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Editors

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ARTICLES

DETERMINING THE ECONOMIC IMPACT OF WEED CONTROL IN ICEBERG LETTUCE USING VARIED RATES OF KERB IN COMBINATION WITH HAND HOEING, *Timothy S. Prather, U.C. Kearney Agricultural Center*

Objectives

Kerb (pronamide) is one of only a few herbicides registered for use in lettuce and loss of Kerb would leave farmers with few weed management options. The objective of these studies was to calculate the economic benefit from using Kerb to control weeds. Several rates of Kerb in combination with hand hoeing were examined, and costs associated with these weed control operations were computed. The main weeds were shepherdspurse, stinging nettle and hairy nightshade, with lesser numbers of black nightshade, common purslane, annual sowthistle and common malva.

Procedures and Results

Six studies were conducted from Salinas to Gonzalez, three in fall 1995 and three in spring 1996. The studies contained four treatments, replicated three times in a randomized complete block design. Plots were four 40 inch wide beds by 75 feet in length. Treatments included: (1) Kerb broadcast applied at 2 lb ai/acre, (2) Kerb banded (two 5” bands) at 2 lb ai/acre, (3) Kerb banded (two 5” bands) at 1 lb ai/acre, and (4) no Kerb; hand weeding during thinning and as needed during the season. Five previous studies were conducted from 1994 to spring of 1995 with two additional herbicide rates, 1 lb ai/acre broadcast and 0.75 lb ai/acre banded. Herbicides were applied immediately following planting and incorporated with overhead sprinkler irrigation the following day.

Each site was cultivated as per normal field operations. Farm laborers were supplied by the grower or contractor and observed during thinning and weeding to determine time required to thin and hoe each plot. Data collected included plant stand counts prior to thinning and hand weeding, time required to thin lettuce, time required to hand hoe weeds, and yield. All data were analyzed using analysis of variance and means were separated using Fisher's Protected LSD at the 5% level of probability. Fall locations did not have high weed populations and data are not presented. Two locations in the spring of 1996 had high weed populations and results from these sites are presented along with total weed control cost summaries from two earlier studies that had low and moderate weed populations. The two locations are coded A (north of Salinas) and B (south of Salinas).

Lettuce stand counts made prior to thinning and at hand weeding showed no treatment differences in the number of lettuce plants (data not shown). Lettuce appeared to be vigorous and uniform throughout the trial area. Shepherdspurse, stinging nettle, and hairy nightshade were the primary weeds present. Weed populations were higher at site B than site A. Kerb applied at a rate of 2 lb ai/acre (broadcast) controlled shepherdspurse better than banded treatments and the unsprayed controls (Figure 1a and b). The 2 lb ai/acre banded treatment had fewer shepherdspurse than the unsprayed control at one site (Figure 1b). Stinging nettle plant density was lowest in the broadcast treatment and increased as the amount of Kerb applied decreased, and was lower in the 2 lb ai/acre banded treatment than the unsprayed control (Figure 1b). Total weed density was always lowest in the broadcast treatment but banded treatments had fewer weeds than the control (Figure 1a and b).

Effects on Thinning

Plots with Kerb applied at 2 lbs ai/acre, banded or broadcast, took 4 to 8 hours/acre less to thin than the unsprayed controls. The 2 lb ai/acre banded treatment took 4.5 to 6.1 hours/acre less to thin than unsprayed controls. At a labor cost of $7.21/hour this translates to savings of $32 to $44/acre. Savings were less at site B, most likely because sheperdspurse was at high levels and was less susceptible to Kerb than stinging nettle. The 1 lb ai/acre banded treatment also had lower thinning times 4 hours less than unsprayed controls ($29/acre savings). Herbicide application lowered weed densities, affecting thinning times more than hand weeding times. Some lettuce plants were lost in areas with high weed densities but laborers were able to adjust the spacing of the next 1 to 2 plants, keeping the average number of plants per yard of row the same. Laborers did remove weeds close to the lettuce plants during thinning by hand. Hand removal required more time and also diminished the benefit of the long-handled hoe. Observations indicated laborers removed weeds by hand every 2 to 5 steps.

Effects on Weed Control

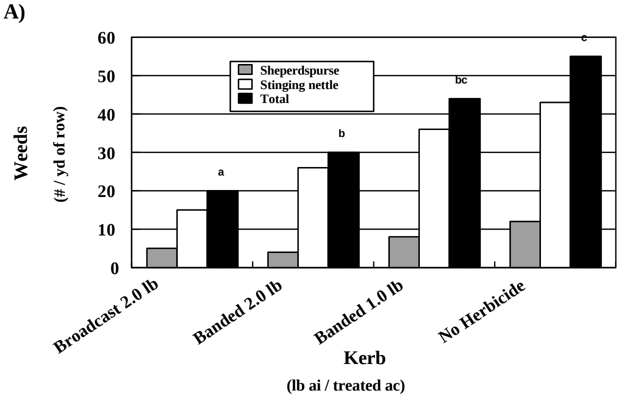
Cultivation and thinning removed most weeds, but left one to six weeds for every 1 yard of bed (Figure 2 a and b). The broadcast treatment had significantly fewer weeds than the unsprayed control (Figure 2a and b), but neither banded treatment had fewer weeds than the control. Plots treated with Kerb 2 lb ai/acre broadcast took 4 to 8 hours less time to hand weed than the unsprayed controls, resulting in an additional cost savings of $28.84 to $56.96 per acre in labor over the unsprayed controls. Weed density was not statistically less for 2 lb ai/acre banded rate, but weeding time was less at site A (2.2 hours), saving $10.04 per acre.

