Dispersal of Navel Orangeworm and Prediction and Prevention of Damage in Almonds

Project No.: 07-ENTO1-Burks

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Interpretive Summary:

In 2007 we: 1) examined the association of the number of NOW in traps with subsequent NOW damage to almonds; 2) examined movement of NOW females in large mating disruption blocks; and 3) examined the effect of methoxyfenozide on male response to virgin-baited flight traps.

<u>Association of the number of NOW in traps with subsequent NOW damage to almonds</u>

- Cumulative sums of males and eggs in flights 1 and 2 were compared to subsequent damage to untreated Nonpareil and Monterey almonds in 41 40-acre plots in Kern County in 2006 and 2007.
- The only association between trap data and damage that was consistent over 2 years was that of males in virgin-baited traps in flight 2 with damage to Nonpareil almonds.
- The association between NOW damage in the Nonpareil harvest with NOW damage to the subsequent Monterey harvest in the same plot was marginally significant in 2006, and highly significant in 2007.
- For this 2-year data set, only 4% of traps in which a cumulative total of ≤10 males were captured in virgin-baited traps in the last three weeks of June had >5% NOW damage.
- These observations suggest that, when a synthetic NOW pheromone lure becomes available, it will be possible to use trap data from part of flight 2 to inform treatment decisions concerning Nonpareil almonds, and monitoring of the Nonpareil almonds themselves can inform treatment decisions concerning Monterey.
- While egg traps in the density used in this study do not predict damage at the plot level, a grid of egg traps over a larger area might be useful in assessing year-to-year

variation in regional NOW pressure. Egg traps might also have an advantage over pheromone traps in providing a more precise biofix for flight 1 in some years.

Movement of NOW females in large mating disruption blocks

- The pattern of NOW harvest damage to Nonpareil was examined at 200 foot intervals along 1000-foot transects.
- These data were compared to past mark-release-recapture experiments and laboratory data on lifespan and daily reproductive capacity.
- The results of this comparison indicate that, while individual NOW of both sexes can travel great distances, in tree nut orchards most oviposition and damage occurs closer to where NOW females emerge from pupae to adults.

Effect of methoxyfenozide on male response to virgin-baited flight traps

- Field experiments examined the effect of Intrepid on the ability of NOW males to locate virgin females in flight traps.
- The results provide possible evidence that reduced ability to find females is greater with exposure to this insect growth regulator than with exposure to Imidan, a neurotoxin.
- If so, Intrepid might be have a more synergistic effect when used in conjunction with mating disruption.

Objectives:

1) Examine the association of the number of NOW in traps with subsequent NOW damage to almonds.
2) Examine movement of NOW females in large mating disruption blocks.
3) Examine the effect of methoxyfenozide on male response to virgin-baited flight traps.

Materials and Methods:

Association of the number of NOW in traps with subsequent NOW damage to almonds

In 2006 and 2007 a single wing trap (Suterra LLC, Bend OR), baited with three virgin females (Burks and Brand 2004), and two NOW egg traps containing almond flakes (Liberty Vegetable Oil Company, Santa Fe Springs CA), were placed near the center of 41 blocks of 40 acres each of almonds. The wing trap was placed in the center of a 220 yard (30 tree) long block of Nonpareil trees between two orchard roads, and the egg traps were placed five trees north and south of the wing trap within the same row. Within this block the alley containing the traps, and two alleys on either side, were flagged to prevent application of insecticide treatments. Harvest samples taken within this 150 tree (2 acre) area examined damage in the absence of residual insecticide treatments, with Nonpareil samples coming from the middle row far from possible insecticide drift.

Sites were selected to include the varieties Nonpareil and Monterey and to avoid mating disruption treatments, and were located throughout the Kern County portion of the San Joaquin Valley, in an area roughly bounded by Highway 33 on the west, Highway 99 on the east, Seventh Standard Road on the South, and County Line Road on the North. In 2006 traps were monitored weekly beginning February 15 for oviposition traps and March 1 for flight traps and ending on September 29. Each week the unmated females in the wing traps were replaced, trap liners were changed, and counts of eggs in egg traps and males in flight traps were recorded. Harvest of Nonpareil occurred between August 15 and September 3, and harvest of Monterey occurred between September 16 and October 20. Nonpareil harvest samples of ~280 Nonpareil and ~265 Monterey nuts were taken from five locations in each plot. All nuts were examined by Paramount Farming research personnel to determine NOW-specific damage, and the proportion of NOW damage in Nonpareil and Monterey at each plot was calculated directly from the five pooled samples.

In 2007 approximately the same procedures were used at the same sites as in 2006. Egg traps were placed in the field beginning February 28 and virgin-baited traps were placed beginning February 14. In 2007 one of the egg traps in each plot was treated with 10% crude almond oil in the almond flakes whereas the other contained untreated almond flakes, as in 2006. In addition in 2007, each plot contained two delta traps each containing a standard egg trap, one with 10% crude almond oil and one without. Harvest dates in 2007 were between August 7 and August 25 for Nonpareil and between September 12 and October 10 for Monterey.

