Emergence of navel orangeworm adults from infested almond mummies in cages was significantly lower after overwintering in vegetation, such as bromegrass at left, than in the residual herbicide treatment.

Management of navel orangeworm and ants

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Orchard cover crops are generally thought to be beneficial in the management of pests, especially certain insects and mites. Depending on how they are manipulated, however, cover crops have the potential to increase damage from some pests. If cover crops are not managed correctly—for example, are mowed at the wrong time or are under stress for moisture—plant-feeding insects may move from the orchard floor into the trees to feed on developing fruit.

To test the effect of different orchard floor management systems on selected insect populations in almonds in the San Joaquin Valley, we monitored mites, peach twig borer, navel orangeworm, and ants at the two experimental orchard sites. Mite populations were low in all treatments during the experiment, and there were no significant differences in plant-feeding and predaceous mites or peach twig borer. There were no differences in the amount of damage from navel orangeworm or peach twig borer in the harvested nutmeats in either orchard. However, we observed differences in overwintering navel orangeworm survival and ant populations.

Navel orangeworm

The navel orangeworm, *Amyelois transitella*, can cause significant crop loss in almonds if not properly managed. Navel orangeworm overwinters in almond mummies left on the tree after harvest, and under some conditions can survive the winter in unharvested nuts left on the orchard floor.

To determine the survival of overwintering navel orangeworm on the orchard floor, we picked unharvested nuts off the ground from heavily infested orchards in the late fall of 1985 and 1986, placed them in the various experimental treatments, and allowed them to overwinter. In 1985 and 1986, 33.5% and 40%, respectively, of the nuts placed in the orchards were infested with navel orangeworm.

We selected 200 nuts at random on December 18, 1985, and placed them in the middle of each of the four replicates in the various treatments in orchard A. Nuts were placed inside 22- x 22-inch wooden cages covered on top with 0.5- x 0.5-inch hailscreen to prevent predation by birds and other vertebrates. The cages were open at the bottom, and the nuts scattered on the ground inside them. Although the plots were mowed in early February 1986, vegetation inside the cages was allowed to grow until the nuts were collected on March 22. The overwintered nuts were placed in emergence cages, and adult moth emergence was recorded three times a week.

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Ant feeding damage to nutmeats was generally highest in resident vegetation and bromegrass, intermediate in clover, and lowest in the residual herbicide treatment.

In the fall of 1986, we conducted a similar experiment at both orchards A and B. We placed 250 nuts inside the wooden cages, which were then set in the center of each plot. After overwintering, the nuts were collected on March 13, 1987, and adult moth emergence recorded. In this second experiment, vegetation within the cages was clipped during the spring of 1987 to simulate mowing.

It was obvious from the appearance of the overwintered nuts that the almond meats were less suitable as navel orangeworm food in all the plots with cover crops. Nutmeats removed from the heavy, moist clover were almost totally disintegrated.

This observation was borne out by the comparisons of adult emergence. In orchard A in both 1986 and 1987, the number of emerged navel orangeworm adults was significantly higher in the complete, residual herbicide treatment than in treatments with a vegetation cover (table 1). Although the differences were not significant in orchard B, the trend was the same; emergence was lower where a cover crop was present.

These results show that fewer navel orangeworms survive the winter on the ground where cover crops are present. The differences might be greater where nuts in cover crops are fully subjected to regular, early-spring mowing. Nuts in the residual herbicide treatments, which do not need mowing, would not be disturbed. Mowing, especially flail mowing, could reduce the navel orangeworm population further by physically destroying the overwintering nuts and larvae.

Ants

Two ant species, the southern fire ant, *Solenopsis xyloni*, and the pavement ant, *Tetrameorium caespitum*, can cause serious damage to almonds by feeding on nutmeats while the nuts are drying on the ground. The presence of 7 to 10 ant colonies per 1000 square feet can increase nutmeat damage by 0.5% per day.

To assess the impact of the different systems on ants, we counted the colonies and measured the ant damage on nutmeats. All active colonies in the cover-crop area in the middle of each replicate (four per treatment in orchard A and five per treatment in orchard B), plus the herbicide-treated strip between the three middle trees down the row (1950 square feet per plot at orchard A and 1311 square feet per plot at orchard B) were counted and recorded before harvest. The number of ant colonies was counted only in orchard A in 1984 and in both orchards in 1985, 1986, and 1987.

Samples of 250 nuts from each plot were collected at harvest and evaluated for insect damage in 1985, 1986, and 1987. Harvest samples were not collected from orchard A in 1984, because the trees were nonbearing.

The colony surveys at orchard A in 1984 show significantly higher populations in the resident vegetation than in the strawberry clover or residual herbicide treatments (table 2). In 1985, colony numbers were up in all treatments, with significantly more in the resident vegetation and the bromegrass than in the residual herbicide treatment. Although not significantly different, colony populations were also lowest in the residual herbicide treatment and the strawberry clover in 1986 in orchard A. An ant control application in orchard A before the 1987 survey reduced colonies in all orchard floor systems, but numbers were significantly lower in the clover than in the other treatments.