Post thinning stand counts showed that lettuce density was the same across treatments. This translates to yields that were also the same across treatments except at site B. At site B, yield of #30 size was reduced, resulting in yield loss for all but the broadcast treatment. Yield of #24 size was not affected. Crop value was $770/acre higher for the broadcast treatment than the untreated control. Banded treatments also out-yielded the control; crop value was $428/acre higher for the 2 lb ai/acre treatment, and $404/acre higher for the 1 lb ai/acre treatment than the control, respectively. The total additional crop value from Kerb application was $808/acre, $466/acre and $442/acre for 2 lb broadcast, 2 lb banded and 1 lb banded, respectively.

Historically, farmers have diligently controlled weeds in lettuce, as evidenced by the nine sites studied having low weed populations (less than 30 weeds/yard of row). Weed control costs were least for the unsprayed treatment when weed populations were at or below 5 weeds/year of row (Figure 5). Banded treatments of 1 lb ai/acre had lowest costs between 5 and 50 weeds/yard of row (Figure 5). Between 50 and 135 weeds/yard of row, 2 lb ai/acre banded had the lowest costs (Figure 5). All sites were managed to prevent yield loss by increasing the investment in hand labor. Yield loss did occur at the highest weed density (135 weeds/yard of row), but it is not known at what density yield loss takes place. In addition, the highest weed densities occurred in the spring, indicating fall weed densities may be lower. Farmers should consider avoiding a field rotation that would result in lettuce planted in the spring in a very weedy field.

Herbicide application was most important in its effect on reducing thinning time at moderate to low weed densities. A 1 to 2 lb ai/acre banded application minimized weed control costs in most cases. If weed populations returned to higher weed densities like these in this study, costs could rise by $3,301,420 for the 71,770 acres in Monterey County.

A)



B)

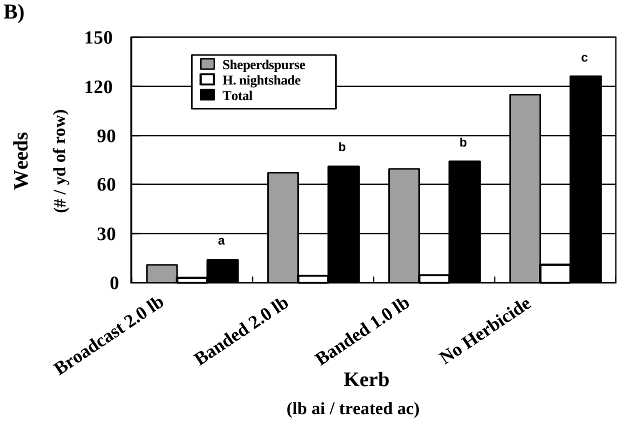
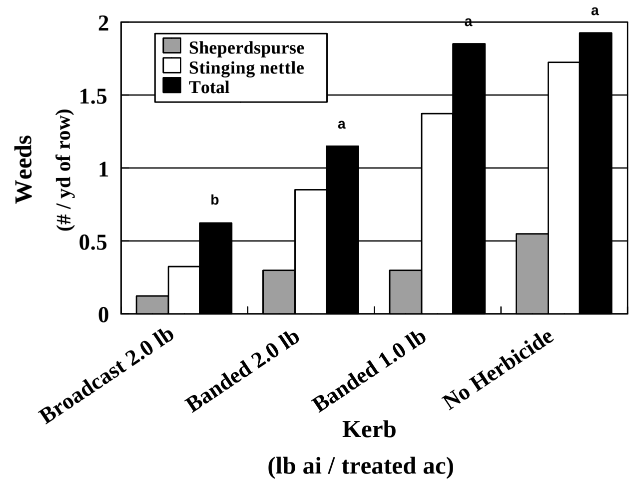


Figure 1. Weed density prior to thinning. Bars for Total with the same letter are not statistically different. Statistical comparisons for individual species are not shown. Site A was north of Salinas; site B was south of Salinas.

A)



