Susceptibility of Six *Hibiscus rosa-sinensis* Cultivars to Giant Whitefly in Southern California

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Hibiscus rosa-sinensis L. is one of the most beloved and esteemed landscape plants in southern California (**Fig. 1**). Prized for its stunning, large, often multi-colored, frequently year-round flowers and luxuriant foliage, it is cultivated wherever winter night temperatures mostly remain about 0°C although healthy, large plants can tolerate damage from brief, slightly subfreezing temperatures and recover quickly as weather warms in the spring. Thus, they are widely grown in coastal plains and valleys but also in interior valleys and the low desert if offered protection from occasional subfreezing temperatures and excessively hot temperatures.

Fig. 1. *Hibiscus rosa-sinensis* is one of the most beloved and esteemed landscape plants in southern California. Here is *H. rosas-sinensis* 'White Wings', part of our trial in Seal Beach, CA reported here, as are all the following photographs).

Hibiscus are typically maintained as perennial shrubs or small trees and can serve as foundation plants in borders, stand-alone specimens, container subjects, potted blooming plants for the winter areas. Hundreds if not thousands of cultivars are recognized that vary in flower shape, size, and color. Individual flowers are used as cut flowers for floral arrangements and for personal adornment, conjuring up images of a tropical motif, especially Hawaii and the South Pacific.

One of the primary obstacles for cultivating hibiscus in southern California are whiteflies (SCHS 2022), especially in more humid coastal areas. At least five types of whiteflies attack hibiscus in California (UCD IPM 2022) and the worst is likely the giant whitefly (*Aleurodicus dugesii*), which was first detected in California in 1992 in San Diego (Bellows and Hoddle 2022, Redak et al. 2021). Giant whiteflies typically attack leaf undersides, sucking plant sap and producing copious amounts of sugary honeydew and waxy, sticky, white, cottony-like material in which they hide from predators, feed, and complete their life cycle (**Figs. 2**–**4**). Severely infested plants will appear like a flocked Christmas tree (**Fig. 5**). The damage can defoliate plants and reduce growth and the sticky white, cottony material makes plants a nuisance around which to work. Also, the excreted

Fig 2. Giant whitefly infested leaves and twigs of *Hibiscus rosa-sinensis* 'Kona'.

Fig. 3. Giant whiteflies are most severe on leaf abaxial surfaces, *Hibiscus rosa-sinensis* 'Brilliant'.

Fig. 4. Giant whiteflies typically produce copious amounts of sticky, white-cottony material, *Hibiscus rosa-sinensis* 'Lipstick'.

Fig. 5. Giant whitefly has severely infested this *Hibiscus rosas-sinensis* 'White Wings', turning nearly the entire plant grayish white.

Fig. 6. Excreted honeydew from giant whiteflies supports the growth of "sooty mold," *Hibiscus rosa-sinensis* 'Lipstick'.

honeydew typically supports the growth of black, non-pathogenic fungi called "sooty mold," which is primarily only unsightly but can be deleterious if it becomes so widespread and thick that it blocks sufficient sunlight from reaching the leaf (**Fig. 6**).

Because giant whitefly adults and early instars are mobile and nymphs are covered with a somewhat impermeable wax, control can be difficult and traditionally required repeated applications of contact and systemic materials. However, use of these materials can decrease the effectiveness of natural enemies, like parasitoid wasps, and damage or kill non-targeted insects and other organisms, many of which are beneficial. Thus, most recommendations now emphasize non-chemical control, such as early vigilance and cutting out, securely bagging, and removal of infested leaves; frequent, regular washing of the leaf undersides with a strong jet of water; planting less susceptible hibiscus cultivars; or removal and replacement of severely infested hibiscus with non-susceptible species (Redak et al. 2021, UCD IPM 2022). Control of ants with baits, which "farm" many sap-sucking insect pests, moving them around and protecting them from predators to harvest their sugary secretions, can be beneficial. Least toxic pesticides like insecticidal soap, neem oil, or horticultural oil also can provide some control. Use of yellow, sticky traps, primarily to monitor population levels, might also help to reduce whitefly populations (UCD IPM 2022).

Our interest in this pest and differences in hibiscus cultivar pest susceptibility arose from the difficulty in controlling them and the presence of two long rows or hedges composed of multiple cultivars near the home of co-author Hodel, who perceived differences in susceptibility or infestation levels among the cultivars. We surveyed these two rows, rated infestation levels, and report the results here.

Materials and Methods

The two rows or hedges of *Hibiscus rosa-sinensis* are in Seal Beach, California, which is classified as Mediterranean-type climate with a strong maritime influence. The site is about three km from the Pacific Ocean and is in Sunset Climate Zone 22 but near the border with Zone 24 (Lane 1988). Winter day and night temperature are typically 18° to 24°C and 4.5° to 10°C, respectively, with lows rarely reaching 0°C while summer day and night temperatures are 24° to 30°C and 15° to 21°C, respectively, with highs rarely reaching 38°C. Average annual rainfall is 300 mm and occurs nearly entirely from November to April.

