1990 ANNUAL PROGRESS REPORT
ALMOND BOARD OF CALIFORNIA

Project No. 90-A11a - Developing Almond Volatiles for Protection Against Navel Orangeworm

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*Objectives:* 1) maximize the efficiency of the navel orangeworm disruptant by determining the effect of reduced application rates on egg laying,

2) determine if period of navel orangeworm ovipositional disruption could be extended by a second application of disruptant, and

3) develop new formulations that possess greater field longevity, are easier to handle, and/or are cheaper to produce.

*Interpretive Summary:*

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.

Two new formulations were developed as possible navel orangeworm ovipositional disruptants. If successful, these formulations should have greater field longevity, be lower in cost, and would be 75% lower in volume for the same amount of active ingredient. Both formulations were tested during mid-season for phytotoxicity, and when applied at the rates to be used for disruption, no leaf burn or leaf drop were observed. One of the formulations was applied to a 20-acre plot during August; however, navel orangeworm populations were too low to adequately measure disruption, with egg counts averaging less than 0.2 eggs/trap/day.

*Experimental Procedures:*

The field testing of navel orangworm 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 extent 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 rows) 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 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.

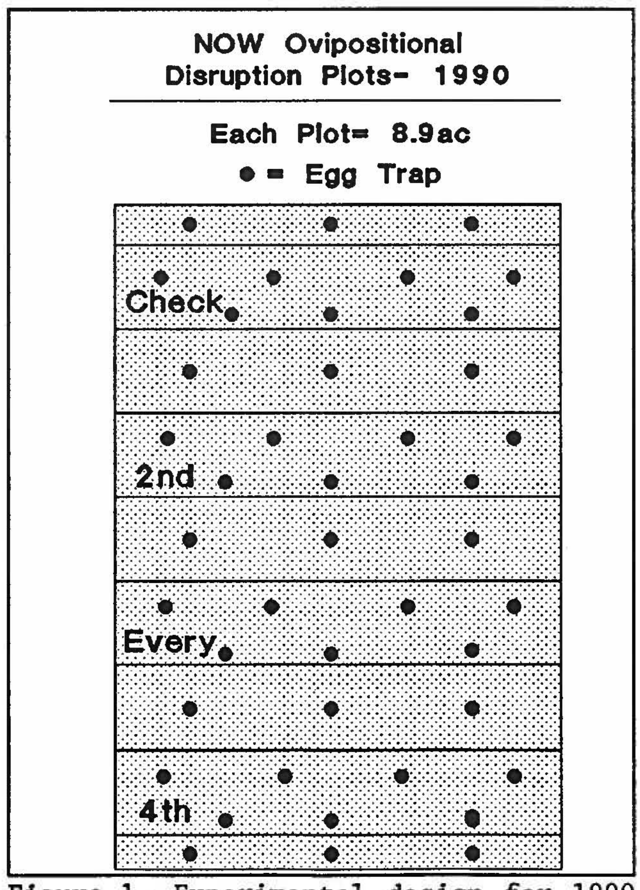


**Figure 1.** Experimental design for 1990 navel orangeworm disruption studies with broadcast application of GF-30. Every= every row of trees treated, 2nd= every other row treated, and 4th= every fourth row treated.

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 4000 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.

Two new navel orangeworm-disruption blends were formulated for field testing, identified as PE-061 and CDS-062. These were assessed for phytotoxicity in late June, at which time a 5% solution of each was applied to run-off to individual trees with a hand sprayer. A second assessment of phytotoxicity was made for these formulations in mid-July in two different locations; each formulation was applied to one row of trees at a rate of 2.75 gal/acre with 50 gal/acre of water using an electrostatic sprayer, and PE-061 was applied to a second row of trees at the same rate and 200 gal/acre of water using an orchard blast sprayer. On August 10, PE-061 was applied again to a 20-acre almond plot that had also received a treatment of Javelin during July. Egg laying and nut damage in this plot were compared with those of a 20-acre plot receiving a Guthion/Omite treatment at hullsplit. Egg laying was monitored by six egg traps positioned throughout each 20-acre plot and these were checked weekly.

