Whitefly Abundance on Rooted Poinsettia Cuttings and Finished Poinsettias

Erfan K. Vafaie[1,3], H. Brent Pemberton[1], Mengmeng Gu[2], David Kerns[3], Micky D. Eubanks[3], and Kevin M. Heinz[3]

Additional index words. greenhouse production, integrated pest management, pest threshold, retailer

Summary. In this study, we surveyed the initial whitefly (Aleyrodidae) populations on rooted poinsettia (*Euphorbia pulcherrima*) cuttings at two commercial greenhouse facilities in both 2017 and 2018 to determine the initial whitefly population at the beginning of poinsettia production and surveyed finished poinsettias at multiple retailers in Tyler, TX, over 2 years to determine whitefly densities considered acceptable by retailers. The initial whitefly population (mean ± se) for all poinsettias was 0.02 ± 0.02 (2017) and 0.33 ± 0.13 (2018) nymphs per plant for grower facility A and 0.05 ± 0.05 (2017) and 0.02 ± 0.01 (2018) nymphs per plant for grower facility B. Of the total 2417 rooted poinsettia cuttings inspected at both locations over 2 years, 29 cuttings had whitefly nymphs (1.2%), 18 had pupae (0.7%), and 23 had exuviae (1.0%). On finished poinsettias sampled at retailers, 4.38 to 40.38 immatures (nymphs + pupae) per plant were found within 60 seconds for any given retailer over the 2 years. We found poinsettias with as many as 220 immatures and 32 adults on a single plant at retailers. This study is the first to quantify densities of whiteflies at retail stores over multiple years.

Pest management decisions in an integrated pest management strategy rely on pest thresholds; however, thresholds have been poorly defined and investigated in greenhouse ornamental production, often resulting in prophylactic use of insecticides. For example, management of whiteflies (Aleyrodidae) on poinsettia (*Euphorbia pulcherrima*) historically has relied on regular applications of insecticides (Palumbo et al., 2001; Sharaf, 1986; Stevens et al., 2000), with some growers applying insecticides every 3 to 5 d (Hoddle and Van Driesche, 1996). However, relying on regular insecticide applications as a pest management strategy may be shortsighted because of the risk of insecticide resistance (Palumbo et al., 2001; Schuster et al., 2010; van Lenteren, 2012), increasingly tighter federal and state pesticide regulations (U.S. Environmental Protection Agency, 2017), and increasing pressure from retailers against the use of specific insecticide classes by commercial growers (Friends of the Earth, 2017). Augmentative biological control (i.e., the regular release of natural enemies to reduce the target pest population to acceptable levels) is a promising strategy that has been increasingly adopted in many areas of the world, including parts of Europe, Asia, and Latin America (Barratt et al., 2018). However, information related to starting pest densities at the grower and acceptable pest densities by the retailer needed for development of an augmentative biological control strategy in ornamental production in the United States is lacking.

Successful management of whiteflies in an augmentative biological control program for poinsettias requires favorable conditions: lack of insecticide residue, few or limited pest species, and low starting whitefly densities (Van Driesche et al., 1999). Suppression of whiteflies has been considered unsuccessful using parasitic wasps, such as *Eretmocerus eremicus*, when initial whitefly densities were greater than 1.0 whiteflies (all life stages) per poinsettia cutting (Van Driesche et al., 1999). Propagative plant materials have been suggested as a major source of whitefly populations in poinsettia production (Buitenhuis et al., 2016); however, there is limited published data to support this assertion. Dipping cuttings, or "immersion," in a pesticide mixture has been suggested as a method to start "clean" as a prerequisite for a successful biological control program (Brownbridge et al., 2014; Buitenhuis et al., 2016; Krauter et al., 2017). More surveys of poinsettia cuttings from propagators will aid in determining whether the cost of preemptive insecticide treatments of poinsettia propagative materials is justified.