The two hedges or rows are composed of 194 individual plants. Row 1, on the south side of 2400 to 2600 Westminster Boulevard, is about 400 m long and roughly stretches from Apollo Drive to Road B. Row 2, varying from 75 to 300 m away from Row 1 and on the north side of 1259 to 2299 Seal Beach Boulevard, is about 375 m long and stretches southwestward from Road B. The 194 plants are nearly evenly split between the two rows with 91 in Row 1 and 103 in Row 2 (**Fig. 7**).

Fig. 7. Location of giant whitefly infestation trial on six cultivars of *Hibiscus rosa-sinensis*, Seal Beach, CA, September, 2022. Area marked in red along Westminster Blvd. is Row 1, that marked in red along Seal Beach Blvd. is Row 2. Image courtesy of Google Earth.

Cultivars are randomly scattered within the rows, often in groups of two to nine of the same cultivar, but some are single plants within the row. Plants appear to be 15 to 30 years of age, have stems from 10 to 30 cm in diameter at ground level, and range from one to three m in height. Because they are maintained as a more or less informal hedge, individual plants are mostly cuboid in shape (longer than wide and deep) although some are cubes. Plants received little care other than an occasional irrigation and pruning for size control. Pruning seems to be irregular with some plants being pruned less frequently than others.

On September 9, 2022, we consensus rated each plant individually for severity of giant whitefly infestation based on percent of canopy infested: 0 = not infested; 1 = 1 to 20% infested; 2 = 21 to 40% infested; 3 = 41 to 60% infested; 4 = 61 to 80% infested; and 5 = 81 to 100% infested. We also rated each plant for leaf cover or canopy density on a similar scale: 1 = 0 to 20% density; 2 = 21 to 40% density; 3 = 41 to 60% density; 4 = 61 to 80% density; and 5 = 81 to 100% density. We recorded whether the plants appeared to have been pruned in the last growing season or not and the presence of leaf chlorosis. Because the plants are on private property, we rated only the side facing the publicly accessed sidewalk, which is the north side for plants in Row 1 along Westminster Boulevard and the south side for those in Row 2 along Seal Beach Boulevard. As part of our analysis, we determined differences, if any, in infestation levels between the north side of the plants (Row 1) and the south side of the plants (Row 2).

Because trichomes (microscopic hairs on various plant surfaces, including leaves) might affect severity of infestation levels among cultivars, we randomly selected 10 leaves of the same size and maturation of each cultivar and, using a compound microscope at 4X and 10X, counted the quantity of trichomes within a randomly selected 4-mm-diameter field of view on the abaxial leaf blade surface, which giant whitefly typically infest, and described their type and size. From the 4-mm-diamteter field of view, we calculate the quantity of trichomes per mm^2.

Eight cultivars of *Hibiscus rosa-sinensis* are included in the two rows (**Table 1**). Because two cultivars were represented by only three plants each, we include them only in the composite analyses.

The disparate quantities of cultivars in the study, from as few as 10 in 'Brilliant' and 'Butterball' to as many as 63 in 'Lipstick' and 75 in 'White Wings', were somewhat challenging for data analysis. We felt the quantities provided sound results when a factor common to at least 10 plants of each cultivar was analyzed, such as individual cultivar analysis for infestation levels and trichome density and composite cultivar analyses for infestation levels and pruning vs. no pruning, canopy density, and north vs. south side of the plant.

Table 1. *Hibiscus rosa-sinensis* cultivars in the giant whitefly susceptibility trial, Seal Beach, CA, September, 2022[z].

Cultivar	Flower Characteristics	Quantity of Plants
'Brilliant'	Single, solid red	10
'Butterball'	Double yellow	10
'Butterfly'	Single, solid yellow	14
'Kona'	Double pink	16
'Lipstick'	Single pink with slightly darker pink center	63
'White Wings'	Single white with red center	75

[z]Two unidentified cultivars composed of three plants each were excluded from most analyses.

Figs. 8–13. *Hibiscus rosa-sinensis* cultivars in the giant whitefly susceptibility trial. **8.** 'Brilliant'; **9.** 'Butterball'; **10.** 'Butterfly'; **11.** 'Kona'; **12.** 'Lipstick'; **13.** 'White Wings'.

