Pest Management in Ornamental Production©

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INTRODUCTION

Ornamental plants are some of the most attractive yet costly plants in production on the planet. Total sales by greenhouse- and nursery-crop growers reached $17 billion in the U.S. in 2006 (Jerardo, 2007), and total gross sales of nursery crops alone totaled $4.65 billion (NASS USDA, 2006). In addition, average sales per acre were $88,411, which is significantly greater than most any other crops on an acre-by-acre basis. However, maintaining a high-value high-quality crop can be challenging for any grower with the myriad plants to grow and the myriad pests to control. Even small blemishes caused by pests can have a profound effect on the quality and value of an ornamental plant. Therefore, pest management in ornamental production is very different than pest management in agriculture because higher standards are expected and prophylactic use of pesticides is common and allows an ornamental grower to sleep at night. But what are some of the challenges and alternatives in pest management faced by the producers of today?

First, attempts to find the most striking colors and selections of ornamental plants have produced some of the most pest-susceptible plants grown. At this point, what is lacking in the ornamental industry is good scientific efforts that identify genes for desirable flower and plant characteristics and identify genes for pest resistance. Once identified, these genes can then be engineered into selected ornamental species. There are much greater efforts in basic genomic research on campuses around the world, so answers are probably right around the corner.

I remember being told by chrysanthemum growers that if I grew the Tuneful cultivar, I was sure to have aphids for my pesticide trials. It was absolute, and I used them for many years until the industry finally gave up on the cultivar, because it was nearly impossible to grow a damage-free, aphid-free Tuneful mum. There went the best plant we ever used for our trials. The point is that there are selections of every cultivated plant that are highly susceptible to certain plant pests and Tuneful mum is not the only example. I'm willing to bet that there are many examples like the one that I just gave.

Second, many scientists recommend that if you produce a healthy plant, it will be more resistant to pest damage. There is also truth, however, to the fact that if a pest is adapted to that plant, then a healthy plant is healthy food too. Recent research suggests that reducing the recommended nitrogen fertilizer level by 50% to chrysanthemums will also reduce the mean abundance of thrips (Chau and Heinz, 2006). Conversely, if you create a healthy well-fertilized plant, it will be well-suited for pest population development.

Another challenge comes from those that compare pest management in agriculture to pest management in ornamental production, and then suggest that ornamental producers can use similar tactics, i.e., less pesticides, or biological control, etc. In contrast to the common monoculture production systems in agriculture, the diversity of plant material grown in greenhouse production systems lends itself to a greater arthropod pest complex. Therefore, the challenge is to protect an aesthetically valuable, highly diverse crop on smaller acreage from a broad spectrum of arthropod pests (e.g., aphids, thrips, leafminers, mites, whiteflies, mealybugs, and fungus gnats).

Finally, the challenge is to reduce pesticide use in an age of constant pressure from consumers and regulators. The trends are obvious and pervasive and will eventually change pest management practices in ornamental production. The sole reliance on pesticide use is a thing of the past, and minimizing pesticide use and use of alternatives is on the rise. There are some successes in alternative strategies (Casey et al., 2006; see International Organization of Biological Control newsletters <http://web.agrsci.dk/plb/iobc/iobc_home.htm>) and some failures, and there are some in the ornamental industry that have given up or are unwilling to make changes from a system that already works, but changes will come and growers of the future must be prepared to face the challenges. You will see that I have not given up on pesticide use as you read this paper; however, wherever there are successes in new pest management alternatives, they should be employed with enthusiasm.

A WORD ABOUT INTEGRATED PEST MANAGEMENT IN ORNAMENTALS

Integrated Pest Management (IPM) is often defined as a method of growing plants with minimum or no pesticide use. Most ornamental producers consider IPM the implementation of biological control, and that's because when scientists mention IPM, the perception is that they mean pest control without chemicals. However, IPM means an integration of all means of control, monitoring, exclusion, cultural, physical, biological, and chemical. Integrated pest management is acknowledged in many agricultural settings where some damage from pests is acceptable, and the use of biological control or natural enemies in those systems may be a viable pest management option. However, sole reliance on either parasitoids or predators in ornamental production will not completely eliminate most arthropod pest populations, particularly if multiple arthropod pests on many different crops are involved. In addition, the presence of the natural enemy or any by-products such as mummified aphids may affect sales. In general, customers tend to shy away from insect- or mite-infested plants regardless of whether it is a pest or a beneficial. It's important to note that biological control must be carefully applied in ornamental propagation because it is rare that it can cause 100% mortality of the pest. Most propagated material is shipped around or into a country, and the marketable crop must be pest free or it stands a good chance of being held and eventually destroyed during inspection.

