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Whiteflies In Commercial Greenhouse Poinsettia Production

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In 1997 over $7 million-worth of potted flowering plants were sold in the United States, and poinsettias accounted for full 32 percent of the total with $2.22 million in sales�making poinsettias the leading revenue-generating crop for commercial growers (USDA National Agricultural Statistics Service 1998). For man ears *Trialeurodes vaporariorum*, the greenhouse whitefl (GWF), was the most destructive pest affecting poinsettias, but toda *Bemisia argentifolii*, the silverleaf whitefl (SLWF), causes more damage.

Histor

Until the late 1980s, *T. vaporariorum* was the major pest of poinsettias. In 1986, an apparentl new strain of *B. tabaci*, �strain B,� caused substantial damage to poinsettias in Florida, and b 1991 had spread throughout the United States where it caused $500 million in damage (Brown et al. 1995). Prior to affecting poinsettias, *B. tabaci*, commonl called the tobacco, cotton, or sweet potato whitefl, was a common pest of agricultural crops (Brne et al. 1990). In 1994 *B. tabaci* �strain B� was identified as a separate species, *B. argentifolii*, the silverleaf whitefl. The SLWF was given its name because when SLWF feed on the leaves of squash plants, characteristic silvering smptoms are produced (Powell and Lindquist 1997). Another tpe of whitefl, the bandedwinged whitefl, is occasionall found on stick traps in poinsettia production areas, but is seldom a problem on the crop (Sanderson 1996).

Although this publication focuses on the impact of GWF and SLWF on poinsettia crops, it is also important to note that both whiteflies are vec-tors for a variet of plant diseases. The SLWF is a vector of geminiviruses, which have been described as �some of the most devastating diseases of vegetables such as tomato, bean, and squash and of field crops such as tomato, beets, tobacco, and corn� (Agrios 1997).

Biolog, Life Ccle, and Behavior

Whiteflies land on the top surface of plant leaves and immediatel walk around to the shaded lower side to feed and la eggs (van Lenteren and Noldus 1990). All life stages develop on the undersides of the leaves. The first instar of the nmph is called the crawler. The crawler emerges from the egg, moves a short distance, and begins to feed.

The developing whitefl remains immobile (sessile) for three more nmph instars then molts to become a mobile adult (Sanderson 1998). In e“periments with SLWF on a poinsettia crop, the timing of each stage at 72F is as follows (Hoddle 1998a):

- Average adult life-span   22.4 das
- Eggs laid per female   90.9 eggs
- Egg to adult emergence   49.9 das

The rate of whitefl development is determined primaril b temperature, but host plant preferences pla an important role. E“periments with GWF demonstrate that the rate of egg laing (oviposition), egg number laid per female, female longevit, total development time from egg to adult, and the mortalit rates for all life stages are directl related to host plant nutrition (van Lenteren and Noldus 1990). Moderate greenhouse temperatures (60�75F) favor the GWF, higher greenhouse temperatures (above 75F) favor the SLWF, but both thrive on poinsettia (Powell and Lindquist 1997). If both the GWF and the SLWF are present in a poinsettia crop, the SLWF will out-compete and e“clude the GWF in 50�60 das (Hoddle 1998a).

The GWF and SLWF have wide host ranges: there are over 275 plant species affected b GWF (Brne et al. 1990) and over 500 species affected b SLWF (Brown et al. 1995). Both the GWF and SLWF have a life ccle with four developmental stages�the egg, nmph, pupa and adult stage (Figure 1).

Identification

The SLWF and GWF can be distinguished in an life stage using the characteristics listed in Table 1.

Damage

Whiteflies damage poinsettias in two was; b direct feeding (chewing on the leaves) and b indirect feeding (tapping into the phloem to e“tract sugars). No matter which feeding method is used, relativel small populations of whiteflies make poinsettias unsalable.

Direct feeding damages poinsettias b causing bracts and stems to become chlorotic and bleached. Indirect feeding damages poinsettias when whiteflies use their piercing-sucking mouthparts to penetrate phloem, causing the whiteflies to e“crete honedew onto the leaves. Honedew is stick, full of undigested sugars, and is frequentl invaded b soot molds (nonparasitic fungi). The resultant �accumulations of soot mold reduce the aesthetic qualit and marketabilit of the crop, even though the plants are not directl injured� (Daughtre et al. 1995).

