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81-E8

INVESTIGATIONS ON CONTROL OF THE NAVEL ORANGEWORM AND MITES ON ALMONDS - 1981

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Summary

Investigations on navel orangeworm, peach twig borer and mites on almond

M. M. Barnes, C. E. Engle, S. C. Welter, R. R. Youngman,
W. S. Seaman, and E. F. Laird, Jr.

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1. We investigated the relationship between degree of orchard mummy sanitation in winter and expected percent infestation, provided that early harvest is practiced and that there are no sources of outside infestation within 1/4 mile. Orchards should be cleaned in winter to an average of 2 mummies per tree. Estimate mummy density in winter by counting mummies on at least 2 trees per acre. This provides a 90% confidence level of being within 20% of the true level. According to 2 seasons' results, this degree of sanitation will result in 2-4% infestation in the orchard. See further details in section on sanitation.

2. Mummy counts in June are closely correlated with expected infestation and can be used to decide on need for treatment at initiation of hull split. See summary on sanitation.

3. Heat summation data were obtained which enable a grower to predict when the enormous increase in navel orangeworm flight activity will occur after hull-split, provided observations are made as to when Nonpareil hullsplit begins in the tops of the trees. This enables timing of harvest to avoid this flight, or timing of treatment.

4. When almond trees are stressed for water, mites do more damage. Water-stressed trees do not develop more mites, rather the combination of mite damage and water stress produces more defoliation.

5. When average daily temperatures are about 85°F, the peach twig borer pheromone rubber septa lose their effective attractancy in 2-3 weeks and should be replaced. See text.

6. Withdrawal of drip irrigation at 70% hullsplit of Nonpareils did not result in more rapid water loss from the hull or more movement of peach twig borer from hull to nutmeat as compared with trees not subject to such water stress. Mite damage was more severe on the water-stressed trees.

7. Intense trapping-out of male peach twig borer moths resulted in approximately 50% control in an organic peach orchard near Beaumont.

8. Variation in infestation confounded interpretation of an extensive trial of permethrin for navel orangeworm applied by helicopter. Future large scale trials such as this should be set up in a Latin Square.

9. Single-tree insecticide plots for larvicidal action should be replicated 15 times.

10. Base line reference curves for susceptibility of navel orangeworm moths to permethrin were determined. These make possible detection of development of resistance, should this take place.

11. A modified spray program for the control of navel orangeworm infestation was studied and consisted of selective applications of Guthion to Nonpareil and late-maturing pollinator varieties. Selective applications were at Nonpareil hullsplit to Nonpareil only and to both Nonpareil and pollinator varieties. Infestation in the Nonpareil trees was not adversely affected by omission of a spray on the late-maturing pollinators. Also, the unsprayed pollinators had nonsignificant reductions in infestation. The potential advantages of this modified program would be (1) lower pesticide costs, (2) less time spent in the spraying operation, and (3) enhancement of predator activity in the unsprayed pollinator trees.

12. A trial of acaricides failed to develop information as the population failed to develop.

Insecticide Performance - 1981

Trial for the Control of Navel Orangeworm on Almonds at Hullsplit

C. E. Engle, M. M. Barnes, and E. F. Laird

An experiment was conducted on a portion of a Superior Farms almond orchard, Kern County, in a continuation of a series of trials to compare larvicidal efficacy of several insecticides for controlling the navel orangeworm on almonds.

Methods and Materials

The experimental block consisted of flood-irrigated 12-year-old almond trees. The trees were planted in a 25X25-ft planting with alternating double rows of the Nonpareil variety to a single row of the Mission or Merced variety. The experimental design consisted of 16 treatments and 1 check, each replicated 10 times in randomized blocks, with single trees serving as the replicated units. Only Nonpareil variety trees were used in the experiment. Treatments were applied using a handgun with a pressure of 400 pounds, providing full coverage, check trees received water only.

At harvest all nuts were shaken from each tree, raked into piles, then sampled, placed in mesh bags, and refrigerated at 40°F until examined. Infestation was tabulated based on 300-nut sample per tree, totaling 3000 nuts per treatment.

