Entomology

Karla Addesso

Section Editor

Field Comparison of Crapemyrtle Bark Scale Infestations between 'Natchez' and Non- 'Natchez' Cultivars

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Index Words *Acanthococcus lagerstroemiae, Eriococcus, Lagerstroemia* spp.

Significance to Industry Little work has been published regarding the susceptibility of different crapemyrtle cultivars, *Lagerstroemia* spp. to the non-native crapemyrtle bark scale, *Acanthococcus lagerstroemiae* Kuwana. Some cultivars are more common in the landscape then others. Among those is the widely planted 'Natchez' cultivar. This research examines the 'Natchez' cultivars susceptibility to *A. lagerstroemiae* in the field in making informed cultivar recommendations for the landscape.

Nature of Work Crapemyrtle bark scale *A. lagerstreomiae* was first discovered by a landscaping company in Richardson, Texas in 2004 on carpemyrtles, *Lagerstroemia spp.* and has since spread to 12 States in the Southeastern United States (1). Its introduced range spans from New Mexico to the Southern states along the Atlantic Coast. The scale causes branch die-back, black sooty mold and reduced flowering (2). It adversely affects the aesthetics, health and value of the plant. Little has been published on the cultivar by cultivar susceptibility of *Lagerstroemia* spp. to *A. lagerstroemiae*. As of December 2011, there were 133 crapemyrtle cultivars available on the market (3). Of those the most common is the 'Natchez' cultivar. This *Lagerstroemia indica* and *Lagerstroemia faurei* hybrid grows up to 30 feet tall, it has white flowers and exfoliating bark that reveals cinnamon tones underneath. It was first introduced by the National Arboretum in 1987 and is recognized as the top performing crapemyrtle in the southeastern United States (4). In this study scale populations collected on 'Natchez' cultivar trees from the field were compared to *A. lagerstroemiae* populations on a pool of unknown cultivar trees to determine the relative susceptibility of the ubiquitous 'Natchez' cultivar to *A. lagerstroemiae* infestation. Other cultivars remained unknown because while 'Natchez' is relatively easy to distinguish from the other 132 cultivars, very similar combinations of bark, flower color and growth type make most other cultivars very difficult to distinguish by sight.

In Brazos County, Texas in spring 2018 *A. lagerstroemiae* samples were collected from 43 'Natchez' cultivar trees and 60 *lagerstroemia spp*. trees of at least three other cultivars distinguished by flower, bark and growth characteristics. Ten 12-inch branch tips were pruned from each tree using a long pole pruner and placed in plastic containers to be taken back to the lab for analysis. Crapemyrtles were sampled from easily accessible sites in urban and suburban settings. Permissions were sought and given by College Station Parks and Recreation and the local Texas Department of

Transportation. Residential areas were avoided both to reduce the variability in *Lagerstroemia* spp. cultural practices and unintended biases that can be associated with accessibility and landowner permission.

In the lab, *A. lagerstroemiae* numbers were counted on each branch and census numbers were pooled among branches to generate a census value for each tree. Population counts consisted of all nymph instars, male cocoons and adult females with intact ovisacs. However, ovisacs were not dissected to count individual eggs. Data was analyzed using JMP® statistical software (JMP®, Version 14.3. SAS Institute Inc., Cary, NC, 1989-2019). The normality of the data was tested using residuals. Data was not normally distributed, and so a Wilcoxon rank-sum test, equivalent to the Mann-Whitney test, was used to determine if the means were statistically different between the scale populations on 'Natchez' and non- 'Natchez' cultivars.

Results and Discussion The average number of *A. lagerstroemiae* present per tree was not significantly different between the 'Natchez' cultivar trees and the non-'Natchez' trees. The test to determine if the means are equal returned a Z value equal to 1.88731 and p-value of .0591. The box plot is shown in fig. 1. This indicates the 'Natchez' cultivar is neither more nor less susceptible to *A. lagerstroemiae* than the pool of non- 'Natchez' cultivar trees. 'Natchez' is the most popular crapemyrtle cultivar, and evidence that it is not especially susceptible to *A. lagerstroemiae* is positive. Until evidence comes to light that there are cultivars with increased or decreased *A. lagerstroemiae* resistance, *A. lagerstroemiae* susceptibility need not be a factor in cultivar choice by stakeholders.

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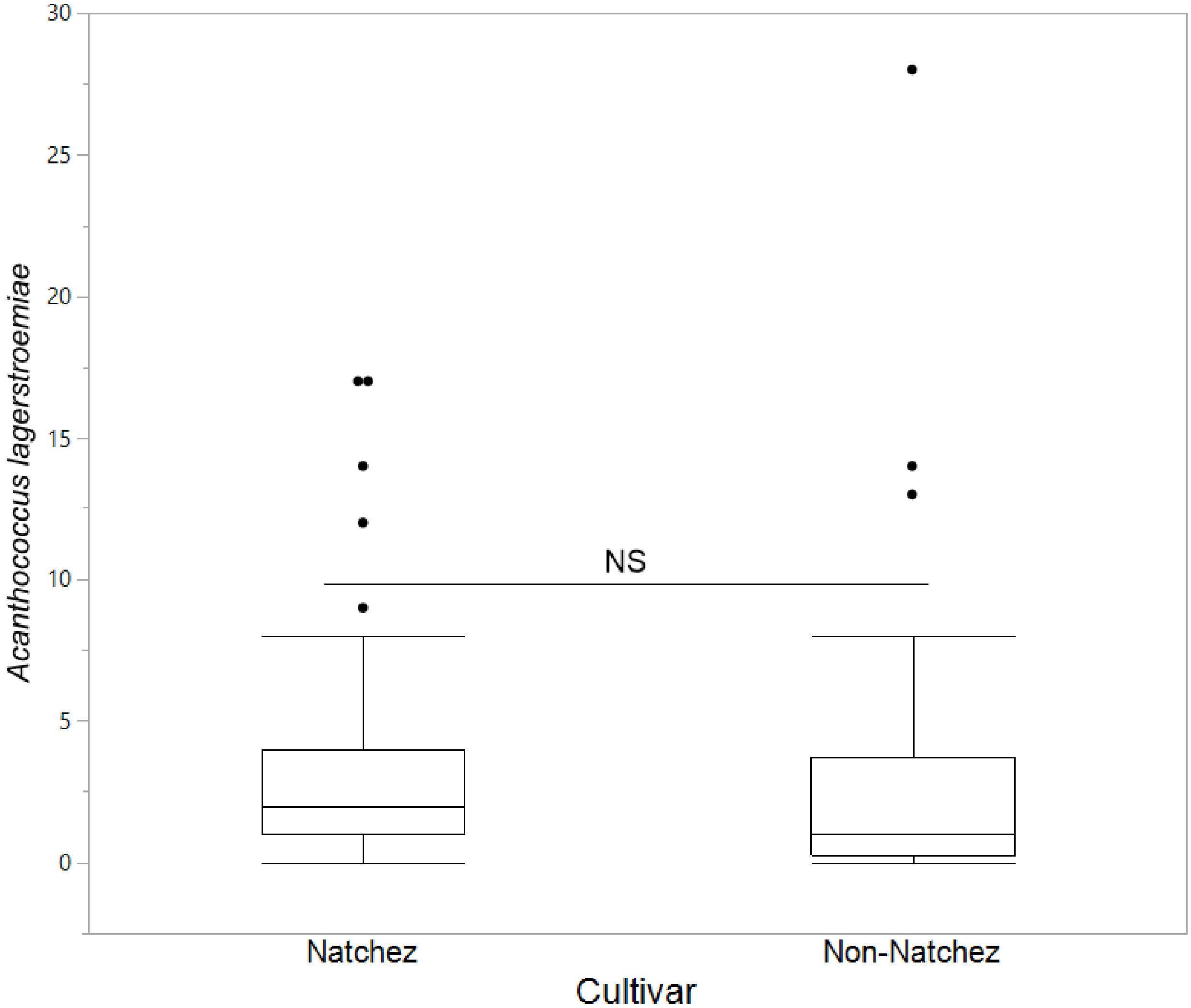

Fig. 1 Box plot of cultivar comparison. Y-axis is the number of scale insects, *A. lagerstroemiae*, per tree. Boxes represent the interquartile range. The horizontal line within the box is the median number of scales per tree for each cultivar. “Whiskers” are the minimum and maximum excluding outliers. The dots represent outliers.