When we "drilled down" or "chopped away" in our data analyses of other factors, such as individual cultivar analyses of infestation levels for pruning vs. no pruning, canopy density, and north vs. south side of the plant, we had less confidence in the results because, in some cases, so few plants (data points) within a cultivar were present for that factor that the analysis lacks a robust confidence level. For example, 'Brilliant' comprised 10 plants total but only two were rated on the south side of the plant, 'Butterfly' comprised 14 plants total but only one was rated on the south side of the plant, and 'Butterball' comprised 10 plants total but only one was rated on the north side of the plant. Analyzing infestation levels for these three cultivars for the factor of north vs. south side of the plant might provide valid results but the confidence level would be sufficiently low to render the results unreliable.

We considered randomly selecting only 10 plants of each of the six cultivars for analysis, for a total of 60 plants in the study, but felt that this method would be discarding significant quantities of data for some cultivars that help to validate accuracy of the results. Thus, we analyzed only cultivars with at least 10 data points per factor per cultivar; when less than 10 data points per factor per cultivar were present, we could still use this data by combining it with that from the other cultivars to create a composite analysis across all cultivars. For example, we analyzed data for north vs. south side of the plant for the 91 north-side plants in Row 1 vs. the 103 south-side plants in Row 2, without regard to cultivar.

We entered the data into an Excel spreadsheet (Microsoft Corp., Redmond, WA) and determined means, standard deviations, and significance (p values) for severity of infestation by cultivar, pruned and unpruned plants, north vs. south side of plant, and quantity of trichomes per mm^2. We checked for correlations between infestation levels and canopy density, leaf chlorosis, and trichome density.

Results and Discussion

Infestation Levels and Cultivars

Giant whitefly mean infestation levels ranged from a low of 1.1 for 'Butterball' to a high of 4.5 for 'Lipstick' (**Table 2**). Of the 15 possible cultivar comparisons, 10 had significantly different mean infestation levels, including nine at the $p<0.01$ level and one at the $p<0.05$ level (**Table 2**). Only 'Brilliant' with 'Butterfly', 'Kona', and 'White Wings', 'Butterfly' with 'White Wings', and 'Kona' with 'Lipstick' showed no significant differences in mean infestation levels.

Redak et al. (2021) suggested that yellow-flowered hibiscus cultivars are less susceptible to giant whitefly than red-flowered cultivars. Our work mostly supports and expands this observation. We found that the red cultivar 'Brilliant' and pink cultivars 'Kona' and 'Lipstick' had higher mean infestation levels (3.4, 4.1, 4.5, respectively) than the yellow cultivars 'Butterball' and 'Butterfly' (1.1 and 2.7, respectively) while the lone white cultivar 'White Wings' (3.2) was somewhat intermediate. Indeed, differences were significant between the red/pink and yellow cultivars in all combinations except for 'Brilliant' with 'Butterfly' while 'White Wings' had a significantly higher mean infestation level than the yellow 'Butterball' but lower than the pink 'Kona' and 'Lipstick'.

Table 2. Comparisons of giant whitefly infestation on six cultivars of *Hibiscus rosa-sinensis*, Seal Beach, CA, September, 2022.

Cultivar	µ Infes-tation[z]	σ Infes-tation[y]	'Butterball'	'Butterfly'	'Kona'	'Lipstick'	'White Wings'
'Brilliant'	3.4	1.1	0.0005[x]	0.0693	0.0894	0.0065[x]	0.2919
'Butterball'	1.1	1.4		0.0044[x]	2.9E-05[x]	1.4E-05[x]	0.0006[x]
'Butterfly'	2.7	1.1			0.0024[x]	1.2E-05[x]	0.0844
'Kona'	4.1	1.3				0.1395	0.0144[w]
'Lipstick'	4.5	1.0					7.3E-09[x]
'White Wings'	3.2	1.5					

[z] Infestation levels, percent of canopy infested: 0 = not infested, 1 = 1 to 20%; 2 = 21 to 40%; 3 = 41 to 60%; 4 = 61 to 80%; and 5 = 81 to 100%. [z]µ = mean.
[y] σ = standard deviation.
Green[x] is significant at p<0.01; Pink[w] is significant at p<0.05.

What accounts for hibiscus cultivar differences in giant whitefly infestation levels is largely unknown. We suspected that it might be due to an easily observable and measured character, such as variation in trichomes (microscopic hairs) on the leaf abaxial surface, or less readily discernable and documentable internal characters, such as cell structure and/or biochemistry. We decided to investigate what impact, if any, trichomes had on giant whitefly infestation.

Infestation Levels and Trichomes

Trichomes are microscopic hairs on plant surfaces (Bar and Shtein 2019, Levin 1973). They vary considerably in size, shape, and function, even on the same organ. They can be unicellular or multicellular, glandular or non-glandular, straight, curved, spiral, hooked, tortuous, simple or branched, peltate or stellate (Levin 1973), erect to variously appressed and sparsely to densely covering the surface (**Fig. 14**).