One of the very first things that should be considered when using IPM in plant production is the use of exclusion. In a perfect world, if you can exclude the expected plant pests then you will never need to apply control measures. It's not a perfect world, but the principle still applies. Exclusion should be a grower's first option, bringing in clean plants or stock, using exclusion screening (Bethke and Paine, 1991; Baker et al., 1994), etc. Applying this principle will indeed reduce the need for some pest control measures, however, careful monitoring is still going to be necessary. In addition to the benefits of exclusion screening, release of natural enemies into the closed system on a preventative basis will be more appealing.

The cornerstone of an IPM program is the use of monitoring to determine if pest control techniques are necessary, and remember, early detection is key to reducing plant damage and reducing production costs. Continuous pest monitoring and accurate record keeping are very useful in anticipating when pests will be most frequent and in anticipating seasonal occurrences. Further, when a problem is found, the question then becomes should it be treated, and unfortunately since this is an aesthetic crop, action thresholds are typically low. I recommend that you visit the University of California Integrated Pest Management (UCIPM) web site to become more familiar with setting action thresholds on your crop (UCIPM Guidelines for Floriculture and Nurseries Robb et al., 2007; also available at: <http://www.ipm.ucdavis.edu/PMG/r280390211.html>). In addition, you should become more aware of the more common pests on common ornamental crops (UCIPM <http://www.ipm.ucdavis.edu/PMG/selectnewpest.floriculture.html>). Other links to good information about pest control in ornamentals that can be found at the UCIPM web site include: Biological Control, Establishing Treatment Thresholds, Managing Pesticide Resistance, and Monitoring with Sticky Traps. There are also links to the following: pests of homes, gardens, landscapes, and turf (including Pest Notes), agriculture and floriculture (Pest Management Guidelines), natural environments, exotic and invasive pests, weather data and products, and degree-day modeling.

BENEFITS OF INSECTICIDE USE

The benefits of applying pesticides as it pertains to the production of ornamental plants is seldom presented and supported (Bethke and Cloyd, 2009). In addition to their selectivity, many of the newer insecticides have short residual activity, are less toxic to humans and mammals, and use less active ingredient (Table 1). They also leave minimal hazardous residues, are less harmful to the environment, and have minimal direct and/or indirect impact on natural enemies including parasitoids and predators. In fact, a number of commercially available alternative pesticides are compatible with beneficials (see references, Bethke and Cloyd, 2009).

Pesticides allow greenhouse producers to control a myriad of arthropod pests, and in general, may be less expensive and more practical than other pest management options. For example, costs associated with using the parasitoid, *Encarsia formosa*, for control of the sweet potato whitefly B-biotype, *Bemisia tabaci* (synonymous with the silverleaf whitefly, *B. argentifolii*) on poinsettia were >300% higher than applying the systemic insecticide, imidacloprid (Stevens et al., 2000). Furthermore, a single application of a systemic insecticide may provide control of several different phloem-feeding insect pests such as aphids, whiteflies, and mealybugs, and any residues may continue to kill insect pests for days or even weeks. The development of traditional broad-spectrum pesticides, however, has declined substantially within the last 10–15 years.

THE CASE FOR A HIGHER STANDARD FOR PROPAGATORS AND PEST MANAGEMENT

Pesticides may also be needed in order to maintain phytosanitary requirements when marketing plants out of state or out of the country. One of the most significant consequences associated with the movement of ornamental plants is the problem of invasive or exotic arthropod pest species. For example, pests that are not indigenous to the U.S.A., but are known to be exotic pests in exporting countries, are more likely to be introduced into new areas. This is a major concern to federal and state agencies responsible for excluding or eradicating exotic arthropod pests. Therefore, stringent

Table 1. Rates and toxicity of the common ornamental pesticides of the past contrasted with the new alternative classes of pesticides.

