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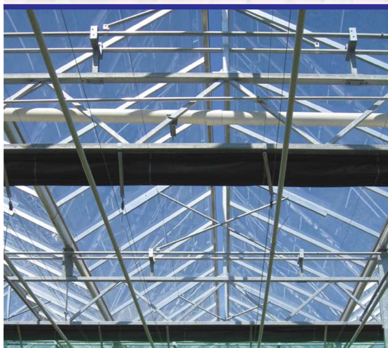

In This Issue

Spring 2011
Volume 5 • Issue 1

Roberto's Message

Vegetative Petunia Propagation and Production Challenges

Several vegetative petunia varieties are proving difficult to grow this year – learn why.

Dr. Roberto G. Lopez[1] and Dr. Erik S. Runkle[2],

Assist. Professor and Floriculture Extension Specialist[1] and Assoc. Professor and Floriculture Extension Specialist[2]

Dear flower growers, businesses, distributors, organizations, and colleagues,

In the past month, we have visited several greenhouse growers across the Midwest and Northeast who have had challenges this year producing some vegetative petunia varieties from different breeding companies. The problem seems to affect yellow cultivars more severely than others. We have observed two problems:

1. Cuttings root well, but toward the end of the liner stage, they lose vigor, turn yellow or develop necrotic spots, and/or die (Figure 1).

2. A small percentage (5 to 10%, sometimes more) of finished plants are stunted and have low vigor (Figure 2).

Some samples have been submitted to the Purdue Plant and Pest Deagnostic lab and MSU's Diagnostic Services, and no pathogens have been found but the media fertility levels were often low and the pH sometimes high (above 6.0). We consulted with Dr. Allen Hammer of Dümmen, who has spent more time determining the likely causes to these issues. It seems pretty clear that these problems involve the over misting, nutritional status of the cutting, fertilizer provided during propagation, as well as plant genetics. The problem likely occurs early during propagation but shows up later once the liners are actively growing. The cutting meristems abort, which could be from a calcium and/or boron deficiency. The cuttings root normally but are unable to grow because of the aborted meristems.

Some of the liners with the aborted meristems may grow from an axillary bud, or perhaps an adventitious bud, if high fertility is provided (300 ppm nitrogen) (Figure 3). The cuttings that do grow from these axillary buds are slower to develop, thus creating the appearance of reduced vigor when mixed with normal liners. When finish plants from unaffected liners are ready for shipping, those from affected cuttings are not (Figure 4).

The following factors can make this problem worse:

- Excessive misting during propagation
- Propagation root medium pH above 5.5
- Little or no fertilizer applied during liner production

Growers are encouraged to use a fertilizer that contains micronutrients at a relatively high rate (e.g., 250 ppm nitrogen) once roots form. In addition, lower the humidity once cuttings become established to promote uptake of calcium and boron, and increase air flow. Avoid low light and cold growing conditions, since plants use less water in those conditions. For more information on how to manage the environment during cutting propagation, visit: http://flowers.hort.purdue.edu

It is always important to remember that symptoms caused by various biotic (insects and diseases) and abiotic (cultural and environmental) factors may mimic each other and thus it is important to first rule out the presence of an infectious causal agent by sending in samples to a diagnostic lab before assuming the symptoms are all caused by nutritional, environmental or genetic factors.

Figure 1. Cuttings begin to turn yellow, develop necrotic (brown) spots and/or shoot tips abort during week 3 of propagation (left). An unaffected cultivar propagated at the same time as the affected cultivar (right). Photo: Roberto Lopez.

Figure 2. Symptoms become more severe during the toning phase of propagation. Photo: Roberto Lopez.

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Roberto Lopez at: rglopez@purdue.edu

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Figure 3. The shoot-tip meristem of petunia (left) aborted during propagation. If fertility levels are sufficient, the axillary buds develop but flowering of those shoots is delayed. Photo: Allen Hammer, Dümmen.

Figure 4. The variability in rooted liners of petunia created a non-uniform finish crop. Photo: Erik Runkle.

Dealing with Bedding Plant and Garden Mum Nutritional Challenges

By Christopher J. Currey[1], Diane M. Camberato[2], and Dr. Roberto G. Lopez[3]

Graduate Student[1], Greenhouse Technician[2], and Assist. Professor and Floriculture Extension Specialist[3]

There are many challenges producers face when growing bedding plants and garden mums. Many of these challenges are rooted in the diversity of plants that we grow in greenhouses. Each year, the greenhouse is filled with literally hundreds of genera, species, and cultivars. This diversity makes growing each crop to perfection under one roof a real challenge. For instance, inducing flowering of all crops is difficult as not all annuals and perennials are in the same photoperiodic response group with respect to flowering. Similarly, the same chemical plant growth retardant and concentration will not suppress stem elongation of all crops. As with other cultural and environmental factors, bedding plants and garden mums vary in their nutritional requirements. This article will focus on meeting the nutritional requirements of bedding plants and garden mums, what factors affect them, and how to monitor for problems.