Although widely employed for taxonomic purposes in helping to identify families, genera, species, and even subspecific taxa (Bar and Shtein 2019, Hardin 1979, Inamdar et al. 1983, Levin 1973, Shaheen et al. 2009), the most critical function of trichomes might be on plant health, specifically the defense they provide against some environmental stresses and herbivory by insects and even larger animals (Wagner et al. 2004).

Environmental conditions affect trichome density in some species (Azmat et al. 2009, Christodoulakis 1989, De Micco et al. 2011, Shtein et al. 2011) and suggest a protection role against abiotic stresses (Bar and Shtein 2019). In hot, xeric environments, trichomes reflect light and reduce transpiration (Ehleringe 1984, Ehleringer 1976, Larcher 2001, Wagner et al. 2004,

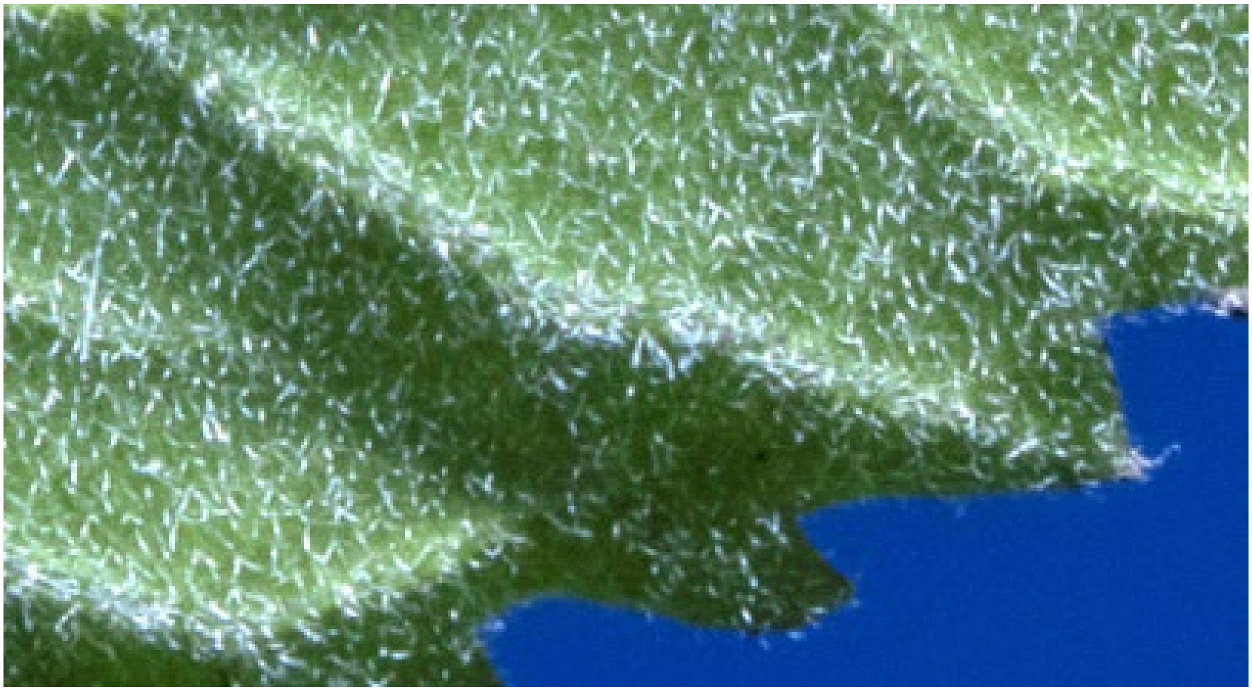

Fig. 14. Densely spaced single, forked, and multi-armed trichomes, abaxial leaf surface of *Hibiscus rosa-sinensis* 'Kona'.

Werker 2000). Trichomes also provide frost protection and trap fog and rain (Werker 2000) and aid in seed dispersal (Wagner et al. 2004).

Trichomes have been shown to reduce insect feeding and colonization on a number of plant species (Elle et al. 1999, Hare and Smith 2005, Levin 1973, Marquise 1992, Romeis et al. 1999, Van Dam and Hare 1998, Wagner et al. 2004). They protect plants by serving as physical barriers to pest movement, ovipositing, and feeding (Kumar 2011, Pillemer and Tingey 1976); they can impale pests on their sharp-pointed apices (Johnson 1975, Levin 1975, Pillemer and Tingey 1976); and glandular trichomes can produce, secrete, and accumulate specialized phytochemicals like terpenes, phenolics, and alkaloids to deter insect predation and increase plant lethality (Johnson 1975, Levin 1973, Raghu 2015).