Whitefly Populations at the Beginning and End of Poinsettia Color Production

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Index Words Integrated pest management, pest threshold, greenhouse production, retailer

Significance to Industry Greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood), and sweetpotato/silverleaf whitefly, *Bemisia tabaci* (Gennadius), are the most economically important and damaging pests of poinsettias; a commodity comprising 17% of the $810 million in annual value of potted flower plants grown for indoor or patio use in the USA (1). The regular release of predatory or parasitic insects to suppress a target pest, known as augmentation biological control, is a promising strategy to reduce whitefly populations in poinsettia production. Important to this approach are the development of thresholds for whitefly populations at the start of the color poinsettia crop and whitefly numbers acceptable to retailers. We present data on whitefly populations on rooted cuttings from two different facilities over two years to provide insight into whitefly populations coming from propagators, and data on whitefly populations on poinsettias from a total of 18 retailers over two separate years to determine retailer thresholds for whiteflies.

Nature of Work Management of whiteflies on poinsettias has historically relied on regular pesticides applications, which may be considered a short-sighted strategy due to pesticide resistance (2-4), increasing federal and state pesticide regulations (5), and increasing pressure from retailers to end use of neonicotinoid pesticides (6), such as imidacloprid, dinotefuran, and acetamiprid. The regular release of predatory or parasitic insects to suppress pest populations, known as augmentation biological control, is a promising strategy that is showing increased adoption in protected culture globally (7). Critics of augmentation biological control in poinsettia production assert that whitefly populations received on cuttings from propagators are too high and retailer thresholds for whiteflies on finished poinsettias are practically zero, both of which are poorly documented in the literature. In this multi-year study, we determine the populations of whiteflies found on rooted cuttings from propagators and whitefly populations at retailers in Texas over two years.

To determine whitefly populations received from propagators, we determined whitefly densities at two growers in 2017 and 2018. Each grower was visited for three consecutive weeks each year and all foliage on 200 newly rooted cuttings were inspected per visit using a 2.5x magnification head lens. Number of whitefly nymphs, pupae, and exuviae were counted per cutting.

To determine whitefly retailer thresholds, we scouted potted poinsettias at ten retailers on December 8, 2016 and seven retailers on December 13 & 14, 2018 located in Tyler, TX. Visually inspecting each plant for 60 seconds, the number of whitefly nymphs plus pupae, exuviae, and adults were counted for up to 30 poinsettias per retailer, depending on availability. In 2018, we also recorded poinsettia pot size, price, producer, and producer geographic location. To maintain anonymity of the retailers and producers, retailers were categorized under one of four groups: big-box stores (physically large multinational establishments), independent garden centers, grocery store florists, and independent florists.

Results and Discussion Cuttings from propagators were mostly free of whiteflies, with immature whiteflies present on only 41 cuttings out of the 2,417 cuttings inspected over the two years. We found no whitefly nymphs or pupae during four out of our twelve visits to the two producers over the two years, and average number of immatures never exceeded 0.48 nymphs/plant (Table 1). Our data from two grower locations over two years supports that starting conditions are below the 1.0 or fewer live nymphs or pupae/cutting needed for successful augmentation biological control for poinsettia production (8).

All retailer types had detectable levels of whitefly infestations on poinsettias, with mean immatures per plant reaching as high as 73 immature whiteflies counted within 60-seconds on a poinsettia (Florist 2018) (Figure 1), despite the premium clientele and price (mean of $83.50 for 10 – 12” pot arrangement) for the florist. The lowest mean whitefly population by retailer type was big-box stores in 2016, with a mean of 4.38 immature whiteflies counted within 60-seconds for a given poinsettia, with a mean price of $5.71 for a 6-inch pot. In 2016, percent of poinsettias infested with immature whiteflies was 43%, 71%, 63%, and 40% for big-box, grocery, garden stores, and florists, respectively. In 2018, percent of poinsettias infested with immature whiteflies was 74%, 81%, 81%, and 100% for big-box, grocery, garden stores, and florists, respectively.

Of the nine different producers that supplied the Tyler TX retailers, only one was completely free of whiteflies (20 poinsettias) (Figure 2). Other producers varied between a mean of 2.8 immatures per plant (Producer C) to 45.15 immatures per plant (Producer D) (Figure 2). With all retailers and years pooled together, we found an average of 25.01 +/- 1.87 (SE) immature whiteflies per plant and 1.64 +/- 0.19 (SE) whitefly adults per plant.

Augmentation biological control programs for whitefly control in poinsettias have effectively maintained whitefly populations below 0.55 – 0.98 nymphs per leaf on finished poinsettias (8), however, release rates of natural enemies were economically unviable. However, our survey results support that retailer thresholds for whiteflies on poinsettias are far from zero and that current pesticide rotation programs utilized by most growers result in higher whitefly populations that can be achieved through an augmentation biological control program.

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Table 1. Mean number of nymphs, pupae, and exuviae found on poinsettia cuttings during each of three consecutive weekly visits to two different growers (A and B) for two years (2017 and 2018).

Year	Facility	Date	Mean nymphs (+/- SE)	Mean pupae (+/- SE)	Mean exuviae (+/- SE)	N
2017	A	Jul. 17	0.01 ± 0.01	0.04 ± 0.02	0 ± 0	210
		Jul. 24	0 ± 0	0 ± 0	0 ± 0	200
		Jul. 31	0.04 ± 0.04	0 ± 0	0.02 ± 0.02	200
	B	Jul. 25	0 ± 0	0 ± 0	0 ± 0	200
		Aug. 2	0.14 ± 0.14	0 ± 0	0 ± 0	200
		Aug. 8	0 ± 0	0 ± 0	0 ± 0	200
2018	A	Jul. 20	0.32 ± 0.27	0.04 ± 0.03	0.11 ± 0.07	200
		Jul. 27	0.48 ± 0.22	0.03 ± 0.03	0 ± 0	200
		Aug. 3	0.2 ± 0.14	0.08 ± 0.04	0.08 ± 0.05	205
	B	Jul. 17	0 ± 0	0 ± 0	0.02 ± 0.01	200
		Jul. 26	0.02 ± 0.02	0 ± 0	0 ± 0	200
		Aug. 2	0.03 ± 0.03	0 ± 0	0 ± 0	202

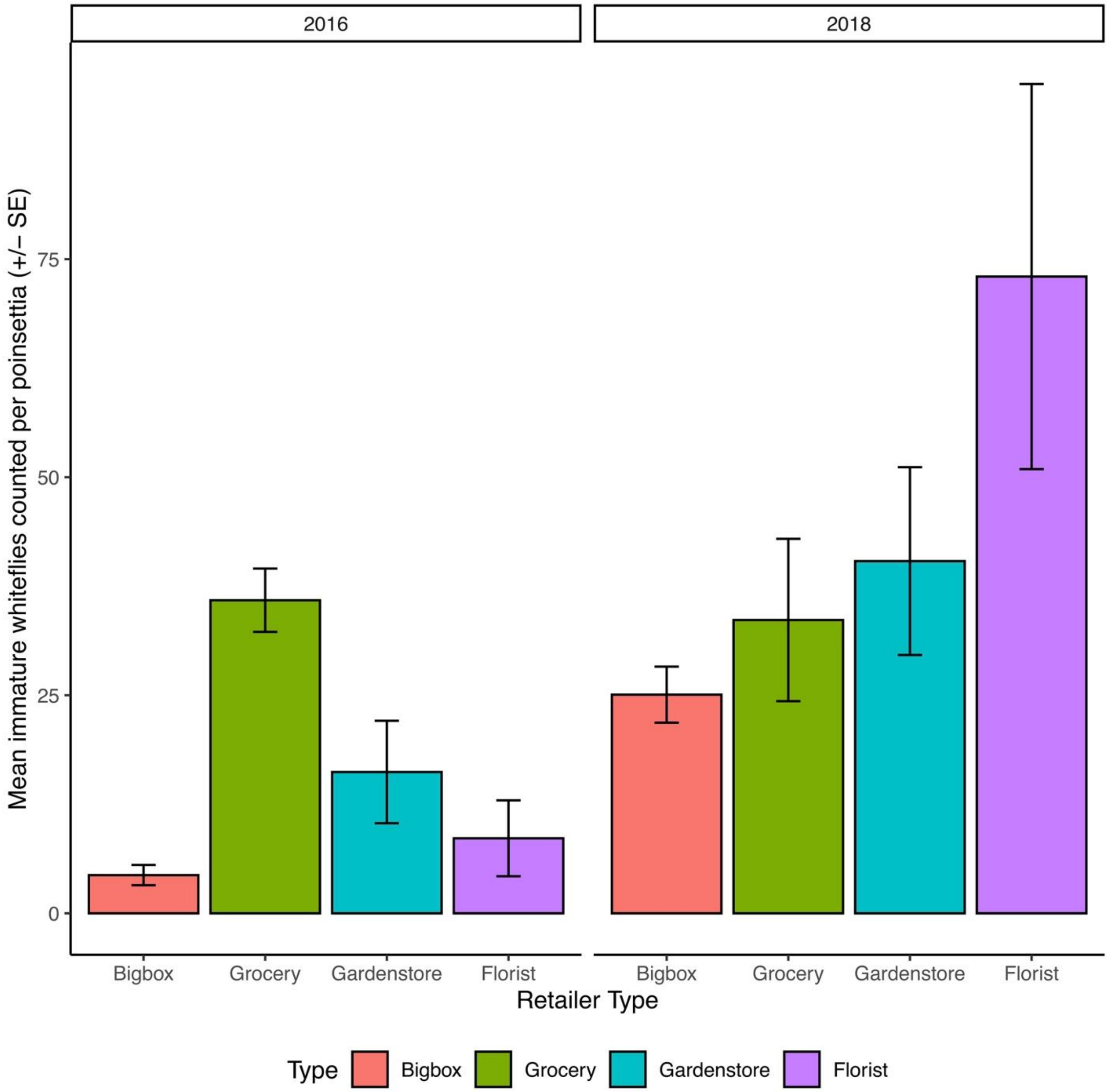

Figure 1. Mean immature (nymphs + pupae) whiteflies (+/- standard error) counted on poinsettias within 60-seconds from different retailer categories over two years (2016 and 2018).

