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# Comparison of Navel Orangeworm Attractants

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**Project No.:** ENTO2.Burks

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## A. Summary

A series of trials compared phenol propionate (PPO) and alternative attractants to monitor NOW in the presence and absence of mating disruption. A season-long experiment briefly examined a novel commercial trap design and demonstrated that PPO and ovibait (Peterson Traps) had similar weekly profiles in the presence and absence of mating disruption, although more moths were captured with PPO than with ovibait. A monitoring trial associated with NOW sterile insect release documented a larger capture of non-target moths than previously observed, consisting primarily of noctuids that were superficially similar to NOW and sometimes outnumbered NOW. Two additional experiments indicate that a novel experimental pheromone formulation attracted NOW in both the absence and presence of mating disruption. Future studies should examine whether this novel pheromone formulation can serve the role in NOW pest management that is currently served by pheromone monitoring lures and PPO.

## B. Objectives (300 words max.)

Overall goal: Provide a consistent and effective strategy for monitoring NOW for pest management, regardless of mating disruption status

### Objectives

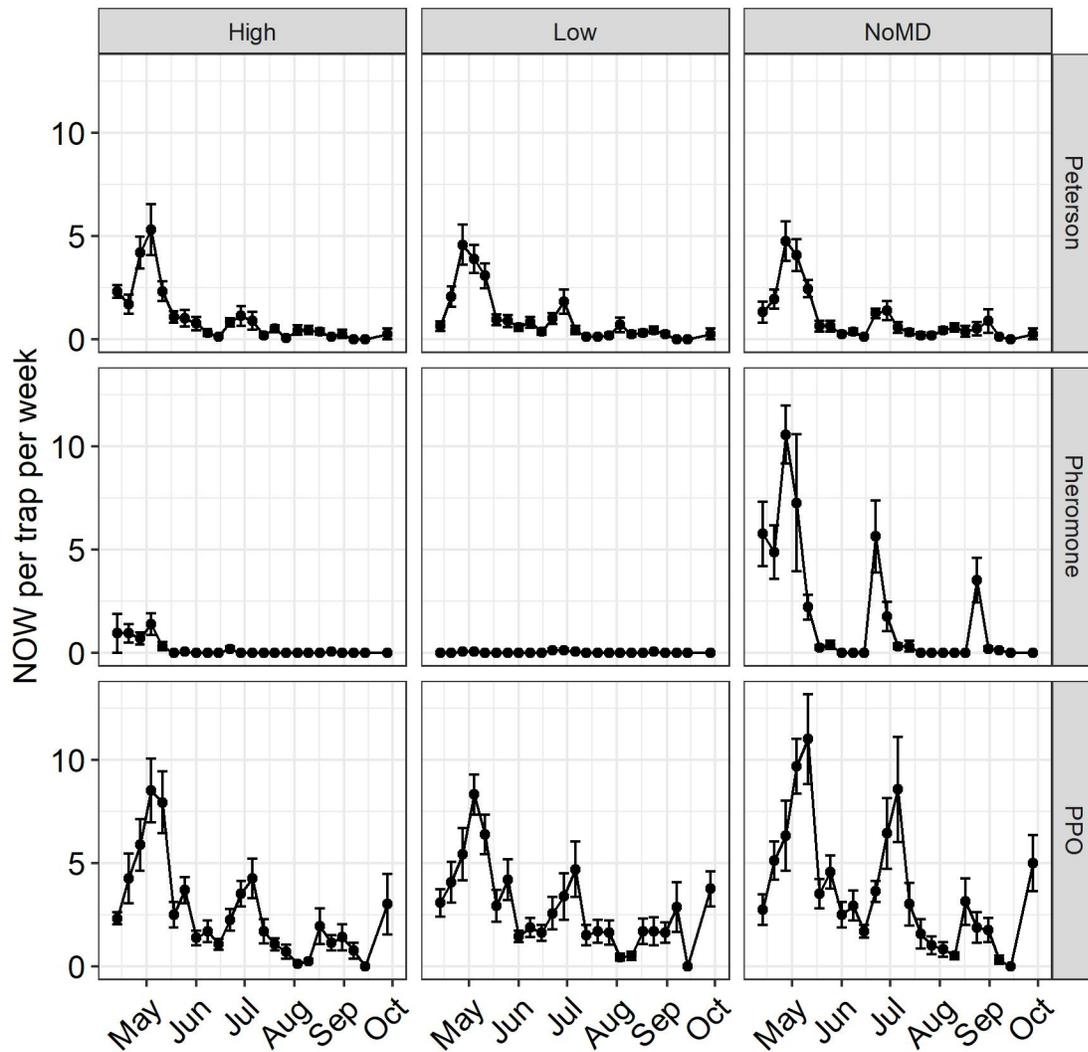
1. Use trials of commercial prototype traps to identify a practical and effective alternative to the delta trap currently used by most PCAs
2. Compare the previously identified PPO trap with ovibait pouches for monitoring females and new candidate attractants.

