SPIDER MITES IN SILAGE CORN: DAMAGE AND MANAGEMENT

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ABSTRACT

Spider mites are an important arthropod pest of corn. Although natural enemies and management strategies may reduce their impact, it is usually necessary to apply miticides in the San Joaquin Valley of California. Trials have demonstrated reduced spider mite populations and in some years significantly higher yields due to miticide application compared to untreated controls. Reductions in acid detergent fiber and neutral detergent fiber in harvested corn have also been documented when spider mites are controlled.

Key Words: silage corn, spider mites, two-spotted spider mite, miticides, acaricides

INTRODUCTION

Although considered by some to be insects, spider mites are more closely related to spiders than to insects. They have a rounded body with no antennae and no separate head or abdomen. Their life cycle begins as a spherical, somewhat translucent egg which hatches into a 6-legged translucent larval stage, followed by two 8-legged nymphal stages and ending as an 8-legged adult. Adult females are larger than adult males but even at that they are very small (less than 0.04 inch). A single female may lay as many as 100 eggs. When conditions promote rapid growth a generation may take as little as 7-9 days. High populations can build very quickly.

Spider mites most commonly live and feed on the underneath side of leaves. They produce webbing which is sometimes more visible than the spider mites. Spider mites have a needle-like mouthpart (stylet) that pierces plant cells, allowing these pests to suck up liquid cell contents and thereby destroy the cells. The most obvious plant symptom caused by feeding begins as chlorotic speckling or stippling on the top side of the leaf. If the population continues to feed and increase in numbers, leaves turn yellow, dry prematurely, eventually turn brown and die. With high populations, yield and quality of corn silage can be reduced.

There are many species of spider mites attacking many different plant species but four have been identified as pests of corn: Twospotted spider mite (*Tetranychus urticae*), Banks grass mite (*Oligonychus pratensis*), Strawberry spider mite (*Tetranychu sturkestani*) and Pacific spider mite (*Tetranychus pacificus*). These spider mites thrive under high temperatures and low humidity. Spider mites are not a problem in the eastern Corn Belt states but become increasingly problematic as one moves into west Texas, Colorado, and Utah. In California's San Joaquin Valley, the twospotted spider mite (TSM) is the most common. Second most important to western corn states, and in many areas the most important, is the Banks grass spider mite (BGM).

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Identification among the species is required in cases where one species in an area has developed resistance to one of the miticides. This would impact miticde selection if a spray application became necessary. The TSM and BGM have different pigmentation which is actually the plant material in their guts showing through their somewhat translucent bodies. In the case of TSM there are 2 dark spots on each side of the adult's body while the BGM has more generalized pigment around the tail end of the adult. TSM also tends to make more webbing, has a more rounded rear end and is larger than the BGM but unless comparing the two species side by side it may be hard to use these latter features. In general, the BGM is more susceptible to miticides than TSM) except in locations where it has developed resistance.

Spider mites survive the winter as adults hunkered down in plants, plant debris or in the soil.. They crawl or are blown in the wind to plants they then infest. The spider mites affecting corn thrive under sunny, hot, dry conditions. They also are promoted by dusty conditions.

Spider mite populations begin on the underside of lower leaves. They move up the plant to newer leaves as old leaves desiccate and the spider mite population increases. In corn, feeding on the ear leaf and higher leaves is more damaging than feeding on lower leaves.

Management strategies to prevent high populations from developing include avoiding water stress. Populations increase rapidly on stressed corn. Sprinkler irrigation will tend to keep spider mite numbers low. However, if corn becomes stressed and the spider mite population flares, sprinklers will not be successful in reducing a high population once established. Reducing dust and weeds can also help reduce spider mite pressure.