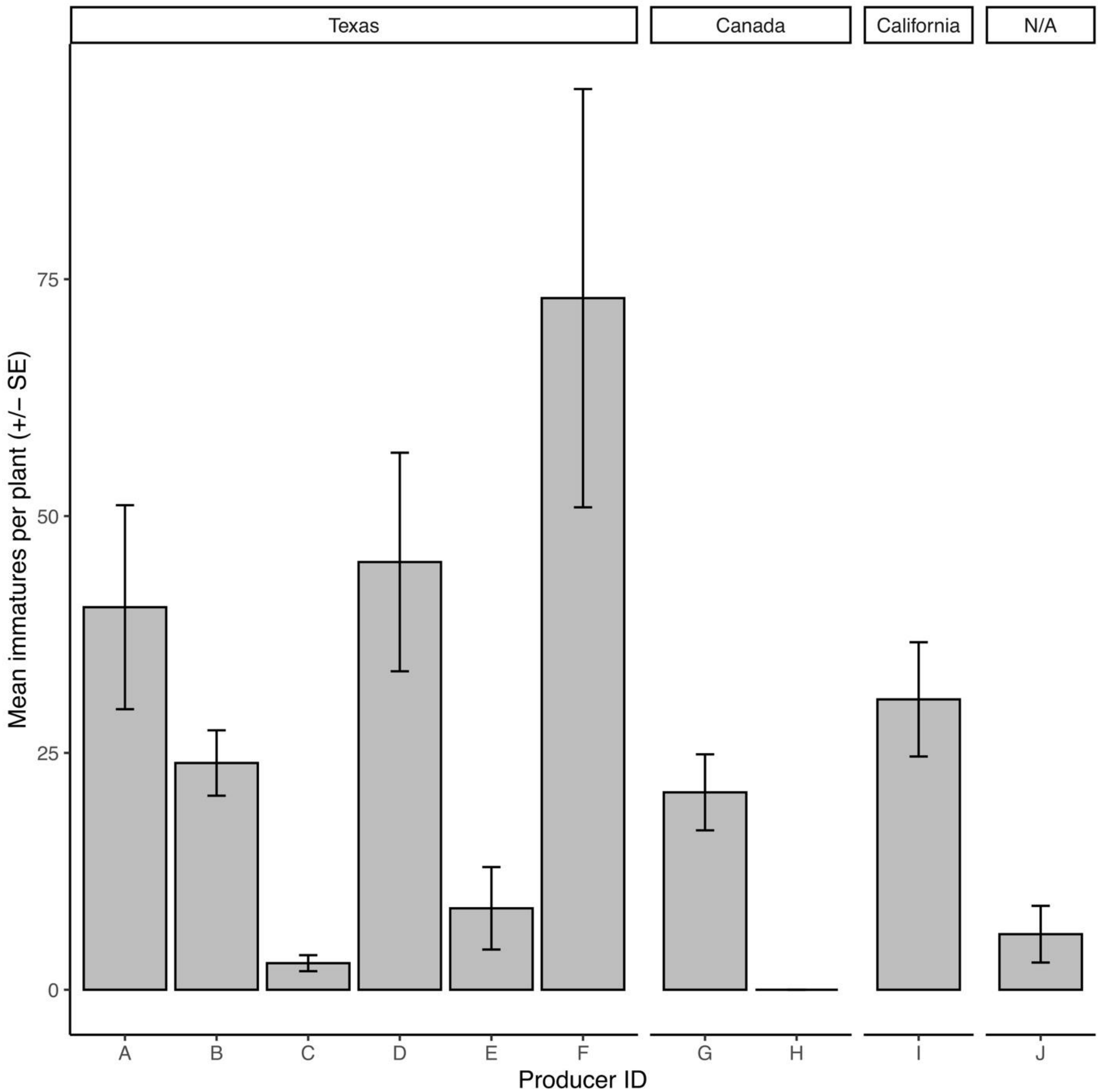

Figure 2. Mean immature (nymphs + pupae) whiteflies (+/- standard error) counted within 60-seconds for each finished poinsettia at different retailers, categorized by producer of the poinsettia and geographic location of the producer.

Host Preference of Parasitoids Imported for Control of *Acanthococcus lagerstroemiae* Kuwana on *Lagerstroemia indica* Linnaeus

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Index Words *Acanthococcus lagerstroemiae, Lagerstroemia indica*, parasitoid wasps, plant volatiles

Nature of Work Predators and parasitoids often use signals from plants to find their prey and hosts. Plants tend to constantly release volatiles into the environment; however, damaged plants may release a greater amount and an increased array of volatiles (3). These volatiles may be used to induce defenses in other neighboring plants (as picked up by eavesdropping) but may also serve as signals to parasitoids and predators, recruiting them to attack the offending herbivores (1, 3). In this paper, we will discuss the use of volatile released by plants to assess host specificity in the *Acanthococcus lagerstroemiae*/*Lagerstroemia indica*/parasitoid system. *Acanthococcus lagerstroemiae* Kuwana (Hemiptera: Acanthococcidae) is a non-native pest of crapemyrtle (*Lagerstroemia indica* Linnaeus) in the United States. Originally from China, it was first reported in the United States from Richardson, Texas in 2004 (2). Feeding by this insect on *L. indica* can cause branch dieback and excess honeydew production that encourages the development of sooty mold (6). So far, native predators have been found of *A. lagerstroemiae* but no native parasitoids have been found in the United States.

Acanthococcus lagerstroemiae were collected from *L. indica* in College Station, TX. Clippings of infested trees were taken using hand pruners and transported back to the laboratory. There the clippings were placed on 10 potted *L. indica* (Natchez cultivar). They were given 6 weeks for *A. lagerstroemiae* to infest and colonize the plants.

Fifteen cm twigs infested with *A. lagerstroemiae* were sent to us from multiple cities in China under the importation permit P526P-17-02746. Shipments were received into a quarantine facility, individual twigs were assigned an identification number, and placed in a glass vial. These vials were observed twice daily and any wasps that emerged were placed in individual shell vials and given an identification number. Wasps were sexed and identified to genus by the parasitoid systematist Dr. James B. Woolley of Texas A&M University. For this experiment, wasps in the genera *Metaphycus* (a primary parasitoid of *A. lagerstroemiae*) and *Marietta* (a hyperparasitoid) received from Jining and Beijing, China were used.

Oven bags were cut to fit over single shoots of potted crapemyrtle plants and placed in a drying oven overnight to bake off any plastic volatiles that may contaminate the volatile samples. Oven bags were then fitted over a single shoot of a potted crapemyrtle and secured using the provided oven bag closures. Small holes were cut into the top corners of the oven bags. Volatile collection filters and charcoal filters were placed into the holes and secured with scotch tape (one of each filter per plant). A vacuum line was attached to the collection filter (outlet) and an air pump was attached to the charcoal filter (inlet). Outlet and inlet flow rates were set to 0.5 L/min. Volatile collections occurred for eight uninfested *L. indica* and seven *L. indica* infested with between 85 and 115 *A. lagerstroemiae*. Volatiles were collected for six hours.

After collection, volatile samples were eluted into individual GC vials using 150 µL of dichloromethane. Additionally, a GC vial with 5 µL of nonyl acetate internal standard was also prepared. All samples and the standard were run on a GC-MS. Differences in means of ng/cm^2 of volatiles found were made using Welch's t-tests. To calculate ng/cm^2, pictures were taken of the leaves from which volatiles were collected and leaf surface area was measured using ImageJ 1.52a software (5). The absolute amount of each volatile was then divided by the leaf area to provide ng/cm^2 of each compound.