The primary factors affecting fertility requirements of bedding plants and garden mums are composition of the fertilizer solution and the amount of nutrients available in the substrate. By necessity many growers need to use a single fertilizer solution and concentration for fertilizing all of their plants. However, bedding plants and garden mums differ in their relative nutrient requirements. Bedding plants can be classified in general categories as light, or medium feeders based on their nutrient requirements. Table 1 provides the two main classes of bedding plant nutrient requirements based on substrate electrical conductivity (EC), which generally reflects the amount of fertilizer in the substrate. For example, New Guinea impatiens are considered light feeders (Figure 1) and excessive stretch can result from excessive fertilization. Alternatively, garden mums are considered heavy feeders. So how can growers accommodate all of these different nutrient requirements? Start by using a fertilizer solution that provides all the essential macro- and micronutrients. This can be achieved by selecting a single fertilizer product that is complete, containing all the essential nutrients, or by blending several macro- and micronutrient sources to make a complete solution. Next, you'll need to select the fertilizer concentration that you'll use in the greenhouse. Generally speaking, when faced with different nutrient requirements it is best to use a moderate concentration when selecting a single fertilizer concentration. By using a single, complete fertilizer solution at a single concentration, growers can adjust the fertility level of the substrate for different crops by altering the leaching fraction during fertigation or alternating fertigation with irrigation of clear water to achieve a target EC. For example, substrate EC levels can be increased for crops such as mums with higher nutritional requirements by decreasing the amount of fertilizer solution leached at each fertigation, or leaching fraction. Similarly, substrate EC levels for crops with lower nutritional requirements may be reduced by increasing the leaching fraction during fertigation or by alternating fertigation with clear water.

Another major factor that affects nutrition is the substrate pH, since substrate pH primarily affects nutrient availability in the root zone. For example, as pH increases, the availability of several micronutrients such as iron decreases, while as the pH decreases micronutrient availability increases. Similar to nutritional requirements, bedding plants have been categorized into three distinct pH requirement groups: 1) iron-efficient (pH 6.0–6.6), 2) general (pH 5.8–6.4), and 3) iron-inefficient (pH 5.6–6.2; Table 2). The primary factors that influence substrate pH are irrigation water quality, fertilizer solution, and substrates. Since, growers will most likely be using a single water source and fertilizer solution, as discussed in the previous section, the best way to accommodate different pH-requirements is by using a substrate with an appropriate pH. The potential to run into serious pH problems is greatly reduced if growers plant crops in substrate with the appropriate pH. Since bedding plants are a relatively short-term crop, substrate pH may not fall out of the desired range as it will with longer term crops such as garden mums. Substrate pH is primarily adjusted prior to planting by adding lime to soilless mixes; as lime additions increase, so does the substrate pH. Growers who mix their own substrate can have complete control over the pH by adjusting their own lime additions and can formulate more acidic or more basic substrates as they wish. For short-term crops like bedding plants, growers can plant all of their crops in a substrate with a general pH (5.8 to 6.4) and decrease or increase the substrate pH for specific crops by applying a one-time acid or lime drench, respectively. Alternatively, if growers purchase pre-mixed substrates they may purchase it with pH values that meet their crop's needs. For instance, growers can select mixes already adjusted to the desired pH or request a certain pH for custom mixes.

Substrate pH and EC levels are closely related to how plants are growing. In turn, the growth and development of bedding plants and garden mums is strongly linked to seasonal changes in temperature and light. A thorough monitoring program can help prevent any nutritional problems. Weekly measurements of substrate pH and EC can help producers monitor the root zone and make pH or fertilizer adjustments well before any visual symptoms would indicate problems. For more information on how to monitor substrate pH and EC, see Purdue Extension Publication HO-237-W, pH and Electrical Conductivity Measurements in Soilless Substrates.

There are a few things growers can do to increase their success with bedding plant and garden mum nutrition. By using a complete fertilizer solution, adjusting leaching fractions, and incorporating clear water into fertilizer programs, growers can accommodate the different nutritional requirements of both bedding plant and garden mum crops. Similarly, by simply adjusting substrate pH at the beginning of the production cycle, crops with different pH requirements can be grown using one water source and fertilizer solution. With a little bit of careful planning before planting, along with regular monitoring of the substrate pH and EC during production, growers can produce a large variety of high-quality bedding and garden mums in a single facility.

Table 1. Relative nutrient requirement groups of common greenhouse bedding plants based on substrate electrical conductivity (EC) measurements from three different substrate tests.

