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IN THIS ISSUE

CITRUS PEELMINER EVADES CHEMICAL CONTROL

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Introduction

As an adult, the citrus peelminer (*Marmara gulosa* Guillen and Davis) is a tiny moth, ¼ inch in length (Guillen et al. 2001). When it attacks citrus, it lays its eggs on the outside of the fruit, the eggs hatch, and the small larvae bore in and tunnel just under the top layer of the rind. The larva moves its head back and forth as it chews, thus creating a mine. As it molts (4-7 times), the larvae and the mine gradually increase in size. After 1-2 weeks (depending on the weather) the larva changes in form and turns pink. At this time, it has developed special mouthparts by which it exits from the mine, moves to a leaf or twig and begins spinning a pupal case. The peelminer remains as a pupa for 1-2 weeks and then emerges as a moth.

During the early to mid 1990s, citrus peelminer was considered to be a minor pest of citrus in the San Joaquin Valley. It was found primarily attacking the fruit of a few Kern County grapefruit and pummelo orchards and infesting the stems of neighboring oleanders and willows. It rarely attacked more than 3% of the fruit in these citrus orchards. Since 1999, citrus peelminer has been an increasing problem in Tulare County. It has attacked a wide variety of grapefruit and navel oranges, it has increased its damage of preferred citrus varieties from 3% to 30-80% of the fruit in an orchard, and it has been found heavily infesting a number of host plants it was previously rarely seen on, including grapes, cotton, stone fruits, ornamentals, vegetables and weeds. This change in behavior suggests that a new biotype of the species has arrived in the region. During the winter freeze of 1998-99, when much of the local citrus fruit could not be marketed, the Tulare County Ag Commissioner's office field biologist observed that peelminer-infested fruit arrived in Tulare County from Mexico. These shipments could not be rejected because the peelminer is considered to be a native species. Problems with citrus peelminer have grown since this period. While morphological studies have not demonstrated differences between the southern California strain that shows periodic outbreaks and the problematical Tulare County strain, it is possible that a new strain entered the region.

Citrus peelminer infestations were severe in 2000, 2001 and 2002 in susceptible varieties of citrus including pummelos, grapefruit and early navels such as 'Fukumoto,' 'TI,' 'Barnfield' and 'Atwood.' In 2001 and 2002, stems and berries of table grape varieties with large berries such as 'Red Globe' were attacked by peelminer. Both citrus and table grape growers experienced rejection of shipments by foreign countries because of peelminer-infested fruit during 2001. Citrus, table grapes and nursery stock have been most severely affected by citrus peelminer. Crops such as cotton, dry beans, vegetables (peppers, squash, eggplant), and ornamentals are not usually economically damaged by citrus peelminer, but can host populations that then invade citrus. Citrus peelminer infests, but does not build up to very high densities, in a wide variety of other crops such as walnuts, avocados, pomegranates, olives and stone fruits.

Materials and Methods

During 2001 we conducted several insecticide trials to determine if we could reduce the number of citrus fruit that became infested with peelminer. Trial 1 was conducted in a 'Melogold' grapefruit block. We examined every piece of fruit on each of 5 trees (single-tree replications) per treatment and rated the fruit as infested or uninfested. We used a Bean handsprayer to apply the insecticides (300 psi, 300 gallons of water per acre) on July 13, 2001. Insecticides tested included Lorsban, Assail (unregistered), AzaDirect, Success, Danitol, Mesa and Micromite (unregistered), 0.5% Sunspray oil, Confirm (unregistered), Intrepid (unregistered), and Platinum applied to the soil (unregistered) (Table 1). Sunspray oil 0.5% was added to all treatments except the systemically applied Platinum and the Confirm and Intrepid treatments in which CS7 (alkyl aryl polyethoxylate and sodium salt of alkylsulfonatedalkylate 60%; Dow AgroSciences) was used as a surfactant. There were also 5 untreated trees that acted as controls. The mean number of infested fruit per tree was calculated before and after treatment using ANOVA followed by the LSD mean separation test.

The second trial was conducted in a 'Fukumoto' navel orchard. We treated large groups of trees hoping to see a greater effect of the insecticides. The grower used a speed sprayer (150 gallons per acre at 2 mph) to treat 6-row swaths with Success, Esteem, Agri-Mek, Baythroid, or Lorsban on August 16, 2001 (Table 2). Half of the acreage had been treated systemically in May with 32 oz of Admire. All treatments except Lorsban, were combined with 0.5% Sunspray oil, and the Esteem+Admire treatment accidentally received 2.5% oil. One untreated swath and one swath treated only with Admire acted as controls. We examined every citrus fruit on 10 trees in the center two rows of each of the treatments and rated them as infested or uninfested. The mean number of infested fruit per tree was calculated before and after treatment using ANOVA followed by the LSD mean separation test.

In 2002 we conducted a third trial in 'Fukumoto' navels. We used a Bean handsprayer (300 psi, 300 gpa) to treat 6 single-tree replications per treatment with Esteem, Intrepid, Provado, Success, Micromite, Micromite combined with Esteem, Micromite+Success and Surround (kaolin clay) (Table 3). All treatments except the untreated control and Surround were combined with 0.5% 415 Sunspray oil. Six trees were left untreated as controls. We examined all of the fruit on each of the 6 single-tree replications per treatment before and after treatments were applied. In this trial, the sampling method included not only counting the number of fruit mined on each sample tree, but also the amount of surface area mined for each fruit. The percentage area of citrus fruit mined was transformed arcsine (squareroot x) before analysis was conducted. The mean number of infested fruit per tree and the mean percentage surface area mined were calculated before and after treatment using ANOVA followed by the LSD mean separation test.