For host preference experiments, air was pumped through a two-channel air delivery system with a charcoal filter in the inlet. Outlet pressure was set to 18 psi and the flowrate was set to 0.7 L/min. These conditions allowed for wasps tested to move around unencumbered by the air being forced through the Y-tube. Wasps were placed in the base of the Y-tube and allowed five minutes to make a choice. If they travelled up one of the arms of the Y-tube two-thirds of the way, they were considered to have made a choice. If they did not travel 2/3 of the way up the arm, they were considered to have not made a choice. Each individual wasp was tested four times. The Y-tube was cleaned with 95% ethanol between each individual tested.

The following treatment combinations were tested for wasps in the genus *Metaphycus*: clean air vs uninfested *L. indica*, clean air vs. *L. indica* infested with *A. lagerstroemiae*, uninfested *L. indica* vs *L. indica* infested with *A. lagerstoremiae*, uninfested *L. indica* vs *Ulmus alata* Michx (winged elm). The first two treatments serve as a negative and positive control, respectively. The next two treatments serve as tests of the ability of the wasps to discern host-specific signals (from *L. indica* that have *A. lagerstroemiae* on them and from *L. indica* when compared with a non-host plant, *U. alata.* The following treatment combinations were tested for wasps in the genus *Marietta*: uninfested *L. indica* vs infested *L. indica*, uninfested *L. indica* vs *U. alata*. G-tests of heterogeneity were used to analyze if there were differences in choices made by the wasps and if there was heterogeneity between the wasps tested (were all of the wasps acting the same in each test).

Results and Discussion Plants infested with *A. lagerstroemiae* released greater amounts of four volatiles than plants without *A. lagerstroemiae* (Fig 1). These volatiles were trans-β-ocimene, E-α-farnesene, Z-α-farnesene, and methyl salicylate. Mean ng/cm^2 of each volatile were not significantly different between treatments (trans-β-ocimene: t=-1.1277, df=6.004, p=0.3025; E-α-farnesene: t=-1.0416, df=6.0001, p=0.3378; Z-α-farnesene: t=-1.084, df=6, p=0.32; methyl salicylate: t=-1.14498, df=8.7918, p=0.1818). These volatiles have previously been implicated in host-finding for natural enemies of other pests in the literature (4, 7) and are likely contributing to the parasitoids' ability to find their hosts.

In the choice tests, wasps in the genus *Metaphycus* did not demonstrate a preference between clean air and uninfested *L. indica* (G=0, df=1, p=1), infested *L. indica* and uninfested *L. indica* (G=0.57339, df=1, p=0.4489), and *L. indica* and *U. alata* (G=0.04764, df=1, p=0.8272) (Fig 2). They did, however, show a preference for infested *L. indica* over clean air (G=5.8221, df=1, p=0.01583) (Fig 2). Wasps in the genus *Marietta* did not demonstrate a preference between infested *L. indica* and uninfested *L. indica* (G=0, df=1, p=1) or *L. indica* and *U. alata* (G=1.9735, df=1, 0.1601) (Fig 3). In all of the choice tests, heterogeneity tests were not significant indicating that wasps all acted the same in the experiments. These results show that *Metaphycus* sp. individuals use volatiles produced by *L. indica* when they are fed on by *A. lagerstroemiae*. However, a lack of significant preference for *A. lagerstroemiae*-infested *L. indica* over uninfested *L. indica* may indicate that wasps have a harder time discerning between herbivore-induced plant volatiles and normal plant volatiles. These results also show us that *Metaphycus* sp. wasps cannot discern between or do not have a preference for host plants in the absence of herbivore feeding. Similarly, *Marietta* sp. individuals did not show a preference for *L. indica* plants with or without *A. lagerstroemiae,* nor did they show a preference for *L. indica* over *U. alata*, indicating that a different set of signals are used to find their parasitoid hosts.

Significance to Industry These results indicate that the volatiles given off by *Lagerstroemia indica* plants change when they are fed upon by *Acanthococcus lagerstroemiae*. These volatile changes are relevant to how parasitoid wasps that use *A. lagerstroemiae* as a host may find them. *Metaphycus* sp. individuals may use these volatiles to find their scale insect hosts, which may ultimately increase their ability to be an effective biological control agent. *Marietta* sp. individuals may use other signals not tested in this study to find their parasitoid hosts.

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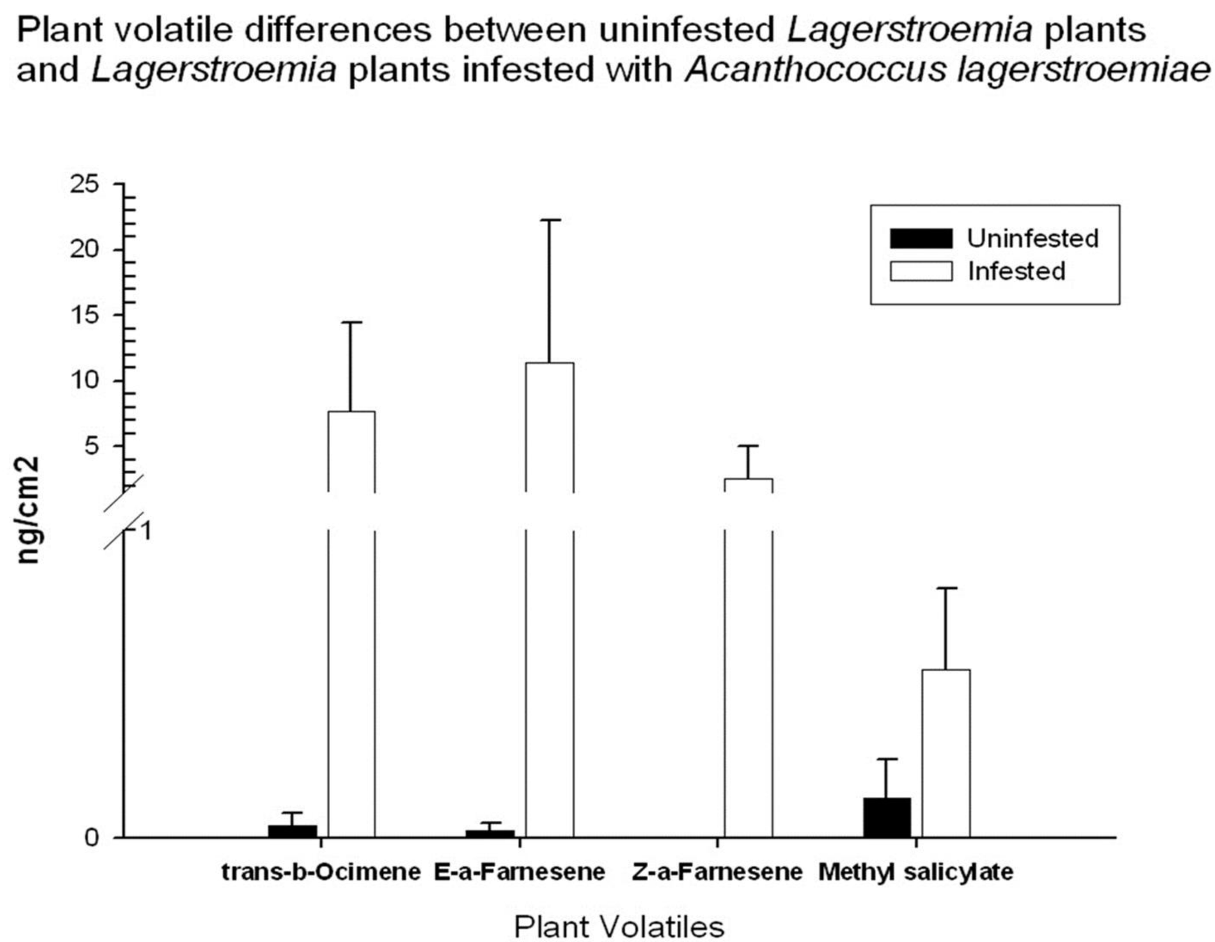

Figure 1. Amounts of volatiles produced by *A. lagerstroemiae*-infested *L. indica* plants and uninfested *L. indica* plants in ng/cm^2. Infested plants produced more volatiles though none were significantly greater using Welch's t-test.

