EFFICACY OF NEONICOTINOID SEED TREATMENTS IN COTTON ON THRIPS AND THRIPS COMMUNITY COMPOSITION IN COTTON IN TEXAS

A Thesis

by

LAUREN KATE CRUMLEY

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MASTER OF SCIENCE

Chair of Committee,	Gregory Sword
Committee Members,	Megha Parajulee
	Gaylon Morgan
Head of Department,	Phillip Kaufman

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ABSTRACT

Seed treatments are common and effective pest control methods in many crop systems. Cotton seed treatments are often used for control of in ground and early season pests. A market shift in seed treatments to neonicotinoid formulations followed the phasing out of aldicarb (Temik®). Imidacloprid and thiamethoxam (Cruiser®) are two commonly used insecticide cotton seed treatments, but concern lies with the possibility of varying degrees of efficacy of these seed treatments on the different thrips species. The common thrips species that infest cotton seedlings are tobacco thrips (*Frankliniella fusca*), flower thrips (*Frankliniella tritici*), western flower thrips (*Frankliniella occidentalis*), and onion thrips (*Thrips tabaci*), each of which exhibit different degrees of susceptibility to various insecticide formulations. To improve the use of neonicotinoid seed treatments against thrips in Texas cotton, it is necessary for us to better understand the thrips species composition across the state, as well as the impact of imidacloprid and thiamethoxam and seed treatments on those species. The evaluated locations include: Chillicothe, College Station, Corpus Christi, Halfway, Kress, Lamesa, Levelland, La Feria, Mercedes, Port Lavaca, Victoria, and Wall, Texas. These are representative samples of cotton growing areas of the high plains, rolling plains, and central Texas regions. Thrips populations were low in 2014 in Chillicothe, Lamesa, and Wall, but there were fewer thrips on plants grown from treated seeds for most sampling dates in College Station, Halfway, and Kress. Imidacloprid treated seed had a greater yield than the control in College Station, which was the only harvested location with thrips populations

exceeding the economic threshold of one visible thrips per true leaf. Greenhouse evaluations of the thiamethoxam and imidacloprid seed treatments efficacy against western flower thrips were also conducted to lend a more controlled view of how well the insecticides work.

DEDICATION

This thesis is dedicated to my parents, Jeff and Adeela, my siblings, Payton, Jill, and Luke, my friends, Julie, David, and Kaylyn, and my husband, Ben, for their love and support of my dreams, and for their constant belief in me.

ACKNOWLEDGEMENTS

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Thank you to my friends, family, and my husband for supporting me in this endeavor and keeping me honest. Your constant support and encouragement kept me going.

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Contributors

This work was supervised by a thesis committee consisting of Dr. Greg Sword advisor, and Dr. Megha Parajulee of the Department of Entomology, and Dr. Gaylon Morgan of the Department of Soil and Crop Sciences.

Greenhouse study work was supported by Mark Arnold, Abdul Hakeem, and Leslie Wells.

The field trials for this study were conducted in part by the graduate committee, and with the help of Dr. Apurba Barman, Steven Biles, Stan Carroll, Sean Coyle, Tommy Doederlein, Jeffery Drymalla, Dr. Abdul Hakeem, Jeff Harrell, Luke Harrell, Dr. Lauren Kalns, Cole Miller, Rick Minzenmayer, Richard Norman, Dr. Pat Porter, Blayne Reed, Danielle Sekula, Cesar Valencia, Kerry Siders, and Dr. Wending Zhou.

Thrips species identification training in this project was aided by Dr. Charles Allen and Mark Arnold.

All other work conducted for the thesis was completed by the student independently.

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CHAPTER I

INTRODUCTION

Seed treatments are common pest control methods in many crop systems. They include a variety of high-performance products for the control of pests and diseases. Pesticides applied as seed treatments create a protective layer around the seed, potentially preventing damage from arthropod pests, nematodes, or fungal pathogens in the soil. Systemic seed treatments are taken up by the plant, and provide protection from the inside out against insects feeding on the plant early in the season. Neonicotinoids are a good example of a systemic insecticide. Their structure promotes uptake into the plant, and provides broad spectrum protection from insects feeding on the seedlings. Because of this, cottonseed treatments are often used for control of in ground and early season pests, such as wireworms, and thrips (Zhang et al. 2011). Neonicotinoids have been the fastest growing class of chemical insecticides. This is due to their broad-spectrum insecticidal activity, low application rates, versatile application methods, systemic characteristics (uptake and translocation in the plant), mode of action, as well as their favorable safety profile in comparison to older chemistries. They have a lower mammal toxicity, but work well on any sucking insect pest feeding on the plant (Tomizawa and Casida 2005). Not only have they gained popularity because of how they work, but also because of the withdrawal of older chemistries as safety regulations changed. A market shift in seed treatments to neonicotinoid formulations followed the phasing out of aldicarb (Temik®), due to safety concerns. Aldicarb is again available in Texas, but many farmers have made changes to equipment since it was phased out, and re-adoption is low. Imidacloprid and thiamethoxam are two commonly used neonicotinoid seed treatments. Imidacloprid was the first of the neonicotinoids adopted for use in the field, as it was the first successfully formulated to have a slower decomposition rate when exposed to sunlight (Jeschke and Nauen 2008).

Concern lies with the possibility of varying degrees of efficacy of neonicotinoid seed treatments on different thrips species. The common thrips species that infest cotton seedlings are tobacco thrips (*Frankliniella fusca*), western flower thrips (*Frankliniella occidentalis*), and onion thrips (*Thrips tabaci*), and each of these species exhibit different degrees of susceptibility to organophosphates, pyrethroids, and other insecticide formulations (Gao et al. 2012). Thrips species have been known to vary depending on location and the species of plants in the area. To improve the use of neonicotinoid seed treatments against thrips in Texas cotton, it is necessary for us to evaluate the thrips species composition across the state, as well as the impact of thiamethoxam and imidacloprid seed treatments on those species. The evaluated locations include: Ballinger, Chillicothe, College Station, Halfway, Kress, and Lamesa. These are representative cotton growing areas of the high plains, rolling plains, and central Texas regions. Greenhouse studies with imidacloprid and thiamethoxam seed treatments were also conducted to lend a more controlled view of the insecticides' efficacy.

Thrips are one of the important insect pests of cotton throughout the U.S. cotton belt. The thrips complex in Texas ranks second in terms of cotton lint yield loss due to insect pests following cotton fleahoppers, (Williams 2013) . Until 2011, thrips were commonly managed by using in-furrow applications of aldicarb (Temik®) and growers achieved satisfactory control. However, discontinuation of the manufacturing and marketing of Temik® forced cotton producers to resort to alternative, commercially available insecticide seed treatments. Temik® became available again in 2019, but many growers phased out the equipment for in furrow application of the product. Growers are primarily still relying on neonicotinoid seed treatments. At the time of this study there were two neonicotinoid insecticides available for cotton seed treatments. Although both insecticides (imidacloprid and thiamethoxam) belong to the same insecticide group, their physical and chemical properties vary, which may result in different efficacy of these products on the target insect pest (thrips). Therefore, evaluation of different seed treatment products in various cotton production regions is necessary to determine their effectiveness in managing thrips populations.

There is also concern that a given product may not be equally effective on all prevalent thrips species impacting cotton across Texas' cotton production regions. A single thrips population may be composed of individuals from multiple species. The common thrips species that infest cotton seedlings are tobacco thrips (*Frankliniella fusca*), flower thrips (*Frankliniella tritici*), western flower thrips (*Frankliniella occidentalis*), and onion thrips (*Thrips tabaci*). Each of these thrips species could have variable levels of tolerance or susceptibility to each of the available insecticide products. Western flower thrips populations have been found to be resistant to both organophosphates and pyrethroids in Australia (Herron et al. 1996). In the US, resistance to pyrethroids within western flower thrips populations has been documented from

Missouri and California as well (Immaraju et al. 1992, Zhao et al. 1995). Historically western flower thrips have shown to develop resistance to insecticides as evident from the previous examples and a number of other reports from around the world. Therefore, it is possible that western flower thrips in cotton could develop resistance to the neonicotinoid seed treatments over time. While western flower thrips are a potential candidate for developing resistance to neonicotinoid seed treatments, there are already reports of resistance development to thiamethoxam in tobacco thrips populations as documented by several researchers from the mid-south US (Stewart 2013).

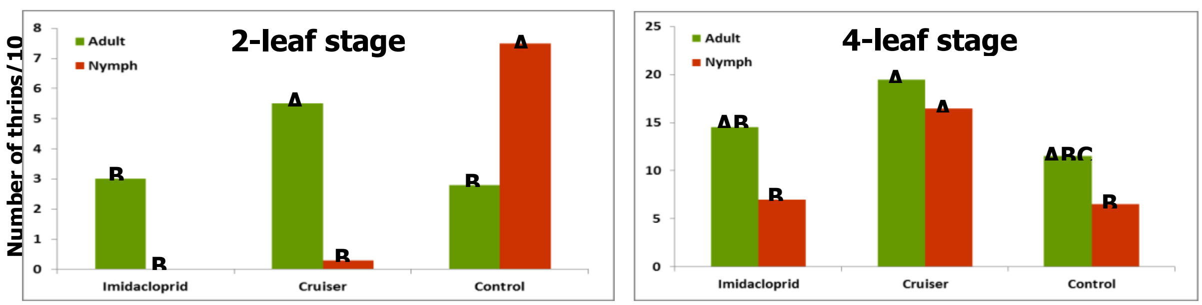

Figure 1. Number of thrips recorded on cotton seedlings resulting from two different neonicotinoid insecticide treated seed plantings along with an untreated control; all three treatments evaluated at two plant growth stages. Data provided by Dr. Roy Parker, Texas A&M AgriLife Extension. (Parajulee 2015)

The thiamethoxam (Cruiser®) resistance in tobacco thrips is a great concern for US cotton growers; not only in the mid-south, but also in Texas. There are also some suggestions that thrips populations in south Texas, which is dominated by tobacco thrips, are less susceptible to Cruiser® as compared to imidacloprid (Fig. 1). The above graphs represent the results from a trial conducted in Matagorda County, Texas, by Dr. Roy Parker and illustrate that the thiamethoxam treated cotton plots had more thrips compared to the seedlings grown from seed treated with imidacloprid. Based on this observed efficacy, it is imperative for us to evaluate these products more closely in different Texas cotton production regions in order to detect any possible resistance development in our thrips populations. The two main objectives of this study addressed the possibility of varying degrees of the neonicotinoid seed treatment efficacy on different species. Specifically, the survey of thrips species present in Texas fields provided information on the current and changing species composition of thrips in Texas cotton, while comparing the seed treatments across different locations gave us direct information on the current level of efficacy of the seed treatment insecticides, especially thiamethoxam. The final goal was to generate information regarding variation in thrips populations across Texas cotton production regions so that our regional growers and consultants have useful information on what thrips species are most likely to occur in their fields, and what available products can be used to effectively control those specific thrips species.

CHAPTER II

MATERIALS AND METHODS

Greenhouse Trials

Initial Greenhouse Trial

To evaluate the efficacy of thiamethoxam and imidacloprid in a controlled environment, a greenhouse study was conducted. Two weeks prior to planting the cotton seeds, we planted solid trays of wheat to build the western flower thrips populations in the greenhouse. Metro-mix® was used as the potting medium for both wheat and cotton in the initial study. Prior experiments in the greenhouse had highest success with planting 1 tray of wheat for every 2 trays of cotton, so 48 trays of wheat were planted to ensure adequate thrips pressure. Fiber Max® 1944 Glytol LibertyLink Bollguard (FM 1944 GLB) cotton seeds were planted with one seed per 32 oz Styrofoam experimental cup. The treatments included thiamethoxam, imidacloprid, and an untreated control. The seeds were treated in a conventional commercial seed treater, but with only insecticide. The seedlings were grown in randomized blocks within trays containing 18 seedlings total, 6 of each treatment. This was replicated 4 times, and each block was a replicate. The trays of wheat were placed evenly along the opposite side of the greenhouse table from the cotton trays. The cotton was planted when the wheat began to show signs of yellowing to encourage thrips movement into the cotton. Samples of 4 trays were collected at 7 days after emergence (DAE), 14 DAE, 21 DAE, and 28 DAE. The samples were collected by cutting the base of the seedlings, 6 seedlings of each treatment were placed in a quart-sized wide-mouth mason jar containing 70% ethanol. Each seedling in the sample set was given a 0-5 vigor rating, 0 being the worst and 5 the best, prior to sampling. This was repeated in each replicate. Thrips were counted from these samples using the thrips washing method (Burris et al. 1990) and compared using a one-way ANOVA comparing seed treatments.

Secondary Greenhouse Trials

During the initial greenhouse trials, observations included a limited response to the seed treatments. After confirming western flower thrips in the greenhouse, we hypothesized this could be a result of using a potting soil rather than a more natural soil type. To test this hypothesis, the same greenhouse test was set up but with three different soil types. One contained the same Metro-mix® as the prior study, one with a dominantly fine sandy type soil (Patricia-Brownfield-Nutivoli) gathered from the field location near Lamesa, and the last with a dominantly loam type soil (Pullman-Randall-Lofton) found near the Halfway field location (Texas 2008). FM 1944 GLB cotton seeds were planted (one per experimental cup), 96 of each seed treatment (thiamethoxam, imidacloprid, and control) by soil type (Metro-mix®, Halfway soil, and Lamesa soil). The experiment was set up the same as the first, but with the additional soil types. Samples of 4 trays were taken at 7 days after emergence (DAE), 14 DAE, 21 DAE, and 28 DAE. The samples were taken by cutting the base of the seedlings and placing 6 seedlings of each treatment in a quart-sized wide-mouth mason jar containing 70% ethanol. Thrips were counted from these samples using the thrips washing method (Burris et al. 1990) and compared using a two-way ANOVA comparing the soil type by treatment. JMP was used for statistics on all tests, and a student’s t test was run.