Results

In trial 1, there were 2-5 fruit per tree infested with small mines just before treatment and the number of fruit infested per tree was not significantly different among the various treatments (F=1.38, df = 11,48, P = 0.21) (Figure 1). At two weeks post-application, most of the treatments had experienced a doubling in the number of fruit infested with mines, and there were no significant differences among treatments (F=1.03, df = 11,48, P = 0.43). The Mesa and Micromite treatments had the lowest increase in the number of mined fruit per tree. At four weeks post-application, the number of infested fruit had increased to 8-17 per tree, and there were still no significant differences among treatments (F=1.06; df = 11,48; P=0.42). Thus, none of the insecticides fully protected fruit from citrus peelminer egg laying, egg hatch, and larval development 4 weeks after treatment.

At the start of trial 2, 10-13 fruit per tree were infested with peelminer larvae (Figure 2). Two weeks post-application, the number of infested fruit had increased to 15-29 per tree in all treatments. Again, the treatments did not prevent citrus peelminer moths from depositing eggs, or eggs from hatching, or larvae from forming new mines. We resampled a subset of the treatments (Success, Esteem, Agri-Mek and Lorsban in the absence of Admire) at 4 weeks post-application and saw further increases in the number of fruit mined, similar to the levels seen in the controls (an additional 8-10 fruit per tree mined). Thus, insecticides did little to slow the increase in peelminer population in this orchard.

In trial 3, the progression of mined fruit (Figure 3) was similar to that seen in the previous two trials. Initially, there were 21-23 fruit per tree with mines and no significant differences among treatments (F=0.01; df = 9,50; P=1.00). The number of mined fruit per tree increased to 36-70 fruit two weeks after treatments were applied. The application resulting in the smallest increase was Micromite+Esteem+oil (from 21 to 36 fruit per tree); however, the average number of fruit infested per tree was not significantly different from the controls (F=1.61; df = 9,50; P=0.14). Four weeks after sprays were applied, the number of mined fruit had increased to 49-88 fruit per tree. The Micromite+Esteem treatment continued to show the lowest increase of infested fruit (49 fruit per tree); however, the number of fruit per tree was not significantly different from the controls (F=1.34; df = 9,50; P=0.24). The grower estimated that an average of 50% of the untreated fruit in this orchard was mined by citrus peelminer, which resulted in a 15-20% reduction in fruit grade in the packinghouse from fancy (1st grade) to choice (2nd grade), or from choice to juice.

Growers suggested to us that lightly mined fruit (<25% of the surface area mined) experience little or no down grading in the packinghouse. When we determined how much of the surface area was mined during the pretreatment sampling, we found that less than 15% of the infested fruit was heavily mined (>25% of the surface area damaged). Four weeks after treatment (Figure 4) the surface area mined had greatly increased and there were significant differences among treatments (F=3.72; df = 9,50; P = 0.0013). The surfaces of the fruit in the untreated controls and in treatments of Provado+oil and Surround were extensively mined (28-36% of infested fruit with heavy mining), indicating little control of peelminer. Treatments of full and half rates of Micromite+oil, Intepid+oil, Success+oil, and Micromite+Success+oil showed significant reductions in the percentage of heavily mined fruit. The greatest reduction in mining occurred for the Esteem+oil and the Micromite+Esteem+oil. In these treatments, we found only 7-10% heavily mined fruit (25-100% surface area affected) that is likely to be severely downgraded.

Discussion

The slowing of mining and the reduction in the surface area of the fruit damaged was helpful but did not fully solve the problem, as moths continued to deposit eggs and infest new fruit as the weeks progressed. There can be numerous generations of citrus peelminer entering a citrus orchard. In addition, at the time of year the moths are flying, fruit is rapidly expanding and thus providing untreated surface area for the moths to deposit eggs. Thus, if chemical control were the best option, then insecticides would have to be applied at frequent intervals. This is both expensive in terms of the cost of the insecticide, as well as in terms of pesticide resistance. Increased spray exposure will select for resistance in peelminer, as well as in other pests such as citrus thrips and California red scale. Finally, one of the most effective insecticides to date, Micromite, is not yet fully registered for California citrus. At this point, we are suggesting that growers avoid insecticide treatments, in order to allow natural enemies to control this pest.

Some San Joaquin Valley citrus growers have experienced greater damage due to citrus peelminer than others. Growers that have peelminer-preferred varieties such as pummelos, grapefruit, and ‘Fukumoto’ navels are at higher risk. In addition, citrus peelminer often builds up in neighboring crops such as grapes or cotton and disperses into citrus when those crops begin to senesce, putting growers in these interfaces at risk. Finally, the citrus peelminer damage seems to be most severe at the margin where it is expanding its range. In 2000, the most severe citrus infestations were in the Lindsay and Strathmore area of central Tulare County. In 2001, the peelminer range expanded northward towards the Woodlake area. By 2002, there were heavy populations in some locations in Fresno County. When the peelminer reaches a new region, the infestations are sometimes heavier than in orchards that have had a population for several years. This may be because the new areas are lacking diseases and parasites that help to reduce the population.

We tested a wide variety of insecticides from pyrethroid, neonicotinoid, organophosphate, insect growth regulator and other categories (Agri-Mek, Mesa, Success and Surround), and found that insecticides applied to citrus were relatively ineffective in slowing the progression of the peelminer infestation. We sampled for native parasitic wasps in February 2001 and July 2002 and found that there are various species attacking citrus peelminer, but, so far, they are not in high enough numbers to control it. A species of wasp, *Cirrospilus coachellae*, from the Coachella Valley of California is reared at UC Riverside and was released in 2001 and 2002 in the San Joaquin Valley. We do not know yet if the parasite has established and if it will do as well in the San Joaquin Valley as it did in other regions; however, we are hopeful that it will help to reduce the severity of citrus peelminer infestations. In Arizona and the Coachella Valley, outbreaks of citrus peelminer occur approximately every 10 years and then subside over a 3-4 year period. We do not yet know if the San Joaquin Valley peelminer outbreak will subside, or if it will continue to use a number of different crops as bridges to reach citrus and cause significant damage to susceptible citrus varieties.