Poinsettias at retailers are not likely completely free of pests, but the acceptable density of whiteflies at retailers has not been determined. The economic threshold on ornamentals has been generally defined as "low" (Stevens et al., 2000) or "essentially zero" (Bethke and Cloyd, 2009), because any pest injury is considered unacceptable. Documented final densities for whiteflies on poinsettias has been limited to retailers in Massachusetts (Hoddle and Van Driesche, 1996; Van Driesche et al., 1999). Implementation of augmentative biological control in poinsettia production requires a better understanding of current accepted whitefly densities at the retailers. In this study, we determine the starting infestation levels of whiteflies on rooted poinsettia

Received for publication 27 Dec. 2019. Accepted for publication 1 May 2020.

Published online 12 June 2020.

[1]Texas A&M AgriLife Research and Extension Center, 1710 N. 3053 FM, Overton, TX 75684

[2]Department of Horticultural Sciences, Texas A&M AgriLife Extension, College Station, TX 77843

[3]Department of Entomology, Texas A&M University, College Station, TX 77843

We thank Kenneth Masloski and Pete Krauter for providing edits to our manuscript.

Mention of trademark, proprietary product, or vendor does not constitute a guarantee or warranty of the product by the authors and does not imply its approval to the exclusion of other products or vendors that also may be suitable.

Portions of this manuscript have also been submitted to Proceedings of the Southern Nursery Association Research Conference 2020. This paper is a portion of the PhD dissertation requirement submitted by Erfan K. Vafaie.

E.K.V. is the corresponding author. E-mail: erfanv@tamu.edu.

https://doi.org/10.21273/HORTTECH04532-19

Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
2.54	inch(es)	cm	0.3937
1.6093	mile(s)	km	0.6214

cuttings at grower facilities and determine whitefly densities on finished poinsettias at the retailer.

Materials and methods

Whiteflies density on cuttings. To determine whether the initial population of whiteflies was low enough for biological control (1.0 or fewer live nymphs and pupae per cutting) (Van Driesche et al., 1999), we determined whiteflies densities at two grower locations in 2017 and 2018 within 50 miles of the Texas A&M AgriLife Research and Extension Center in Overton, TX. Two hundred newly rooted poinsettia cuttings (4–6 weeks postarrival from various propagators) were selected randomly for inspection during each visit at each grower for 3 consecutive weeks during the months of July and August. For each poinsettia cutting inspected, whitefly nymphs, pupae, and exuviae were counted using a ×2.5 magnification head lens. In total, at least 2400 cuttings were inspected over the 2 years. Cuttings were sourced from propagators in Central America and South America, which also supply cuttings to other parts of the United States and Canada. Cultivar names of each cutting were also recorded to determine any potential cultivar differences in initial whitefly densities. The two grower facilities are labeled A and B to maintain anonymity.

Whitefly density at retailers. Whitefly numbers on poinsettia plants sampled at retail stores were defined as commercially acceptable pest densities. We assumed that poinsettias on retailer shelves were considered acceptable by the retailer for sale, whereas unacceptable poinsettias would have been returned to the supplier or culled. Acceptable retailer whitefly densities were determined by scouting poinsettia crops at 10 different retailers in 2016 (8 Dec.) and seven retailers in 2018 (13–14 Dec.) in Tyler, TX. Number of immatures (nymphs + pupae), exuviae, and whitefly adults were counted for 60 s/plant, between 10 to 30 plants per retailer, depending on availability. The source of the poinsettia (2018 only), pot size, price, bract color, and aesthetic rating were also recorded to tabulate any potential trends with whitefly density. Aesthetic rating was recorded by looking at the whole plant from a scale of 0 (whiteflies easily seen, occurrence of honeydew, development of sooty mold, plant stretched, canopy thinning, and yellowing leaves) to 10 (unable to detect whiteflies, no honeydew, no sooty mold present, compact plant, no thinning or yellowing leaves). We considered a rating of 7 or less to be a threshold below which marketability is greatly reduced. To maintain anonymity of the sources of infested poinsettias and to determine potential differences in acceptable whitefly densities based on clientele, retailers were categorized under one of four groups: big-box stores (physically large, multinational establishments), independent garden centers, grocery store florists, and independent florists. Because of pricing and specialization, we anticipated the independent florists and garden centers to have lower whitefly populations than the big-box and grocery stores. Growers that supplied the poinsettias to retailers were anonymized with a single capital letter; it should be noted that growers A and B at the retailer are the same as facilities A and B from our whitefly infestation on cuttings data.