Field Trials

The field trials consisted of three cotton seed treatments (thiamethoxam, imidacloprid, and control) with 4 replications. Plot size was 4 rows wide by 50 feet long, with 5 foot alleys separating the plots. Each trial consisted of 12 plots: 4 replicates of 3 treatments, randomized within the replication (block). The sites for the field trials were all located in Texas. The locations for 2014 were as follows: Kress (Swisher county), Halfway (Hale county), Lamesa (Dawson county), Wall (Tom Green county), Chillicothe (Hardeman county), and College Station (Burleson county). All trials were conducted in irrigated locations. Kress, Halfway, Lamesa, Wall, and Chillicothe had center pivot irrigation systems, while College Station was row watered. The cotton variety used was the same as in the greenhouse studies, FM 1944 GLB. This cotton variety was chosen as it is suited to all of the trial sites, as well as having some tolerance to root-knot nematodes. No nematicide was applied to the seeds in order to avoid interaction with the conventionally commercially applied insecticide seed treatment. Planting dates were adjusted in each location according to the local conditions, and sampling took place at the cotyledon, 1-2 true-leaf, and 3-4 true-leaf stages of the plants. Ideally, sampling was to take place at 7 day intervals, but inclement weather and other management logistics forced deviation from the 7 day intervals in some cases. During sampling, 10 random seedlings from each plot were placed in a wide mouth quart-sized mason jar and taken to the lab to be processed using the thrips washing method (Burris et al. 1990). The number of thrips larvae, adults, and total number of thrips from each plot was recorded. Adult thrips were placed in 70% ethanol until they could be slide mounted for species identification. Thrips counts were compared using a one-way ANOVA on each seed treatment separated by sample dates. Fifteen plants were hand harvested from the middle two rows of each plot in Halfway. The middle two rows of the 4 row cotton plots were harvested at the end of the season with a two row John Deere 9920 cotton picker in College Station at the end of the growing season. In College Station, a sample of each plot was ginned in a table top gin. Since turnout of lint can be different in a tabletop gin than a commercial one, lint turnout per acre was also estimated at a standard 38% of the total seed cotton weight (Willcutt 2010). Halfway harvest samples were ginned in a microgin research gin, comparable to a commercial gin. Harvest data were compared using a one-way ANOVA in JMP and compared using a student's t test.

Thrips Species Identification

Adult thrips specimens from field trial collections were stored in 70% ethanol after washing and counting. These specimens were mounted in polyvinyl alcohol, as a cost effective and semi-permanent slide mounting medium that also cleared specimens. Five to ten individual thrips were mounted on each slide, bubbles removed, covered with a cover slip, and placed in an oven at 50ºC for 7 days. Once cooled, specimens were identified using an interactive cd key (Moritz 2006).

CHAPTER III

GREENHOUSE RESULTS

Greenhouse Trials

In the first greenhouse trial, no significant difference between treatments at any time intervals were found, but over the first 3 weeks the thrips populations increased. At the 3rd true leaf stage, about 42 thrips per seedling were observed (Fig. 2). Soil selection likely impacted our results, and this trial was repeated using field soil in addition to a potting soil.

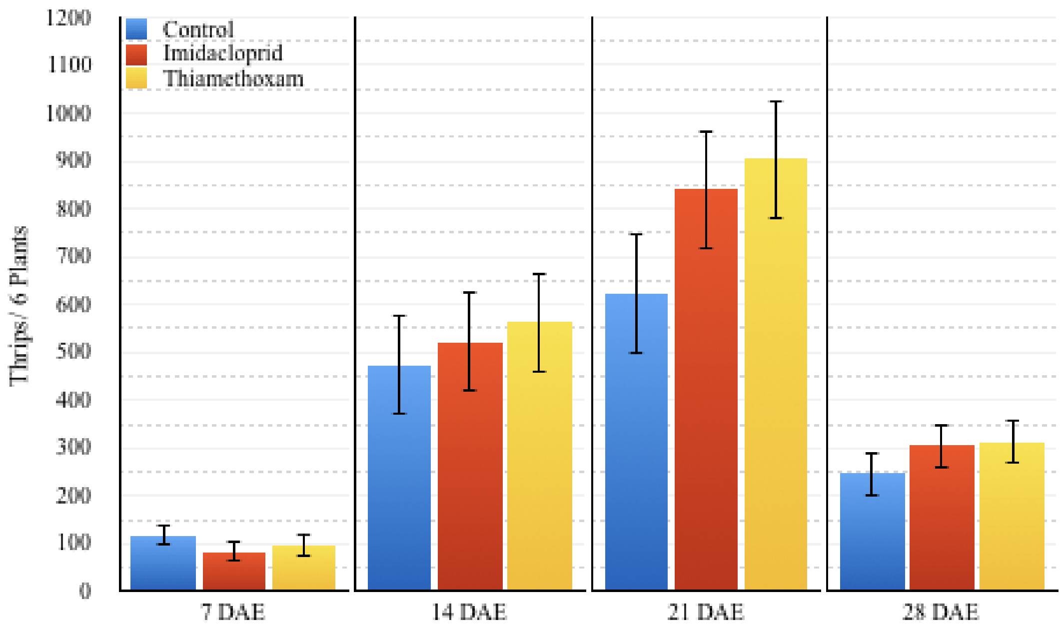

Figure 2. Total number of thrips per 6 plants in the greenhouse at 7, 14, and 28 DAE. There were 3 separate treatments: a control, imidacloprid, and thiamethoxam. There was no significant difference between treatments at any sampling date.

Greenhouse Trials with Different Soil Types

The second set of greenhouse trials included soil collected from Halfway, Lamesa, and Metro-mix®. There was little difference between treatments in thrips numbers (Fig. 3) or plant vigor at 7 DAE (Fig. 4). There was no observable effect of soil type on seed treatment efficacy.

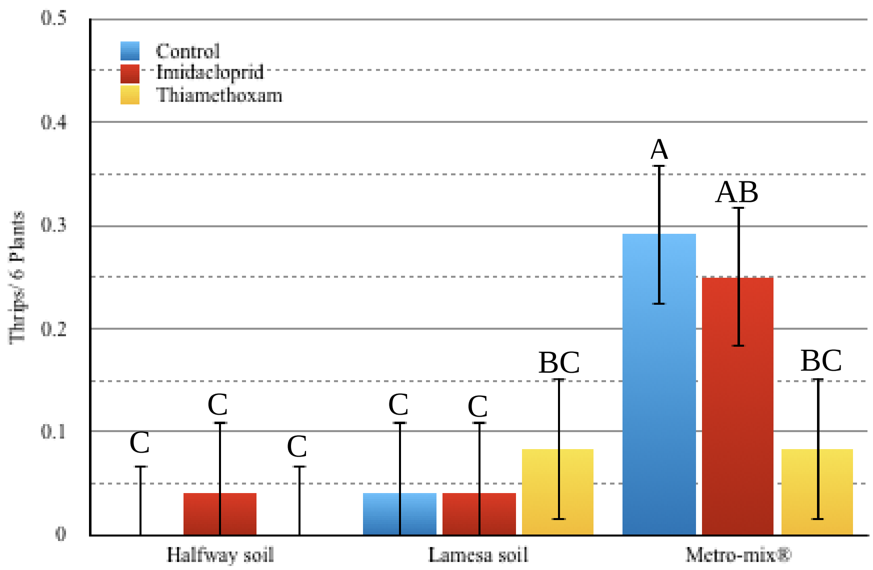

Figure 3. Total thrips per plant 7 DAE on 3 treatments (imidacloprid, thiamethoxam, and control) on 3 soil types (Halfway field soil, Lamesa field soil, Metro-mix®).

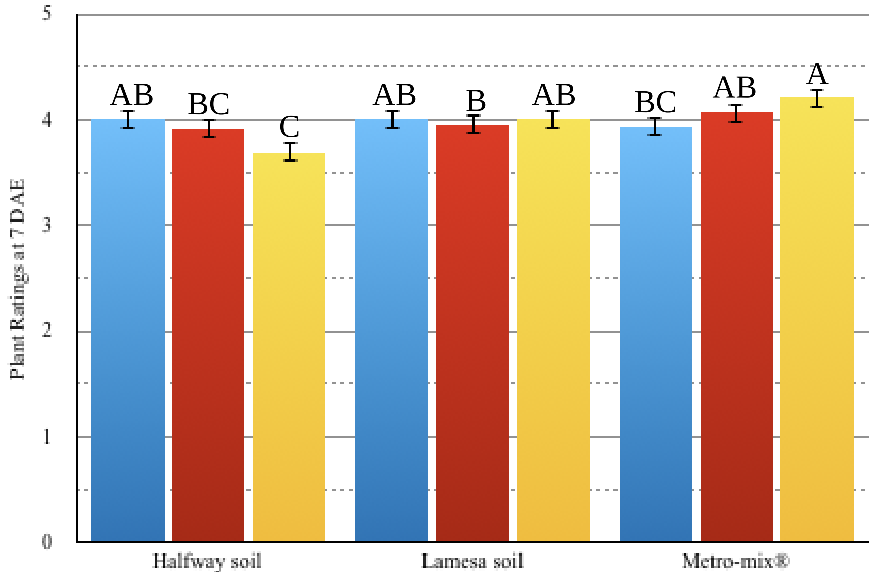

Figure 4. Average plant vigor rating 7 DAE on 3 treatments (imidacloprid, thiamethoxam, and control) on 3 soil types (Halfway field soil, Lamesa field soil, Metro-mix®).

At 14 DAE there was still very little difference between vigor and thrips populations in treatments (Fig. 5)(Fig. 6), but thrips populations were slightly higher in Metro-mix® than in other treatments (Fig. 5).

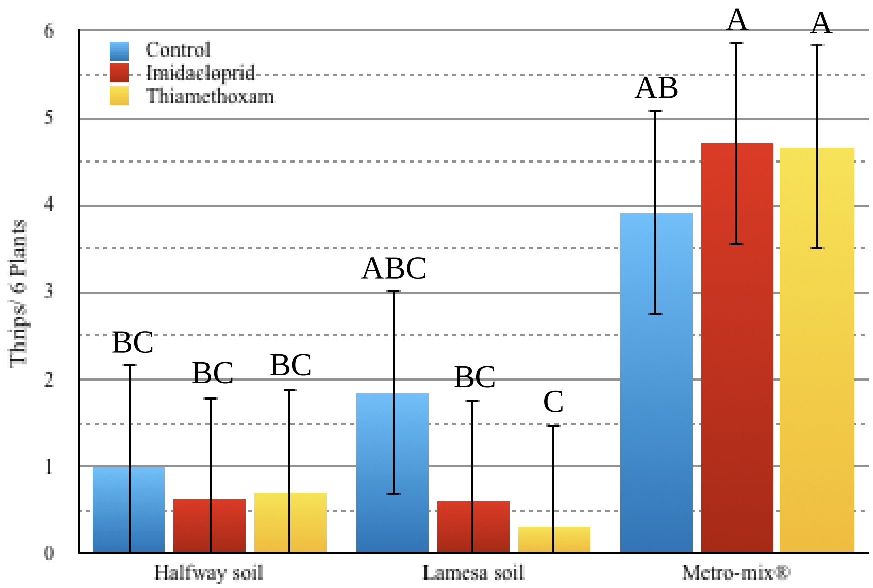

Figure 5. Total thrips per plant 14 DAE on 3 treatments (imidacloprid, thiamethoxam, and control) on 3 soil types (Halfway field soil, Lamesa field soil, Metro-mix®).

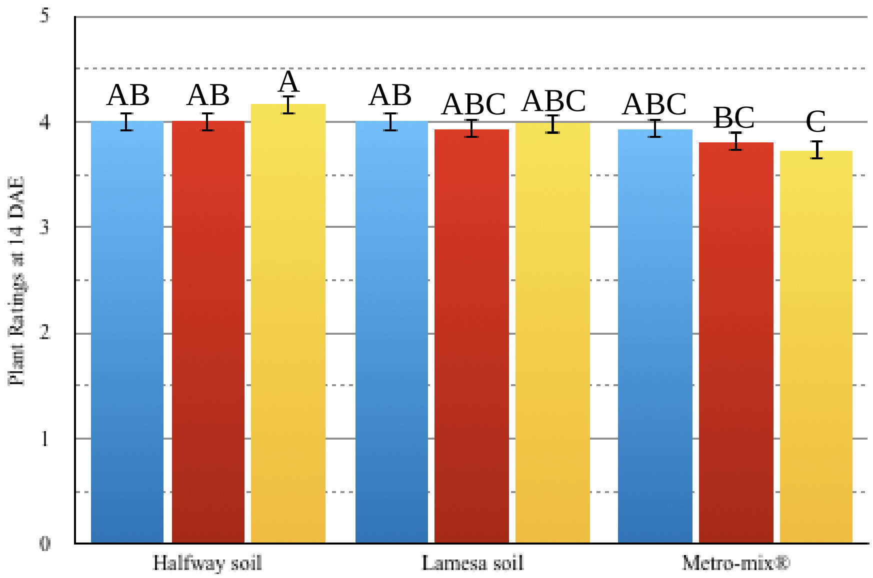

Figure 6. Average plant vigor rating 14 DAE on 3 treatments (imidacloprid, thiamethoxam, and control) on 3 soil types (Halfway field soil, Lamesa field soil, Metro-mix®).