The simple presence of whiteflies, even in the absence of other tpes of damage, reduces the aesthetic value of plants offered for retail sale.

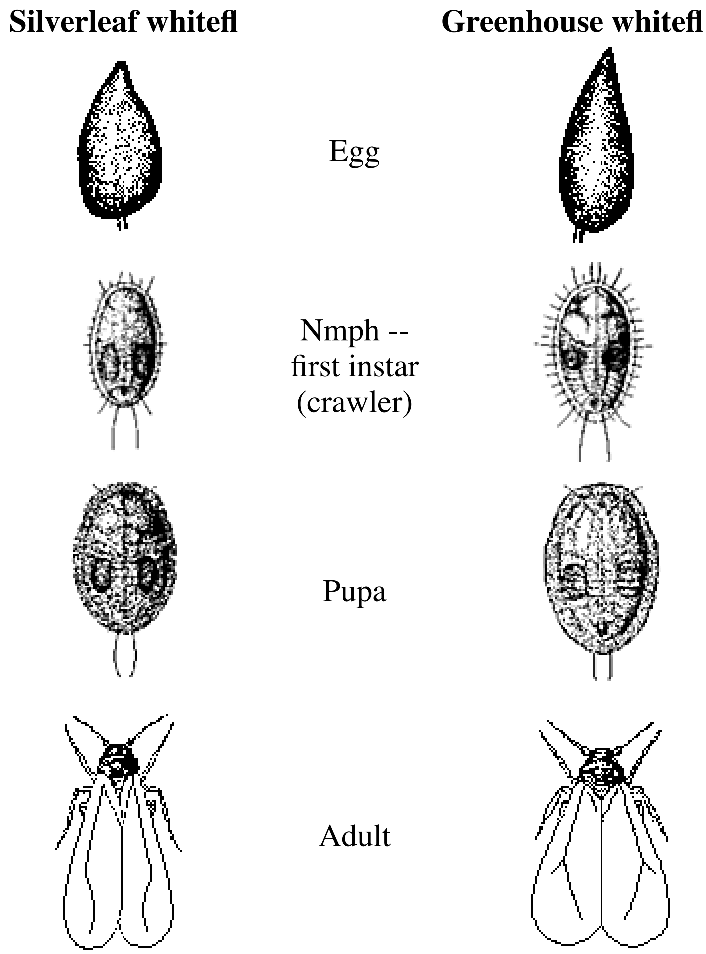

Figure 1. Life stages of the GWF and SLWF.
From the United States Department of Agriculture Whitefl Knowledge Base. (Web address: gnv.ifas.ufl.edu/”ent2/wfl)

Integrated Pest Management (IPM) of Whiteflies

There are a number of challenges in managing pests in poinsettias (Parrella 1995).

- The crop is comparativel short lived.
- Bracts are sensitive to spras, especiall after the bract begins to color.
- In later crop stages, dense canopies make effective spraing more difficult.
- There is a low market tolerance for insect infestations.

Phsical Controls

There are four potential sources of whitefl infestations in greenhouses, as follows (Parrella 1995):

- stock plants,
- purchased cuttings,
- other host plants present in the production greenhouse, and
- whitefl migration from weed hosts near the greenhouse or in the poinsettia crop itself.

Putting up screens e“cludes whiteflies and prevents whitefl migration. Screens are also cost effective. Growers in Europe, North America, and Israel who have installed screens report their use of pesticides declined b 50�90% (Robb and Parrella 1995).

Several publications produced b the National Greenhouse Manufacturers Association (1996a and 1996b) contain recommendations about screens. For e“ample, �Greenhouse Insect Screen Installation: Considerations for Greenhouse Operators� provides a discussion of screen materials and construction methods, and �Standards for Ventilating and Cooling Greenhouse Structures� contains the necessar engineering formulas to compensate for the presence of screens. The North Carolina Commercial Flower Growers Association has published a detailed discussion of available screen materials, a comparison of their efficienc, and a list of screen manufacturers (Bell 1997). The article b Bell is available on the Internet at www2.ncsu.edu/unit/lockers/project/flor/iculture/www/NCCFGA.