*Results:*

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

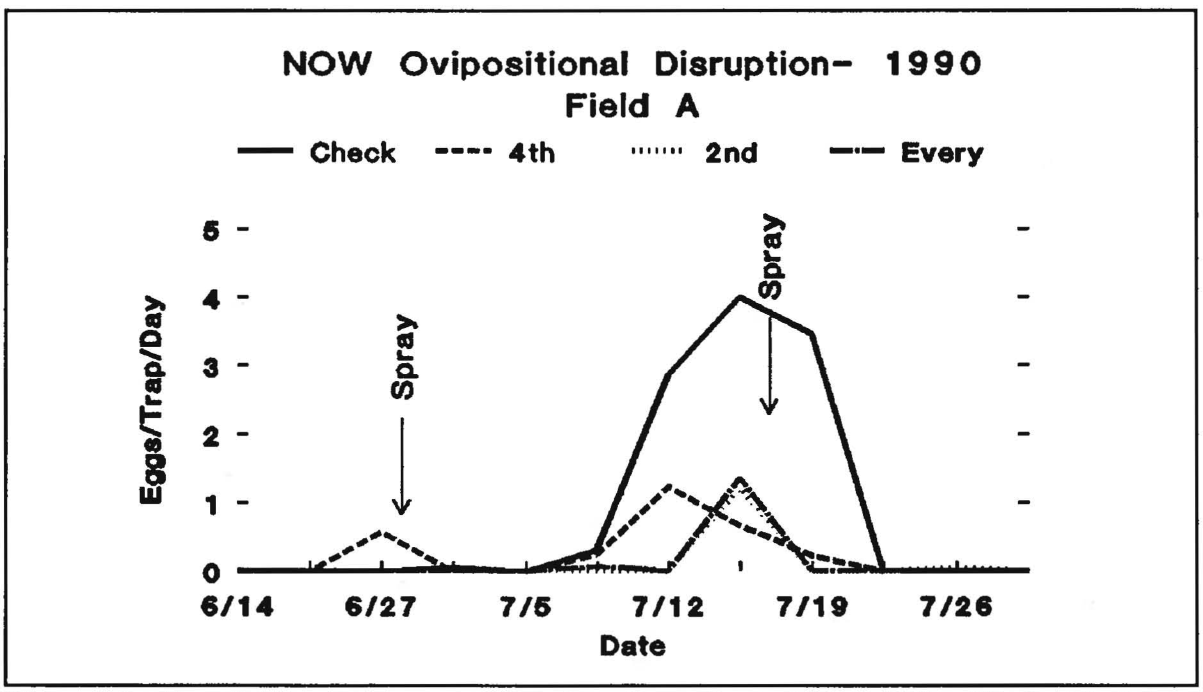


**Figure 2.** Navel orangeworm egg laying from June 14 to July 29 in Field A. Experimental plots were treated with GF-30 every row of trees (Every), every other row (2nd), every fourth row (4th), or left untreated (Check).

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 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