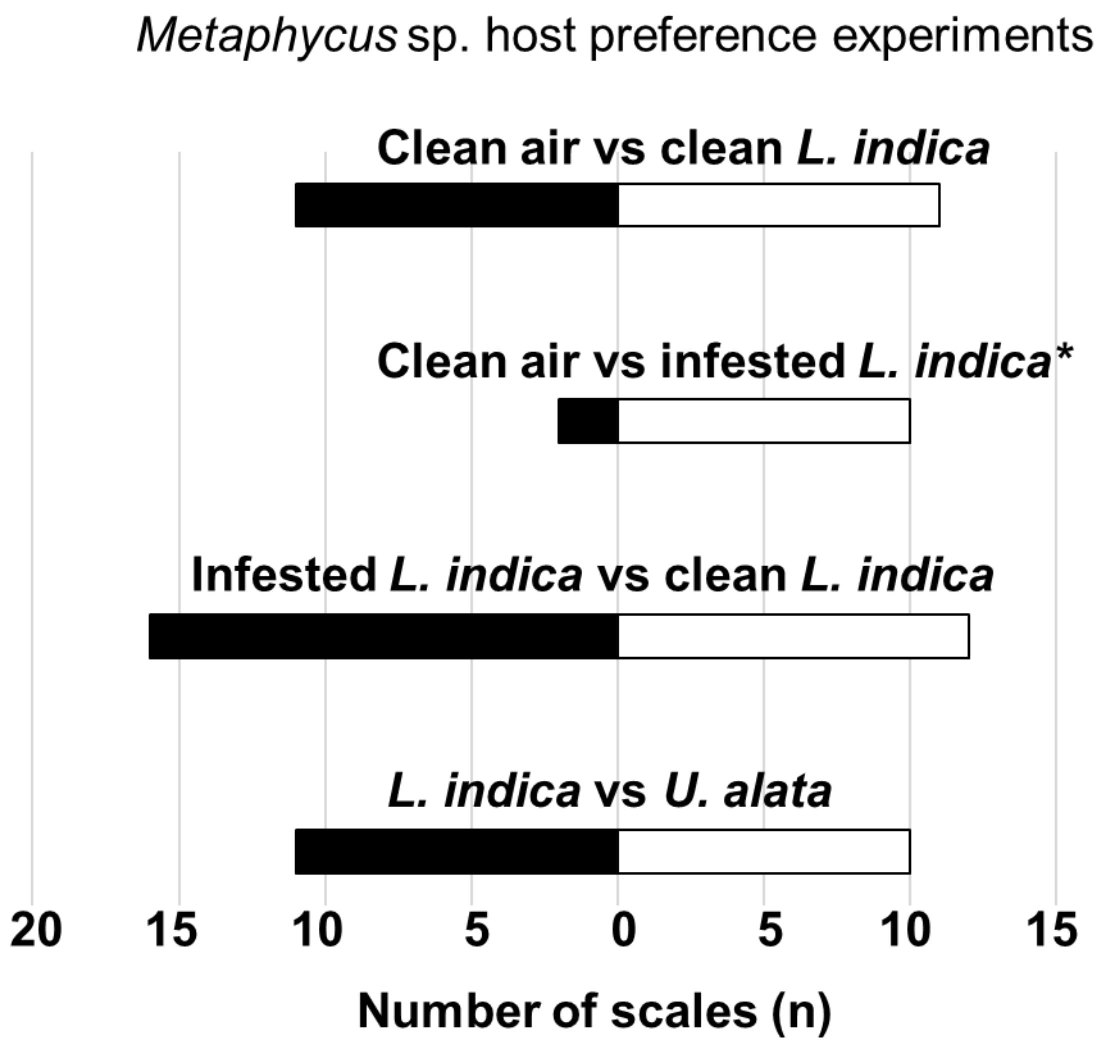

Figure 2. Host preference experiments for *Metaphycus* sp. individuals. Clean air vs infested *L. indica* was the only significant preference (G=5.8221, df=1, p=0.01583). All other preference experiments were not significant.

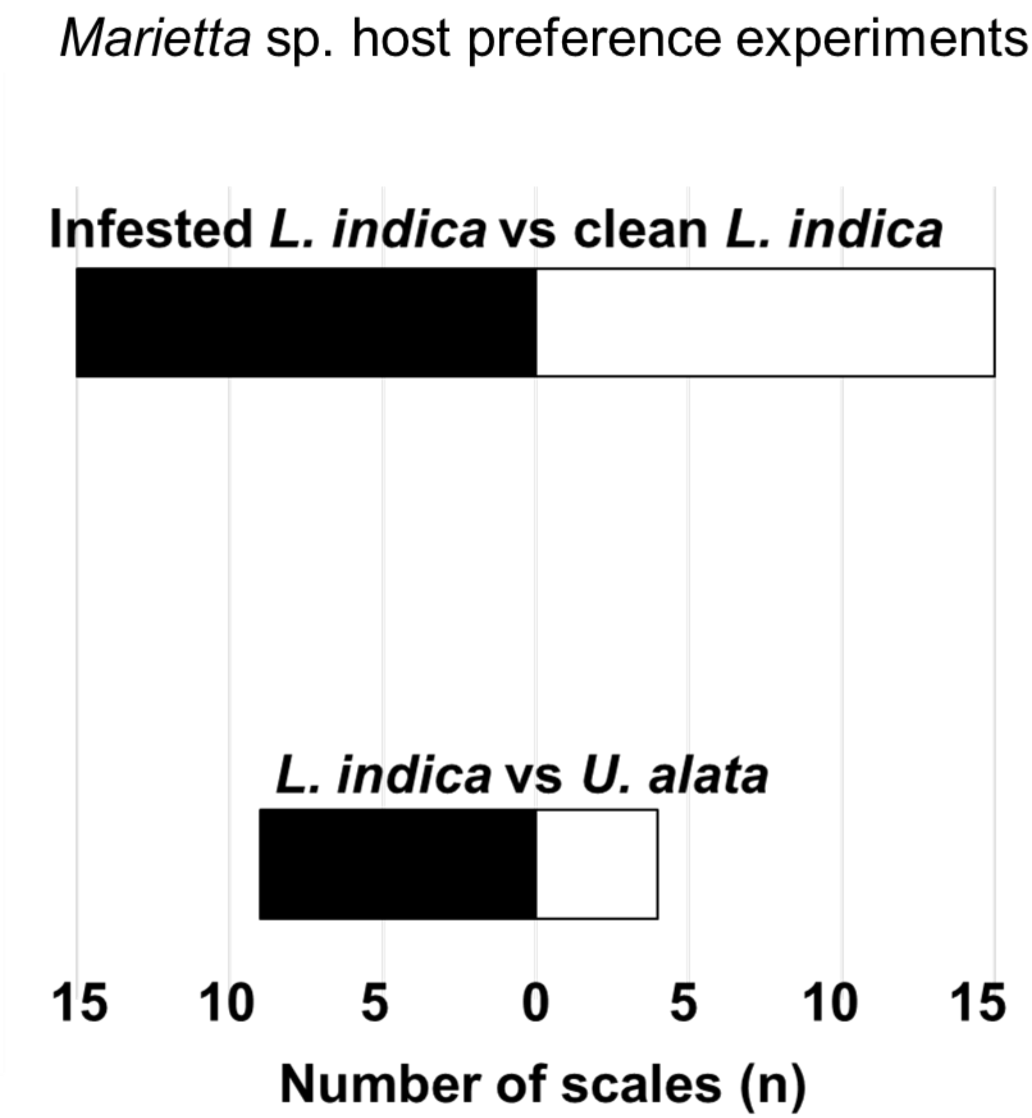

Figure 3. Host preference experiments for *Marietta* sp. individuals. Neither host preference experiment was significant.

Managing Flatheaded Borer in Woody Ornamental Production Systems

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Significance to the Industry The flatheaded apple tree borer (FAB), *Chrysobothris femorata* (Oliver) (Coleoptera: Buprestidae), is a major pest in nursery production. The presence of FAB is common in many deciduous shade, fruit and nut trees, especially those that are newly transplanted or otherwise under stress. The economic losses due to infestation of young maple trees, particularly *Acer rubrum* L., is significant for nursery growers. Flatheaded apple tree borers can significantly impact nursery production for up to four years after transplanting, causing mortality or rendering trees unmarketable from trunk scaring (Oliver et al. 2010). The larval FAB damage results from tunneling beneath the bark and is generally first recognized by a sunken dark area on the trunk, which may eventually split to reveal caked frass. The damage caused by the larvae when they feed beneath the bark weakens vascular function, thereby causing the mobility of water and nutrients to be insufficient. Early application of systemic insecticides containing imidacloprid (or other neonicotinoids) is the most common treatment for nursery growers. Control of flatheaded borer larvae with contact insecticides requires that sprays be applied shortly before oviposition, so that the newly hatched borers ingest a lethal dosage while chewing through the bark at the point of egg attachment (Potter et al. 1988). Use of insecticides can have direct effects on non-target arthropod pests and their natural enemies. (Dawadi et al. 2019) Alternatives to minimize the use of insecticides are needed to provide additional management tools to nursery growers. Research conducted at the TSU Nursery Research Center has shown that the incorporation of winter cover crops can significantly reduce the number of trees attacked by the FAB.