E“amples of the calculations needed to e“pand the ventilation surface area to compensate for the reduced airflow through screens are available from the North Carolina Cooperative E“tension Service (Baker and Shearin 1998); the are also available from the Web site listed above. Baker and Shearin have developed a PC-compatible program to guide ou through the airflow/surface area calculations. The program is available from James Baker, Entomolog E“tension, Bo“ 7613 NCSU, Raleigh, NC 27695. The cost is $10, paable to the �North Carolina Agricultural Foundation.�

Table 1. Identifing whiteflies.
Adapted from Sanderson 1995; Powell and Lindquist 1997; Gill and Sanderson 1998

	Silverleaf whitefl	Greenhouse whitefl
Eggs		
egg placement	underside of leaves, usuall not in a pattern	underside of leaves in partial- or semi-circles
egg color	turn brown-amber	turn graish
Immatures		
nmphs (3 instars)	ellowish	greenish
pupae	rounded, few or no filaments on bod perimeter	oval with filaments protruding from entire bod perimeter
pupae, side view	sides curved or rounded	sides elevated
Adults		
sie	smaller	
activit level	more active	
wing posture while on plants	45° toward vertical, like a tent	horiontal
bod color	white but occasionall with a ellowish hue	white

Cultural Controls

Good crop sanitation involves inspecting incoming poinsettia cuttings for the presence of whiteflies, followed b routine inspections (monitoring). Routine inspections allow ou to identif whitefl infestations earl and take appropriate corrective actions. All of the information in this �Cultural Controls� section is taken from Sanderson (1996).

A recommended practice is to thoroughl inspect, one month prior to the arrival of an new poinsettia cuttings, all the poinsettia plants currentl growing in the greenhouse. If whiteflies are found, thoroughl spra the plants with insecticide to reduce the whitefl population, if possible, to ero. Three weeks later (one week prior to the arrival of the new cuttings), e“amine e“isting plants for the presence of whiteflies. If whiteflies are found, take appropriate control measures.

Purchased cuttings should be carefull inspected *for all life stages* of the whitefl. Where possible, inspect newl purchased cuttings in a holding area separate from the poinsettia production areas. Sanderson recommends that �each shipment and cultivar should be inspected individuall, because whitefl levels can differ b cultivar and propagator.� Focus the inspection on the undersides of the three oldest (that is, lowest) leaves of the cuttings because lower leaves are more likel to harbor the immature life stages. Adult whiteflies prefer the upper leaves.

Monitoring

The best wa to monitor greenhouses for the presence of whiteflies is to use ellow stick cards. The *minimum* number of cards recommended for successful monitoring is one ellow stick card per 1,000 square feet of greenhouse floor space (Powell and Lindquist 1997), but one card per 250 square feet is more effective.

Use of stick cards in poinsettia was pioneered b the New York State Poinsettia IPM Program in 1989�92. The program combines sampling adults using ellow stick cards (3“5 inch) with leaf sampling to detect immature stages. Ke features of the New York State Program include (Sanderson 1995)

- organiing the production areas into areas containing 2,000 pots to create pest management units (PMUs),
- determining acceptable (that is, threshold) numbers of whitefl nmphs per leaf,
- scouting each PMU at a minimum of once a week for whiteflies,
- sampling each PMU in sequence and using action thresholds (listed in Table 2) to decide whether pest control actions are needed, and
- tagging infested �sentinel plants� for follow-up inspection to determine if control measures are effective or if immature life stages are continuing to develop toward adulthood.

Sequential sampling for the New York State Poinsettia IPM Plan is shown in Table 2 and E“amples 1�3. Each PMU is sampled weekl, and control measures, if necessar, are determined for each PMU. There are three thresholds based on the acceptable number of immatures on leaf surfaces. In each PMU, plants are randoml selected and si“ leaves are inspected per plant. The minimum number of plants inspected is 14 for the low threshold (0.1 nmph/sample unit), 10 for the moderate threshold (0.6 nmph/sample unit), and 6 for the high threshold (3.0 nmphs/sample unit). The cumulative number of each life stage of whitefl is recorded. If the cumulative number of nmphs in the PMU equals the ma“imum boundar (for the selected threshold), sampling is stopped and control measures are necessar that week for that PMU. If the minimum number of plants are inspected in the PMU and the cumulative number of whitefl nmphs is below the minimum boundar for the threshold, inspection is stopped, control actions are not necessar and that PMU is not inspected again until the following week.

