, discounts, or invitations to special sales or events) as a thank you for their patronage.

An advantage for a retailer to offer such a program is that there is little that they may need to explain to their customers as to the usage and benefits of a loyalty program. Customers understand the basic function of loyalty programs and rewards redemption, as they most likely belong to another program already. Regardless of the type of program that is offered there are a few key concepts that should be considered: how customer

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OFA Mission Statement

To support and promote floriculture professionals through lifelong learning, career enhancement, and public awareness.

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ofa Management



Disasters – Be Prepared!

by Gary Hudson and Karissa Anderson

What would you do if your garden center were suddenly submerged for 3 weeks under 9 inches of salt water? Think it can't happen? That's what folks at The Plant Gallery in New Orleans thought before Hurricane Katrina hit. The only sure thing about natural disasters is that they can happen anytime, anywhere, to anyone.

The best time to respond to a disaster is *before* it happens. A relatively small investment of time and money today may prevent severe damage and disruption in the future.

When a devastating fire struck the garden center at White's Nursery in Chesapeake, Virginia, owner Norm White found that the firm had not adequately documented numerous structural changes and equipment additions. That oversight caused the settlement with the insurance company to be much more difficult, taking six months longer than necessary. Norm is quick to point out that it is the insurance company's job to settle for as little as possible, so be certain that you document and photograph everything. Careful preparation will also allow you to quickly and efficiently get everything back to normal, from cleaning up to settling with insurance carriers.

If a fire wasn't enough of a learning experience, Norm found out after a recent hurricane passed through, that his

generator had a problem, which required a cleaning of the filters and restarting every couple of hours. Now Norm's checklist includes test starting and running all emergency equipment once a month to ensure preparedness.

Every area in the country is subject to some kind of disaster like floods, hurricanes, earthquakes, ice storms, landslides, or wildfires. Even man-made disasters – oil spills, civil unrest, arson, gas explosions, etc. – can be devastating. No area is immune, and while some disasters provide a warning, most definitely do not!

Ask yourself: If the worst happened, how would it affect my business and my family? Would we survive if the business were closed down for weeks, months, or perhaps the entire revenue season? What can we do to make sure we survive? Be a little pessimistic now and assume it will happen to you. A well-developed disaster plan for your home or business, along with detailed checklists of things to do and supplies to have on hand, will let you rest a little more easily.

There are four steps you should take to get ready to handle the impact of a disaster:

Step One – Assemble a Disaster Committee

The first and most important step is to acknowledge a disaster might happen and it might affect you. Begin the planning process by forming a disaster planning committee. Choose one representative from each area or department. With committee representatives spread throughout the company, you create visibility and indicate your endorsement of the planning process. To emphasize the importance of the committee, make sure the participants are formally appointed, their positions are announced company-wide, and their individual responsibilities are included in each member's job description.



Founding Steward





When designing the emergency protocol, make functional assignments of specific responsibilities. Name a response team leader, safety captain, emergency coordinator, public information officer, computer data protection specialist and a principal finance officer. These people can be on the disaster planning committee or can be chosen from the rest of the staff. The number of people chosen will depend on the size of your staff and team. In a small firm, some members will wear several hats. What's important is that dependable staff members are named to each position.

Response Team Leader: Has complete authority to implement the disaster plan. He/she communicates to the committee on the location of the incident command post, on-ground flash reports, personnel, and available disaster supplies. This person is responsible for periodically checking on emergency battery life and/or expiration dates of fire extinguishers, and keeping all aspects of the disaster plan current.

Safety Captain: Plans and communicates with emergency agencies and other involved parties.

Emergency Coordinator: Manages employees and gives staff assistance during an emergency response. He/she determines the impact of the natural disaster and keeps the other committee members updated.

Public Information Officer: Communicates with the other committee leaders to determine the extent of damage and determines which staff members will be able to assist in recovery. He/she also distributes press releases, if appropriate. This should be the only person permitted to speak to the press. Never allow anyone except authorized and trained individuals to communicate with the media. The press and public will want to know what happened. Be proactive. Don't make them chase you for information.

Computer Data Protection Captain: Secures computer file back-ups as soon as possible after any emergency. Since computers hold critical business information, this person should back-up all computer files on regular monthly pre-determined dates and store them in a safe off-site location.

Principal Finance Officer: Reports all accounting and financial activity associated with the emergency event to the safety captain. This includes funds collected for disaster relief and emergency assistance, grants for emergency preparedness, and other expenses attributed to the emergency.

Remember, it's up to you how you staff the positions, but these are essential functions to consider, regardless of your firm's size.

Step Two – Consider the Worst-Case Scenario

In step two you spend time recognizing and analyzing possible disasters, potential hazards, and probable emergencies. Be aware of the less obvious situations, i.e., the river that might overflow its banks or the dam that might break 50 miles away, triggering a flood in your area. Recognize and understand your company's vulnerability and you will heighten your capacity for handling emergencies.

Contact Numbers: What are the contact numbers you'll need in an emergency? List the contact information for vital services

such as electricity, water, sewer, gas, telecommunication, and transportation. You'll also need the contact information for critical resources such as equipment, services, operations, and personnel. These resources will allow you to continue regular business functions. In addition, you may need to contact external professional resources, such as the fire department, hospitals, state and local police, utilities, contractors, emergency equipment suppliers, and insurance carriers. Distribute these vital contact numbers to all disaster committee members.

Safe Place: Where will you go when the lights go out or a tornado, hurricane, or earthquake devastates the area? Establish an emergency meeting place and make certain all staff members know where it is and how to get there safely.

Equipment: What special equipment will be necessary? Research and have on-hand emergency equipment for fire suppression, communication, and first aid, along with emergency power equipment, like generators and batteries. In addition to the emergency equipment, you may also need to contact external professional resources listed above.

Step Three – Develop the Plan

Every person in your business should know the plan and their role in it. Disasters often create feelings of panic, so having a series of checklists can help bring focus during the emergency.

The first priority is to assess the situation and determine what must be done to protect all your assets – people, equipment, records, and inventory. The goal is to get the business back up and running as quickly as possible. Create and distribute a key resource list to your staff so they can assist in gathering necessary equipment, supplies, and services. One way to facilitate this task is to create mutual aid agreements with other firms, especially for large equipment. Having this predetermined understanding with another company can aid your efforts tremendously when several businesses are competing for the same services in a difficult time. Make sure every staff member has easy access to the plan and knows their role.

This plan shouldn't just be written down and then set aside in a file for future use. It's critical to practice your plan with all of your team members, just like fire drills in school.

Step Four – Implement the Plan

A plan isn't worth the paper it's written on if it isn't disseminated and integrated into all company operations. Discuss the plan regularly with managers and employees. Encourage them to think about implementation and ask for their input. They may have solutions you haven't considered. Perform emergency drills and test the staff on their knowledge of the plan.

When evaluating the plan, some *great* questions to ask yourself include:

1. Does the plan reflect lessons learned from drills and actual events?
2. Are all names, titles, and contact information in the plan?
3. Do members of the emergency management group and emergency response team understand their respective responsibilities?

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Disasters – Be Prepared!

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4. Have new members been trained?
5. Are emergency supplies monitored on a regular basis?

Some *fantastic* questions to ask are:

1. Does the plan reflect recent changes in the physical layout of the facility?
2. Are the exits still in the same locations?
3. Do you know your inventory?
4. Do your records support the inventory? Make sure you have a current inventory of plants and equipment.

Some *exceptional* questions are:

1. Do you have up-to-date photos of facilities and assets?
2. Do you have documents and photos of all changes and additions?
3. Are they stored in a secure off-site location?

The plan is a dynamic document. Keep the plan in view, think about it often, update it regularly, and test it on a regular basis.

Disaster Checklist

Being prepared means knowing the safe and dangerous places in your home/work facility. It means training employees to use the fire extinguisher and enrolling them in first-aid courses. It also means having the proper insurance. Talk to your insurance broker and review your actual coverage.

When disaster does strike, it will be helpful to have to-do checklists. The following lists will help you to prioritize what must be done at your business and at home during and after an emergency.

During a Disaster:

1. Fill bathtubs, sinks, and jugs with clean water in case the municipal water supply becomes contaminated.
2. Listen to a battery-operated radio for the latest information. Have a supply of fresh batteries on hand at all times.
3. If local authorities tell you to do so, turn off all utilities at the main power switch and close the main gas valves.
4. If there is a need to evacuate, do so immediately.
5. If floodwater begins to rise, retreat to second floor or roof. Be sure you have an exit if water rises further – do not enter closed attics where you can get trapped by rising water. When help arrives, evacuate. Don't stay to protect your property.
6. Avoid walking through floodwater. It may be contaminated by sewage, chemical waste, or other disease-spreading substances. Wash hands thoroughly with soap or disinfectant spray.
7. Do not drive through a flooded area. A car can be carried away with just two feet of water.
8. Stay away from downed power lines and electrical wires, especially those hidden under water in flooded areas. Contact with the wires – or the water they are in – may be fatal.
9. Keep your car gas tank full.
10. Turn the refrigerator and freezer to the coldest settings (if not instructed by officials to turn off utilities). Fill plastic

bags with water, freeze, and store in the freezer. They will keep food cold longer and provide additional drinking water.

11. Store valuable documents in a waterproof container; if not in a safety deposit box, keep where they can be accessed quickly in case of evacuation.

After the Disaster:

1. Avoid making major financial decisions during the first days after a natural disaster.
2. Contact agencies that can provide assistance: FEMA, Red Cross, Salvation Army, Volunteers of America, National Voluntary Organizations Active in Disasters (NOVAD), and State and County offices of Emergency Preparedness.
3. If your home or business suffered damage, call your hazard disaster insurance agent to file a claim. Make sure to clearly state where and how you can be reached.
4. Take photos of the damage and save damaged personal property. This will make it easier to file a claim.
5. Check for structural damage before re-entering your home or business. Be especially careful in the case of a building collapse.
6. Do not use matches, cigarette lighters, or other open flames when re-entering the property. Gas may be trapped inside.
7. If you smell gas or hear hissing near the property, open windows, leave quickly, and call the gas company.
8. Keep the power off until an electrician has inspected your system for safety.
9. Avoid using toilets and the taps until you have checked for sewage and water line damage.
10. Throw away any food – including canned food – that has come into contact with floodwaters.
11. Boil water for drinking and cooking until local authorities report your water supply is safe.

Make sure delegated family members/employees know how to shut off the gas, electricity, and water utilities. Don't shut off gas unless there is a leak or fire. If it is turned off, it must be turned back on by a qualified technician.

Disaster Supplies

Supplies you may need to have readily available:

1. A first aid kit and instruction booklet.
2. Some type of shelter – a plastic tarp, tent, emergency blankets, large garbage bags, etc.
3. Water – at least 1/2 gallon of water per person, per day, in non-breakable containers. You should be prepared for a 72-hour period. It's recommended that you buy commercially bottled water. Store in a cool, dark place, like a closet floor or in the basement, so it will last indefinitely.
4. Keep a supply of water purification tablets in your emergency kit, such as Halazone or Globaline. Read instructions carefully before using.

5. Keep a supply of non-perishable food, such as canned or dehydrated food, dried fruit, and canned juices. Remember a manual can opener.
6. Flashlights and spare batteries stored in waterproof bags.
7. Battery AM/FM radio and spare batteries, stored in waterproof bags, or, alternatively, hand-crank flashlights and radios.
8. Class ABC fire extinguisher.
9. Essential medication and supplies. Keep at least a one-week supply in your emergency kit.
10. Toilet paper, soap, toothpaste, toothbrush, etc.
11. Keep an array of tools. You should have a pipe or crescent wrench to turn off natural gas and water valves, a crowbar, a lighter, a supply of matches in a waterproof container, and a whistle for signaling. A generator may come in handy. Remember to test your equipment at least quarterly.
12. You should also have the contact information for all of your family and employees (including a number outside

of the area, if possible). ALL family and managers should have a copy.

While it may sound daunting, much of this list is already on hand. It's a matter of putting it in accessible places for emergencies.

Be prepared by developing and implementing your plan. You may turn a potential disaster into an adventure.

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Trend Observations from the Old World – Bits and Pieces from a Recent Trip to Germany

by Kerstin P. Ouellet



There's no question that the world's trend watchers like to look to the United States to find out what's hot and hip in many parts of life. Be it the entertainment industry, technology, science, fashion, and much more, the world listens when the fashionistas, media moguls, tech heads, and scientists on this side of the Atlantic share their wisdom. So one might wonder why when it comes to the green industry the shoe is generally on the other foot. In the horticultural and floricultural universe, the trends are often set in Europe, and it's usually only a question of time before they make their way across the big pond. True, not all European trends will be successful here, but if we don't look at them we'll miss them all.