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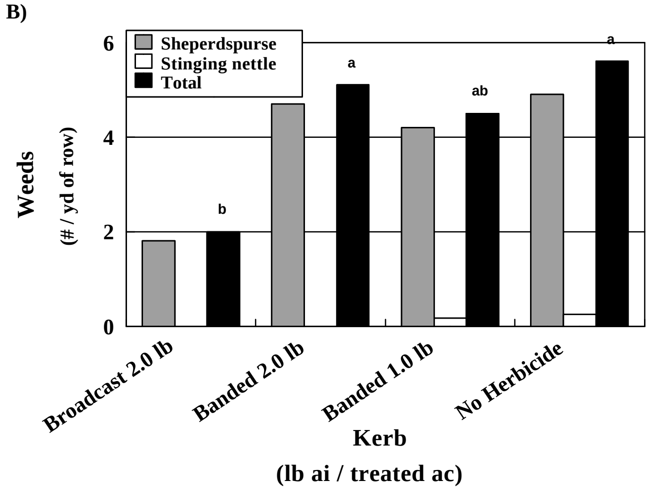
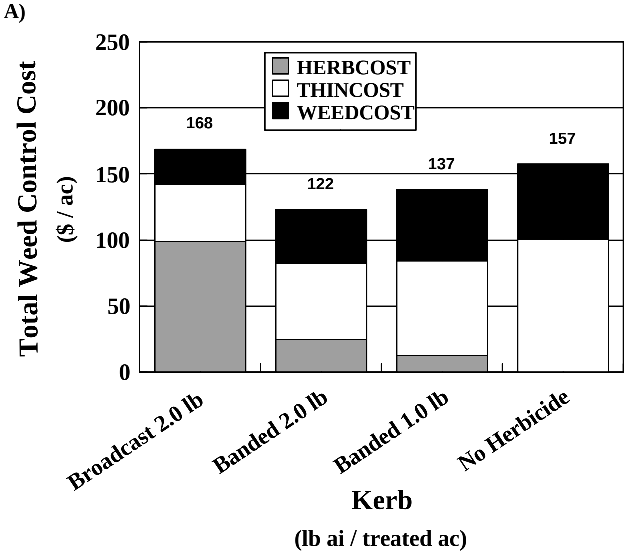


Figure 2. Weeds present prior to hand weeding. Bars for Total with the same letter are not statistically different. Statistical comparisons for individual species are not shown. Site A was north of Salinas; site B was south of Salinas.

A)



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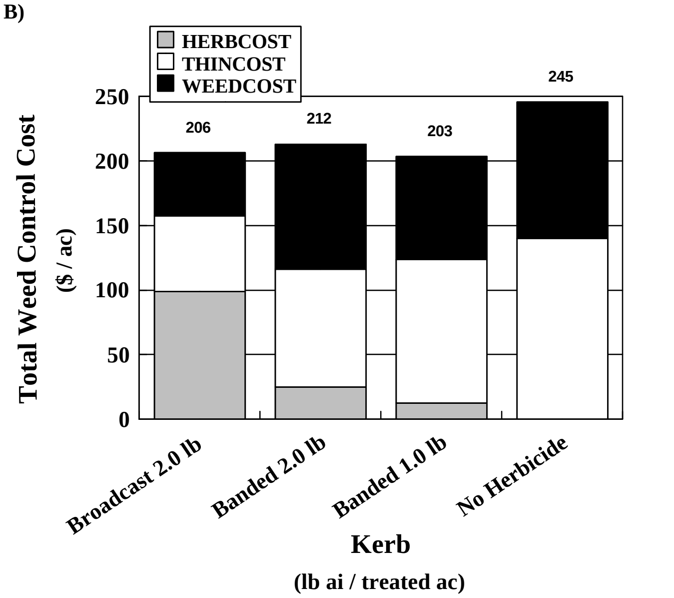

Figure 3. Total weed control costs excluding cultivation. Labor cost of $7.21 per hour and $24.71 per lb ai Kerb were used in the calculations. Site A was north of Salinas; site B was south of Salinas.

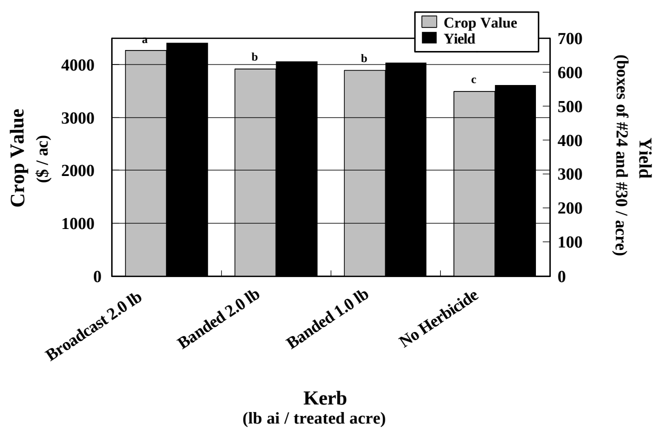

Figure 4. Yield and crop value ($6.21/box) at Site B where weed densities were highest.

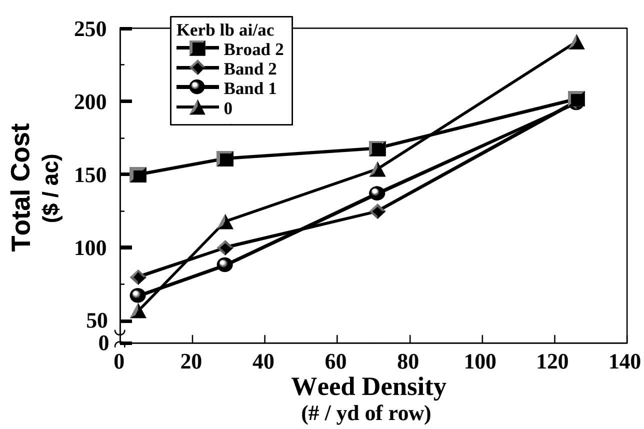

Figure 5. Total weed control costs, excluding cultivation, at a range of weed densities.