Statistical analyses and interpretation of results. All statistical analyses were performed in R (version 3.5.3; R Foundation for Statistical Computing, Vienna, Austria) using RStudio (version 1.2.5001; RStudio, Boston, MA). The numbers of nymphs and pupae on rooted cuttings (all cultivars and sampling periods within year combined) were compared between years within each grower facility using the Wilcoxon signed-rank test to determine whether data from multiple years could be pooled. The number of whitefly immatures and adults found on poinsettias at the retailers was compared between different growers using a Wilcoxon rank sum test pairwise comparison with Benjamini-Hochberg correction (Benjamini and Hochberg, 1995); we expected to find differences in final whitefly densities among growers. Graphical representations of results were generated using ggplot2 (Wickham, 2016).

Results and discussion

Whitefly density on cuttings. The number of nymphs counted on rooted poinsettia cuttings was significantly different between 2017 and 2018 at grower facility A ($P < 0.001$; Table 1); however, the number of nymphs (facility B), pupae (facility A), and exuviae (facilities A and B) on rooted cuttings was not significantly different between 2017 and 2018 on infested poinsettia cuttings (P = 0.320, 0.573, 0.055, and 0.084, respectively). No pupae were found on any of the rooted cuttings at facility B for 2017 or 2018. Mean nymph numbers (± SE) per cutting for all poinsettias (regardless of whether they showed signs of whitefly infestation) in 2017 was 0.02 ± 0.02 (facility A) and 0.05 ± 0.05 (facility B) nymphs per cutting, and in 2018 was 0.33 ± 0.13 (facility A) and 0.02 ± 0.01 (facility B) nymphs per cutting.

Of the total 2417 rooted poinsettia cuttings inspected at both locations over 2 years, 29 had at least one whitefly nymph (1.2%), 18 had at least one pupa (0.7%), and 23 had at least one exuvia (1.0%). Of the 19 rooted cutting cultivars observed, only nine had

Table 1. Total poinsettia cuttings inspected and infested, and mean nymphs, pupae, and whitefly exuviae on infested poinsettia cuttings from two growers (A and B) over 2 years (2017 and 2018); at least 200 cuttings were inspected per visit using a ×2.5 magnification head lens.

Yr	Grower	Plants inspected (no./row)	Plants infested (no.)	Whiteflies on infested plants [mean ± SE (no.)][z]		
				Nymphs	Pupae	Exuviae
2017	A	610	9	1.22 ± 1[y]	1 ± 0.41	0.44 ± 0.34
	B	600	1	28	0	0
2018	A	605	25	8.04 ± 2.65[y]	1.2 ± 0.44	1.52 ± 0.63
	B	602	6	1.67 ± 0.92	0 ± 0	0.5 ± 0.22

[z]Mean calculation only includes plants with at least one nymph or pupa.
[y]Significantly different between years within the same grower facility for specific whitefly life stage by pairwise comparisons using the Wilcoxon rank sum test ($P < 0.05$).

Table 2. Total poinsettia cuttings inspected and infested, and mean nymphs, pupae, and whitefly exuviae on infested poinsettia cuttings by poinsettia cultivar. Data pooled from two facilities (A and B) over 2 years (2017 and 2018); at least 200 cuttings were inspected per visit using a ×2.5 magnification head lens.