## C. Annual Results and Discussion (This is the core function of this report)

Both objectives were addressed with four trials during the 2020 growing season: First, a season-long trial in a series of orchards near Huron (Fresno County) compared the profile of NOW trapped with pheromone, phenol propionate (PPO), and ovibait (Peterson traps) (Figure

1). Second, an experiment using alternative pheromone and trap formats identified a potential alternative for monitoring in the presence of mating disruption (Table 1). Third, trials in almond orchards near row crops demonstrated a greater challenge with by-catch of moths superficially similar to NOW than we have previously seen (Figure 2). Finally, late-season experiments demonstrated that one of the pheromone-based attractants from the second trial has potential for monitoring in both the presence and absence of mating disruption and may have advantages over PPO (Figure 3).

**Figure 1.** Weekly NOW per trap (mean and SE, n = 16) in almond plots with two mating disruption treatments (High, Low) and no mating disruption (NoMD)



The first experiment (Fig. 1) conducted monitoring research on top of a comparison of two mating disruption treatments with a non-mating disruption grower standard (i.e., the same sanitation, chemical control, and harvest practices were used in all plots). In this study PPO was used by itself (not co-presented with a pheromone lure), and all attractants were presented in wing traps modified by bending the wires to allow us to clip in and remove trap liners. In the absence of mating disruption, all three attractants gave similar information (Figure 1, right three panels). We briefly used a trial commercial wing trap intended to simplify trap

changes, but in practice this trial design increased rather than decreased trap servicing time. In the presence of mating disruption, pheromone traps were completely suppressed, whereas both ovibait and PPO traps gave similar information about population timing. For example, all trap types indicate a peak for flight 2 on approximately July 1. The PPO traps captured more adults than the ovibait (Peterson) traps. This suggests that failure to detect a NOW population of economic concern is less likely with traps baited with PPO trap compared to ovibait traps. The two mating disruption treatments differed only in that the “High” treatment meso-dispensers (Cidetrak MESO NOW, Trécé Inc., Adair OK) was placed conventionally in the upper canopy using poles, whereas in the “Low” treatment the meso-dispensers were placed without poles at a height of around 5-7 feet. A growing body of evidence suggests that this labor-saving lower placement is equally or more effective compared to the higher placement for NOW in almonds. It is important to note that this evidence cannot be taken as relevant for other target pests (e.g., codling moth) and other crops.

Experiment 2 (Table 1), conducted in a pistachio orchard in July and August 2020, used trap size to examine differences in performance between different formulations of a pheromone lure. A standard optimized monitoring lure was compared to two experimental formulations, TRE2340 and TRE1541. Both formulations emit much more pheromone than the monitoring lure, and they differ in the mixture of compounds emitted. We compared them in standard 12 x 12 inch wing traps and in experimental 48 x 48 inch traps fabricated with foam wall insulation panels with adhesive covering the lower surface.

**Table 1. NOW per trap (mean and SE, n = 3) from 7 July to 3 Sep 2020**

Lure	48 × 48 inch traps	12 × 12 inch traps
Pheromone monitoring lure	246 ± 68a	257 ± 48a
TRE 2340	71 ± 35b	69 ± 10b
TRE 1541	2 ± 0.3c	2 ± 0.7c

