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Whiteflies In Commercial Greenhouse Poinsettia Production

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 whitefly (GWF), was the most destructive pest affecting poinsettias, but today *Bemisia argentifolii*, the silverleaf whitefly (SLWF), causes more damage.

History

Until the late 1980's, *T. vaporariorum* was the major pest of poinsettias. In 1986, an apparently 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*, commonly called the tobacco, cotton, or sweet potato whitefly, was a common pest of agricultural crops (Byrne et al. 1990). In 1994 *B. tabaci* strain B was identified as a separate species, *B. argentifolii*, the silverleaf whitefly. The SLWF was given its name because when SLWF feed on the leaves of squash plants, characteristic silvering symptoms are produced (Powell and Lindquist 1997). Another type of whitefly, the bandedwinged whitefly, is occasionally found on sticky 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 vectors for a variety 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).

Biology, Life Cycle, and Behavior

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

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

- Average adult lifespan 22.4 days
- Eggs laid per female 90.9 eggs
- Egg to adult emergence 49.9 days

The rate of whitefly development is determined primarily by temperature, but host plant preferences play an important role. Experiments with GWF demonstrate that the rate of egg laying (oviposition), egg number laid per female, female longevity, total development time from egg to adult, and the mortality rates for all life stages are directly 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 exclude the GWF in 50 - 60 days (Hoddle 1998a).

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

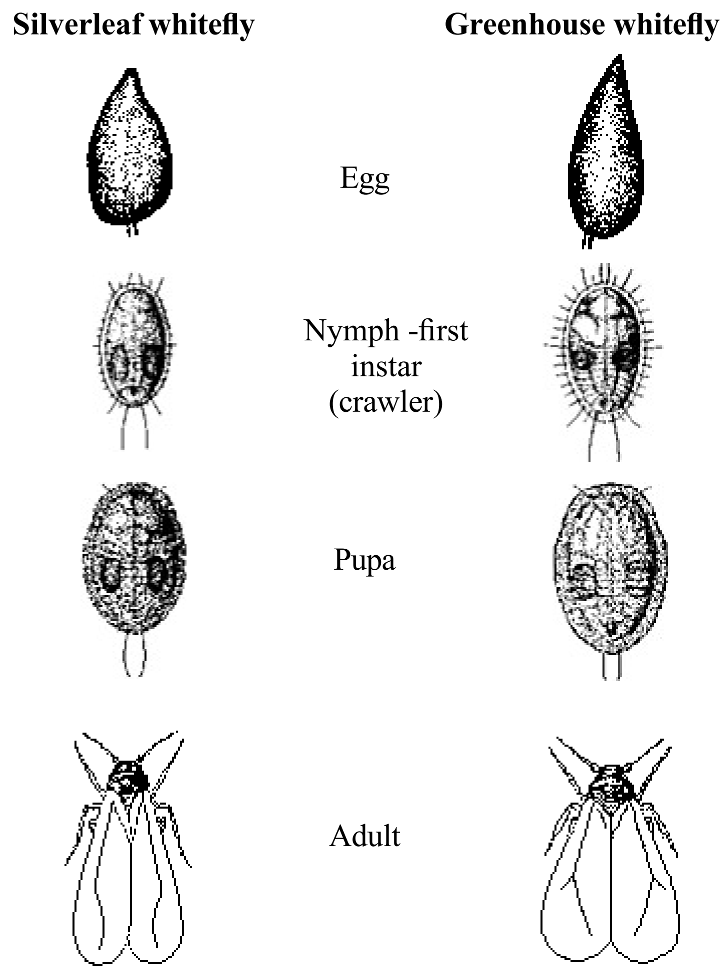

Figure 1. Life stages of the GWF and SLWF.
From the United States Department of Agriculture Whitefly Knowledge Base.

Identification

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

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

	Silverleaf Whitefly	Greenhouse Whitefly
Eggs		
Egg Placement	underside of leaves, usually not in a pattern	underside of leaves in partial or semi-circles
Egg color	turn brown-amber	turn grayish
Immature Stages		
Nymphs (3 instars)	yellowish	greenish
Pupae	rounded; few or no filaments on body	oval; filaments protruding around body
Pupae, side view	sides curved or rounded	sides elevated
Adults		
Size	smaller	
Activity level	more active	horizontal
Wing position when resting	45° toward vertical, like a tent	
Body color	white but occasionally with a yellowish hue	white

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 sprays, especially after the bract begins to color.
- In later crop stages, dense canopies make effective spraying more difficult. There is a low market tolerance for insect infestations.

Physical Controls

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

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

Putting up screens excludes whiteflies and prevents whitefly migration. Screens are also cost effective. Growers in Europe, North America, and Israel who have installed screens report their use of pesticides declined by 50 - 90% (Robb and Parrella 1995).

Several publications produced b the National Greenhouse Manufacturers Association (1996a and 1996b) contain recommendations about screens. For example, 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 necessary 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 efficiency, and a list of screen manufacturers (Bell 1997).

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 any new poinsettia cuttings, all the poinsettia plants currently growing in the greenhouse. If whiteflies are found, thoroughly spray the plants with insecticide to reduce the whitefly population, if possible, to zero. Three weeks later (one week prior to the arrival of the new cuttings), examine existing plants for the presence of whiteflies. If whiteflies are found, take appropriate control measures.

Purchased cuttings should be carefully inspected for all life stages of the whitefly. Where possible, inspect newly purchased cuttings in a holding area separate from the poinsettia production areas. Sanderson recommends that each shipment and cultivar should be inspected individually, because whitefly levels can differ by 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 likely to harbor the immature life stages. Adult whiteflies prefer the upper leaves.