Predatory insects and mites can help keep spider mite populations under control. Thrips, such as the 6-spotted thrips (*Scolothripssexmaculatus*), are early season predators feeding mainly on eggs. Spider mites provide an important food source for minute pirate bugs (*Oriustristicolor*), big-eyed bugs (*Geocoris* spp.) and other general predators. Naturally occurring predatory mites also help reduce populations. Augmenting the natural population with releases of reared predatory mites has been tried but has not proven practical due to cost and lack of definitive guidelines. Numbers of predatory mites needed and timing of release are two of the variables that need to be determined. The release of predatory mites would have to be before the spider mite population causes significant damage but, if released too early, there won't be enough spider mites to maintain the predator population. If possible, maintain beneficial insect and predatory mite populations by avoiding applications of broad spectrum insecticides for other pests. Varieties with lepidopteron biotech traits may help in this regard.

Different states have different guidelines for action thresholds for spider mites. For example, in some states if the lower 1/3 of the plants shows damage, spider mites can be found on the middle third of the leaves and the corn is not yet at hard dough, then treatment should be considered. Evaluate the cost of the treatment and the value of the crop. In the San Joaquin Valley, humidity is always low and temperatures are consistently high with the result that spider mites are almost always a pest in early corn. Because spider mites feed primarily on the underside of leaves, spray coverage is essential. In California, the recommendation is to scout when plants are small enough to still go in with a ground spray rig. If spider mites can be found throughout the field, an application is recommended.

Miticides

Current miticides registered in California for use in corn are: propargite (Comite), spiromesifen (Oberon), hexythiazox (Onager), and etoxazole (Zeal). Fenpyroximate has received a federal label and has been submitted to the California Department of Pesticide Regulation. California registration is expected in April or May of 2014. In California the name will be Miteus. In Kansas, Colorado, New Mexico, Texas, and Oklahoma it is labeled as Portal and in other crops this active ingredient is sold under the name of Fujimite. Bifenthrin (Capture) also has spider mites on its label but in California is used primarily as a broad spectrum insecticide when other pests are present. It was not included in the trials reported in this paper.

Table 1. List of miticides for use against spider mites in corn.[1]

Miticide	Active Ingredient	Company	Mode of Action	Resistance Category
Comite	propargite	Chemtura	Contact on juveniles and adults	12C
Oberon	spiromesifen	Bayer	Contact on all but most effective on juveniles	23
Onager	hexythiazox	Gowan	Growth regulator, eggs are sterile, contact toxin on eggs & juveniles	10A
Zeal	etoxazole	Valent	Contact on eggs, inhibits molting, eggs are sterile	10B
Miteus*	fenpyroximate	Nichino	Contact on eggs juveniles & adults	21

*Label as Portal in Texas, Oklahoma, New Mexico, and Kansas; Registered in other crops as Fujimite; Expected registration in CA in spring 2014 under the name of Miteus.

[1]Adapted from a table produced by David Haviland, UCCE Farm Advisor, Kern County.

TRIALS

Several trials have been conducted in the San Joaquin Valley of California on small and large scale plots to evaluate spider mite control and yield. The two spotted spider mite was the most predominant, if not the only, spider mite in these trials. All trials were conducted on non-brown midrib (BMR) varieties.

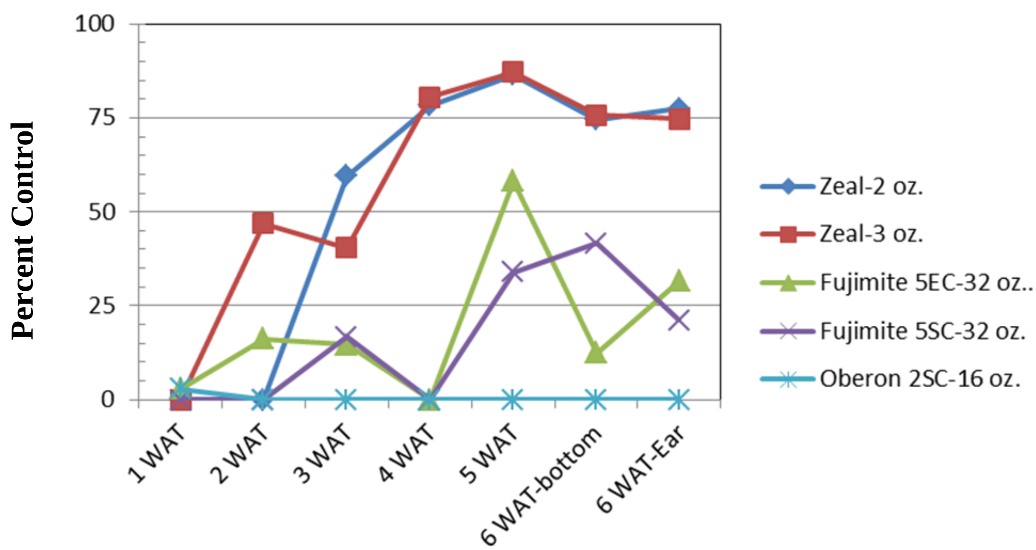
Small plot studies were conducted at the UC West Side Research and Extension Center to supplement grower field studies. These studies allowed us to evaluate additional treatments, and especially unregistered materials, compared with the field studies. The small plot studies were done in plots measuring 6 rows wide and 80-120 feet long with 4 replications. Treatments were applied with a John Deere high clearance sprayer with 5 nozzles per row at 20 GPA. Treatments were delayed until a spider mite infestation developed which was usually 6-8 weeks after planting and the corn was ~5 feet tall. This was generally the latest date possible in order to get a ground sprayer into the field. A nonionic surfactant (NIS) was used with all miticides.