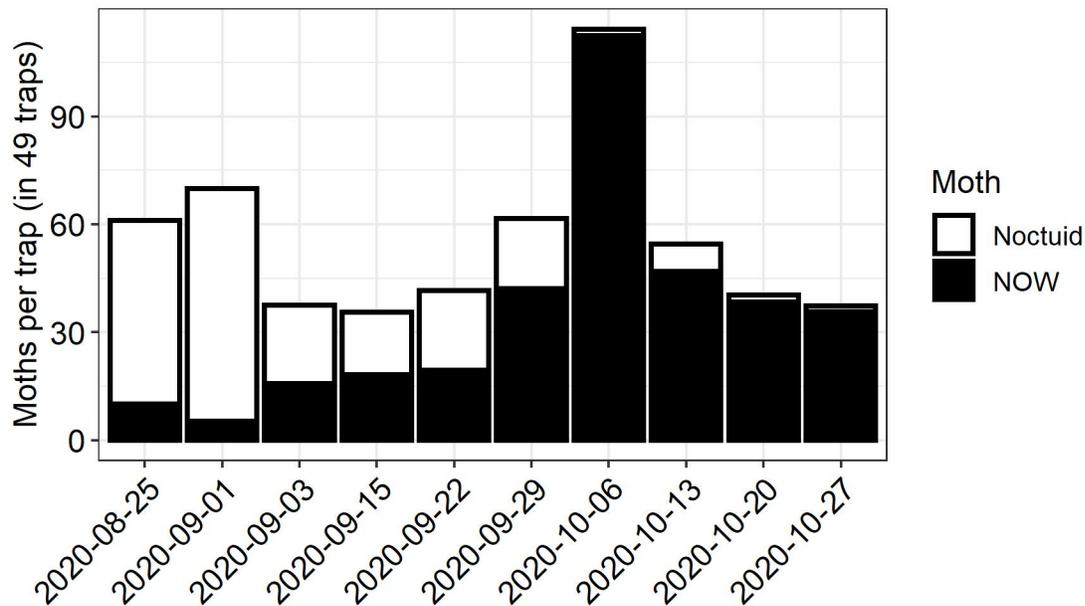
Means within columns follow by different letter are significantly different (experiment-wise  $P < 0.05$ , GLM with negative binomial distribution).

We hypothesized that the larger traps would capture more NOW due to moths that approached the lure but did not come as close for the experimental lures as to the optimized lure. The data did not support that hypothesis. However, one of the experimental formulations (TRE 2340) consistently captured NOW, albeit at a lower level than the optimized monitoring lure. This observation was the basis of Experiment 4 (described below). This experiment was conducted in a pistachio orchard because the particular site offered high abundance. Also, the large trap format required all trap to be placed at the edge of the orchard, and the particular site chosen facilitated that logistic requirement.

Experiment 3 (Figure 2) comes from an observation as part of the current NOW sterile insect release program (ENTO24, Wilson and Burks). Observations from the AHPIS/CDFCA program in early summer indicated recapture of sterile NOW dropped from the program Cessna aircraft from 500 feet. The Zone I pistachio orchard in this program was adjacent to orchards under mating disruption, and the monitoring lures used by CDFCA were ovibait (Peterson traps) and PPO lures used in a trap also containing a pheromone lure. The recapture by CDFCA was in contrast to an experiment in 2018 in which sterile NOW were released by Cessna over a non-mating disruption orchard with pheromone lures, and recapture was vanishingly small. Drops

were arranged at two-week intervals over 640 acres of pistachios without mating disruption, and a 7 x 7 grid of PPO-pheromone traps was arranged evenly across the 640 acres. Both the CDFA pilot site and the ad hoc Wilson-Burks sites were close to row crops, and it became evident that small, gray moths similar in color to NOW (Noctuidae, possibly beet armyworm) were in high abundance and captured in high numbers in the PPO-pheromone traps. While the species could be distinguished with close examination, the noctuids greatly increased the time required to collect data from traps (Figure 2). We have previously encountered by-catch in PPO traps for NOW, but not in such great abundance with moths superficially similar to NOW. This by-catch seems to be associated with proximity of tree nut orchards to certain row crops.

