PROJECT No. 98-RC-o0 FINAL REPORT

ANT MANAGEMENT IN ALMONDS, 1998: SAN JOAQUIN VALLEY

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INTRODUCTION AND OBJECTIVES

Southern fire ant, *Solenopsis xyloni* McCook, has become one of the major pests damaging almonds in the last two decades throughout the San Joaquin Valley (SJV). The pavement ant, *Tetramorium caespitum* (Linnaeus) is also damaging, but damage is limited to the northern SJV and Sacramento Valley. The ants forage on the nuts after the nuts are dropped on the ground during harvest. Damage on the nuts can range from small nicks and holes, which downgrade the crop, to removal of the entire nut meat, which reduces crop size. Downgrading of the crop, which reduces the premium paid to the grower, is the more important damage. Crop damage of over 25% has been reported from some orchards in 1998.

Lorsban® (chlorpyrifos) and Pounce® (permethrin) are the only currently registered insecticides for ant control in almonds. Data from previous trials have shown Pounce to be only marginally effective. Lorsban is one of many organophosphate pesticides which are under scrutiny as part of the Food Quality Protection Act and may not be available to growers in a few years. This trial was undertaken to evaluate several new materials for ant control in comparison to Lorsban and to provide efficacy data for registration of alternatives.

Other objectives of this project include developing improved monitoring methods for identifying ants and determining ant population levels within orchards and to evaluate and extend the use of those methods to the industry. Comments on these objectives are below.

METHODS AND MATERIALS

The project was established in four locations in the San Joaquin Valley: Kern County, Fresno County, Merced County and San Joaquin County. This was done in order to test the materials over a wide geographic region and also, in the case of San Joaquin Co., to test the materials against pavement ants which are not a problem in central and southern SJV. Non-bearing orchards were used in most locations in order to minimize the necessity for crop destruction.

General Experimental Procedures

The individual experiments were laid out as a randomized complete blocks with multiple factors. The factors were the various insecticides, treatments in the spring vs. pre-harvest, cover crop vs. no cover crop where possible and baits applied in piles vs. broadcast in two of the locations. Individual plots were approximately 0.25 to 0.33 acres except for one San Joaquin Co. site which was limited to 0.14 acres due to orchard size and the need for crop destruction. In the Kern, Fresno and Merced locations, the spring and pre-harvest treatments were applied to separate plots so that each plot received only one application during the experiment. In the San Joaquin locations, the pre-harvest applications were made to the same plots as the spring applications so that, where both timings of the same material were used, those plots received two applications. Chemicals evaluated in the trial included chlorpyrifos (Lorsban®), hydramethylnon (Amdro®), pyriproxyfen (Knack®), fenoxycarb (Logic®), abamectin (Clinch®), permethrin (Pounce®), spinosad, phosmet (Imidan®) and natural pyrethrums (Alternative Action®, Inseloco®). These last two were included to address concerns of organic growers. Table 1. shows the treatments, rates and nominal application timing and dates for all locations:

Note that the principal materials for evaluation in all locations were Lorsban, Amdro, Knack, Logic and Clinch. Other chemicals, as noted above, were added in individual trials where space was available. Logic was applied only at the spring timing and Clinch was applied only at pre-harvest at the Fresno location. The pre-harvest timing for the baits was determined from previous data and observations regarding the length of time effects began to be observed after application. The pre-harvest treatment timing for Lorsban was determined by the label PHI of 14 days. Application dates varied with location because of local issues such as rain, inability to access the orchard, and scheduling conflicts. The liquid spray treatments were applied with boom sprayers using flat fan nozzles and covered the entire plot. 100 GPA was used in the Fresno, Kern and Merced locations; 50 GPA was used in the San Joaquin Co. locations. Baits were applied in either piles uniformly distributed through out the plot (approximately 80/plot) or by broadcast spreader covering the entire surface.

Evaluations of ant activity were done using slices of hotdog placed in plastic vials with snap caps. The open vials were laid, eight per plot, on the ground throughout the plot to minimize variability from nest location within the plots. The vials were capped shut and retrieved after two hours of exposure, trapping the ants within. Ant numbers and species were counted. This method was used in Kern, Fresno and Merced locations. In San Joaquin, the vials were left for 24 hours due to lower numbers of ants. In addition, a visual rating of damage to the hotdog slice was done at that location. Evaluations of ant activity were done weekly at the Fresno location starting in the first post-treatment week. Samples were collected biweekly in the Kern and San Joaquin locations and monthly at the Merced location.

Ant damage evaluation was done at nominal "harvest". Since most of these locations were non-bearing orchards, harvest timing was based on surrounding orchards. Almond bait stations, which consisted of plastic tubes containing shelled almonds and either screened or capped at each end to exclude birds and rodents, were laid on the ground throughout each plot. There were ten stations, each containing 10 almonds, per plot. The stations were allowed to remain undisturbed for 3-4 days and then removed from the orchard. The stations were then placed in a freezer to kill the ants and the contents then examined for the number of almonds damaged. A subjective rating of the extent of damage was made and/or the weight of almonds taken.

RESULTS AND DISCUSSION

The impact of treatments on fire ant activity, as measured by "hotdogging", for the various locations are shown in Figures 1-7, 9. Generally, Lorsban, Amdro and, in most cases, Clinch significantly reduced activity of ants within the first week or two after treatments were applied. This was usually the case for both spring and pre-harvest applications. The pre-harvest applications of Lorsban and Imidan in Kern County failed to have any effect on ant activity, however. The activity of both Lorsban and Amdro tended to decline after 5-7 weeks with Lorsban lasting 2-3 weeks longer in most locations. In the San Joaquin orchard #1, there was a resurgence of fire ants to greater numbers than the control in both the Amdro and the Clinch treatments. The insect growth regulators, Knack and Logic, usually took 4-7 weeks to significantly reduce fire ant activity below the control, with Knack usually working faster. They both reduced activity over a longer period than the others, lasting up to 12 weeks. Clinch showed similar longevity. Pounce was evaluated in the Kern, Merced and San Joaquin locations. After a brief knockdown of ant activity, numbers quickly rebounded to levels comparable to the control (Figs.3, 5, 9, 10). Imidan appeared to have some short term suppressive effect in the Merced location but, as noted above, failed to have any effect when applied pre-harvest in Kern Co. The pyrethrum (Alternative Action / Insecolo) mound treatments in the Kern location had no effect on ant activity.

The effect of materials on pavement ant activity was evaluated in the San Joaquin Co. orchards and are shown in Figs. 8 and 10. Amdro, Lorsban and, in one location, Clinch gave immediate knockdown of pavement ants which held for 10-12 weeks. Knack, Logic and, in the other SJ Co. location, Clinch took approximately 6 weeks to reduce numbers below the control and then held for the remainder of the sampling period. Pounce had no effect in reducing pavement ants. There was no way to separate damage by pavement ants from that by fire ants so, in the San Joaquin locations, the damage rating includes both species.

Damage to almonds at harvest time are shown in Tables 2-4. A significant treatment effect was observed for harvest damage in Kern Co. The Clinch, Knack and Logic treatments were significantly better at minimizing damage to nuts. Amdro, despite reducing ant activity as well as the best of the other treatments, was only slightly better than the check in reducing nut damage. In the San Joaquin orchard #1 location, no damage to the almonds within the bait stations was evident despite having an ant population comparable to the other locations. This location had a heavy ground cover consisting of spotted spurge over the experimental area. Fire ants have been observed to forage heavily on spotted spurge seeds and we speculate that the abundant food source already available to the ants attracted them away from the almonds. Generally, materials applied at the pre-harvest timing were more effective than the same materials applied in the spring. Despite being highly effective in reducing ant activity in the spring, Lorsban, Amdro, Knack and Clinch could not hold ant numbers low enough to prevent significant damage to nuts at harvest. Pre-harvest applications of Lorsban, Knack and Amdro resulted in the lowest nut damage in most of the locations. However, the Amdro treatments in Fresno Co. failed to reduce damage below the control. Clinch and Logic, while reducing damage below the control in most instances, were less effective than Knack and Lorsban. Pounce, spinosad, and Imidan were, essentially, ineffective.