Effect of trichome density, arrangement, size, and shape on whitefly infestation levels has been investigated for various crops with somewhat mixed results. Butler and Henneberry (1984) and Butler et al. (1986, 1991) found that high trichome density was related to high sweetpotato whitefly infestation levels on cotton. For greenhouse whiteflies, Bilderback and Mattson (1977) and Castané and Albajes (1992) found a similar relationship on poinsettias and *Pelargonium* cultivars, respectively. However, Kishaba et al. (1992) found that trichome density was not as critical as their length and how they were arranged in determining sweet potato whitefly density on white-flowered gourds.

In *Hibiscus*, the presence of glandular and non-glandular trichomes is characteristic for the genus (Essiett and Iwok 2014, Shaheen et al. 2009), and both adaxial and abaxial leaf surfaces typically have several types, making an indumentum of varying texture and density (Shaheen et al. 2009).

In *Hibiscus rosa-sinensis*, Inamdar et al. (1983) reported that leaves had simple, stellate, capitate, and clavate trichomes, with the former common and the latter three rare. Shaheen et al. (2009) reported capitate, clavate, peltate, stellate, and conic trichomes; in size, capitate were 35–42.5 × 25–325 µm (micron, a millionth of a meter), clavate 62.5–100 × 3–7 µm, peltate 15–30 µm wide, stellate 95–170 × 7.5–22.5 µm, and conic 62.5–135 × 7.5–15 µm. Sayed et al. (2012) found glandular and non-glandular trichomes on both leaf surfaces; non-glandular were simple and unicellular or stellate with two to four radiating, unicellular arms arising from a common base. Arms of simple trichomes had thick, lignified walls, striated cuticle, and were 100–180 × 18–33 µm while those of stellate trichomes had thick, lignified walls, smooth cuticle, acute apices and were 135–300 × 15–25 µm. Glandular trichomes were fewer in quantity with a globular, multicellular head 20–30 × 18–22 µm on unicellular stalk 10–15 × 8–12 µm. Essiett and Iwok (2014) reported 2-armed glandular and 3-, 4-, and 5-armed non-glandular trichomes on the abaxial leaf surface with glandular trichomes 197 × 42 µm.

Trichomes that we were able to observe on the *Hibiscus* cultivars in our study varied in quantity per mm^2 (density), mostly from 0.49 for 'Butterball' to 2.45 for 'Lipstick', but with an outlier of 6.94 for 'Kona' (**Table 3; Fig. 14**). Meagher and Estrada (1994) observed similar densities on *H. rosa-sinensis* cultivars, none of which we had in our study, that mostly ranged from 0.4 to 2.8 per mm^2 with an outlier of 11.5 per mm^2. Trichomes were simple, forked, or multi-armed stellate

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Table 3. Mean trichome density and shape and size on the abaxial leaf surface of six cultivars of *Hibiscus rosa-sinensis*, Seal Beach, CA, September, 2022.

Cultivar	μ^z density/ mm^2	σ^y density/ mm^2	Shape and Size (µm)^x
'Brilliant'	1.19	0.25	Stellate with multiple arms; 400 × 300
'Butterball'	0.49	0.17	Stellate with multiple arms; 750 × 750
'Butterfly'	1.69	0.89	Stellate with multiple arms; 250–300 × 100–300
'Kona'	6.94	1.00	Simple and stellate with 2 or 3 arms; 250–300
'Lipstick'	2.45	0.96	Stellate with multiple arms; 400 × 300–600
'White Wings'	0.72	0.33	Stellate with 2–5 arms; 250 × 500

^{z} µ = mean. ^{y} σ = standard deviation. ^{X} µm = micron, one millionth of a meter.

Table 4. Comparisons of mean trichome density on the abaxial leaf surface of six cultivars of *Hibiscus rosa-sinensis*, Seal Beach, CA, September, 2022.

Cultivar	μ[z] density/ mm²	'Butterball'	'Butterfly'	'Kona'	'Lipstick'	'White Wings'
'Brilliant'	1.19	3.27E-06[y]	0.1389	9.8E-09[y]	0.0059[y]	0.0035[y]
'Butterball'	0.49		0.0028[y]	6.1E-09[y]	0.0004[y]	0.0762
'Butterfly'	1.69			7.6E-10[y]	0.1099	0.0107[x]
'Kona'	6.94				3.7E-08[y]	2.0E-09[y]
'Lipstick'	2.45					0.0008[y]
'White Wings'	0.72					

[z] μ = mean.
Green[y] is significant at p<0.01; Pink[x] is significant at p<0.05.