Thrips populations at 21 DAE had risen significantly in plants in Metro-mix®, but there was no difference in treatments within any of the soil types (Fig. 7). This follows with the hypothesis that seed treatments wear off more quickly in the looser potting mix than in field soil. There was little difference in plant vigor, except with the Metro-mix® control. (Fig. 8)

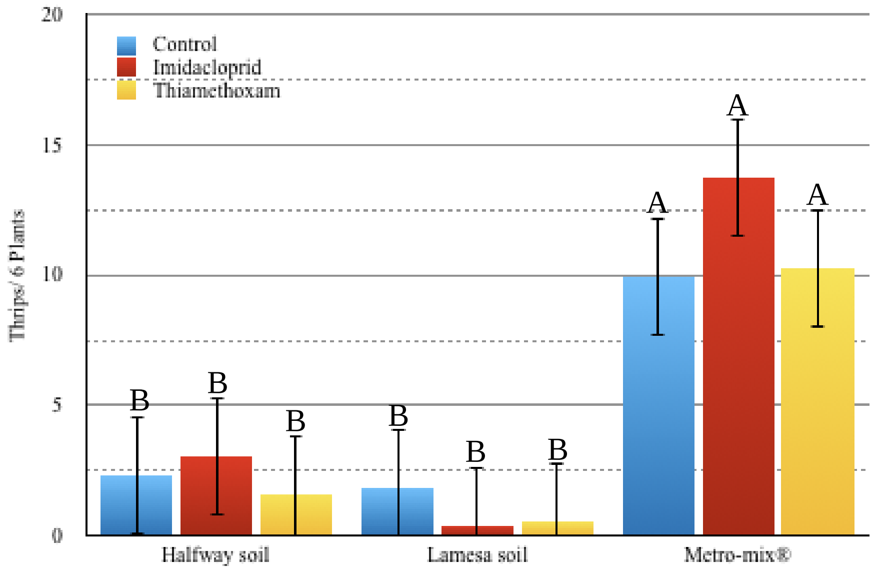

Figure 7. Total number of thrips per plant 21 DAE on 3 different treatments (imidacloprid, thiamethoxam, and control) on 3 different soil types (Halfway field soil, Lamesa field soil, Metro-mix®).

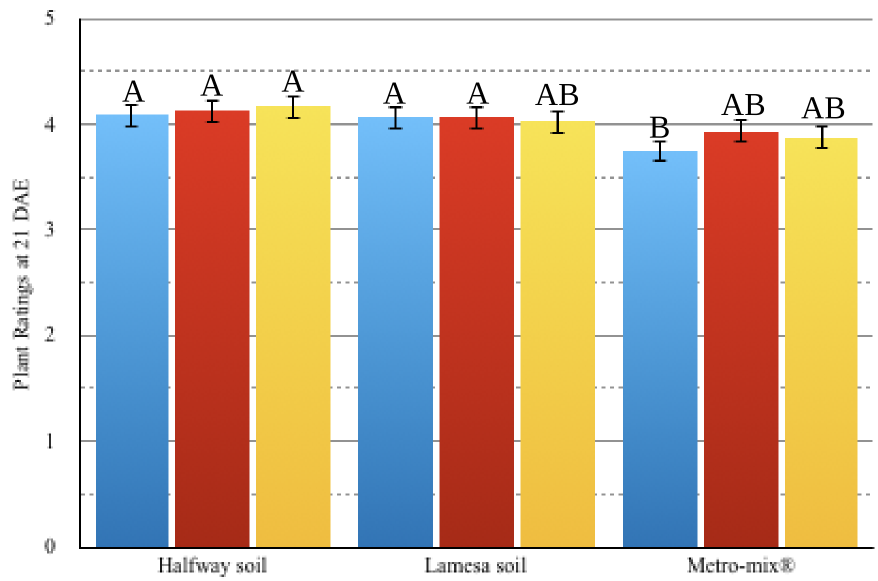

Figure 8. Average plant vigor rating 21 DAE on 3 treatments (imidacloprid, thiamethoxam, and control) on 3 soil types (Halfway field soil, Lamesa field soil, Metro-mix®).

Thrips populations in all of the Metro-mix® plants were higher than in the field soil potted plants (Fig. 9) at 28 DAE, and the thrips damage had taken more of a toll on them. The untreated Metro-mix® was the most damaged, but there was no difference between treatments in the field soil potted plants. (Fig. 10)

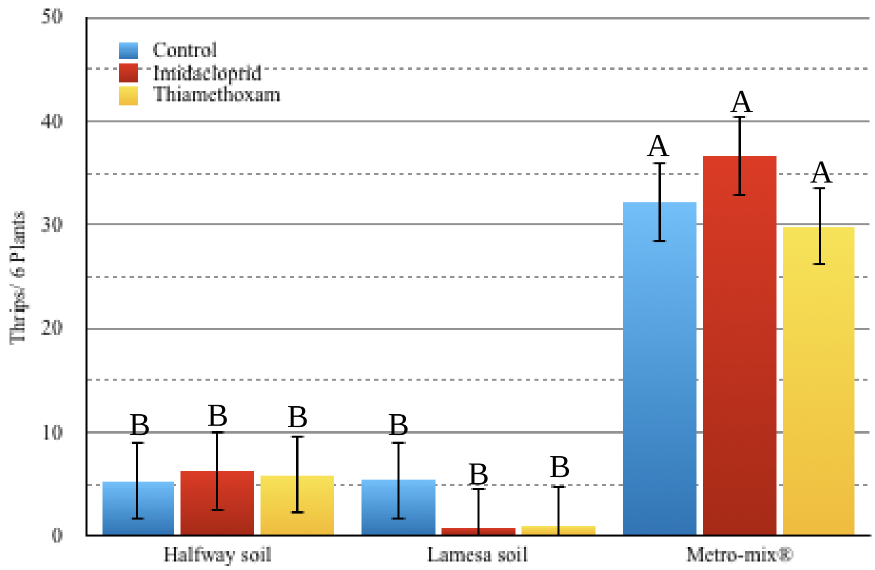

Figure 9. Total number of thrips per plant 28 DAE on 3 different treatments (imidacloprid, thiamethoxam, and control) on 3 different soil types (Halfway field soil, Lamesa field soil, Metro-mix®).

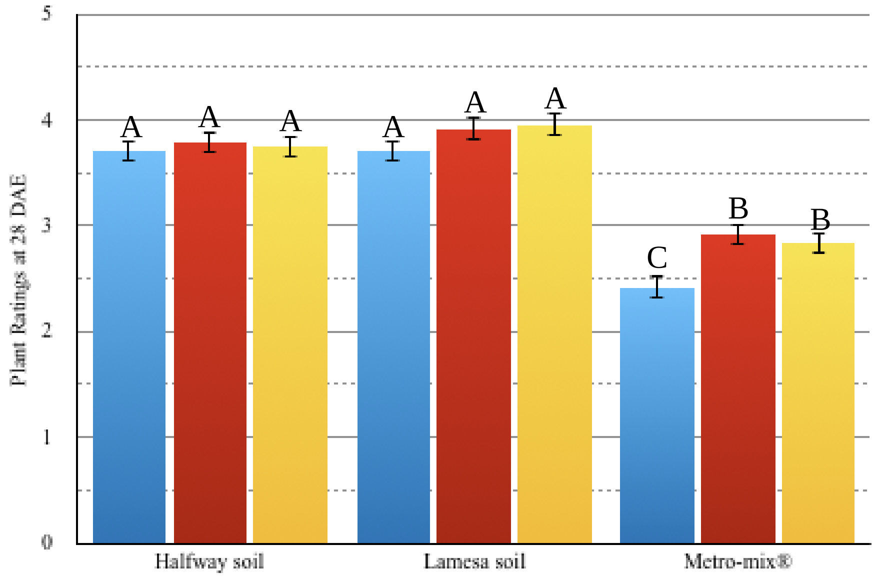

Figure 10. Average plant vigor rating 28 DAE on 3 treatments (imidacloprid, thiamethoxam, and control) on 3 soil types (Halfway field soil, Lamesa field soil, Metro-mix®).

CHAPTER IV
FIELD RESULTS

2014 Field Trials

Field trial evaluations of neonicotinoid seed treatment efficacy against thrips were conducted throughout Texas in 2014 were conducted at Chillicothe, College Station, Halfway, Kress, Lamesa, and Wall. A location near Levelland, TX was also planted, but hailed out twice and was not replanted a third time. These are representative sample areas of the High Plains, Rolling Plains, and Central Texas areas. Thrips populations were low in Chillicothe, Lamesa and Wall, but there were fewer thrips in treated seeds for most sampling dates in College Station, Halfway and Kress. Imidacloprid treated seed resulted in greater yield than the control in College Station, which was the only harvested location with thrips populations exceeding treatment threshold (one visible thrips per true leaf) levels.

Thrips populations were highest during the first sampling date at the cotyledon stage. This location was planted on 5/13/2014, and cooler weather led to slower emergence. Thrips populations declined due to environmental factors before the next sampling date, and insecticide activity had likely worn off after 28 days. No sampling was made after the second set, as the location experienced high winds and was replanted to sorghum. (Fig. 11)

The field in Halfway was planted on 5/6/2014, and the first collection made at the cotyledon stage. Thrips populations were fairly low, with at most finding 14 thrips on 10 seedlings. There was a difference in treatment during sampling at the cotyledon stage, but not at the other plant stages. Thrips pressure did not exceed the economic threshold at this location with in-field visual sampling (Fig. 12). At harvest on 11/22/2014, there was no difference between the lint yield of treatments. (Fig. 13)

The field location near College Station was planted on 4/25/14, and thrips populations were higher at the initial sampling in the control than either of the treatments. The next sampling date was not until 6/4/14 due to wet weather, and after 41 days the seed treatments had likely worn off. This was the only location with thrips populations above the economic threshold in season. (Fig. 14)

The imidacloprid seed treated plots yielded higher than the control at harvest on 10/29/2014 in College Station. (Fig. 15)

Thrips populations near Lamesa, Chillicothe, and Wall were low due to environmental conditions, this location did not reach the economic threshold and no difference in thrips population was observed. (Fig. 16, Fig. 17, Fig. 18)

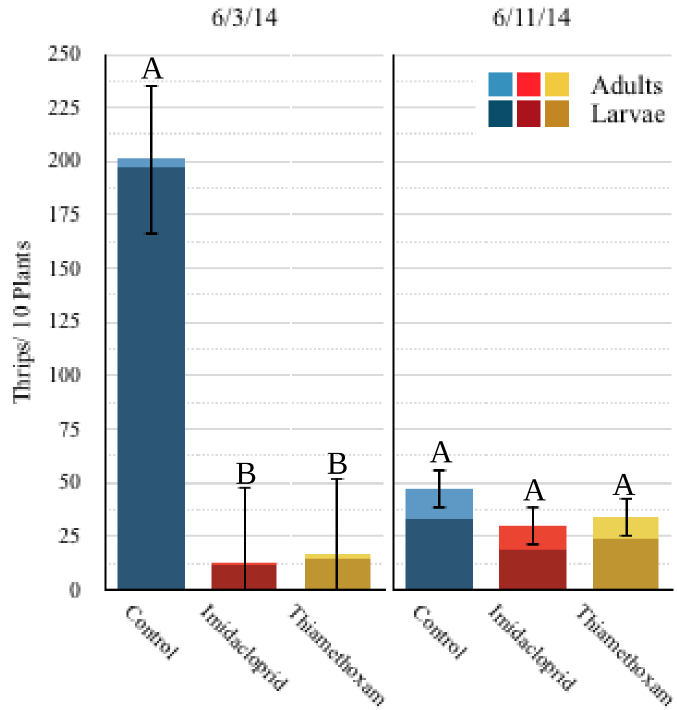

Figure 11. Average number of thrips per 10 seedlings in field located near Kress, TX (Swisher County) in 2014.