Results

Table 1 presents average percent of infested almonds per treatment. This experiment compares larvicidal action only in thorough coverage sprays.

Table 1. Results of replicated experiment on control of navel orangeworm with full coverage[1] sprays, Nonpareil variety, McFarland, 1981.

	Treatment	Formulation	Lb a.i./ acre[2]	Avg. % infested at harvest	Avg. % control
3.	Pay Off	2.5 EC	0.15	4.5	46.4 b[5]
6.	Ammo	2.5 EC	0.10	4.9	41.7 ab
11.	FCR-1272	1.69 EC	0.075	5.8	31.0 ab
2.	Guthion	50 WP	2.0	6.0	28.6 ab
8.	Ambush	2.0 EC	0.20	6.1	27.4 ab
16.	Larvin	4.18 EC	1.50	6.3	25.0 ab
7.	Cymbush	3.0 EC	0.10	6.8	19.1 ab
9.	Avermectin	0.03 EC	0.05	7.0	16.7 ab
10.	Avermectin + oil[3]	0.03 EC	0.05	7.0	16.7 ab
15.	Larvin	4.18 EC	2.0	7.2	14.3 ab
14.	Imidan	50 WP	4.0	7.3	13.1 ab
5.	Pounce	3.2 EC	0.2	8.4	- ab
4.	Orthene	75 S	2.0	8.4	- ab
13.	Imidan + buffer X[4]	50 WP	4.0	8.7	- a
12.	SIR 8514	25 WP	0.5	9.0	- a
1.	Check	-	-	8.4	- ab

[1]Application by handgun in 10 replicated blocks of single tree plots.

[2]Treatments applied at 7% hullsplit, July 6-7, except Treatment #2 which was applied 45 days pre-harvest, July 1.

[3]Spray oil (80 sec 414°) added at 1 qt/100 gal.

[4]Buffered to pH 3.8.

[5]Averages in the same column followed by the same letter are not significantly different at $P < 0.05$ using Duncan's new multiple range test.

It is evident from the variable data presented that the experiment was unsuccessful. Several of the treatments have been used in previous experiments successfully, yet in this experiment they performed no better than the check treatments. We cannot accurately assess the reasons for this failure.

Evaluation of Helicopter Sprays of Permethrin

C. E. Engle, M. M. Barnes, S. C. Welter, and E. F. Laird, Jr.

Five schedules and rates of permethrin were applied in a large Kern County orchard. Each treatment was replicated 4 times and each replicate was ca. 30 acres. The infestation results of this extensive trial show that the infestation was much higher on the S end of this 540-acre block. Also, since the check areas were only 1 acre in size, it is apparent that the moth kill provided by permethrin severely decreased infestation in these small check plots. The distribution of the infestation and the small size of the checks serve to confound the results of the trial such that it is not possible to make a valid interpretation of the results. For example, when subjected to an analysis of variance, 1 application at 0.2 lb/acre is better than 2 applications. Because of the chance assignment of the replicates of the 2-application schedule toward the S end which was more heavily infested, the distribution of the infestation obviously confounds the data. All such trials in the future should be set up using a Latin square.

Effect of insecticides timed at Nonpareil hullsplit upon navel orangeworm infestations in late-maturing varieties

S. Welter, C. E. Engle, and M. M. Barnes

Currently, insecticides may be applied for navel ornageworm control based upon the maturation stage of the predominant variety, Nonpareil. Generally, when the Nonpareil variety exhibits 5-10% hullsplit, then an insecticide is uniformly applied to the entire orchard. Almonds are not susceptible to navel orangeworm infestation until the outer hull sufficiently separates to allow the entry of a 1st-instar navel orangeworm larva. Several varieties, including the Texas Mission and Merced, do not undergo hullsplit until approximately 2-4 weeks after the Nonpareil variety. Therefore, insecticides applied at Nonpareil hullsplit to later-maturing varieties must remain effective for an additional 2-4 weeks in order to provide control comparable to navel orangeworm suppression in the Nonpareil variety. In addition, previous studies by M. Hoy have demonstrated that insecticide applications for navel orangeworm control may result in outbreaks of spider mites. Consequently, studies were undertaken to determine the effect of selectively applying pesticides only to the Nonpareil variety. This modified spray program was evaluated for the effects upon navel ornageworm infestations both in the Nonpareil and late-pollinating varieties, as well as the effects upon the spider mite populations and the associated beneficial complexes.