Sampling consisted of collecting 20 leaves per plot weekly for 6 to 7 weeks after treatment. The lowest leaf on the plant that was still ~70% green was selected. On the last sample date, leaves were also collected from the ear zone. Spider mites were recovered in the laboratory using a washing – flotation technique and the number of immature and adult mites was counted under magnification.

2012. One characteristic about the West Side Research and Extension Center is that the spider mite populations are very late to develop but once the mite infestation begins the numbers "explode". Therefore, to show good to excellent control, a product must have very long residual in/on the corn leaves. For the first 2 to 3 weeks after application, the spider mite level was very low including in untreated plots. In 2012, mite populations in untreated plots averaged less than 10 and less than 50 mites per leaf for the first 2 and 4 weeks, respectively after application. Between weeks 4 and 5, the population increased 5-fold.

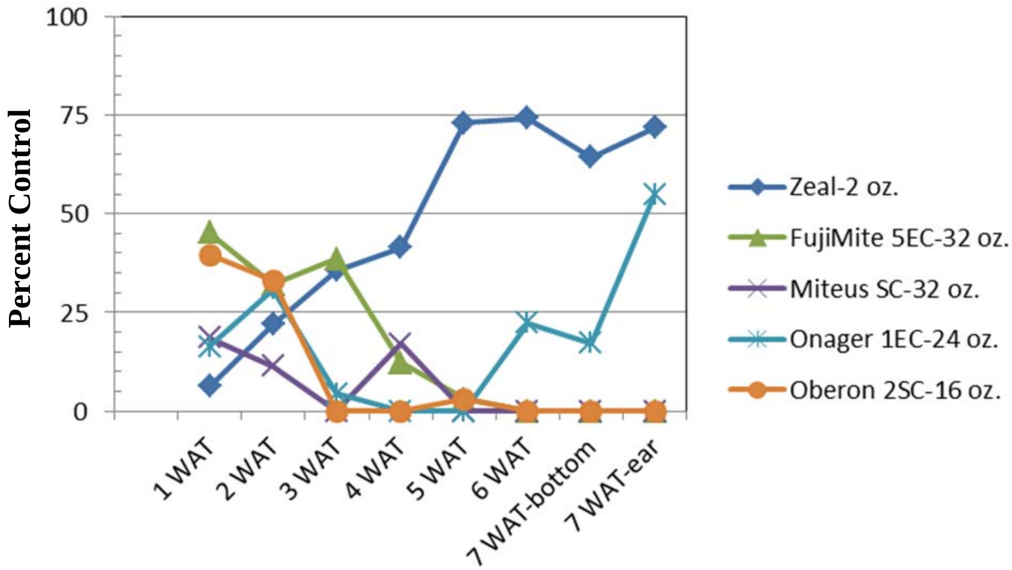
Miticide efficacy in 2012 is shown below. At 1 week after treatment (WAT), only slight mite control was seen. At 2 WAT, the 3 oz. rate of Zeal showed about 50% control whereas the 2 oz. rate was still not showing much activity. This speed-of-kill was the primary difference seen between the two rates of Zeal. The maximum percentage control with Zeal was about 75-80% control at 4-6 WAT. The two formulations of Fujimite showed similar results peaking at about 40 to 55% mite control but overall performing somewhat erratically. The EC formulation of pesticides is problematic for volatile organic compounds (VOC) regulations, thus the desire to move away from this formulation type. Oberon in this study was not effective.

