1990 ANNUAL PROGRESS REPORT
ALMOND BOARD OF CALIFORNIA

Project No. 90-A11B	Field Testing of Navel Orangeworm Oviposition Disruptant Formulations
Project Leader:	Dr. Tom Baker Department of Entomology University of California Riverside, California (714) 787-5811
Cooperating Personnel:	Dr. Harvey Yoshida, UC Riverside Dr. Larry Phelan, Ohio State University Jean Hudgins, Paramount Farming Co., Bakersfield, CA
Objectives:	1) Maximize the efficiency of the navel orangeworm disruptant by determining the effect of reduced application rates on egg laying, and 2) Determine if period of navel orangeworm ovipositional disruption could be extended by a second application of disruptant.

Note: This was a collaborative project between Dr. Phelan's laboratory at OSU (Project 90-A11A) and Dr. Baker's laboratory at UC Riverside in which Dr. Baker's lab performed the field application, sampling and damage assessment. Thus, Dr. Baker's report (below) which reports the field results will be nearly identical to Dr. Phelan's.

Interpretive Summary:

(As per Dr. Phelan's report 90-A11A)

Field testing of our standard navel-orangeworm-disruptant formulation (GF-30) this season again demonstrated successful reduction in egg laying. Using the same application rate as in previous years (1.7 gal/acre a.i.), plots were treated every row, every second row, or every fourth row, for a total of 18 acre/treatment. After the first application (June 28), egg-laying was disrupted for 2 weeks by 99% in plots treated every row and by 100% in second-row plots relative to untreated plots. Plots treated every fourth row showed 94% disruption during the first 10 days, but no disruption was measured at the two-week count. After a second application on July 17, egg-laying was again eliminated in every-row and second-row plots, and reduced by 93% in fourth-row plots when measured three days later; however, one week later, egg laying had declined to zero in control plots and remained there for two weeks so that disruption in treated plots could not be assessed. When egg laying resumed in control plots (now three weeks after application), disruption in every-row and second-row plots had declined to 51% and 54%, respectively, and had dropped to 22% in fourth-row plots. In all, this season's trials confirm the conclusions of last year that the GF-30 formulation produces >98% ovipositional disruption for about two weeks. In addition, it appears that application of the material to every second row is as effective as application to every row. As such, this will mean a 50% reduction in costs for material and application to the grower.

Experimental Procedures:

(As per Dr. Phelan's report 90-A11A)

The field testing of navel orangeworm disruption using different application rates and a second application of disruptant took place in the almond orchards of Paramount Farms. Navel orangeworm disruption measured in field trials during the past two years was based on an application rate of 1.7 gal/acre of the active ingredient. We wanted to know if this rate could be reduced without a significant reduction in efficacy. Furthermore, a possible advantage of behavioral disruption over insecticides is that uniform coverage of the crop during application may not be necessary, so that rather than diluting the formulation, we tested lower per-acre application rates by spraying every second or every fourth row of almond trees, and comparing these plots for NOW activity with plots given the standard every-row application and with untreated plots. Secondly, since our past work had indicated that one application of the NOW disruptant was insufficient to protect the almond crop for the entire season, we set out to determine if a second application of the disruption formulation could extend this period of protection. Thus, when eggs started to be laid again in plots that had been treated with disruptant, we made a second application. Two orchards were utilized for these two objectives: one measuring 77.5 acres and the second 72.5 acres, both of which were 51 trees wide with trees in a diamond pattern. Each of these orchards was divided into four 8.9-acre (12 row) treatment plots, between which were located 8.9-acre untreated buffer zones to reduce inter-treatment effects. Figure 1* shows the treatment assignments for Field A; assignments of disruptant-treated plots were rerandomized in Field B. The untreated Check plot remained at the north end of the field since the prevailing wind during the time of testing was reported to come from the northwest. We wished to minimize any NOW-disruption effect in the Check plot brought about through contamination by the odor plumes from treated plots. Standard black navel orangeworm egg traps were used to monitor ovipositional activity throughout the season, with seven uniformly-spaced traps assigned to the experimental plots and three traps were placed in each of the untreated buffer zones. Traps were checked twice per week from June 14 to August 23, the latter being the date of almond harvest in those orchards.