Acknowledgments

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Guillen, M., D. R. Davis, and J. M. Heraty. 2001. Systematics and biology of a new, polyphagous species of *Marmara* (Lepidoptera: Gracillariidae) infesting grapefruit in the southwestern United States. Proc. Entomol. Soc. Wash. 103: 636-654.

Table 1. Trial insecticide treatments for citrus peelminer infesting 'Melogold' grapefruit.

Formulation	Chemical name	Class of insecticide	Rate/acre	415 oil or surfactant
Lorsban 4E	chlorpyrifos	organophosphate	3 pt	0.5% oil
Danitol 2.4 EC	fenpropathrin	pyrethroid	21 1/3oz	0.5% oil
Success	spinosad	fermentation product	6 oz	0.5%
Confirm 2F		insect growth regulator	16 oz	6 oz CS2
Intrepid 2F		insect growth regulator	8 oz	6 oz CS2
Micromite 80 WG	diflubenzuron	insect growth regulator	6.25 oz	0.5% oil
Azadirect 1.2%	azadirachtin	Neem	32 oz	0.5%
Mesa EC (1%)	milbemectin	fermentation product	20 oz	0.5% oil
Assail 70 WP	acetamiprid	neonicotinoid	5.7 oz	0.5% oil
Platinum 2 SC	thiomethoxam	neonicotinoid	16.6 oz	-
Sunspray 6E Oil	NR 415 oil	spray oil	0.5%	-

Table 2. Insecticide treatments for citrus peelminer infesting 'Fukumoto' navel oranges.

Formulation	Chemical Name	Class of insecticide	Rate per acre	% Sunspray 6E oil	Admire 2F
Success	spinosad	fermentation product	6 oz	0.5%	32 oz
Esteem 0.86	pyriproxifen	insect growth regulator	16 oz	2.5%	32 oz
Agri-Mek 0.15 EC	abamectin	macrocyclic lactone	10 oz	0.5%	32 oz
Baythroid 2	cyfluthrin	pyrethroid	6.4 oz	0.5%	32 oz
Lorsban 4E	chlorpyrifos	organophosphate	4 pts		32 oz
Success	spinosad	fermentation product	6 oz	0.5%	-
Esteem 0.86	pyriproxifen	insect growth regulator	16 oz	0.5%	-
Agri-Mek 0.15 EC	abamectin	macrocyclic lactone	10 oz	0.5%	-
Baythroid 2	cyfluthrin	pyrethroid	6.4 oz	0.5%	-
Lorsban 4E	chlorpyrifos	organophosphate	4 pts		-

Table 3. Insecticide treatments for citrus peelminer infesting 'Fukumoto' navel oranges.

Formulation	Chemical name	Insecticide class	Rate per acre	% Sunspray 6E oil
Success	spinosad	fermentation product	6 oz	0.5%
Micromite 80 WG	diflubenzuron	insect growth regulator	6.25 oz	0.5%
Micromite 80 WG	diflubenzuron	insect growth regulator	3.125 oz	0.5%
Esteem 0.86	pyriproxifen	insect growth regulator	16 oz	0.5%
Micromite+Success	diflubenzuron+spinosad	IGR+spinosad	10 oz + 6 oz	0.5%
Micromite+Esteem	diflubenzuron+pyriproxifen	IGR+IGR	6.4 oz + 16 oz	0.5%
Provado 1.6 F	imidacloprid	neonicotinoid	20 oz	0.5%
Intrepid 2F	methoxyfenozide	insect growth regulator	8 oz	0.5%
Surround	kaolin clay	repellent	50 lb	-