In previous trials, Logic has demonstrated good efficacy in reducing ant activity and damage. We observed differences in the Fresno location this year relative to the bait acceptance between Logic, Knack and Amdro. We conducted a small experiment where we compared differences in bait uptake and noted that much more bait was removed from piles of Amdro bait followed by less removal of Knack and relatively low removal of Logic. Our speculation is that this difference may be due more to the formulation of the bait and the amount of soybean oil added to the corn grits to make it attractive. That large differences in added oil may exist between products and even between batches of the same products is reflected in the comments of one of the chemical company representatives. He reported that previous years' formulations of his product were "soaked" in oil where this year's batch was relatively dry. Therefore, the differences in performance we observed between the baits in these trials may, in large part, be due to differences in bait attractiveness rather than the inherent effectiveness of the active ingredient. Research must continue on optimizing the attractiveness of the baits as well as needed improvements in quality control for the manufactured product.

It must also be emphasized that the damage measurements in this trial are much higher than what would be expected in a commercial orchard because of the methodology used to evaluate "harvest" damage. We feel these data reflect relative differences in performance of the products, however.

The Kern County trials provided data for evaluating treatment effects by the application method, i.e. baits applied in piles vs. broadcast and also the effects of a cover crop vs. "clean" cultivation. There were significant differences for both factors. Pile applications resulted in approximately two weeks longer reduction in ant activity for Clinch, Logic, Amdro, and to a lessor extent, Knack. There was a significant difference in the measured ant activity where weeds, primarily spotted spurge, were controlled vs. where the weeds were allowed to grow. Measured ant activity was higher where weeds were controlled than where present. It is unknown, at this time, whether this difference is due to a difference in ant population between the two management techniques or if the weeds are simply attracting the ants away from the bait containers. We suspect the latter. This factor will be evaluated in more depth in the 1999 season.

With regard to the objective in this project for developing a sampling method for predicting damage levels, the data generated during the monitoring efforts are still being analyzed relative to predicting potential damage to the nuts. However, since these trials were conducted in non-bearing orchards, no actual harvest conditions were present to correlate measured ant activity with damage occurring under those conditions. An additional factor, which has been recently noted, is the high variation in the quality of the shell seal in Nonpareils. It is known that shell seal is an important factor relating to the amount of insect damage among different varieties. The factors that contribute to variations in shell seal in Nonpareils is the subject of another currently funded project. Results from that project will be critical to the development of a damage prediction technique.

With regard to the objective for developing educational/identification tools for industry use, observations of ant behavior made in the various locations will be added to currently available and forthcoming publications. Information on the recent observations of another ant species, *Solenopsis molesta*, or thief ant, causing damage and the finding of pavement ants in some Fresno County orchards will also be added.

The data developed in this project has been made available to the respective chemical manufacturers for their use in the registration process. One material, Clinch, has received a Federal Section 3 registration for almonds, walnuts and citrus and is now in active review with the California Department of Pesticide Regulation. It is hoped that the material will be available for use in the 1999 season. The material, hydramethylnon, does not have a tolerance for any food crop in the US with little likelihood for one in the foreseeable future. We will discontinue working with that product. The material pyriproxifen performed very well, has tolerances on some food crops, registration pending on apples and pears and company interest for pursuing registration for ant control. Hopefully, it also will soon provide an alternative method of ant management for almond growers.

ACKNOWLEDGEMENTS
We would like to thank the following growers for their kind generosity and assistance in conducting this project: Paramjit and Nindy Dosanjh of Doaba Farming Co. in Kern County, Tim Parichan of Parichan Farms in Fresno Co., Morimoto Farms in Merced Co., and Doug George and Cliff Vander Veen for use of their orchards in San Joaquin County. The project could not have been completed without the capable assistance of Marjie Bartels, Bob Cedarquist, Matt Fossen, Amanda Bulls, Dawn Brunmeier and Win Rogers. We thank them very much.

Table 1. Chemicals, rates, seasonal timing and treatment dates for ant control evaluation in the San Joaquin Valley.

Chemical	Rate (product/Acre)	Nominal Timing	Kern	Fresno	Merced	SnJqn 1*	SnJqn 2*
Lorsban 4E	8 pts	Spring	1-May	19-May	7-May	20-May	30-May
Lorsban 4E	8 pts	Pre-harvest	14-Aug	24-Aug	7-Jul	31-Aug	11-Aug
Lorsban 4E	8 pts	Pre-harvest "Late"			25-Aug		
Amdro bait	2 lbs	Spring	1-May	22-May	7-May	20-May	30-May
Amdro bait	2 lbs	Pre-harvest	31-Jul	14-Jul	7-Jul	31-Aug	11-Aug
Knack bait	2 lbs	Spring	1-May	22-May	7-May	20-May	30-May
Knack bait	2 lbs	Pre-harvest	17-Jul	14-Jul	7-Jul	21-Jul	
Logic bait	1.5 lbs	Spring	1-May	22-May	7-May	20-May	30-May
Logic bait	1.5 lbs	Pre-harvest	17-Jul		7-Jul	21-Jul	
Clinch bait	1.0 lbs	Spring	1-May			20-May	30-May
Clinch bait	1.0 lbs	Pre-harvest	31-Jul	14-Jul	7-Jul	31-Aug	11-Aug
Pounce	1.0 pt	Spring	1-May		7-May		30-May
Pounce	1.0 pt	Pre-harvest					11-Aug
Spinosad	1.5 lbs	Spring	1-May		7-May		
Spinosad	1.5 lbs	Pre-harvest	31-Jul		7-Jul		
Imidan	4.5 lbs	Spring			7-May		
Imidan	4.5 lbs	Pre-harvest	14-Aug		7-Jul		
Alternative Action/Insocolo**		Spring	1-May				
Untreated control							

*The spring and pre-harvest treatments were applied to the same plots.
**This material was sprayed directly on the mounds only.

Table 2. Damage to almonds from fire ants, Kern County orchard. Data are from preharvest treatments; there were no significant differences among treatments at the spring application.

Material/Timing	Percent of nuts with ant damage[1]	Percent of nuts with >0 to ≤10% damage[1,2]	Nut weight loss[1,3]
Lorsban	60.1 bc	18.5 b	1.43 bc
Imidan	69.4 c	20.7 b	1.69 cd
Knack	23.2 a	8.1 a	0.82 ab
Logic	24.2 a	8.1 a	0.50 a
Amdro	50.8 b	10.1 a	1.75 cd
Clinch	15.2 a	6.7 a	0.39 a
Spinosad	62.7 bc	20.1 b	1.22 abc
Control	75.9 c	9.8 a	2.53 d

[1]Means followed by the same letter(s) are not significantly different (LSD, p=0.05)
[2]Percent of nuts in samples subjectively rated as having some but less than 10% ant damage.
[3]Grams of nut meat removed from almond bait station.

Table 3. Damage to almonds from fire ants, Fresno County orchard.