Nature of Work Red maple 'Franksred' cuttings were propagated and later transplanted into size #3 containers with slow release fertilizers (15-15-15 NPK) in spring 2018. A cover crop was planted in September 2018 at Moore's Nursery, Irving College, TN, which consisted of a blend of crimson clover (15 lb/acre) and triticale (30 lb/acre). In November 2018, four hundred #3 containers were transplanted into the cover crop field. Trees were arranged in 10 rows with 40 trees per row (5 ft tree spacing, 7 ft row spacing). Two methods of cover crop management were evaluated to assess growth of trees while minimizing the threat of FAB attacks: 1) cover crop was allowed to senescence naturally or 2) a post-emergent herbicide was used to kill the cover crop within the tree rows when it reached 60 cm in height to reduce tree-cover crop competition (May 16th 2019). In addition to these treatments, two controls were evaluated: 3) pre and post-emergent herbicides were used to maintain a clean 1 ft radius around the tree trunks, and 4) trees were grown with tree ring mulch mats extending in a 1 ft radius around the base of the tree. These two treatments were used as a control for standard row management practices (herbicided rows). The use of mulch mats to prevent weeds at tree bases was added to address the current debate over whether herbicide treatments cause more FAB attacks. Row middles were mowed periodically to allow access to the field. Tree growth and FAB attacks will be evaluated for 2 years post-transplant (2019-2020). During the first year, diameter at 6 in, height, and canopy index, were evaluated from transplant until October 2020 in order to assess the influence of cover crop on first year plant growth. In November 2019, preliminary data on FAB attacks in all treatments was recorded. A second round of FAB evaluation is scheduled for 2020 when first year FAB damage will be more apparent.

Results and Discussion The results for the tree growth reinforce the previous data collected in 2016 and 2017, suggesting that the presence of cover crop will reduce tree growth. The herbicide treatment had the greatest increase in caliper with an average of 8.5 mm (0.33 in) during the first year, the second treatment with the most growth was the mulch matt with 6.7 mm (0.26 in) growth, and 6.3 mm (0.25 in) for the cover-early kill treatment. The cover crop treatment caliper increased only 5.2 mm (0.20 in) during the first year. Few FAB damaged trees were identified in fall 2019. Preliminary data of FAB attacks by treatment indicated that cover crop at the base of the trunk was effective at reducing FAB attacks. The cover crop treatment only had 2 trees out of 100 damaged by FAB. The herbicide treatment and mulch treatment had 5 damaged trees each and the cover-early kill treatment had 6 damage trees, suggesting for now that the cover crop works best if it is permitted to naturally senescence. Flatheaded apple tree borer damage will be evaluated again in spring 2020 when damage is more visible to update the total number of trees damaged in the first year of the test.

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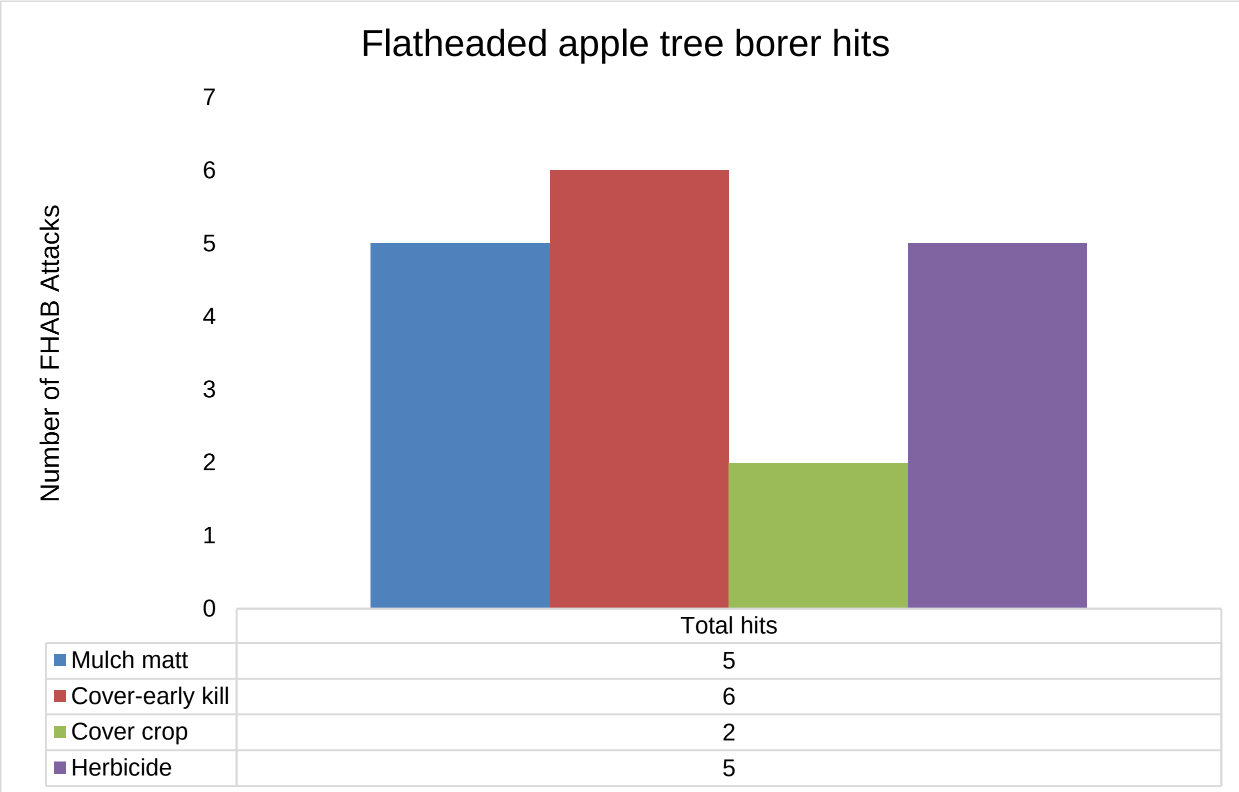

Figure 1. Total number of red maple trees attacked by FHAB in Year 1 for the treatments 1) cover crop, 2) post-emergent herbicide, 3) cover-early kill, and 4) trees grown with the mulch matt.

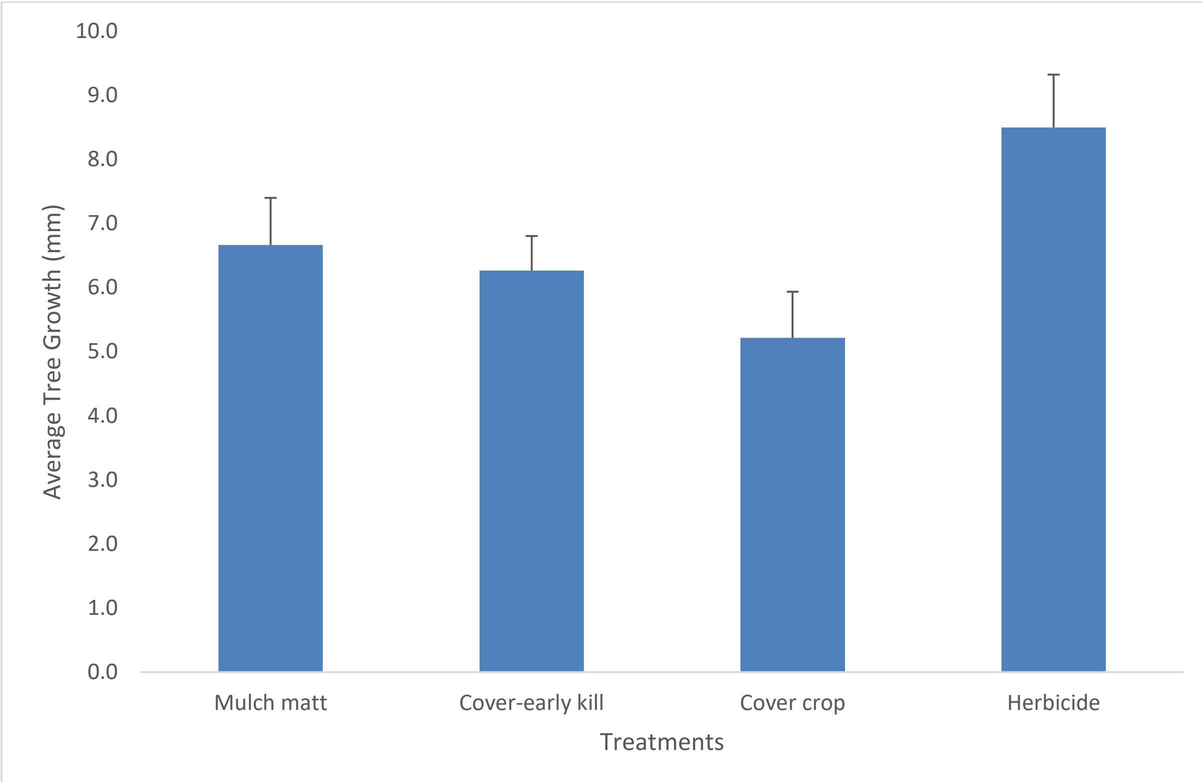

Figure 2. Diameter growth of ‘Franksred’ red maple trunk during Year 1.