**Figure 2.** Weekly summary of NOW and non-target moths captured in PPO-pheromone traps



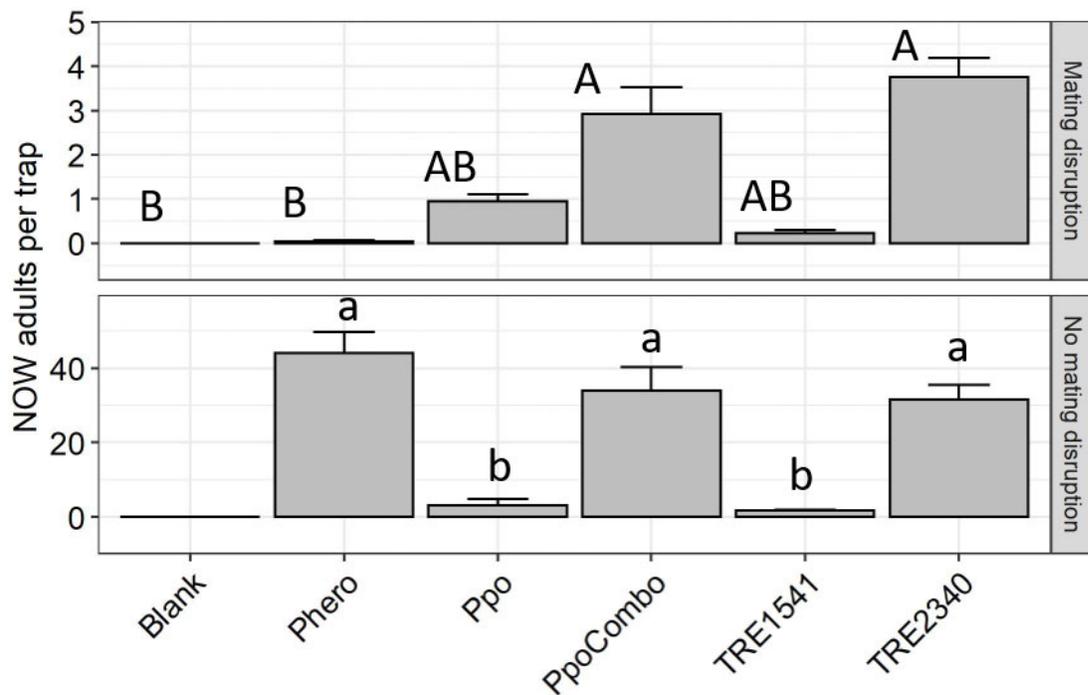
Experiment 4 (Figure 3) was a follow-up to experiment 2. It compared performance of the experimental pheromone lures to PPO with or without a pheromone lure in the presence or absence of mating disruption. All attractants were placed in standard wing traps. Captures of NOW were compared using a standard randomized complete block experiment, with trap treatments randomized to trees 160 feet apart within orchard rows (replicate blocks), and the rows serving as replicate blocks 320 feet apart. In mating disruption orchards, spacing was modified slightly to center traps between aerosol dispensers.

The two experimental treatments (TRE 2340 and TRE 1541) were compared to PPO alone, PPO with a pheromone lure, a pheromone lure alone, and a blank trap. Based on past experience, we expected that the PPO lure with pheromone would capture more NOW than the PPO lure alone and the pheromone lure would capture the most NOW in the absence of mating disruption and no NOW in the presence of mating disruption. We wished to determine how TRE 2340, the more attractive lure in experiment 2, would compare to the two PPO

treatments. We also wished to determine whether TRE 1541, the less attractive lure in experiment 2, captured more NOW than were accidentally entangled in a trap with no attractant.

Interestingly, in this experiment traps baited with TRE 2340 captured as many NOW in the presence of mating disruption as traps baited with both PPO and a pheromone lure, and more than traps baited with PPO alone (Fig. 3). Traps baited with TRE 1541 captured numerically more NOW than the blank trap. The difference was not significant ( $P > 0.05$ ), but the Tukey procedure placed TRE1451 in a different multiple comparison range from the blank trap. Far fewer NOW were captured in the mating disruption sites than in the non-mating disruption site. Based on previous results, we believe the difference is due to different NOW abundance between the two sites rather than a result of the mating disruption treatment. The location of the experiment in presence of mating disruption was moved on approximately 1 October in an attempt to get noctuid by-catch in this test. However, by that time the abundance of noctuids had diminished (Fig 2) so we were unable to test the hypothesis that the pheromone-based attractant would have less by-catch than PPO.

**Figure 3.** Cumulative NOW per trap per week (mean and SE, n = 6) in almonds with and without mating disruption from 10 August to 27 October, 2020



In the non-mating disruption lure, the pheromonal attractant TR 2340 captured numerically fewer moths than pheromone (Figure 3, lower panel), but the 25% difference was not statistically significant and was far smaller than the 3- to 4-fold difference seen in experiment 2 (Table 1). We hypothesize that this difference is at least in part because experiment 2 was placed at the very edge of the orchard due to logistic constraints, whereas traps in experiment 4 were placed in the interior of the orchard.

In summary, experiments from 2020 provide preliminary evidence that TRE 2340 provides some of the advantages of PPO (attracts NOW similarly in presence or absence of mating disruption) without some of the disadvantages. We presume that, because TRE 2340 is a pheromone-based product, by-catch will be less of a problem with TRE 2340 compared to PPO. Previous studies have suggested that the number of females captured in ovibait traps is more closely associated with subsequent damage compared to pheromone traps. There is, however, a trade-off between prediction value and detection sensitivity. We have submitted a proposal to the Almond Board of California to monitor with TRE2340 and ovibait traps in treated and control plots associated with future mating disruption tests, in order to compare traps numbers with damage samples taken in these tests. We also look forward to repeating experiment 3 at a time and place where the noctuids are more prevalent and by-catch is more of an issue.

#### **D. Outreach Activities**

**Chuck Burks.** Mating Disruption and Biorational Control in Fruit Crops. Presented at the Biocontrols USA Conference and Expo, Portland OR, March 5, 2020, to approximately 100 growers, PCAs, and industry personnel from CA, OR, and WA.

