Summary

A study was conducted in 2011 to determine how effective pre-tassel miticide applications were at preventing economic damage to corn from spider mites. Understanding factors that contribute to mite development and survival during early vegetative growth will give producers a better knowledge of how to manage mite infestations so that the management options available are the most economical and best for preventing significant yield losses from spider mites.

The 2011 growing season was one of very harsh conditions due to the extreme drought and high temperatures. The corn was under moisture and temperature stress which were ideal for early and rapid spider mite population buildup. There were two trials conducted, one with miticide application on 1-2ft tall corn (SM Early 1-2ft) and the second with miticide application on 3-4ft tall corn (SM Early 3-4ft). Predator populations in both the SM Early 1-2ft and SM Early 3-4 ft trials were a key factor for causing mite populations to collapse. In the SM Early 1-2 ft trial, predators helped to keep mite densities low initially, but when mite populations began to increase rapidly the predators could not prevent mites from causing significant feeding damage in the untreated check. Miticides were applied to the 1-2 ft tall corn even before mite densities were bad or causing any visible damage. These applications resulted in the suppression of the buildup of spider mite densities and damage to treated plots was below that in the untreated check.

The SM Early 3-4 ft trial showed that under these stressful conditions, and when predators had been reduced by a targeted insecticide application, the mite densities could buildup to relatively high numbers before corn reached the tassel growth stage. Because of this situation, the application of miticides suppressed mite densities and damage below the untreated check, but could not prevent a certain level of damage from occurring in each of the miticide treatments. Predators eventually increased to levels that controlled mites, but not until damage had already occurred.

The suppression of mite feeding damage in the miticide treatments did not result in statistical differences grain yields between miticide treated plots and the untreated plots. The lack of significant difference was likely due to small plot yield variability. But, when damage
ratings by treatment were related to yield there were 18.4 Bu/ac and 16.4 Bu/ac yield loss for each increase in damage rating, respectively, for the SM Early 1-2 ft and SM Early 3-4 ft trials. This would be a substantial monetary loss of $115.00/ac and $102.50/ac for each increase in damage rating if corn sold for $6.25 per bushel.

Introduction

Spider mites infesting corn are responsible for significant economic losses for Texas producers from lost yield and relatively high costs for controlling mite infestations. Mites will infest, on average, 50% of the corn acreage on the Texas High Plains yearly and cause 20% or more yield loss. The costs associated with purchasing miticides and making an application can be as high as $25 to $30 per acre per application. None of the transgenic corn hybrids being marketed for control of caterpillar pests or corn rootworm have any effect on spider mites. Mite infestations are most damaging after corn has tasseled and during the grain filling growth stages. Spider mites have not developed resistance to the currently registered miticides, but optimum spray coverage is required for them to be effective. Since spray coverage is key to effective control, some producers and crop consultants have adopted the practice of spraying these products when corn is in the early to mid-vegetative growth stages. Although this is often a common practice, producers and their consultants do not know exactly 1) when an application is needed or how long the chemical will be effective, 2) what impact natural predators and environmental conditions have on mite suppression or on the need to spray, 3) which vegetative stage and what mite infestation level justifies a chemical application and 4) which product would be most effective and economical under different mite infestation circumstances. Understanding the impact of these factors on mite management will allow control strategies to be identified so miticide applications can be used more effectively and economically. This information will reduce wasteful applications and improve the efficacy of the miticides when applications are needed. A study was conducted in 2011 to address these questions so 1) producers will have a better knowledge of how to manage mite infestations and so 2) the management options available are the most economical and best for preventing significant yield losses from spider mites.

Objective

1. Evaluate miticide applications at vegetative growth stages V3-V5 (up to 2 ft tall) and V6-V8 (approximately 4 ft tall) for prevention of damaging infestations.
2. Evaluate the efficacy of Comite, Oberon, and Onager when applied at the designated growth stages for economical season long damage protection.
3. Determine the impact natural predators and environmental conditions have on pre-tassel mite infestations related to early season miticide applications.