Active ingredient	Chemical class	Formulation	Rate 100/gal[a]	PPM AI /100 gal	Oral toxicity LD_{50} (Rat) (mg/kg)
Acephate	Organophosphate	75% WSP	453.6 g	898	1447
Chlorpyrifos	Organophosphate	20% ME	1478.7 ml	782	50 to 500 (bird)
Carbaryl	Carbamate	43% SL	946.4 ml	1075	590
Bifenthrin	Pyrethroid	7.9% NF	1182.9 ml	247	632
Abamectin	Macrocyclic lactone	2% EC	236.6 ml	12	300
Pyriproxyfen	Insect growth regulator	11.23% IGR	354.9 ml	106	4,733
Imidacloprid	Neonicotinoid	21.4% Flowable	50.3 ml	29	4,870
Pymetrozine	Selective feeding blocker	50% WDG	283.5 g	375	>5,000
Buprofezin	Insect growth regulator	70% WSB	396.9 g	602	>5,000

[a] Highest recommended label rate per 100 gallons of water for a foliar application against common ornamental arthropod pests.

phytosanitary practices including pesticides may be imperative, which then allows the continued export and import of ornamental plant material among countries.

Many growers in Southern California are constantly faced with the prospect of sales loss or complete shutdown, if an invasive pest is found at their facility. Indeed, this has actually occurred with increasing frequency in the last few years, and the list of occurrences is too long to repeat herein. Some of the shut downs are associated with a single plant or plant species (i.e., bamboo mealybug, *Palmicultor lumpurensis*), and only a single plant species on the facility is affected. The Diaprepes root weevil, however, threatens the citrus industry and is polyphagous, which means it feeds and reproduces on a great number of host plants. An infested nursery in San Diego lost 2 weeks of sales, and not a single plant was allowed to leave the site until they treated every plant on the majority of the facility with a drench application of an approved pesticide against the larval stage of the weevil and a spray application against potential egg deposition. In addition, all of the long-term, large boxed trees had to be held for 6 months before they could be moved or sold from the site.

There are serious pests that originate from outside the county and the state that can have a very significant impact on the ornamental industry in Southern California, and in order to protect the industry, the propagators, wholesalers, brokers, and suppliers that move product need to be held to a higher standard with respect to their pest control management. Plants need to be completely clean before moving. It can be done.

Q Biotype Sweetpotato Whitefly: Special Case. The Q biotype sweetpotato whitefly, *B. tabaci* Gennadius (formerly silverleaf whitefly, *B. argentifolii*) is a special case, but it identifies with many of the points made in the text above (learn more of the story at: <http://mrec.ifas.ufl.edu/lso/bemisia/bemisia.htm>). The Q biotype originated in the Mediterranean area and is capable of multiple levels of insecticide resistance. In fact this insect is resistant to common insecticides (e.g., imidacloprid, pyriproxyfen, etc.) used in ornamentals and agriculture in the U.S.A. (Horowitz et al., 2005).

Propagators offshore were doing their best to manage whiteflies on their crops, but in the long run, they were shipping whiteflies into the U.S.A. on cuttings. There was clear evidence of at least three different plant types shipped in from four different countries that contained the Q biotype. The cotton and vegetable industries did not want the Q biotype to become established in the U.S. because it was already resistant to the pesticides successfully used in management programs to control the resident B biotype. Their fear was that if this new biotype established in the U.S.A. they would have to start all over developing a new management program for Q at great cost until the new program was implemented. Through substantial efforts by the ornamental industry and the Q biotype Technical Advisory Committee, the potential threat faced by the Q biotype was eased. Research demonstrated that the Q biotype was susceptible to several pesticides not formerly considered in Europe, and the ornamental industry began to use these pesticides to clear the Q biotype from stock plants. Those products also provided options to the cotton and vegetable industries so that if the Q biotype was detected, only the chemical would change not the successfully developed management practices. To date the Q biotype has not been identified in either cotton or vegetable production in the U.S.A., which is a testament to the ornamental industry's efforts to control this pest.

One important lesson learned from this experience was that the ornamental industry has a special responsibility to produce pest-free plant products because the plants move. Plants that move from site to site, from state to state, etc., pose a special threat to plant producers of all types. In effect, the ornamental industry will continue to be given a black eye and greater scrutiny unless they can demonstrate they are using the best management practices possible to keep their crops clean and free of pests.

Another benefit of the collaboration in the Q biotype Technical Advisory Committee was the development of a management practice that everyone in the industry can use to control whiteflies (<http://mrec.ifas.ufl.edu/lso/bemisia/bemisia.htm>). This management program was developed by a large group of people who were in agreement on how the program can be used to clean a crop from the rooting stage all the way to finishing.

CONCLUSIONS

The future demands changes in pest management techniques in ornamental production. That is a given. All avenues of IPM must be employed in order to minimize pest pressure and subsequently minimize pesticide use. The use of IPM techniques may be more intensive, but it should be employed with enthusiasm if ornamental production is to remain viable under the current consumer and regulatory climates.