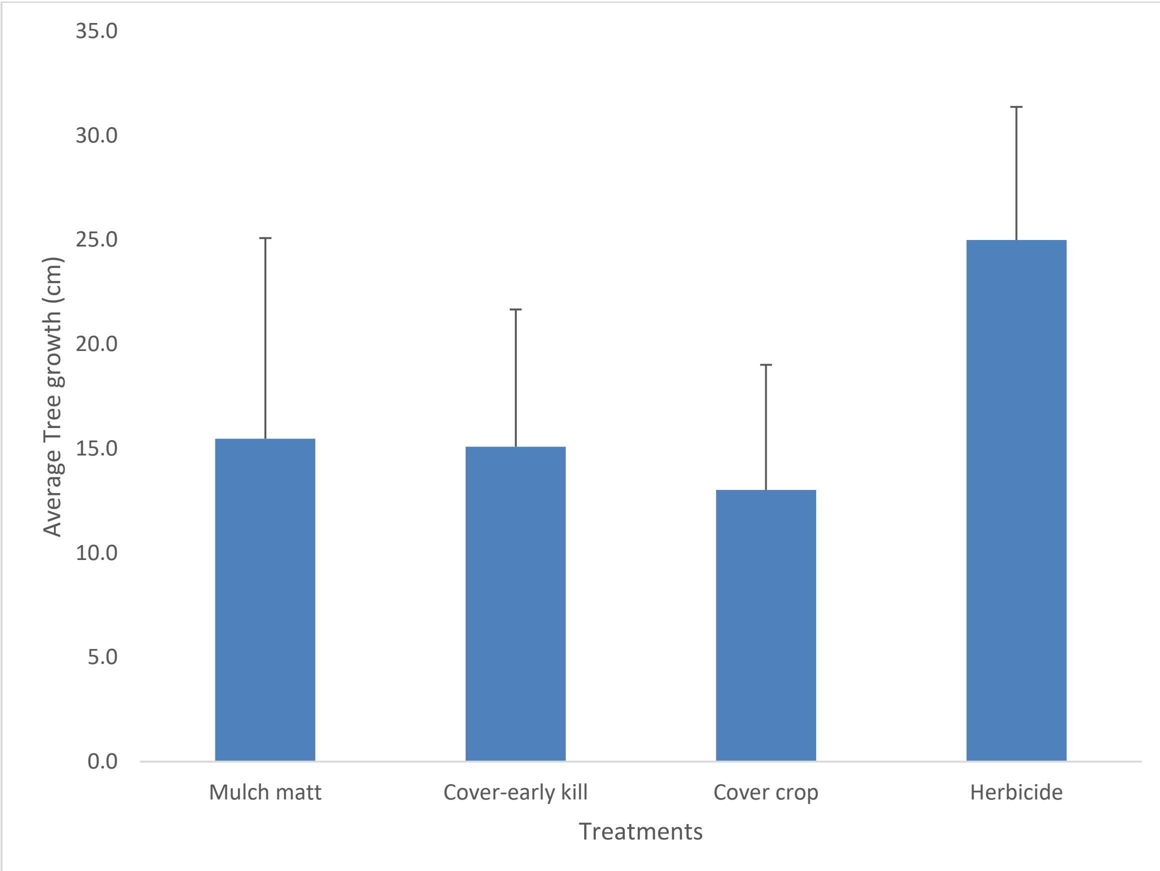

Figure 3. Overall growth of 'Franksred' red maple during the year 1.

Optimization of Phytophthora Effective Systemic Fungicides for Ambrosia Beetle Management

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Significance to the Industry Non-indigenous ambrosia beetles (Coleoptera: Curculionidae: Scolytinae) are important pests of stressed nursery trees. These beetles tunnel in the sapwood and inoculate symbiotic fungi and pathogenic fungi. The attacks may cause sap stains, shot holes in the bark, foliage wilting, and tree death. Growers often use ethanol baited traps to monitor for ambrosia beetle activity (and improve insecticide treatment timing. However, even optimal timing of the most effective trunk spray treatment (i.e. Permethrin) does not prevent all attacks. Tree stress is a major factor in tree attacks, and flood stress and winter damage in particular are known to induce attacks (1), making it more challenging to protect trees. Trees under stress produce ethanol (2) making them more attractive to ambrosia beetles. Fungicides may be an alternative strategy to control ambrosia beetles by targeting their symbiotic fungal relationship. In addition, several systemic fungicides are reported to reduce plant stress by strengthening the plant. If plant stress and the stress-related ethanol signals can be reduced by fungicides, then beetle attacks may be reduced.

Nature of Work The objective of this study was to determine the effects of systemic fungicides on prevention of ambrosia beetle tree attacks on flood and disease stressed trees**.** Experiments were performed at the Tennessee State University Otis L. Floyd Nursery Research Center, McMinnville, TN (TSU-NRC) on a semi-shaded logging road in a mixed deciduous forest (predominantly *Quercus* spp. and *Carya* spp.).Two tests were performed in spring 2019 (April to May) and fall 2019 (October to November), but only the spring test is completed and being presented. Individual redbud trees (*Cercis canadensis* L.) in 11.4 liter containers obtained from Taylor Nursery (McMinnville, TN) and not previously treated with insecticides or fungicides were used as the experimental unit. Redbuds were selected due to their intolerance to root flooding and likelihood to induce ambrosia beetle attacks. All treatments were replicated six times in a randomized complete block design (RCBD) with trees spaced 1 m apart and 5 m between replicates.

Fungicide Treatments: Systemic fungicides were drench applied to container substrates at either 1- or 3- weeks before initiation of flood stress (Table 1). Fungicide pre-treatments were staggered so that flood stress was initiated at the same time on all treatments.

Disease Treatment: Half of the experimental trees were inoculated with *Phytopthora cinnamomi* (obtained from the culture collection of Dr. Fulya Baysal-Gurel at the TSU-NRC). The pathogen was grown on rice grains for 2 weeks (Homes and Benson method). Trees were artificially inoculated by burying four colonized rice grains 1 cm below the container substrate surface on equally spaced sides of the tree at 1-day before flood initiation.

Flood Treatment: Roots and container substrates of trees were completely immersed at the 1- or 3-weeks after fungicide drenching and 3 days before *P. cinnamomi* inoculation. The simulated flood-stress event was maintained for 5 days.

Trees were checked for ambrosia beetle attacks about three times per week for 3 weeks and all gallery entrances were circled with a wax pencil to prevent re-counting. Trees were dissected in the laboratory to determine species of ambrosia beetle in galleries, presence of fungi, and depth of adult beetle tunneling. Roots were washed and plated to determine *P*. *cinnamomi* infection. A root disease rating also was performed. Data were analyzed using a General Linear Interactive Model (GLIM) distribution (Proc Genmod; SAS 9.3; SAS Institute, Cary, NC).

Results and Discussion All treatments had ambrosia beetle attacks. A total of 964 attacks were record during a 3 week period. Among systemic fungicide treatments in the *P*. *cinnamomi* absent group. Empress at 1 week before flooding, Orkestra at 3 wk before flooding, or Segovis at 1 or 3 weeks before flooding had significantly less beetle attacks in comparison to control (Fig. 2). With the Empress, there was a trend for most fungicides to have more attacks at 1-than 3- weeks after treatment (significant of Orkestra and Tartan).In contrast, in the *P.cinnamomi* present group, most of the systemic fungicides at 1 week and some at 3 week had more attacks than control treatment. Like the *P. cinnamomi* absent group, had more attacks at 1 than 3 weeks. Results indicate some fungicides did reduce beetle attacks, but others like Pageant and Subdue maxx did not provide a significant advantage from the control. The Pageant results were unexpected based on past studies where it provided a clear reduction in attacks (3).) Allowing more time (i.e., 3 weeks) for the fungicides to translocate. The average number of tree attacks per tree with extensive damage (i.e.,> 10 % trunk diameter) overall was less in the *P. cinnamomi* absent group than the *P. cinnamomi* present group .Empress at 1-week and Segovis at 3- weeks before flooding both had greater damage extent than control and fungicide treatment were detected, but Pageant, Segovis, and Subdue Maxx varied in which week before flooding had more damage extent (fig.3.). Tartan overall had the lowest damage among Fungicides. The reason for variations among 1- and 3 week before flooding treatments are unknown, but overall, no fungicide completely prevented extensive damage.