CONTROL OF SAN JOSE SCALE IN STONE FRUITS, *R. E. Rice and R. A. Jones, U. C. Kearney Agricultural Center*

I. Efficacy of Pyriproxyfen (Esteem)

A field trial to evaluate the efficacy of Esteem® (pyriproxyfen), an insect growth regulator, was conducted at the Kearney Agricultural Center, Parlier, CA. Esteem was applied at rates of 30 and 40 g a.i./acre in combination with Volck Supreme spray oil. The rate of oil was six gal/acre in both Esteem treatments. Also included in this trial were a standard treatment of diazinon at two lb a.i./acre with six gal of Volck Supreme oil, an oil treatment alone at six gal/acre, and an untreated check. Insecticides were applied by handgun as delayed dormant treatments on February 3, 1997 to mature ‘Santa Rosa’ plums using seven single-tree replications per treatment in a randomized complete block design. Approximately three gal of spray material was applied per tree. The trees in this orchard had never been treated with organophosphate insecticides; susceptibility of scale to diazinon was expected to be high compared to orchards treated annually with dormant sprays.

Treatment efficacy was based on collection of San Jose scale crawlers on double-sided sticky tape (two per tree) over two consecutive weeks during emergence of the first generation crawlers, and also for two consecutive weeks during the second generation of crawler emergence.

Sticky tapes were applied for first generation crawler emergence on April 24 and were counted on May 1 and May 8, 1997. Tapes for evaluation of crawler densities during the second generation emergence were applied to the trees on June 25 and were counted on July 2 and July 9, 1997.

Fruit samples were also collected twice during this trial. A green fruit sample comprised of 30 fruit per replication was harvested on June 3. A mature fruit sample comprised of 75 fruit per replication was harvested on June 18.

The results of the sticky tape collections in the first generation (Table 1) show that both treatments of Esteem plus oil resulted in zero collections of scale crawlers, while the untreated check averaged 72.7 crawlers per tape over the two-week period. The diazinon plus oil standard dormant treatment averaged 2.3 crawlers per tape; the oil alone averaged 10.7 crawlers per tape (equivalent to approximately 71% reduction in crawler populations using this treatment).

Crawler collections during the second generation on sticky tape showed an average of 191 crawlers per tape in the untreated checks, with less than three crawlers per tape in the two Esteem treatments (Table 1). Green fruit harvested on June 6 showed an infestation level of 6.2% in the untreated check, while the Volck oil alone, and standard diazinon plus oil dormant treatments had only 0.5% infested fruit. Both of the Esteem treatments had no infested fruit in this sample. The mature harvest fruit sample taken on June 18 showed a slight increase in all treatments with the untreated check having 6.9% infested fruit, the Volck oil and standard diazinon plus oil treatments still with <1% infestation, while the Esteem treatments each had <0.5% infested fruit.

The results of this trial show that Esteem is a very effective insect growth regulator for control of San Jose scale on deciduous tree fruits. Registration of this product for use in stone fruits should be pursued and encouraged. It was also interesting to find that the crawler populations shown in sticky tape counts in the two standard treatments (oil, oil plus diazinon) were not reflected in the infested fruit samples. This is perhaps due to inadequate replication of sticky tapes per tree, resulting in insufficient random sampling of the crawler populations.

Table 1. Efficacy of Esteem® (pyriproxyfen; V-71639) for control of San Jose scale on Santa Rosa plums.[1/]

	Average No. Crawlers Per Sticky Tape[2/]		Percent Infested Fruit	
			June 4	June 18
Treatment	1st Gen.	2nd Gen.	Green	Harvest[3/]
Check	72.7	191.0	6.2	6.9 a
Volck oil	21.4	37.6	0.5	0.6 b
Diazinon + oil	2.3	6.9	0.5	0.4 b
Esteem @ 30 g a.i./acre plus oil	0.0	2.3	0.0	0.2 b
Esteem @ 40 g a.i./acre plus oil	0.0	0.6	0.0	0.4 b

1/ Applied February 3, 1997; high-volume handgun spray; seven single-tree replications per treatment. Kearney Agricultural Center, Parlier, CA.

2/ 1st and 2nd generation crawler collections on 4/24 – 5/8, and 6/25 – 7/9/97, respectively.

3/ Means followed by the same letter are not significantly different at p. = 0.05, Fisher's protected LSD Test.

II. Efficacy of Buprofezin (Applaud®)

Field trials to establish efficacy of the insect growth regulator buprofezin (Applaud®) for control of San Jose scale in deciduous tree fruits were continued in 1997 at the Kearney Agricultural Center, Parlier, CA. Applaud was applied to mature 'Fantasia' nectarines at 1.5 lb a.i./acre as a delayed dormant treatment on February 6, 1997 and against emerging first generation crawlers on April 17, 1997. In addition to the two Applaud treatments, a standard dormant treatment of diazinon plus Volck oil, at 400 gpa, was applied on January 17. An untreated check was also included in this trial. All materials were applied using an Air-O-Fan GB-34 commercial sprayer operated at 1.8 mph. Five replications comprised of nine trees each were used for each treatment, arranged in a Latin square design.