Materials and Methods

Trial 1

Both a modified and unmodified spray program were established within a 12-year-old, flood-irrigated orchard south of Delano, Kern County. Each spray program was replicated in 3 pairs as 5-acre blocks. The unmodified spray program consisted of an application of Guthion 50WP and Omite 6E to all three varieties in the orchard, Nonpareil, Texas Mission, and Merced. The Guthion was applied at 2.0 lb a.i./acre, while the Omite was applied at 3.0 lb a.i./acre. The modified spray program consisted of an application of Guthion and Omite at the same rates to only the Nonpareil variety. The pesticides were applied with ground air-blast sprayers at 500 gal/acre.

Ten trees of each variety were selected from the center of each of the 5-acre plots. Two hundred nuts were collected from each tree and handcracked for estimation of navel orangeworm infestation. The Nonpareil, Merced, and Texas Mission varieties were harvested on 8/13, 9/4, and 9/4, respectively.

Mite population levels were determined on 10 Nonpareil trees and 10 pollinator trees (5 Merced and 5 Texas Mission) from the center of each of the 5 acre plots. Twenty-four leaves were selected from each tree on 7/2, 7/16, 7/23, 7/30, 8/6, 8/13, 8/20, and 8/27. Counts of spider mites, phytoseiids, and general insect predators were made under a dissecting microscope. Determinations made from slide mounts showed mite populations to consist of 100% Pacific spider mite, while the phytoseiid populations consisted of 100% *Typhlodromus occidentalis*.

Hullsplit was determined for each variety on 7/6, 7/21, 8/3, and 8/13. One hundred nuts were randomly selected from each variety for each 5-acre plot.

Trial 2

Trial 2 is identical to Trial 1 except as noted. The unmodified spray program consisted of a uniform application of Imidan 50 WP and Omite 30 WP to all three varieties. The Imidan was applied at 4 lb a.i./acre, while the Omite was applied at 2.7 lb a.i./acre. The pesticides were applied with a ground air-blast sprayer at 400 gal/acre. The Nonpareil, Merced, and Texas Mission varieties were harvested on 9/1, 9/16, and 9/16, respectively. Spider mite populations and their associated predators were examined on the following dates: 7/5, 7/15, 7/22, 7/29, 8/5, 8/12, 8/19, and 8/26. Hullsplit was determined for each variety on 7/7, 7/21, 8/3, and 8/13.

Results

Trial 1

The seasonal development of hullsplit within each variety is shown in Fig. 1. The results for navel orangeworm infestations are shown in Table 1. No significant differences were observed between the modified and unmodified spray programs in regard to navel orangeworm infestation for any variety. The Nonpareil variety, which was treated identically within each program, showed a nonsignificant 2.5% reduction in the unmodified spray program. Both the unsprayed Merced and Texas Mission varieties in the modified spray program showed a nonsignificant reduction in navel orangeworm infestation.

Initially, spider mite populations remained at low levels for both the Nonpareil and pollinator varieties in both spray programs. After approximately 30 days, spider mite populations started to increase in both the Nonpareil and pollinator varieties, as shown in Fig. 2 and 3, respectively. No significant differences were observed between either spray program except prior to July 30. While the programs were statistically different prior to July 30, there were no biologically significant differences between the programs.