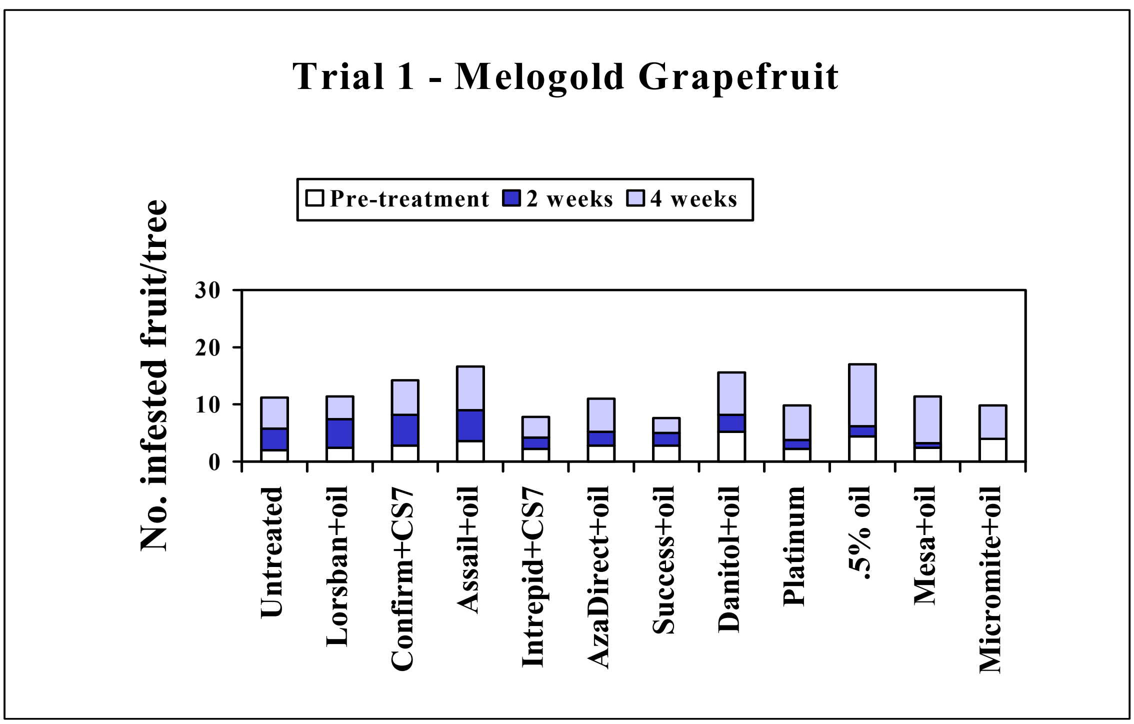

Figure 1. Effect of insecticides on citrus peelminer, Trial 1.

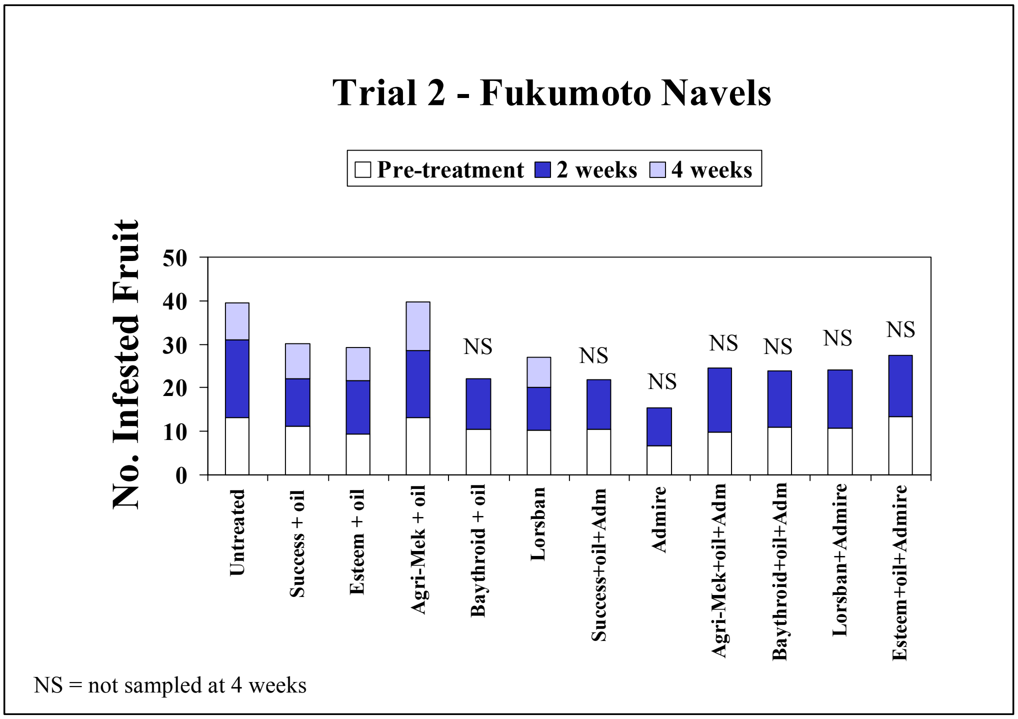

Figure 2. Effect of insecticides on citrus peelminer, Trial 2.

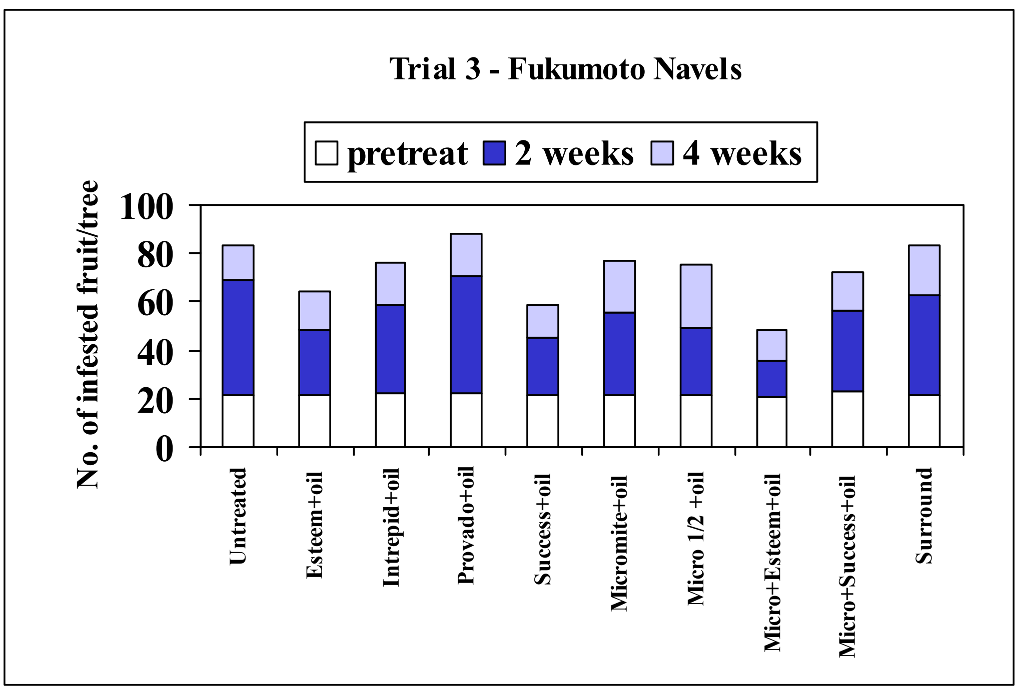

Figure 3. Effect of insecticides on citrus peelminer, Trial 3.