Methods & Materials

Agronomic Practices and Weather
Two trials were conducted in a field at the North Plains Research Field, Texas AgriLife Research facilities near Etter, TX. Agronomic practices for irrigation, fertilizer, and herbicide were standard for corn production in the Texas High Plains. Climatic conditions were extremely hot and dry and the field was under severe heat and drought stress at times even with the field being furrow irrigated on a 7 to 10 day schedule. A total of only 0.01 inch of rain fell during June, 0.84 inch during July, 0.53 inch during August, and no rain in September prior to harvest on September 21. Daytime temperatures were exceptionally hot during the summer months. The number of days with temperatures between 95º F and 99º F in June, July, August, and September were 10 days, 16 days, 17 days, and 2 days, respectively. The number of days with temperatures ≥ 100º F were 13 days, 13 days, and 10 days for June, July, and August, respectively (Figure 1).

![Figure 1. Daily temperatures.](image)

**Trial and Experimental Design**

One trial, designated as *SM Early 1-2 ft*, was arranged in a randomized complete block design having four (4) replications. This trial was initiated when corn was at vegetative growth stages V3-V5. The other trial, designated *SM Early 3-4 ft*, was arranged in a latin square design with four (4) replications. This trial was initiated when corn was at vegetative growth stages V6-V8. For both trials, plots were six rows wide (30 inch center) by 50 ft. long.

**Miticide Application**

For both trials, miticide treatments were sprayed at 14.50 gpa with a CO2 pressurized (30 psi) hand-carried backpack sprayer with the boom held 20 inches above the corn canopy. The boom was equipped with 5 (T-Jet XR8002VS) flat fan nozzles on 20 inch centers. The miticides evaluated were Comite II (3 pt/A), Oberon (6 fl oz/A), Onager (12 fl oz/A) and were compared to an untreated check. A non-ionic oil concentrate adjuvant, Premium, was added to the spray mixture of Oberon and Onager at a 1% v/v rate.
SM Early 1-2 ft: The treatments were applied June 11 when corn was in the V5 growth stage (ca. 1 ½ ft. tall). At application the temperature was 59° F with a light wind of 4-5 mph from the east-southeast. No rain fell the week before application and only 0.06 inch on June 15, 4 days after application. No other rain occurred the rest of June.

SM Early 3-4 ft: An application of Asana (0.1 lb ai/A) was applied on June 11 to all rows in the area for this test. The application was made to control thrips migrating from adjacent wheat fields that prey on mites. The trial was treated with miticides on June 30 when corn was in the V-8 growth stage (ca. 4 ft. tall). At application the temperature was 72° F with winds of 5-6 mph from the southwest. No rain fell the week before application and only 0.04 inch on July 3, 3 days after application. No further rain occurred until July 25 (0.58 inch).

Insect Samples and Damage Ratings
Sample counts were taken 1 to 2 days before the miticide applications and at designated days after being treated (DAT). The number of visible mobile mites and predators were counted from 2 leaves per 5 plants per plot with the aid of an Optivisor® binocular magnifier, model DA10. The leaves sampled at each date were the 3rd and 4th leaf up the plant from the lowest leaf on the plant with at least 1/3 of the leaf green. The predators sampled were Stethours sp. (spider mite destroyer) larvae and adults, sixspotted thrips (Scolothrips sexmaculatus) and western flower thrips (Frankliniella occidentalis (Pergande)) nymphs and adults, predatory mites, minute pirate bugs (Orius sp.) nymphs and adults, and miscellaneous predators. The miscellaneous predators were several species of lady beetle larvae and adults, green lacewing (Chrysoperla sp.) larvae, syrphid fly larva, and spiders (various species).

Counts in the SM Early 1-2 ft trial were taken June 9 (pre-treatment), June 17 (6 DAT), June 23 (12 DAT), July 7 (26 DAT), and July 22 (42 DAT). Counts taken in the SM Early 3-4 ft trial were on June 29 (pre-treatment), July 7 (7 DAT), July 14 (14 DAT) and July 27 (27 DAT).

A rating for mite feeding damage within a plot was taken using a 1-10 damage scale: 1 = 1%-10% of the plant leaf area with mite damage, 2 = 11% – 20% plant damage, …., 10 = 91% - 100% (dead plant). Ratings were taken at each sample date in the SM Early 1-2 ft trial and after treatment applications were made in the SM Early 3-4 ft trial.

Harvest Samples
Harvest samples were collected from each trial on September 21 by hand pulling ears from one 17.4 ft linear section per plot. The number of ears and plants were recorded.
from each of the 17.4 ft linear sections. Ears were shelled with a small plot sheller and processed (weights, moisture content, bushel weight) to determine yield.