For characterization and comparison of temperature in the study region in 2006 and 2007, the UC IPM online degree-day calculator (http://www.ipm.ucdavis.edu/WEATHER/ddretrieve.html) was used to retrieve maximum and minimum data from Kern County recording stations at Blackwell Corner, Famoso, Lost Hills, Shafter (CIMIS 54, 138, 146, and 5, respectively), and Wasco (NCDC 9452) and compute degree-day accumulation from January 1 to August 15 of 2006 and 2007. A 30 year data set of normal highs and low temperature for Wasco, based on data from 1971 to 2000, was also downloaded from the National Climatic Data Center Site (http://cdo.ncdc.noaa.gov/climatenormals/clim84/CA/CA049452.txt), recoded, and used with the UC IPM online degree-day calculator to calculate daily normal NOW degree-days for that site.

For comparison of trap data and damage, flight 1 for both 2006 and 2007 was defined as the weeks between February 15 and June 7, and flight 2 was defined as the weeks between June and July 26. Pearson correlation was used to examine the association between sums of males and eggs in traps at each plot for flights 1 and 2 and NOW damage to the subsequent Nonpareil and Monterey harvests from those plots. Trap sums and proportions of almonds with NOW damage were respectively transformed as sqrt (x + 0.5) and arcsine (sqrt(proportion)). Later flights are not examined because data from flights 3 and later are not likely to be useful for treatment decisions. Comparisons were based on the respective Nonpareil and Monterey harvest from 40 and 33 plots in 2006, and 41 and 33 Monterey plots in 2007. Monterey harvest data were available for fewer plots because of variation in pollinator varieties. The 25th and

50th percentile values for sums of males in virgin-baited traps for the last three week of June were determined for the 41 Nonpareil harvest for the two years using the SAS (SAS Institute, Cary NC), UNIVARIATE procedure, and the resulting values were used as proposed thresholds. These proposed thresholds were compared with damage categories (either under or over limits of either 2 or 5% damage in untreated almonds), and R (CRAN, http//:www.r-project.org) was used to calculate the Agresti-Coull confidence interval (Agresti, Introduction to Categorical Data Analysis, ISBN 978-0-471-22618-5), for the proportion of harvests with the proposed threshold exceeding either 2 or 5% NOW damage.

Movement of NOW females in large mating disruption blocks

Mark-capture experiments were conducted in adjacent 160 acre blocks under treatment with methoxyfenozide (Intrepid) and mating disruption. The location of these treatments were Ranch 335, sections 18-3 and 18-4; ranches 360 and 630, and ranches 354 and 358. Within each 160 acre block arrays of delta traps baited with almond meal were placed in a grid of 4 east-west lines containing 10 traps per line per plot (i.e., 40 traps in the conventional plot and 40 traps in the mating disruption plot), with the nearest traps 144 feet on either side of the border between the adjacent treatment plots, and subsequent traps at 264 foot intervals. Black light trapping was also conducted in these 160 acre treatment blocks. A mark-capture experiment was conducted beginning on May 3, with 6-acre strips of trees 400 feet on either side of the border between the adjacent blocks treated with a 10% solution of chicken egg white (in the conventional plot), or whole milk (in the mating disruption plot). In addition 9 equally-spaced virgin-baited wing traps were placed in each 160 acre treatment block, as described above. Mark-capture experiments were commenced at these three locations on May 3, and data were collected for the next 11 days.

Because of poor recovery of females in this experiment, patterns of NOW damage to Nonpareil and Monterey almonds were also examined at 200 foot intervals along 1000 foot transects from the edge toward the center of almond plantings. Samples of approximately 300 nuts each were collected from five adjacent trees at point on the transect (Figure 1). The most extensive sampling of was done at Ranch 335, where samples were taken at the time of harvest, August 9 for Nonpareil and October 4 for Monterey, and examined to determine infestation as previously described. An additional eight transects of Nonpareil were sampled between August 25 and August 27 on the north and south sides of ranches 358 and 358, on the east side of ranch 361, and at two locations along the west edge of ranch 371.

For all transects, Pearson correlation of damage with distance from the edge was used to determine whether a gradient was present. Transects in which there was significant correlation of damage with distance from outside of Ranch 335, 1-way ANOVA was used with a Dunnett post test for comparisons of treatment means with a control, using the edge (0 feet) damage level as the “control”. For Ranch 335, a nested 2-way factorial ANOVA, with distance nested within the variety*treatment interaction, was used to examine effects of distance from the edge. An arcsine transform of proportional

NOW damage data was used for analysis, and means and standard errors of untransformed data are presented in figures and tables.

Effect of methoxyfenozide on male response to virgin-baited flight traps

A randomized complete block experiment was conducted in 40-acre almond plots centered on either side of four 160 acre blocks. In each plot, four virgin-baited traps were arranged in a square, 165 feet apart and near the center of the plot. Virgin-baited traps were prepared and monitored weekly, as described above. In the first application, on May 1, the "Imidan" plots received no pesticide, whereas in the second they received phosmet (Imidan) or methoxyfenozide (Intrepid). Males captured on the four virgin-baited traps in each plot were pooled for analysis. Paired Student's t-tests were used to examine the difference between males in Intrepid and Imidan treatment plots each week, and between the average number of males in per trap in Imidan and Intrepid plots for two weeks before and after the July 5 treatment. The males per plot were transformed as sqrt (x – 0.5) before analysis, and untransformed data are shown in the text and figure.