EC (mS/cm)			
Light (1:2 dilution of 0.26 to 0.76) (SME of 0.76 to 2.0) (PourThru of 1.0 to 2.6)		**Medium (1:2 dilution of 0.76 to 1.25) (SME of 1.5 to 3.0) (PourThru of 2.0 to 3.5)**	
ageratum	begonia, fibrous	alyssum	bougainvillea
celosia	coleus	calendula	campanula
cosmos	geranium, seed	carnation	centaurea
gerbera	impatiens	cleome	clerodendrum
marigold	New Guinea impatiens	dahlia	dianthus
pansy	primula	dusty miller	exacum
salvia	snapdragon	geranium, vegetative	larkspur
zinnia		lily, Asiatic	lily, Oriental
		lobelia	morning glory
		ornamental kale	ornamental pepper
		pepper	petunia
		phlox	portulaca
		tomato	verbena

Adapted from Warner, 2007.

Table 2. Relative pH requirement groups of common greenhouse bedding plants and garden mums.

pH				
Iron-efficient group (6.0 to 6.6)	**General group (5.8 to 6.4)**		**Iron-inefficient group (5.6 to 6.2)**	
lisianthus	angelonia	begonia	argyranthemum	azalea
marigold	garden mum	fuchsia	bacopa	brachycome
New Guinea impatiens	helichrysum	heliotrope	calibrachoa	dianthus
geranium, seed	heuchera	impatiens	diascia	nemesia
geranium, zonal	geranium, ivy	tomato	pansy	petunia
	verbena, broad-leaved		scaevola	snapdragon
			verbena, fine-leaved	viola

Adapted from Argo and Fisher, 2010.

Figure.1 A compact New Guinea impatiens crops that was not over fertilized.

Identifying Boron Deficiency and Corrective/ Preventative Actions

By Dr. Neil Mattson[1] and Dr. Brian Krug[2]

Assist. Professor & Floriculture Extension Specialist[1] & Floriculture Extension Specialist[2]

Symptoms

Boron (B) is classified as an immobile element in plants; once B has been taken up by the plant it cannot be reallocated to other portions of the plant when B availability in the substrate is limited. As with other immobile elements, symptoms first appear on new leaves. Boron is required to build plant cell walls, therefore, when not enough B is available the areas of the plant with rapidly growing new cells (i.e. the growing point and new leaves are affected first). The growing point often aborts (effectively "pinching" the plant) this leads to proliferation of branches. The branches and new growth are distorted, thick, and brittle; also the upper foliage can exhibit a mottled chlorosis (i.e. scattered yellowing of leaves). When the roots are examined they are often short and stubby.

Unlike most nutrient deficiencies that typically exhibit symptoms uniformly across the crop, B symptoms can appear randomly within a crop, section, or even flat/pot. For example, in Figure 1 we can see pansy and petunia demonstrating symptoms of B deficiency.

Causes

Boron is absorbed by plant roots and moved through the plant in the transpiration stream, and similar to Calcium (C) active water movement through the plant is required to drive B uptake. Conditions that can cause B deficiency include: low B in tap water or fertilizer, high C levels (which can inhibit B uptake), inactive roots (waterlogged or dry substrate, or cold root-zone), high humidity, substrate packed too tightly, or high pH. B deficiency is most often observes in pansy and petunia – especially those growing with a limited substrate volume (i.e. in plug trays or packs).

Prevention and Solutions

Prevention is key. While plants that exhibit B deficiency symptoms usually recover after corrective measures have been taken, the time required for recovery will be lengthy. In many cases B deficiency occurs early in the germination/seedling stage (in particular with pansy and petunia). At this growth stage symptoms of B deficiency are subtle and often go unnoticed. Symptoms may become more obvious later in production although the actual deficiency conditions occurred earlier. Therefore, proactive cultural practices to prevent B deficiency from developing, especially for crops with a history of B deficiency, are most effective. Cultural practices that can help prevent B deficiency from developing include: avoid overwatering plug trays and flats, lowering greenhouse humidity by venting in outside air, using fans to promote air movement, or raising greenhouse/root-zone temperatures. Drench applications with a B containing product can also be used for preventative and corrective measures. Use caution when applying supplemental B; plants require only a small amount of B and over application of B leading to toxicity is easily done. Some products that can be used:

• Soluble Trace Element Mix (S.T.E.M.) at 4 ounces per 100 gallons (supplies 4 ppm B plus other trace elements).

• Borax (11% Boron) at 0.75 ounces per 100 gallons (supplies 6 ppm B).

• Solubor (20% Boron) at 0.4 ounces per 100 gallons (supplies 6 ppm B).