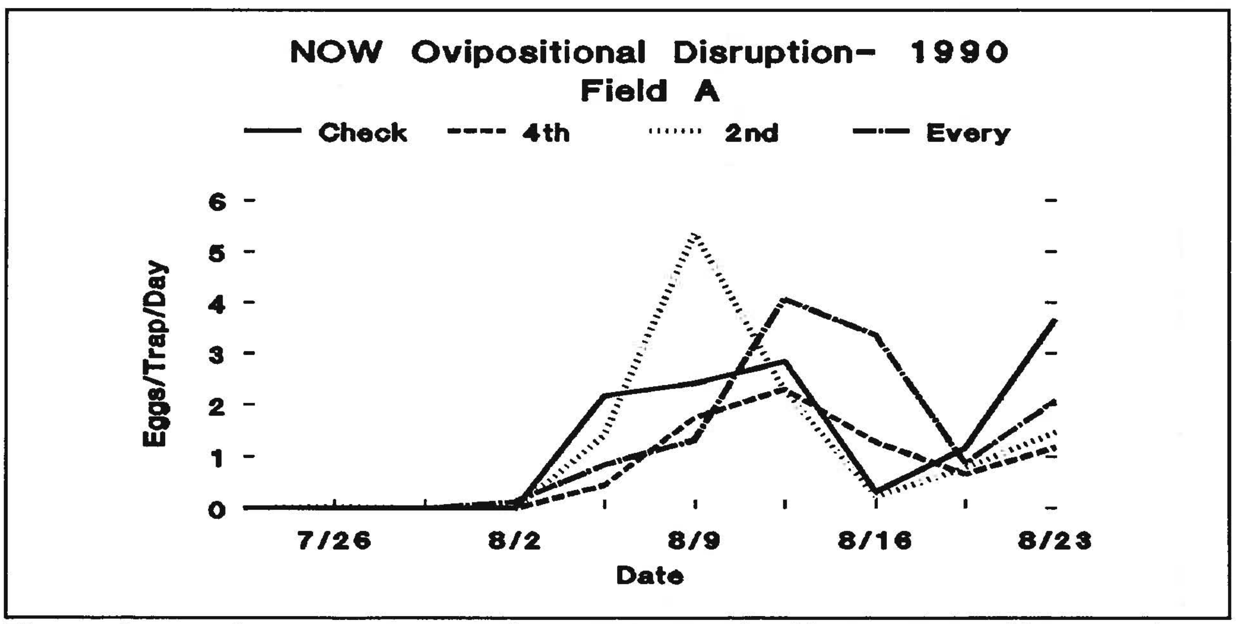


**Figure 3**. Navel orangeworm egg laying from July 23 to August 23 in Field A. Experimental plots were treated with GF-30 every row of trees (Every), every other row (2nd), every fourth row (4th), or left untreated (Check).

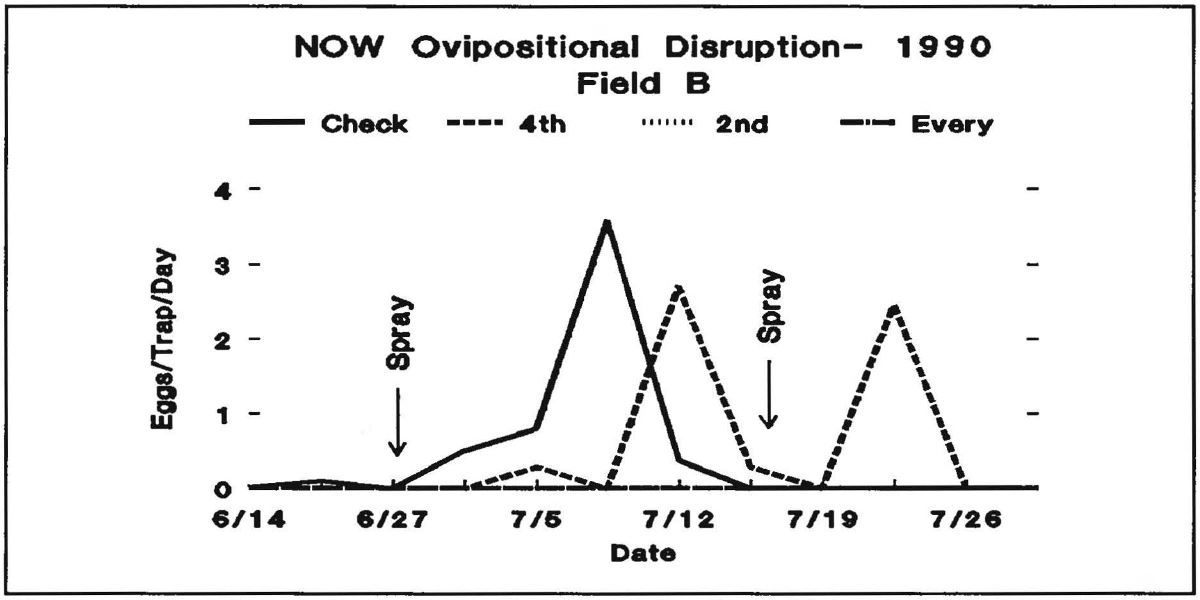


**Figure 4.** Navel orangeworm egg laying from June 10 to July 29 in Field B. Experimental plots were treated with GF-30 every row of trees (Every), every other row (2nd), every fourth row (4th), or left untreated (Check).