Results and Discussion:

Association of the number of NOW in traps with subsequent NOW damage to almonds

The two years for which data are presented here were distinct in climate, NOW damage to almonds, and seasonal patterns in male and egg trap activity. NOW damage in 2006 was moderately high in both Nonpareil and Monterey and not significantly different between the varieties, whereas in 2007 NOW damage was low overall and significantly lower in Monterey than in Nonpareil (Table 1). The correlation between NOW damage in the Nonpareil and in the subsequent Monterey crop within the same year was positive, and was marginally significant in 2006 and very highly significant in 2007 (Table 2). There was a marginally significant negative correlation between NOW damage in the Monterey harvest in September 2006 and the Nonpareil harvest in August 2007. The two within-year correlations suggest that NOW damage in Nonpareil is a useful guide to NOW pressure in the subsequent Monterey harvest. We speculate that the negative correlation between navel orangeworm damage in Monterey in 2006 and in the subsequent Nonpareil harvest in 2007 is due to a tendency of managers to treat more aggressively against NOW in areas that received greater damage the previous year, in combination lower pressure in 2007.

Patterns of seasonal activity in egg traps, and the relationship between egg trap and virgin-baited traps, were also different between 2006 and 2007. In 2006 distinct peaks of egg trap activity were evident for first and second flight, and the start of male and egg activity occurred at approximately the same time in both trap types (Figure 2A). In 2007 flight 2 egg activity was not evident and flight 1 male activity began earlier and ended later compared to egg trap activity data (Figure 2C). The difference between 2006 and 2007 is as great when trap activity is plotted against degree-day accumulation (Fahrenheit) beginning January 1 rather than calendar date (Figure 2B, D). Few females were captured in oviposition-baited traps in the first two flights in 2007 (a total of 35 in flight 1 and 7 in flight 2), thus these data are not further analyzed here. We also do not repeat or extend the analysis, presented in the preliminary report for the proceedings of the 35th Annual Almond Industry Conference, in which we examined the effect of crude almond oil on females and eggs in traps.

The accumulation of NOW degree-days on June 14 at 5 recording stations was a highly correlated (r^2 = 0.09, P = 0.0037) between 2007 and 2006 suggesting that, despite differences in temperatures at the stations, they accumulated heat units at a very similar rate. The mean degree-day accumulation for these stations on July 14 was 1621 in 2006 and 1792 in 2007; this difference was significant (t = 5.33, df = 4, P = 0.0067). Using the 30-year normal data for the Wasco station the degree-day accumulation was 149 on March 15, 540 degree-days on May 1, and 1734 degree-days on July 4. The degree-day accumulations in Wasco on these dates in 2006 and 2007 were 107% and 164%; 83% and 136%, and 105% and 199% respectively with respect to the 30-year normal. Thus the early part of flight 1 (March 15-May 1), was cooler for 2006 than 2007. It is possible that this difference in spring conditions is why male activity began earlier than egg activity in 2007 (the warmer spring), but the two were synchronous in 2006 (the cooler spring, and the worse of the two years for NOW damage).

In the preliminary report we noted that the variation in egg trap activity between 2006 and 2007 seemed to reflect the variation in damage more than did the variation in numbers of males captured in virgin-baited traps. However, when the two-year data set was examined, the only unambiguously significant correlation of NOW damage with trap activity within plots that was that of the Nonpareil harvest with males in virgin-baited traps in flight 2 (Table 3, Figure 3).

Arguably the most practical use of association of trapping data with damage is to find a threshold value at which damage is sufficiently improbable that managers are willing to forego planned treatments. Given that significant association of trap numbers with damage occurred only in flight 2, the treatment most likely to be assessed in this manner is a hull split treatment. Here we assumed that this treatment decision would have to be made by the end of June, and examined the proportion of plots with Nonpareil damage >2% and >5% among orchards with the bottom 25th and 50th percentile of the cumulative number of males captured in virgin-baited traps in the first 3 weeks of June (10 and 23 males, respectively). While different in statistical methodology, this is analogous to a method used to develop treatment threshold for codling moth based on pear ester lures (Knight & Light, Can. Entomol. 137:739-747, 2005). For the 10-male threshold 23 of the 81 year*plot observations qualified; 8 in 2006 and 15 in 2007. For the 23-male threshold these numbers were 20 and 23, respectively. While the 95% confidence interval is relatively larger for the smaller threshold because it is based on a smaller sample size, these data suggest that a threshold of ≤10 males captured in virgin-baited flight traps over the last three weeks of June might provide assurance of low probability of NOW damage in untreated Nonpareil almonds (Table 4). Further validation of this proposed threshold is in progress.

Currently identification of attractive blends of NOW pheromone components has not resulted in a useful NOW pheromone lure because of problems with stability of some components. When a NOW pheromone lure becomes available, care must be taken in application of the data reported here. Obviously the threshold level will have to be re-examined and probably revised for a synthetic pheromone. However, it must also be kept in mind that a lure that captures more moths is not necessarily better if prediction of damage is an objective. For instance, lower pheromone doses capturing fewer moths proved better for prediction of damage in apples and pears by *Argyrotainia pulchellana* Haworth (Lepidoptera: Tortricidae) (Faccioli et al., Entomol. Exp. Appl. 68:165-170, 1993).