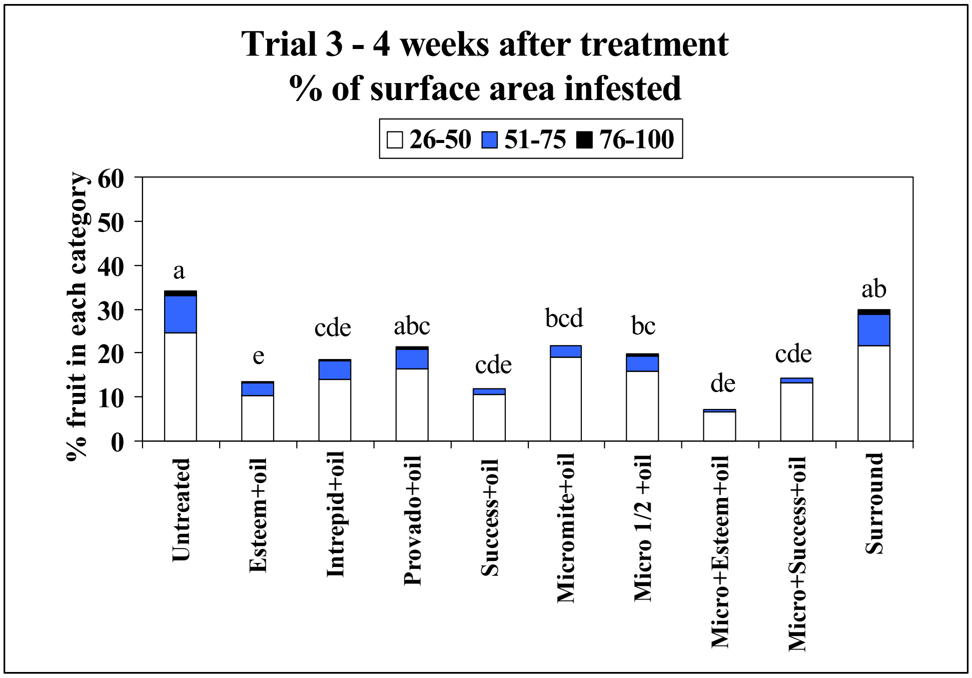

Figure 4. Percentage of fruit heavily infested by peelminer and likely to be downgraded.

EVALUATION OF CANDIDATE INSECTICIDES FOR CONTROL OF THE CORN LEAFHOPPER, *DALBULUS MAIDIS*, IN THE SAN JOAQUIN VALLEY

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Abstract

Candidate insecticides, including registered and non-registered materials, were evaluated for their ability to control the corn leafhopper. Thimet and Admire, applied at planting, reduced leafhopper population for approximately 30 days after application. Foliar applied Capture, Admire and Meta Systox R (MSR) reduced leafhopper populations for approximately 10 to 14 days. Prescribe seed treatment failed to maintain leafhopper populations below those of the untreated control. Due to the lateness of the season and cool weather, we were unable to determine if reductions in leafhopper populations resulted in a reduction in the incidence of corn stunt disease. Not all insecticides evaluated are currently registered for use on silage corn.

Introduction

The corn leafhopper, *Dalbulus maidis* (DeLong and Wolcott), is found on corn (*Zea mays* L.) throughout much of the southeastern and southwestern United States. In addition to yield losses caused by feeding injury (Bushing and Burton 1974), corn leafhopper is an important vector of corn stunt disease caused by *Spiroplasma kunkelii* (CSS). Corn stunt is a debilitating disease that can cause even greater yield losses than those attributable to leafhopper feeding alone (Nault 1985). In the United States, both feeding injury and corn stunt disease have been of greatest significance on late planted corn (Pitre et al. 1967, Bushing and Burton 1974). However, since 1996, the problem in California has appeared earlier each year and in 2002, significant losses occurred as early as June. In California, the corn leafhopper has been reported from Los Angeles, Riverside, Kern, Kings, Tulare and Fresno counties (Bushing and Burton 1974, Bushing et al. 1975). In 2002, we recovered corn leafhoppers from Madera, Merced, Stanislaus, San Joaquin, Sacramento, Solano and Yolo counties. *S. kunkelii* was also detected in leafhoppers from Sacramento County.

Corn leafhopper was first reported causing injury to field corn in Fresno and Tulare counties in 1942 (Frazier 1945). It is not known when CSS was first introduced, but Frazier (1945) described a "…. disease of corn apparently hitherto unreported from California ...." that fits the description of the disease caused by S. *kunkelii*. Corn leafhopper was again reported in the late 1960s (Bushing and Burton 1974, Bushing et al. 1975) and in

1981 (Steve Wright, personal communication). Apparently, damage was due solely to leafhopper, as no evidence of corn stunt disease was reported. Historically, corn leafhopper outbreaks have lasted only one or two years. In 1996, however, corn leafhopper populations reached extremely high levels on late maturing corn in Fresno, Tulare and Kings counties, and many fields had a high incidence of corn stunt. Since then, leafhopper populations and corn stunt disease have continued as a yearly problem, increasing in severity in the southern San Joaquin Valley.

Insecticides evaluated for corn leafhopper control appear to give mixed results with most providing only minimal, short-term protection (Bhird and Pitre 1972, Bushing and Burton 1974, Bushing et al. 1975, Summers and Stapleton 2002). The study described here was conducted to determine the efficacy of both registered and non-registered insecticides for corn leafhopper control in the San Joaquin Valley.

Materials and Methods

Location. Trials were conducted at the University of California Kearney Research and Extension Center, Parlier CA.