Monitoring

The best way to monitor greenhouses for the presence of whiteflies is to use yellow stick cards. The minimum number of cards recommended for successful monitoring is one yellow sticky 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 by the New York State Poinsettia IPM Program in 1989 - 92. The program combines sampling adults using yellow sticky cards (3 - 5 inch) with leaf sampling to detect immature stages. Key features of the New York State Program include (Sanderson 1995) organizing the production areas into areas containing 2,000 pots to create pest management units (PMUs), determining acceptable (that is, threshold) numbers of whitefly nymphs 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 Examples 1 and 3. Each PMU is sampled weekly, and control measures, if necessary, are determined for each PMU. There are three thresholds based on the acceptable number of immatures on leaf surfaces. In each PMU, plants are randomly selected, and six leaves are inspected per plant. The minimum number of plants inspected is 14 for the low threshold (0.1 nymph/sample unit), 10 for the moderate threshold (0.6 nymph/sample unit), and 6 for the high threshold (3.0 nymphs/sample unit). The cumulative number of each life stage of whitefly is recorded. If the cumulative number of nymphs in the PMU equals the maximum boundary (for the selected threshold), sampling is stopped, and control measures are necessary that week for that PMU. If the minimum number of plants are inspected in the PMU and the cumulative number of whitefly nymphs is below the minimum boundary for the threshold, inspection is stopped, control actions are not necessary, 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 by 40 percent (Sanderson et al. 1994).

Biological Control

Many commercial growers raise multiple crops, use continuous crop cycles, and need to control man pests simultaneously (Hein and Parrella 1994). In contrast, poinsettias are often the only crop in the greenhouse, have a single growing cycle, and are affected by only one pest, the whitefly. This makes poinsettias an excellent 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

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

From: Sanderson et al. 1994. Used with permission.

Example 1: Low Threshold. The number of nymphs is less than lower limit, therefore no action required this week. IPM scout randomly 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 nymphs were found after the completion of the required sample. Since zero is less than the lower limit of one, no action required this week.

Example 2: Low Threshold. The number of nymphs reach upper limit, management action required this week. IPM scout sets out to sample the PMU. If one nymph is found in an of the first 8 plants, the upper limit has been reached and a management decision is required.

Similarly, if two nymphs are found on the 10th through 14th plant, a management decision is required. The scout found no nymphs until the 6th plant when 1 nymph was found, which meant that the upper limit was reached. A management decision is required this week for this PMU.

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

Entomopathogenic Fungi

Entomopathogenic fungi, also known as mycopesticides or mycopathogens, are fungi that pre on insects. Entomopathogenic fungi are a useful component of an IPM program because they are relatively host specific, inexpensive to produce, able to function in a wide range of greenhouse environments, and safe to humans (Brownbridge et al. 1994). One type of entomopathogenic fungus, *Beauveria bassiana*, is very effective when whitefly populations are low. Three to five sprays typically 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 commercially 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 whitefly. *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 whiteflies with these organisms cost 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 experimental and commercial greenhouses (Hoddle 1998b). The advantage of using parasitoids in combination with IGRs is that fewer IGR applications are necessary, which reduces the probability that whiteflies will develop resistance to the IGRs (Hoddle 1998b).

Chemical Control

Imidacloprid, a member of a new class of synthetic insecticides called chloronicotinyls, has proven extremely 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 systemic, has a low mammalian toxicity, 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 you plan pesticide rotations.

Table 3. Pesticides labeled for whiteflies on poinsettias.

Class	Common Name	*	Trade Name	Effective On
BO	azadirachtin (neem)		Azatin, Neemazad	Nm, Pp
BO	pyrethrum	1	PT 1100, X-clude	Nm, Ad
C	bendiocarb	4	Dycarb, Turcam	Nm, Ad
C	oxamyl		Oxamyl	Nm, Ad
C	fenoxycarb		Precision, Preclude	Nm, Pp
CH	endosulfan	2	Thiodan	Ad
CN	imidacloprid	2	Marathon	All Stages
HO	hort oils	3	Sun Spray, Ultra	Eg, Nm, Pp
IGR	diflubenzuron		Adept	Nm, Pp
IGR	kinoprene	1	Enstar II	All Stages
IGR	pyriproxyfen	1,2	Distance	Eg, Nm
Mb	Beauveria bassiana	6	Naturalis, Botanigard	All Stages
OP	chlorpyrifos		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	cyfluthrin		Decathlon	Nm, Ad
P	fluvalinate		Mavrik	Nm, Ad
P	fenpropathrin	1	Tame	Nm, Ad
P	lambda-cyhalothrin	2	Topcide	Nm, Ad
P	permethrin	2	Astro	Nm, Ad
P	resmethrin		Resmethrin	Nm, Ad
Py	pyridaben	7	Sanmite	Nm, Ad

1 Do not apply to bracts
2 Limited amount per crop
3 Some tank mix restrictions
4 Foliage and blooms must be dry
5 Only 3 consecutive applications
6 Incompatible with fungicides
7 Rotate 2 other products between

BO=Botanical, **C**=Carbamate, **CH**=Chlorinated Hydrocarbons, **CN**=Chloronicotinyl, **HO**=Horticultural Oils, **IGR**=Insect Growth Regulator, **Mb**=Microbial, **OP**=Organophosphates, **P**=Pyrethroids, **Py**=Pyridazinone

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

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

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