Figure 1. Pansy (above) and petunia (next page) demonstrating symptoms of Boron deficiency. (Photos by Brian Krug, University of New Hampshire)

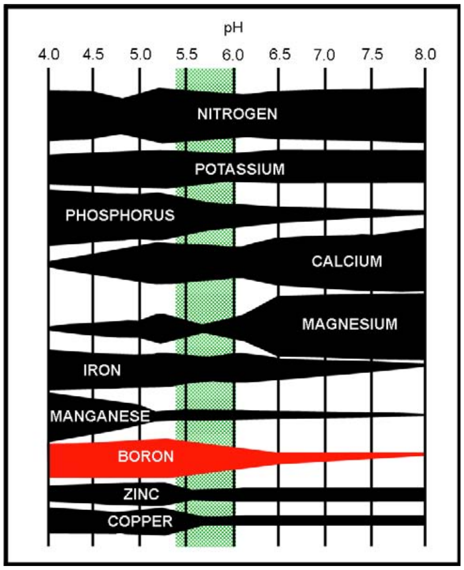

Figure 2. Availability of Boron is related to Root-Zone pH. The graoh above illustrates relative nutrient availability as a function of substrate pH. High pH favors Boron deficiency. Occasionally, if tap water contains too much Boron, low pH can favor Boron toxicity. (Graph by Doug Bailey University of North Carolina)

ABA Applications Delay Drought-induced Wilting in Garden Mums

By Dr. Michelle Jones[1] & Dr. Nicole Waterland[2]
Assoc. Professor[1] & former graduate student[2]

Plants such as garden mums may experience irregular irrigation frequency during shipping and in retail displays. The result is rapid substrate drying, plant wilting, and reduced shelf life. The plant hormone abscisic acid (ABA) helps plants survive drought stress by closing their stomata and reducing water loss. A new anti-transpirant (Contego™ Pro SL; Valent BioSciences) that contains s-ABA, the biologically active form of abscisic acid, will soon be available for commercial use to enhance postproduction drought tolerance.

The effectiveness of s-ABA was evaluated on *Chrysanthemum ×morifolium* 'Brandi', 'Colina Red', 'Flashy Gretchen', 'Golden Cheryl', 'Regina' and 'Wilma'. Well-watered chrysanthemums in 6 inch (15-cm) pots were sprayed with 0 or 500 ppm s-ABA (ConTego™ Pro SL, Valent BioSciences Corp.) plus a surfactant (0.05% CapSil). Plants were treated at the marketable stage, when only a few of the flowers were open (stage 2). Half of the plants from each ABA treatment had water withheld (drought-stressed) until the plants were visually wilted, and the other half (irrigated controls) were irrigated daily. The shelf life of the mums was determined as the number of days that plants remained turgid (not wilted) when water was withheld. Irrigated control plants were treated with s-ABA to evaluate any symptoms of phytotoxicity. After plants had wilted they were irrigated to evaluate plant recovery. Recovery was evaluated for 3 days.

s-ABA applications effectively delayed water loss and visual symptoms of wilting in all cultivars except Brandi (Table 1). Treated plants wilted from 1.6 to 3.8 d later than untreated (0 ppm) plants when water was withheld. 'Flashy Gretchen', `Regina' and 'Wilma' had the longest shelf life extension (Table 1 and Figure 1A). s-ABA treatment also allowed severely drought-stressed garden mums to recover and remain marketable after wilted plants were re-watered (Figure 1B). No phytotoxicity was observed on any of the cultivars.

Figure 1. 'Flashy Gretchen' sprayed with 0 (left) or 500 ppm s-ABA (right). Water was withheld until the plants were visibly wilted and then they were re-watered. (Above) 8 d with no water. S-ABA treated plants were still not visibly wilted. (Below) Wilted plants were re-watered on day 9. The photo was taken after 3 d of re-watering. The s-ABA plants recovered completely and were considered to be marketable, while the untreated (0 ppm s-ABA) plants did not recover.

Table 1: Time to wilt and shelf life extension in mums treated with s-ABA.

Cultivar	Time until wilted (days)		Shelf life
	0 ppm	500 ppm	extension (d)
Brandi	1.7 a	2.5 a	0.8
Colina Red	3.8 b	5.5 a	1.8
Flashy Gretchen	5.5 b	9.3 a	3.8
Golden Cheryl	2.2 b	3.8 a	1.6
Regina	3.8 b	7.0 a	3.3
Wilma	4.8 b	8.5 a	3.8

Conclusions

• ConTego ™ Pro SL is an s-ABA biochemical that can effectively enhance drought tolerance in garden mums.

• Responses are cultivar specific.

• S-ABA applications reduce water loss by decreasing stomatal conductance.

• Drought –induced wilting is delayed without any phytotoxicity. Read label carefully as phytotoxicity will occur in certain species.

• Many cultivars are still marketable after severely wilted plants are re-watered.

References

Waterland N., J.J. Finer and M.L. Jones (2010) Abscisic Acid Applications Decrease Stomatal Conductance and Delay Wilting in Drought-stressed Chrysanthemums. HortTechnology 20: 896-901.

Reducing Storm Damage to Your Greenhouses

By Dr. John W. Bartok
Agricultural Engineer

Nature seems to be getting more violent in recent years with frequent earthquakes, increased numbers of hurricanes and record-breaking snowstorms. Insurance damage claims have increased considerably. The International Building Code has revised upward its wind and snow loading requirements for some areas of the US.