Cultivar	Plants inspected (no./row)	Plants infested (no.)	Whiteflies on infested plants [mean ± SE (no.)][z]		
			Nymphs	Pupae	Exuviae
Astro Red	35	0	—	—	—
Christmas Beauty Cinnamon	14	0	—	—	—
Christmas Beauty North Pole	16	0	—	—	—
Christmas Beauty Princess	21	0	—	—	—
Christmas Beauty Red	412	3	11.33 ± 8.41	0 ± 0	0 ± 0
Christmas Cheer	39	0	—	—	—
Classic Pink	37	1	25	6	2
Classic Red	1,047	23	4.78 ± 1.79	0.7 ± 0.3	0.22 ± 0.14
Classic White	111	0	—	—	—
Enduring Marble	43	1	0	0	1
Ice Crystal	101	2	0 ± 0	0 ± 0	1 ± 0
Maren	25	0	—	—	—
Premium Lipstick Pink	59	1	2	4	0
Premium Picasso	35	1	13	0	8
Premium Polar	19	0	—	—	—
Prestige Red	280	2	0	0.5 ± 0.5	0.5 ± 0.5
Snowflake Red	54	0	—	—	—
Whitestar	50	6	10.83 ± 8.75	1.17 ± 0.98	3.5 ± 2.08
Wintersun White	16	0	—	—	—

[z]Mean calculation only includes plants with at least one nymph or pupa.

any signs of infestations: 'Christmas Beauty Red' (NPCW10158), 'Classic Pink', 'Classic Red', 'Enduring Marble' (PER10603), 'Ice Crystal', 'Premium Lipstick Pink', 'Premium Picasso', 'Prestige Red', and 'Whitestar' (Table 2). The highest number of nymphs counted on a rooted cutting overall was 54 nymphs on cultivar Whitestar from facility A in 2018. Caution should be used in drawing conclusions about cultivar susceptibility to whiteflies from these data because several factors, such as propagator conditions, sample size, or local sources of infestation, could result in differences in whitefly densities. Differences in cultivar susceptibility should be tested through controlled studies.

Sufficient suppression of whiteflies on poinsettias can be achieved in an augmentative biological control program when starting populations are as high as 1.0 whiteflies (of all stages) per poinsettia cutting (Van Driesche et al., 1999), which is 50-fold higher than the average number of whiteflies (all stages combined) we found on rooted cuttings for the location and year with the highest population (facility A in 2018) of our sampled data. It should be noted that the source of our observed whitefly densities were likely from a combination of the propagators and from local natural populations, because we inspected cuttings that had been rooted at the local facility for 4 to 6 weeks before inspection. Despite the potential local source of whitefly populations and variation in initial whitefly numbers, our whitefly infestation count data from two different grower locations over 2 years suggest infestation levels on cuttings received from propagators are well within the acceptable range for initiating an augmentative biological control program.

While attempting to meet market demand, when given an opportunity, growers might choose cultivars that may start with a lower infestation of whiteflies. Our study is not a controlled cultivar choice test by whiteflies, and validation of cultivar differences requires additional data. In choice tests, whiteflies demonstrated preference and better performance (i.e., greater population growth) on light-green-leaf poinsettias compared with dark-green-leaf poinsettias (Medina-Ortega, 2011). Our survey found 'Whitestar' cuttings tended to have the highest proportion of plants infested and among the highest mean nymphs, pupae, and exuviae compared with all other cultivars, followed by 'Classic Pink', 'Premium Picasso', 'Classic Red', and 'Premium Lipstick Pink'. On the other hand, cultivars Classic White and Ice Crystal had practically no signs of whitefly infestations despite more than 100 rooted poinsettias being inspected for each. It should be noted, however, that whitefly populations aggregate both within and between plants (Liu et al., 1993), and differences in initial infestation between cultivars may have been the result of the relatively small sample size. In addition, other factors such as propagator facility and location may be explanatory variables for the observed initial infestation levels.