The trap data for 2007 (Figures 2C, D), suggest that egg traps may have advantages for determination of the time of flight 1. We believe that the failure of egg traps to predict damage in this study is because damage in individual plots in this study was based on data from only 2 egg traps. In our preliminary report we argued that it was necessary to use >8 traps to reliably detect eggs (>0 on ≥1 trap 95% of the time), given the mean of 4 eggs per trap seen on the week following July 5 2006. Given that >75% of traps had no eggs in flight 2, it is probable that 2 egg traps per 40 acre plot was not sufficient to provide meaningful data to correlate with damage. While it is likely that better correlation of trap data with damage could be obtained with more egg traps, egg traps are also more labor-intensive than pheromone traps and there is a limit beyond which it is not practical to use more traps. Data from many egg traps over a region could be used to provide a general index of NOW pressure for that year, which a manager would then have to combine with experience and insight concerning local conditions. This is effectively what was accomplished with the trap shown here for the 41 plots examined in 2006 and 2007, and it is doubtless the current actual practice for many field managers and pest control advisors.

Movement of NOW females in large mating disruption blocks

As discussed in the previous section, NOW abundance was generally low in Kern County almonds in 2007 compared to other years. Over 11 days of trapping following the start of the mark-capture experiment, 33 males were captured in the 54 virgin-baited wing traps and 12 females were captured in the 240 delta traps baited with almond meal which were used to monitor the three 320 acre study sites. The number of females captured was too low to make any comparison concerning female movement.

Of six transects examined at ranches where only Nonpareil was sampled, there was significant ($P<0.05$) correlation between distance from the edge and NOW damage in only two. There were significant differences in NOW damage between in Ranch 361 ($F = 6.76$, df = 5, 24; $P = 0.0005$), and Ranch 371 ($F = 10.86$, df = 5, 24; $P<0.0001$). In each of these two transects all points ≥400 feet from the edge had significantly less NOW damage than the edge (Figure 4).

For Ranch 335 a 2-way factorial ANOVA was significant ($F = 11.70$, df = 3, 456; $P<0.0001$), and found significant differences in NOW damage due to NOW treatment with either methoxyfenozide or mating disruption ($F = 14.84$, df = 1, 456; $P = 0.0001$), between Nonpareil and Monterey ($F = 28.33$, df = 1, 456; $P<0.0001$). The treatment-variety interaction was also significant ($F = 4.81$, df = 3, 456; $P = 0.0288$), and there were significant differences among distances along the transects (F = 11.06, df = 20, 456; P<0.0001). In all cases the edge samples had significantly more damage than those 400-1000 feet from the edge, and there were not significant differences among the latter (Table 5).

The areas to the north, west and south of Ranch 335 were planted in pistachios. In Kern County mature pistachios generally support greater NOW abundance compared to mature almonds (Burks et al. 2008). In Nonpareil almonds the greatest damage at Ranch 335 occurred on the west transect in the methoxyfenozide block and on the south transects of both the methoxyfenozide and the south sides of both the methoxyfenozide and mating disruption plots (Figure 5). For the east transect of the methoxyfenozide and the west transect of the mating disruption site, the “edge samples” were adjacent and at the edge of treatment blocks rather than the border with another crops (Figure 1). In these transects the damage was uniformly lower in Nonpareil (Figure 5A, 5B), but more variable in Monterey (Figure 5C, 5D).

These data indicate that, where there is high NOW pressure from outside a plot, the area of very high damage is generally confined to the first 200-400 feet between dropped to a plateau level for that plot. This was truer for the earlier Nonpareil than for the later Monterey harvest. These observations are consistent with other research results. In 2006 we found a similar distribution over the first several days of a mark-capture experiment with newly-eclosed females. In the laboratory we have examined longevity and fecundity of NOW under of temperature/photoperiod regime typical for June 20 in Kern County. We found that, while female with access to sugar solution live 13 ± 0.7 d (mean ± SE), and 44 ± 8% of fertile eggs were deposited by the end of the second night after eclosion. Thus, while NOW are capable of traveling considerable distances, various lines of evidence indicate that, in tree nut orchards, most oviposition and most damage occurs fairly near the location where the female emerges from the pupa.

<u>Effect of methoxyfenozide on male response to virgin-baited flight traps</u>

During the two-weeks following the July 5 application of either phosmet or methoxyfenozide, the difference in males between the two treatments was greater than any time from early June through the end of the monitoring season (Figure 6). Fewer males were captured in plots treated with methoxyfenozide than in those treated with phosphet, although these differences were not significant (July 5: t = 1.88, df = 3, P = 0.16; July 12: t = 1.77, df = 3, P = 0.18). The only week in which there was a significant difference between the number of males captured in the phosmet and methoxyfenozide treatment plots was that of May 17, when more males were captured in the methoxyfenozide than in the phosmet plots (t = -5.68, df = 3, P = 0.0108).