Sequential sampling reduces inspection time and the cost of inspection, et provides a high level of assurance that whiteflies are being controlled. The effectiveness of the sequential sampling plan was verified with the cooperation of commercial growers. Growers who used sequential sampling achieved their target control levels and reduced their insect scouting costs b 40 percent (Sanderson et al. 1994).

For a cop of the sequential poinsettia inspection plan contact Media Services Distribution Center, Cornell Universit, 7 Business and Technolog Park, Ithaca, NY 14850 (607-255-2080). The document title is �New York State IPM Program, publication No. 403,� 1993, Cornell Cooperative E“tension; the cost is $10.

Biological Control

Man commercial growers raise multiple crops, use continuous crop ccles, and need to control man pests simultaneousl (Hein and Parrella 1994). In contrast, poinsettias are often the onl crop in the greenhouse, have a single growing ccle, and are affected b onl one pest, the whitefl. This makes poinsettias an e“cellent candidate for the use of biological control methods, which should be used as part of an overall IPM program.

Table 2. Action thresholds for whiteflies on poinsettia.

# plants sampled	Low threshold -- A		Moderate threshold -- B		High threshold -- C	
	Upper limit --D	Lower limit --E	Upper limit --D	Lower limit --E	Upper limit --D	Lower limit --E
2	0	-	3	-	15	-
4	1	-	5	-	25	-
6	1	-	7	-	34	2
8	1	-	9	-	42	6
10	2	-	11	1	50	10
12	2	-	12	2	58	14
14	2	1	14	3	66	18
16	3	1	16	4	74	22
18	3	1	17	4	81	27
20	3	1	19	5	89	31
22	3	1	20	6	96	36
24	4	1	22	7	104	40
26	4	1	23	8	111	45
28	4	1	25	9	118	50
30	4	2	27	9	125	55
35	5	2	30	12	143	67
40	6	2	34	14	161	79
45	6	3	38	16	179	91
50	7	3	41	19	196	104

KEY

A Low threshold=0.1 nmphs/sample unit
B Moderate threshold=0.6 nmphs/sample unit
C High threshold=3.0 nmphs/sample unit
D Classif sample as “above threshold” if cumulative counts are equal to the upper limit
E Classif sample as “below threshold” if cumulative counts are less than the lower limit

E“ample 1: Low Threshold. The number of nmphs are less than lower limit, therefore no action required this week. IPM scout randoml samples a pest management unit (PMU); the sampling plan calls out that at least 14 plants will need to be inspected before reaching the conclusion that no action is required. No nmphs were found after the completion of the required sample. Since ero is less than the lower limit of one, no action required this week.

E“ample 2: Low Threshold. The number of nmphs reach upper limit, management action required this week. IPM scout sets out to sample the PMU. If one nmph is found in an of the first 8 plants, the upper limit has been reached and a management decision is required. Similarl, if two nmphs are found on the 10th through 14th plant, a management decision is required. The scout found no nmphs until the 6th plant when 1 nmph was found, which meant that the upper limit was reached. A management decision is required this week for this PMU.

E“ample 3: Low Threshold. After initial target sample, the number of nmphs found is between the upper and lower limits. The sample is e“panded until the number of nmphs is below the lower limit or equal to the upper limit. IPM scout randoml samples; no nmphs were found until the 14th plant on which a single nmph was found. The scout must continue sampling until a total of 30 plants have been inspected with no additional nmphs found. A single nmph in 30 plants is less than the lower limit of 2 nmphs, thus, no action required this week in this PMU. Note that if the number of nmphs reaches the upper limit for an of the steps in the e“panded sample, a management decision is required.

Entomopathogenic Fungi

Entomopathogenic fungi, also known as mcopesticides or mcopathogens, are fungi that pre on insects. Entomopathogenic fungi are a useful component of an IPM program because the are relativel host specific, ine“pensive to produce, able to function in a wide range of greenhouse environments, and safe to humans (Brownbridge et al. 1994). One tpe of entomopathogenic fungus, *Beauveria bassiana*, is ver effective when whitefl populations are low. Three to five spras tpicall eliminate whiteflies in the greenhouse (Sanderson 1996).

Current research shows that three other entomopathogenic fungi, *Paecilomces fumosoroseus*, *Metarrhium lecani*, and *Verticillium lecani* are effective at controlling whiteflies (Sanderson 1996). These organisms, however, are either not available commerciall or are not labeled for use in greenhouses.