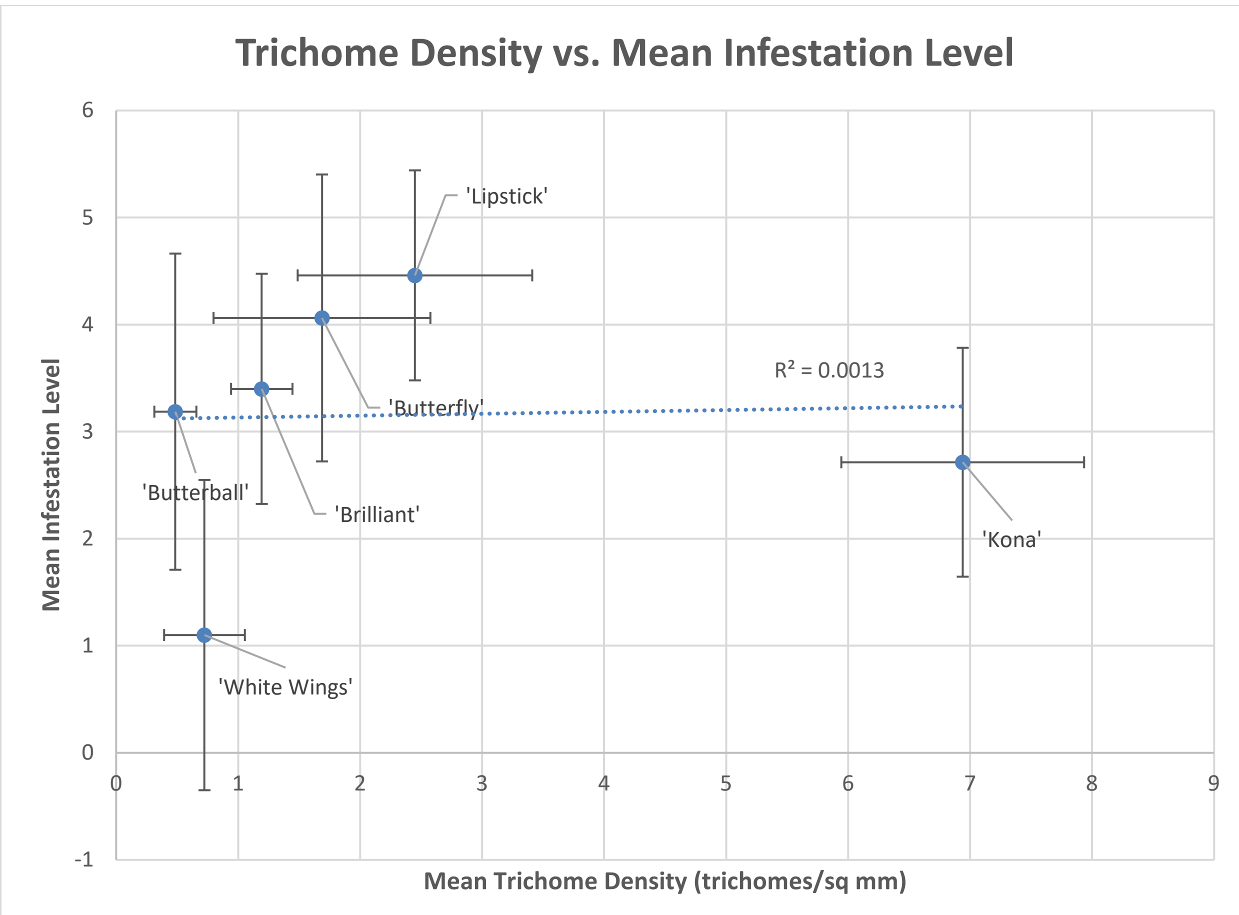

Fig. 15. Correlation of mean trichome density on the abaxial leaf surface and giant whitefly infestation levels of six cultivars of *Hibiscus rosa-sinensis*, Seal Beach, CA, September, 2022. Bars are standard deviations.

in shape, and tended to be slightly or significantly larger, up to double the size reported in the literature, ranging from 250 to 750 µm in length and width. The stellate ones were mostly three-dimensional, like a multibranched tree, or sometimes two-dimensional or flat like a starfish. Trichomes were often uniformly leaning (slightly appressed) in the same direction.

Differences in mean trichome density were mostly significant among the cultivars (**Table 4**), suggesting that the density of trichomes, perhaps along with their shape and size, could be a useful tool for identification. Only 'Butterfly' with 'Brilliant' and 'Lipstick' and 'Butterball' with 'White Wings' did not have significantly different mean trichome densities.