Each year there are reports of greenhouses that have been damaged by weather and natural events. Greenhouse design is different than conventional farm buildings in that the structural profile has to be small to allow maximum light to reach the plants. Most farm buildings are over designed to handle severe weather conditions.

Damage to greenhouses can include racking of the frame, bending of the hoops, broken glass or torn plastic and uplifted foundation posts. Preparation ahead of time can minimize the damage.

Wind Loading

Wind forces that act on a greenhouse are influenced by numerous factors including the basics of wind speed, greenhouse orientation, exposure, and height and shape of doors or vents that may be open. The wind passing over a greenhouse creates a positive pressure on the windward side and a negative pressure on the leeward side. These can combine to create a force that wants to collapse or overturn the building. An 80 mph wind can produce a pressure of 16 pounds per square foot (psf). For example, the 10′ by 100′ sidewall of a gutter-connected greenhouse would have to resist a 16,000 pound force.

Wind can also create a force similar to an aircraft wing that wants to lift the greenhouse off the ground. An 80 mph wind blowing perpendicular to the side of a 28′ x 100′ hoop house can create a lifting force of 220 pounds per foot of length or 22,000 pounds of uplift on the whole structure. When you consider the total weight of materials and equipment in the greenhouse is about 6000 pounds, the foundation must have a withdrawal resistance of about 300 pounds each. This is why building inspectors frequently require that the posts be surrounded by concrete. Although you have no control over the force or direction of severe winds, here are a few tips to help minimize storm damage:

• Check the area for loose objects. Anything that can be picked up and hurled through the glazing should be secured or moved indoors. Metal chimney (stove pipe) sections should be secured with sheet metal screws.

• Inspect for dry or weak tree limbs that could fall on the greenhouse.

• Close all openings including vents, louvers and doors. The effective force of the wind is doubled when it is allowed inside the building. The wind on the outside puts a pressure or lifting force on the structure. The wind inside tries to force the walls and roof off.

• On air inflated greenhouses, increase the inflation pressure slightly by opening the blower's intake valve. This will reduce the rippling effect. Check to see that the plastic is attached securely and that any holes are taped.

• Disconnect the arm to the motor on all ventilation - intake shutters and tape the shutters closed. Then turn on enough exhaust fans to create a vacuum in the greenhouse. This will suck the plastic tight against the frame.

• Windbreaks can reduce the wind speed and deflect it over the greenhouse. Conifer trees (hemlock, spruce, pine, etc.) in a double row located at least 50′ upwind from the greenhouse can reduce the damaging effects of the wind. Wood or plastic storm fencing can be used as a temporary measure.

Snow Loading

Snow that accumulates on a greenhouse can put significant weight on the structural members. Snow loads vary considerably from 0 along the southern coastline to more than 100 pounds per square foot in Northern Maine. Local building codes specify the design snow load.

Snow can be light and fluffy with a water equivalent of 12 inches of snow equal to 1inch of rain. It can also be wet and heavy with 3 inches equal to 1 inch of rain. Snow having a 1 inch rain water equivalent will load a greenhouse with 5.2 psf. This amounts to 6.5 tons on a 25′ x 96′ greenhouse. The following are a few pointers to consider before the next snow season:

• The foundation piers or posts should be large enough to support the weight of the building including crop and equipment loads.

• All greenhouses should have diagonal bracing to keep it from racking from the weight of the snow or force of the wind.

• Collar ties and post connections should have adequate bolts or screws. This is a weak point in some greenhouse designs.

• Allow 10' to 12' between individual greenhousefor snow accumulation and to prevent sidewalls from being crushed in.

• When building new hoophouses, consider using a gothic design that sheds snow easier. In hoop shaped houses, install 2 inch x 4 inch posts under the ridge every 10' when heavy snow is predicted.

• The heating system should be large enough to maintain 60°F to melt snow and ice. It takes 250 Btu/hr per square foot of glazing to melt a wet snow falling at a rate of 1 inch per hour. Heat should be turned on in the greenhouse or under the gutter several hours before the storm begins.

• The plastic should be tight and inflated to at least 0.25 inch water pressure. This can be checked with a monometer. Any cracked or broken glass should be replaced.

• Energy screens should be retracted to allow heat to the glazing.

• A standby generator should be available with adequate fuel for the duration of the storm to power heaters, fans and blowers.

Selection of greenhouses that meet the International Building Code and good construction techniques are important considerations when building new greenhouses.

A little preparation before a storm can minimize damage from severe weather events.

Reprinted from Floriculture Greenhouse Update: <www.negreenhouseupdate.info>.