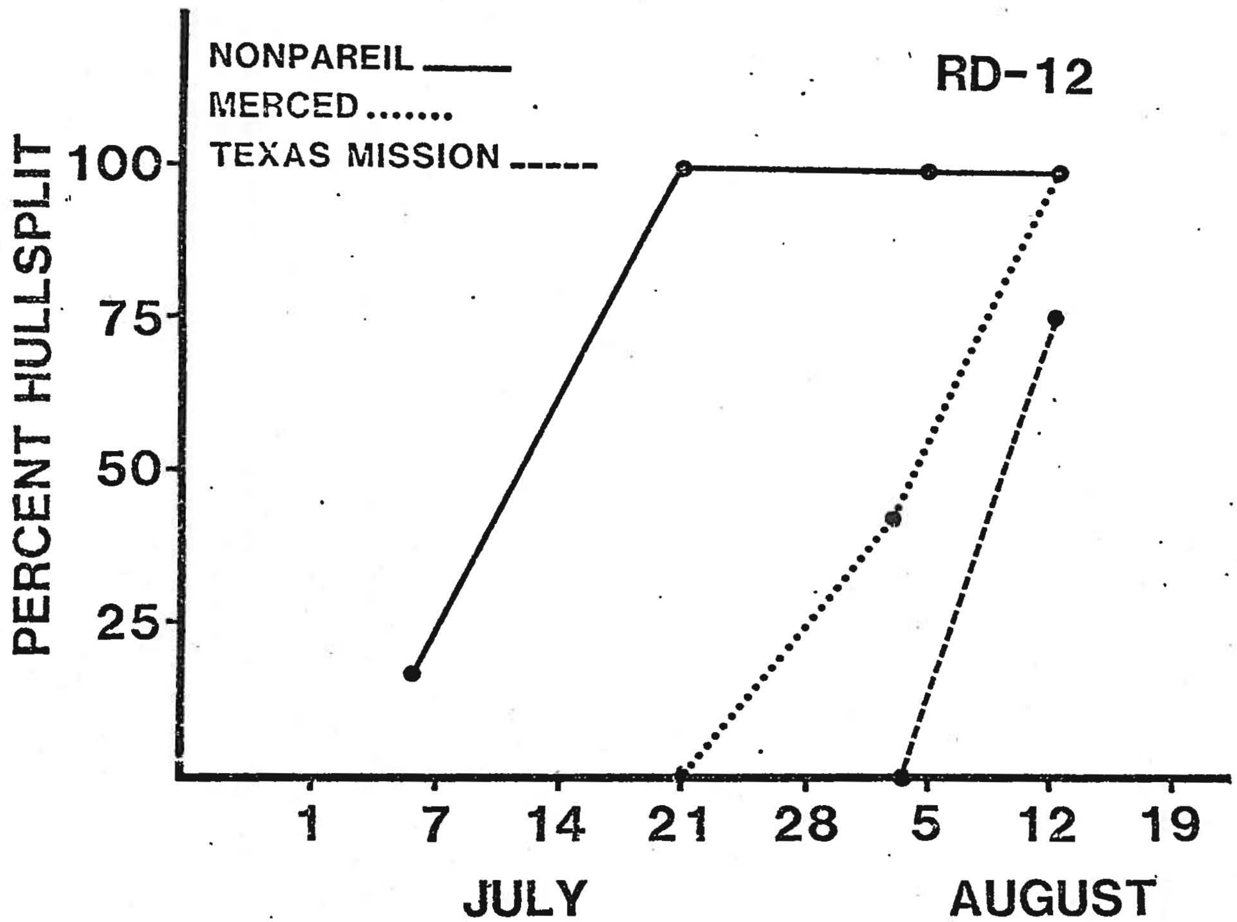

FIG. 1. Hullsplit recorded in three almond varieties, Ranch RD-12.

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Table 1. Efficacy of Guthion applications at the Nonpareil 45-day preharvest interval for navel orangeworm control in late-maturing almonds.

Program	Pollinator treatment	Rate[1] lb a.i./acre	Avg. % infested by variety: Nonpareil	Merced[4]	Texas Mission[4]
Unmodified spray program	Guthion 50W	2.0	8.0 a[2,3]	28.0 a	5.9 a
	Omite 6E	3.0			
Modified spray program	Untreated	-	10.5 a	26.6 a	4.0 a

[1]Applied on 7/6/81 at 500 gal formulated spray/acre.