During a recent trip to my native Germany, I kept my eyes peeled for the next big thing. And while I can't say I could single out one predominant trend that could shake up our industry, I made a lot of interesting observations that we can utilize here to give our businesses an edge over the competition. Since being good isn't good enough any more, being different is imperative.

An Upward Trend

I admit, my forte is container gardening, and it seems my eyes are genetically pre-programmed to seek them out and to spy for anything new. Of course, when I say "new" it could mean that old is new, but I don't want to get ahead of myself here. Well, I am pleased to say that things are looking up for container gardening. Not that things were ever "down" per se, but what I've noticed is that there is a lot of vertical dimension in container gardening in Germany these days. Tall and lean is the motto. Plant choices are selective and even minimalistic at times, with only a few or sometimes just one plant featured. The container itself is an integral part of the design and chosen with at least as much consideration as the plants. The planters are relatively plain but upscale, with their plainness making them so versatile for many design directions from elegant to contemporary.

I definitely noticed the use of evergreens in containers. That's such a great solution especially for public places and businesses. They are easy to care for, can withstand a period of inclement

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Trend Observations from the Old World

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Figure 1. Plain Jane or simple elegance? You decide. The right combination of container and plant can be stunning with a single plant. And it's proof that a good container garden doesn't need to have a trailing petunia or verbena. The small river rocks on top complement the design and reduce evaporation.



Figure 2. If one plant is too boring for you, add a few more, but stick with one (subtle) color, like here with white. The randomly trailing ivy branches keep the design casual, and the woven branches that are wrapped through the design give it an earthy touch. The addition of wooden branches is something I noticed quite often, and it made for a super simple but highly effective touch.



Figure 3. If the planter doesn't give you the vertical dimensions you want, add a climber with a trellis for the same effect.



Figure 4. To soften the industrial blue of this urn, the random twig branches give it a very natural and organic touch.

weather without looking shaggy, and are very season-neutral from spring through fall (and possibly even into winter). That's one of those times when something old is suddenly "new" again.

Lucrative Landscapes

For a look at what's trendy in the landscape business I visited the "BUGA," a national garden show that takes place every other year and always in a different city. This year it was in Gera, a former East German town. While the annual beds had been more or less annihilated by weeks of rain and cool temperatures, the perennial, grasses, and shrub beds withstood the rain and gave a few inspirations for creative landscape design.

I couldn't help but be reminded of the vertical dimensions in container gardening when I saw the accumulation of glass ornaments in a grass meadow (Figure 5). I can't quite pinpoint why, but it looks "very IKEA" to me. What a clever and simple way to dress up ornamental grasses. The grass meadow fits perfectly with today's sustainability buzz, and the glass ornaments are young, hip, and cool. I bet it would appeal to generations X and Y (it does to me, and I'm Gen X myself).



Figure 5. Glass ornaments dress up ornamental grasses.

Another observation made at the show and in parks everywhere is the trend toward natural play structures that blend in with the landscape. The subtle, natural playgrounds don't assault the park landscape with the gummy-bear-colored play structures



Figure 6. Wood is the material of choice in public playgrounds found in Germany's parks.

usually found on this side of the big pond, but instead they are pleasing to the eye, blend in with the background, and teach kids that nature is beautiful in itself.

Last but not least in the landscape department I'd like to share a picture that I wouldn't call a "trend," but I wanted to show it because it so amazingly illustrates how the right choices of perennials can not only harmonize nicely with each other, but also with their surroundings. The color-coordinated harmony of perennials and the church (or tower) and houses in the background are an inspiration in their simplicity and tastefulness. Sometimes we just need to see beyond of what's right before our eyes to get the whole picture.



Figure 7. Color-coordinated harmony.

Flashy Florals

The many fantastic floral arrangements that I saw at the BUGA show would easily provide enough fodder for an article just on floral design ideas, but let me share two pictures that once again pick up the "upward trend" that I described in container gardening earlier. Vertical definitely seems to be the way to go. From small centerpieces to impressive, free-standing arrangements, up, up, up is the word of the times. Whether it's only the flowers that provide the height or it's the container, they all stand tall and proud to show off their beauty. Just take a look at Figures 8 and 9 (page 8) – they speak for themselves.

Setting the Tone

The last idea I'd like to share is the combination of music and flowers. Sure, a lot of you play music in your stores already (you do, right?), but why not bring the two even closer. After all, both are about the beauty in life, and more often than not those who appreciate one also appreciate the other. A whole display at the BUGA show was devoted to musical instruments tied (often literally) into floral arrangements.

Visitors were invited to "connect their favorite flowers to their favorite music." And while I'm not saying you should stuff your uncle's tuba with flowers, there is certainly a take-home idea or two to be had here. Playing music in the store, naming arrangements after famous music pieces, selling floral arrangements in a set with a CD, adding greeting cards that play

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Trend Observations from the Old World

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Figures 8 & 9. Things are moving up, up, up.



Figure 10. Hit the right note with creativity.

music when they're opened, using musical instruments as store decoration, adding live music to an in-store event ... there are endless possibilities to combine the two and to create add-on sales. Now that's music to everybody's ears.

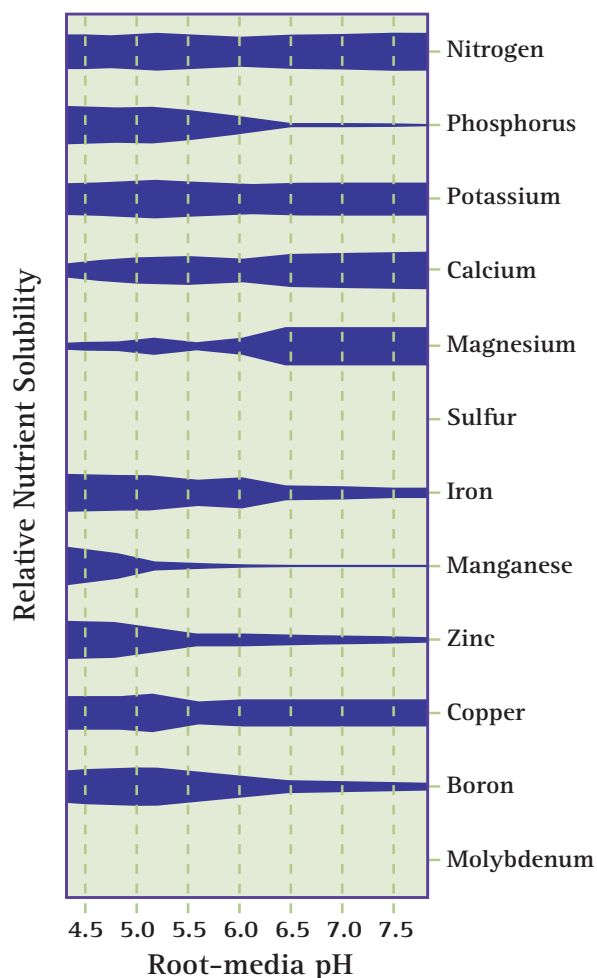
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pH and Micronutrient Management in Container Grown Crops

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Figure 1. Relative solubility of nutrients at different pH levels in one soilless medium (graph based on research by John Peterson, OSU).



Recognizing pH-Related Problems

Iron plays a key role in diagnosing pH-related problems. Iron is required by plants to produce chlorophyll, the pigment in leaves that give plants their green color. Because iron (as well as other micronutrients) is not mobile within the plant, deficiencies tend to show as chlorosis in the new growth or growing tip, whereas toxicities tend to show as chlorosis and necrosis in the older growth.

High pH-induced iron deficiency is usually caused by a combination of factors. Micronutrients (especially iron) become less soluble as the pH of the root medium increases (Figure 1), reducing the potential for uptake by the plant. Some plant species like petunias are inefficient at taking up iron from the soil solution. As the media pH increases, the plant is unable to take up enough iron to produce chlorophyll in the new growth (growing tip), and chlorosis occurs (Figure 2). As deficiency becomes more severe, plants lose vigor and the foliage becomes almost completely white with necrotic (dead) areas forming at the growing points.

Low pH-induced iron/manganese toxicity is also caused by a combination of factors. Micronutrients (especially iron and manganese) become more soluble as the pH of the root medium decreases (Figure 1). Some plant species, like geraniums or marigolds are very efficient at taking up iron from the soil solution. As the media pH drifts down, the plant can accumulate excess iron and manganese in the older leaves, leading to chlorosis (yellowing or bronzing), necrosis (dead tissue) on leaf margins or as necrotic "pin-prick" leaf spots over the leaf surface, and eventual leaf death (Figure 3 page 10). Figures 4a, b, and c (page 11) provide additional examples of iron inefficient, neutral, and efficient plants.

Why do Media pH Problems Arise?

Poor buffering of soilless media. In the last 25 years, the move away from the use of field soil in container media has resulted in less buffering (chemical resistance to pH change).

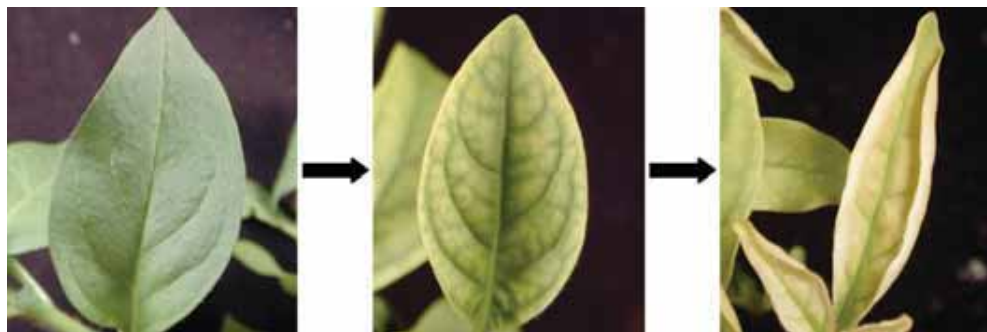


Figure 2. The progression (from left to right) of high-pH induced iron deficiency in petunias. Note that yellowing occurs in the new growth first. Research by Brandon Smith, Paul Fisher, and Bill Argo.

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pH and Micronutrient Management in Container Grown Crops

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Figure 3. The progression (from left to right) of low-pH induced iron/manganese toxicity in geraniums. Note that the bronzing, chlorosis, and necrosis occurs on the older growth first. Research by Brandon Smith, Paul Fisher, and Bill Argo.

Although the use of soilless media has many benefits (uniformity, consistency, aeration, and sterility), one downside is that media pH can change (sometimes rapidly) over time even if the root medium starts within an acceptable range at time of planting. Media pH can drift up or down depending on the balance of factors including water alkalinity, lime activity, acidification of the medium by plant roots, and use of an acid or basic reaction fertilizer. As a result, it is important not to blame problems on the root medium, but rather to also understand how grower management can cause pH to change over time.

Limestone. Limestone is added to container media to neutralize the acidity of the peat- or bark-based media. Typically, a sufficient amount of limestone is added to increase the media pH to around 6.0. The amount that needs to be added (incorporation rate) depends on the reactivity of the lime, which is influenced by several factors including their chemical composition, particle size, and hardness. These factors will also influence the strength and duration of the buffering given by the limestone. If you consistently run into problems with high or low media pH, and you have correctly matched the fertilizer type with water alkalinity, consider changing the lime type or rate.

Fertilizer type. You cannot measure the acidic or basic reaction of a water-soluble fertilizer by measuring the pH of the stock tank or the solution coming out of the end of the hose. Rather, it is the tendency of a water-soluble fertilizer to change media pH over time. Information on any bag of fertilizer will include the acidic or basic reaction of a water-soluble fertilizer and the strength of that reaction, as measured by “calcium carbonate equivalency” (CCE) (Table 1).

More importantly, the label tells the type and percentage of the different forms of nitrogen (ammonium, nitrate, or urea), as well as the percentage of the other nutrients contained in the fertilizer. In general, ammoniacal and urea nitrogen are acidic and tend to drive the media pH down, whereas nitrate nitrogen is basic and tends to drive the media pH up.

Several factors are important when using fertilizers to raise or lower media pH:

- Nitrate nitrogen (NO₃-N) only increases media pH when the fertilizer is taken up by plant roots. Therefore, if plants are

Table 1. Calcium carbonate equivalency (CCE), and the percent of acidic nitrogen = ammoniacal + urea nitrogen/total nitrogen, contained in several commercially available water-soluble fertilizers.

Formula	CCE	% Acidic Nitrogen
21-7-7	1520 acidic	100%
20-20-20	680 acidic	70%
20-10-20	429 acidic	40%
17-5-17	0 acidic	25%
13-2-13	330 basic	5%

¹Percent acidic nitrogen is calculated as the sum of ammoniacal and urea nitrogen divided by the total nitrogen contained in the formula

²Units for CCE are pounds acidity or basicity per ton of fertilizer.

small or are stressed and not growing, nitrate has little influence on media pH.