Material/Timing	Percent of nuts with ant damage	Percent of nuts with >0 to ≤10% damage[2]
Lorsban/Spring	71.4 de[1]	20.1
Lorsban/Pre-harvest	19.3 a	12.3
Amdro/Spring	85.2 e	15.9
Amdro/Pre-harvest	82.7 e	17.7
Knack/Spring	61.9 c	18.0
Knack/Pre-harvest	35.6 b	18.2
Logic/Spring	82.1 de	13.1
Clinch/Pre-harvest	59.4 c	19.8
Untreated	92.1 e	15.6

[1]Values followed by the same letter(s) are not significantly different (DMRT, p= 0.05).
[2]Percent of nuts in samples subjectively rated as having some but less than 10% ant damage.

Table 4. Damage to almonds from fire ants, Merced County orchard.

Material/Timing	Percent of nuts with ant damage[1]	Percent reduction of sample weight[1, 2]
Lorsban/Spring	66.6 bcd	41.3 bcdef
Lorsban/Pre-harvest	66.6 bcd	32.1 abcde
Lorsban/Late Pre-harvest	47.8 ab	26.1 abc
Amdro/Spring Piles	78.1 de	50.6 defg
Amdro/Spring Brdcst	80.3 de	53.6 fg
Amdro/Prehrvst Piles	51.6 abc	24.9 ab
Knack/Spring Piles	82.5 de	52.8 efg
Knack/Prehrvst Piles	31.6 a	14.0 a
Logic/Spring Piles	83.4 de	42.7 bcdef
Logic/Spring Brdcst	80.9 de	51.3 defg
Logic/Prehrvst Piles	72.5 cd	51.3 defg
Clinch/Prehrvst Piles	77.5 de	31.4 abcd
Clinch/Prehrvst Brdcst	71.3 cd	47.3 cdefg
Pounce/Spring	70.9 cd	47.7 defg
Spinosad/Spring Piles	94.7 e	64.4 g
Spinosad/Prehrvst Piles	72.2 cd	51.9 defg
Imidan/Spring	77.8 de	60.5 fg
Imidan/Pre-harvest	85.6 de	57.4 fg
Untreated	87.2 de	54.1 fg

[1]Values followed by the same letter(s) are not significantly different (Fisher's Protected LSD, p=0.05).
[2]Mean percent loss of weight of almond sample after exposure to ants.

Table 5. Damage to almonds by fire and pavement ants, San Joaquin Co. orchard 2.

Material/Timing	Percent nuts With Ant Damage[1]	Rating of Percent Consumed[2]
Lorsban/Spring+Prehrvst	1 a	0 a
Amdro/Spring+Prehrvst	13 ab	6 ab
Knack/Spring@2 lbs	35 cd	21 bcd
Knack/Spring@1.5 lbs	45 d	30 d
Knack/Spring@1.0 lbs	40 cd	22 cd
Logic/Spring+Prehrvst	24 bc	12 abc
Clinch/Spring+Prehrvst	36 cd	17 bcd
Pounce/Spring+Prehrvst	64 e	47 e
Untreated	79 e	59 e

[1]Values followed by the same letter(s) are not significantly different (DMRT, p=0.05).
[2]Nuts were visually rated for the percentage of nut meat consumed by ants during exposure.

Figure 1. Avg. number of ants per 8 vials per plot, spring treatment. Fresno Co. orchard.

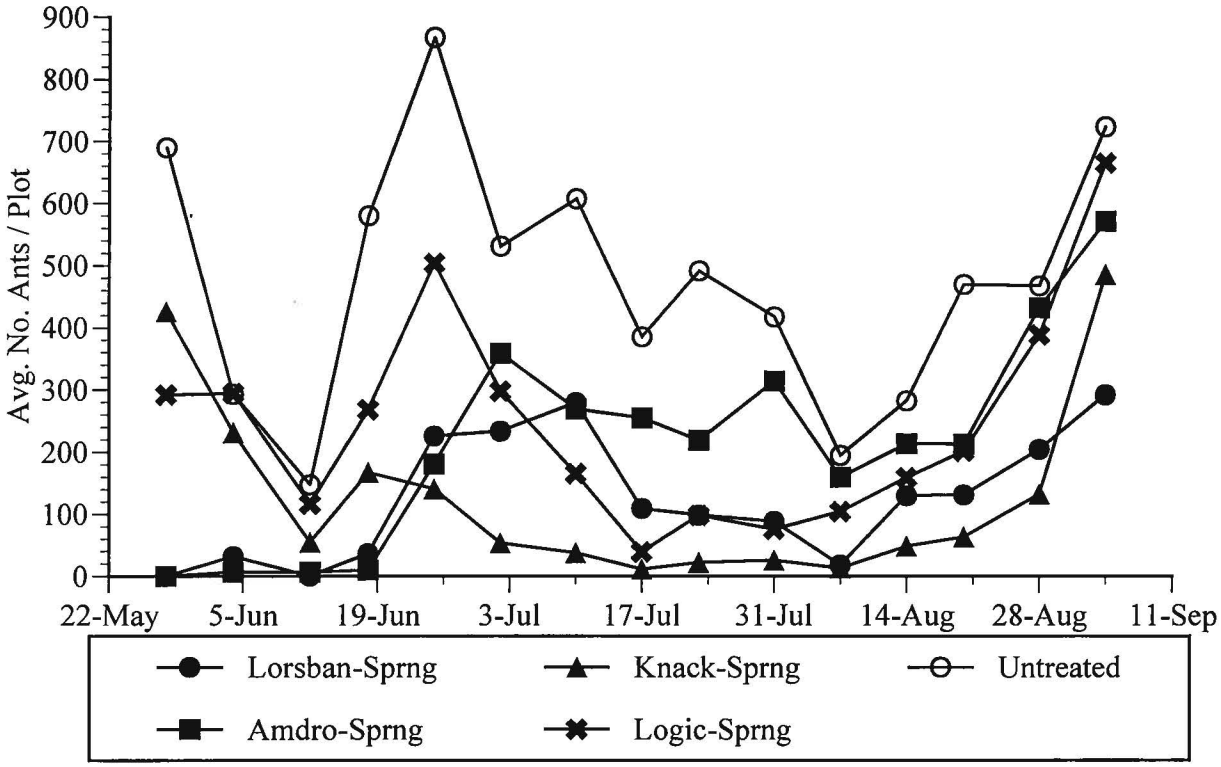

Figure 2. Avg. number of ants per 8 vials per plot, pre-harvest treatment. Fresno Co. orchard.