Control efficacy was evaluated by two sticky tapes applied to scaffold limbs of the center tree in each replicate to collect crawlers during the first generation emergence in late April-early May, and second generation crawler emergence in late June-early July. Tapes were positioned at the same sites on each limb for all crawler collections. Scale infestation was also measured by a green fruit sample on June 4 (40 fruit per replicate) and a mature fruit harvest sample on July 7-8 using 100 fruit per replicate.

The results of this trial (Table 2) showed no statistical difference in control of San Jose scale with the standard diazinon and oil dormant spray compared to the untreated check. The delayed dormant treatment with Applaud and oil applied on February 6 provided a significant reduction in scale control, while the Applaud treatment applied in mid-April reduced the scale population, but not to a level significantly different from the untreated check. The failure of the standard diazinon dormant treatment is believed due to several factors, primarily resistance of the scale population to organophosphate insecticides as a result of over 20 years of organophosphate treatments for control of San Jose scale, oriental fruit moth, and peach twig borer. In addition, the trees in this orchard have been mechanically topped for many years, resulting in a large "crow's nest" effect in the tops of the trees which tends to protect scale populations from sprays of any sort, including the dormant sprays in winter. The high level of scale present in the orchard at the beginning of the trial also added to control problems, and demonstrates the value of not allowing populations of San Jose scale to reach such high levels before effective controls are applied.

These results indicate that Applaud applied as a dormant or delayed dormant treatment or Applaud treatments applied against the first generation of crawlers in April or May could provide improvement in San Jose scale control programs compared to standard organo-phosphate treatments.

Table 2. Efficacy of Applaud® (buprofezin) for control of San Jose scale on Fantasia nectarines. Kearney Agricultural Center, Parlier, CA, 1997.[1/]

Treatment	Applic-ation	Average No. Scale Crawlers Per Tape 1st Gen.	2nd Gen.	Percent Infested Fruit 6/4/97 Green	7/7/97 Harvest[2/]
Check	–	10.2	25.2	5.5	17.4ab
Diazinon 2.0 lb a.i. plus 6.0 gal oil/acre	1/17/97	20.2	102.1	3.5	20.0a
Applaud 1.5 lb a.i. plus 6.0 gal oil/acre	2/6/97	1.2	10.4	0.5	6.0c
Applaud 1.5 lb a.i. plus 6.0 gal oil/acre	4/17/97	10.7	34.0	4.0	11.2bc

1/ Treatments applied on dates shown at 400 gpa with an Air-O-Fan GB-34 sprayer.
2/ Means followed by the same letter are not significantly different at p. = 0.05, Fisher's Protected LSD test.

III. Efficacy of Standard Dormant Sprays

Field trials were conducted in several orchards at the Kearney Agricultural Center in 1997 to evaluate the efficacy of diazinon and carbaryl for control of San Jose scale and to also compare high-volume sprays (400 gpa) to low-volume (100 gpa) using the same material for control of San Jose scale. In these trials, diazinon 50W was applied at 2.0 lb a.i./acre with 6 gal Volck Supreme oil per acre. Carbaryl was applied at 4.0 lb a.i. with 6.0 gal oil per acre. All treatments were applied on January 24, 1997 using an Air-O-Fan GB-34 commercial sprayer. Only nectarine and plum cultivars were used in these trials because it is easier to evaluate scale control treatments on smooth-skinned fruit rather than on peaches. All orchards were mature (10-20 years old) and had been treated annually with standard organophosphate (primarily diazinon) and oil dormant sprays.

Trials were evaluated by inspection of fruit picked at random at the commercial harvest date for the respective cultivars. A minimum of 250 fruit per cultivar (range 250-600) were examined for presence or absence of scale, with presence of a single scale on a fruit scoring that fruit as infested.

The results of these trials (Table 1) show that in all comparisons of diazinon dormant sprays at 100 gpa versus 400 gpa ('Fantasia,' 'Red Diamond,' 'Royal Diamond,' and 'Casselman') there were no significant differences between the two rates of spray application. This result was not expected but is believed due to the high level of tolerance or resistance in the respective scale populations to organophosphate insecticides. Consequently, the volume of spray applied was immaterial to success or failure of the treatment.

The comparisons of carbaryl dormant sprays at 100 versus 400 gpa ('Red Diamond,' 'Queen Rosa,' and 'Casselman') showed that although infested fruit levels were high in all treatments, the 400 gpa rates of application reduced the infestation levels on fruit by significant amounts in two of the trials compared to the 100 gpa rates of application.

Mite samples from 'Red Diamond' nectarines and 'Royal Diamond' plums on July 28 and August 8 respectively (100 brushed leaves per treatment) showed no significant differences in two-spot, Pacific, or European red mite populations between the two types of insecticide. Red mite populations were slightly elevated in the 400 gpa carbaryl treatment in plums, but were countered by high populations of predaceous Phytoseiid mites.