Broad Mites in the Greenhouse

By Dr. Raymond A. Cloyd
Professor of Entomology

Broad mite (*Polyphagotarsonemus latus*) is a mite species that may be encountered in greenhouse production systems. Broad mites are classified as tarsonemid mites and feed on plants in over 60 plant families including a wide-variety of horticultural crops such as African violet, begonia, chrysanthemum, cissus, cucumber, cyclamen, dahlias, delphinium, eggplant, English ivy, exacum, fuchsia, impatiens, New Guinea impatiens, pepper, snapdragon, strawberry, tomato, and zinnia. Broad mites have been a major pest of transvaal daisy (*Gerbera jamesonii*) crops grown in greenhouses since the 1930's (Figure 1). Unfortunately, they cannot be observed with the naked eye (Figure 2).

Broad mites are typically a problem under favorable conditions for development and reproduction; temperatures between 60 ºF and 70 ºF (15 ºC and 21 ºC), relative humidity of 70% to 80%. However they tend to avoid light. All life stages (e.g., egg, larva, nymph, and adult) may be present during the growing season. They feed on young leaves and flower parts including buds, which may retard growth and prevent flowers from fully developing (Figure 3). They tend to reside and feed on the meristematic tissues of plants, requiring tender living tissue, which provides an ideal food source for development. The presence of broad mites typically occurs after plant injury is noticeable as opposed to actually detecting the mites themselves.

Biology and Damage

Broad mite adults are approximately 0.0009 inches (0.25 mm) long, shiny, amber to dark-green in color, and oval in shape. There are four distinct life stages: egg, larva, nymph, and adult. Females can lay four eggs per day, with the potential to lay up to 25 eggs during their life-span. Eggs are oval-shaped, white, and covered with bumps. Six-legged larvae emerge from eggs, which transition into eight-legged nymphs, and then eventually adults. Adult females are oval and broad-shaped, and amber to dark green in color; however, actual color depends on the host fed upon. Females also have short, thin hind legs. Males are usually smaller than females but are also amber in color, and possess long legs. Broad mites feed primarily on young leaves and flowers. Broad mites are cell-feeders and use their stylet-like mouthparts to feed on the epidermis on the underside of young leaves causing leaf-margins to curl downward, and become brittle, rigid, and shriveled. They may also inject toxins during the feeding process. Extensive broad mite populations may cause individuals to move and feed on the top of leaves resulting in severe leaf distortion. Furthermore, lower leaf surfaces may appear bronzed.

Broad mite feeding damages the meristematic tissue of the growing tip or apical shoot, which may inhibit growth, decrease leaf number, leaf size and area, and reduce plant height. In addition, leaves may increase in firmness and appear darker green in color than normal. The damage may resemble that from exposure to a phenoxy-based herbicide (e.g., 2,4-D).

In general, development from egg to adult takes 4 to 6 days in the summer, and 7 to 10 days in the winter. Broad mites may spread among greenhouse crops via air currents, leaves of adjacent plants in contact with each other, and by workers handling infested plants and then touching non-infested plants. In addition, broad mite females are phoretic and will attach onto the legs and antennae of greenhouse whitefly (*Trialeurodes vaporariorum*) or sweet potato whitefly B-biotype (*Bemisia tabaci*) adults. However, adult whiteflies may not remain still long enough for the mites to attach and may even resist attachment by the mites. Broad mites will not attach onto thrips or aphids.

Management

Broad mites require a food source for survival, so implementing sanitation practices, such as cleaning greenhouses prior to introducing new plants and disinfecting benches will help to alleviate problems with broad mites. Broad mite populations are difficult to suppress with contact miticides because they are located in the meristematic tissues. Miticides with translaminar properties may be more effective and typically have broad mites on the label. Translaminar means that, after a foliar application, the material penetrates leaf tissues and new terminal growth; forming a reservoir of active ingredient within the leaf or new growing points. As a result, these miticides are more likely to come in contact with broad mites feeding in the meristematic tissues. Those miticides labeled for suppression of broad mite populations are presented in Table 1. Preventative applications may be required; particularly on highly susceptible crops because once damage is evident it is too late to initiate practices that may have suppressed populations of broad mites. As such, it is recommended to rouge out and immediately dispose of plants exhibiting symptoms, and those adjacent to symptomatic plants in order to prevent the spread of broad mite populations.

Biological control of broad mite is another management option and involves the use of commercially-available predatory mites. The predatory mite, *Neoseiulus barkeri* has been successfully used in suppressing broad mite populations, and the predatory mites, *Neoseiulus* (=*Amblyseius*) *cucumeris* and *N. californicus* may be utilized against broad mite populations on certain greenhouse-grown crops including vegetables. It is important to apply predatory mites early in the crop production cycle before broad mites become established.