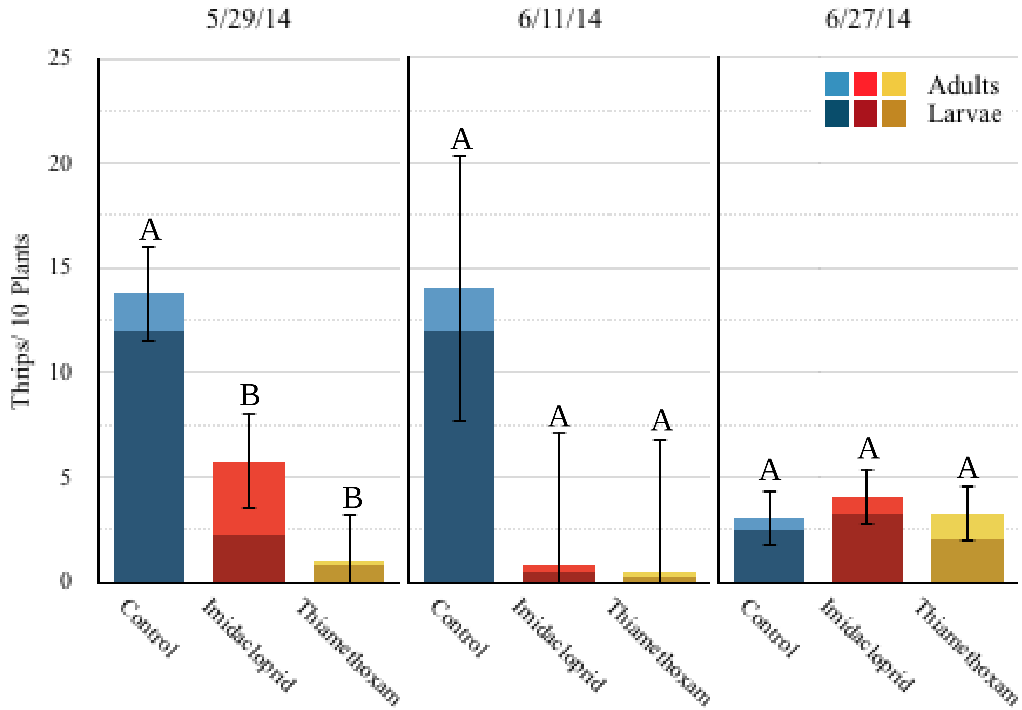

Figure 12. Average number of thrips per 10 seedlings in field located near Halfway, TX (Hale County) in 2014.

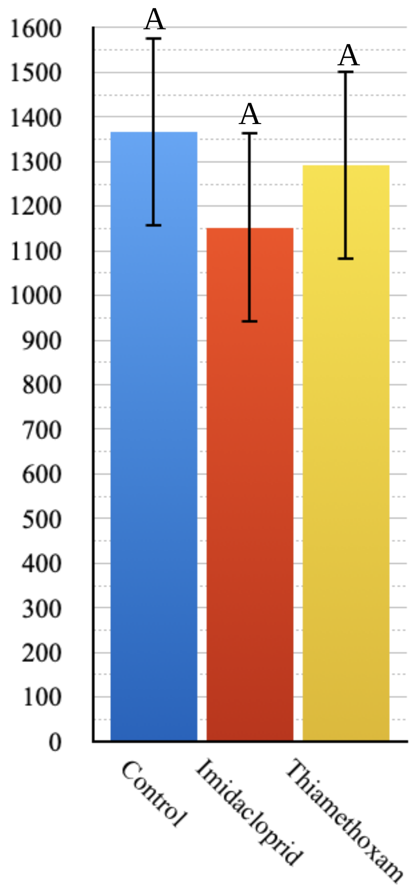

Figure 13. Average ginned weight/acre in lbs in field located near Halfway, TX (Hale County) in 2014.

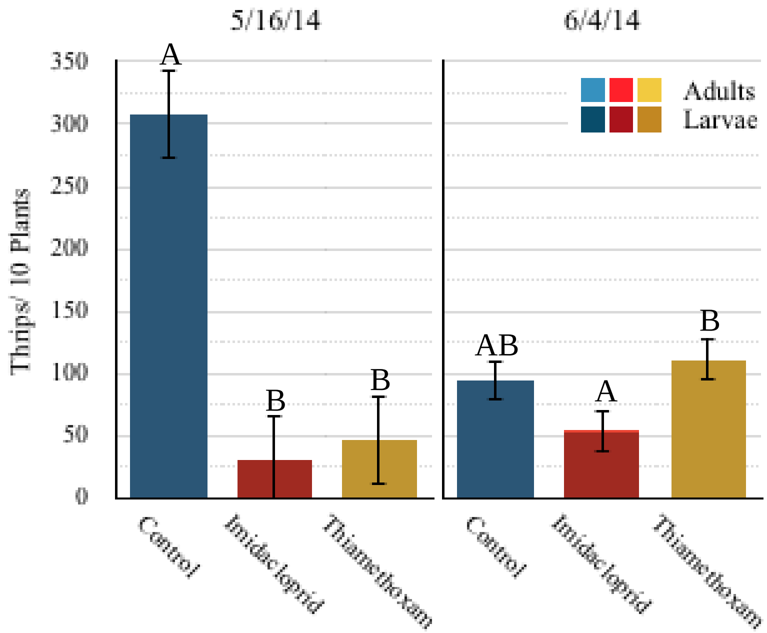

Figure 14. Average number of thrips per 10 seedlings in field located near College Station, TX (Burleson County) in 2014.

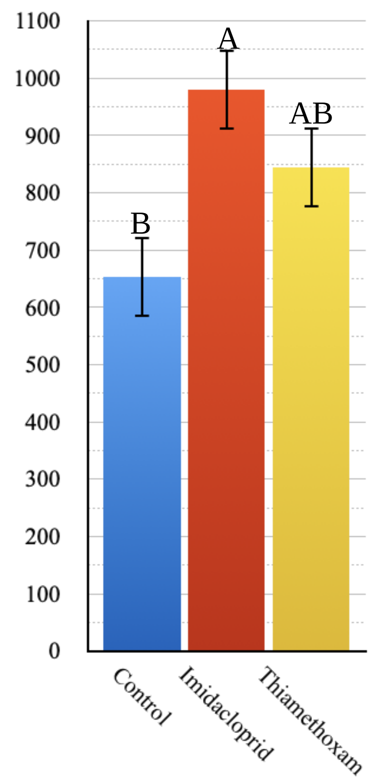

Figure 15. Average ginned weight in lbs calculated with total harvest weight at 38% turnout in field located near College Station, TX (Burleson County) in 2014.

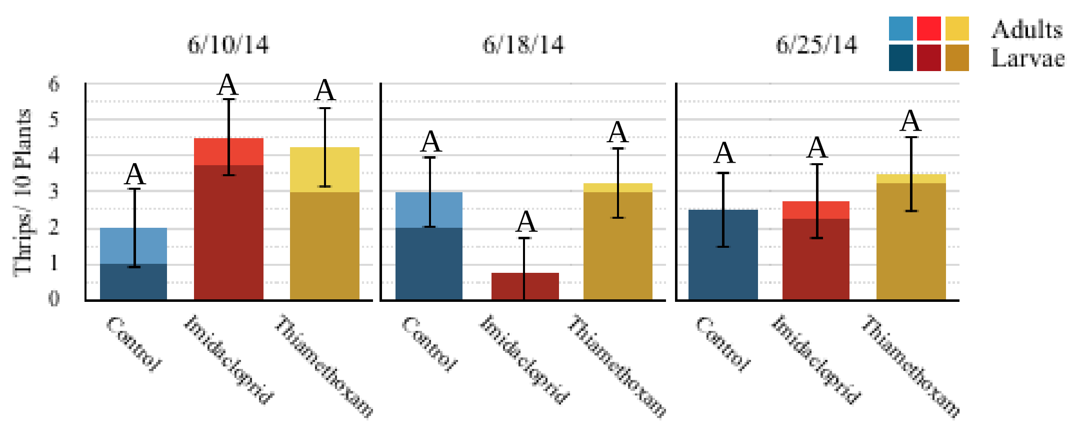

Figure 16. Average number of thrips per 10 seedlings in field located near Lamesa, TX (Dawson County) in 2014.

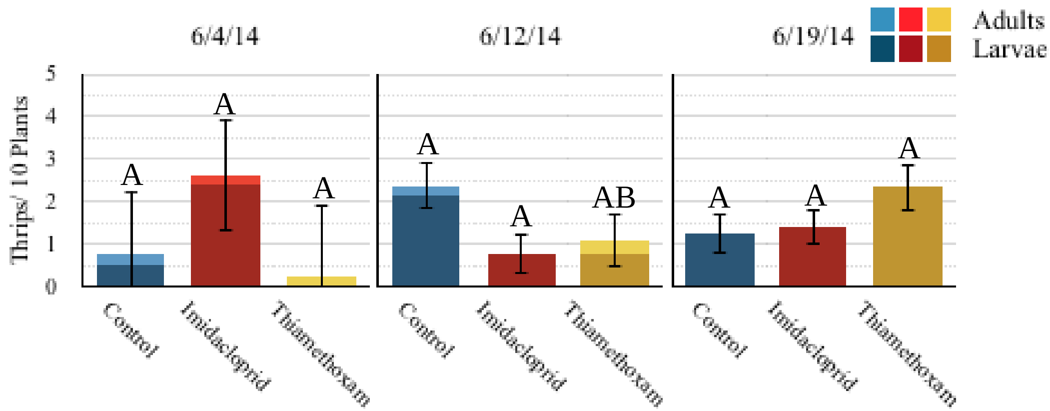

Figure 17. Average number of thrips per 10 seedlings in field located near Chillicothe, TX (Hardeman County) in 2014.

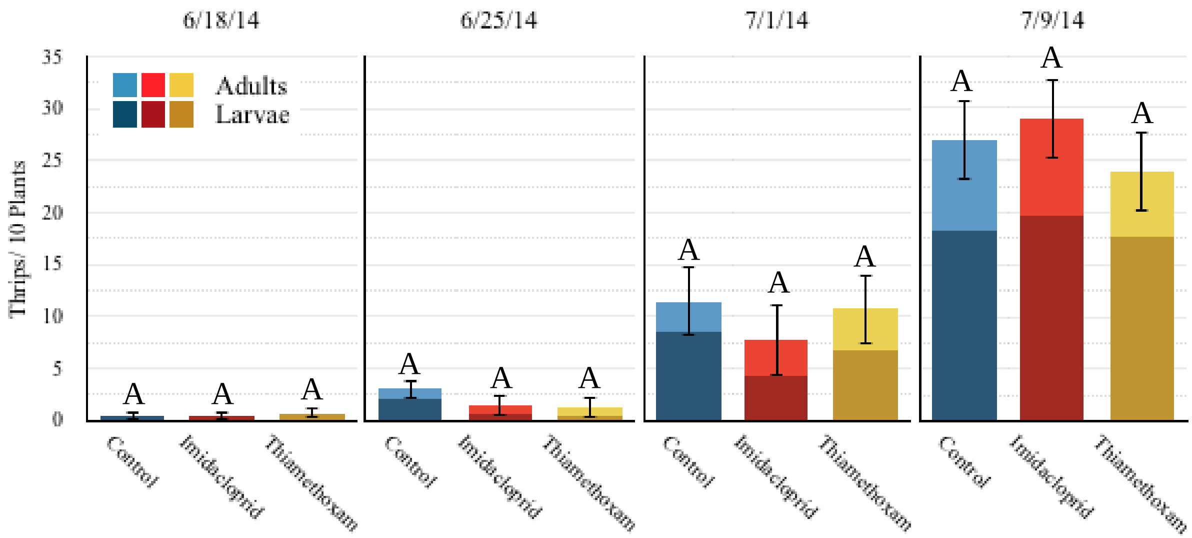

Figure 18. Average number of thrips per 10 seedlings in field located near Wall, TX (Tom Green County) in 2014.

2015 Field Trials

The evaluated locations throughout Texas in 2015 included: College Station, Corpus Christi, Halfway, Kress, Levelland, Mercedes, and Wall. These are representative sample areas of the High Plains, Rolling Plains, and Central Texas, Gulf Coast, and Rio Grande Valley areas. Thrips populations were low in Corpus Christi, Halfway, Kress, Levelland, Mercedes, and Wall.

The field location near Levelland had low thrips populations in cotyledon stage cotton, but did increase by the first true leaf stage. The control had significantly more thrips than both imidacloprid and thiamethoxam at sampling during the first true leaf stage. Environmental conditions prevented a third sample date (Fig. 19).

The field locations near Halfway and College Station were only sampled once due to environmental conditions. The sample near College Station this sample was taken late and after heavy rainfall as well, so it is likely the seed treatment had worn off in this location. Thrips did not exceed the economic threshold during the season at either location and there was no difference between treatments. (Fig. 21, Fig. 22)

Thrips populations were low in the field location near Corpus Christi. This location did not experience thrips pressure above the economic threshold. The first sample date exhibited a difference between the control and imidacloprid treated seed, but thrips numbers were very low, with only one thrips found between 10 seedlings. (Fig. 23)

Thrips pressure in the field locations near Kress and Mercedes did not reach the economic threshold in season and there was no difference between treatments due to low thrips numbers. (Fig. 20, Fig. 14)

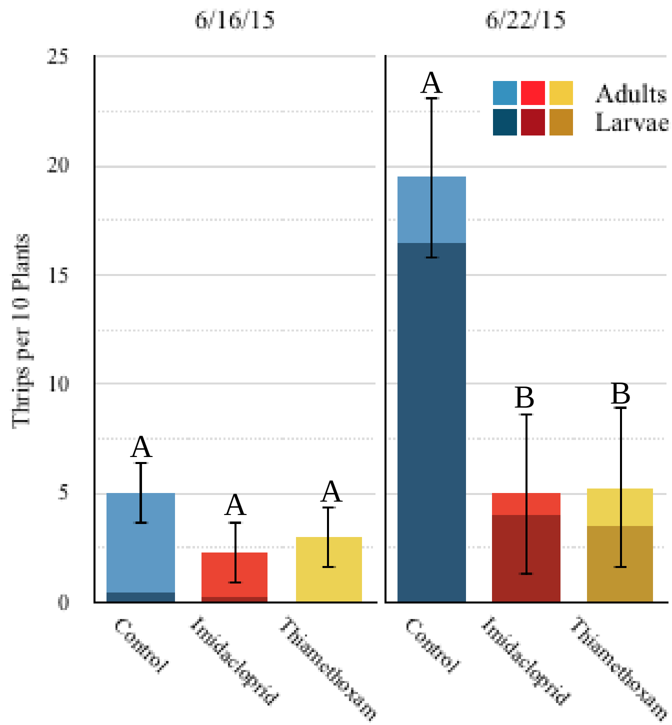

Figure 19. Average number of thrips per 10 seedlings in field located near Levelland, TX (Hockley County) in 2015.