#### **E. Materials and Methods (500 word max.):**

Experiment 1: Four square orchard quarter-sections (160 acres each) were used at replicate blocks in almond orchards south of Huron, CA. Treatment plots (30 acres) were superimposed on these blocks, and treatments of either grower standard, low meso-dispensers, or high meso-dispensers were randomly assigned to three of these blocks. Wing traps baited with either ovibait (Peterson Trap Company, Visalia CA), pheromone (PHERECON NOW L<sup>2</sup> Low, Trécé Inc.), or PPO (PHERECON NOW PPO-HR L<sup>2</sup>, Trécé Inc.). Within each mating disruption treatment plots, four orchard rows served as subplots. Traps in the subplots were ≥ 160 feet from the sides of the mating disruption plot or each other. The pheromone and ovibait traps were in adjacent trees, while the PPO trap was 160 feet away within the same row. The four traps of each type within the four mating disruption replicate plots were considered experimental units for the purpose of comparing trap performance (n = 16). For this report, weekly plots of the three trap types are visually compared. Other than the experimental traps used briefly as described in the report, all Trece and Sutterra wing traps were bent to allow the bottom to clip in, as described in Burks et al. 2020

Experiment 2: A commercial pheromone lure (PHERECON NOW L<sup>2</sup> Low, Trécé Inc.) and two experimental attractants (TRE 2340 and TRE 1541, Trécé Inc.) were hung from the center roof of either a standard orange wing trap (Sutterra LLC, Bend OR) or a 48 x 48 inch traps fabricated with foam wall insulation panels with glue (Tanglefoot, Orthos Group, Marysville OH) covering the lower surface. The large traps were placed in the gap between the outmost and next tree over the orchard berm, and the wing traps were hung at shoulder-to-head height in the canopy of the penultimate tree in the row. The six trap-attractant combinations were placed in random order in rows 160 feet apart, and three such replicate blocks were separated by buffers of 320 feet. Cumulative trap capture over the time of the experiment was compared by analysis of deviance using a generalized linear model (GLM) with a negative binomial error distribution (Proc GENMOD, SAS, Cary NC), with a Tukey adjustment for comparison of multiple means.

Experiment 3: Standard orange wing traps (Suterra LLC) baited with PPO (Experimental pouches) and a pheromone lure (PHERECON NOW L<sup>2</sup> Low, Trécé Inc.) were placed in an even grid formed from 7 orchard rows, with traps approximately 640 feet apart. Traps were serviced weekly and the liners were changed and examined to determine the species of moths captured. For this report, a weekly stacked vertical bar plot is used to display the week-to-week variation in the numbers of NOW and by-catch moths per trap.

Experiment 4: A randomized complete block arrangement was used as described in the report. In the non-mating disruption trial, the cumulative capture per trap was compared between treatments was compared using a generalized linear mixed model (GLMM, SAS Proc GLIMMIX) with a negative binomial error distribution. The blank control, in which only one of six traps captured a single NOW over the length of the experiment, was discarded in order to allow the GLMM model to be fit to the remaining treatments. The number of moth captured was lower in the mating disruption sites, and adequate model fit was not obtained with GLMM or GLM models. A non-parametric Kruskal-Wallis test was therefore used to compare treatments, with a Dunn post-test for differences of means using the Bonferroni adjustment for multiple means. The nonparametric test was performed in R 4.0, using the packages DescTools, FSA, and rcompanion.

## **F. Publications that emerged from this work**

### Peer-reviewed publications

**Burks, C. S., B. S. Higbee, and J. J. Beck. 2020.** Traps and attractants for monitoring navel orangeworm (Lepidoptera: Pyralidae) in the presence of mating disruption. *J. Econ. Entomol.* 113: 1270-1278.

**Haviland, D. R., J. P. Rijal, S. M. Rill, B. S. Higbee, C. A. Gordon, and C. S. Burks. 2020.** Management of navel orangeworm (Lepidoptera: Pyralidae) using four commercial mating disruption systems in California almonds. *Journal of Economic Entomology* <https://doi.org/10.1093/jee/toaa297>.

**Wilson, H., C. S. Burks, J. E. Reger, and J. A. Wenger. 2020.** Biology and management of navel orangeworm (Lepidoptera: Pyralidae) in California. *Journal of Integrated Pest Management* 11(1): 25, 1-15.

### Industry publications

**Rijal, J. P., C. S. Burks, and S. Gyawaly. 2020.** Exploring tools for almond orchards under mating disruption, pp. 36-40, CAPCA Advisor, December 2020.