We were unable to find a significant relationship between mean trichome density and infestation level (R^2 = 0.0013) (**Fig. 15**). If we exclude the outlier 'Kona', a weak trendline with the remaining cultivars is present (R^2 = 0.5291) (**Fig. 16**). Similar to our results, Meagher and Estrada (1994) generally found no relationship between trichome density and sweetpotato whitefly infestation

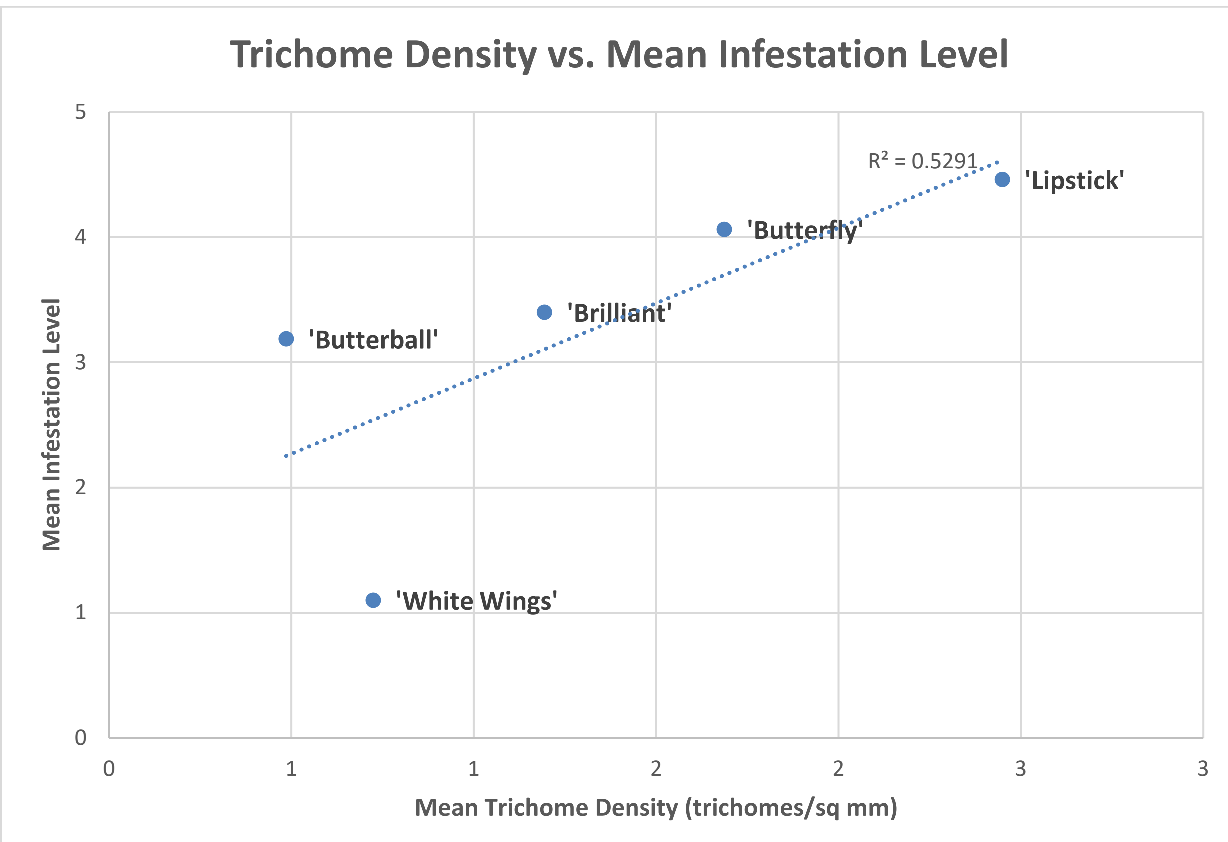

Fig. 16. Correlation of mean trichome density on the abaxial leaf surface and giant whitefly infestation levels of five cultivars of *Hibiscus rosa-sinensis* ('Kona' excluded), Seal Beach, CA, September, 2022.

levels on *Hibiscus* cultivars, none of which we had in our study. However, comparing sweetpotato whitefly, which is small, only about 0.5 to 1.5 mm long, with giant whitefly, which is large, about 5 mm long, and what effect trichomes had on infestation levels might be difficult because of the size differences of the two pests. Based on pest and trichome density and size, it would seem that trichomes might affect giant whitefly infestation levels even less than those of significantly smaller pests, like the sweet potato whitefly, perhaps because giant whiteflies are simply too large to be much impacted directly by the much smaller trichomes regardless of their density. Giant whiteflies could more easily "walk" over the trichomes as a person walks across a maintained lawn while smaller pests might be more hindered.

Perhaps other trichome characteristics, such as arrangement and shape might affect giant whitefly infestation levels by providing a suitable microclimate and/or offering protection from predators. Trichomes might even assist giant whitefly infestations by helping to protect predators and anchor whitefly egg masses or the entire whitefly biome. Further work is needed on this subject and the potential for breeding whitefly-resistant cultivars.