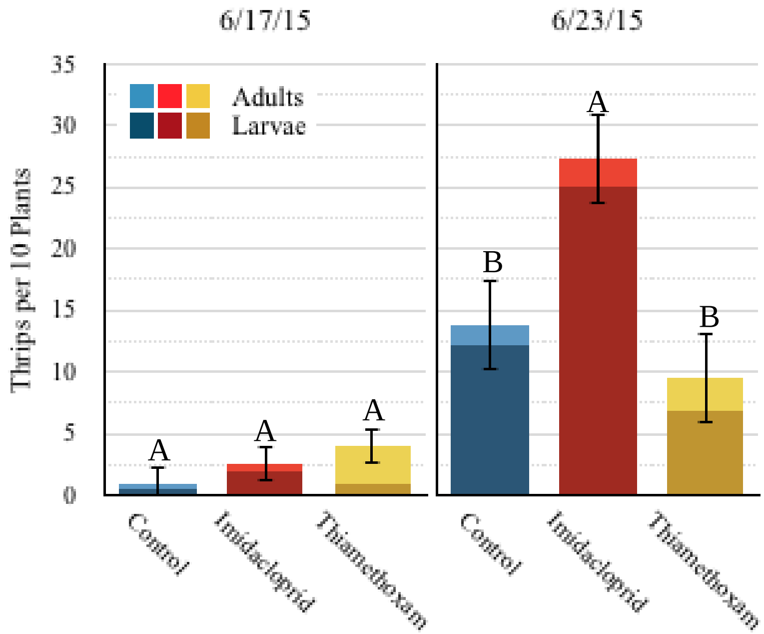

Figure 20. Average number of thrips per 10 seedlings in field located near Kress, TX (Swisher County) in 2015.

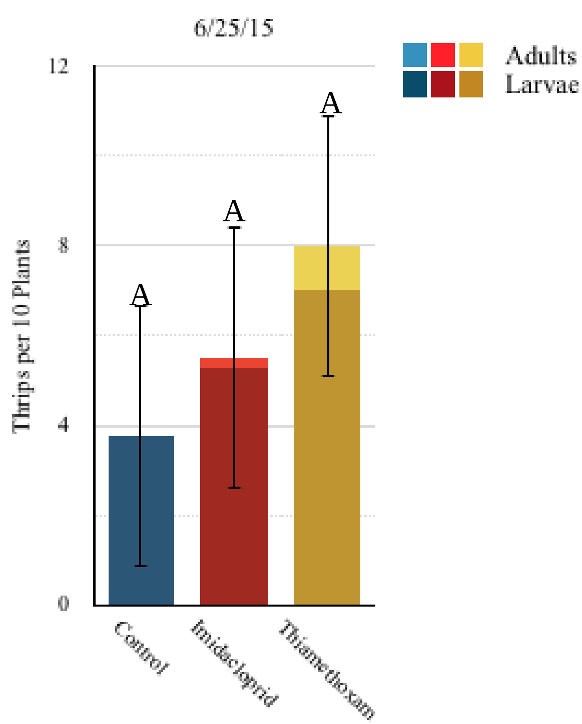

Figure 21. Average number of thrips per 10 seedlings in field located near Halfway, TX (Hale County) in 2015.

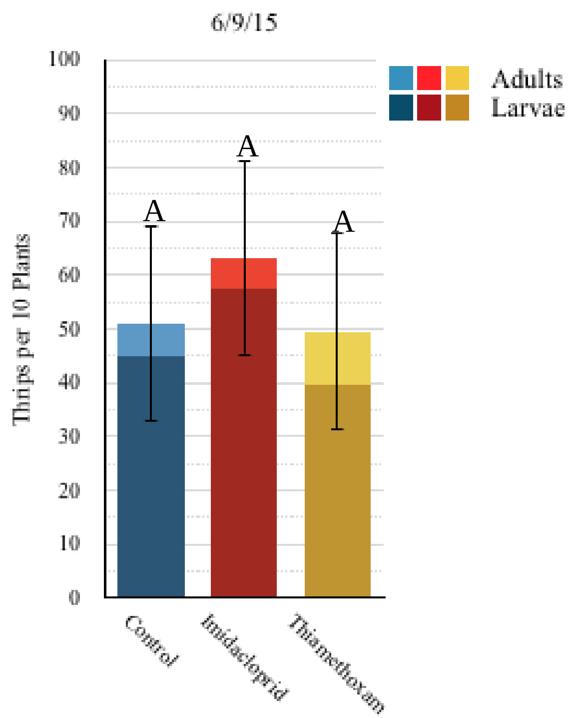

Figure 22. Average number of thrips per 10 plants from field near College Station, TX (Burleson, County) in 2015.

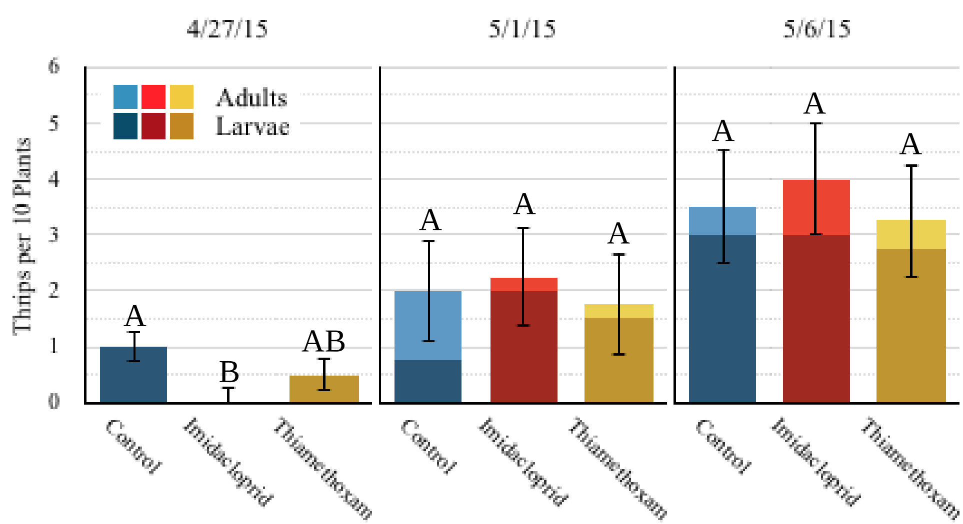

Figure 23. Average number of thrips per 10 plants from field near Corpus Christi, TX (Nueces, County) in 2015.

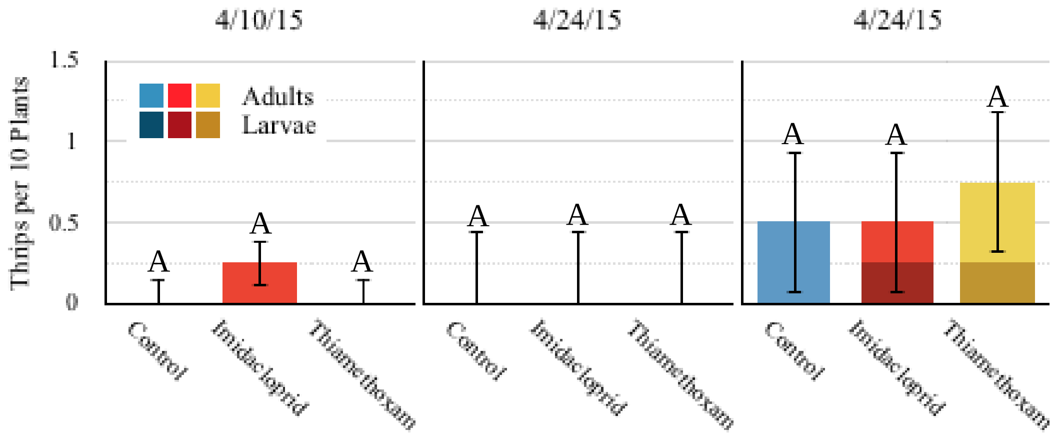

Figure 24. Average number of thrips per 10 plants from field near Mercedes, TX (Hidalgo, County) in 2015.

CHAPTER V
THRIPS SPECIES COMPOSITION

In 2014 and 2015, *Anaphothrips obscurus*, *Frankliniella fusca* (tobacco thrips), *Frankliniella occidentalis* (western flower thrips), *Frankliniella williamsi*, and *Thrips tabaci* (onion thrips) were found in cotton samples from the Kress field location. The dominant species in these samples were western flower thrips and onion thrips. Tobacco thrips were also present in low numbers. Both years saw an increase in onion thrips numbers from the first sample date to the second. (Fig. 25).

In 2014 and 2015, *Anaphothrips obscurus*, *Chirothrips texanus*, *Frankliniella occidentalis*, and *Thrips Tabaci* were found in cotton samples from the Halfway field location. In 2014, an increase of grass thrips at the second sample set was observed. Onion thrips and western flower thrips were dominant species both years. One *Chirothrips* was picked up in 2015 as well. (Fig. 26)

In 2014 and 2015 *Anaphothrips obscurus*, *Frankliniella fusca*, *Frankliniella occidentalis*, *Haplothrips verbasci*, and *Thrips Tabaci* were found in cotton samples from the Lamesa field location. In 2014, a crash of western flower thrips numbers, and a lower population of thrips overall, followed by an increase in western flower thrips numbers was observed. One late season sample showed western flower thrips still present in the field. (Fig. 27)

In 2015, *Anaphothrips obscurus*, *Chirothrips texanus*, *Frankliniella fusca*, *Frankliniella occidentalis*, and *Thrips Tabaci* were found in cotton samples from the

Levelland field location. There was a decrease in western flower thrips numbers and an increase in onion thrips numbers from the first sample set to the second. (Fig. 28)

In 2014 and 2015, *Anaphothrips obscurus*, *Chirothrips texanus*, and *Frankliniella occidentalis* were found in cotton samples from the Chillicothe field location. Thrips numbers were low in all sample sets for this location. (Fig. 29)

In 2014, *Anaphothrips obscurus*, *Frankliniella occidentalis*, and *Thrips Tabaci* were found in cotton samples from the Wall field location. There was an increase in western flower thrips from the first sample set to the second. (Fig. 30)

In 2014 and 2015, *Frankliniella fusca* and *Thrips Tabaci* were found in cotton samples from the College Station field location. Tobacco thrips were the dominant species both years. (Fig. 31)

In 2014 the species *Frankliniella fusca* and *Frankliniella occidentalis* were found in cotton samples from the La Feria field location. Western flower thrips were the dominant species at this location. (Fig. 32)

In 2014 and 2015, *Frankliniella fusca*, *Frankliniella occidentalis*, and *Thrips Tabaci* were found in cotton samples from the Victoria field location. In 2014, western flower thrips numbers decreased from the first sample set to the second, while onion thrips and tobacco thrips numbers stayed close to the same. In 2015, tobacco thrips were the dominant species present, but did have a decrease in numbers from the first sample date to the second. This location experienced a population shift from a dominant western flower thrips population in 2014, to a dominant population of tobacco thrips in 2015. (Fig. 33)

In 2014, *Frankliniella fusca* and *Thrips Tabaci* were found in cotton samples from the Port Lavaca field location. Tobacco thrips were found in higher numbers than onion thrips in this sample. (Fig. 34)

In 2015, *Frankliniella occidentalis* and *Thrips Tabaci* were found in cotton samples from the Mercedes field location. Thrips numbers were low at this location, only one of the 3 samples taken had adult thrips in condition for identification. (Fig. 35)

In 2015, the species *Chirothrips texanus*, *Frankliniella fusca*, and *Frankliniella occidentalis* were found in cotton samples from the Corpus Christi field location. Thrips numbers were low at this sample location, but western flower thrips were the main species in both sample sets. (Fig. 36)

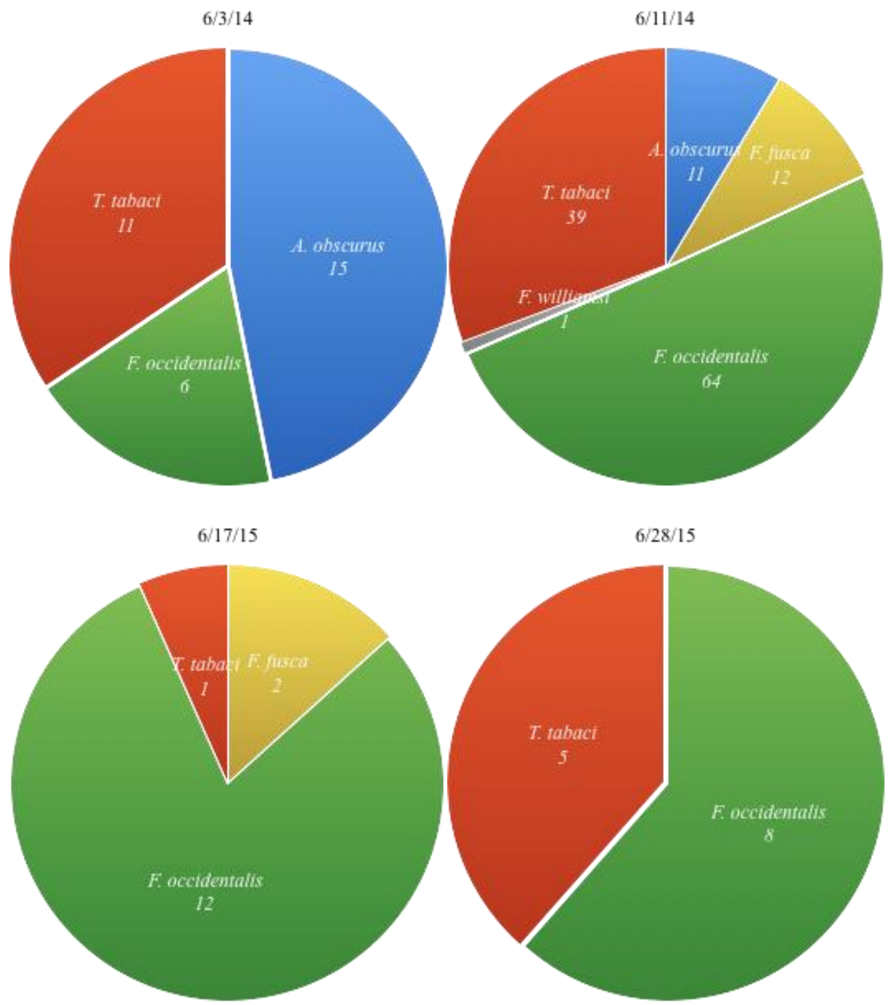

Figure 25. Thrips species composition in Kress, TX (Swisher County).