[2]Treatment replicated 3 times. Replicate consists of mean percent infestation of 10 center trees.

[3]Means in the same column followed by the same letter are not significantly different at P <0.05 using Duncan's New Multiple Range Test.

[4]Late-maturing variety.

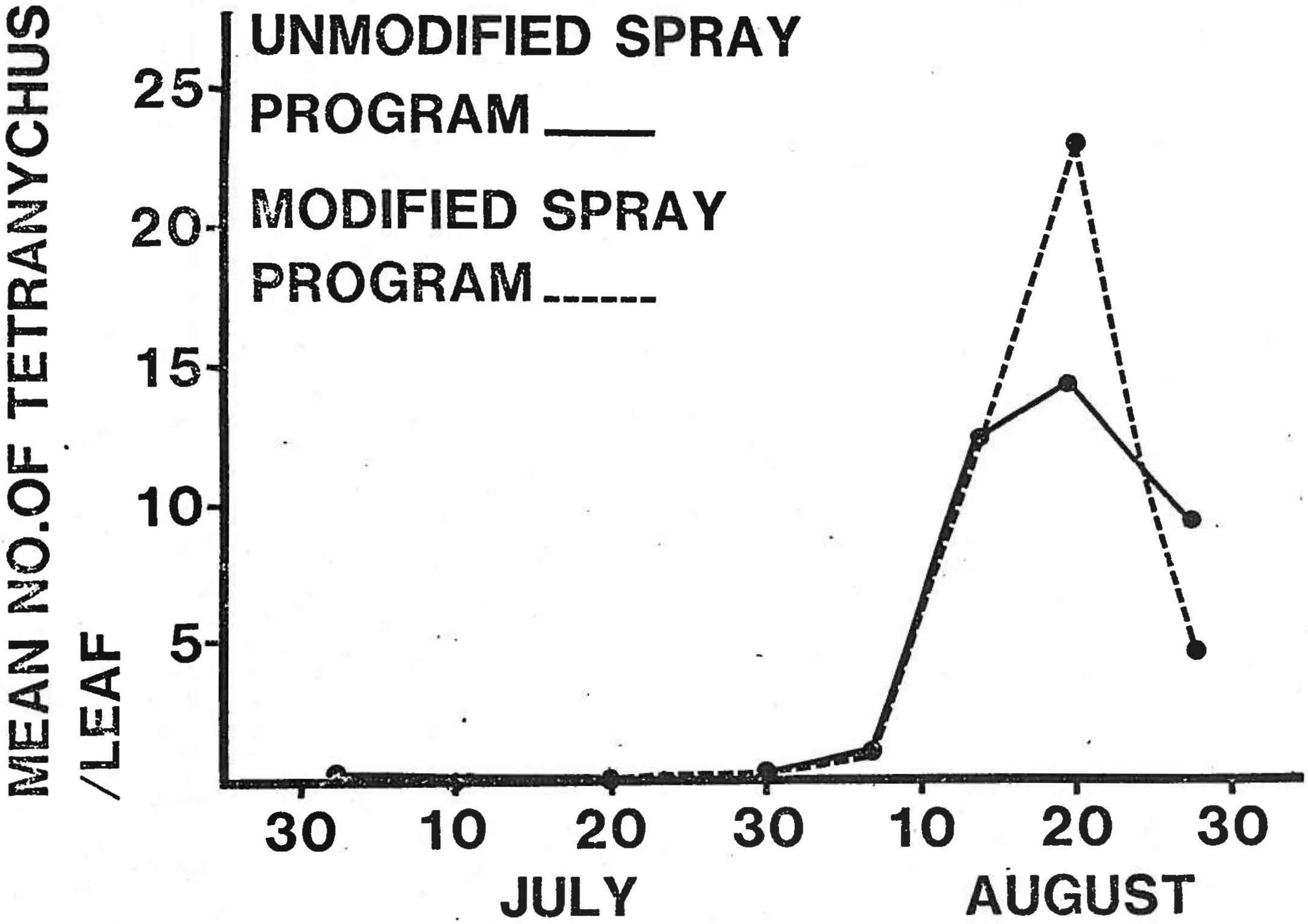

FIG. 2. Effect of the modified spray program upon Tetranychus mites in the Nonpareil variety.