Figure 1. Percentage spider mite control in field corn at various weeks after acaricide application, 2012, UC West Side Research and Extension Center, Five Points, CA.



2013. Spider mite populations on the lower leaf were consistently less than 50 per leaf for the entire 7 week sampling period. Levels were about double that on the ear leaf at 7 WAT. Zeal performance peaked at about 75% control at 5 to 7 WAT. From 1 to 4 WAT, there was a gradual increase in efficacy with Zeal. Of the other four products, only Onager reached the 50% control level and that was on the ear leaves at 7 WAT. Oberon, Fujimite and Miteus showed some initial spider mite control (1 and 2 WAT) but the residual control was lacking.

Figure 2. Percentage spider mite control in field corn at various weeks after acaricide application, 2013, UC West Side Research and Extension Center, Five Points, CA.



Large scale trials in 2010, 2012, and 2013 were conducted on growers' fields. Plots were either 12 rows (2012 and 2013) or 24 rows (2012) wide and a quarter of a mile long with 4 replications in a randomized complete block design. Applications were made with a commercial sprayer using drop nozzles at 20 gpa. A nonionic surfactant (NIS) was used with all miticides except Comite. In 2010 plots were sprayed on June 23 when plants were 5-6 ft tall; in 2012 applications were made on May 31 when plants were 4-5 ft tall; and in 2013 miticides were applied on May 23 when plants were about 4 ft in height. Harvest was on August 3, August 14, and August 6, in 2010, 2012 and 2013 respectively.

Due to the size of the trials, calibration of equipment, and desire of the chemical companies, rates of the materials varied from year to year. In addition, new miticides came on the market and were included in later trials. The table below summarizes which materials and rates were used in each trial.

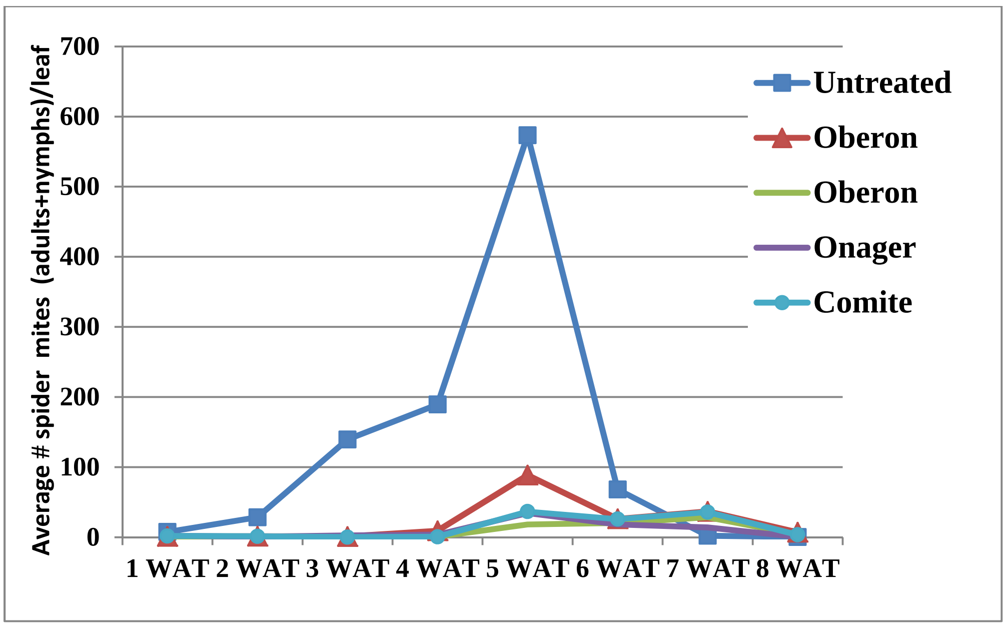
Table 2. List of treatments for 2010, 2012 and 2013 spider mite trials, Tulare County, CA.