Approximately 440 gal of GF-30 navel orangeworm disruptant were formulated in Ohio and shipped to Bakersfield. This formulation blend had been tested in our 1989 field trials and was found to be effective in disrupting navel orangeworm egg-laying for approximately 10-14 days. Applications of the disruptant were made using two conventional orchard sprayers with 100 gal/acre water. The first application was made on June 28, in anticipation of almond hullsplit, and the second application made on July 17. Plots were also compared for nut damage at the time of harvest; within each plot, ten nut samples were taken with approximately 200 nuts per sample, for a total of about 4,000 nuts per treatment (both fields). In addition, nut damage was also assessed in two neighboring orchards that had been managed by the grower using a conventional pesticide regime of Guthion/Omite mix applied at hullsplit.

Results:

(As per Dr. Phelan's report 90-A11A)

Navel orangeworm egg-laying was somewhat delayed this year in our plots compared to previous years, particularly in Field A. This was an assessment echoed by other growers and consultants with which we have spoken. So even though sprays were made late in June in anticipation of hullsplit, eggs did not start showing up in our Check plots until closer to the middle of July. For Field A, significant egg laying began in the Check plot between July 9 and 12, and peaked on July 15 (Figure 2*). Since egg laying began to increase in disruption-treated plots during July 9-15, we made our second application on July 17, which was 19 days

*Please refer to 1990 Annual Progress Report #90-A11A.

after the first spray. Unfortunately, within a week of this application, egg laying dropped off to zero in the Check plots (Figure 2*). Thus, in hindsight, we did not time our sprays to make optimal use of our disruption materials. Nevertheless, we did see a profound reduction in egg laying in all three treated plots during July. During August, we had a fairly high navel orangeworm activity in all of the plots of Field A, during which time we did not apply any disruptant (Figure 3*). No differences among the plots were evident in egg-laying patterns during this time. We had similar results in our second field, in which egg laying in the Check plot began July 2-5 and peaked July 9 (Figure 4*). We saw virtually no eggs laid during July in the plots treated either every row or every other row; however, disruption of egg laying was considerably less successful in those plots that were sprayed only every fourth row during this period. As in Field A, we experienced higher navel orangeworm activity in August, when no disruptant was applied and no differences in egg laying were evident among treatments (Figure 5*).

The effect of the different application rates is made somewhat more clear by looking at total egg laying by month for both fields combined. During July when the two applications were made, we found that navel orangeworm egg laying was reduced by about 50% in plots treated every fourth row (Figure 6*), and reduced by more than 90% in plots that were sprayed every row or every other row. In contrast, during August when no disruption was attempted, navel orangeworm egg laying was very similar in all of the plots (Figure 7*). The difference in navel orangeworm egg counts on monitoring traps between July and August probably greatly underestimated the real increase in egg laying during August because it is a well-established fact that navel orangeworm egg traps show a very significant decline in their efficiency as the almonds mature on the trees and provide high levels of competition as oviposition sites. It is probably because of this higher level of egg laying during August that when the almonds were harvested late in August, no differences in nut damage were measured among the plots (Figure 8*). Interestingly, we also found no significant difference in nut damage between our untreated Check plots and two neighboring orchards that had been managed with conventional pesticides. The contention that egg laying was much higher in August than in July is affirmed by the fact that when navel orangeworm damage was subdivided according to age class, we found that about 90% of the damaged nuts contained larvae. Given the 3-4 week life cycle of the navel orangeworm, these larvae must have resulted from the August flight. When we compared the numbers of nuts containing shed pupal skins, which would have resulted from adults emerging from eggs laid in July, we see a different pattern of damage. Generally, adult nut infestation was lower in the disruption plots than in the Check plots or in the insecticide-treated orchard (Figure 9*), although the only significant differences in damage were those between plots treated every row or every fourth row and insecticide-treated plots. The number of nuts containing empty pupal cases is undoubtedly more reflective of navel orangeworm damage occurring in July, although it must be acknowledged that the relative level of adult infestation in fourth-row-treated and second-row-treated plots does not correspond very well with the relative level of July egg laying measured for those two treatments. Part of the problem may be due to the fact that we are looking at differences in damage at 1% and below, where variability as a percentage of the mean would be expected to be high.