Corn Leafhopper Infestation. In order to ensure a large population of corn leafhoppers, we planted 12 rows (30 inch centers, 220 feet in length) of silage corn dubbed "the nursery field" on 17 June 2002. Beginning in July, we collected leafhoppers on a weekly basis from silage fields in Kings and Tulare counties and released them in the nursery field.

Insecticide Plot Preparation. Raised planting beds were formed with a tractor drawn bed shaper-tiller (B. W. Implement Co., Buttonwillow, CA). The distance between bed centers was 30 inches. Granular fertilizer (15-15-15) at 800 pound per acre was applied using a 'Vicon' applicator. Dual Magnum herbicide (Syngenta, Greensboro, NC) at 1.33 pints/acre, was applied to the beds in 50 gal of water per ha with an FMC hydraulic sprayer, Model DP20 3PT (FMC, Jonesboro, AR) equipped with 'Tee Jet 8004' (Spraying Systems Co., Bellwood, IL) nozzles. Both fertilizer and herbicide were incorporated to a depth of 6 inches with a second pass of the bed shaper, after which the beds were ring-rolled.

Plot Layout, Experimental Design and Planting. Treatments (insecticides) were arranged in a randomized complete block design with five (5) replications. There were a total of 12 treatments and the design used resulted in six plots (treatments) planted on one side (north) of the nursery strip and six on the other (south) side of the nursery strip. Each plot consisted of four (4) rows, 30 feet long. There was a 10 foot walkway between each plot and two unplanted rows (ca. 5 feet), the full length of the field, between each set of plots. The blank rows provided easy access for spraying and sampling without disturbing the plots. Plots were planted on 3 September 2002 using a tractor-drawn John Deere planter. Seed (Asgrow RX913) was planted approximately 1.5 inches deep and 4-5 inches apart within the row. Prescribe (imidacloprid, Gustafson, Plano, TX) treated seed (Pioneer 3223) was planted on 4 September 2002 using a 'Planet Jr.' hand planter. The planter was calibrated to deliver the same seeding rate at the same depth as the tractor-drawn John Deere planter. All plots were furrow irrigated the following day to facilitate germination and activate the soil-applied insecticides.

Insecticide Applications. Preplant Soil Applications. Thimet and Admire were applied preplant. Thimet granules were applied using a 'Clampco' applicator (Clampco, Inc., Salinas, CA). Granules were placed approximately one (1) inch off the center of the row and 1 to 1.5 inches below the seed placement. A lay-by application was made in the same manner. Admire insecticide, in the equivalent of 20 gal water, was injected into the soil using a tractor-drawn shank. The insecticides were injected approximately one inch off the center of the row and 1 to 1.5 inches below the seed placement.

Foliar Applications. Foliar applications were made using a CO_2^- powered backpack sprayer. Materials were applied in the equivalent of 20 gal of water per acre at 40 psi, using 'TX12 Conejet' nozzle tips (Spraying Systems Co., Bellwood Il.). See Table 1 for application dates, rates and formulations of all insecticides.

Movement of Leafhoppers from Nursery Corn to Insecticide Trial. To facilitate the movement of the corn leafhoppers from the nursery corn to the trial corn, the former was cut, using a sickle bar mower, on 20 September 2002. Although some leafhoppers had already moved from the nursery to the trial field, this is considered as the infestation date. The corn was allowed to "dry" for one week allowing all of the adult leafhoppers to move to the newly emerged trial corn. The nursery corn was then shredded, forcing any remaining leafhoppers into the trial corn.

Leafhopper Sampling. Leafhopper populations were sampled by taking D-vac suction samples from 1 meter (39 inches) of row in one of the two center rows. Stand counts were taken in all plots and final leafhopper numbers are presented as number of individuals per plant.

Corn Stunt Determination. On 12 November, 10 leaves from 10 plants in each plot were selected at random and tested by ELISA for the presence of *S. kunkelii.* A standard DAS Peroxidase ELISA assay was used (Agdia Inc., Elkhart IN). Symptomatic tissues from leaf veins which included phloem tissues were macerated in extraction buffer at a 1:10 wt to vol ratio. Samples were applied to a plate coated with specific antibody for CSS. The plates were washed and followed with enzyme conjugate and substrate to develop the assay according to a standard protocol. Both known positive and negative controls also were used.

Determination of S. kunkelii in leafhoppers. Five lots of five leafhoppers each, taken at random from the nursery field prior to cutting were tested for the presence of *S. kunkelii* using PCR techniques. Our method was based on that of Barros et al. (2001). Specific primers were developed to the Spiralin genes of the corn stunt spiroplasma. The most reliable set of primers "CSSF1" and "CSSR1" were used to develop a reliable assay for use in our diagnostic situation. Initially, the samples were prepared according to the methods of Barros et al. (2001), but were later modified to use a Fast Prep total DNA extraction method.

Statistical Analysis. The leafhopper population was evaluated by analysis of variance and the means separated with Fisher's Protected LSD (Abacus Concepts, 1989).

Results and Discussion

Leafhopper Testing for S. kunkelii. All five leafhoppers samples tested positive for the presence of *S. kunkelii.*

Leafhopper Control. In samples taken on 1 October 2002, all materials except Comite and Prescribe reduced adult leafhopper numbers below those in the untreated control (Table 2). Capture alone worked as well as the combinations of Capture and Comite or Capture and Dimethoate. Meta Systox R worked as well as Capture and any of its combinations. The soil applied Thimet and Admire continued to maintain leafhopper populations below those of the untreated Control for up to 5 weeks after application, which was about 4 weeks following seedling emergence (Table 2). The seed treatment Prescribe failed to keep adult populations below those of the untreated control (Tables 2 and 3). It is interesting that the soil- and foliar-applied Admire significantly ($P < 0.05$) reduced leafhopper populations below that of the untreated control, but Prescribe-treated seed did not. Both contain imidacloprid as the active ingredient. The reason is not known, but the finding will be evaluated again next year. By 14 days post-treatment (foliar sprays) and 6 weeks after the materials were applied preplant to the soil, control by all materials was beginning to break down with considerable statistical overlap present (Table 4). At this point, another application would have been needed to maintain control.