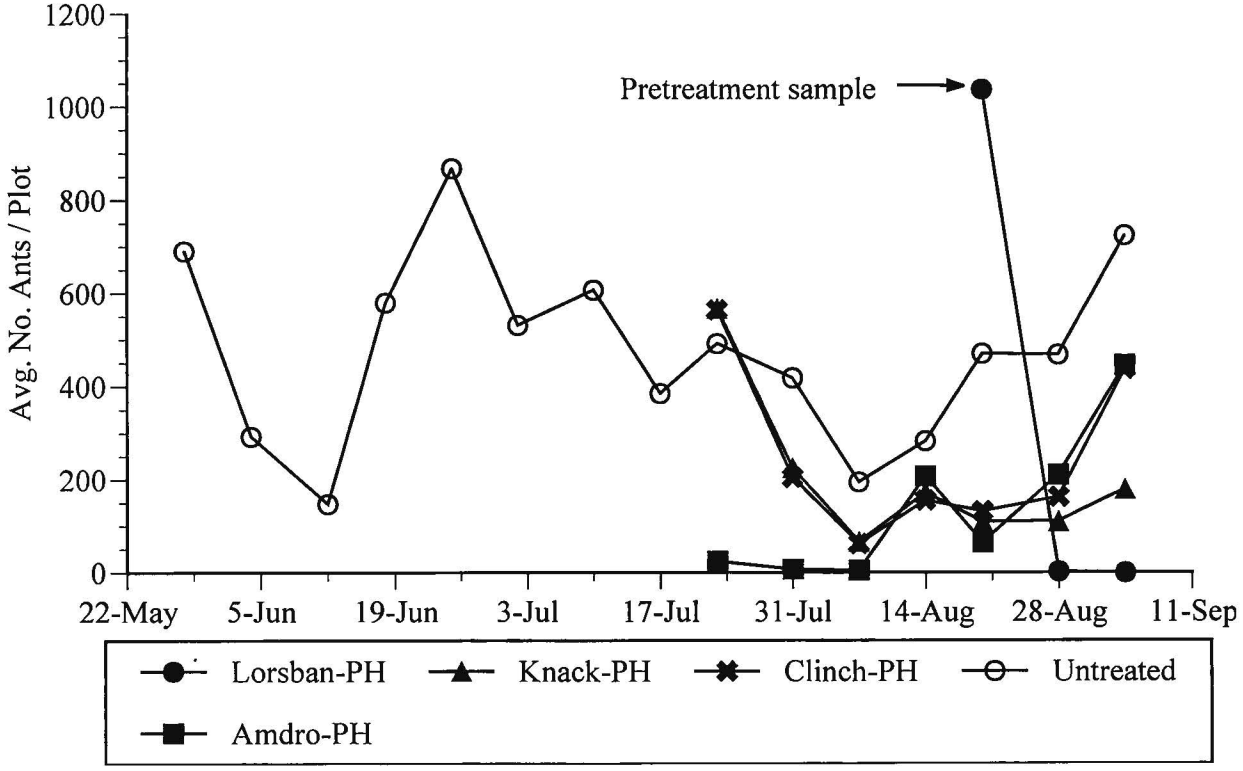

Figure 3. Avg. number of fire ants per 8 vials per plot, spring treatment. Kern Co. orchard.

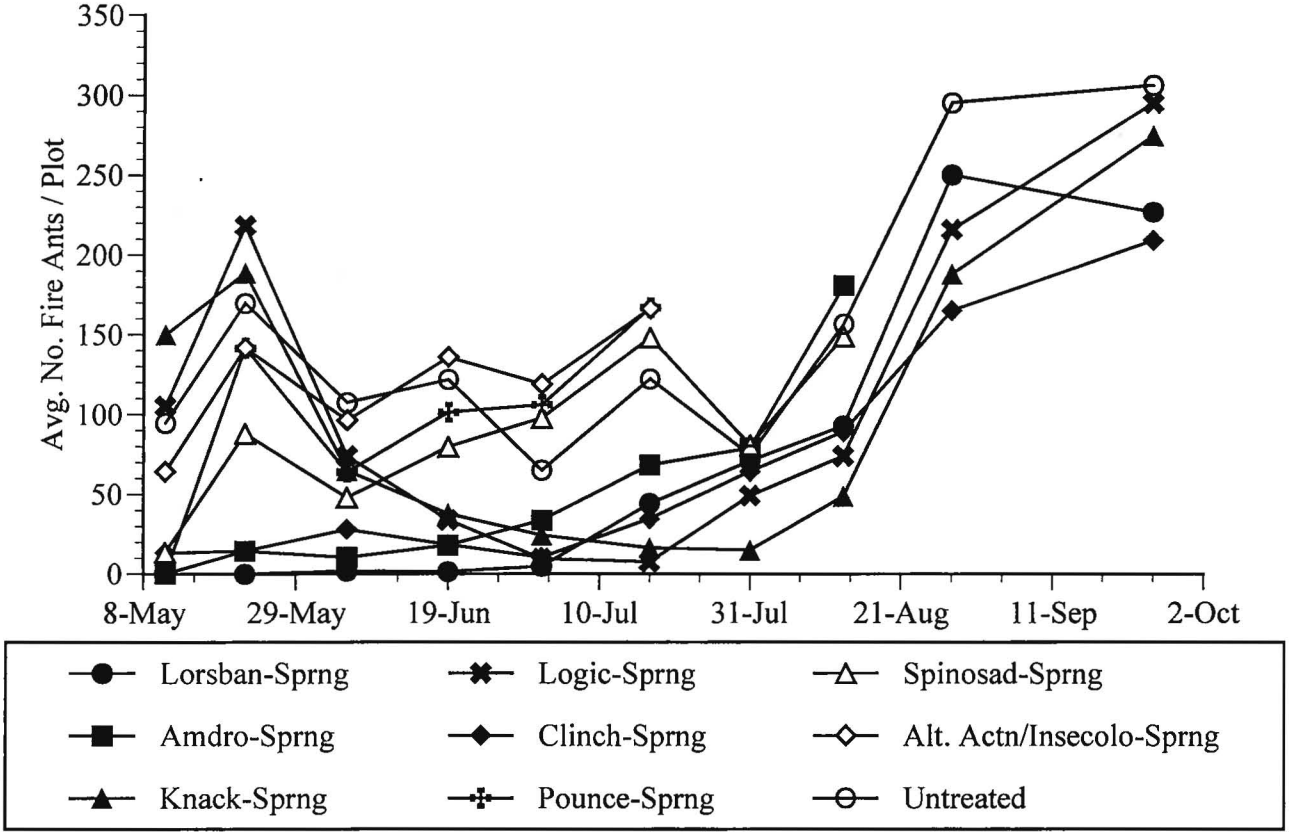

Figure 4. Avg. number of fire ants per 8 vials per plot, preharvest treatment. Kern Co. orchard.

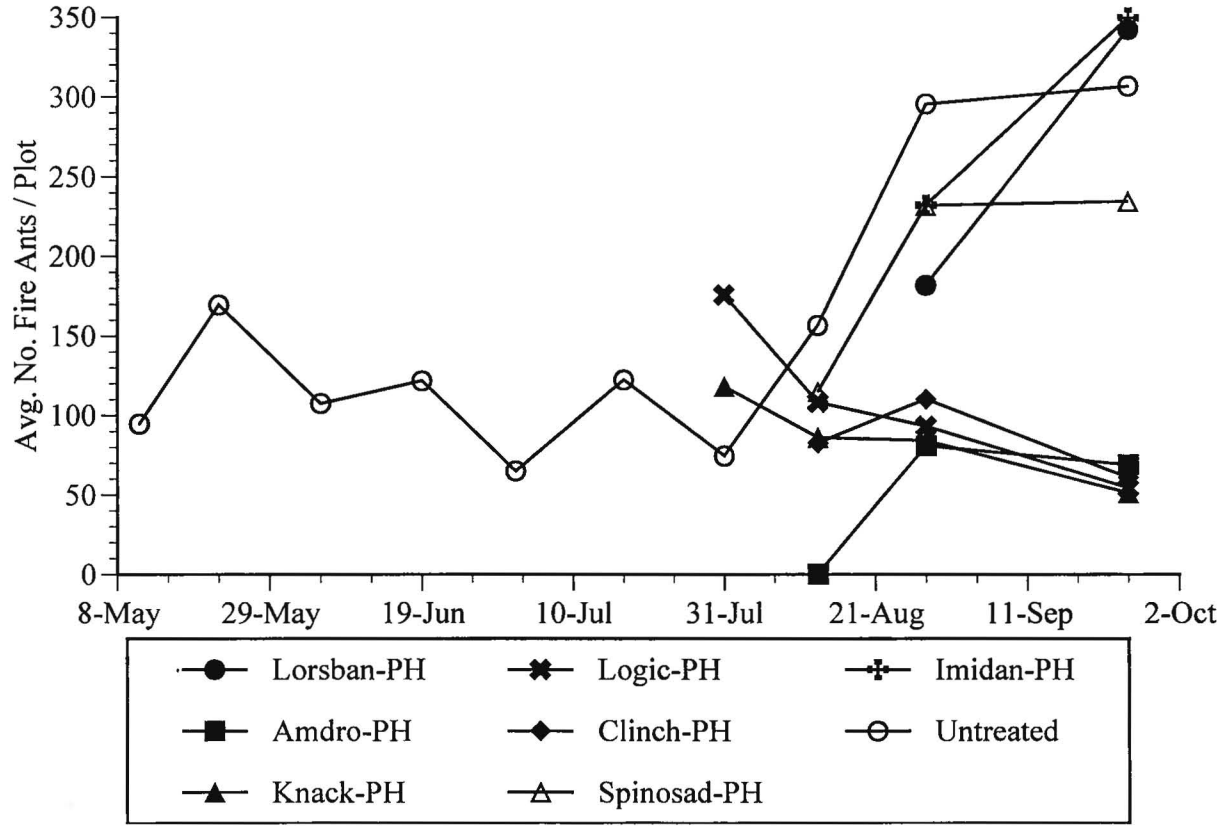

Figure 5. Avg. number of fire ants per 8 vials per plot, spring treatment. Merced Co. orchard.