In conclusion, we have confirmed our previous findings that a fatty-acid-based formulation can disrupt navel orangeworm egg laying by more than 90% for about two weeks. Furthermore, although in hindsight the timing of our broadcast sprays could have been better optimized, it appears that multiple applications of the disruptant can extend the time of effective crop protection. Of a particularly positive nature is the finding that applying the disruptant to alternate rows is as effective as applying to every row. This should lower the costs of application as well as the disruption materials by approximately 50%, helping make this strategy more economically feasible. Finally, we continue to attempt to increase the feasibility of this approach through the development of new formulations.

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*Please refer to 1990 Annual Progress Report #90-A11A.

Project: Evaluation of a Mass Egg-Trapping Program for the Navel Orangeworm

Note: This project was conducted without funding from the Almond Board of California or any source outside UC Riverside.

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Objectives:

1) To determine whether navel orangeworm damage could be reduced by the mass deployment of egg traps as competing oviposition sites; and
2) To test the effectiveness of an inexpensive, experimental egg trap in a mass trapping program.

Interpretive Summary:

An experimental egg trap, supplied by Scentry, Inc., was evaluated under field conditions for its effectiveness in a mass trapping program. Although there were no statistical differences in egg trap counts between the untreated check and treated plots for each sample date, treated plots received a lower number of eggs for approximately 2 weeks following the mass deployment of egg traps (01 August). Moreover, nut samples obtained just prior to harvest did not reveal any significant differences in percent infestation between treated and untreated check plots. Evaluation of treatment effects may have been hindered by relatively low egg counts throughout the trapping period.

Experimental Procedures:

Paramount Farming Company (Bakersfield, CA) provided the test site. Twenty acres of pistachios were divided into 12 plots. Four plots (6.7 acres) were assigned to an untreated check treatment and the remaining 8 plots (13.3 acres) were used for mass trapping. The egg traps were baited with a synthetic fatty acid mixture (supplied by Scentry, Inc.) and were deployed on 01 August on every large tree within the treated plots. Traps were secured to a tree limb approximately 5 feet above the soil surface. Smaller nonbearing trees that were interplanted among the larger trees did not receive traps. There was a total of 78 traps per acre. All plots were monitored using black Pherocon® IV egg traps. There were 3 traps per plot (36 total) and they were baited with a mixture of almond press cake and 10% crude almond oil. The bait within these traps was replaced every 14 days. Egg counts were recorded and the traps rerandomized within the same tree every 3 to 4 days throughout the study. An assessment of infestation was made prior to harvest whereby 1,200 nuts were randomly sampled from 24 trees within each plot. The samples were then taken to the laboratory where a grand total of 14,400 nuts were cracked and inspected for signs of navel orangeworm damage.

Results:

In general, egg counts were very low throughout the entire test period. The mean number of eggs per trap reached a high of only 11.17 on 06 August (Figure 1). Moreover, egg counts dropped precipitously during mid August and remained relatively low for the duration of the test.

There were no significant differences in the mean number of eggs per trap between the treated and untreated check treatments for each sample date (Figure 1). However, traps within the treated plots had a generally lower number of eggs for approximately 2 weeks following the August 1st deployment of traps. As a corollary to the egg counts, there were no significant differences in mean percent infestation between the treated (1.84%) and untreated check (0.83%) plots (Table 1). The very low infestation level was undoubtedly a direct result of the overall lull in egg counts.

Periodic examinations showed that there were virtually no eggs laid on the mass-deployed experimental traps. A subsequent test conducted by Scentry, Inc., determined that a sample of the same fatty acid impregnated lures used in the experimental traps was effective in stimulating egg-laying when placed in black Pherocon® IV egg traps. These findings infer that the substrate used in the experimental egg traps was not conducive to navel orangeworm oviposition. It has been documented that navel orangeworm females exhibit a strong preference for ovipositing in tight, protected areas as within the crevice of an almond nut at hullsplit. The substrate on the experimental traps used in this study was only lightly textured. Although it was part of Scentry's goal to produce a cost-effective, economical trap, it appears that the material used in this design did not provide a suitable substrate for oviposition.

From previous year's results we have evidence to support the contention that mass trapping, as a control strategy, has definite potential against the navel orangeworm. A synthetic fatty acid mixture has proven to be an effective bait and was able to significantly reduce damage when used in black Pherocon® IV egg traps. Although the Pherocon® egg trap has proven to be effective at an approximate per unit cost of $3.00 (based on December 1989 researcher price list, Trécé, Inc.), they would be prohibitively expensive in a mass trapping program.