Treatment	**Rate per Acre**	**Maximum Label Rate/Application**	**2010**	**2012**	**2013**
Untreated			Yes	Yes	Yes
Comite	3 pts	3 pt	Yes	Yes	Yes
Oberon 2SC	12.8 fl oz	16 fl oz	Yes	Yes	--
Oberon 2SC	16 fl oz	16 fl oz	Yes	--	Yes
Onager	16 fl oz	24 fl oz	Yes	Yes	--
Onager	20 fl oz	24 fl oz	--	--	Yes
Zeal	2.5 oz	3 oz	--	--	Yes
Zeal	3.0 oz	3 oz	--	Yes	--
Miteus SC	2 pt	2 pts	--	--	Yes

To assess <u>spider mite populations</u>, the fourth or fifth leaf from the ground was randomly selected at weekly intervals from the 2 center rows of each plot. Leaves were collected 50-100 ft from either end of the field, placed in paper bags and refrigerated until counted, usually on the same or the following day. In 2010 and 2013, eight leaves from each end of the trials were collected for counting spider mites. In 2012, six leaves from each end were collected for a total of 12 leaves per plot.

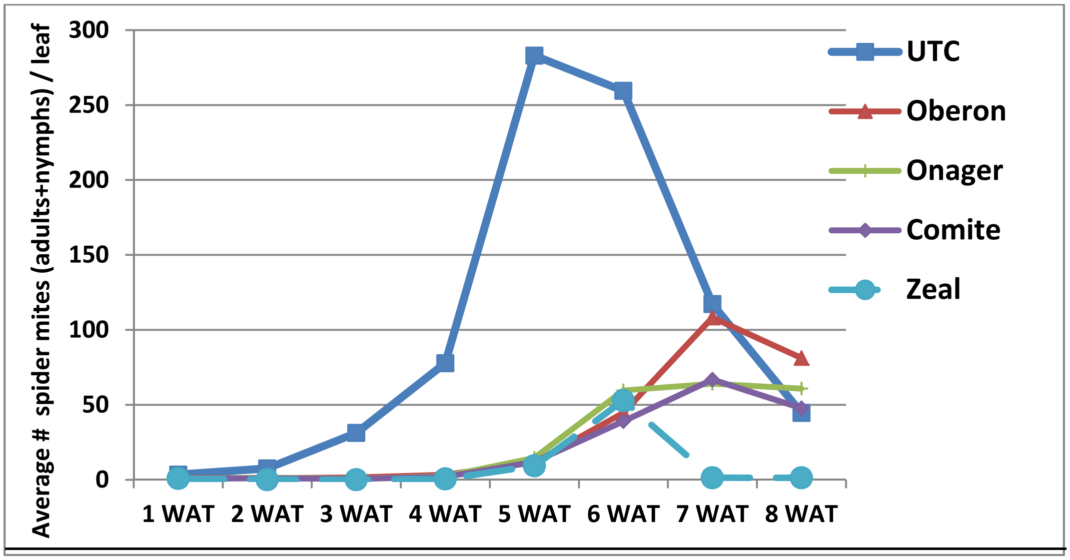
In 2010 (Figure 3), the spider mite population in the untreated control (UTC) built up a moderate population for several weeks, rose to a peak around 600 spider mites per leaf and then quickly dropped. Counts did not differ among the miticide treatments remaining low throughout the trial, although the Oberon at mid-label rate increased noticeably for a short time in early August.