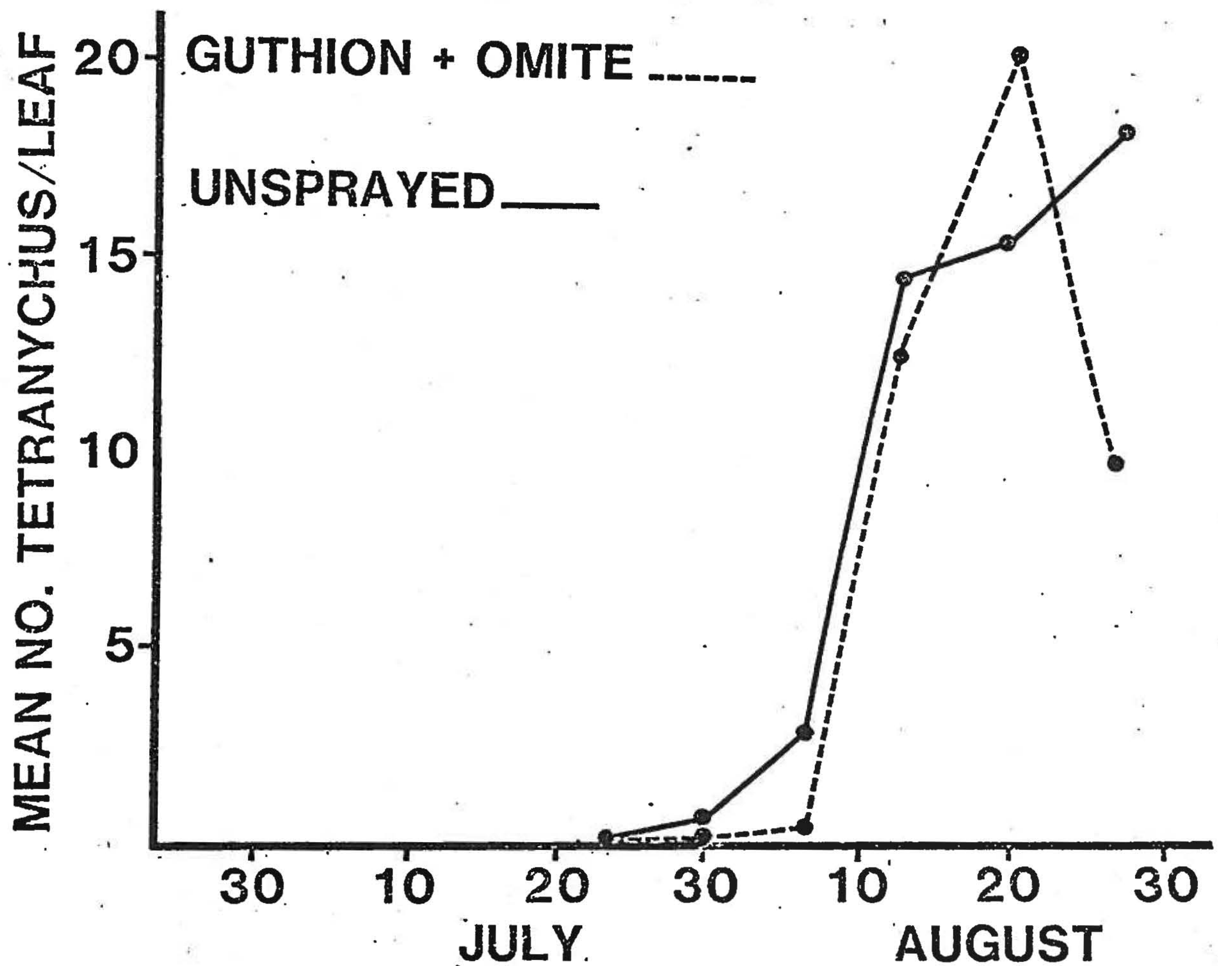

FIG. 3. Effect of Guthion and Omite upon Tetranychus mites in late-maturing pollinators.