Hot water treatments are another potential management option that has been suggested as a means of dealing with broad mites. In fact, it has been shown that exposure times between 15 and 45 minutes at temperatures between 105 ºF (40 ºC) and 110 ºF (43 ºC) are effective in killing broad mites. Plants have to be immersed in the hot water long enough to allow penetration into areas such as the meristematic tissues where the mites are located, and at the same time not damage plants. Producers may consider implementing this procedure; however, this is a short-term solution with no residual affect as plants placed back among crops can be infested.

Table 1. Miticides (active ingredient and trade name) that have broad mite on the label, and activity (translaminar and/or contact).

Common Name (active ingredient)	**Trade Name**	**Activity**
Abamectin	Avid	Translaminar and contact
Chlorfenapyr	Pylon	Translaminar and contact
Fenpyroximate	Akari	Contact
Pyridaben	Sanmite	Contact
Spiromesifen	Judo	Translaminar and contact

Figure 1. Broad mite damage on gerbera.

Figure 2. Broad mite adult and eggs.

Figure 3. Broad mite injury on Torenia.

Pythium Root Rot of Herbaceous Plants

Dr. Janna Beckerman

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Pythium spp. attacks plant roots primarily, but also cause cutting rots, stem rots, and foliar blight under the right conditions, and is a significant problem in the greenhouse and nursery industries (Figure 1).

The three most commonly encountered species of root-rotting Pythium species in the greenhouse industry are *Pythium irregulare*, *Pythium ultimum*, and *Pythium aphanidermatum*. The two most commonly encountered species, *P. ultimum* and P. *irregulare* are ubiquitous pathogens regularly found in the field, sand, pond and stream water, and decomposing vegetation. Identifying which *Pythium* is causing the problem in your greenhouse is important as some *Pythiums*, like *P. ultimum*, have very wide host ranges. Also, which species of *Pythium* you have may dictate when damage will occur: Infection by *P. aphanidermatum* occurs more often at higher temperatures (above 77 °F) whereas *P. ultimum* diseases are most serious when temperatures are below 68 °F. These different *Pythium* infections are often seen early in poinsettia production under hot weather (by *P. aphanidermatum*), and then again towards the end of production with the cooler temperatures by *P. ultimum*.

All *Pythium* species favor wet conditions with high soil soluble salts in the potting medium. *Pythium* is found contaminating commercially available soilless potting mixes, and readily contaminates sterilized soil or soilless mixes by the careless use of dirty tools, containers, and proximity to previously infected plants or media. Fungus gnats and shore flies have been shown to vector *Pythium* within greenhouses.

Symptoms

Root rot symptoms, regardless of the pathogen, are surprisingly similar. The first symptoms of Pythium infection include stunting, however careful examination of root tips early in the infection will show only dead tips. With Pythium root rots, roots appear water-soaked, and the root cortex easily sloughs off leaving a strand of vascular tissue. This is not a conclusive symptom, but one to note. On the stems of cuttings, a soft, watery rot may develop. Key signs include the cells of the plant root containing round, thick walled oospores and or round zoosporangium. An accurate diagnosis of this disease is essential as fungicides labeled to control other root rots (e.g., Thielaviopsis, Fusarium, Rhizoctonia) will not be effective against Pythium root rot (Figure 2).

Disease Cycle

Pythium is a fungal-like organism, similar to, but also distinct from fungi. Like a fungus, *Pythium* grows and colonizes a plant through the production of hypha (pl. hyphae), threadlike, filamentous cells that extract nutrients from the host plant. When hyphae from opposite mating types meet, thick-walled oospores are produced. These oospores serve as overwintering structures. Upon germination, an oospore may produce more hyphae, or develop a zoosporangium, which produce motile zoospores that swim to, and infect plants. Zoosporangia can also germinate and infect plants directly, too. Zoospores that reach the plant root surface form cysts that then germinate, infect and invade the plant root. As the hyphae grow, they release enzymes that destroy the root tissue and absorb nutrients as a food source.

Sanitation

Surface clean and disinfect all bench surfaces, tools, trays, containers, and equipment that will contact the potting mix; use high-quality cuttings, and immediately remove any cuttings or plants that show symptoms of disease.

Media

Cover and store soil-less mixes in an area that will not be contaminated. Peat-vermiculite potting mix often suffer from high soluble salts, with plants developing root injury that predisposes them to Pythium. Media with a moisture holding capacity above 70% has been reported to seriously increase damage from *P. ultimum*, and the use of highly decomposed (dark) peat results in worse Pythium root rot compared to non-decomposed medium or light peat.

Watering and Fertilization

Overwatering and over-fertilization increase rates of infection by Pythium. In addition to overwatering, the use of poorly draining medium, or the placement of pots or flats in standing water, will also affect drainage and predispose plants to infection by *Pythium*. Excess watering also creates conditions conducive for shore flies and fungus gnats, which feed on roots and damage them, providing an infection court for *Pythium*. These insects are also effective vectors of the pathogen, spreading the disease throughout the greenhouse or growing area. Pythium diseases are also more severe on over-fertilized plants. The cause of this damage is two-fold: Excess nitrogen suppresses the natural defense response of the plant, and the accumulation of salts in the growing medium damages root tips, providing an easy means for *Pythium* to infect.