As reported in the preliminary report, the difference between the average males per plot for the two weeks before and after the July 5 treatment was not significant for phosmet (t = 1.51, df = 3, P = 0.20), but was marginally significant for methoxyfenozide (t = 2.36, df = 3, P = 0.09) (Table 6).

These data offer weak support for the hypothesis that the growth regulator, methoxyfenozide affects the ability of males to respond to calling females to a greater degree than the organophosphate, phosmet. We do not believe that differences in males following treatment are due to acute toxicity of the insecticides to males, because we have not observed large declines in the past with application of these insecticides and because the insecticides are primarily targeted at NOW neonates and larvae. The failure to see a difference in the first application between males captured with a methoxyfenozide application compared to no application might have been due to greater abundance of males. It may also have been due to greater vigor, since the overwintering flight 1 males would have began their development the previous fall on fresher almonds compared to the mummies that presumably supported the development of the flight 2 males.

Recent Publications:

Burks, C. S., and D. G. Brandl. 2004. Seasonal abundance of navel orangeworm (Lepidoptera: Pyralidae) in figs and effect of peripheral aerosol dispensers on sexual communication. 8 pp. Journal of Insect Science 4: 40.

Burks, C. S., B. S. Higbee, D. G. Brandl, and B. Mackey. 2008. Sampling and pheromone trapping for comparison of abundance of *Amyelois transitella* in almonds and pistachios. Entomologia Experimentalis et Applicata (In press).

Higbee, B. S., and C. S. Burks. 2008. Effects of mating disruption treatments on navel orangeworm (Lepidoptera: Pyralidae) sexual communication and damage in almonds and pistachios. Journal of Economic Entomology (In Press).

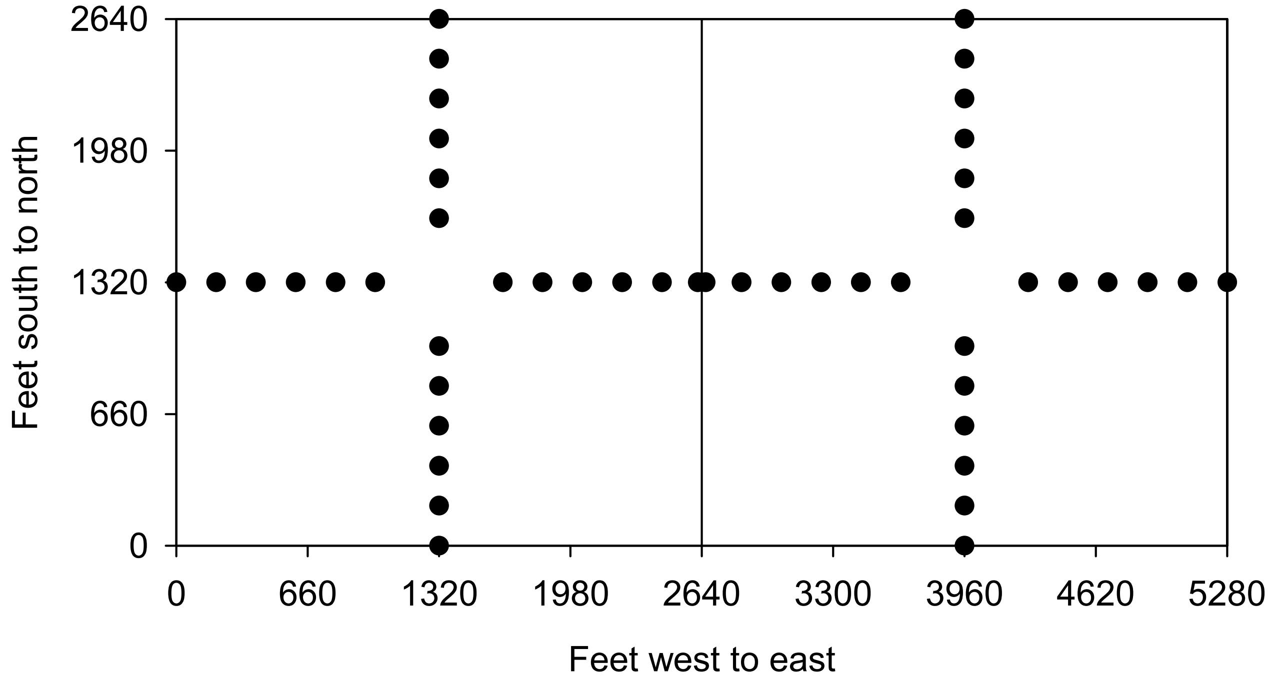

Fig. 1. Plot map showing pattern of sampling transects used to examine the pattern of NOW damage at Ranch 335. The 160 acre block on the west was treated with methoxyfenozide, and the block on the right was treated with mating disruption. Samples were taken at 200 foot intervals between 0 and 1000 feet from the borders of the blocks, as depicted above. At each point samples of approximately 300 nuts were taken from the canopy of each of five adjacent trees. Sampling was conducted shortly before the trees were shaken for harvest (August 9 for Nonpareil and October 4 for Monterey). The areas to the north, west, and south were planted in almonds, and there were grapes to the east.