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Table 1. List of systemic fungicide used for the management of ambrosia beetle.

Trade Name[a]	Group Name	Active Ingredient		Application Rate		FRAC Code	Company
		Name	%	ml/liter	g/liter		
Empress	Strobilurin	Pyraclostrobin	23.3	0.47	---	11	BASF
Orkestra	Strobilurin	Pyraclostrobin	21.3	0.78	---	11	BASF
	----	Fluxapyroxad	21.3			7	
Pageant	Strobilurin	Pyraclostrobin	12.8	---	1.35	11	BASF
	----	Boscalid	25.2			7	
Segovis	----	Oxathiapiprolin	18.7	0.25	---	49	Syngenta
Subdue Maxx	Metalaxyl	Mefenoxam	22.0	0.16	---	4	Syngenta
Tartan	Strobilurin	Trifloxystrobin	4.17	3.12	---	11	Bayer
	Triazole	Triadimefon	20.9			3	

[a] Mode of action: Empress, Orkestra, Pageant, and Tartan are quinone outside inhibitors, Segovis works by oxysterol binding protein homologue inhibition, and Subdue Maxx targets RNA polymerase I.

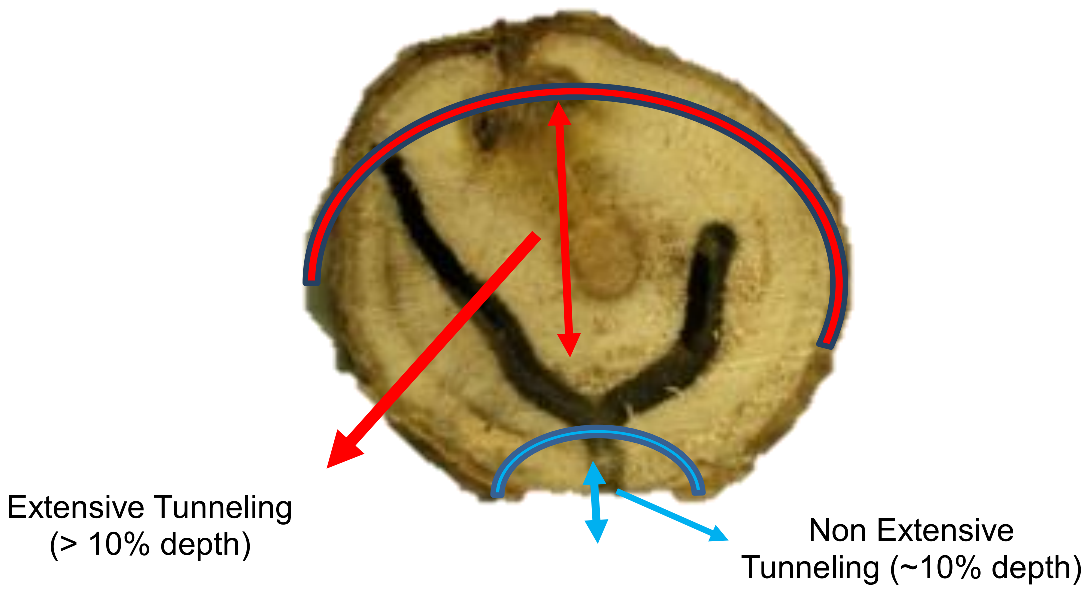

Figure 1. Extensive tunneling and non-extensive tunneling by ambrosia beetle in sapwood.

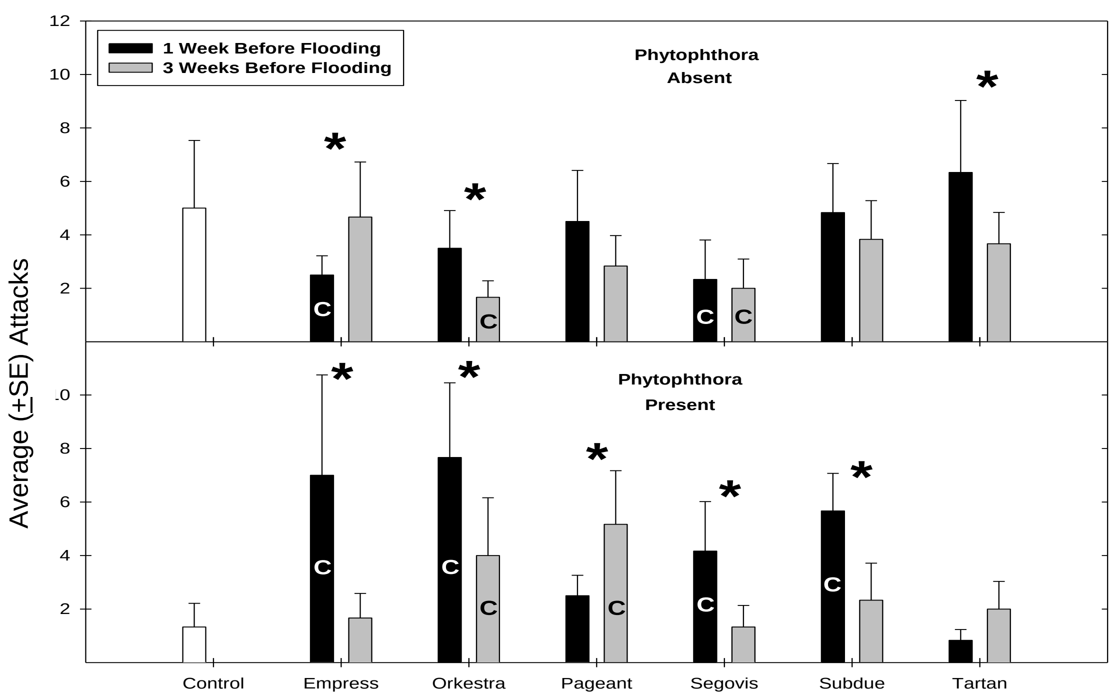

Figure 2. Average attacks by ambrosia beetles on trees treated at 1 and 3 weeks prior to flooding. C = Significantly different from control (*P* < 0.05). *= Significantly different between individual fungicide timings (1 week vs. 3 weeks) *(P* < 0.05).

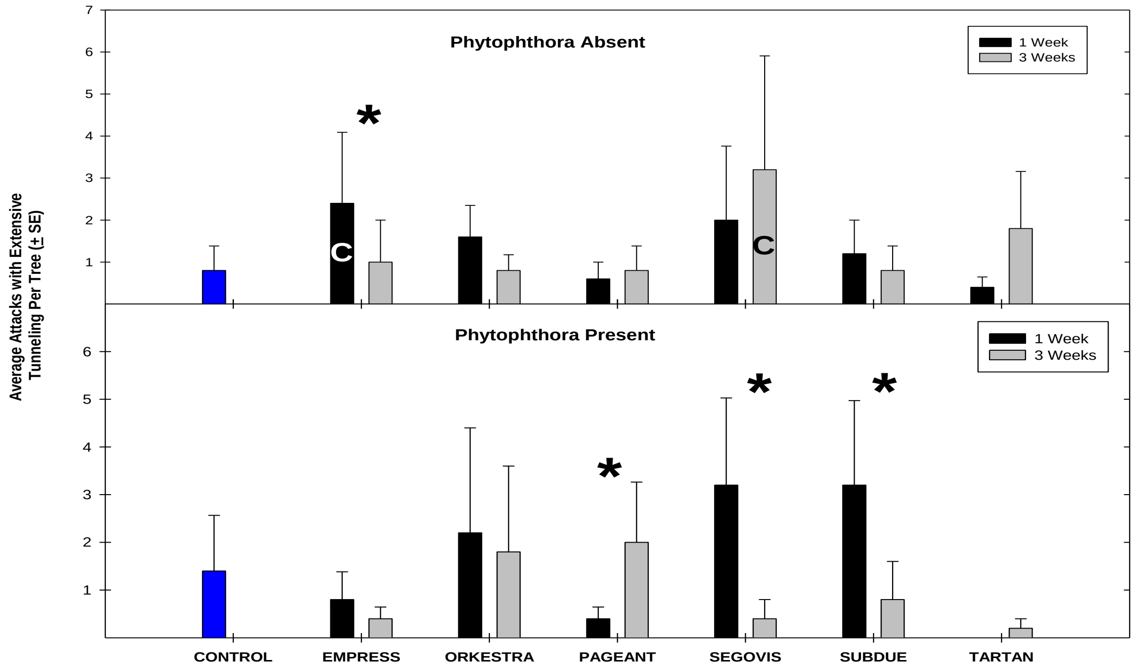

Figure 3. Average number of attacks with extensive tunneling by ambrosia beetles. C = Significantly different from control ($P < 0.05$). *= Significantly different between individual fungicide timings (1 week vs. 3 weeks) ($P < 0.05$).