- Ammoniacal nitrogen (NH₄-N) can cause the media pH to go down even if the plant is small or is not growing, because soil bacteria acidify the medium through a process termed nitrification.
- Ammoniacal nitrogen is less effective at lowering media pH in cool, saturated soil because nitrification is inhibited. In addition, ammonium toxicity in plants can occur in cool, wet conditions because plants are more likely to take up excess ammonium.

Irrigation water pH and alkalinity. Irrigation water pH affects the solubility of chemical and fertilizer salts but has little effect on media pH. Instead, media pH is affected by water alkalinity, which is a measure of the basic ions, mainly bicarbonates and carbonates, dissolved in the water. Alkalinity can be thought of as the “liming content” of the water, and irrigating with high concentrations of alkalinity can cause media pH to increase over time. Alkalinity can be reported a number of different ways including ppm or mg/liter calcium carbonate (CaCO₃), milliequivalents (meq.) of CaCO₃ alkalinity, and ppm or mg/liter



Figure 4a. Iron-inefficient group (also known as the petunia group). Plants of the iron-inefficient group are prone to iron deficiency, especially when combined with low fertilizer concentration (low iron concentration) or high media pH (low iron solubility). Examples include bacopa, calibrachoa, diascia, nemesia, pansy, petunia, snapdragon, and vinca. Grow at a lower pH range of 5.4 to 6.2 to increase solubility of iron. Plants of this group are often misdiagnosed as a “high feed” or “high iron” group. These plants do not necessarily require higher rates of fertilizer or iron, but are especially sensitive to high pH and the need for adequate supply of iron.



Figure 4c. Iron-efficient group (also known as the geranium or marigold group): Plants of this group are prone to iron/ manganese toxicity, especially when combined with high fertilizer concentration (high iron and manganese concentrations) and low media pH (high solubility). Examples include marigold, seed and zonal geranium, New Guinea impatiens, and lisanthus. Grow at a higher pH range, 6.0 to 6.6 to limit the solubility of iron and manganese.



Figure 4b. General group: Plants of this group do not tend to have either high or low pH related problems. Examples include chrysanthemum, impatiens, ivy geranium, and poinsettia. Grow at a moderate pH range of 5.8 to 6.4.

bicarbonate. To convert between units, 50 ppm CaCO₃ alkalinity = 1 meq. CaCO₃ alkalinity = 61 ppm or mg/liter bicarbonate.

Matching the acidity derived from the fertilizer with the alkalinity of the irrigation water is the most important decision growers can make to maintain a stable pH (Table 2). A low alkalinity water should be balanced with a fertilizer containing little acidic nitrogen (i.e. low ammonium fertilizer). A high alkalinity water can be balanced with a fertilizer containing high levels of acidic nitrogen (i.e. high ammoniacal fertilizers), although this is not a good approach in cool, dark weather because of the risk that plants may accumulate toxic levels of ammonium.

Conclusion

Media pH is affected by a number of factors. However, once the crop is planted, two factors that you have control of are the irrigation water and water-soluble fertilizer. Decisions about the type and concentration of fertilizer, and the water alkalinity used to grow the crop should be based on regular testing (every one to two weeks). Simply measuring media pH, media EC, and the EC of the fertilizer solution can solve most nutritional problems

Table 2. Approximate guidelines to matching the ammoniacal nitrogen levels in the water-soluble fertilizer with water alkalinity in order to achieve a stable media pH over time.

Alkalinity Concentration (in ppm CaCO ₃)	CCE (in lbs./ton)	% Acidic Nitrogen	Examples
250 – 300	>500 acidic	>50%	20-20-20 21-7-7
150 – 250	200 acidic – 450 acidic	40%	20-10-20 21-5-20
60 – 150	150 acidic – 150 basic	20% – 30%	17-5-17 20-0-20
30 – 60	> 200 basic	<10%	13-2-13 14-0-14

¹Percent acidic nitrogen is calculated as the sum of ammoniacal and urea nitrogen divided by the total nitrogen contained in the formula. For example, most 20-10-20 fertilizers have 8 percent ammoniacal nitrogen and 12 percent nitrate nitrogen, and 20 percent total nitrogen. 8/20 gives you 40 percent or 40 percent of the total nitrogen is in the ammoniacal form.

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pH and Micronutrient Management in Container Grown Crops

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Alkalinity can be reduced by injecting a strong mineral acid into the irrigation water. Typical choices are sulfuric, phosphoric, or nitric acid. The easiest way to calculate the amount of acid needed is to use the acid addition calculator from Purdue University and North Carolina State University (www.ces.ncsu.edu/depts/hort/floriculture/software/alk.html). Alkalinity concentrations can also be estimated based on water pH. While rough estimates of the relationship between water pH and alkalinity exist, the best method for correlating water pH and alkalinity is to use an alkalinity test kit to measure the alkalinity concentration in your greenhouse or nursery at a range of water pH levels, and then graph the results.

If acidification is used, you still have to balance the reaction of the fertilizer with the water alkalinity. Use the alkalinity of the water after acidification to determine which fertilizer will work best.

Wide range in crops. Species differ in their nutritional needs and can be separated into three nutritional groups based on their efficiency at taking up micronutrients.

by alerting growers to problem trends before plants are stressed. A soil test of pH is also an easy way to confirm a suspected media pH problem. Don't forget to monitor other factors (i.e. root diseases, greenhouse temperatures, pest problems, and high or low media EC) to help rule out these problems, because many factors other than media pH can cause problems in the crop.

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Garden Center

Implementing a Customer Loyalty Program

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purchases will be recorded, benefits offered, and whether loyalty has really been established.

How Loyal are Members?

The basic goal of offering a loyalty program is to encourage consumers to spend as much of their discretionary income as possible at a particular retail outlet. It is possible that customers will only choose to shop at the retail outlet when a discount is offered or when bonus points or rewards need to be spent. One question retailers ask is how many consumers are members of at least one loyalty program? Sources indicate participation varies among age groups; 85 percent of consumers age 18 to 35; 78 percent of consumers age 35 to 45; and 85 percent of consumers age 55 and older (Anonymous, 2003). Other sources indicate that at least one-third of consumers have two or more loyalty cards (Young and Stepanek, 2003).

Income level is a key determinant of whether someone is likely to be a loyalty program member. Membership is greater for consumers with an income higher than \$50,000. Specifically, those with an income of \$50,000 to \$100,000 have an 84

percent participant rate, while consumers with even higher incomes, greater than \$100,000, participate at a 93 percent rate. Those with income levels less than \$50,000 participate at a 76 percent rate (Anonymous, 2003).

Industries with the greatest participant rate and whose cardholders use the card during each visit include supermarkets (58 percent and 84 percent, respectively), drugstores (27 percent and 79 percent, respectively), and the travel industry (23 percent and 68 percent, respectively) (Anonymous, 2003).

Observing how these programs are implemented and how customers can use their rewards is a good strategy for any retailer considering this venture. By becoming a member of several loyalty programs, retailers can see firsthand whether a program's benefits are appealing, if it is easy to redeem rewards, and if, overall, signing up for membership produced the outcome they expected.

Though consumers are signing up for memberships, not all may be classified as loyal. Seventy-five percent of survey participants said that they were satisfied with the businesses



they most recently patronized. In regards to whether survey participants were “truly loyal” to businesses they patronize, 34 percent responded with a “yes” (Young and Stepanek, 2003). Another source indicated that 55 percent of consumers are not loyal to the stores they frequent (Yin, 2003). Considering the supermarket industry alone, it is not unreasonable for consumers to belong to several loyalty programs offered by food retailers in their area and choose where they shop based on which one offers the best discount or greatest rewards for the week.

Program administration does have costs, typically between 2 percent and 5 percent of revenues (Beal, 2004). Costs depend on software and hardware that needs to be purchased, what customer information will be recorded, who will analyze the data, and how customers will be informed about their rewards. Prior to implementing any program, retailers need to determine whether potential costs are reasonable and if a realistic return on investment can be expected.

Inviting and Rewarding Customers

Retailers can ultimately decide who will be invited to join their loyalty program, and as expected there are pros and cons for every option. Programs may have few restrictions, used primarily as a tool to encourage all customers to join, even those who make infrequent purchases or just visit the store to browse. Hence, discounts available to all loyalty program members are identical regardless of how much they spend. A potential outcome is that the program won't necessarily encourage loyalty. Rather, casual customers will wait until each store offers benefits and then shop only at that time.

Programs can also reward customers based on the amount they spend over a period of time. This type of program has a greater chance of increasing profits and can give a better indication of which customers are actually loyal. Advertise the program through all possible methods: newsletters, circulars, web site, and in-store displays. Also, announce that anyone can join but stress that rewards are based on accumulation of purchases.

Several options are possible for reward redemptions:

- a) Coupons issued once a certain amount is spent in the store – For example, once customers have spent \$100 on merchandise they would receive a coupon for 10 percent off their next purchase.
- b) Discounts issued in incremental amounts or percentages – For example, with each \$50 purchase the customer is eligible for a 5 percent discount. If customers spent \$100 a 10 percent discount coupon would be issued; if \$500 is spent a 25 percent discount coupon would be issued. Each retailer would determine the maximum discount allowed.
- c) Discounts available on specific products – Based on stock available or the desire to promote sales of certain items, retailers can provide discounts on specific products.
- d) Invitations to special events – Retailers can use the program to develop a guest list for special events and advance notice of sales and promotions.

Even if a retailer chooses a selection of products that a discount can be applied to, benefits offered should still appeal to members. Also, it should be convenient for customers to redeem

their rewards, and the program should be tailored to meet their needs and interests. If, for example, customers who belong to a garden center's loyalty program live in an apartment or in an area with limited lawn space, discounts that apply to trees and shrubs may not have much value to them. Customers will be more inclined to participate in programs and make purchases if they are rewarded in a manner that appeals to them.

Tracking Customer Purchases

One of the most important components of the loyalty program is keeping track of how much customers purchase. This factor will be just as important to members as it is to the retailer. The use and value of a program can deteriorate quickly if program participants feel that their purchases are not being correctly accounted for.

Two methods provide the basis for recording purchasing activity. In the first, a computerized point-of-sale (POS) system is used to record customers' purchases. The system records purchases via an account linked to a bar-coded loyalty card or customers are asked for an identifier, such as a telephone number, during the transaction. POS systems can tabulate purchases and generate reward certificates once a certain amount of merchandise is purchased. In addition, a POS system can record and categorize purchases, allowing retailers to learn what their customers have purchased in the past, how often, and in what quantities.

A more realistic system for a small, independent retailer, in order to reduce costs associated with administering the program, is to transfer the record keeping to the customer. Purchases are not recorded electronically or tallied by the retailer; rather the customer is responsible for the safe keeping of the loyalty card. Several programs are commonly used:

- Purchases are recorded on a business-sized piece of paper using a “punch,” rubber stamp, salesclerk's initials, or gummed stamp, with each mark representing the purchase of one item. After a predetermined quantity of items is purchased the card can be redeemed for a free, identical item.
- Customers collect coins or tokens, each representing a certain amount in dollars purchased (for example each token represents a \$10 purchase). Coins can be redeemed, up to a certain value, on future purchases.
- Customers collect their sales receipts and once a certain pre-tax amount has been purchased, for example \$100, the customer is entitled to a free gift or discount.

When signing-up for membership, customers should be informed that they need to keep track of their purchases and that if the loyalty card, coins/tokens, or receipts are lost or damaged then they, unfortunately, lose any accumulated benefits.

Changing or Ending a Loyalty Program

Before introducing the program, retailers should consider all program aspects and ask employees for their input. All individuals involved should review loyalty programs to which they belong and incorporate features they like and believe their customers will value. Once a program has been implemented,

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Implementing a Customer Loyalty Program

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changes should be avoided since this can cause confusion and frustration. Customers may be discouraged from buying if they believe that the program isn't delivering what was promised.

If it is necessary to discontinue a loyalty program, every effort should be made to contact customers about changes or cancellation and to also announce the information in the store, in newsletter articles, and on the web site. Be sure to inform members several weeks or months in advance and offer compensation comparable to benefits or discounts that can no longer be redeemed. Offer a coupon with an open-ended expiration date so that customers understand that the retailer is sincere in efforts to help members adjust to the change.

Compensatory coupons could be based on several factors: an actual discount based on past amount purchased; an award amount that is slightly greater than the actual amount owed (a good faith effort); or an entirely new type of reward system that the retailer is interested in implementing. Whatever option is chosen, it is imperative that customers find it has value and is worth visiting the store to redeem the reward. This will ensure that customers are not further upset as they may become even more dissatisfied if the offer is seen as a half-hearted attempt.

Increasing Consumer Loyalty?