Ant damage to nutmeats generally paralleled the data for ant colonies. In 1985 in orchard A, damage was significantly lower in the residual herbicide treatment than in the others (table 3). In 1986, the residual herbicide treatment was again significantly lower in damage than the bromegrass and resident vegetation, but not significantly different from the clover. Although an ant control application had been made before harvest, a similar relationship carried through in 1987, except that bromegrass and clover were not significantly different.

The trends tended to be the same at orchard B, but ant populations were low in all plots and did not show any significant differences in either the number of colonies or ant damage to nutmeats (tables 2 and 3). It is interesting that, although the number of ant colonies in 1986 in orchard B was similar to colonies in orchard A in 1984, no significant damage occurred to nutmeats in orchard B. We cannot explain the lack of damage in orchard B.

TABLE 1. Average number of navel orangeworm adults emerging from overwintered almond mummies

Treatment	Orchard A 1985/86	Orchard A 1986/87	Orchard B 1986/87
No. nuts/cage	200	250	250
Blando bromegrass	3.3b*	0.2 b	0.4 a
Salina strawberry clover	2.3b	0.0 b	1.0 a
Resident vegetation	1.5 b	1.4 b	3.2 a
Residual herbicide	9.3 a	10.8 a	7.0 a
Chemical mow	—	—	5.2 a

NOTE: Averages followed by the same letter are not significantly different, using Duncan's multiple range test. P = 0.05.
* Number of adults that emerged/caged sample.

TABLE 2. Colonies of southern fire, *Solenopsis xylon*, and pavement ant, *Tetramorium caespitum*

Treatment	Orchard A 1984	Orchard A 1985	Orchard A 1986	Orchard A 1987[◊]	Orchard B* 1985	Orchard B* 1986
Blando bromegrass	8.2 ab[§]	30.5 a	28.8 a	4.3 a	2.0 a[¶]	5.8 a
Salina strawberry clover	5.2 b	19.0 bc	15.2 a	2.0 b	7.0 a	6.0 a
Resident vegetation	11.8 a	27.0 ab	19.8 a	3.7 a	3.8 a	8.0 a
Residual herbicide	3.0 b	11.2 c	15.8 a	5.2 a	2.0 a	2.0 a
Chemical mow	—	—	—	—	5.2 a	3.8 a

NOTE: See table 1 NOTE. P = 0.05.
* Colony numbers too low for survey in 1987, orchard B.
◊ Insecticide treatments applied before survey in 1987.
§ Average number of ant colonies in the herbicide strip and cover areas by each treatment per three tree spaces 26 x 3 x 25 ft.
¶ Average number of ant colonies in the herbicide strip and cover areas by each treatment per three tree spaces 23 x 3 x 19 ft.

TABLE 3. Percent almond nutmeats damaged by ants under four vegetation management systems

Treatment	Orchard A 1985	Orchard A 1986	Orchard A 1987	Orchard B 1986	Orchard B 1987
	%				
Blando bromegrass	7.1 a	12.6 a	3.9 ab	1.37 a	0.0 a
Salina strawberry clover	7.5 a	7.6 ab	2.1 bc	1.17 a	0.0 a
Resident vegetation	8.5 a	12.3 a	4.7 a	0.52 a	0.2 a
Residual herbicide	0.2 b	2.0 b	0.6 c	0.77 a	0.1 a
Time between knocking and pickup	8 days	2 days	5 days	7 days	7 days

NOTE: See table 1 NOTE. P = 0.01.

Conclusions

At orchard A, Blando bromegrass, Salina strawberry clover, and resident vegetation had similar effects on overwintering navel orangeworms in unharvested nuts left on the orchard floor. Fewer navel orangeworm adults emerged from nuts on the ground where vegetation was present than in plots where all vegetation was controlled by residual herbicide treatment. However, the number of ant colonies and the amount of nutmeat damage was significantly higher in the resident vegetation and bromegrass treatments, and intermediate in the clover treatment, when compared with the herbicide treatment. In orchard B, although navel orangeworm survival tended to be higher in the residual herbicide plots, no significant differences in any of the comparisons were observed. The reasons for this are unknown. It should be noted that the orchard was more shaded during the growing season, and the soil was somewhat less sandy.

Although our findings are preliminary, it appears that ant problems can be aggravated where vegetation exists. Growers should monitor orchard floors carefully where ground cover is present, and apply treatments when colony numbers and the interval between knocking the nuts on the ground and pickup indicate damage may be excessive.

Overwintering navel orangeworm populations are a more serious threat where residual herbicide treatment is used. The problem of increased overwintering in residual herbicide treatments could be overcome by following a good winter sanitation program to reduce the number of mummies to very low levels. This would deprive overwintered females of egg-laying sites and limit the number of offspring produced by the first generation. If significant numbers of mummies are still in the trees when overwintered females are laying eggs, the navel orangeworm problem may be aggravated by complete, residual herbicide treatments.

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