These trials demonstrate conclusively that San Jose scale populations in orchards under commercial control practices are resistant to organophosphate insecticide sprays. The results add increased emphasis to the need for improved scale control with the development and registration of insect growth regulators (IGRs) as one of the better options for future IPM programs. In addition, in situations where growers have been having difficulty controlling San Jose scale with organo-phosphate insecticides and have also been using lower rates of spray application, rotation of insecticides to currently registered products such as carbaryl, and applied at the higher volumes of spray per acre, would seem to offer improved control over previous practices using low-volume application rates and organo-phosphate insecticides.

In the two orchards where diazinon and carbaryl were compared directly to each other, the 100 gpa application of carbaryl was no better than either of the diazinon rates on 'Red Diamond' nectarines, but was significantly better on 'Casselman' plums. The 400 gpa application of carbaryl showed significant improvement over the diazinon treatments in both orchards. It should be noted, however, that this is probably a short-term effect. Continued reliance on only one new insecticide for scale control would probably quickly lead to resistance to that material as well. Cross-resistance to organophosphates (e.g. – diazinon) and carbamates (e.g. – carbaryl) has already been observed in other insect species.

Table 3. Efficacy of dormant sprays for control of San Jose scale on stone fruits.[1/]

Cultivar	Treatment	GPA	Harvest Date	Percent Infested Fruit[2/]
Fantasia nectarine	diazinon	100	7/7/97	20.4a
Fantasia nectarine	diazinon	400	7/7/97	20.0a
Queen Rosa plum	carbaryl	100	7/10/97	61.2a
Queen Rosa plum	carbaryl	400	7/10/97	34.4 b
Royal Diamond plum	diazinon	100	7/16/97	26.2a
Royal Diamond plum	diazinon	400	7/16/97	27.0a
Red Diamond nectarine	diazinon	100	7/9/97	23.3a
Red Diamond nectarine	diazinon	400	7/9/97	27.1a
Red Diamond nectarine	carbaryl	100	7/9/97	27.2a
Red Diamond nectarine	carbaryl	400	7/9/97	9.6 b
Casselman plum	diazinon	100	8/21/97	39.2a
Casselman plum	diazinon	400	8/21/97	51.2a
Casselman plum	carbaryl	100	8/21/97	24.4 b
Casselman plum	carbaryl	400	8/21/97	18.4 b

[1/] Treatments applied on dates shown at 100 and 400 gpa with an Air-O-Fan GB-34 sprayer.

[2/] Means followed by the same letter for respective cultivars are not significantly different at p. = 0.05, Fisher's Protected LSD test.

USE OF COVER CROPS FOR LEAFHOPPER CONTROL IN THE LODI-WOODBRIDGE WINEGRAPE REGION

K. M. Daane, G. Y. Yokota, and M. J. Costello, U.C. Kearney Agricultural Center and UCCE Fresno County

The Lodi-Woodbridge Winegrape Commission has sought to develop an Integrated Pest Management (IPM) Program specifically suited to pest problems in its region. One area of interest is the use of cover crops for improved pest management and soil health. We designed a grower-collaborative study in the Lodi-Woodbridge region to test the effects of cover cropping on leafhopper pests and their natural enemies. In theory, pest densities decrease and natural enemy densities increase in more diverse ecosystems because cover crops provide natural enemies with additional habitat and/or food.

The western grape leafhopper (GLH) and variegated leafhopper (VLH) are pests in the Lodi-Woodbridge region. Nymph and adult feeding damages leaves directly. Their excretion promotes the growth of sooty molds on leaves and fruit. Adult leafhoppers can disrupt harvest operations because, when disturbed, they will scatter haphazardly and fly into the eyes, ears, nose, and mouth of nearby field workers. There have been a number of studies that investigated the effect of cover cropping on leafhopper pest status and/or natural enemy abundance (see 1,2,5,6,7). However, due to the complexity of the vineyard ecosystem and regional or seasonal differences, those studies have not shown a consistent effect of cover crops. With this in mind, we present data from the final year of a 3 year experiment that shows how cover crops affected leafhopper numbers and vine conditions at one site in the Lodi-Woodbridge region.

Material and Methods

Studies on populations of leafhoppers and their natural enemies (spiders and the egg parasite *Anagrus*) took place at the Robert Mondavi vineyard in a 20 acre block of Cabernet Sauvignon. Three treatments were tested: (1) no cover crop, (2) native grass mix (no irrigation), and (3) native grass mix and irrigation. The native grasses consisted of a mixture of blue wildrye (*Elymus glaucus*), meadow barley (*Hordeum brachyantherum*), and California brome (*Bromus carinatus*). These grasses will remain green if irrigated. Herein lies the difference between the 2 native grass treatments -- one will go dormant by mid-July and the other will remain green throughout the summer (these differences may be important for the cover crops' action as a predator or alternative prey refuge). The treatments were arranged in a randomized complete block, with 4 replications (12 plots, plot size ~1.5 acres each).

Leafhopper nymphs were counted on 20 leaves per plot at peak densities for each leafhopper generation. Percentage parasitism was determined by counting the number of live and hatched (e.g., a live leafhopper emerged) and parasitized or mummified (e.g., a live parasite emerged) leafhopper eggs on 10 leaves per plot, for each leafhopper generation. Spiders and other generalist predators were sampled monthly by placing a cloth funnel (~3 X 3 feet) under a section of vine and shaking the canes and trellis above the funnel. The dislodged predators were collected in a bag held beneath the funnel, placed in 70% EtOH, and identified to genus or species.