For certain industries, loyalty programs do encourage members to spend more money on purchases. Supermarkets report that loyalty program members spend, on average, 48 percent more than non-members. For the clothing industry, the average is an 18 percent increase in spending over customers who are not loyalty program members (Keiningham, et al. 2005). Even though it appears that these programs have succeeded, merely offering a loyalty program and investing little else into the business may produce positive responses for only a short period of time.

When a retailer does not improve the shopping experience, beyond offering select discounts, loyalty cannot be won and customers can become trained to only shop when sales or promotions are offered. Retailers need to make certain that customer service, product availability and selection, and other "experiential" factors (i.e., aesthetics and educational opportunities) meet customer expectations and persuade them to return to the retailer again and again.

To the extent that they apply, the following questions should be considered and revisited frequently:

- What is offered that makes the shopping experience convenient and easy?

- Are all staff members, regardless of position or rank, friendly and knowledgeable?
- Are an appropriate number of check-out stations provided and staffed?
- Is the product selection appealing and in stock, even during sales and special events?
- Is the store layout easy to navigate?
- Are goods stocked according to usage?
- Are displays attractive and do they promote ideas for customers to replicate in their own home, garden, or property?
- Is technical service provided so that customers can call to ask questions and inquire about assembly, maintenance, and repair to goods they purchased from the store?

The bottom line is that a loyalty program alone does not guarantee repeat purchases; rather it is only one component that successful retailers implement. It is equally important to make sure that all staff members treat customers well, that customers have a positive shopping experience, and that they feel the retailer values their patronage. The resulting outcome can be a lasting relationship that is beneficial for both parties. A continued series of positive experiences further encourages the customer to shop there, and the customer truly becomes loyal.

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Production Tips for Vegetative Perennials

by Cathy Whitman, Art Cameron, Erik Runkle, and Sonali Padhye

Vegetatively propagated cold-hardy herbaceous perennials are now readily available as unrooted cuttings and can be produced alongside vegetative annuals and tender perennials. Many excellent seed-propagated cultivars exist, but vegetatively-propagated varieties often offer superior ornamental characteristics, consistency, and uniformity. Flower timing and plant appearance can be quite predictable from these clonally-propagated selections. Keep in mind that many of these exciting new varieties are patented, so unlicensed propagation is prohibited.

Production issues for vegetative perennials are similar in many cases to those of vegetatively-produced bedding plants, though there may be more steps to complete flower induction. Excluding issues of stock plant management, we can divide the production of vegetatively-propagated perennials into three main phases: rooting of cuttings and plant establishment (rooting phase), bulking cuttings to increase plant size (bulking phase), and finishing plants so that they are marketable (forcing stage). The forcing phase often requires providing cold treatments, daylength manipulation, or both, so that plants are in flower when marketed. This article provides some recommendations for success during these three phases of herbaceous perennial production that will aid your efforts to produce quality perennials including leucanthemum, campanula, and coreopsis (Figures 1-3).



Figure 1. *Leucanthemum* 'Broadway Lights'



Figure 2. *Campanula* 'Merrybells Bright Blue'



Figure 3. *Coreopsis* 'Jethro Tull'

Rooting and Establishment of Cuttings: Timing and Environmental Control are Essential for Success Stick Quickly After Arrival

When starting with unrooted cuttings, it's important to stick the cuttings as soon after arrival as possible. Boxes should be opened immediately upon arrival to inspect cutting quality and to allow any excessively cold or warm air to be released. Most

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Production Tips for Vegetative Perennials

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perennial cuttings can tolerate a short period of storage at 41°F if protected from desiccation or water loss. Remember that cuttings are living, breathing organisms that require a constant source of oxygen for respiration. If packaged in impermeable materials, they can suffocate.

Moisture

The propagator's goal is to prevent desiccation until enough roots have developed. Adequate moisture is essential, but it is a delicate balance. Too much mist can cause water-logged media, disease problems, leaching of nutrients from media and leaves, and slower rooting. The less a cutting is misted during propagation, the fewer problems will develop. Apply mist frequently enough to prevent wilting and only until water evenly coats the leaves but does not drip off. Some perennials are quite sensitive to excess moisture. In the Michigan State University (MSU) research propagation greenhouse, we have noticed that some varieties of *Achillea* and *Saxifraga arendsii* are particularly prone to rot if misted too much. The application of a spreader-sticker as a foliar spray can improve the uniformity and contact of mist droplets on leaves that are glossy or waxy.

One desirable strategy is a two-part system that provides both humidity and mist. We suggest maintaining propagation greenhouse relative humidity around 80 percent using steam, high-pressure fog, or a fan-driven water atomizer, which will help reduce the need for misting. There should be minimal air movement in the propagation greenhouse to reduce evaporation. Covering cuttings with a plastic tent is an alternative to a mist system, though attention should be given to control of light and temperature. In all cases, moisture should be gradually decreased as rooting proceeds.

The rooting medium must be kept moist but never water logged since developing roots need oxygen to thrive. For most species, a 50 percent peat/50 percent perlite mix works well, but growers can increase the proportion of perlite for slower-rooting species like campanula 'Birch Hybrid'.

Light Levels

Light intensity during propagation must be low enough so that cuttings are not stressed but high enough to drive photosynthesis, which promotes root initiation and development. Appropriate light levels depend on the stage of rooting and should gradually increase through propagation. From stick to callus formation, typically the first week after sticking, we recommend a maximum of 1,500 footcandles ($300 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$). Once roots have initiated, aim for a maximum of 1,500 to 2,000 footcandles. When roots are filling half the plug, increase to 2,500 to 3,500 footcandles (500 to $700 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$) to start acclimating the plants to the greenhouse environment.

The total amount of light a plant receives in a day is termed the daily light integral (DLI). Cuttings of *Phlox paniculata* 'David' rooted best for us when they received between 5 and 11 $\text{mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$. Those propagated under 2.2 $\text{mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$ or lower rooted more slowly and had fewer roots. Therefore, excessive shade can be as

problematic as excessive light during propagation, especially in northern locations from November through February.

Photoperiod

Many varieties of herbaceous perennials flower in response to daylength (actually they respond to the length of the dark period), and it is important to know the photoperiodic response for the varieties you're rooting. Photoperiod is rarely controlled in propagation houses, but if long-day plants experience long days during rooting, they will most likely start forming flower buds in the plug tray. Cuttings that are producing flowers often root poorly. In addition, faded flowers provide a perfect environment for botrytis. If rooting long-day plants during March through September, propagators should consider pulling black cloth to provide short days (12 to 13 hours or shorter) to prevent premature flowering.

Temperature

To promote root growth more than shoot growth and to reduce the need for mist the temperature of the rooting medium should be higher than the air temperature. Bottom heat works well to maintain desirable medium temperatures of 73 to 77°F. Air temperatures can be between 68 and 73°F when bottom heat is used but should be 77 to 80°F if no bottom heat is used, so the media is sufficiently warm.

Length of the Rooting Phase

Auxins are a class of plant hormones that accelerate rooting of many species, and most cuttings will benefit from a dip in the rooting hormone indole-3 butyric acid (IBA) at 1,500 to 2,500 ppm. For some slow-rooting crops, we have used concentrations up to 10,000 ppm.

Herbaceous perennials are a diverse group of species, so some will root quickly while others will root slowly. If good rooting conditions have been provided, many will be ready to leave the propagation greenhouse two and a half to three weeks after sticking. Most other species are fully rooted within four weeks. Monitor rooting closely, and move rooted plugs out of propagation as quickly as possible.

Transplanting and Bulking

Herbaceous perennials are successfully marketed in containers ranging from 4 inches up to several gallons in size, depending on the species. Whether starting with plants from rooted cuttings, tissue culture, or divisions, choose an appropriate finish container size and then allow plants to nearly fill their containers before they are induced to flower. If pinching is needed, do so during bulking. When using very large containers, consider using several plugs per pot. For cold-requiring species that flower very soon after exposure to warm temperatures (spring ephemerals such as *Phlox subulata*), plants should completely fill their containers before cooling to ensure a full flowering plant.

You don't want the plants to flower prematurely during this stage of production if you can help it, so it's important to know the flowering requirements of each crop. Producers may need to



provide short days for long-day plants until plants have developed sufficient vegetative growth. A photoperiod of 12 to 13 hours is short enough to avoid flowering in most long-day plants we've tested. For day-neutral plants, there are no photoperiod manipulations that will delay flowering.

For the majority of species, higher light levels during production will result in higher quality plants that are sturdy, well-branched, and have more flowers. Shade lovers like hosta, astilbe, and ferns may need some shade during periods of high light intensity.

Moderate temperatures of 60 to 68°F are suggested for growing-on and forcing of most temperate herbaceous perennial species. However, some are heat lovers (*Helianthus*, *Hibiscus*) and do best at temperatures above 73°F. Look to their places of origin for clues on optimal environmental conditions. For example, silver-leaved species native to arid regions (*Achillea*, *Lavandula*, and *Perovskia*) often perform best under high light and relatively dry conditions.

Most herbaceous perennials are not heavy feeders, so provide 125-150 ppm N, 10-20 ppm P, 100-150 ppm K, and micronutrients at every irrigation. Maintain the pH between 5.8 and 6.4 for most species and use a well drained medium.

Forcing

For maximum sales, plants must be flowering during spring when customers are in the garden centers. Simply providing warm temperatures in late winter is not enough to ensure spring flowering of many perennials. Two environmental factors control flowering in most herbaceous perennials: some require a period of cold temperatures or vernalization to flower, and many flower in response to daylength. Growers must do some research to find the flowering requirements of their chosen crops. Research at MSU over the last 15 years has identified the flowering requirements of over 500 varieties of herbaceous perennials. Visit www.hrt.msu.edu/perennialresearch for specific information.

Vernalization

If a crop requires or benefits from vernalization, there are several different ways to supply a cold treatment. Many growers utilize natural cooling by overwintering their crops in minimally heated structures. A variety of coverings are available to protect plants from temperature extremes, desiccation, and damage from pests. It is safest to keep root temperatures above 28°F. Alternately, growers can use temperature-controlled coolers or even purchase pre-cooled liners from a number of producers. The optimum cooling temperature and duration vary by species. In general, we have found that six weeks of temperatures from 32 to 41°F is adequate. Cold treatments should be avoided for a few species. For example, mortality of some hibiscus is high during cold treatments.

Photoperiod

Many varieties of herbaceous perennials do not need cold to flower and can readily be produced in flower the first season. Some will bloom under ambient day lengths, but for others, photoperiod is the key to have them in bloom for that all-important spring season. The majority of temperate perennials we've tested that respond to photoperiod are long-day plants, meaning they either require long days to flower, or just bloom more quickly under long days than short days. To provide long

days, use day-extension lighting to create a 16-hour photo-period, or use night-interruption lighting for 4 hours during the middle of the night (best is from 10:00 pm to 2:00 am). Light intensity for photoperiodic lighting should be at least 10 footcandles ($2 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$) at plant level. Response to photoperiod can be quite dramatic, and some plants (*Asclepias*, *Hosta*) will quickly go dormant under short days. In contrast, a few of the species we've trialed bloom more quickly under short days, and some that naturally bloom in the fall are actually long-day/short-day plants.

Height Control

Any crop is more appealing if plants have attractive proportions and sturdy stems. This is true for herbaceous perennials. Variety selection is the first step to producing a crop that is the desired height. Many newly-released varieties are more compact than older selections of the same species (for example, *Leucanthemum*, *Phlox*, *Salvia* and *Veronica*). Plants will be more compact under higher light intensities, so avoid crowding or shading during the bulking and forcing stages.

Because there are times when plant growth retardants (PGRs) are needed, we have evaluated a variety of PGRs on hundreds of perennials. While no single chemical controls height on all species, uniconazole (Concise, Sumagic) was effective on the widest range of varieties tested. Daminozide (B-Nine, Dazide) and paclobutrazol (Bonzi, Downsize, Paczol, Piccolo) were also effective on many species. We recommend using foliar spray or possibly liner dip applications so that the growth-retarding effect is relatively short in duration. The effect of PGR drenches may be too persistent when the consumer transplants the perennials into their garden.

Research on herbaceous perennials is one of the thrusts of the Floriculture Group at Michigan State University. We thank private greenhouse growers and horticulture suppliers that have funded most of this research. To become a perennial research partner with MSU, please contact Erik Runkle or Art Cameron.

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Understanding Photoperiod & Flowering

by Ryan Warner



The ability to control environmental variables such as temperature and photoperiod is critical for successful production of greenhouse crops. Temperature is the primary factor determining how quickly a plant develops (i.e. how quickly it unfolds new leaves). Photoperiod, or day length, is the primary factor determining when in development many greenhouse crops flower. In nature, this response to day length has evolved to ensure that plants flower, and subsequently produce seed, during appropriate times of the year. In northern climates, this ensures successful reproduction before the cold temperatures of winter, while in warmer parts of the world flowering may be timed to avoid an excessively wet or dry season.