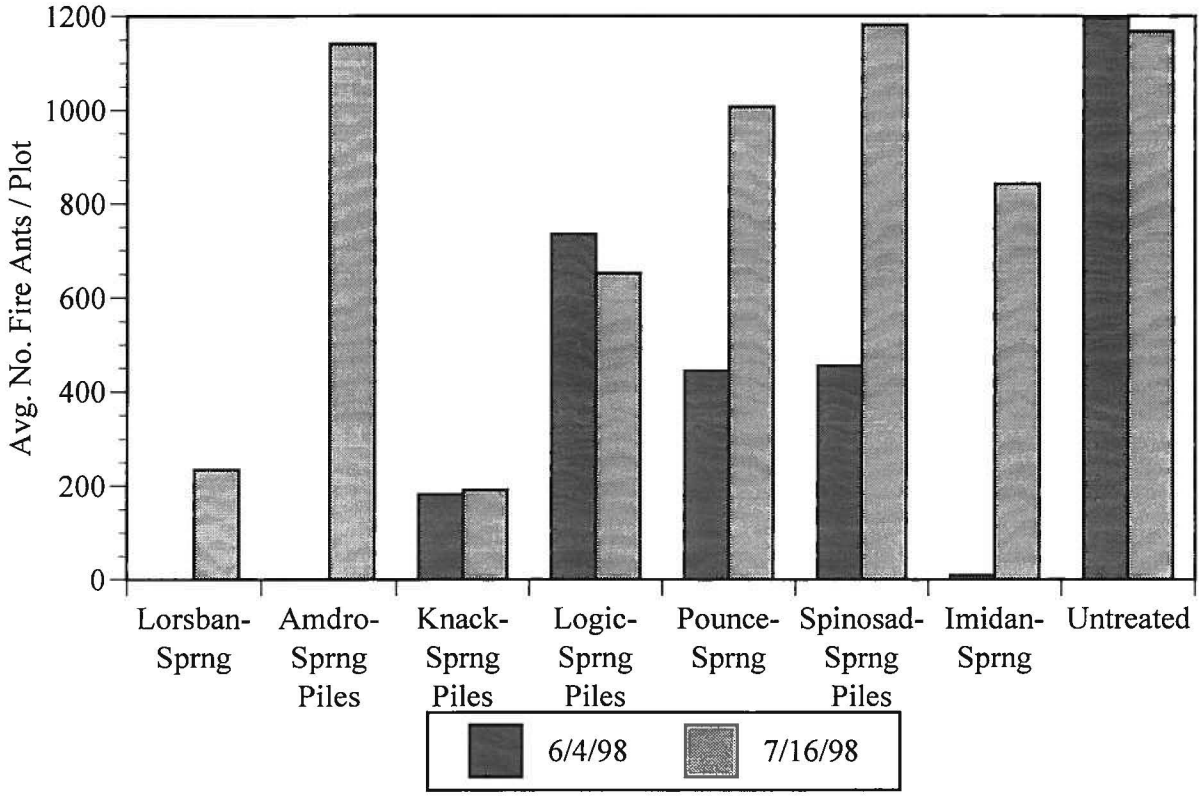

Figure 6. Avg. number of fire ants per 8 vials per plot, preharvest treatment. Merced Co. orchard

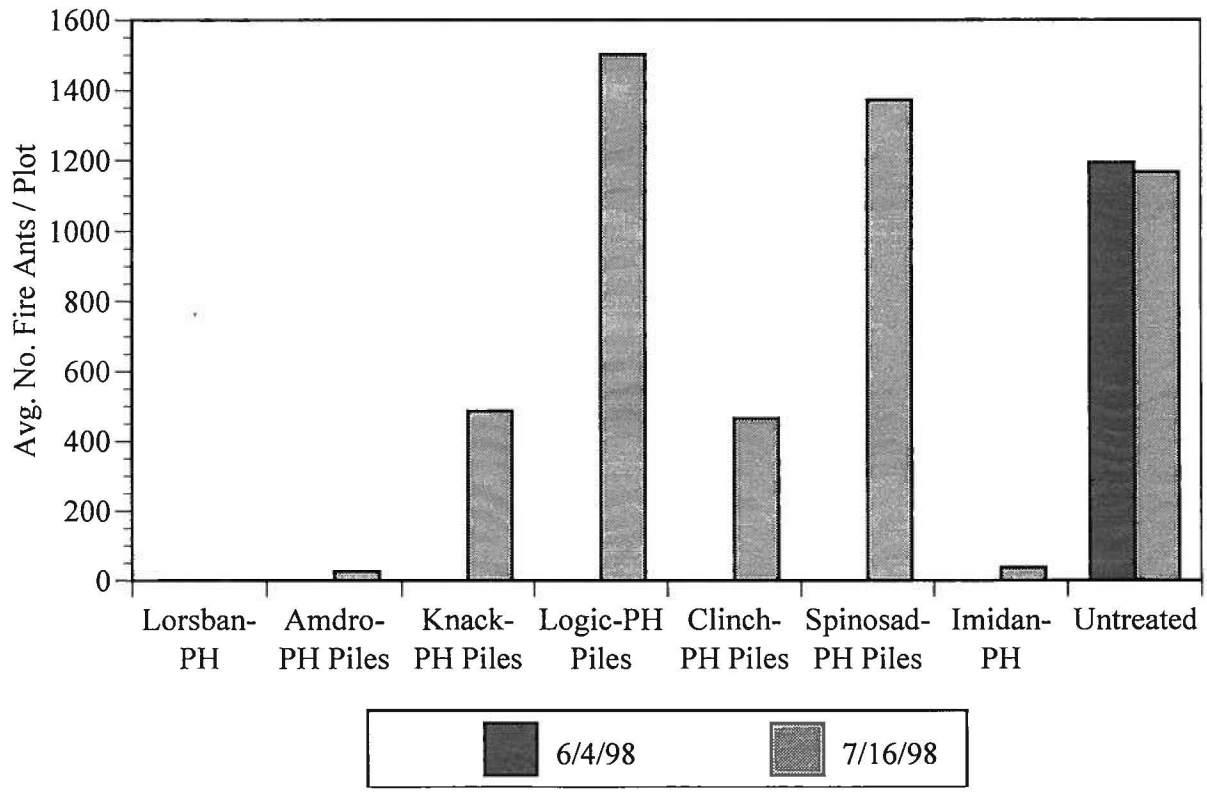

Figure 7. Avg. number of fire ants per vial per plot, spring treatment. San Joaquin Co. orchard 1.