After bloom, the number of clusters per vine were counted on 10 vines per plot. At the same time, leaf petiole samples were collected and leaf nitrate levels determined for each plot. The level of water stress of leaves was estimated by monthly measurements with a pressure bomb on 5 leaves per plot. Also, 2 aluminum tubes for neutron probe measurements were placed in each plot and measurements of soil moisture were taken each month at 1-foot intervals (to a depth of 5 to 8 feet). At harvest, berry weight and percentage soluble solids were determined by collecting 100 berry samples in each plot.

Data were analyzed by Analysis of Variance (SYSTAT), separating means by Tukey's Honestly Significant Difference (HSD). Means are presented in numbers per sample (±SEM). All references to tests of significance are at $P < 0.05$.

Results and Discussion

Leafhopper nymphs The densities of the 2 leafhopper species varied significantly. GLH never reached economically damaging levels (economic injury levels are ~20 nymphs per leaf) In the second generation, GLH densities climbed to ~9 nymphs per leaf but, in the third generation, declined to ~2 nymphs per leaf. In contrast, VLH nymph counts rose steadily and reached damaging levels in the third generations in all treatments (Fig. 1).

There were treatment effects. In the second generation, there were significantly fewer GLH in the native grass treatment (no irrigation) as compared with the other 2 treatments. In contrast, VLH nymph counts were significantly lower in the native grass and irrigation treatment in both the second ($P = 0.034$) and third generations ($P < 0.001$) (Fig. 1). Note that the reduction in VLH densities is <15% and has little economic importance.

Egg parasitism Egg parasitism can explain, in part, the low GLH densities. In all plots, there were very few GLH eggs per leaf and ~60 and 75% of the eggs were parasitized in the second and third leafhopper generations, respectively. Percentage VLH egg parasitism was much lower than GLH. In the first brood there is little difference between percentage parasitism of GLH and VLH eggs, both <10%. However, in the second and third broods, VLH egg parasitism was ~15% only. The dramatic difference between GLH and VLH egg production and egg parasitism can largely account for differences in nymph density and economic damage between these 2 species.

There were few differences in the number of live and parasitized VLH eggs among treatments. In one case, there was a significantly greater level of parasitism in the native grass and irrigation treatment in the third leafhopper generation, as compared with the no cover crop and native grass (no irrigation) treatments. This does not necessarily mean that *Anagrus* spp. activity was higher in the irrigated treatment. In this case, there was no difference in the number of eggs parasitized. Rather, there were significantly fewer eggs laid on vines in the native grass and irrigation treatment and this led to a greater percentage parasitism.

Predators Spiders continued to be the dominant leafhopper predator collected, representing >90% of all ambulatory predators in the funnel samples. Throughout this 3-year study, we have sought to determine if predator numbers are higher in cover cropped treatments. Results showed no obvious differences among treatments in the number of spiders collected. In fact, in 1996 there was a remarkably similar pattern of abundance for the total spiders (Fig. 2), the most common spider species (*Cheiracanthium inclusum*, *Theridion dilutum*, *Theridion melanurum*, *Oxyopes scalaris*), and all other spider species combined.

Cheiracanthium inclusum, the agrarian sac spider, is a large nocturnal hunter that is commonly found in grape bunches in summer and under the bark in fall and winter. We believe it is one of the best leafhopper predators in the Mondavi vineyard. The most common spider species were sit-and-wait webbuilders, called cobweb weavers (*Theridion dilutum* and *Theridion melanurum*). These small spiders construct a fine, irregular network of webbing, typically on the underside of leaves and within the bunches. Both the agrarian sac spider and the cobweb weavers began the season at low densities and then increased throughout the season, with their highest densities recorded between August and November. The results suggest that there is little carry over of spiders during the winter and, because this pattern was similar in all treatments, there is no indication that the native grasses acted as a winter refuge. The 1996 results were also notable in the low densities of 2 spider species that are typically common in vineyards with year-round cover crops. These species are the funnel weaver, *Hololena nedra*, and the antmimic spider, *Trachelas pacificus*. The data suggest that while cover cropping may influence predator species composition -- there are many other factors (e.g., vine cultivar, soil type, regional climate, vineyard age) that also play a role in influencing which predators are present and what their abundance might be.

Vine health Another factor that influences leafhopper biology is vine quality (3,4,5). Work in Thompson seedless grapes showed that adult leafhoppers migrated to and deposited more eggs on vines that had higher irrigation levels. In wine grapes, there is considerably less applied irrigation than in raisin or table grapes; nevertheless, we assumed that leafhopper biology would be similar and the vines that received more irrigation would have higher leafhopper densities. Similarly, we believed that because the cover crops compete with the vines for nutrients, the vines in the native grass treatments would have deficient nitrogen levels and this would also lead to lower leafhopper densities. Not all these patterns held true in the 1996 season.