The understanding that many plants flower in response to day length has allowed for year round production of photoperiodic crops in greenhouses. For example, the short-day plant chrysanthemum started being produced throughout the year once it became known that short days induced flowering in this crop. Artificially shortening the photoperiod by covering plants with blackout cloths allowed for flowering during periods of the year when day lengths are naturally long. In this article, I will review the important concepts of photoperiodism and flowering, and discuss the physiology behind greenhouse production techniques for manipulating photoperiod.

Concepts and Terminology of Photoperiodism

There are several components of photoperiodism that come together to determine what is necessary to induce flowering in photoperiodic plants. The first is the *photoperiodic response group* of the species. Others are the *critical photoperiod* of the species and the number of *photoinductive cycles* necessary to induce flowering.

Plants can be classified into the following three photoperiodic response groups. *Short-day plants* are those that flower when the day is shorter than some critical length. Actually, what is more important is the length of the night. So, short-day plants are actually induced to flower when the *night is longer* than some critical length. This has important consequences for how photoperiod is manipulated in the greenhouse, which will be discussed below. *Long-day plants* are those that flower when the night is shorter than some critical length. Plants that do not flower in response to day and night length are referred to as *day-neutral plants*.

The critical day and night lengths are not the same for all long-day plants or for all short-day plants. Each photoperiodic species has its own critical photoperiod for flowering. For example, while both *Coreopsis grandiflora* 'Early Sunrise' and

Campanula carpatica 'Blue Clips' are long-day plants, *Coreopsis* 'Early Sunrise' has a critical photoperiod of 14 hours (meaning that the night has to be shorter than 10 hours), while *Campanula* 'Blue Clips' has a critical photoperiod of 16 hours (night length less than 8 hours) for flowering. Therefore, if you were using day-extension lighting to provide long days, and you only had the lights on long enough to provide a total photoperiod of 14 hours, this would be insufficient to induce flowering in *Campanula*. In general, a photoperiod of 16 hours will be long enough to induce flowering in all long-day greenhouse crops.

Within the short-day and long-day plant categories, plants can exhibit either a *facultative* or obligate *response*. Plants with a facultative photoperiod requirement will eventually flower under long days or short days, but will flower much earlier in development (meaning they form fewer leaves below the first flower) if grown under the appropriate photoperiod. For example, the facultative long-day plant *Petunia hybrida* 'Fantasy Pink Morn' flowered after unfolding 19 leaves when grown under a long photoperiod (night-interruption) and 34 leaves when grown under a 9-hour photoperiod, which also meant a 3 week increase in crop production time.

Finally, plants also vary in how many days under the appropriate photoperiod are necessary for flower induction. In some extreme cases, only a single photoinductive cycle may be necessary to induce flowering. For example, the short-day plants *Pharbitis nil* (a type of morning glory) and *Xanthium strumarium* (cocklebur, a common weed) will flower after receiving a single short day, while chrysanthemum is generally described as needing about 30 short days for complete floral initiation. Once the necessary number of photoinductive cycles has been delivered, plants can usually be grown under non-inductive photoperiods without delaying flowering.

Research at Michigan State University on photoperiodic control of flowering in bedding plants has identified that for the facultative short-day plant *Cosmos bipinnatus*, as few as five 9-hour days are sufficient to induce flowering (Figure 1). Increasing the number of short days to 15 further accelerated flowering, even when plants were moved to a long day environment (provided as night-interruption lighting) after receiving the 15 short days. In contrast, the long-day plant *Rudbeckia hirta* 'Indian Summer' required 25 to 30 long days for floral induction. For most photoperiodic bedding plant crops we have found that three to four weeks under the appropriate photoperiod is enough to ensure flowering, with short-day plants generally requiring fewer photoinductive cycles than long-day plants. Herbaceous perennials and potted plants that

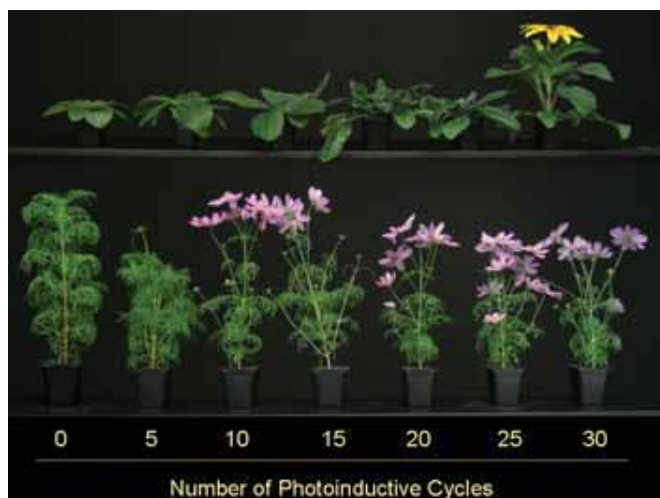


Figure 1. *Rudbeckia hirta* 'Indian Summer' (top row) required 25 to 30 long days for floral induction, while *Cosmos bipinnatus* 'Sonata Pink' (bottom row) flowered after receiving as few as 5 short days.

are photoperiodic for flowering should generally be grown under photoinductive cycles for longer periods of time to ensure complete, uniform flowering.

Manipulating the Photoperiod to Control Flowering of Greenhouse Crops

The main ways growers manipulate daylength to control flowering are:

1. Using blackout cloth to promote flowering in short-day crops.
2. Providing long days with day-extension lighting.
3. Night-interruption lighting.
4. Cyclic lighting during night-interruptions.

Flowering in short-day plants has been described as a “dark-dominant” process, while flowering in long-day plants has been described as a “light-dominant” process. What do these mean and why are they important to you as a grower? The dark-dominant nature of flowering in short-day plants means that it generally takes less light (either lower intensity light, a shorter duration of light, or both) as a night-interruption to *inhibit* flowering in short-day plants than the amount of light needed to *induce* flowering in long-day plants. For example, even a few minutes of light in the middle of the night was enough to prevent flowering in the short-day plant *Pharbitis nil*. Therefore, it is critical to monitor any potential sources of light pollution when growing short-day crops such as poinsettia or chrysanthemum to prevent delays or inhibition of flowering. Blackout cloths are commonly used to promote flowering of short-day crops even when the natural photoperiod is short to ensure that there is no light pollution.

For night-interruption lighting, $2 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ of light (approximately 10 footcandles for incandescent lamps) is usually recommended to ensure that plants will perceive the night-interruption. However, flowering in short-day plants may be inhibited by light levels well below this value. Use a quantum sensor to measure and ensure that any light pollution is less than $0.1 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ in greenhouse areas used to produce

poinsettias, chrysanthemums, or other short-day crops. Similarly, if you are using a blackout cloth system to produce short-day crops, be sure to measure the light levels under the cloth to identify any tears or other light pollution coming from lights in other parts of the greenhouse. Don't trust your eyes to estimate levels of light pollution. The human eye is a terrible estimator of light intensity, as our eyes can rapidly adjust to a wide range of light intensities.

Why Does Night-Interruption Lighting Simulate a Long-Day Length?

Early research into photoperiodism in plants identified that following a short day (for example, 9 hours of light) plants exposed to light for a few hours during the middle of the night responded as if they were grown under long-day lengths (i.e. short-day plants were prevented from flowering, while flowering was promoted in long-day plants). This finding made it clear that it was the length of the *night* that was most important for controlling photoperiodic responses.

Based on this research, night-interruption lighting, generally turning lights on from 10 p.m. to 2 a.m. and providing at least $2 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ of light, has become a widely used technique for controlling photoperiodic plant responses such as preventing premature flowering in poinsettia or inducing flowering in long-day plants. How does this work? Recent research has identified a protein (called CO) that initiates the genetic program for flowering, and we are now starting to understand how it works to promote flowering in long-day plants.

In brief, the production of this CO protein in plant cells follows a circadian rhythm, meaning it follows the same pattern repeated every day. The CO protein is produced at high levels in the late afternoon/evening and during the night, but is produced at very low levels during the morning and afternoon. However, if plants are exposed to darkness when this CO protein is being produced, as it is during short-day conditions, the CO protein is quickly degraded, preventing it from functioning to initiate flowering. During long-day lengths or under night-interruption lighting, peak production of CO coincides with light exposure. In this case, another plant protein called phytochrome, which is a light-absorbing protein called a photoreceptor, acts to prevent the degradation of the CO protein, allowing it to function to initiate flowering.

So when using night-interruption lighting, the peak production of CO protein coincides with light exposure, and therefore goes on to initiate flowering in long-day plants. Although less is currently known about the mechanisms controlling flowering of short-day plants, recent evidence suggests that the mechanism described above for the CO protein promoting flowering in long-day plants is also active in short-day plants, but in short-day plants CO acts to *prevent* flowering instead of promoting flowering.

One recent twist on night-interruption lighting is the use of cyclic lighting. Instead of providing 4 hours of continuous light, incandescent lamps are cycled on and off such that plants are exposed to 6 minutes of light during each 30-minute period (i.e. 20 percent of the time) for 4 hours, or high-pressure sodium

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Understanding Photoperiod & Flowering

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lamps are mounted to an irrigation boom that is run back and forth over the crop for 4 hours in the middle of the night.

Cyclic lighting has been found to be very effective for inhibiting flowering in short-day plants, but sometimes not as effective for promoting flowering of long-day plants. This comes back to the concept that flowering in short-day plants is a dark-dominant process, and even very low amounts of light are sufficient to inhibit flowering, whereas higher light intensities and/or longer durations are required to induce flowering in long-day crops. Still, cyclic lighting has been successfully implemented to induce flowering in long-day crops such as snapdragon, but you may want to ensure that plants are exposed to light for at least 50 percent of the 4-hour night break.

By understanding some of the basics of how photoperiod impacts flowering, it is easier to understand why we use techniques such as night-interruption lighting or blackout cloth to control flowering of greenhouse crops.

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ofa Interior Plantscape

What to Do, What to Do? Part 2

by Joel Pesapane

In my last article (July/August 2007 issue) I gave some basic suggestions regarding plant care, pest control, and the beginning steps of the process of ensuring client satisfaction. Many of the suggestions were targeted toward managers and owners, particularly those dealing with vendors. The average horticultural technician often feels powerless because many factors are out of their control. They don't do the design, select the plants, or grow them. We then expect the chosen plants to be cared for and to live for an extended period of time in an artificial environment that is far from conducive to plant health. I really feel that the job of the plant technician is the hardest in our industry.

Planting Preparation

Before plants leave your facility make sure that everything has been done to give them a chance to survive in an office space. Examine the plants and remove any visible time release fertilizer from the soil, being careful not to break the prill open and release two months of fertilizer all at once. One way of doing this is to turn the plant on its side and scrape off the top of the soil. Once the excess that remained on the plant is removed, you can flush the excess fertilizer out of the soil by watering the plant twice. The first watering will place the fertilizer salts in suspension. The second watering will leach them out of the soil. If you have a method of measuring soluble salts in the media, test a sample of plants from each grower to make sure that the salts are in the range of 1 to 2 dS/m. This should be adequate for most plants in an office. If they are going into a very high light area you can supplement the fertilizer later.



Spray the plants with a cleaner that cuts through dust, spray residue, and iron stains from well water. There are a number of products that you can use. Make sure that there is compatibility with your water supply and adjust the pH of your spray solution to ensure you are not adding to the bathtub ring that soap can leave when hard water is present.

Pest Control

During the technician program at the OFA Short Course this year, the single biggest concern was fungus gnats. These little critters are driving us and our customers crazy. They are attracted to carbon dioxide, so they fly around people's faces and disrupt work. They don't bite people, but they have been accused of it. We track client calls, and fungus gnats are by far our biggest complaint.

To control the problem, we have instituted an approach that targets two phases of fungus gnat development: the larva which breed in the soil and the adults which fly around. If you have trouble identifying where the gnats are coming from there is a simple diagnostic tool to use. Place thin slices of potato on top of the soil of the suspected culprits. If larvae are present they will gather under the potato slices within several days; when you turn the slices over the larvae will be immediately visible. I know that we have been taught that the larvae are only in the top 2 inches of soil, but my studies have shown that they can be evenly distributed from top to bottom of a 17-inch pot.

In order to adequately control this pest you need to disrupt two life stages. We drench the soil with Gnatrol™, a biological



control that was originally developed to control mosquito larvae in malarial areas. Make sure that enough product is applied to the soil to thoroughly wet the root ball. After applying the drench do not water the plant again until the control has had a chance to work. Apply a second round of potato slices to be sure that the problem is under control.