It is apparent that no single pest-management strategy will effectively and efficiently solve every arthropod pest problem, so other pest management strategies must be implemented or considered in conjunction with the use of pesticides including: monitoring, exclusion, cultural, physical, biological, and chemical. Pesticide use will, however, continue to be a significant strategy in dealing with arthropod pest populations so that greenhouse producers can stay competitive in both national and international markets.

Some key factors to consider:

- IPM
  - Exclusion or prevention methods
  - Practice and train staff on all aspects of IPM
  - Do not hold old plants or pet plants and destroy heavily infested plants so that pests cannot return to the crop
  - Know the beneficials and employ biological control where possible
- Monitoring
  - Determine an action threshold that triggers a control effort
  - Monitor for pests on a daily basis using those in contact with the crops on a daily basis
  - Recognize that there are susceptible varieties that can be used as monitoring tools
  - Keep good records so that you can identify hotspots and seasonal occurrences
- Chemical control
  - Use softer alternative chemicals during cooler winter months, i.e. soaps, oils, and biologicals saving the conventional products for outbreaks

- Spot treat hotspots to minimize pesticide use and retain susceptibility of pest populations
- Rotate chemicals by IRAC class (<http://www.irac-online.org/>)

Summary of the benefits of insecticide use on ornamentals:

- Insecticide technology provides a wide range of properties, uses, and methods of application to ornamental producers
- Increased production
- Increased quality
- Newer insecticides readily degrade and have short life spans
- Newer insecticides are more selective — have less affect on nontarget organisms
- Newer insecticides are used at much lower rates
- Newer insecticides have low mammalian toxicity
- Newer insecticides generally pose less threat to ground water contamination
- They are readily available to the ornamental market
- Rapid action of insecticides means immediate results
- They are highly reliable
- Insecticides reduce insect pressure below the aesthetic injury level
- They control or eradicate exotic or invasive insects found on ornamentals
- Costs of insecticides and their use are minimal compared to the benefits
- Growers can treat a pest problem in progress with insecticides
- They are inexpensive in comparison to other pest management techniques
- Many times insecticides are the only practical or available pest control technology
- They can be used in an emergency pest situation

LITERATURE CITED

Baker, J.R., J.A. Bethke, and **E. Shearin.** 1994. Insect screening, pp155–170. In: W. Banner, and M. Klopmeyer [eds.]. New Guinea Impatiens: a Ball Guide. Ball Publ., Batavia, Illinois.

Bethke, J.A., and **R.A. Cloyd.** 2008. Pesticide use in ornamentals: what are the benefits? Pest Mgmt. Sci. 65:345–350.

Bethke, J.A., and **T.D. Paine.** 1991. Screen hole size and barriers for exclusion of insect pests of glasshouse crops. J. Entomol. Sci. 26(1):169–177.

Casey C., J. Newman, K. Robb, S.A. Tjosvold, J.D. MacDonald, and **M.P. Parrella.** 2006. IPM program successful in California greenhouse cut roses. California Agric. 61(2):71–78

Chau, A., and **K.M. Heinz.** 2006. Manipulating fertilization: a management tactic against *Frankliniella occidentalis* on potted chrysanthemum. Entomologia Experimentalis et Applicata. 120:201–209.

Horowitz, A.R., S. Kontsedalov, V. Khasdan, and **I. Ishaaya.** 2005. Biotypes B and Q of *Bemisia tabaci* and their relevance to neonicotinoid and pyriproxyfen resistance, Arch. Insect Biochem. Physiol. 58:216–225.

Jerardo, A. 2007. Floriculture and nursery crops outlook. Floriculture and nursery crops yearbook. USDA Economic Research Service, U.S. Dept. Agric., Washington, DC. <http://www.ers.usda.gov/Publications/flo/> Accessed 11 May, 2008.

NASS, USDA. 2006. Nursery Crops 2006 Summary. Agricultural Statistics Board. Sept. 2007. Economic Research Service, US Dept. Agriculture, Washington, DC. <http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1115> Accessed 30 Sept. 2009.

Robb, K.L., H.S. Costa, J.A. Bethke, and **M.P. Parrella.** 2007. Insects and mites. UC IPM pest management guidelines: Floriculture and ornamental nurseries. University of California ANR Publication 3392. Davis, California.

Stevens, T.J., R.L. Kilmer, and **S.J. Glenn.** 2000. An economic comparison of biological control and conventional control strategies for whiteflies (Homoptera: Aleyrodidae) in greenhouse poinsettias. J. Econ. Entomol. 93:623–629.