As expected, there was significantly less nitrogen (in ppm) in the native grass (354 ± 109) and native grass and irrigation (301 ± 237) treatments than the no cover treatments (1783 ± 389). Surprisingly, there was significantly more clusters per vine in the 2 native grass treatments. We conclude that the levels of nitrogen fertilizer applied and the amount of nitrogen used by the cover crops left an adequate amount for fruit production. There have been studies that suggest that nitrogen levels are positively correlated to leafhopper densities (4). Such a relationship makes sense from a biological perspective as leafhopper densities are higher on more vigorously growing vines and an increase in nitrogen fertilization typically leads to increased vine vigor. To test, we regressed peak third generation nymph density against nitrogen levels (measured at bloom). There was a positive ($y = 39.33 + 0.35x$) but non-significant ($P = 0.236$) correlation. There are many possible explanations for this lack of significance, not the least of which is the disparate irrigation amounts applied and the effects of cover cropping on soil health.

Measurements of soil water amounts and leaf turgor pressure (an indication of water held in the leaves) found significant differences among the treatments. At the beginning of each season (May 24), the amount of water in the upper soil layers is relatively even among treatments, as a result of winter rains (Fig. 2) However, the percentage soil moisture increased at greater soil depths in the native grass and irrigation treatment, while it decreased in the unirrigated treatments. Over the next 2 sampling dates (Jun 21 and Jul 24), percentage soil moisture followed a similar pattern. In August, pre-harvest irrigation was applied to all treatments. This did little to affect soil moisture in the no cover treatment (as measure ~3 weeks after irrigation). There was, however, a noticeable increase in percentage soil moisture in the upper soil regions in the native grass (no irrigation) treatment (Fig. 2). Post-harvest irrigation to all treatment resulted in a similar pattern as pre-harvest irrigation - a dramatic increase in percentage soil moisture in the upper regions of both native grass treatments. The percentage soil moisture recorded corresponds well to pressure bomb measurements (data not shown). We conclude that the permanent, native grasses improved soil structure and better enabled natural and irrigated water to permeate to the lower soil depths. This resulted in less evaporation at the soil surface and better soil water conservation.

Berry Yield and Quality The most important measurements of treatment effects are on yield and berry quantity. In 1996, the number of clusters per vine was significantly greater in the native grass treatments. Berry weight was significantly greater in the native grass and irrigation treatment -- as happened in past years. There was no difference among treatments in measurements of soluble solids.

The results suggest that while the native grasses may not have altered the numbers of beneficial insects on the vines, the cover copping did improve soil condition and vine health. It was surprising that the number of clusters per vine was greater in the native grasses treatments because the measured levels of nitrogen were so much lower, as compared with the no cover treatment. We conclude that the nitrogen fertilization levels were adequate for yield in the native grass treatments (~300-350 ppm as measured by leaf petiole samples). That berry weight was greater in the irrigated treatment is not surprising. In 1995, the irrigated treatment resulted in a lowered berry brix at harvest -- which was counter-productive for early harvest and quality wine. In 1996, the greater than average summer temperatures resulted in faster berry ripening and more even soluble solids measurements in all treatments.

Conclusions

At the Mondavi site, VLH was the primary leafhopper pest, whereas GLH population densities stayed below 10 nymphs per leaf. A major reason for this difference has to be the rate of egg parasitism, which peaked at ~80% for GLH, but topped out at ~20% for VLH. As in past years, there was a treatment effect, with VLH nymph density significantly lower in the native grass and irrigation treatment in the second and third broods. However, this was not the result of any parasite or predator that could be measured by our sampling program, as natural enemy numbers were similar in all treatments.

Cover cropping did affect soil condition and vine health. Water stress was low when first measured in May, and rose steadily in all treatments until the first irrigation in August (naturally, there was a consistent and significant difference between irrigated and non-irrigated treatments). When leaf water potential was measured post-irrigation, stress had decreased in the native grass treatments, but continued to increase in the no cover treatment. Also, there was consistently more water available in the lower soil regions in the native grass treatments after each irrigation. These results indicate that the native grasses, whether irrigated or not, act as a mulch to reduce soil surface evaporation and may change soil structure to increase water permeability to the lower soil regions -- where water is still available to the vines.

We conclude that the cover crops greatest benefits may not be in pest management, but in their affects on soil health. For this reason, we suggest that decisions on cover cropping and cover crop species selection be based on each vineyard's soil characteristics and nutrient needs. Finally, throughout this study, we found either neutral or positive benefits from cover crops with respect to leafhopper control. That we did not find significant increases in all natural enemy numbers does not lessen the positive role that cover crops can play in pest management, reflected by the 15-20% reduction in leafhopper numbers that typically accompanied cover crop use. Therefore, cover crops may be used as <u>one</u> component of a leafhopper pest management program, but they should not be relied upon as the primary control mechanism.

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(Figure not available)

Fig. 1. Mean (± SEM) GLH and VLH densities in the no cover, native grass, and native grass and irrigation treatments. In each grouping, means followed by different letters are significantly different.

(Figure not available)

Fig. 2. Mean (± SEM) spider densities in no cover, native grass, and native grass and irrigation treatments show little difference in total spider abundance for total spiders.

(Figure not available)

Fig. 3. Mean soil water content (% by volume) for each sample date, plotted by soil depth for no cover, native grass, and native grass and irrigation treatments.