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

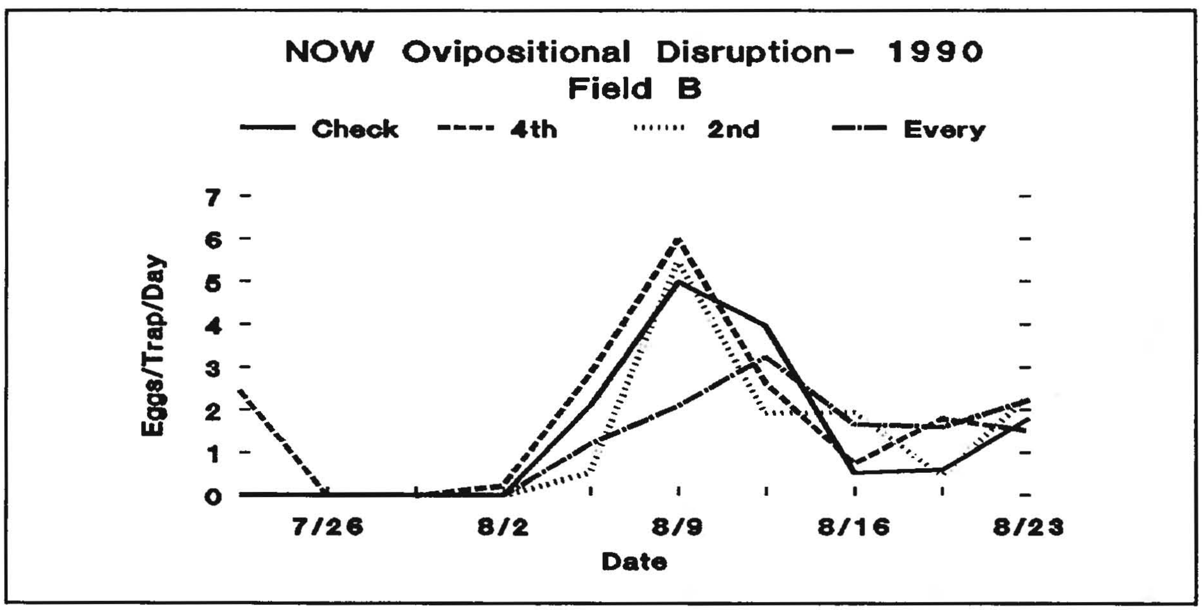


**Figure 5.** Navel orangeworm egg laying from July 23 to August 23 in Field B. Experimental plots were treated with GF-30 every row of trees (Every), every other row (2nd), every fourth row (4th), or left untreated (Check).

