

Cultural management of the navel orangeworm by winter sanitation

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Larvae of the navel orangeworm infest almonds during and after hullsplit, rendering the nut meats unmarketable. The insect also damages other nut, fruit, and legume crops by invading dried or decayed fruit and occasionally by entering undamaged fruit.

The life cycle of the navel orangeworm, *Amyelois transitella* (Walker), on almonds lends itself to control by cultural techniques. Larvae overwinter in nuts that remain on the tree after harvest. They emerge as moths in late March through June, depending on temperature, and lay their eggs on the remaining nuts of the previous year's crop. Moths of this first brood begin to emerge in late June. Initially, moths lay eggs only on old nuts. Following hullsplit, egg-laying occurs on nuts of the new crop. Moths of the second brood emerge in time to reinfest the new crop.

Two cultural procedures for managing the navel orangeworm that several researchers have shown to be effective are orchard sanitation and early harvest. In orchard sanitation, nuts remaining in trees after harvest are removed by mechanical treeshakers or by hand-poling. This kills larvae in the nuts and reduces egg-laying sites for moths emerging from the overwintering brood. Early harvest involves timing harvest operations to avoid egg-laying by moths of the second brood.

During 1981 and 1982, we conducted a study to evaluate the efficacy of winter sanitation in current commercial almond production. We monitored 15 mature orchards in the Sacramento Valley (Butte, Colusa, Sutter, and Yolo counties) and 18 mature orchards in the San Joaquin Valley (Fresno, Kern, Kings, Madera, and Merced counties). We determined the number of nuts remaining on the trees in each orchard in January

or early February by counting the nuts per tree for all trees on a transect of the orchard. Growers harvested when 95 to 100 percent of the almonds at head height showed signs of hullsplit. In most orchards, five 100-nut samples were collected at harvest and cracked by hand to evaluate the percentage of damage by navel orangeworm. Insecticide applications for the navel orangeworm were applied at the growers' discretion, based on the use of egg traps to monitor moth flights.

The average yield per orchard in our study was 1,335 pounds of nut meats per acre, with no significant difference between the orchards in either the Sacramento or San Joaquin valleys. Further, no difference was found between the valleys with respect to damage rate in relation to winter nut counts.

Of the 33 orchards monitored, 9 received no chemical treatments for the navel orangeworm, 9 received one treatment, and 15 received two or three treatments. The average number of nuts remaining on trees the previous winter in untreated orchards was 0.87 ± 1.52 (mean plus or minus standard deviation). This was significantly less than the average number of such nuts remaining in orchards that received one treatment (28.14 ± 74.89) or two or three treatments (34.16 ± 40.52). These results indicate that a good sanitation program the previous winter reduced the number of applications required by growers.

Less damage was recorded in the untreated orchards where winter sanitation was practiced. The percentage of damage at harvest in these orchards was 1.98 ± 2.38 . It rose to 5.02 ± 4.44 in orchards receiving one navel orangeworm treatment, and to 7.86 ± 5.35 in orchards receiving two or three treatments. This difference was significant, indicating

that some damage by the navel orangeworm will occur in orchards where a substantial number of nuts remain, even when pesticides are applied to control the insect.

Well-timed chemical applications appeared to decrease the amount of damage that would have occurred in orchards where winter sanitation was not practiced. In the absence of chemical intervention, nut damage by navel orangeworm increased at a rapid rate from about 4 percent at winter nut carryover levels of two per tree to about 9 percent at levels of six per tree.

These results are especially important, since almond growers often receive premium prices for loads of nuts delivered with low kernel damage, and they confirm prior studies showing that damage can be reduced to low levels by removing nuts that remain in the trees during the winter.

Recent economic analysis has shown that the cost of winter nut removal is roughly equivalent to that of a single insecticide application and that the procedure is cost-effective over a wide range of nut prices. Our results show that the technique is feasible in commercial orchards throughout the major almond-growing areas of California and that it can reduce the need for insecticide applications for the navel orangeworm.

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