Another good larvae control is *Steinernema feltiae* nematodes. Think of these as the hunter/seeker class of control. When applied as a drench, these microscopic worms will find the larva of fungus gnats and parasitize them. The only problem is that nematodes are perishable living organisms and must be used within a relatively short period of time of receiving them. A second biological control that acts as a predator are Hypoaspis mites. I have not had great success with the mites, but I was able to clean up a significant infestation in a conservatory using the nematodes supplemented by a spray of pyrethrin.

You must also treat for adults, or the problem will simply resurrect itself. Whitmire Laboratories makes several total release aerosol products that, depending on your state and local laws, may be used in your facility to control adult fungus gnats. Make sure that you occasionally switch chemical controls so that the insect does not develop resistance. Switching classes of chemicals is encouraged; in other words do not use just neonicotinoids or carbamates. Along with these treatments make sure that you are scouting with yellow sticky cards, your first line of defense in tracking flying insects.

What Can be Controlled?

The most basic thing you can control is cleanliness. It is of utmost importance that the leaves of the plant are clean. This allows better light transmission to the chloroplasts within the leaves and the production of more energy for the plant. Cleaning also helps with early detection of insect pests. It is easier to deal with pests before they have spread throughout the plant and reproduced.

Vickie Cate of Evergreen Interiors in California invented a product called Paws. It is a sleeve made of two pieces of a felt-like material sewn together that slips over your forearm. We add a mild soap (not detergent) to water and dip the Paws in the water, slip them over our hands, and then wipe down the leaves. Cleaning one quarter of the plant on every visit will help you remember to turn the plant so that the growth is even, and after every four visits will have a clean plant. If you notice a problem with insects while you are wiping down the leaves, add some Jungle Rain Plant Cleaner™ to the water to provide a better cleaning solution. In addition this product has a very pleasant citrus aroma, a real bonus in the public relations area as opposed to stronger smelling chemicals. Please remember that this is being done as part of plant cleaning and not pest control. Pest control, including recommending techniques or products to be used, may only be done by certified pesticide applicators. Wash anything used to clean the plants every day to make sure that pests are not transferred from one plant to another. I do not like a feather duster for this reason. They are hard to clean and can easily transfer mites. Same thing for lambs wool dusters.

Irrigation

Perhaps the biggest maintenance decision is when and how much to water. Sub-irrigation, properly used, will extend the life of your plants, lessen your labor costs, and provide increased client satisfaction. We use them all, from aquafuers to wicks for aglaonemas to zamias.

A consistent source of hydration that allows the soil to moderately dry will produce a better plant. When these systems do not work it is most often because the account manger does not trust the system and either checks it too often or “tops” off the water every visit, never allowing the soil to dry enough to let oxygen in. The old rules still apply. It is important to keep most soils “evenly moist but not constantly wet.” This means that if you are using a subirrigation unit you must allow the water reservoir to go dry before filling it up again so that oxygen has a chance to get into the root system. If this is not done, anaerobic conditions will stress roots and root rot organisms (Pythium and Phytophthora) will more easily attack weakened and declining roots. Do not ask me which is worse or how to determine which you have. Does not matter. Both will result in dead roots and a dead plant. The cure is not to apply fungicides but to water properly. Allowing the soil to dry moderately so that oxygen can penetrate the pore spaces between the soil particles will help maintain root vigor, making them more resistant to this “dangerous duo.”

Proper watering techniques for plants that are not on a sub-irrigation system should emphasize allowing the soil to dry moderately between waterings. The key is to water the plant thoroughly so that the root ball is totally saturated. There should be a slight run off of water through the drain holes of the grow pot. One way of determining this is to slip a thin piece of wood or a piece of paper between the sides of the grow pot and the decorative container. If the bottom is moist then sufficient water has been applied. There should not be standing water in the bottom of the decorative container after a day or two. Standing water encourages bacterial and fungal growth. If organic particles are in this water they will rot and smell, not what the customer is paying us for. Placing the grow pot on a riser of some sort to keep it out of any water that may accumulate will help to avoid this problem.

When watering, it is best to remember to water the soil and not the foliage. While foliar diseases are usually not a problem in an interiorscape because of the lower humidity, you can spread pathogens by splashing water from leaf to leaf. Interestingly enough the most common problem on cissus, powdery mildew, can be alleviated by hitting the leaves with a forceful stream of water.

Diseases

Every year when I was on the interior plantscape committee for the OFA Short Course diagnostics was suggested as a possible topic. The truth is that disease diagnostics are not economically viable or something that we can have a significant effect on. It costs almost as much to diagnose a bacterial disease on a plant as it does for a human. The lab costs are about the same, and if it comes back as a viral or bacterial infection, there

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What to Do, What to Do? Part 2

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really is nothing that can be done for disease control in an interior plantscape except to remove the infected foliage, increase the light levels, and pray. If the disease is systemic the only option is to dispose of the plant before the disease spreads. The problems with *Erwinia* have practically stopped the production of *Philodendron selloum*. Cultural and mechanical (removing the leaf) controls, along with scouting, remain our main allies in combating disease.

If you notice a problem that you suspect is bacterial or viral, make sure you wash your hands and sterilize any equipment before treating other plants. Bacterial diseases will often show up on foliage as soft, sometimes smelly water soaked spots. While they are not transmittable to humans, we can vector the disease from plant to plant with pruners, dusters, and our hands. Good hygiene will pay off with healthier plants.

Nutrition

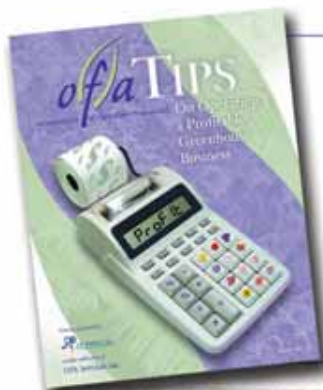
Most of the problems that we see on plants are due to environmental or cultural reasons. One, in particular, is the overuse of fertilizer in the mistaken belief that plants need to be fed regularly. Because of the lower light in interiors, most of the plants that we use only need a light feed of a complete fertilizer about twice per year. I am not writing about plants in a conservatory or greenhouse, just those in the standard office that are surviving in 50 footcandles of light. Before the advent of soilless media, most of the nutrients that plants needed were even more readily available, and we did not have as many problems with micronutrient uptake. It's important to check that

the media pH is in a range that will allow for a full complement of nutrients needed. I have found that all the necessary chemicals are often present, but the range of the media pH is such that the plant cannot take up the nutrients. Look at a chart that shows what nutrients are taken up at what pH, and you can see why some plants will show nutrient deficiencies even though you may have applied both macro and micro nutrient solutions. One suggestion for ameliorating this problem is to simply remove the plant from the grow container and place about an inch of fresh media in the bottom of the pot. There is a compressed peat pellet that we have used that has been effective for this treatment.

There really is nothing fancy about plant care. The simplest things are sometimes the hardest. Light, air, proper temperature, food, and water. Does this sound familiar? It is the same for humans and plants. The difference is that we can adapt to conditions much more quickly than the plants can. They need us to make sure that they have the essentials so that they can keep on delivering that burst of color and that breath of oxygen.

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Garden Center

Adding On Adds Up To Bigger Sales and Better Service

by Bob & Susan Negen



A sure fire way to increase your sales without spending one red cent on advertising is to get more from the customers already buying something from your store. One of the most effective ways to do this is to add-on to every sale. Done properly, adding-on is great customer service – not a pushy sales pitch. In fact, most of the time you haven't given good customer service if you haven't suggested add-on items.

Here's a perfect example from my own life. I recently got my first pair of glasses from a local optometrist (getting older is a bummer!). It is a beautiful store with friendly employees, and I got great advice from the doctor – so I was very satisfied with the experience and felt very good about our relationship.

I was pleased until ... I had to go back two days later to get the special cleaning stuff for the fancy lenses they sold me. Until ... I had to go back a week and a half after that to get the repair kit with the tiny screwdriver and replacement screws (and they were closed on Saturday afternoon). And until ... I needed to go back yet again to get some of those clip-on sunglasses. By my third trip I was seriously annoyed and frustrated. Because they didn't sell me everything I needed the first time, I wasted a lot of time – time spent better ways than driving to their store.

The bottom line is when your customer leaves your store with everything they need and WANT, you have a win-win situation. They're happy and your sales are bigger!

You have two great opportunities to add-on with every customer. Take advantage of them both and watch your sales and customer satisfaction soar. First, you should add-on with the "main" sale. When I was in the kite business I would add-on string and a tail whenever a customer bought a kite. If you are in the vacuum business you sell extra bags, the shoe business you sell socks and extra laces ... you get the idea. Although the technique seems obvious, you'd be amazed at how many business owners miss this golden opportunity.

Your next opportunity occurs after the "main" sale is made and you bring your customer to the register. The area surrounding your cash register should generate enormous amounts of money for you. This is where you put your impulse items, those crazy items that nobody needs but lots of people will buy. I recently read that in independent hardware stores the biggest selling item (units, not dollars) is no longer keys, but candy.

Make sure your register add-ons are fun to buy, easy to sell, and perhaps most importantly, have high profit margins. The favorite register add-on in my toy store was a whistling balloon helicopter – blow up a balloon, attach it to the wings, and let it fly with a silly whistling sound. We sold them by the thousands at about a 70 percent margin!

Everyone can find great register add-ons. One of our clients has a high-end gallery and wasn't sure this register add-on idea would work for her business, but she decided to give it a try. Their best add-on was a "Fizz Ball," a large bath salts ball in beautiful colors and delicious scents that fizzes when you drop it in the tub. They were in sophisticated wrap and piled high in a huge glass bowl – gorgeous. She estimates that adding-on at the register increased her holiday sales by \$10,000. Wow!

Here are two tips for making register add-ons super sales generators:

1. Don't put too many items at the register as add-ons. If there are too many choices, your customers will be overwhelmed and choose none. Rotate different items until you've found your best add-ons and then keep 'em on the counter and keep 'em in stock!
2. Make sure everyone on your staff shows every customer an add-on at the cash register before they give the total dollar amount for the sale. A quick demonstration and an enthusiastic endorsement will persuade even more people to buy. The trick is to add-on constantly and consistently until it becomes a habit.

It can't be stated strongly enough that if you and everyone who works in your store attempt to add-on to every single sale, you will see significant sales increases. It's the little things done well, and done all the time, by everyone in your organization that mean the difference between constant struggle and the type of success you deserve.

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ofa Academic Update

The Ohio State University

by Peg McMahon

The floriculture program at The Ohio State University (Ohio State University to all but the most pretentious) is very active on all three land grant fronts (discovery, teaching, and outreach).

Discovery

Dr. Michelle Jones focuses her research on three projects that involve flowering senescence. She is using genetic engineering and the D.C. Kiplinger petunia microarray to improve identification of genes that control flower petal senescence to improve postproduction flower quality. Another project is discovering how nutrients remobilize during flower petal senescence. Both of those projects are in collaboration with Dr. Charles Krause, USDA-ARS. Michelle's third project is identifying protein changes during flower petal senescence, again to enhance postproduction quality.

Dr. Jim Metzger is developing a bioengineering technique that he believes has very practical applications for ornamental plants, especially for species used in containers and hanging baskets. He and his graduate student have transformed plants using a drought-tolerant gene from Arabidopsis that has been engineered to only express in the guard cells (control opening and closing of the stomates). Their intention is to develop water stress-tolerant plants that do not exhibit the severely restricted growth currently seen in plants that have had all of their cells modified by the same or similar genes. Currently, their transformed plants show good drought tolerance with only a small (10 percent) reduction in growth compared to untransformed plants.

Dr. Claudio Pasion has at present two areas of research. In collaboration with Dr. Jonathan Frantz from the USDA-ARS, Claudio is studying the feasibility of increasing the use of controlled release fertilizers (CRF) in greenhouse container crops. There are indications that this fertilization method leaches less nutrients than the traditional fertigation method making it more environmentally sound. However, growers feel uneasy using CRF because they think they lose control of the fertility program. This research is geared toward answering growers' questions and concerns in this area.

Dr. Pasion is a member of an OSU and USDA-ARS team of researchers that will be conducting experiments to evaluate the potential use of Fiberfill™ clusters made of polyethylene terephthalate (PET) or a cellulose polymer as a growing media component, rooting substrate, and other alternatives used in horticulture. Preliminary experiments have shown very promising results.

Dr. Pasion conducts a bedding and container plant cultivar evaluation trial each year. The trials provide valuable

information about the performance of these cultivars to growers. In addition, the bedding plant trial is located on a main thoroughfare (leading to the football stadium) through the OSU campus and has created considerable interest among students, faculty, staff, and visitors traveling that route.

Each year he also conducts a poinsettia evaluation trial with growers around the state that provides growers with information about cultivar performance.