Infestation Levels and Pruning

As a composite of all cultivars, pruned plants had significantly lower mean giant whitefly infestation levels than unpruned plants (2.5 vs. 4.1, respectively, $p<0.01$). Also, pruned plants had significantly lower mean canopy densities than unpruned plants (3.5 vs. 4.5, respectively, $p<0.01$). These differences were also true for the north and south sides of plants; mean infestation levels on the north side of pruned plants were significantly lower than those on the north side of unpruned plants (2.7 vs. 4.6, respectively, $p< 0.01$) and infestation levels on the south side of pruned plants were significantly lower than those on the south side of unpruned plants (2.3 vs. 3.8, respectively, $p<0.01$). Also, whether on the north or south sides of plants, mean canopy density was significantly lower on pruned vs. unpruned plants (**Table 5**).

The only individual cultivar with at least 10 data points per factor, 'White Wings', had significantly lower mean giant whitefly infestation levels between pruned and unpruned plants (2.6 and 3.8, respectively, $p<0.01$) and significantly lower mean canopy densities between pruned and unpruned plants (3.7 and 4.5, respectively, $p<0.01$). The other five cultivars followed the same trend as 'White Wings' but of those, only 'Butterfly' showed a significant difference and all five had less than 10 data points per factor per cultivar, making the data somewhat unreliable (**Table 5**).

As one of the recommended management strategies for giant whitefly, pruning likely reduces infestation levels mostly by removing infested leaves and reducing population levels. Pruning might also be effective in lowering infestation levels because it is a growth retarding process, reducing leaf area that whiteflies can colonize.

Table 5. Comparison of pruning vs. no pruning on giant whitefly infestation and canopy density of six cultivars of *Hibiscus rosa-sinensis*, Seal Beach, CA, September, 2022.

Cultivar	Factor	μ^z Infestation Pruned	μ Infestation Unpruned	P-Value	Qty Pruned	Qty Unpruned
TOTAL	Infestation[y]	2.5	4.1	0.01[w]	76	118
	Canopy Density[x]	3.5	4.5	0.01[w]	76	118
NORTH SIDE	Infestation	2.7	4.6	0.01[w]	43	48
	Canopy Density	3.8	4.4	0.01[w]	43	48
SOUTH SIDE	Infestation	2.3	3.8	0.01[w]	33	70
	Canopy Density	3.1	4.5	0.01[w]	33	70
'Brilliant'	Infestation	3.1	4.5	0.14	8	2
	Canopy Density	2.5	4.5	0.08	8	2
'Butterball'	Infestation	0.8	2.5	0.61	8	2
	Canopy Density	2.5	2	0.84	8	2
'Butterfly'	Infestation	2.5	3.7	0.04[v]	11	3
	Canopy Density	3.7	5.0	0.01[w]	11	3
'Kona'	Infestation	3	4.5	0.14	5	11
	Canopy Density	4.4	4.1	0.53	5	11
'Lipstick'	Infestation	4.0	4.5	0.32	4	59
	Canopy Density	4.8	4.6	0.51	4	59
'White Wings'	Infestation	2.6	3.8	0.01[w]	37	38
	Canopy Density	3.7	4.5	0.01[w]	37	38

[z] μ = mean.
[Y] Infestation levels, percent of canopy infested: 0 = not infested, 1 = 1 to 20%; 2 = 21 to 40%; 3 = 41 to 60%; 4 = 61 to 80%; and 5 = 81 to 100%.
[x] Canopy density, percent canopy coverage: 1 = 0 to 20% density; 2 = 21 to 40% density; 3 = 41 to 60% density; 4 = 61 to 80% density; and 5 = 81 to 100% density.
Green[w] is significant at $p<0.01$; Pink[v] is significant at $p<0.05$.

Infestation Levels and North vs. South Side of Plant

We postulated that a more favorable environment on the north side of the plant, including less exposure and more shade, more moderate and uniform temperatures, higher humidity, and less wind, than on the south side might impact infestation levels. However, no significant differences existed in mean giant whitefly infestation levels comparing the north to the south sides of the plant as a composite of all cultivars or among the six cultivars. As a composite of all cultivars, mean infestation levels were slightly higher on the north side of plants than the south side (3.70 vs. 3.31, respectively, $p = 0.07$) but the difference was insignificant. Among individual cultivars, the results were mixed, with some showing higher mean infestation levels on the north than the south side and others showing the opposite, but none was statistically significant ($p = 0.12$ to 0.86).

Infestation Levels and Canopy Density and Leaf Chlorosis

Mean giant whitefly Infestation levels showed only a very weak correlation to canopy density ($R^2 = 0.19544$), indicating that plants were able mostly to retain leaves when even severely infested.

Conversely, mean giant whitefly infestation levels showed a weak inverse correlation with leaf chlorosis ($R^2 = -0.25665$).

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