Fig. 3.Average number of spider mites (adults+juvenile) per leaf , based on 16 leaves, 2010 Tulare County Trial, Tulare, CA



In 2012 (Figure 4), the spider mite populations in the UTC again built up a moderate population but this population was sustained for a week before slowly declining. Not shown in the data but observed was that the population moved up to the ear leaves as lower leaves desiccated in the UTC. In mid-July, the populations started to increase in each of the miticide-treated plots but they never reached the levels found in the UTC. Furthermore, in the Zeal plots populations dropped quickly back down to very low numbers within a week. At harvest in 2012, the lower leaves in the UTC were visibly drier than the lower leaves in treated plots.

Figure 4.Average number of spider mite (adult+juvenile) per leaf, based on 12 leaves, 2012 Tulare County Trial, Tulare, CA.



In 2013 (Figure 5), the population in the UTC rose quickly and then dropped very quickly. Comite and Zeal treatments remained low throughout the season. Populations in the Oberon, Onager and Miteus treatments increased noticeably for short periods before decreasing. High numbers of predatory spider mites were observed in 2013 (Figure 6) and possibly account for the rapid reduction in the spider mite population in the untreated check as well as helping to keep numbers down in the treated areas.

Figure 5. Average number of spider mites (adult+juvenile) per leaf, based on 16 leaves, 2013 Tulare County Trial, Tulare, CA.

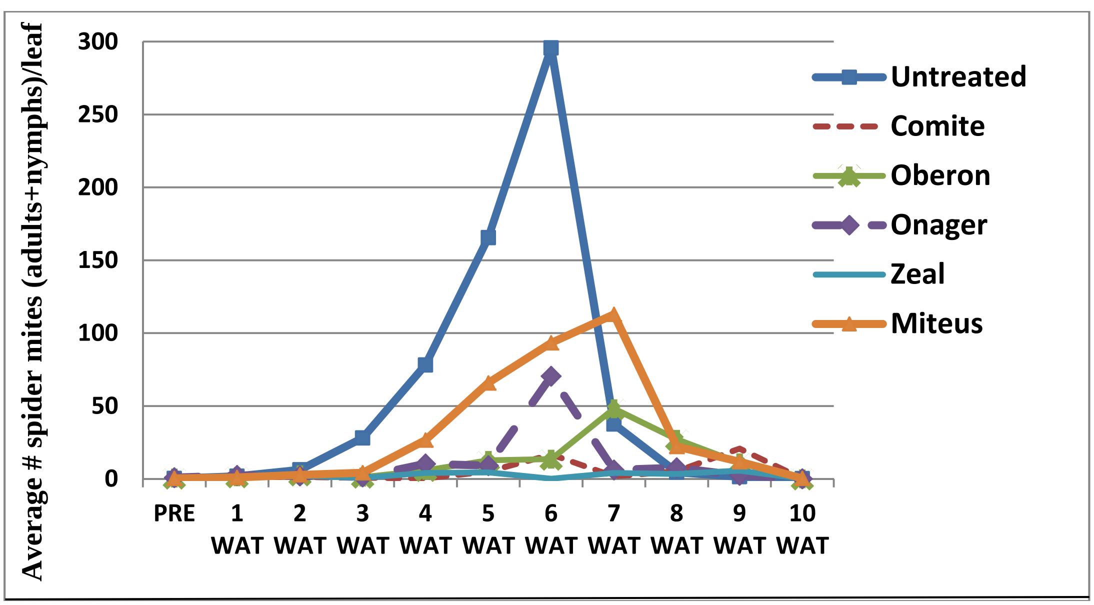
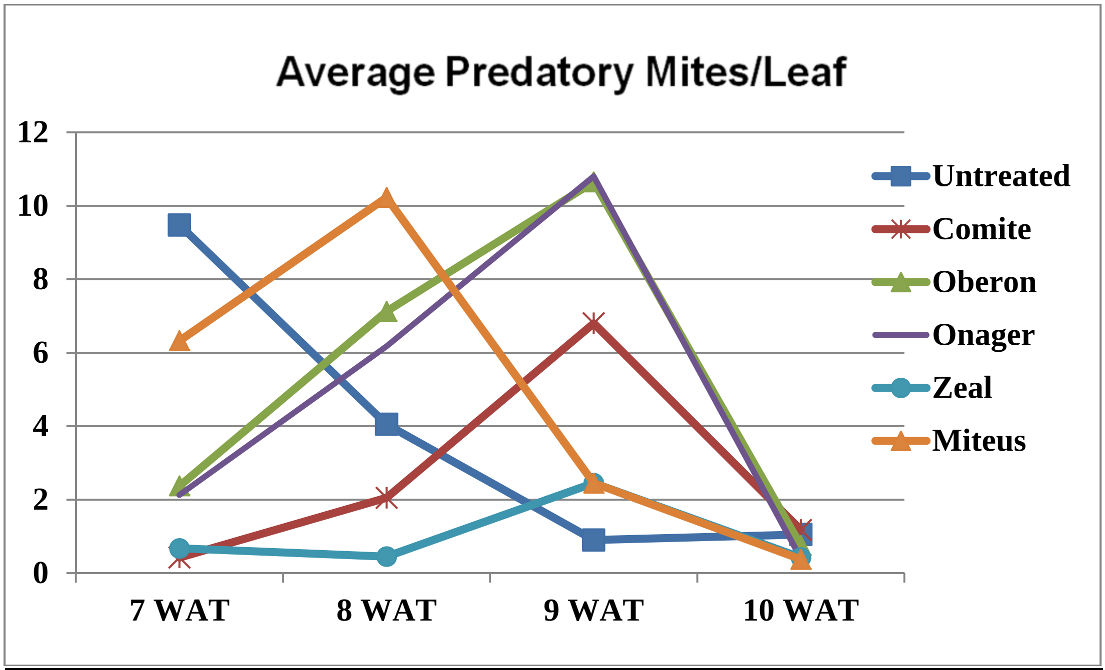