Dr. Peg McMahon, along with Dr. Joseph Albano of the USDA-ARS, is beginning a project to evaluate a tropical landscape plant used extensively in south Florida as a potential annual bedding plant in temperate zones (8 or less).

Dr. Bob McMahon is working with Dr. Luis Canas (Entomology) on the use of hot water as an insect control technique.

Outreach

Drs. Jones and Pasion work with faculty in Agricultural Engineering, Entomology, Plant Pathology, and county extension personnel to coordinate Extension Reloaded programs for growers. For more information regarding Extension Reloaded, please refer to the May/June 2005 *OFA Bulletin*.

At the OSU Greenhouse Engineering Workshop organized by Dr. Peter Ling, Dr. Jones made a presentation and conducted a hands-on workshop. She also gives presentations for growers on recognizing symptoms of ethylene damage in the greenhouse and postproduction quality. Drs. Ling, Pasion, and Jones recently published an article on greenhouse energy. "Save Energy, but Watch for Hidden Risks." *GM PRO 26: 75-79. 2006*

In addition to collaborating with other departments and Extension personnel, OSU faculty are involved in various other green industry activities. Dr. Pasion regularly visits greenhouses and publishes an electronic newsletter for growers. Dr. Bob McMahon is the fruit and vegetable judge at the Wayne County fair each year and gives several talks to garden clubs and societies. All faculty participate in the OFA Shortcourse and other OFA activities throughout the year.

The outreach component of Dr. Pasion's poinsettia evaluations occurs in early December when representative plants are brought to the Columbus campus to be on display. This is done in conjunction with the student poinsettia sale – a very popular annual fundraiser. Customers of the sale are invited to evaluate the trial poinsettias. With the help of OFA's Dr. Steve Carver, the responses are analyzed and results made available to growers. Interestingly, the participants now come to the sale as much to see and evaluate the cultivars as to buy their poinsettias.





Teaching

Dr. Bob McMahon teaches several floriculture classes at the Agriculture Technical Institute in Wooster. This includes four production classes and an interiorscape class. Dr. Jones is a guest lecturer and lab instructor in his pot plant production class. Bob also supervises floriculture student internships and practicums.

Dr. Jones mentors and advises three PhD students. She also teaches a scientific writing class for graduate students on how to write and review refereed journal articles.

Dr. Peg McMahon teaches greenhouse production and interiorscaping classes at the Columbus campus. She also leads a two-day field trip class to greenhouse and allied businesses each year. In addition she teaches the required introductory course (once a year) and senior capstone course (twice a year). This coming spring she is offering a new class "Techniques in Bedding Plant Production." It is a hands-on class that will make students responsible for growing many of the bedding plant species used in the OSU Chadwick Learning Gardens and Dr. Pasian's garden and container cultivar trials. She is also facilitating a group of faculty from across the university in a program designed to make them better teachers.

Dr. Jim Metzger advises three PhD students. He also teaches the required undergraduate botany course for horticulture and crop science majors and two graduate level plant physiology classes. He is a member of the team that teaches a graduate class in plant science research methods.

Dr. Pasian advises graduate students. He is also teaching, for the first time this fall, an undergraduate class he developed, "The Latino Workforce". It is for students who will likely be working with or supervising Latino workers. The class presents an overview of the cultural, historical, and legal issues faced by immigrant workers in agriculture and how those issues affect workplace relations.

Both Dr. McMahons are in the process of revising their respective textbooks: *An Introduction to Greenhouse Production* (Bob) and *Hartmann's Plant Science* (Peg).

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ofa Grower

Biorational Insecticides

by Scott W. Ludwig

If you attended the recent OFA Short Course or have been reading trade journal publications lately, you probably have noticed the trend toward sustainable production. There are a number of reasons for growers to move toward sustainable production practices. These include marketing opportunities, reduction of labor force, higher energy costs, stricter pesticide regulations in some locations, water quality regulations, and local government restrictions on production activities. While pest management is only a small part of a sustainable system, it is critical that the system have a strong integrated pest management component (IPM). Most IPM programs today rely on the use of biorational insecticides. This is partially the result of fewer old chemistries left on the market.

What is a biorational insecticide? Historically, many of the insecticides used by ornamental producers were broad-spectrum insecticides that indiscriminately killed both beneficial and pest arthropods. While some growers lament the loss of these products, many growers are developing IPM programs relying on the use of biorational pesticides. Biorational insecticides are

insecticides that are effective against a target pest but are less detrimental to natural enemies.

There is a wide range of insecticides that are considered biorational: soaps, oils, botanicals, systemic insecticides, insect growth regulators, microbially-derived products, and living microbes such as fungi and bacteria. The way a product is formulated and applied can also affect its classification as a biorational. Unlike the older synthetic insecticides, many biorationals must come into contact with the target pest. As a result, proper application is essential and multiple applications may be required.

A number of new products that are available (or about to be registered) for use on greenhouse crops can be considered biorationals. These include QRD 400 (trade name will be available soon), TriCon, MilStop, and Aria. QRD 400 (AgraQuest, Inc.) is a plant extract derived from *Chenopodium ambrosioides* var. *ambrosioides*. The extract works by several modes of action to control a broad range of soft-bodied insects. This product is

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Biorational Insecticides

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Table 1. Means number of chrysanthemum aphids per 5 chrysanthemum leaves.

Treatment	Rate per 100 gallons	Days After First Treatment			
		0	1	7	8
TriCon	51 fl. oz.	64.2 a	0.2 e	2.2 c	0.0 c
TriCon	102 fl. oz.	83.3 a	5.8 bc	8.8 bc	1.3 c
Milstop	2.5 lbs.	72.8 a	0.5 de	13.3 b	0.5 c
Milstop	5.0 lbs.	69.2 a	2.2 cde	17.3 bc	0.8 c
QRD400	1 gal	111.2 a	4.2 cd	29.5 b	18.8 b
Capsil	7.5 fl. oz.	90.7 a	13.3 b	34.5 ab	12.8 b
Aria	0.7 fl. oz.	90.0 a	58.0 a	18.8 b	28.2 b
Water		83.5 a	71.2 a	143.2 a	181.0 a

Means within column followed by the same letter are not significantly different (Tukeys HSD, P>0.05).

under final stages of development and should be on the market shortly. TriCon (BioWorks, Inc.) is a blend of borax, orange oil, and biodegradable surfactants. Borax disrupts the outer layer of the organism causing various detrimental effects. MilStop (BioWorks, Inc.) is a potassium bicarbonate based, broad-spectrum foliar fungicide. Although MilStop is not a registered insecticide, growers have observed reduction of aphids and whiteflies after its use. This control is most likely due to other ingredients in the formulations besides the potassium bicarbonate. Aria (flonicamid, FMC Inc.) is a new chemistry class that prevents insects from feeding. The insect dies from dehydration and starvation. Aria is effective against sucking insects only. Capsil spray adjuvant (The Scotts Company) is an organosilicone adjuvant widely used by ornamental growers together with pesticides.

A study conducted in a greenhouse at the Texas A&M University System Agricultural Research and Extension Center evaluated Aria, QRD 400, TriCon, MilStop, and the surfactant Capsil for their ability to control chrysanthemum aphids on chrysanthemums. Chrysanthemum plants were grown with a single plant in a 4-inch pot containing a natural infestation of chrysanthemum aphids. Foliar treatments were applied using an R & D® CO2 backpack sprayer with an 8002VS tee-jet flat spray nozzle at 60 psi. All the treatments except Aria were applied on day 0 and 7. Aphids were counted prior to treatment and 24 hours after each treatment. At each sample period, the number of chrysanthemum aphids were counted on five terminal chrysanthemum leaves. The following treatments were evaluated (product/100 gal): TriCon (51 fluid ounces per 100 gallons), TriCon (102 fluid ounces per 100 gallons), MilStop (2.5 pounds per 100 gallons), MilStop (5.0 pounds per 100 gallons), Aria (0.7 ounces per 100 gallons), QRD400 (1 gallon per 100 gallons), Capsil (7.5 fluid ounces per 100 gallons), and water.

The TriCon, Milstop, QRD 400, and Capsil reduced the aphid populations after both applications (Table 1). The aphids that

the survived the treatments most likely did not come into contact with the insecticide applications. One day after the second application (day 8), the TriCon and Milstop treatments resulted in the lowest aphid populations. All the treatments resulted in lower aphid populations compared to the control.

A second application at a closer time interval may eliminate any aphids that survived the first spray before they are able to reproduce. By seven days after treatment, the Aria application resulted in a reduction of aphids compared to the untreated control, but it did not reduce the aphids to an acceptable level. This may have been due to the fact that the lowest rate of Aria was evaluated, and a rate higher than 0.7 ounces per 100 gallons may be required to effectively control chrysanthemum aphids.

It is important to note that Capsil is a spreader sticker and MilStop is a fungicide; they are not registered as insecticides. No phytotoxicity was observed with any of the treatments. While these products cannot be used for insect control alone, they will have an impact on aphids when used according to label instructions.

As new products enter the market it is import to understand how they work and how to properly incorporate them into your pest management program. Monitor pest populations before and after an application to determine how the insecticide impacted the population.

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OFA Fact Sheet: Black Root Rot (*Thielaviopsis basicola*)

by Janna Beckerman

Of all plant health problems, root rots tend to be the most under-diagnosed. This is not surprising, considering that most plants present themselves to the world as a mass of stems, leaves, and flowers, with the roots neatly hidden in a soil (or soilless) substrate. As such, roots are not immediately viewed, and are often examined as an afterthought, when all other causes of disease have been exhausted. Unfortunately, soilborne fungi, even in soilless mixtures, are the cause of some of the most widespread and serious diseases in the greenhouse. One such soilborne disease is *Thielaviopsis basicola*, the causal agent of black root rot.

Black root rot (BRR) is a common pathogen of both nursery and greenhouse plants. In the greenhouse, commonly infected plants include pansy, cyclamen, vinca, petunia, poinsettia, geranium, and viola – approximately 120 plants in over 33 different families! BRR gets its name for the obvious black root rot that develops on the roots of infected plants. Unfortunately, this symptom often gets confused with infection by *Pythium*. Above ground, plants exhibit the characteristic symptoms associated with root rot: stunted growth, yellowing (chlorosis), and dieback (Figure 1). Symptoms often resemble nitrogen deficiency. Examination of roots reveals blackened, rotted roots. Roots are not mushy or water-soaked, however, and may develop black, longitudinal cracks. Blackened lesions may appear at the tips of feeder roots and contrast sharply to healthy, white adjacent portions. Characteristic dark brown to black, thick-walled, barrel-shaped chlamydospores can be observed in infected tissues after rinsing the roots of growing media



Figure 1. Off-colored plants are a signal of root problems, *Thielaviopsis* in this case.



and then viewing them carefully with a hand lens (Figure 2). Professional diagnostic services will utilize a microscope to conclusively identify this pathogen.

In examining the spores (Figure 2), an obvious feature of this pathogen's biology becomes apparent. This is one thick-walled, tough spore! As such, its ability to persist and survive is an issue in its management. To make matters worse, the thick-walled black overwintering spore (termed a chlamydospore) is only one part of its lifecycle. *Thielaviopsis* also produces conidia, smaller spores that are easily dispersed in soil, water, and splashing media. It is probably through these smaller, lighter spores that the disease spreads, whereupon it eventually develops these black, thick-walled spores that allow it to persist as a thoroughly unwelcome greenhouse guest. Fungus gnats and shore flies also vector this fungus.

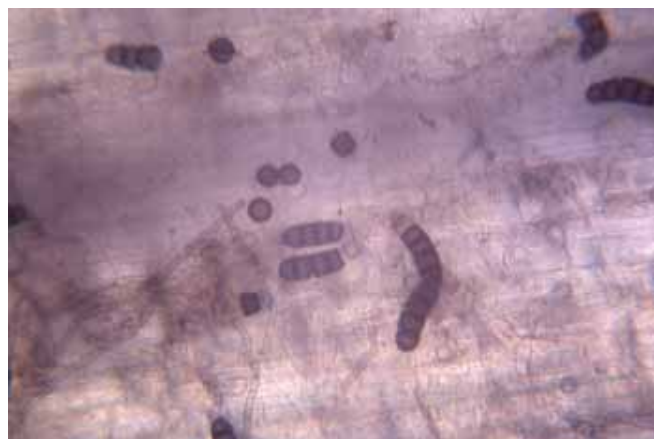


Figure 2. The dark thick-walled, multi-celled spores embedded in roots are characteristic of *Thielaviopsis*. Photo courtesy of Karen Rane.