Table 1. Percent NOW damage (mean ± SE) to Nonpareil and Monterey almonds in 41 40 acre plots almond plots in Kern County in 2006 and 2007

Year	Nonpareil	Monterey
2006	4.19 ± 0.84	4.36 ± 0.90
2007	1.07 ± 0.21	0.51 ± 0.10*

*NOW damage in harvests of different varieties in the same year significantly different (Paired Student's t-test, P<0.05)

Table 2. Correlation between NOW damage in earlier and subsequent harvests 41 40 acre almond plots in Kern County in 2006 and 2007

Year and Harvest			
Earlier	**Subsequent**	**r**	**P**
Nonpareil 2006	Monterey 2006	0.34	0.0547
Monterey 2006	Nonpareil 2007	-0.30	0.0920
Nonpareil 2007	Monterey 2007	0.70	<0.0001

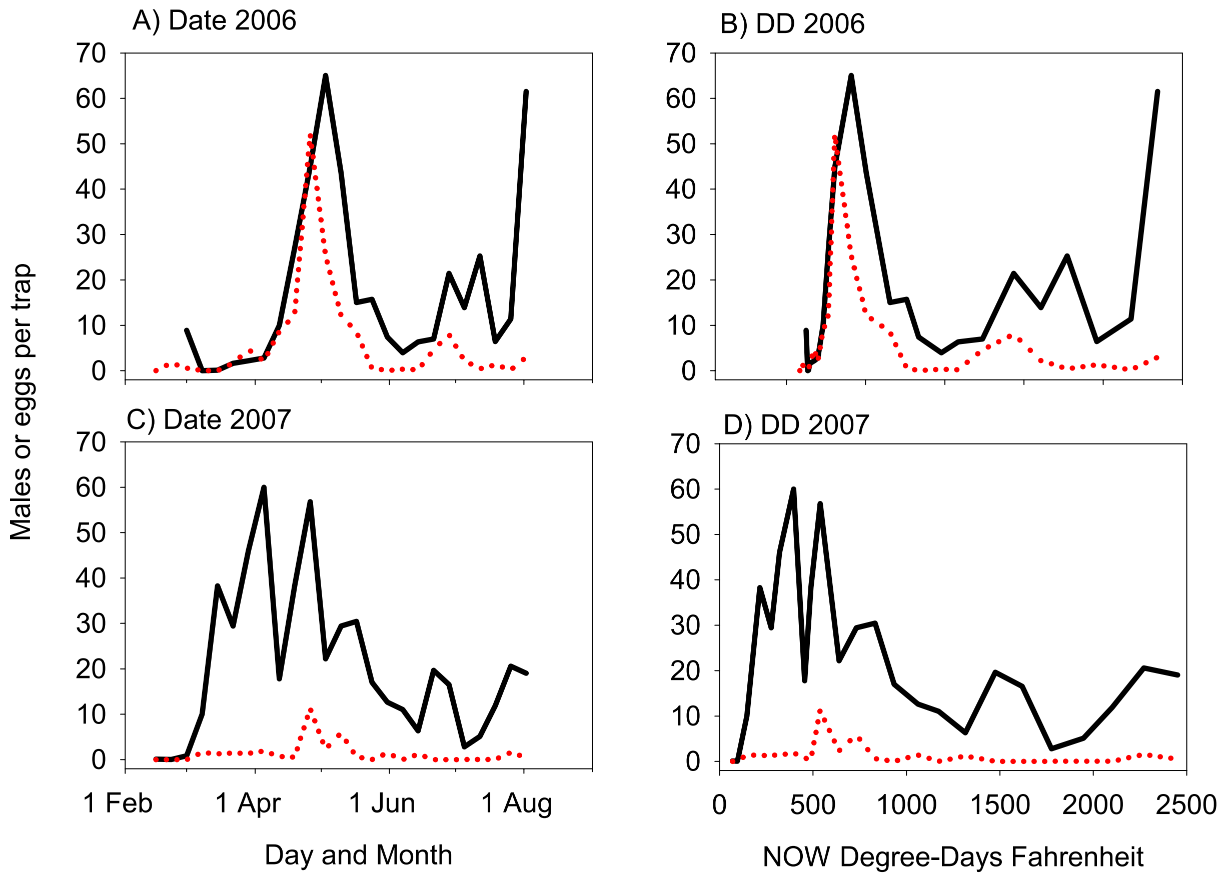

Figure 2. Seasonal variation in weekly means of males captures in virgin-baited wing traps (solid black line), and eggs on egg traps (dotted red line), in 41 40 acre plots in Kern County in (A, B) 2006 and (C, D) 2007, plotted by (A, C) calendar date and (B, C) NOW degree-days Fahrenheit.