The phytoseiid populations were not significantly different between spray programs for either the Nonpareil or pollinator varieties (Fig. 4 and 5).

Monitoring was stopped on 8/27 because the spider mite populations had far exceeded economically damaging levels.

Trial 2

Seasonal development of hullsplit within each variety is shown in Fig. 6. Navel orangeworm infestations were not significantly different for any variety within either the modified or unmodified spray program (Table 2).

Spider mite populations never exceeded levels of 0.2 mites per leaf in either the Nonpareil or pollinator varieties within either spray program (Fig. 7 and 8). Similarly, the phytoseiid populations remained at extremely low levels with no significant differences being detectable between spray programs as shown in Fig. 9 and 10.

Discussion

The uniform application of an insecticide at Nonpareil hullsplit for navel orangeworm control does not appear justified. The unsprayed pollinators exhibited either a nonsignificant reduction in navel orangeworm infestation or a slight nonsignificant increase of 1.2% in the Texas Mission variety. Similarly, navel orangeworm suppression in the Nonpareil variety was not adversely affected by the omission of an insecticide to the late-maturing pollinators.

In addition, spider mite populations did not significantly differ between spray programs within any variety. Unfortunately, the data do not suggest a marked improvement in predator conservation. Conservation of natural predators by selectively spraying only the Nonpareil variety may be possible if the initial population levels were higher.

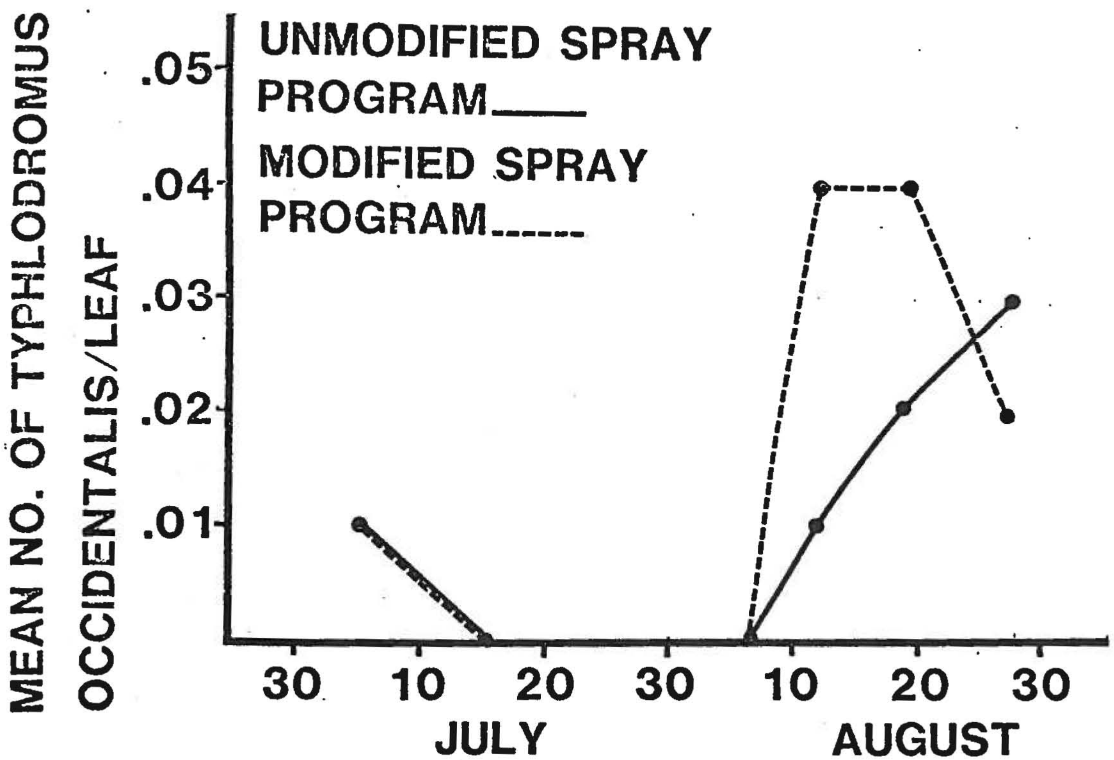

FIG. 4. Effect of modified spray program upon *Typhlodromus occidentalis* in the Nonpareil variety.