Data Analysis
Data were first corrected using the formula \( \text{Log}(x + 1.0) \) and then analyzed using PROC GLM analysis of variance (SAS 9.2 version). Treatment mean differences for spider mite and predator infestations and damage ratings were separated with Tukey’s test \( (P=0.05) \). For yield samples (Bu/ac, ears, plants), the treatment mean differences were separated with Duncan’s Multiple range test \( (P=0.05) \). Estimates of miticide percent control was determined by Henderson’s formula (Henderson and Tilton. 1955. J. Econ. Entomology. Vol 48 (2): 157-161).

Results & Discussion
Spider mite infestations are an extremely difficult problem for producers in the Texas High Plains because the miticide products that are toxic to mites are less effective when sprayed to tassel corn, which is when mite infestations cause the worst damage and greatest yield loss. The primary reason for poor control on tassel stage corn is related to less than optimum spray coverage. Therefore, applications are often applied before tassel in an attempt to improve miticide coverage, and therefore efficacy and as a preventative treatment. Unfortunately, the effectiveness and benefit from making these early season applications are really unknown because there are many factors (climate, natural enemies, etc.) that can prevent mite infestations from ever reaching an economically damaging level or that allows mite infestations to cause substantial damage in a short period of time. This project was initiated to learn more about the dynamics of early season spider mite infestations and mite control efforts. The studies for this project were designed to learn how effective early season miticide applications are for season long mite management. This involves understanding what impact climatic conditions and natural predators have on early season spider mite populations and on the efficacy and residual control of miticide products. To understand these interactions both studies were conducted under natural field conditions.

Spider Mite Early 1-2 ft Trial
The trial was conducted to represent when producers apply a miticide with Roundup herbicide for early season weed control. The producer’s rational for making this application is that it will control mites migrating from adjacent wheat fields and they hope it will prevent mites from developing damaging infestations later in the season. The data for this trial showed low numbers of mites (1 to 2.4 per two sampled leaves/plant) infesting the corn on June 9 (Pre-trt) prior to the miticide applications (Figure 2). At this date, the dominant predator was western flower thrips (99.9% of the predator population) and numbers were from 4.7 to 6.5 thrips per two sampled leaves/plant (Figure 3). The percentage of these thrips that were adults ranged from
67.7% to 81%. These numbers demonstrate the migration of mites and western flower thrips from wheat fields located south and west of the corn trial and were only separated by a dirt road. By six days after miticides had been applied, mite densities were increasing but still relatively low (5 to 12 per two sampled leaves/plant). At this date there was no real evidence showing the impact of the miticide applications as there were no statistically significant difference among the miticide treatments and the untreated check. The western flower thrips continued to increase and be the dominant predator (99%), but the percentage of adults was lower (38%) compared to an increase in immature thrips (62%). This shows the migration of mites and predators from the wheat fields were declining, and that the populations on corn were becoming established. By June 23 (12 DAT) and July 7 (26 DAT), there was evidence that the miticides had an impact on mite densities, as mite numbers in the untreated check were increasing at a statistically greater rate than in the miticide treatments. Statistically there were no differences among the miticides at either date, but at the July 7 sample the mite densities in the Comite treatment were statistically similar to the mite densities in the untreated control plots. In general this indicates that the miticides were effective in controlling mites up to 26 DAT. The sharp increase in mite densities between the 12 DAT and 26 DAT sample could be related to stress conditions (heat and moisture) when temperatures began to be severe (Figure 1). At the July 7 sample when mite densities were at their highest levels, the predator numbers were declining but the species complex was becoming more diversified. The predators across the treatments were comprised of miscellaneous predators 7% to 31%; western flower thrips adults 3.7% to 10.8%; six-spotted predatory thrips adults 1.6% to 18.5%; immature thrips 40.7% to 56.5%; and minute pirate bug nymphs 6.5% to 11.1%. This rapid acceleration of mite infestation caused mite feeding damage to also be accelerated (Figure 4). By the 41 DAT (July 22) sample the mite populations were collapsing, which were probably related to the presence of the predatory thrips from July 7 to July 22. This mite population collapse was earlier than what typically occurs during this stage of ear development. Typically in this early stage of ear development mite densities escalate.
Figure 2. Spider mite densities before treatment and to 41 days after miticide application (DAT). Texas AgriLife North Plains Research Field. Bars within a sample date having the same letter are not significantly different according to Tukey’s mean separation test (P=0.05, SAS Institute 2009).