Table 3. Correlation of numbers of males or eggs in traps in flights 1 and 2 with subsequent NOW damage in harvest samples of Nonpareil and Monterey almonds in 41 40 acre Kern County almond plots in 2006 and 2007

		Flight 1		**Flight 2**	
Trap Type	**Variety**	**r**	**P**	**r**	**P**
Virgin-baited	Nonpareil	0.04	0.74	0.30	0.0074
	Monterey	-0.24	0.05	0.03	0.78
Egg	Nonpareil	0.16	0.17	0.15	0.16
	Monterey	-0.10	0.40	0.20	0.10

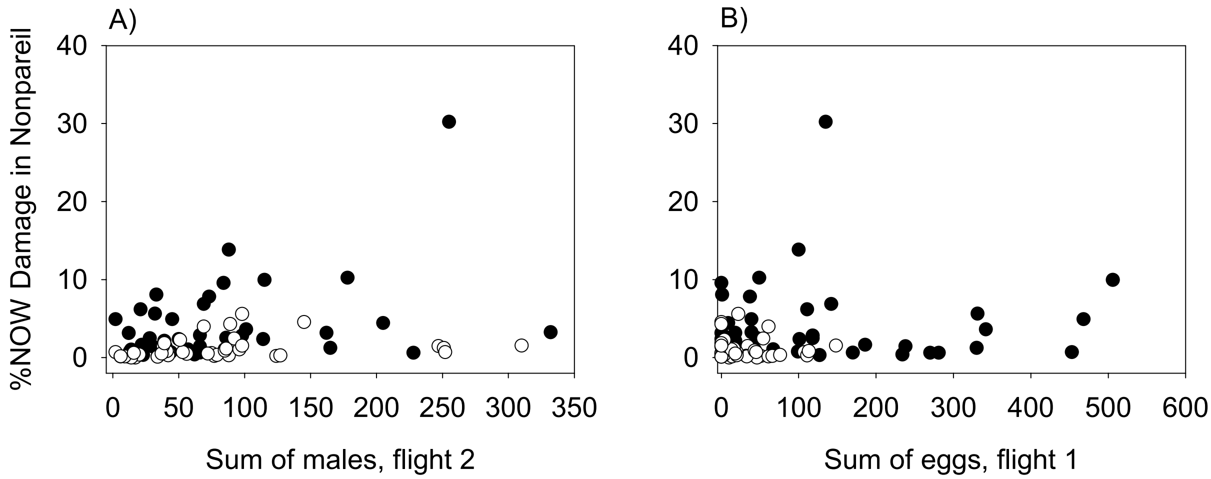

Figure 3. NOW harvest damage to Nonpareil almonds in 41 40 acre almond plots in 2006 (black) and 2007 (open) v. (A) the sum of male in virgin-baited wing traps in flight 2 and (B) the sum of eggs on egg traps in flight 1. There was significant correlation of NOW damage with males in virgin-baited traps in flight 2, but not with eggs on egg traps in flight 1.

Table 4. Percent of 41 40 acre plots (with 95% confidence interval) in 2006 and 2007 with Nonpareil damage over 2 or 5% for two values of cumulative male threshold for the last 3 weeks in June

Trap threshold (males, cumulative over the last 3 weeks of June)	%Plots with >2% damage	%Plots with >5% damage
10	22 (9, 42)	4 (0, 23)
23	25 (16, 43)	12 (5, 25)

Figure 4. Percent NOW damage by distance from edge for transects at ranches 361 (black dots), and 371 (white dots). All points ≥400 feet from the edge have significantly less NOW damage than the edge sample (ANOVA with Dunnett post test, P<0.05).

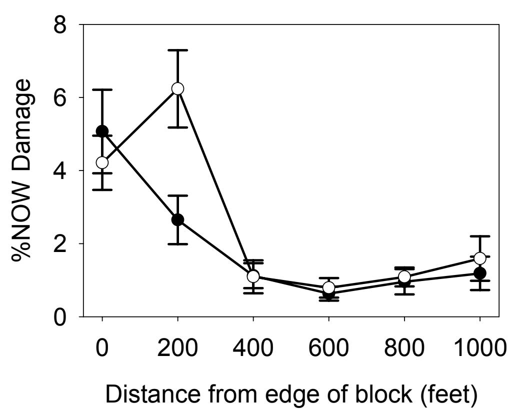

Table 5. Percent NOW damage (mean ± SE), in adjacent 160 acre almond blocks treated with methoxyfenozide or mating disruption (Ranch 335)

		NOW Treatment	
Variety	**Distance (feet)**	**Methoxyfenozide**	**Mating Disruption**
Nonpareil	0	10.6 ± 1.97a	7.1 ± 1.12a
	200	4.4 ± 0.75b	4.8 ± 0.67b
	400	2.4 ± 0.24bc	3.0 ± 0.22bc
	600	3.3 ± 0.38bc	3.8 ± 0.21bc
	800	2.9 ± 0.42bc	4.0 ± 0.50bc
	1000	2.1 ± 0.36c	2.7 ± 0.22c
Monterey	0	11.9 ± 2.02a	15.8 ± 2.01a
	200	4.2 ± 0.58b	4.5 ± 0.43b
	400	3.6 ± 0.58b	5.0 ± 0.53b
	600	4.3 ± 0.69b	7.3 ± 1.25b
	800	3.9 ± 0.73b	5.7 ± 0.88b
	1000	2.9 ± 0.43b	4.7 ± 0.54b

Means followed by different letters are significantly different (ANOVA with Fisher's protect LSD, P<0.05).