Corn Stunt Determinations. All samples were negative (ELISA) for *S. kunkelii.* We determined that due to the lateness of the season and cool temperature, the titer of *S. kunkelii* was too low to detect. This was confirmed by re-testing 10 leaves from 10 plants from the control plots, which all gave negative results. We then dug the plants up, placed them in pots, treated them with Thimet to kill any leafhoppers, and moved them into the greenhouse where they were maintained at approximately 85/50° F day/night temperatures. These same 10 plants, 10 leaves from each plant, were re-tested 30 days later and all were strongly positive for *S. kunkelii.*

Conclusions and Recommendation

The corn leafhopper is fairly easy to control with a number of insecticides, although the duration of control leaves something to be desired. The real question remains, can controlling the leafhopper result in a reduction in the incidence of corn stunt disease? This question will require additional evaluation, although Summers and Stapleton (2002), working with sweet corn, found that while foliar sprays and soil-applied materials significantly reduced populations of corn leafhopper, neither reduced the incidence of corn stunt infected plants. It appears that a preplant treatment of Thimet or Admire may provide up to 4 weeks of leafhopper control. It is not known at this time if this reduction in leafhopper populations resulted in a reduction in the incidence of corn stunt disease, or if the protection afforded provided sufficient time for the corn to develop beyond the stage where corn stunt had a significant impact on yield. Hruska and Peralta (1997) found that protection from infection from the seedling to whorl stage resulted in a significant reduction in the latter effects of corn stunt. While leafhopper feeding alone can cause yield and quality losses (Bushing et al.

1975), the greater threat is corn stunt disease. Together with the relationship between leafhopper control and the incidence of corn stunt disease, these are areas of badly needed research.

Due to inclement weather, we were unable to take any leafhopper samples following the lay-by application of Thimet, so we do not know the possible impact of this treatment, either alone on in combination with the preplant application. Plans for the coming year include: (1) an earlier trial where we can assess the impact of insecticides and leafhopper control on the incidence of corn stunt disease; (2) a lay-by application of Thimet four weeks after planting; and (3) a combination of soil- and foliar-applied Admire or a preplant and lay-by treatment with Admire.

Cautionary Statement

Admire, either as a soil application or a foliar spray, is currently **not** registered for use on silage corn. Growers are advised not to use this material in their production of silage corn. Likewise, Meta Systox R is currently registered **only** on sweet corn and does not have a registration for silage corn; thus, similar caution is advised.

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Table 1. Dates, formulations and rates of insecticide applications tested for the control of corn leafhopper, 2002. Parlier CA.

Material	Formulation	Rate a.i./A	Application Date
Control	—	—	—
Thimet (phorate)[a]-Planting	20G	1.2 lbs	30 Aug.
Thimet-Lay-by [1]	20G	1.2 lbs	14 Oct.
Thimet-Planting & Lay-by [1]	20G	1.2 + 1.2 lbs	30 Aug./14Oct.
Capture [2] (bifenthrin) [b]	2EC	0.10 lbs	27 Sept.
Capture+Comite [c]	2EC & 6.55EC	0.05 + 2.46 lbs	27 Sept.
Capture+ Dimethoate [2 d]	2EC + 4EC	0.10 + 0.50 lbs	27 Sept.
Admire (imidacloprid)[e] at Planting	2F	0.33 lbs	30 Aug.
Admire-Foliar	2F	0.25 lbs	27 Sept.
Prescribe [f] (imidacloprid) [e] Seed Treatment	—	—	3 Sept.
Meta Systox R [3 g]	2EC	0.50 lbs	27 Sept.
Comite (propargite)	6.55EC	2.46 lbs	27 Sept.

[1] Not sampled for leafhoppers due to cold, rainy weather conditions following the application
[2] Plus Agri-dex Spray [d] Adjuvant
[3] S-[2-(Ethylsulfinyl)ethyl] *O,O*-dimethyl phosphorothioate
Registered trade mark of: [a] Micro Flo, [b] FMC, [c] Unroyal, [d] Helena, [e] Bayer, [f] Gustafson, [g] Gowan

Table 2. Number of Adult Leafhoppers per Plant (1 October 2002) [1]

	Mean	
Capture	0.164	a
Capture+Dimethoate	0.192	a
Thimet @ planting	0.224	a
MSR	0.246	a
Thimet planting / lay-by	0.404	a
Capture+Comite	0.526	a
Admire @ planting	0.536	a
Admire – Foliar	1.078	a b
Prescribe seed treatment	1.710	b c
Comite	1.748	b c
Control	2.156	c
Thimet @ lay-by [2]	2.206	c

[1] Means followed by the same letter(s) are not significantly different at $P < 0.05$; Fisher's Protected LSD.
[2] Treatment had not been applied at time of sampling.

Table 3. Number of Adult Leafhoppers per Plant (4 October 2002) [1]

	Mean	
Capture+Dimethoate	0.146	a
Capture+Comite	0.170	a
Thimet @ planting	0.206	a
Capture	0.254	a
Admire @ planting	0.270	a
MSR	0.288	a
Thimet planting / lay-by	0.294	a
Admire – Foliar	0.412	a
Control	1.092	b
Prescribe seed treatment	1.164	b
Comite	1.598	b c
Thimet @ lay-by [2]	2.014	c

[1] Means followed by the same letter(s) are not significantly different at $P < 0.05$; Fisher' Protected LSD.
[2] Treatment had not been applied at time of sampling.