Figure 3. Predator densities before treatment and to 41 days after miticide application (DAT). Texas AgriLife North Plains Research Field. Bars within a sample date having the same letter are not significantly different according to Tukey’s mean separation test (P=0.05, SAS Institute 2009).

Damage symptoms were not noticeable or at very low levels prior to July 7 when mite densities were low (Figure 4). But, with the rapid increase in mite densities and the feeding
pressure to July 22 there was a significant increase in feeding damage to the corn. The highest level of damage was to plants in the untreated check. The suppression of mite infestations by the miticides did keep damage levels below that seen in the untreated check and each of the miticide treatments were statistically similar to the other miticides. But, if the mite populations had not collapsed due to predation there could have been even greater levels of feeding damage. These data show how quickly mite populations can build and cause significant damage.

![Graph](image-url)

Figure 4. Weekly mite feeding damage before treatment and to 41 days after miticide application (DAT). Texas AgriLife North Plains Research Field. Bars within a sample date having the same letter are not significantly different according to Tukey’s mean separation test (P=0.05, SAS Institute 2009).

The subsequent impact of the feeding damage on corn yields in the different miticide treatments and the untreated check did not separate statistically, even though there was a 191 to 237 bu/ac yield difference (Figure 5). The inability to detect statistical differences is most likely associated with variability among individual plot yields in these small plot trials. However, when the average yield per treatment is plotted to the average feeding damage rating at the 41 DAT (July 22) sample there is a high correlation ($R^2 = 0.9994$) in yield loss to damage rating (Figure 6). This correlation shows that for each increase in damage rating there was an 18.5 bu/ac loss in grain yield.
Figure 5. Mean yield (bars) and damage (dots) at 41 days after treatment of miticides. Yield bars with the same upper case letter are not significantly different according to Duncan’s multiple range test (P=0.05). Damage ratings (dots) with the same lower case letter are not significantly different according to Tukey’s mean separation test (P=0.05).

![figure5.png](image)

Figure 6. Linear relationship for damage ratings (41 DAT sample) from mite feeding to mean yield (Bu/ac).

![figure6.png](image)

For every 1 damage rating increase there was a 18.5 Bu/ac yield loss.

\[
y = -18.463x + 293.01
\]

\[R^2 = 0.9994\]
Spider Mite Early 3-4 ft Trial

This trial was conducted to determine if applying miticides when corn is 3-4 ft tall provides effective control of spider mite infestations. The miticide applications were sprayed on June 30 when corn was at the V8 growth stage. Infestations of spider mites had reached very high levels by June 29 which may be associated with the extremely high daytime temperatures and having been sprayed on June 9 with a pyrethroid (Asana) insecticide to kill predators (Figure 7). At this date predator numbers were much lower (0.8 to 1.8 predators per two sampled leaves/plant) in comparison to the spider mite numbers (Figure 7 and Figure 8). On average, this was a ratio of 1 predator per 121 spider mites. The predator complex were comprised of immature thrips (0% to 69%), adult western flower thrips (9% to 44%), adult six-spotted thrips (0% to 17%), miscellaneous predators (9% to 44%), and a few minute pirate bug nymphs (0% to 6%). At 7 days after miticide application, mite densities increased, except in the Onager application, and not as great in the Oberon application when compared to the mite densities in the untreated check and the Comite application. The percentage of control by these three miticides was 27%, 46%, and 63%, respectively, for Comite, Oberon, and Onager. Overall, the predator numbers per two sampled leaves/plant (1.4 to 4.5) had not changed much from the pre-treatment count, but there was a change in the predator complex. Six-spotted thrips adults (< 2.2 %) and miscellaneous predators (<14.8%) declined while the immature thrips increased to 44% to 95% of the population. At 14 days after treatment, the efficacy of the three miticides improved to 43%, 64%, and 83% control for Comite, Oberon, and Onager, respectively. Statistically, there were no differences in the level of mite control between applications of Oberon and Onager. Control of mites was not evident from the application of Comite until 14 days after treatment when mite density levels were statistically similar to Oberon and Onager. The total predator population still remained relatively stable at 1.6 to 1.95 predators per two sampled leaves/plant. The percentage of six-spotted thrips adults (2.6% to 6.3%) did begin to rebound from the previous week. By 27 days after treatment, the predator population collapsed in all of the treatments. This collapse may have been due to an increase in the predator population which averaged 3.8 to 5.5 predators per two sampled leaves/plant (27 DAT) (Figure 8). On this sample date, counts for minute pirate bug predator were higher than previous samples (averaged 5.3% adults and 7% nymphs). But, the predator complex was still predominately composed of thrips (83.6%). For the thrips alone, 9.8% were six-spotted thrips adults, 14.1% were western flower thrips, and 76.1% were immature thrips.