Figure 6. Average number of predatory mites per leaf, 2013 Tulare County Trial, Tulare, CA.



Yields were obtained by weighing the silage trucks and collecting moisture samples at the silage pile. In 2010 and 2012, 5 rows at or near the center of each plot were weighed for yield data. In 2013 yields were determined from the harvest of 6 rows from the center of each plot.

In 2010 and 2012, there were no differences in the moisture at harvest among treatments but in 2013 the Zeal treatment had significantly higher moisture than the Comite and the Miteus treatments (Table 3). Onager and Oberon had significantly more moisture than Comite plots.

Yields (Table 3) are shown adjusted to 70% moisture for all 3 years. In 2010, yields ranged from a low of 33.0 tons/acre for the UTC to a high of 39.4 tons/acre. There were no differences among the miticide materials and they significantly produced more than the untreated check by an average of 6 tons/acre.

In 2012, yields ranged from a high of 41.4 tons/acre to a low of 32.4 tons/acre for the UTC. Comite and Zeal applications, which were applied at maximum label rates, produced higher yields than Oberon and the UTC. Onager out-produced the untreated check but did not yield better than Oberon. In this trial, Oberon and Onager were applied at mid-label rates.

In 2013, the range between the lowest and highest yielding treatments was much smaller than in the previous two years with a low of 38.6 and a high of 41.6 tons/acre, less than 3 tons/acre difference. Yield from the UTC was not significantly less than any of the miticide treatments with the exception of Comite. Comite at the high label rate produced yields significantly higher than the UTC, Oberon (high label) Zeal (mid-label) and Miteus treatments. Although mite counts this year for the untreated check reached about the same peak as in the previous year, the high population was not sustained for as long as it was in the preceding year, perhaps due (at least in part) to the high numbers of predatory mites.

Table 3. Yield results from 3 years of spider mite trials, Tulare County, CA[1]

