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Bait formulations and longevity of navel orangeworm egg traps tested

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Standardization of pest monitoring practices and materials to maximize sensitivity to pest populations in the field is a foundation of effective integrated pest management (IPM). In response to changes in the availability of commercial bait material for navel orangeworm (NOW) egg traps, we evaluated potential alternative bait materials for use in monitoring this key pest of almonds, pistachios, walnuts and figs. Navel orangeworm egg traps baited with uninfested nutmeats were as effective as almond meal plus 10% crude almond oil, whereas traps baited with freeze-killed, navel orangeworm–infested nutmeats were less effective. The use of nut mummies (culled during winter orchard sanitation) as trap bait may not produce consistent results since the level of navel orangeworm infestation of these nuts is typically unknown. Three seasons of field tests showed that egg traps baited with almond meal plus 3% or 10% crude almond oil received similar numbers of navel orangeworm eggs, and these traps were equally effective for at least 10 weeks.

When navel orangeworm (NOW) infests nuts and figs, they will contain larvae or pupae and fecal material of the pest. Likewise, navel orangeworm infestation is highly correlated with the infection of nuts by Aspergillus spp., which produce carcinogenic aflatoxins. Both result in losses for growers.

Navel orangeworm (Amyelois transitella) larvae enter figs or nuts through open ostia (figs) or holes in damaged nut hulls (especially codling moth entrance wounds in walnuts); they also enter after hull-splitting and drying of almonds, pistachios and walnuts, which occurs normally as these nuts mature. It is believed that navel orangeworm lay eggs on susceptible hosts in response to changes in odors — associated with the physical maturity changes — emitted from the nuts and figs, and possibly in response to altered tactile cues associated with these physical changes. The host odors are attractive to female navel orangeworm, which then lay eggs on the host; mated navel orangeworm females are known to fly upwind to odors from crude almond oil (CAO) (Phelan and Baker 1987).

The ability to monitor pests is a key component of any integrated pest management (IPM) program. The navel orangeworm is a primary pest of about 1.1 million acres of nuts and figs in California, and currently it is monitored by direct counts of eggs or larvae on the host and by navel orangeworm egg traps (Rice et al. 1976). Trapping data is used to time the early harvest of almonds prior to egg-laying by the third generation of navel orangeworm and for timing insecticide sprays for the third generation in pistachios (Bentley and Surber 1986). The more accurately navel orangeworm populations can be tracked, the better they can be managed, particularly with newer, reduced-risk insecticides that have shorter residual times or require more precise application timing to maximize their effect on navel orangeworm numbers. Although the sex pheromone for this insect has been reported (Coffelt et al. 1979; Leal et al. 2005; Millar and Kuenen 2005), it is ineffective in sticky traps compared to traps baited with unmated females (Kuenen et al. 2001; Millar and Kuenen 2006). Therefore, egg traps will remain important for years to come in the IPM of navel orangeworm.

Current commercial egg traps consist of plastic vials (3.375 inches by
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Egg trap tests

Tests were conducted in almond, fig and pistachio orchards in Madera County during the 2001 to 2003 growing seasons. Navel orangeworm egg traps were purchased from Trécé, Inc. (Adair, Okla.) and were filled at least 75% with baits to ensure that the traps’ windows remained covered with bait throughout the test periods (see also Van Steenwyk et al. 1986). Traps were suspended on branches about 5 feet above the ground in the outer half of the canopy, and treatments were placed in randomized complete block designs with five or more replicates per test. Each replicate block was laid out along tree rows with at least 65 feet between traps within the replicate blocks and at least 65 feet between replicate blocks (actual spacing was determined by tree spacings within and between rows). The first trap in each row was at least 165 feet in from the nearest orchard road. All test blocks consisted of areas with no orchard drive rows or any other open spaces within larger orchard blocks.

Typically, egg counts were taken at weekly intervals. After each count, traps were re-randomized by moving them one tree forward within the replicate, and then the last trap in the row was moved to the first trap position in the same row. Trap baits were always formulated in the Kuenen lab, but plot specifics and the choice of orchards were conducted independently by our labs to ensure adequate orchard representation.

Data were analyzed graphically and by ANOVA. No data transformations were necessary as indicated by Bartlett’s test for homogeneity of variances (Sokal and Rohlf 1981). Egg counts (eggs/trap/week) were analyzed by 2-way ANOVA using PROC GLM in SAS, and mean separation tests (alpha = 0.05) were conducted with Tukey’s HSD test (SAS 2001). No significant block effects were found in any of our studies (P > 0.05).

Nutmeats vs. almond meal plus oil

Since some growers and pest control advisors use nutmeats collected from orchard sanitizing procedures in their egg traps, our first test in 2001 compared traps baited with (1) almond pieces, (2) pistachio pieces, (3) navel orangeworm-infested almond pieces, (4) navel orangeworm-infested pistachio pieces, (5) almond meal plus 10% (by weight) crude almond oil or (6) left empty as control traps. For the infested nut pieces, navel orangeworm larvae had been freeze-killed (as they would be by users of culled mummy nuts).