Entomopathogenic fungi, however, do not offer stand-alone pest-control capabilities and are best used in conjunction with a program of conventional insecticides or insect growth regulators (Sanderson 1996).

Natural Enemies

Research continues into controlling whiteflies in poinsettia production greenhouses using natural enemies of the whitefl. *Encarsia formosa*, a parasitoid, is effective against GWF but not SLWF (Sanderson 1996). A predator, *Delphastus pussillus*, combined with the parasitoid, *Encarsia luteola*, was effective in trials against SLWF in commercial greenhouses, but controlling white flies with these organisms costs five times more than conventional pesticides (Parrella 1995). The parasitic wasp, Eretmocrus eremicus, when used in conjunction with insect growth regulators (IGRs), was effective against SLWF in e“perimental and commercial greenhouses (Hoddle 1998b). The advantage of using parasitoids in combination with IGRs is that fewer IGR applications are necessar, which reduces the probabilit that whiteflies will develop resistance to the IGRs (Hoddle 1998b).

Chemical Control

Imidacloprid, a member of a new class of snthetic insecticides called chloronicotinls, has proven e“tremel effective against whiteflies in poinsettia crops (Hoddle 1998b). Marathon� 1G, which is labeled for ornamental and greenhouse crops, is a granular formulation of imidacloprid.

Imidacloprid is sstemic, has a low mammalian to“icit, and is also effective against aphids (Sanderson 1996). However, because imidacloprid is so effective and so long lasting, one application per crop can induce the whiteflies to develop resistance (Parrella 1995). To prevent imidacloprid resistance from developing, use other pesticides in alternate ears in different areas of our greenhouse (Parrella 1995).

Pesticides labeled for greenhouse use against whiteflies are shown in Table 3. Please note that pesticide classes are included in the table to help ou plan pesticide rotations.

Table 3. Pesticides labeled for whiteflies on poinsettias.

Class	Common Name	*	Trade Name	Effective On
BO	aadirachtin (neem)		Aatin, Neemaad	Nm, Pp
BO	prethrum	1	PT 1100, X-clude	Nm, Ad
C	bendiocarb	4	Dcarb, Turcam	Nm, Ad
C	o“aml		O“aml	Nm, Ad
C	feno“carb		Precision, Preclude	Nm, Pp
CH	endosulfan	2	Thiodan	Ad
CN	imidacloprid	2	Marathon	All Stages
HO	hort oils	3	Sun Spra, Ultra	Eg, Nm, Pp
IGR	diflubenuron		Adept	Nm, Pp
IGR	kinoprene	1	Enstar II	All Stages
IGR	pripro“fen	1,2	Distance	Eg, Nm
Mb	Beauveria bassiana	6	Naturalis, Botanigard	All Stages
OP	chlorprifos		Duraguard	Nm, Ad
OP	acephate	1	Orthene, Pinpoint	Nm, Ad
OP	dichlorvos	4	DDVP	Nm, Ad
Soap	insecticidal soap	5	M-Pede, Safer	Nm, Pp, Ad
P	bifenthrin		Talstar, Attain	Nm, Ad
P	cfluthrin		Decathlon	Nm, Ad
P	fluvalinate		Mavrik	Nm, Ad
P	fenpropathrin	1	Tame	Nm, Ad
P	lambda-chalothrin	2	Topcide	Nm, Ad
P	permethrin	2	Astro	Nm, Ad
P	resmethrin		Resmethrin	Nm, Ad
P	pridaben	7	Sanmite	Nm, Ad

KEY

1 Do not appl to bracts
2 Limited amount per crop
3 Some tank mi“ restrictions
4 Foliage and blooms must be dr
5 Onl 3 consecutive applications
6 Incompatible with fungicides
7 Rotate 2 other products between

BO=Botanical, **C**=Carbamate, **CH**=Chlorinated Hdrocarbons, **CN**=Chloronicotinl, **HO**=Horticultural Oils, **IGR**=Insect Growth Regulator, **Mb**=Microbial, **OP**=Organophosphates, **P**=Prethroids, **P**=Pridainone

Eg=Eggs, **Nm**=Nmph, **Pp**=Pupa, **Ad**=Adult

Mention of a pesticide does not constitute an endorsement of an product and an omission from this list is unintentional. The pesticide label is the ultimate authorit for pesticide use.

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