The feeding damage (ratings 1.5 to 2.3) to plants was beginning to be noticeable in all treatments by the 17 DAT sample (Figure 9). Feeding damage continued to increase by the 27 DAT, but statistically the damage was less in the miticide treatments than in the untreated check. The miticides suppressed the mite populations and slowed the progression of feeding damage. But, based on the relatively high number of mites at the pre-treatment sample date and how quickly mite feeding caused damage, the miticide applications probably should have been applied earlier. As in the SM Early 1-2 ft trial, the predators were an important contributor to the mite population collapsing. If mite populations had continued to feed, the level of damage to the untreated check would have increased. But these data show that under these heavy mite infestations, predators alone cannot prevent significant feeding damage within the short period of time needed for mite populations to build to damaging levels.

Corn yields did not differ statistically among the miticide treatments and the untreated check, even though there was a 178 bu/ac to 225 bu/ac difference (Figure 10). This is partially...
explained by plot variability. But, the average yield in the Onager treatment was much lower than expected when compared to the average amount of feeding damage. This difference is most likely due to other factors (late emergence) affecting yield in two of the Onager plots.

Figure 7. Spider mite densities before treatment and to 27 days after miticide application (DAT). Texas AgriLife North Plains Research Field. Bars within a sample date having the same letter are not significantly different according to Tukey’s mean separation test (P=0.05, SAS Institute 2009).
Figure 8. Predator densities before treatment and to 27 days after miticide application (DAT). Texas AgriLife North Plains Research Field. Bars within a sample date having the same letter are not significantly different according to Tukey’s mean separation test (P=0.05, SAS Institute 2009).

Figure 9. Weekly mite feeding damage from 7 to 27 days after miticide application (DAT). Texas AgriLife North Plains Research Field. Bars within a sample date having the same letter are not significantly different according to Tukey’s mean separation test (P=0.05, SAS Institute 2009).
However, the relationship of mean yield (Bu/ac) for each treatment to the mean treatment damage rating at 27 DAT show there was a 16.4 Bu/ac yield loss for every 1 damage rating increase. It is interesting that the yield loss per damage rating increase from the SM Early 1-2ft trials (18.4 Bu/ac) was very similar to the yield loss in the SM Early 3-4 trial. At these yield reductions the monetary loss for $6.25/Bu corn would be $102.50 per ac and $115.00 per ac, respectively, for 16.4 Bu/ac and 18.4 Bu/ac losses per damage increase. These are substantial monetary losses and this suggests that miticide applications at either 1-2 ft or 3-4 ft tall corn growth stage would have been economical under these mite infestations and conditions.
In general, these two trials show that mite populations could develop to damaging infestation levels under severe climatic conditions as encountered in 2011. For these conditions applying miticides (Comite, Oberon, and Onager), when corn was 1-2 ft tall and 3-4 ft tall, suppressed the mite populations and helped prevent corn from becoming as severely damaged as corn that was not treated. However, corn in the miticide treatments did not sustain a certain level of feeding damage which was due to the heavy development of mites under these conditions. Predator densities were important to causing mite densities to collapse, but the predators could not prevent economically damaging mite infestations. Although, differences in grain yields could not be shown between the miticide treatments and the untreated check, these data showed that as feeding damage increases there was a corresponding loss in grain yield.

These data are only representative for the two studies conducted in 2011 and do not represent findings from studies conducted in 2010 which showed different results. The two studies will be repeated in 2012 and the findings from all of the studies will be used to make a final reported.
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