There were no differences in trap catch among uninfested almond, uninfested pistachio or traps baited with crude almond oil (P > 0.05) (fig. 1), whereas traps baited with infested almond or infested pistachio pieces were significantly lower (P < 0.05) than uninfested almond pieces. The control traps received few eggs. Commercial bait is easier to handle and more easily standardized. Further, since the almond meal containing 10% crude almond oil was as effective a trap bait as the uninfested nutmeats, and since the components are easily manipulated, our subsequent tests focused on assessing the influence of varying amounts of...
% CAO by weight

A

2001

Mean egg/trap/week
(± 1 SE)

0 5 10

Mean egg/trap/week
(± 1 SE)

0 1 3 10

B

2002

Mean egg/trap/week
(± 1 SE)

0 1 3 10

C

D

Wheat
Almond

Monitoring with egg traps allows growers to better time harvests and more effectively apply lower-risk insecticides. Left, a midseason pistachio cluster and, right, nuts mummifying after harvest.

In 2001, traps were hung in a Madera County (A) almond orchard May 17–23 and checked daily, and (B) pistachio orchard July 11–Aug. 1 and checked weekly. In both orchards, one trap per bait type was hung in each of five blocks for a total of 40 traps. In 2002, traps were hung in a Madera County (C) pistachio orchard Aug. 8–Sept. 5, and (D) almond orchard Oct. 8–Nov. 5. In both orchards, one trap per bait type was hung in each of seven blocks for a total of 56 traps, and checked weekly. In 2001, there were no significant differences in egg counts within bait types. In 2002, columns having no letters in common are significantly different within bait types; $P < 0.05$, Tukey’s HSD test. All bars represent ± one standard error.

In summer 2003, we also examined the longevity of trap baits. Fifteen traps were baited with 3% crude almond oil and 15 with 10% crude almond oil on trap capture.

**Standardizing trap baits**

Comparisons were made between traps baited with almond meal or red wheat bran mixed with 0%, 1%, 3% or 10% crude almond oil by weight, based on the weight of almond meal. Thus, traps with a given percentage of crude almond oil contained the same amount of crude almond oil plus almond meal on trap capture.

In 2003, we conducted two further tests of almond meal plus crude almond oil only, since the wheat bran plus crude almond oil baits typically captured fewer eggs. Trap capture data were combined for the two tests and showed nearly equal trap catch at all doses of crude almond oil tested ($P > 0.05$) (fig. 3).

In this last study and our first with almond meal plus crude almond oil, the treatment without crude almond oil was as good as or better than those with crude almond oil. This is perplexing, since all the almond meal and crude almond oil came from single batches, respectively, from the vendor. It is also important to note that in all our tests, trap capture variability was high and mean trap catch in relation to the dosage of crude almond oil shifted continuously. Even with replicated and repeated tests, consistent significant differences were rare. Nevertheless, over the course of all tests, treatments with almond meal plus 3% crude almond oil typically performed well, so we are compelled to recommend it as the best treatment in this monitoring technique.

**Trap bait longevity**

In summer 2003, we also examined the longevity of trap baits. Fifteen traps were baited with 3% crude almond oil and 15 with 10% crude almond oil on
almond meal, and aged (held) in a laboratory incubator at 90°F. Every 2 weeks, five traps of each dosage were removed and held at −4°F until we had traps that were aged at 90°F for 0, 2, 4 and 6 weeks (−4°F is a standard laboratory freezer temperature, at which little or no evaporation of odor compounds occurs). For this test, traps of all age categories were placed in a fig orchard when day-time highs were regularly 90°F to 95°F. Traps were positioned in a randomized complete block design and egg counts were taken weekly for 4 weeks. There were no differences in the capture efficiency of these aged egg traps \((P > 0.05)\) (fig. 4) even after aging in the lab for 6 weeks and use in the field for 4 weeks.

Practical implications

Tests over three field seasons and in several orchards demonstrated that almond meal mixed with crude almond oil is an effective trap bait, and traps baited with a near-neutral carrier (wheat bran) plus crude almond oil were not as effective \((P < 0.05)\). In addition, traps baited with pistachio or almond nutmeats were as effective as almond meal plus crude almond oil; however, freeze-killed, navel orangeworm larvae–infested nuts captured significantly fewer eggs \((P < 0.05)\).

The variability in egg counts on the traps was always high, with the standard errors typically exceeding the means. Although significant differences in trap counts were rare among the almond meal/crude almond oil baits, traps with almond meal plus 3% or 10% crude almond oil tended to capture the greatest number of eggs, and both traps were equally effective over 10 weeks. We conclude that almond meal plus 3% crude almond oil will be effective in the field, with little or no loss of efficiency for at least 10 weeks.

References


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