Table 4. Number of Adult Leafhoppers per Plant (10 October 2002)

	Mean	
Capture+Dimethoate	0.396	a
Thimet planting / lay-by	0.440	a
Capture+Comite	0.592	a b
Capture	0.602	a b
Thimet @ planting	0.690	a b c
Admire – Foliar	0.770	a b c
MSR	0.866	a b c
Admire @ planting	1.164	a b c
Comite	1.230	a b c
Control	1.854	b c d
Thimet @ lay-by [2]	2.060	c d
Prescribe seed treatment	2.764	d

[1] Means followed by the same letter(s) are not significantly different at P < 0.05; Fisher's Protected LSD.
[2] Treatment had not been applied at time of sampling.

ABSTRACTS

4TH NATIONAL IPM SYMPOSIUM, Indianapolis, IN, April 7-10, 2003

Effect of elevated CO_2 on C_3 crop endurance to a C_4 weed: Some preliminary findings. *Anil Shrestha, Shawn Ashkan, Dave Goorahoo and Genett Carstensen, University of California Kearney Agricultural Center; AG Gas[SM]; and Center for Irrigation Technology, California State University, Fresno*

Enrichment of CO_2 has been found to enhance crop growth. However, the effect of CO_2 elevation on crop-weed competition has not been adequately explored. This aspect is of further interest in C_3 crops which are often poor competitors with C_4 weeds. Any increase in the competitive ability of C_3 crops by CO_2 enrichment may result in an increase in weed thresholds and a decrease in the need for postemergence weed control. A study was conducted to test the effect of the density of a C_4 weed, purple nutsedge (*Cyperus rotundus*) on the growth and yield of a C_3 crop, tomato (*Lycopersicon esculentum*). The plants were grown in pots in the field under ambient CO_2 conditions and at elevated CO_2 levels ranging from 1.5 to 2 times ambient concentrations, with weed densities of 0, 1, 2, 3 and 4 nutsedge tubers/pot. Nutsedge densities up to 3 tubers/pot had no effect on tomato yield under elevated CO_2 conditions whereas, densities greater than 2 tubers/pot lowered tomato yield under ambient conditions. The tomato plants maintained their biomass under all levels of nutsedge densities in the elevated CO_2 treatment. In the ambient treatment, tomato biomass was lower when nutsedge density exceeded 3 tubers/pot. Elevated CO_2 had no effect on nutsedge biomass and number of tubers produced. Further studies are required to assess the impact of elevated CO_2 on crop-weed competition and their implications to integrated pest management.

Comparing the presence-absence sampling technique to a five minute search for webspinning spider mites. *Carolyn Pickel and Bill Olson, Statewide IPM Program UCCE Sutter-Yuba Counties and UCCE Butte County*

The presence-absence sampling technique for webspinning mites is a useful method of determining need for treatment and reduces likelihood of treating without justification. However, very few Pest Control Advisors (PCAs) use this technique because it is too time consuming. A "Five-minute search" monitoring technique, similar to what Pest Control Advisors (PCAs) currently use with a rating system added, was evaluated in 2001 and 2002. Results were then compared with the presence-absence technique to determine if any correlation between the two could be made. The "Five-minute search" monitoring technique for webspinning mites was performed in the same area of the orchard as the presence-absence technique, but the "Five-minute search" was conducted first so that scouts would not be influenced by the results of the presence-absence technique. The new monitoring technique involved looking for symptoms of webspinning mites, as well as, looking at individual leaves with a hand lens to evaluate mite predator and webspinning mite populations. The rating system included six categories that were assigned a numerical value for webspinning mites (none, low, low/moderate, moderate, moderate/high, high) and three categories for mite predators (low, moderate, high). There was a high correlation $R^2 = 0.63$, $P > 0.01$ in 2001 and $R^2 = 0.84$, $P > 0.01$ in 2002. The development of a technique similar to what is already used that is reliable, quantifiable, and enables quick assessment of population levels to make treatment decisions will be easier to implement.

Looking large; thinking wide: Understanding the landscape to manage western tarnished plant bugs. *Peter B. Goodell and Kris Lynn, UCCE and DANR University of California Kearney Agricultural Center*

Western tarnished plant bug (WTPB) is a pest on many agronomic and horticultural crops in California's San Joaquin Valley. In most crops, this pest moves into the field from external sources such as neighboring crops or plants. Understanding and characterizing the landscape in which WTPB develops will be key in improving IPM approaches to its management. We have developed tools and approaches to examine township scale areas for crop mix, spatial arrangement, temporal changes, and source/sink relationships. Many of these tools are based in ArcView GIS programs and routines. Timely land use maps have been obtained for Kern County through the Agricultural Commissioner's office. These were used to compare and contrast 50 townships for cropping composition and adjacency of cotton and alfalfa forage. In one 5,000 acre cropping community, WTPB was monitored through the year and its population densities represented spatially.

IPM in California cotton: How integrated is it? *Sonja B. Brodt, Peter B. Goodell, and Rose L. Krebill-Prather, University of California, Davis; University of California Kearney Agricultural Center; and Washington State University, Pullman*

A comprehensive mail survey of 266 California cotton growers examined trends in use of a large array of pest control practices, ranging from pest monitoring methods to use of organophosphate insecticides. Some preliminary results from data analysis by the University of California Statewide Integrated Pest Management Program will be presented here. The current analysis focuses on the degree of integration of biological, cultural, and chemical pest control practices for a few of the most significant pests of cotton.