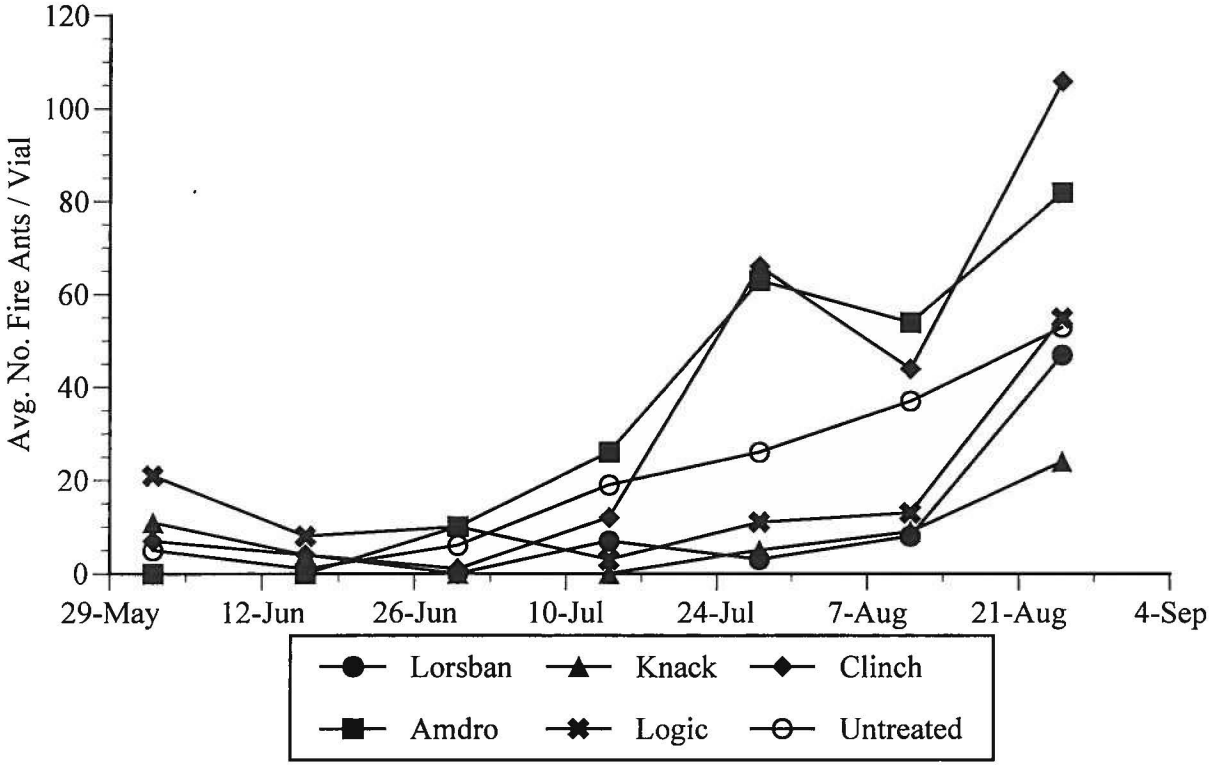

Figure 8. Avg. number of pavement ants per vial per plot, spring treatment. San Joaquin Co. orchard 1.

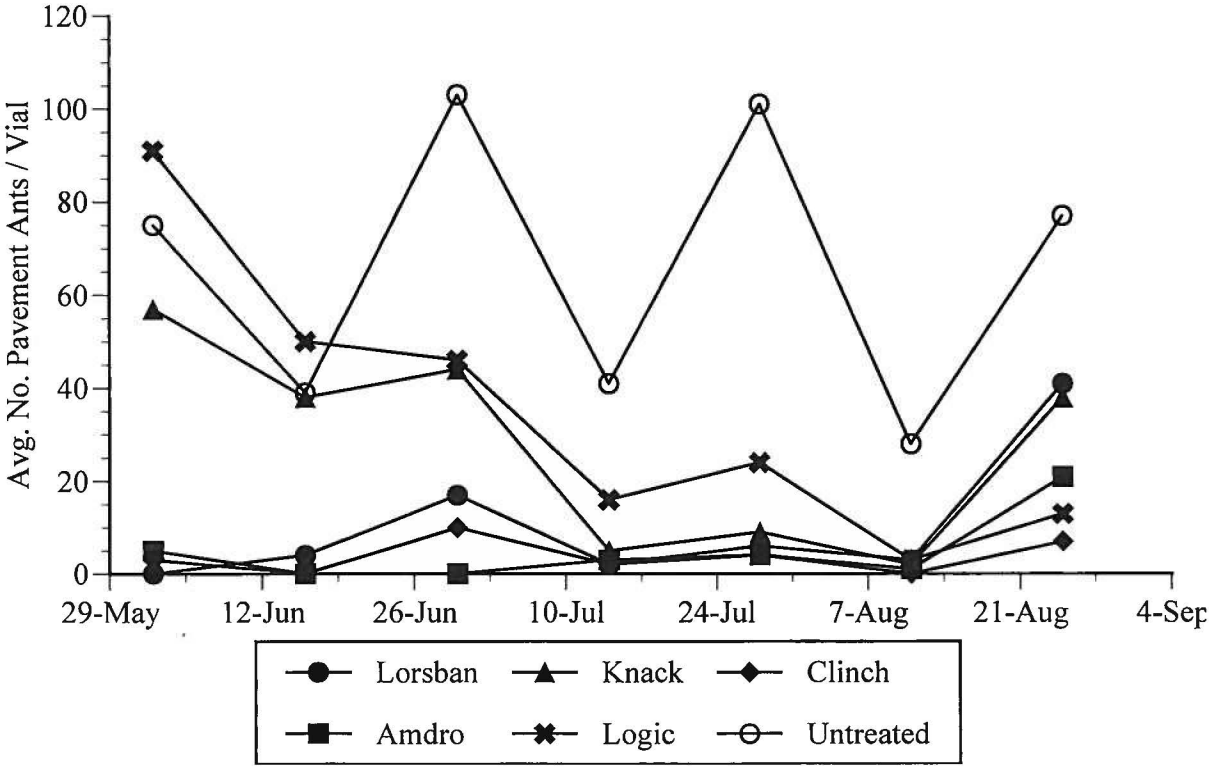

Figure 9. Avg. number of fire ants per vial per plot, spring treatment. San Joaquin Co. orchard 2.