		Percent Moisture at Harvest			Tons/A adj. to 70% Moisture		
Treatment	**Rate per Acre**	**2010**	**2012**	**2013**	**2010**	**2012**	**2013**
Untreated	--	67.8	59.6	65.9 ab	33.0 b	32.4 d	39.4 bc
Comite	3 pts	68.0	64.2	64.1 c	38.9 a	37.7 b	41.6 a
Oberon 2SC	12.8 fl oz	68.2	63.0	--	39.4 a	34.3 cd	--
Oberon 2SC	16 fl oz	67.4	--	66.2 ab	38.4 a	--	38.6 bc
Onager	16 fl oz	67.9	62.8	--	39.3 a	36.3 bc	--
Onager	20 fl oz	--	--	66.2 ab	--	--	40.2 ab
Zeal	2.5 oz	--	--	67.1 a	--	--	38.3 bc
Zeal	3.0 oz	--	64.1	--	--	41.4 a	--
Miteus SC	2 pt	--	--	64.7 bc	--	--	38.2 c
Probability		*>50*	*0.41*	*0.03*	*0.02*	*0.00*	*0.02*
LSD (.05)		*NS*	*NS*	*0.02*	*3.86*	*3.17*	*1.98*
Coefficient of Variation (%)		*2.95*	*5.59*	*1.7*	*6.62*	*5.61*	*3.3*

[1]Values within a column followed by a common letter do not differ at the 5% level of probability.

Spider mites can also impact the pre-ensilage quality of corn. In 2012, all the miticide treatments except Oberon (mid-label rate) had significantly lower percent acid detergent fiber (ADF %) and neutral detergent fiber (NDF %) than the UTC. In 2010, although individually the miticide treatments did not reduce the % ADF, when analyzed as a group they reduced the % ADF from 30.1% for the UTC to an average of 28.2% for the miticide treatments. The difference that year in %NDF was not significant. In 2013 there were no differences in % ADF or % NDF digestibility (30 hr) among any of the treatments.

Table 4. Fiber analyses from 3 years of spider mite trials, Tulare County, CA.

Treatment	Rate per Acre	Acid Detergent Fiber (%) 2010	Acid Detergent Fiber (%) 2012	Acid Detergent Fiber (%) 2013	Neutral Detergent Fiber (%) 2010	Neutral Detergent Fiber (%) 2012	NDF digestibility-30 hr (%) 2013
Untreated	--	30.1	32.3 a	26.1	47.6	50.7 a	49.5
Comite	3 pts	28.4	27.3 bc	25.3	46.0	43.1 bc	51.3
Oberon 2SC	12.8 fl oz	28.0	30.3 ab	--	44.4	47.7 ab	--
Oberon 2SC	16 fl oz	28.5	--	26.4	46.0	--	50.5
Onager	16 fl oz	27.9	28.0 bc	--	45.0	43.5 bc	--
Onager	20 fl oz	--	--	26.2	--	--	50.8
Zeal	2.5 oz	--	--	26.1	--	--	50.6
Zeal	3.0 oz	--	25.8 c	--	--	40.4 c	--
Miteus SC	2 pt	--	--	26.8	--	--	50.4
	Probability	*0.33*	*0.01*	*0.69*	*0.26*	*0.01*	*0.70*
	LSD (.05)	*NS*	*3.25*	*NS*	*NS*	*4.90*	*NS*
	Coefficient of Variation (%)	*5.59*	*7.26*	*4.90*	*3.08*	*6.98*	*3.00*

SUMMARY

In small plot trials conducted at the UC West Side Research and Experiment Center, Zeal was most effective in controlling spider mite populations. Oberon provided very little control and Onager and Miteus performed in the middle. In large scale trials, spider mite infestations impacted yield and quality of corn for silage. Currently registered miticides were effective, when applied by ground, in reducing spider mite populations and, in two of three years, increased yields by 6 to 9 tons/acre compared to untreated plots. In the third year, only one treatment (Comite) produced significantly higher yields than the UTC by just over 2 tons/acre. In general, Zeal and Comite reduced spider mite counts the most with Oberon, Onager and Miteus also reducing counts but to a lesser degree. Oberon's performance in 2010 was excellent but spider mite counts and yield results were less impressive in 2012 and 2013. Together with the results from the small trials conducted 60 miles to the west, it raises the question as to whether or not there are populations of spider mites with resistance to that acaricide. It is important for pest control advisors and growers to be alert to areas where resistant populations may be occurring. The mode of action for each of the miticides tested in these trials is different which provides the opportunity to rotate materials and minimize selection pressure for development of resistant spider mite populations and the loss of effective miticides.

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