Management

It goes without saying that the use of pathogen-free plants is a key step in managing this disease. Unfortunately, many plug growers are able to effectively manage plug production in such a way that symptoms go undetected until the plug trays are subjected to some sort of stress (cool, hot, high pH, etc.) that can exacerbate BRR. Summer pansy production (for fall plantings) creates tremendous plant stress resulting in outbreaks of BRR, particularly in parts of the country where water pH rises to 8 or even 8.5 in the summer. For spring production, wet media,

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OFA Fact Sheet: Black Root Rot (*Thielaviopsis basicola*)

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coupled with temperatures between 55° to 61°F, drives the disease, particularly when soil pH is alkaline (above pH 7). Regardless of season, pathogen growth can be reduced if soil media is brought to pH 5.5 or below, or even prevented at pH 4.8. Unfortunately, many plants do not grow well under such acid conditions, although pansies appear to grow quite well at a pH of 5.5.

In operations where tray recycling is necessary, the thick-walled chlamydo spores create a serious contamination issue. Trays must be cleaned and scrubbed with a 10 percent solution of bleach (1 part bleach to 9 parts water) WITH detergent – the detergent is necessary to get the bleach through the thick wall to kill the spore. Trays must soak for 30 minutes. Commercial products, such as Zero-Tol (2.5 ounces per gallon sprayed onto trays) or Greenshield (1 tablespoon per gallon for 10 minutes as a dip) are effective in eliminating *Thielaviopsis* spores.

Regardless of the fungicide chosen, even the best fungicides fail to provide good control once symptoms are seen, which is why it is so important to be proactive and treat if there is a history of *Thielaviopsis*. Unfortunately, fungicide use for control of BRR has been inconsistent, at best, with one exception: Thiophanate-methyl (Cleary's 3336, Fungo WSB,

OHP 6672). Terraguard (triflumazole) and Medallion (fludioxanil) are labeled for use, but both have given inconsistent results under different conditions. To date, no strobilurins tested have provided adequate control for this disease.

Regardless of the fungicide chosen, preventative treatments should be applied at recommended intervals and rates as described on the label. Proper dose and rate ensures the greatest likelihood for success and minimizes the risk of developing fungicide resistance. To further prevent fungicide resistance issues from developing, tank or rotate an active ingredient like Thiophanate-methyl with either Terraguard or Medallion, or use BanRot (etridiazole + thiophanate methyl) to prevent both black root and fungicide resistance in black root rot from becoming established!

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Regular Safety Communication

by Gary Hanson

One of the keys to a successful safety program is regular communication between management and employees. Employees need to be kept up to date on safety-related programs, policies, accidents, and the overall effectiveness of the company safety efforts. Ongoing safety training is also an important element that needs to be part of your company's communication efforts.

Posting memos on the safety programs and regular meetings should be a part of your communication efforts. The most effective method is regular meetings. These, however, have to be planned and conducted properly. All too often these meetings are not conducted effectively and the desired results of the meeting are not achieved. Some of the major problems with these meetings include the following:

- Not being scheduled in advance.
- Being conducted sporadically or canceled entirely.
- Passing out information for employees to read without time for follow through.
- Supervisors or presenters not prepared to review the material thoroughly.
- Meeting area not appropriate for conducting a meeting.

All of these distract from the effectiveness of a meeting presentation and have a negative impact on the overall safety program. In order to ensure that the meetings are achieving the desired effect, the following guide should prove valuable:

- Plan the meeting in advance.
- Select an appropriate location to conduct the meeting which affords limited distractions.



- Advertise in advance when the meeting will be held and the main topic to be covered.
- Start the meeting on time.
- Ensure that the presenter or instructor can easily be heard.
- Give employees a chance to report any safety concerns they may have or safety suggestions. Note the suggestions given.
- Look around the room to ensure each employee has an opportunity to speak.
- Report to the group any actions taken by management to correct unsafe conditions previously reported.
- Discuss the safety performance since the last meeting, good or bad.
- If good, congratulate and thank the group.
- If not so good, ask the group for their suggestions to improve the safety performance.
- Discuss all employee accidents and close calls.
- Advise of any new programs or policies that are to be implemented.
- Discuss these and explain the reasons why these are being implemented.

If the meeting is to include a Safety Training topic the following items need to be considered:

- Ensure the presenter or instructor reviews the topic in advance in detail.
- An outline should be available.
- Key points should be determined in advance.
- Relate the topic to the operation.
- Start by telling a story or using an example relating to the topic.
- Note the Key Points (no more than five) that are to be covered in the meeting.
- For each key point list two to three questions for the group to respond to.
- Get employees involved by using the questions.
- Ask them to relate their own stories or examples.
- The presenter or instructor should lead the discussion.
- Note do not read the topic.
- Cover each key point one by one. When finished ask the employees if they have any additional questions or comments.
- Close the meeting by recapping the items that were covered.
- Follow up on any of the items noted by the employees.

The meeting should only last 15 to 20 minutes in total, unless there is a special topic or item that needs to be covered. This format will also allow your company to provide not only communication on your safety programs, but reinforce your company's safety training program. The time invested will pay your company back many times over.

Gary Hanson
 American Safety & Health Management Consultants Inc
 Article provided via Compensation Consultants Inc,
 Dublin, Ohio.



ofa Academic

What's IR-4 Done for Me Lately?

by Charles Krause

The Agricultural Research Service (ARS) is the primary in-house research organization of the United States Department of Agriculture. The Ohio component, The Application Technology Research Unit (ATRU) is located in Wooster at the Ohio Agricultural Research and Development Center (OARDC) and at a worksite at the University of Toledo. ATRU research must be based on sound science and fit into the ARS National Research Programs (www.ars.usda.gov).

What is IR-4?

One component of the ARS program provides tools for growers of specialty crops throughout the nation. The Inter-regional Project #4 (IR-4) was established in 1976 to obtain pesticide registration and label expansion for specialty crops (minor crops; ornamental and food-use crops). Based in

Wooster, Ohio at the OARDC, the IR-4 program is committed to providing safe and effective pest management tools for growers of specialty crops including food-use and ornamentals, and is a cooperative research project between ARS, federal research, state experiment stations, and the private sector, collaborating with U.S. Environmental Protection Agency (USEPA). The program seeks to fill the gap between grower's needs and statutory requirements of USEPA to provide seamless interagency collaboration between ARS and CSREES.

In short, without IR-4, few weed, disease, and insect management tools would be available today. For 40 years state and federal scientists have conducted product safety and efficacy

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What's IR-4 Done for Me Lately?

Continued from page 29

studies resulting in more than 14,000 registrations. Separate funds are appropriated by Congress specifically for the IR-4 Program. These monies are used to conduct high priority studies as determined at annual national IR-4 workshops and subsequent IR-4 liaison meetings. Stakeholders are encouraged to attend IR-4 workshops

Needless to say ATRU expresses its appreciation to the faculty and administration of The Ohio State University/OARDC in Columbus and Wooster for their long-term associations with our programs, and to our new cooperators at the congressionally-initiated ATRU Greenhouse Production Research Group at the University of Toledo.

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OFA Membership & Financial Reports

Membership as of September 30, 2007

Association Category	Total
Active Grower	1,117
Active Non-grower	1,066
Students, Educators, Retirees	218
Subscribers	266
Award of Excellence & Reciprocal Agreement	27
Total	2,694

Ohio Florists' Association Inc. and Subsidiary Consolidated Statements of Activities for the Year Ended December 31, 2006

Revenues:

Short Course and Trade Show	\$1,988,354
Dues	\$278,998
Publications and advertising	\$84,086
Short Course sponsorship	\$60,436
Workers' Compensation program	\$28,988
Investment income (loss)	\$93,072
Miscellaneous	\$9,769
Total revenues	\$2,543,703

Expenses:

Short Course and Trade Show	\$733,463
Personnel costs	\$888,765
Contributions	\$59,383
Professional fees	\$34,728
Depreciation and amortization	\$44,516
Communications	\$57,878
Publication costs	\$70,109
Office equipment leases	\$30,030
Computer equipment and maintenance	\$50,958
Building maintenance, utilities, and taxes	\$46,748
Administrative meetings/functions	\$89,670
Public relations	\$16,002
Travel	\$29,952
Credit card processing fees	\$9,788
Postage	\$10,578
Office supplies and other	\$17,728
Telephone	\$13,845
Insurance	\$10,400

Total expenses \$2,214,541

Increase in Net Assets	\$329,162
Net assets – beginning of year	\$1,237,908
Net assets – end of year	\$1,567,070



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ofa News

Welcome New OFA Members

Anthony Tesselaar International – Silvan Victoria, Australia
 April Showers Greenhouse – Millersburg, OH
 Ash Craft Industries – Ashtabula, OH
 Baker's Greenhouses – Mumford, NY
 Barbott Farms & Greenhouse – Stevensville, MI
 Belmont Nursery – Fresno, CA
 Benary – Arden, NC
 Big Brook Greenhouse – Cable, WI
 Connie's Country Greenhouse – Latham, IL
 Country Corner Greenhouse – Marshall, IN
 Country Way Garden Center – Fairport, NY
 Creek Side Garden – Littleton, CO
 Cyndi's Garden Center – North Bend, OH
 Eagle Landscaping – Brainerd, MN
 Felicity Flowers & Gifts – Felicity, OH
 Finger Lakes Fresh – Ithaca, NY
 Fisher's Greenhouse Inc – Columbus, OH
 Flower Bed Nursery – Lumberton, MS
 Flower Boutique – Groveport, OH
 Frederik Meijer Gardens – Grand Rapids, MI
 Frisella Nursery Inc – Defiance, MO
 Good Earth Greenhouse LLC – River Forest, IL
 Green Earth Greenhouses – Godfrey, IL

Hort Nutrition – Williamston, MI
 Indecor Ltd – Beijing, China
 Interior Plant Design – Stockton, NJ
 Meridian St Greenhouse – Indianapolis, IN
 Mills Flowers – Gananoque, ON, Canada
 Morganville Flower Farm – Morganville, NJ
 Overdevest Nurseries LP – Bridgeton, NJ
 Plant Health Care Inc – Pickerington, OH
 Riverside Greenhouses LLC – Andover, NJ
 School House Garden Market – Bloomsburg, PA
 Seneca Greenhouse – Buffalo, NY
 Source Force Supply LLC – Cedarburg, WI
 Studebaker Nurseries – New Carlisle, OH
 The Flower Shop – Chesapeake, OH
 TropiCare of Oregon/Mossbarn.com – Saint Paul, OR
 Neil Mattson – University of Minnesota – Saint Paul, MN
 Eileen Nelson – University of Wisconsin – Madison, WI
 Verdi Garden Center – Verdi, NV
 Vienna Sparkle – South Vienna, OH
 Westerlay Orchids – Carpinteria, CA
 Western Farm Service – Hubbard, OR
 Wolf Mountain Farm – Doniphan, MO

Welcome New OFA Subscribers

Lori Ball, Paul Ecke Ranch – Encinitas, CA
 Lifang Li, Beijing Flower & Tree Corporation – Beijing, China

Grace Poindexter, Anchor Point Greenhouse – Anchor Point, AK
 Al Zyslra, TrueLeaf Technologies – Petaluma, CA



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OFA Outreach Education

Bringing Pack Trials to You

November 6

Michigan Greenhouse Grower Expo, Lansing, Michigan

There is no place like the California Pack Trials to be captivated by new plant products and the potential they could bring to your bottom line. But not everyone has the opportunity to go, and those that do are often overwhelmed by the range and volume of options. Join Catherine Evans, Tim Hodson, David Kuack, and Delilah Onofrey, editors of four of the leading floriculture industry magazines, as they share their favorites and why. Also, Drs. Will Healy and Art Cameron will share the secrets that make the selections "tick." Come join in the banter, wrangling, and fun. More information is available at www.ofa.org/outreach.

OFA Event Calendar

November 4, 2007	Ohio Certified Florist (OCF) Test - Columbus, Ohio
November 6, 2007	Bringing Pack Trials to You - Lansing, Michigan
November 13-14, 2007	Poinsettias: The Nuts & Bolts AND The Dollars & Cents - Encinitas, California

Poinsettias: The Nuts & Bolts AND The Dollars & Cents

November 13 - 14

Paul Ecke Ranch, Encinitas, California

Wholesale and retail growers are constantly evaluating their production and marketing of poinsettias. To help growers squeeze every last dollar out of the cost of production while still providing a top quality crop, this 1.5-day symposium will be offered. In this intense poinsettia symposium you'll learn about scheduling, temperature, light, nutrition, media, water, height management, diagnostics, and varieties.

Presenters Jan Hall and Roger Kehoe (Paul Ecke Ranch), Allen Hammer (Dummen), Harvey Lang (Fischer USA), Richard Lindquist (OHP Inc), and Stefan Reiner (Selecta First Class) will introduce new forms and presentations, varieties, and specialty programs that can help growers reap a great margin. More information is available at www.ofa.org/outreach.

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