Whitefly density at retailers. We counted an average of 4.38 to 40.38 immature whiteflies per plant for all retailers in 2017 and 2018 combined (Table 3). We found up to 220 immatures on a single plant in 2018 at a grocery store florist. We also found up to 32 adults on a single plant in 2018 at an independent garden center. The independent florist and garden center did not appear to have fewer whitefly immatures or adults compared with the grocery store florists and big-box stores over both years, despite consistently higher marketability rating and price (Table 3); however, statistical inference was avoided because of the great differences in replicates (stores) and subsamples (plants within stores). All retailer types had a wide distribution of immature

Table 3. Mean immature and adult whiteflies, proportion of finished color poinsettias infested with immatures and adult whiteflies, mean price, and median poinsettia aesthetic rating from different retailer types over 2 years.[z]

Yr	Type	Immatures [mean ± SE (no.)]	Adults [mean ± SE (no.)]	Proportion immatures	Proportion adults	Mean price [mean ± SE ($)]	Aesthetic rating 0–10 scale [median (min-max)]	Stores (no.)	Plants inspected (no./row)
2016	Big-box	4.38 ± 1.16	0.2 ± 0.07	0.43	0.13	5.71 ± 0.19	8 (5–9)	3	84
	Grocery florist	35.89 ± 3.63	0.83 ± 0.22	0.71	0.24	5.86 ± 0.13	7 (4–9)	6	103
	Garden center	16.2 ± 5.87	2.47 ± 0.7	0.63	0.50	7.08 ± 0.09	8 (7–9)	1	30
	Florist	8.6 ± 4.35	0.8 ± 0.59	0.40	0.30	57.5 ± 7.43	10 (8–10)	1	10
2018	Big-box	25.07 ± 3.21	1.21 ± 0.21	0.74	0.41	8.34 ± 0.3	10 (4–10)	4	102
	Grocery florist	33.63 ± 9.31	2.78 ± 1.1	0.81	0.56	6 ± 0	9 (7–10)	1	27
	Garden center	40.38 ± 10.77	9.1 ± 1.68	0.81	0.95	4.95 ± 0	9 (8–10)	1	21
	Florist	73 ± 22.08	6 ± 2.33	1.00	0.80	83.5 ± 12.27	10 (10–10)	1	10

[z]Aesthetic rating was recorded by looking at the whole plant on a scale of 0 (whiteflies easily seen, occurrence of honeydew, development of sooty mold, plant stretched, canopy thinning, and yellowing leaves) to 10 (unable to detect whiteflies, no honeydew, no sooty mold present, compact plant, no thinning or yellowing leaves). Marketability of the plant was considered greatly reduced when the aesthetic rating was 7 or less. The median, minimum (min), and maximum (max) aesthetic ratings for all poinsettias within a retailer type is summarized. Finished poinsettias were inspected for whiteflies for 60 s/plant, with several plants (10–30) inspected per retailer over the 2 separate years (2016 and 2018).