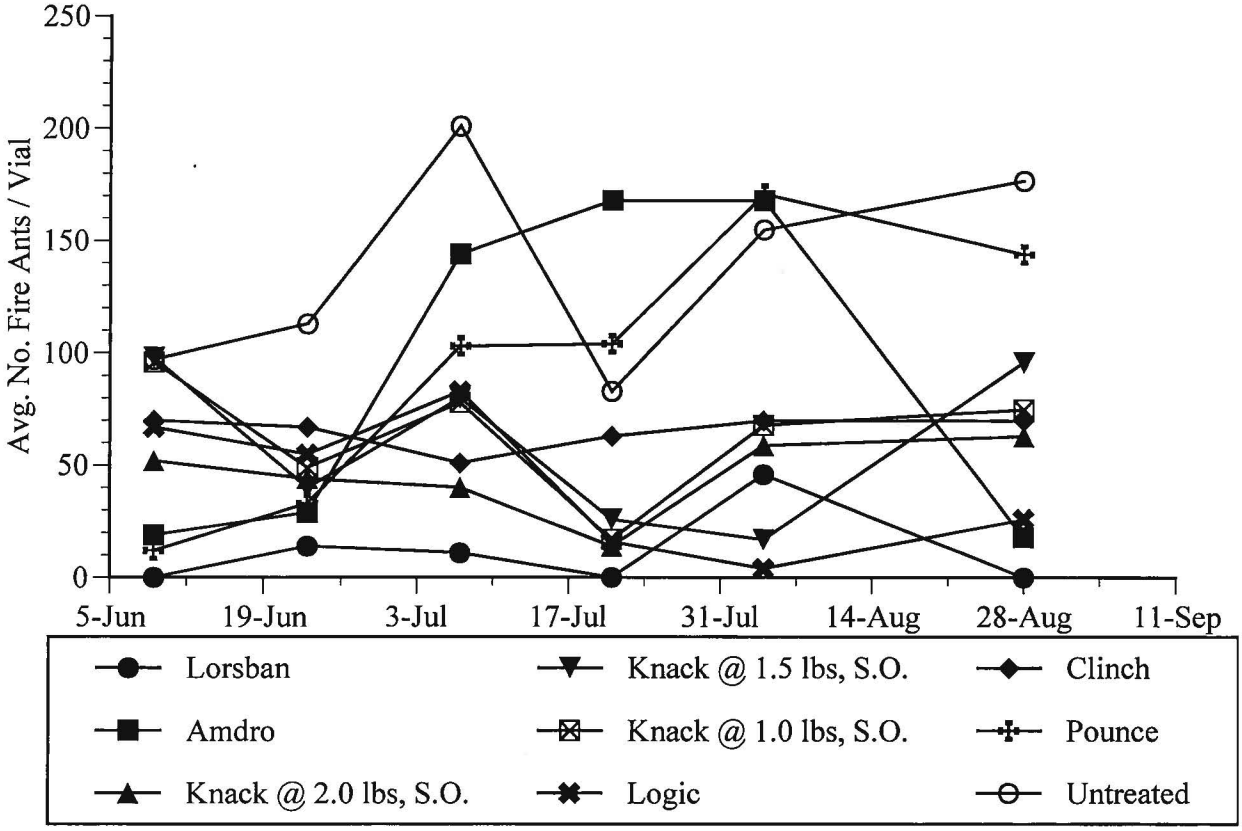

Figure 10. Avg. number of pavement ants per vial per plot, spring treatment. San Joaquin Co. orchard 2.

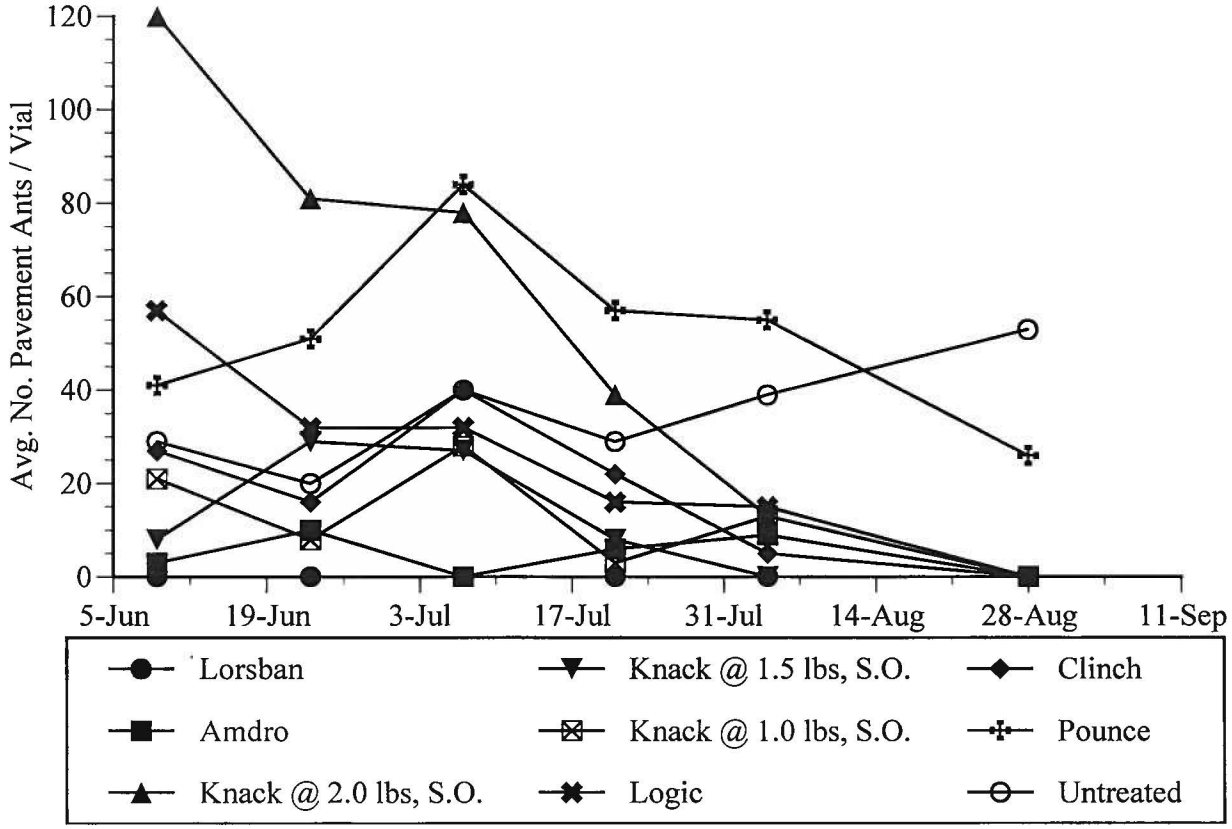

Figure 11. Damage to nuts in sample at nominal harvest, Sept 8-10, Kern Co. site. Data are from preharvest treatments. No significant differences occurred in spring treatments.

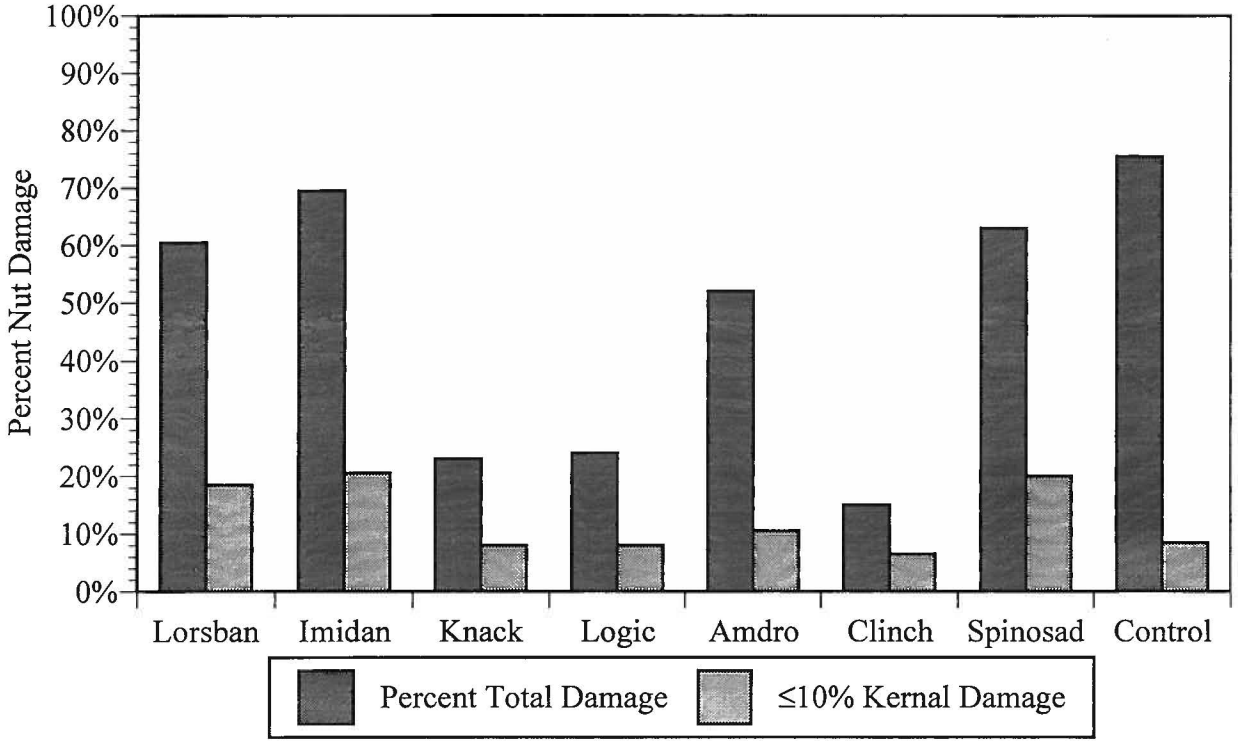

Figure 12. Damage to nuts at nominal harvest, Sept 11-15, from both treatment timings, Fresno Co. site.