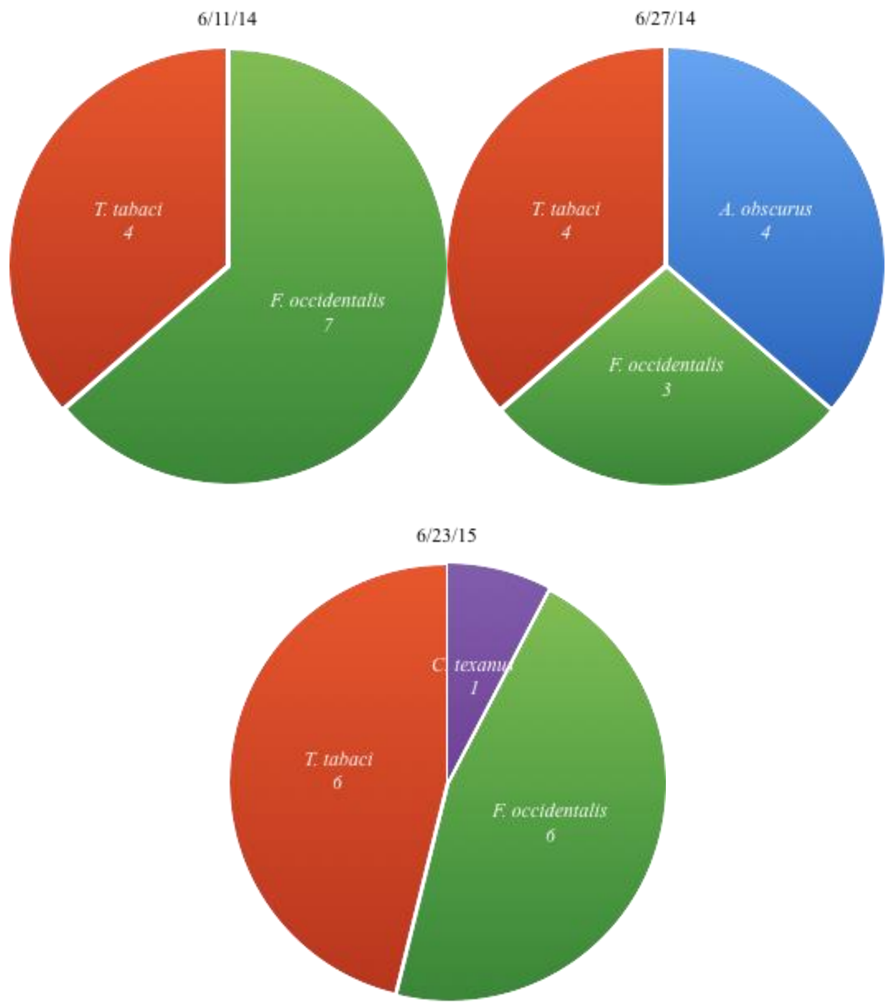

Figure 26. Thrips species composition in Halfway, TX (Hale County)

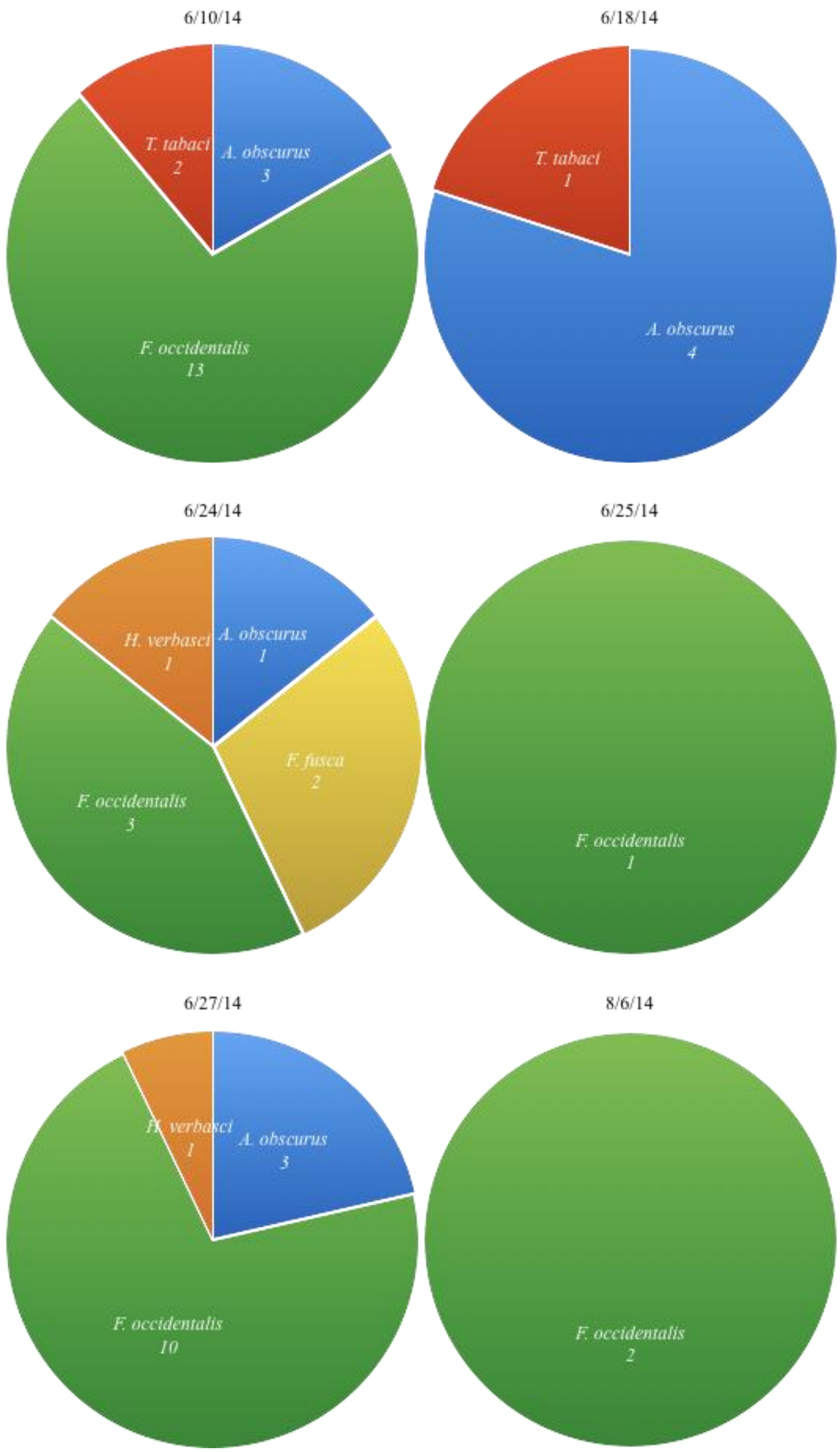

Figure 27. Thrips species composition in Lamesa, TX (Dawson County).

Figure 28. Thrips species composition in Levelland, TX (Hockley County).

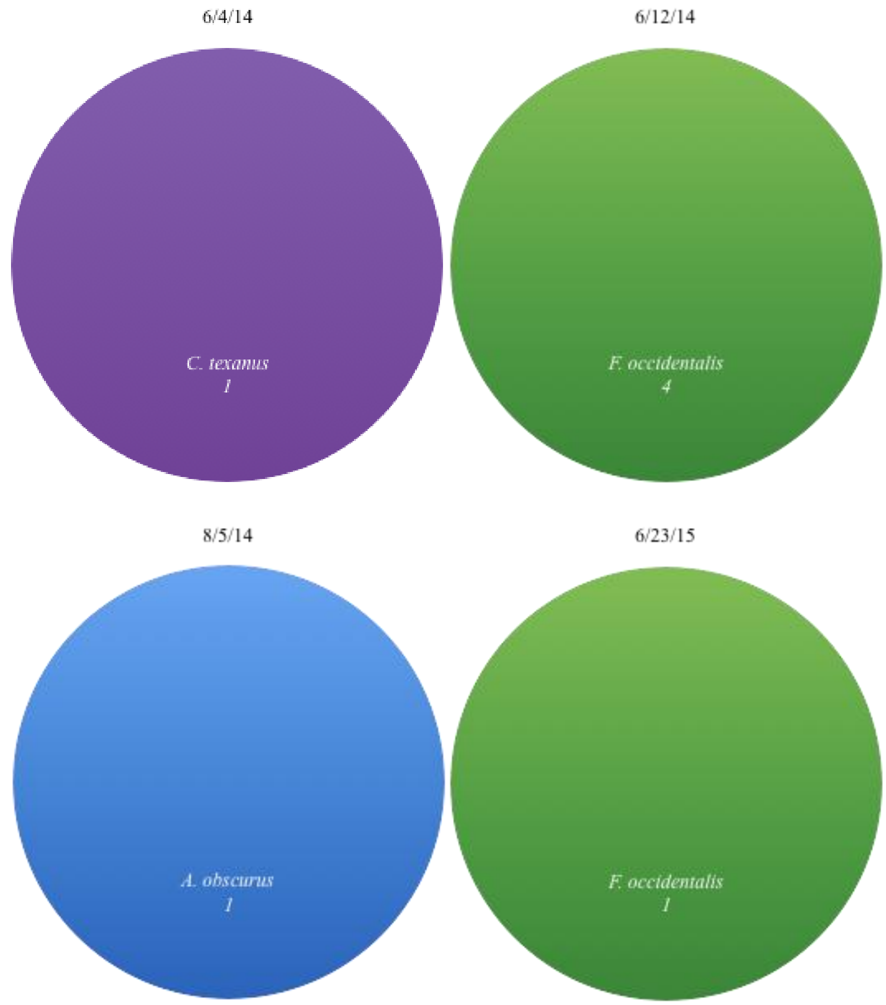

Figure 29. Thrips species composition in Chillicothe, TX (Hardeman County).

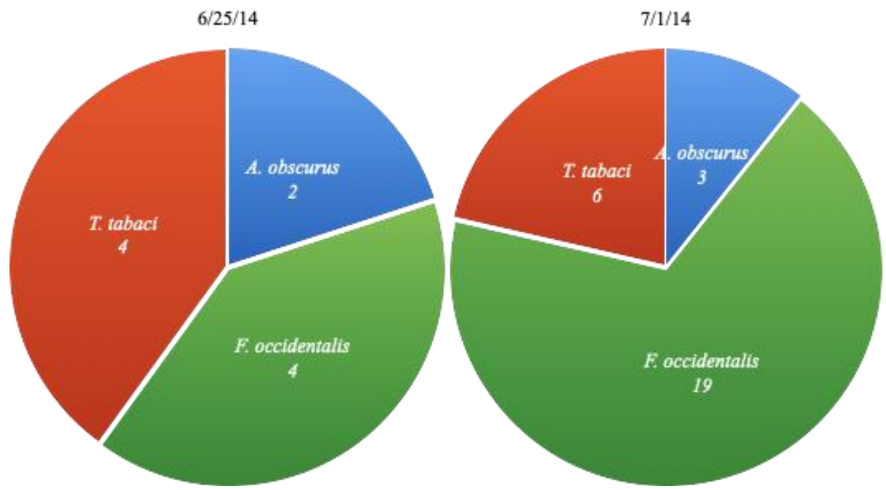

Figure 30. Thrips species composition in Wall, TX (Tom Green County).