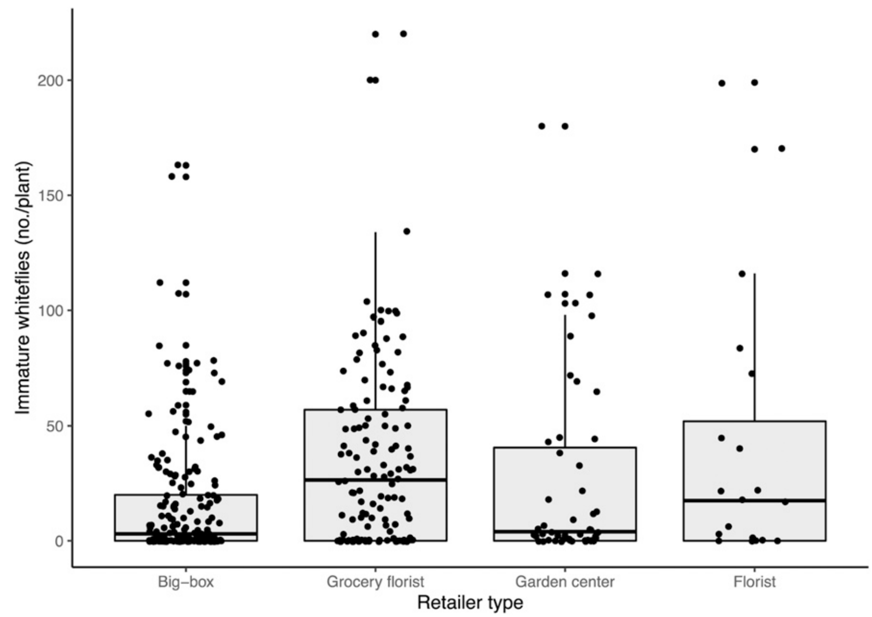

Fig. 1. Immature whiteflies counted per finished color poinsettia by retailer group. Finished poinsettias were inspected for 60 s/plant, with several plants inspected per retailer over 2 separate years (2016 and 2018). Retailers were categorized into one of four types based on expected differences in retailer thresholds: big-box (seven stores), grocery (seven stores), garden store (two stores), and florist (two stores).

whitefly infestation levels (Fig. 1), making it hard to identify an acceptable threshold for whitefly densities. Most poinsettias inspected were in 6- to 6.5-inch pots (big-box, 169; grocery store florist, 130; independent garden center, 51; independent florist, 15); however, some pots were 8 inches or larger (big-box, 17; independent florist, 5) and some were 4 inches (grocery store florist, 20). Even when poinsettias had up to 220 immatures (2018, grocery store florist), the store manager expressed that their poinsettias were considered relatively clean and whitefly free compared with the previous year, and was surprised to learn of whitefly populations on their poinsettias.

Significant differences among poinsettia growers for immature and adult whitefly populations were observed at retail stores (Table 4); however, only one (grower H from Canada) had no poinsettias infested with immatures or adult whiteflies. Excluding grower H, the percentage of poinsettias infested with immature whiteflies from different growers varied from 35% to 100%. We included the store unique identifier in Table 4, because it is possible that poinsettias from one grower may become a whitefly source for another grower's poinsettias at the retailer, rather than whiteflies coming from the grower. There was no clear pattern between level of infestation with immature whiteflies and poinsettia source location; poinsettias from Texas, California, Canada, and an unknown source location all had some poinsettias with more than 50 immatures per plant (Fig. 2).

Thresholds for poinsettias have included virtually "zero" tolerance or undetectable populations, but neither have been defined based on acceptable whitefly populations at the retailers. Hoddle and Van Driesche (1996) found an average of 0.01 to 0.02 whitefly nymphs per leaf by inspecting six leaves from a total of 30 plants. In a similar study, Van Driesche et al. (1999) found an average between 0.55 to 0.98 nymphs per leaf on finished poinsettias. Both studies were conducted in Massachusetts, with information about the grower or original source lacking, and similar studies have not been conducted since. Our survey of different retailers supports that "zero" or "undetectable" populations may not accurately describe marketplace whitefly thresholds on potted poinsettias, and there is a need to establish realistic and quantifiable thresholds for these and other ornamental plants. This study marks the first publication to our knowledge that provides a multiyear and multilocation survey of whiteflies on rooted poinsettias, and the first to

Table 4. Mean immature and adult whiteflies, and total proportion of finished color poinsettias infested with immature and adult whiteflies.[z]