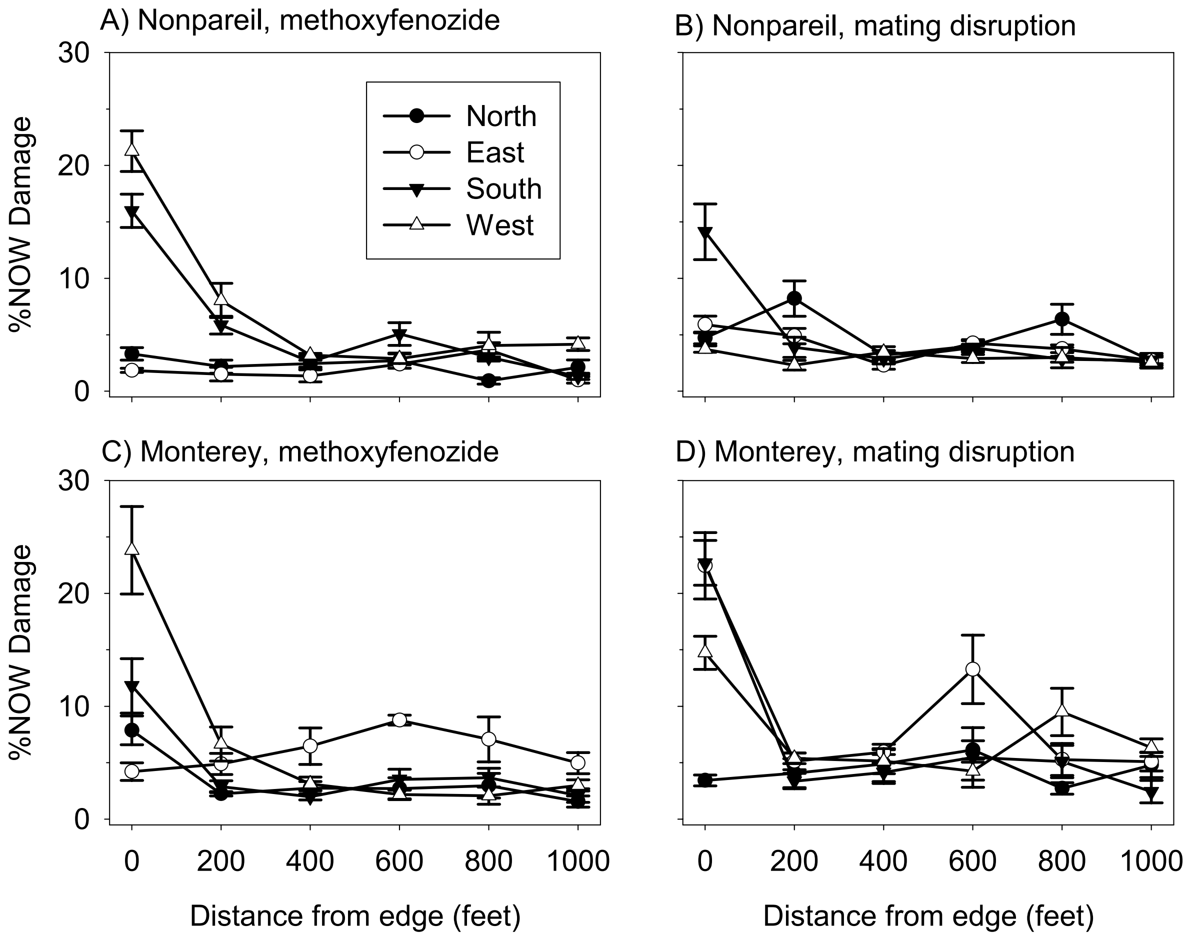

Figure 5. Percent NOW damage v. distance from edge of adjacent 160 acre blocks (Ranch 335), treated with methoxyfenozide or mating disruption for (A, B) Nonpareil and (C, D) Monterey almonds treated with (A, C) methoxyfenozide and (C, D) mating disruption. Transects were located as shown in **Figure 1**.

Figure 6. NOW per trap per week in paired plots treated with either Intrepid (May 1 and July 1), or Imidan (July 5 only). The dashed vertical lines show treatment dates. The difference between the males captured in virgin-baited flight traps was greater for the two weeks immediately following the July 2 treatment than at any time from May 17 to the end of the season.

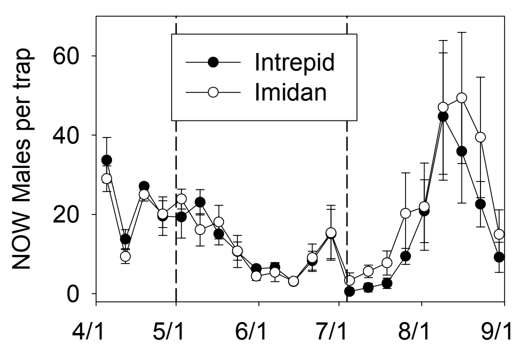

Table 6. NOW per virgin-baited trap (mean ± SE) averaged by plot over the two weeks before and after insecticide treatments on May 1 and July 5

Application	Period	Imidan	Intrepid
May 1	Before	22.5 ± 1.00	23.3 ± 2.72
	After	20.0 ± 2.60	21.2 ± 3.67
July 5	Before	12.2 ± 5.15	11.7 ± 4.28
	After	4.5 ± 1.22	1.1 ± 0.52