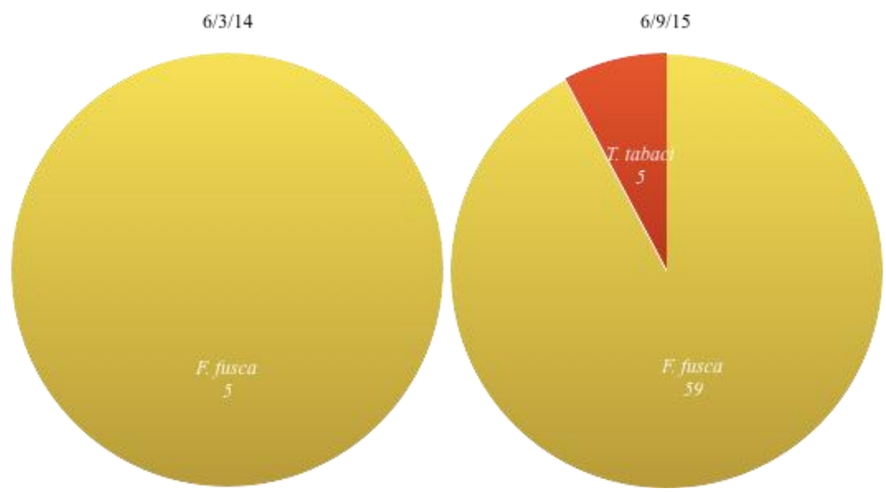

Figure 31. Thrips species composition in College Station, TX (Burleson County).

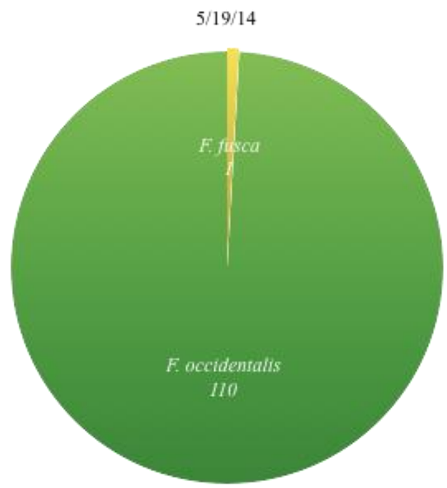

Figure 32. Thrips species composition in La Feria, TX (Cameron County).

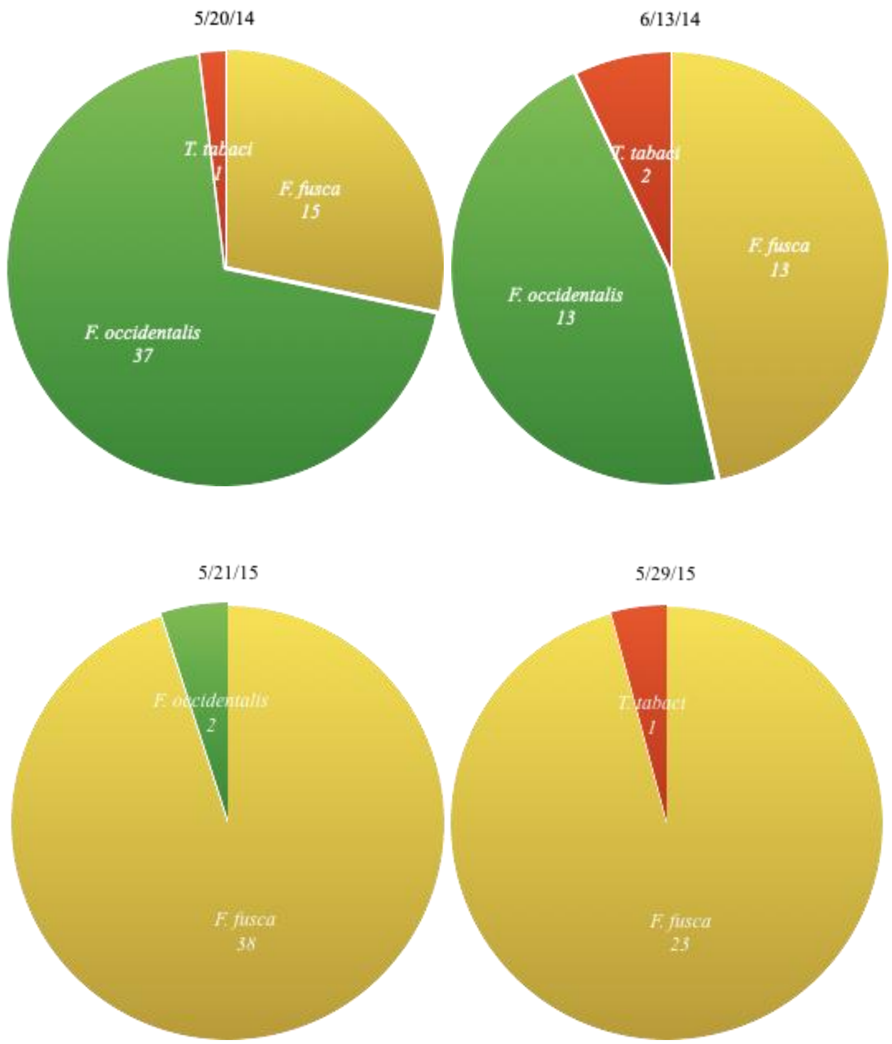

Figure 33. Thrips species composition in Victoria, TX (Victoria County).

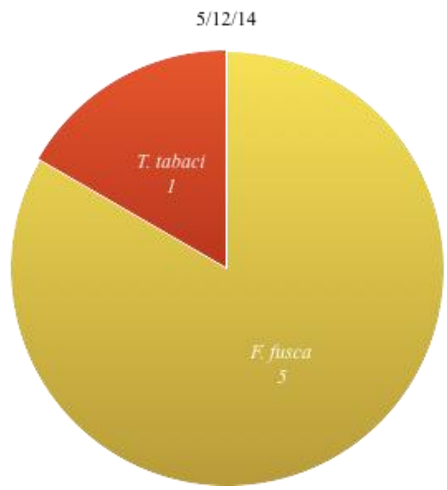

Figure 34. Thrips species composition in Port Lavaca, TX (Calhoun County)

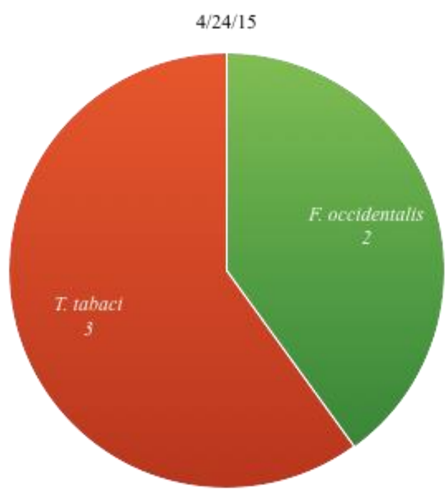

Figure 35. Thrips species composition in Mercedes, TX (Hidalgo County).

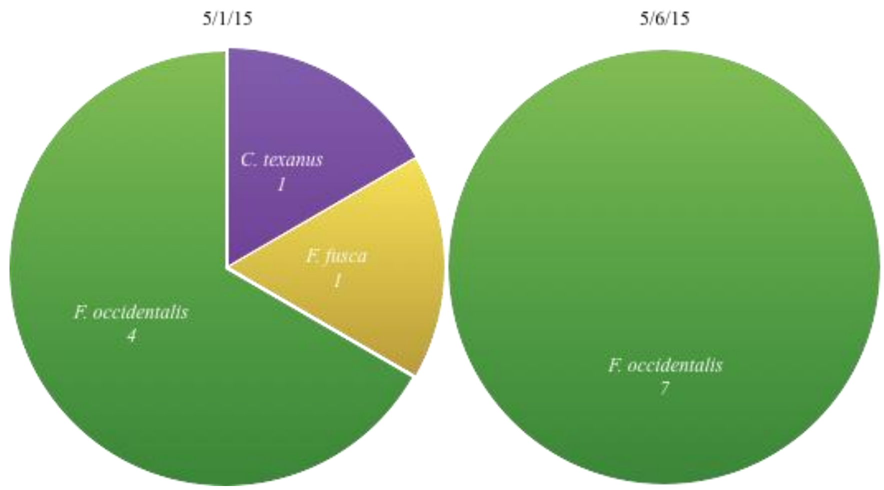

Figure 36. Thrips species composition in Corpus Christi, TX (Nueces County).

CHAPTER VI

CONCLUSIONS

The purpose of these experiments was to determine the efficacy of neonicotinoid seed treatments for controlling thrips in Texas, and to survey the thrips species present in cotton fields in Texas to determine if resistance to these insecticides is a problem. The species present across the state included dominant populations of tobacco thrips (*Frankliniella fusca*) and western flower thrips (*Frankliniella occidentalis*). Both of these species have exhibited the potential for insecticide resistance in other parts of the US, but did not exhibit resistance to thiamethoxam or imidacloprid in the tests performed in this study. We did find that there can be some benefit to knowing what the dominant thrips species is in an area before selecting a seed treatment insecticide. There were shifts in the thrips population, the Victoria sample location had a shift from western flower thrips as a dominant species in 2014 to tobacco thrips being the main species in 2015. This could pose a challenge in controlling the population without knowing what the dominant species will be at the time of planting the crop.

If thrips are present, we found that imidacloprid and thiamethoxam seed treatments can offer control of thrips populations, and can negatively impact yield. There is still a place for seed treatments as control of thrips early season. The next step for this would be a comparison of cost and efficacy of in season application of commonly used insecticides for thrips and comparing those with the use of seed treatment options.

Greenhouse Trials

Initial Greenhouse Trials

There was no difference between treatments in the initial greenhouse trials. There was a gradual increase of thrips during the first three weeks, then the numbers dropped off after the wheat began to dry down (Fig. 2).

Greenhouse Trials with Different Soil Types

There was little to no difference between treatments until 21 DAE. At this point the Metro-mix® treatments had significantly more thrips than the other soil types. This may be due to the size difference we noted between plants, but the overall vigor was about the same as the plants in soils from field locations (Fig. 3, Fig. 4, Fig. 5, Fig. 6, Fig. 7, Fig. 8, Fig. 9, Fig. 10). There may be another interaction with microbes or soil structure that could explain the discrepancy between thrips activity on plants in the Metro-mix® versus field soil. Soil type may also have an impact on the uptake and longevity of the seed treatment, this adds another factor for growers to consider when selecting a seed treatment.

Field Trials

In 2014, seed treated with thiamethoxam or imidacloprid had fewer thrips than seed not treated with an insecticide for up to 8 weeks (Halfway location) after planting. Due to dry and cool weather conditions, these plants still had fewer than 5 true leaves and were still considered susceptible to thrips damage. Field locations in 2014 at Kress, Halfway, and College Station had fewer thrips in plants with seed treatments than in untreated plants (Fig.11, Fig. 12, Fig. 15). In-season thrips populations did not exceed the economic threshold at trial sites near Wall, Lamesa, or Chillicothe in 2014, and no difference in treatments was observed (Fig. 16, Fig. 17, Fig. 18).

The imidacloprid treated seed yielded higher than the untreated at harvest in the College Station field location (Fig 15). None of the other locations differed in yield between treatments.

In 2015, thrips populations were below threshold in all locations. Levelland was the only location with differences in thrips population between treatments (Fig 19). The untreated cotton had more thrips than either of the treated cotton samples in this location, but all samples were still below the economic threshold.

Due to low numbers of thrips, no evidence of resistance at any location was determined, but variation in species susceptibility was suggested by imidacloprid yielding better than the control in College Station in 2014, while the thiamethoxam treated seed did not (Fig. 15).

Field Results

In College Station in 2015, there was an observable difference in yield between imidacloprid and the control treatment and thiamethoxam (Fig. 18). In just one location, it is not enough to suggest resistance concerns in our thrips populations, but does support the concern for a need to know the species composition of your area before selecting an insecticide. Kress had thrips numbers exceeding the economic threshold in 2014, but we observed good control in both imidacloprid and thiamethoxam seed treatments (Fig. 11). There was also control of thrips in the first sample set in Halfway by both seed treatments (Fig. 12). Both Kress and Halfway had populations of western flower thrips and onion thrips (Fig. 25, Fig. 26). Kress had a few tobacco thrips, but in College Station tobacco thrips were the dominant species both years (Fig. 25, Fig. 26, Fig. 31).

Thrips Species Composition

Western flower thrips have a history of resistance to pyrethroids in the US and have shown to develop resistance to other insecticides from a number of reports across the world(Immaraju et al. 1992, Zhao et al. 1995, Herron et al. 1996). They are a candidate for insecticide resistance problems. Neonicotinoid resistance has been documented in the mid-south US in tobacco thrips already (Stewart 2013). The data from our field locations is insufficient to draw conclusions on the presence of resistant thrips but can give a glimpse into the species composition of each area. The challenge lies with our inability to sample what species prior to choosing a treatment, as the treatment decisions need to be made prior to planting. The species composition in Victoria was a good example of this, in 2014 western flower thrips were the dominant species, but in 2015 the population had shifted, and tobacco thrips were the most common (Fig. 31). A better understanding of the conditions impacting the thrips species composition over time would be necessary to make pre-plant control decisions.