Grower[y]	Store[x]	Source	Immatures [mean ± SE (no.)]	Adults [mean ± SE (no.)]	Proportion immatures	Proportion adults	Total plants (no.)
A	4	Texas	40.38 ± 10.8 ab[w]	9.1 ± 1.7 a	0.81	0.95	21
B	2, 10, 11	Texas	23.94 ± 3.5 a	1.47 ± 0.4 b	0.69	0.39	62
C	7, 8	Texas	2.8 ± 0.8 c	0.11 ± 0.1 cd	0.35	0.11	46
D	1	Texas	45.15 ± 11.5 b	3.55 ± 1.4 ef	1.00	0.65	20
E	6	Texas	8.6 ± 4.4 ac	0.8 ± 0.6 bce	0.40	0.30	10
F	6	Texas	73 ± 22.1 b	6 ± 2.3 af	1.00	0.80	10
G	1, 2	Canada	20.84 ± 4.0 a	1.32 ± 0.3 be	0.84	0.48	31
H	3	Canada	0 ± 0 d	0 ± 0 d	0.00	0.00	20
I	12, 13	California	30.65 ± 6.0 ab	1.39 ± 0.4 be	0.76	0.39	46
J	9	NA	5.87 ± 3.0 c	0.53 ± 0.3 bc	0.47	0.27	15
P value			<0.001	<0.001			

[z]Poinsettias were inspected for whiteflies for 60 s/plant at several retailers in Tyler, TX, over 2 years (2016 and 2018) and were split-based on original poinsettia grower. The geographic location (Source) and store unique identifier (Store) where each specific grower sold its poinsettias are shown.
[y]Growers A and B are the same as in Table 1.
[x]Rows with matching store numbers could be found within the same store.
[w]Any two means within a column not followed by the same letter are significantly different by pairwise comparison using the Wilcoxon rank sum test ($P < 0.05$).
NA = source of poinsettias not available.

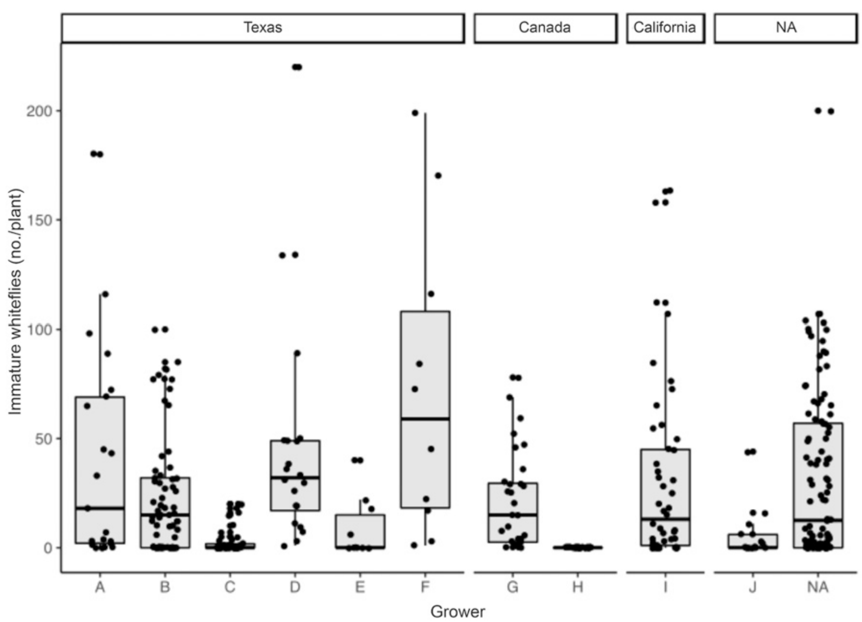

Fig. 2. Number of immature whiteflies on finished color poinsettia. Poinsettias were inspected for whiteflies for 60 s/plant. Several plants were inspected at different retailers in Tyler, TX, over 2 years (2016 and 2018) and were split-based on original grower. The identity of the poinsettia grower was not recorded in 2016, and all poinsettias were subsequently lumped under "not available" (NA).

consider poinsettia source, retailer type, and multiple years within a single study for whitefly thresholds on poinsettias.