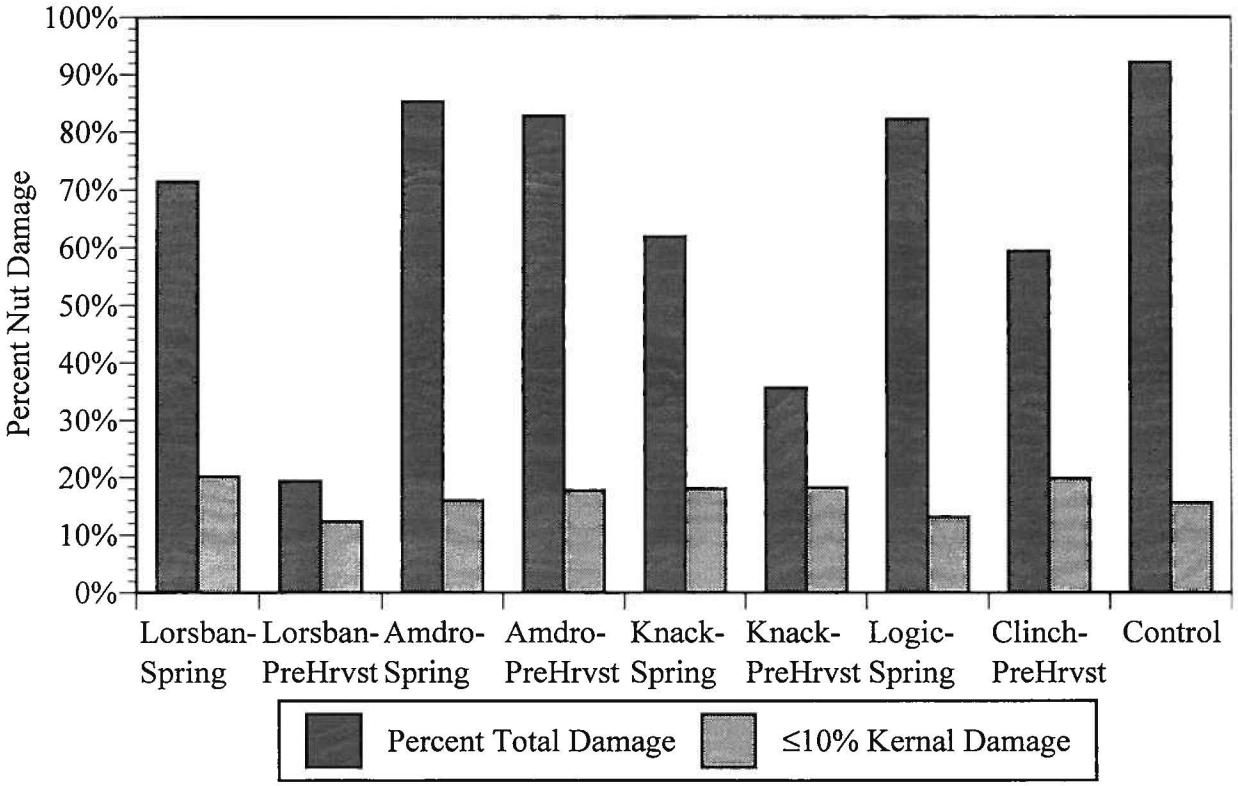

Figure 13. Damage to nuts at nominal harvest, Sept 15, Merced Co. site. Data are from preharvest treatments. No significant differences occurred in spring treatments.

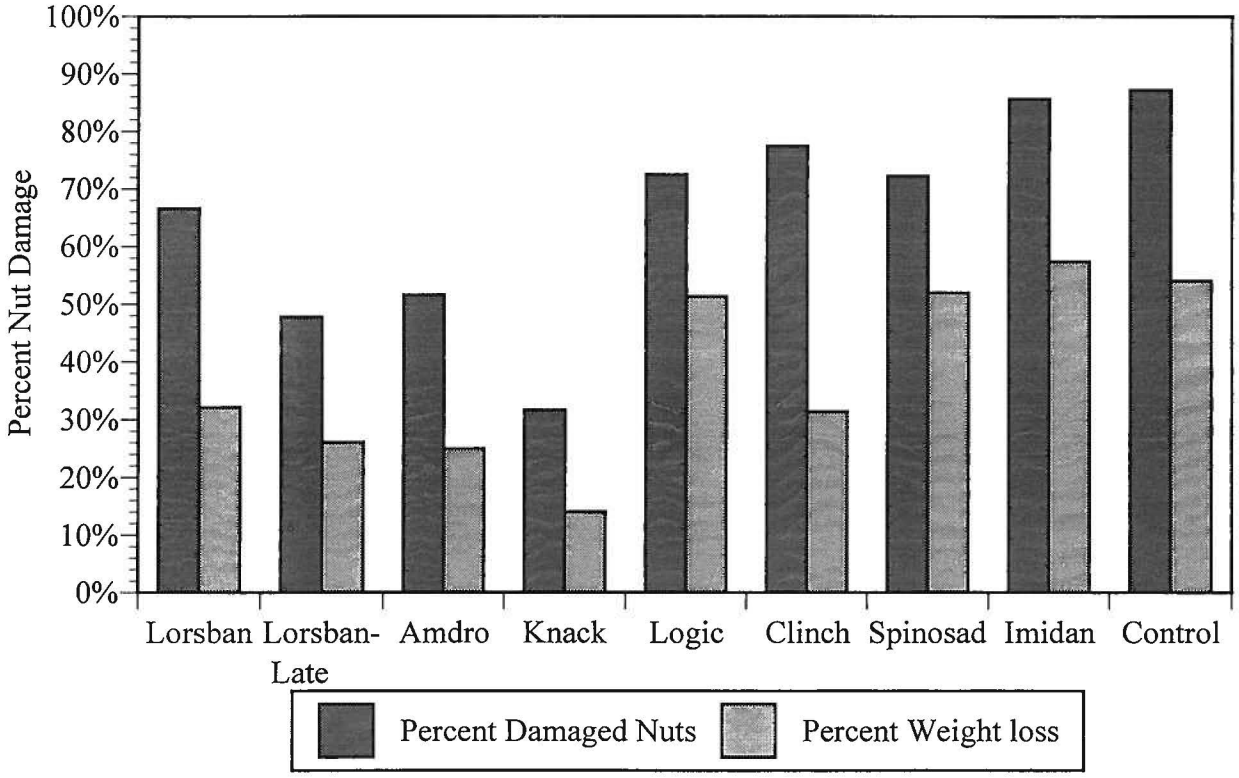

Figure 14. Damage to nuts at nominal harvest, Aug 28, San Joaquin Co. site #2. Knack and Logic were applied only in spring, the rest had both spring and preharvest treatments