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APPENDIX A

THRIPS SPECIES COMPOSITION

Table 1. Thrips Species Composition in Kress, TX (Swisher County)

Date	*A. obscurus*	*C. texanus*	*F. fusca*	*F. occidentalis*	*F. williamsi*	*H. verbasci*	*T. tabaci*	Unidentifiable	Total
6/3/14	15	0	0	6	0	0	11	16	48
6/11/14	11	0	12	64	1	0	39	62	189
2014 Total	26	0	12	70	1	0	50	78	237
6/17/15	0	0	2	12	0	0	1	0	15
6/28/15	0	0	0	8	0	0	5	0	13
2015 Total	0	0	2	20	0	0	6	0	28

Table 2. Thrips Species Composition in Halfway, TX (Hale County)

Date	*A. obscurus*	*C. texanus*	*F. fusca*	*F. occidentalis*	*F. williamsi*	*H. verbasci*	*T. tabaci*	Unidentifiable	Total
6/11/14	0	0	0	7	0	0	4	0	11
6/27/14	0	0	0	7	0	0	4	0	11
2014 Total	0	0	0	14	0	0	8	0	22
6/23/15	0	1	0	6	0	0	6	0	13
2015 Total	0	1	0	6	0	0	6	0	13

Table 3. Thrips Species Composition in Lamesa, TX (Dawson County)

Date	*A. obscurus*	*C. texanus*	*F. fusca*	*F. occidentalis*	*F. williamsi*	*H. verbasci*	*T. tabaci*	Unidentifiable	Total
6/10/14	3	0	0	13	0	0	2	0	18
6/18/14	4	0	0	0	0	0	1	0	5
6/24/14	1	0	2	3	0	1	0	2	9
6/25/14	0	0	0	1	0	0	0	0	1
6/27/14	3	0	0	10	0	1	0	4	18
8/6/14	0	0	0	2	0	0	0	0	2
2014 Total	11	0	2	29	0	2	3	6	53

Table 4. Thrips Species Composition in Levelland, TX (Hockley County)

Date	*A. obscurus*	*C. texanus*	*F. fusca*	*F. occidentalis*	*F. williamsi*	*H. verbasci*	*T. tabaci*	Unidentifiable	Total
6/16/15	0	0	1	37	0	0	3	0	41
6/22/15	1	1	0	11	0	0	9	0	22
2015 Total	1	1	1	48	0	0	12	0	63

Table 5. Thrips Species Composition in Chillicothe, TX (Hardeman County)

Date	*A. obscurus*	*C. texanus*	*F. fusca*	*F. occidentalis*	*F. williamsi*	*H. verbasci*	*T. tabaci*	Unidentifiable	Total
6/4/14	0	1	0	0	0	0	0	2	3
6/12/14	0	0	0	4	0	0	0	0	4
8/5/14	1	0	0	0	0	0	0	0	1
2014 Total	1	1	0	4	0	0	0	2	8
6/23/15	0	0	0	1	0	0	0	0	1
2015 Total	0	0	0	1	0	0	0	0	1

Table 6. Thrips Species Composition in Wall, TX (Tom Green County)

Date	*A. obscurus*	*C. texanus*	*F. fusca*	*F. occidentalis*	*F. williamsi*	*H. verbasci*	*T. tabaci*	Unidentifiable	Total
6/25/14	2	0	0	4	0	0	4	0	10
7/1/14	3	0	0	19	0	0	6	5	33
2014 Total	5	0	0	23	0	0	10	5	43

Table 7. Thrips Species Composition in College Station, TX (Burleson County)

Date	*A. obscurus*	*C. texanus*	*F. fusca*	*F. occidentalis*	*F. williamsi*	*H. verbasci*	*T. tabaci*	Unidentifiable	Total
6/3/14	0	0	5	0	0	0	0	0	5
2014 Total	0	0	5	0	0	0	0	0	5
6/9/15	0	0	59	0	0	0	5	0	64
2015 Total	0	0	59	0	0	0	5	0	64

Table 8. Thrips Species Composition in La Feria, TX (Cameron County)

Date	*A. obscurus*	*C. texanus*	*F. fusca*	*F. occidentalis*	*F. williamsi*	*H. verbasci*	*T. tabaci*	Unidentifiable	Total
5/19/14	0	0	1	110	0	0	0	14	125
2014 Total	0	0	1	110	0	0	0	14	125

Table 9. Thrips Species Composition in Victoria, TX (Victoria County)

Date	*A. obscurus*	*C. texanus*	*F. fusca*	*F. occidentalis*	*F. williamsi*	*H. verbasci*	*T. tabaci*	Unidentifiable	Total
5/20/14	0	0	15	37	0	0	1	0	53
6/13/14	0	0	13	13	0	0	2	0	28
2014 Total	0	0	28	50	0	0	3	0	81
5/21/15	0	0	38	2	0	0	0	0	40
5/29/15	0	0	23	0	0	0	1	0	24
2015 Total	0	0	61	2	0	0	1	0	64

Table 10. Thrips Species Composition in Port Lavaca, TX (Calhoun County)

Date	*A. obscurus*	*C. texanus*	*F. fusca*	*F. occidentalis*	*F. williamsi*	*H. verbasci*	*T. tabaci*	Unidentifiable	Total
5/12/14	0	0	5	0	0		1	0	6
2014 Total	0	0	5	0	0	0	1	0	6

Table 11. Thrips Species Composition in Mercedes, TX (Hidalgo County)

Date	*A. obscurus*	*C. texanus*	*F. fusca*	*F. occidentalis*	*F. williamsi*	*H. verbasci*	*T. tabaci*	Unidentifiable	Total
4/24/15	0	0	0	2	0	0	3	0	5
2015 Total	0	0	0	2	0	0	3	0	5

Table 12. Thrips Species Composition in Corpus Christi, TX (Nueces County)

Date	*A. obscurus*	*C. texanus*	*F. fusca*	*F. occidentalis*	*F. williamsi*	*H. verbasci*	*T. tabaci*	Unidentifiable	Total
5/1/15	0	1	1	4	0	0	0	0	6
5/6/15	0	0	0	7	0	0	0	0	7
2015 Total	0	1	1	11	0	0	0	0	13

APPENDIX B

MAPS

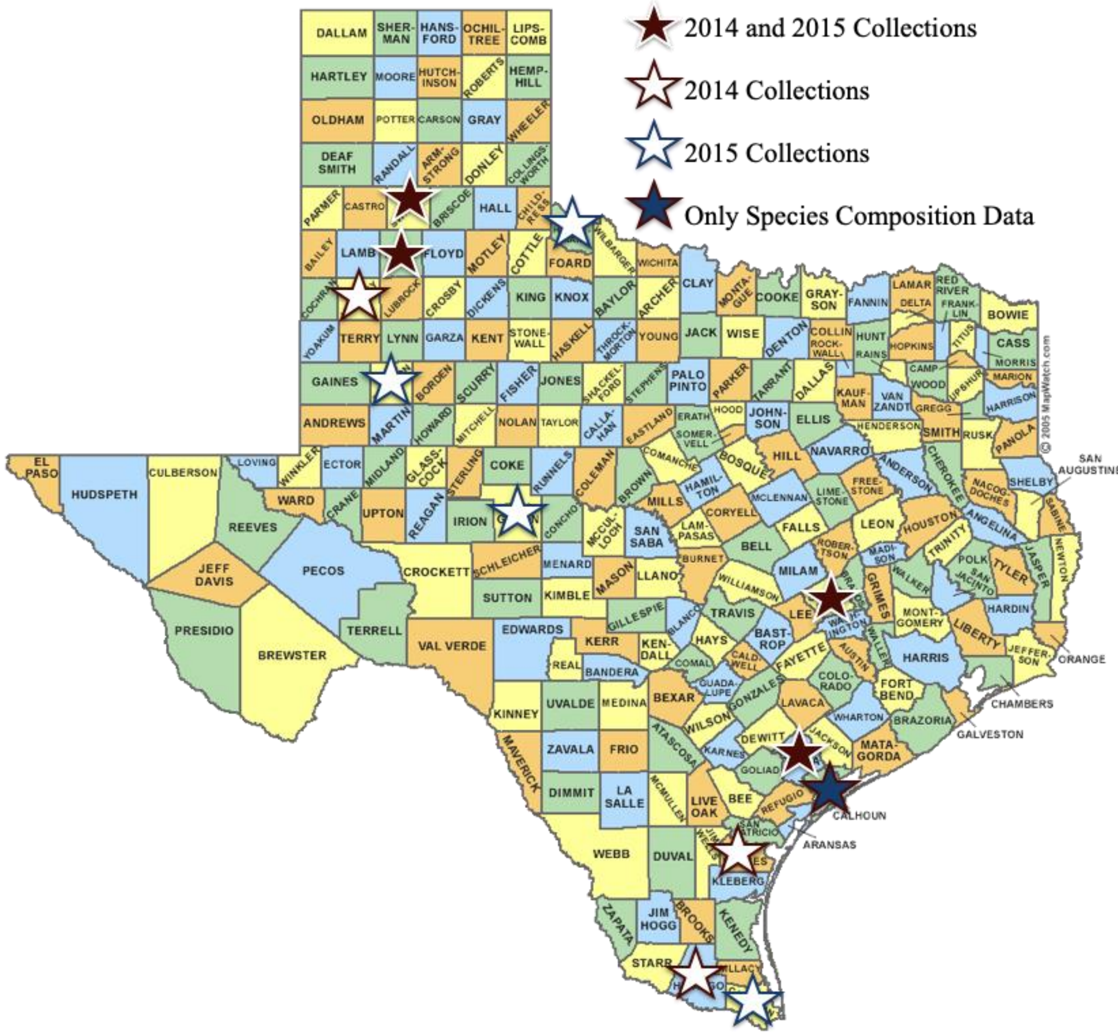

Figure 37. Field Trial Locations on County Map(Paper 2014)

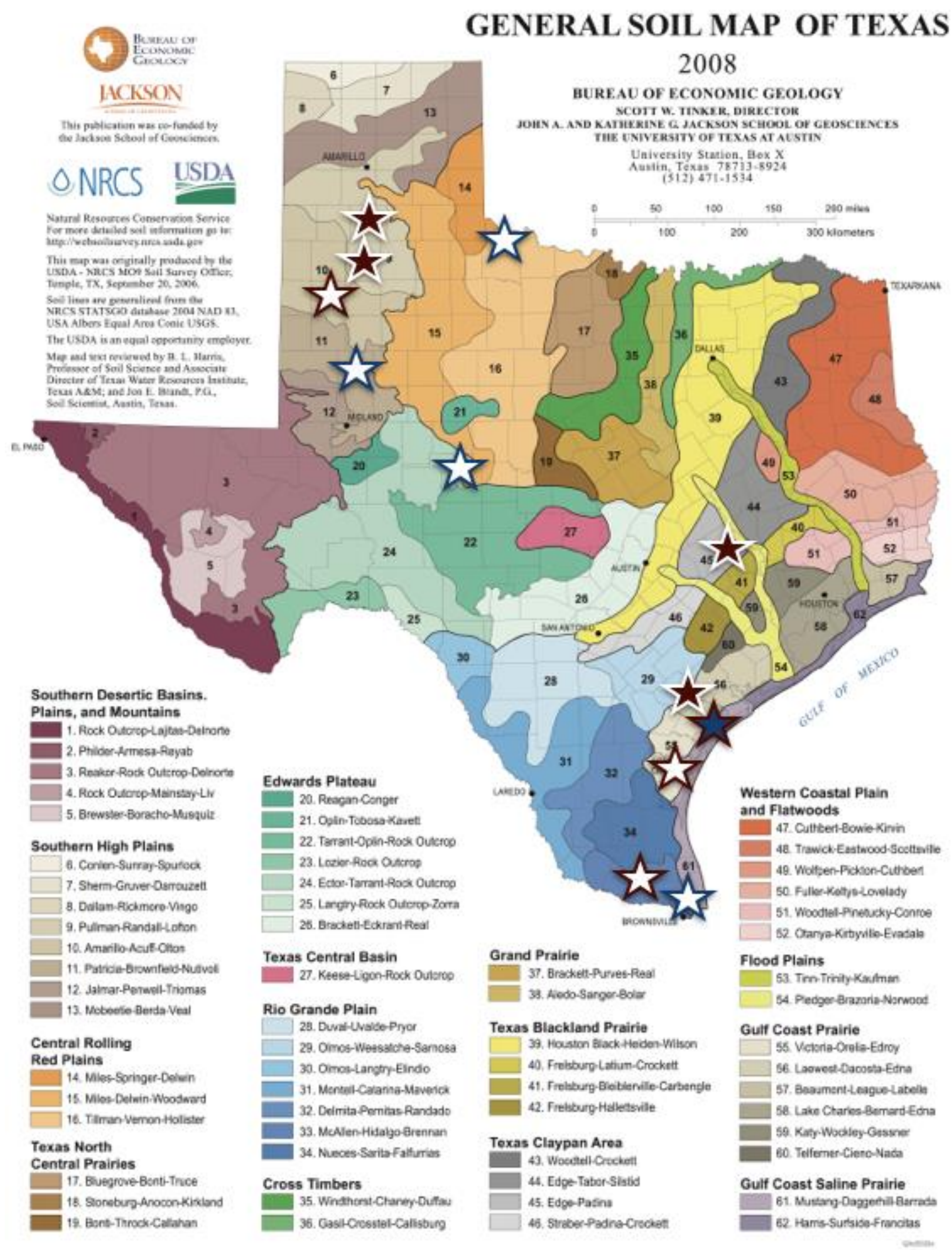

Figure 38. Field Trial Locations on Soil Type Map with County Lines(Texas 2008)