When using pond or stream water for irrigation, place the intake pipe well above the bottom of the pond so that sediment is not drawn in, but also make sure the pipe isn't near the surface, either. If *Pythium* contamination is a problem, slow sand filtration is an effective method for removing *Pythium* (and other plant pathogens) from recycled water. Other water treatment options include ultraviolet radiation, ozonation, and chlorination.

Plan Ahead

If you have had problems in the past with Pythium, be proactive to prevent outbreaks with you upcoming mum crops. Biological control agents such as *Trichoderma harzianum* or *Gliocladium virens* do provide some protection when disease pressures are low; however, overwatering or excessive fertilization will reduce their efficacy to the point where severe outbreaks of Pythium can occur despite the use of biological controls. If severe outbreaks have occurred in the past, consider incorporating a granular fungicide (i.e., Banrot 8G) in your potting mix in lieu of a biological control agent, and re-evaluate your cultural practices that may result in excess water or fertilizer.

Prevention is the key to managing this disease as Pythium root rot is difficult to control once rot has begun.

Chemical Controls

Numerous fungicides are labeled for Pythium control. All of these provide the best result if applied to prevent infection from occurring. Growers should regularly scout their greenhouse for disease, confirm diagnosis by sending samples to a diagnostic lab, and quickly provide an effective fungicide program to minimize losses from this disease.

Developing an effective program is challenging, and growers must recognize that misuse of these fungicides (and some very adaptable Pythiums) has resulted in fungicide resistance. In work done by Moorman et al., 2002, almost 40% of the P. *aphanidermatum* and *P. irregulare* isolates were found to be resistant to mefenoxam; this is important because these two species were encountered in 74% of all *Pythium* cases from 1996 through 2001 in Pennsylvania. If Subdue Maxx or other chemicals do not appear to be protecting your plants, switch to another product.

Fungicide application for control of Pythium works best when applied as a protectant. Below is a list of fungicides labeled for disease control. When developing a fungicide rotation, be sure to choose fungicides that have different FRAC codes to minimize the risk of fungicide resistance developing in your greenhouse.

Table 1. Fungicides for Pythium root rot management.

Common name	**FRAC Code**	**Trade Name**
Etridiazole	M	Truban, Terrazole
etridiazole + thiophanate methyl	1+M	Banrot
fosetyl-Al	U	Aliette
phosphorous acid	U	Alude, Biophos, Rampart
mefenoxam	4	Subdue Maxx
propamocarb	28	Banol
cyazofamid	21	Segway
fluopicolide	43	Adorn
fenamidone	11	Fenstop
Premixes	**FRAC Code**	**Trade Name**
etridiazole + thiophanate methyl	1+M	Banrot
mefenoxam + fludioxanil	1+12	Hurricane

Figure 1. Poor drainage led to widespread Pythium infection of this garden mum crop. Most of the pictured plants had moderate to severe root rot, but aboveground symptoms varied considerably, as seen here.

References

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Moorman, G. W., Kang, S., Geiser, D. M., and Kim, S. H. 2002. Identification and characterization of Pythium species associated with greenhouse floral crops in Pennsylvania. Plant Dis. 86:1227-1231.

Upcoming 2011 Industry and University Events				
Date	**Event**	**Location**	**Speaker/Topic**	**Website/ Email**
June 9	NWIFA	TBA	TBA	http://faculty.pnc.edu/emaynard/nwifa/nwifa.html
June 16	NIFGA	Fort Wayne, IN	Tincaps Baseball Game	https://www.facebook.com/Northeast-Indiana-Flower-Growers
June 27-29	Seeley Conference	Ithaca, NY	Education	http://www.hort.cornell.edu/seeleyconference/
July 9-12	OFA Short Course	Columbus, OH	Education and Trade Show	http://www.ofa.org/shortcourseinfo.aspx
Aug. 1-12	Michigan Garden Plant Tour	Throughout MI	Display Gardens	http://planttour.hrt.msu.edu/
Aug. 9	Michigan Garden Plant Showcase	E. Lansing, MI	Educational and Garden Tour	http://planttour.hrt.msu.edu/
Sept. 7	NIFGA	Heller's Nursery Decatur, IN	Educational and Tour	E-mail: bernie.greenhouse@gmai.com
Sept. 12-14	OFA Plug and Cutting Conference	San Jose, CA	Education and Trade Show	http://www.ofaconferences.org/
Oct. 5-6	Canadian Greenhouse Conference	Toronto, Canada	Education and Trade Show	http://www.canadiangreenhouseconference.com/
Oct. 12	NIFGA	N. Mancester Greenhouse, N. Mancester, IN	Educational and Tour	E-mail: bernie.greenhouse@gmai.com

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