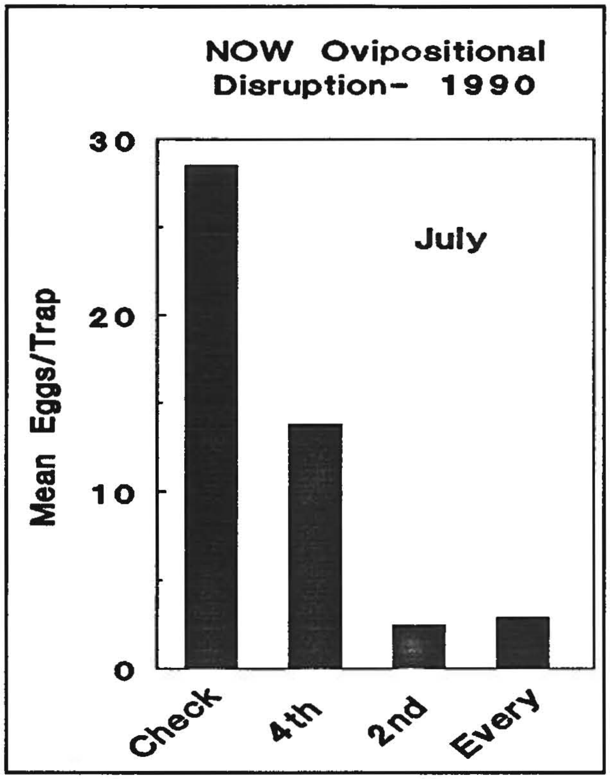


**Figure 6.** Combined navel orangeworm eggs/trap for Fields A and B during July in plots treated with GF-30 every row of trees (Every), every other row (2nd), every fourth row (4th), or left untreated (Check).

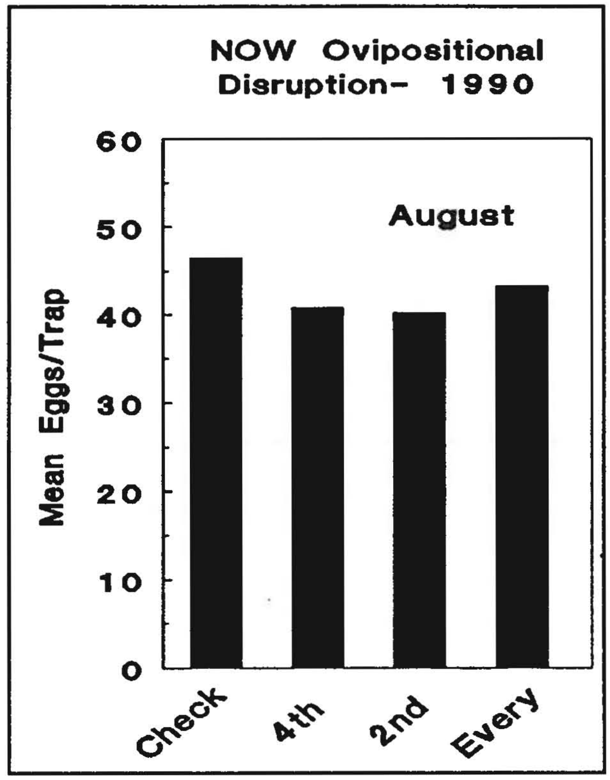


**Figure 7.** Combined navel orangeworm eggs/trap for Fields A and B during August in plots treated with GF-30 every row of trees (Every), every other row (2nd), every fourth row (4th), or left untreated (Check).

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.

With regard to the third objective of developing new disruption formulations, this summer we carried out phytotoxicity studies on two new candidates. The primary goal sought in developing new formulations is to increase the period of effective ovipositional disruption; however, if either of these two formulations proves effective in the field, they would also have the addition benefits of being of much lower cost than GF-30 and would also provide formulation will cause phytotoxicity.

With this confidence that phytotoxicity was not a problem, disruption studies were planned for August with two growers. Unfortunately, one grower was not able to apply the formulations as planned. The second grower applied PE-061 on August 10; however, this was too late to provide an opportunity for measuring disruption, as the third flight of the navel orangeworm had already peaked, and egg counts in the traps were very low by this time: 0.25 eggs/trap/day and 0 eggs/trap/day for PE-061 and Check plots, respectively, for the week of August 15; 0.28 eggs/trap/day and 0.2 eggs/trap/day, respectively, for the week of August 22. These counts are consistent with the levels of egg laying seen in our concurrent disruption studies at Paramount Farms located nearby (Figures 3 and 5). Not surprisingly, there was also no difference in nut damage, 4% for both the PE-061-treated and untreated plots. Thus, there is not much one can conclude from this test, other than to gain additional assurance that phytotoxicity is not a problem.

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. PE-061 and CDS-062 represent two candidates that feature significant improvements over GF-30 in terms of cost and ease of handling. We are anxious to test these in the coming year for their ability to disrupt navel orangeworm egg laying.