This year's findings underscore the importance of an effective trap design. In addition to a long-lasting attractive bait, a trap must also provide a substrate suitable for oviposition. Therefore, we are still faced with the challenge of developing an effective egg trap at a cost that would be competitive with conventional insecticide applications. Further, research including collaborative projects between the University and private industry will help achieve this goal.

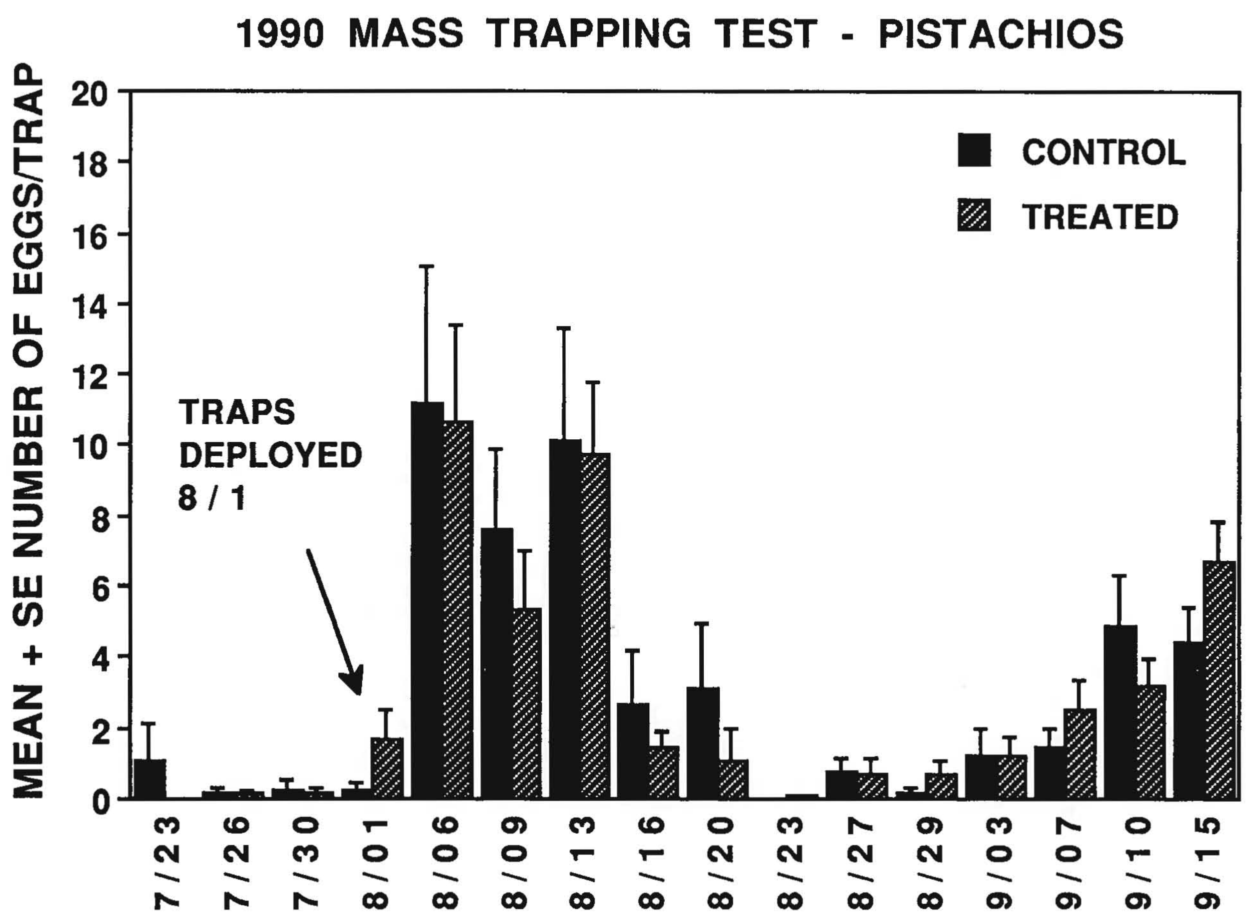

Figure 1. Results of 1990 Mass Trapping Test of Navel Orangeworm on Pistachios.

Table 1. Mean Percent navel orangeworm infestation on pistachio.

Treatment	Mean	±	SE
Control	0.833	±	0.156 NS[a]
Treated	1.844	±	0.187 NS

[a]No significant differences between means (P>0.05; Duncan's Multiple Range Test).