Literature cited

Barratt, B.I.P., V.C. Moran, F. Bigler, and J.C. van Lenteren. 2018. The status of biological control and recommendations for improving uptake for the future. BioControl 63:155–167.

Benjamini, Y. and Y. Hochberg. 1995. Controlling the false discovery rate: A practical and powerful approach to multiple testing. J. R. Stat. Soc. B 57:289–300.

Bethke, J.A. and R.A. Cloyd. 2009. Pesticide use in ornamental production: What are the benefits? Pest Mgt. Sci. 65:345–350.

Brownbridge, M., R. Buitenhuis, T. Saito, A. Brommit, P. Cote, and G. Murphy. 2014. Prevention is better than cure: Early-season intervention to control whitefly on poinsettia. Integr. Control Prot. Crop. Temp. Clim. IOBC WPRS Bull. 102:23–28.

Buitenhuis, R., M. Brownbridge, A. Brommit, T. Saito, and G. Murphy. 2016. How to start with a clean crop: Biopesticide dips reduce populations of *Bemisia tabaci* (Hemiptera: Aleyrodidae) on greenhouse poinsettia propagative cuttings. Insects 7:48.

Friends of the Earth. 2017. Nursery and retailer commitments. 20 Oct. 2019. <https://foe.org/nursery-retailer-commitments/>.

Hoddle, M.S. and R.G. Van Driesche. 1996. Evaluation of *Encarsia formosa* (Hymenoptera: Aphelinidae) to control *Bemisia argentifolii* (Homoptera: Aleyrodidae) on poinsettia (*Euphorbia pulcherrima*): A lifetable analysis. Fla. Entomol. 79:1–12.

Krauter, P.C., K.M. Heinz, and S. Arthurs. 2017. Protecting unrooted cuttings from sweetpotato whitefly, *Bemisia tabaci* (Hemiptera: Aleyrodidae), during propagation. J. Insect Sci. 17(4):1–4.

Liu, T.-X., R.D. Oetting, and G.D. Buntin. 1993. Distribution of *Trialeurodes vaporariorum* and *Bemisia tabaci* (Homoptera: Aleyrodidae) on some greenhouse-grown ornamental plants. J. Entomol. Sci. 28: 102–112.

Medina-Ortega, K.J. 2011. Poinsettia (*Euphorbia pulcherrima* Willd. ex Klotzsch: Euphorbiacea) resistance mechanisms against the silverleaf whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) biotype B. Ohio State Univ., Columbus, PhD Diss.

Palumbo, J.C., A.R. Horowitz, and N. Prabhaker. 2001. Insecticidal control and resistance management for *Bemisia tabaci*. Crop Prot. 20:739–765.

Schuster, D.J., R.S. Mann, M. Toapanta, R. Cordero, S. Thompson, S. Cyman, and R.F. Morris. 2010. Monitoring neonicotinoid resistance in biotype B of *Bemisia tabaci* in Florida. Pest Mgt. Sci. 66:186–195.

Sharaf, N. 1986. Chemical control of *Bemisia tabaci*. Agr. Ecosyst. Environ. 17:111–127.

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

U.S. Environmental Protection Agency. 2017. Revised certification standards for pesticide applicators. 4 May 2017. <https://www.epa.gov/pesticide-worker-safety/revised-certification-standards-pesticide-applicators>.

Van Driesche, R.G., S.M. Lyon, M.S. Hoddle, S. Roy, and J.P. Sanderson. 1999. Assessment of cost and performance of *Eretmocerus eremicus* (Hymenoptera: Aphelinidae) for whitefly (Homoptera: Aleyrodidae) control in commercial poinsettias crops. Florida Entomol. Soc. 82:570–594.

van Lenteren, J.C. 2012. The state of commercial augmentative biological control: Plenty of natural enemies, but a frustrating lack of uptake. BioControl 57:1–20.

Wickham, H. 2016. ggplot2: Elegant graphics for data analysis. Springer-Verlag, New York, NY.