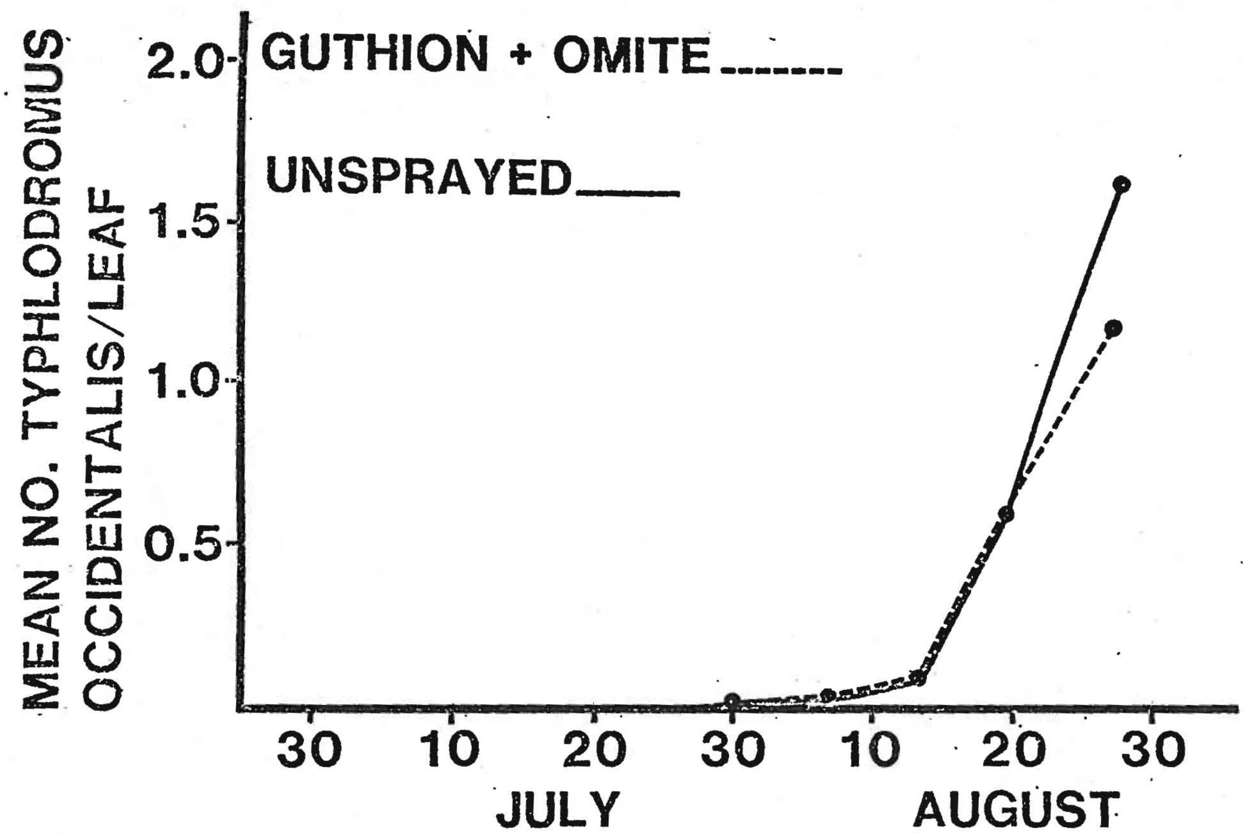

FIG. 5. Effect of Guthion and Omite upon *Typhlodromus occidentalis* in late-maturing pollinators.

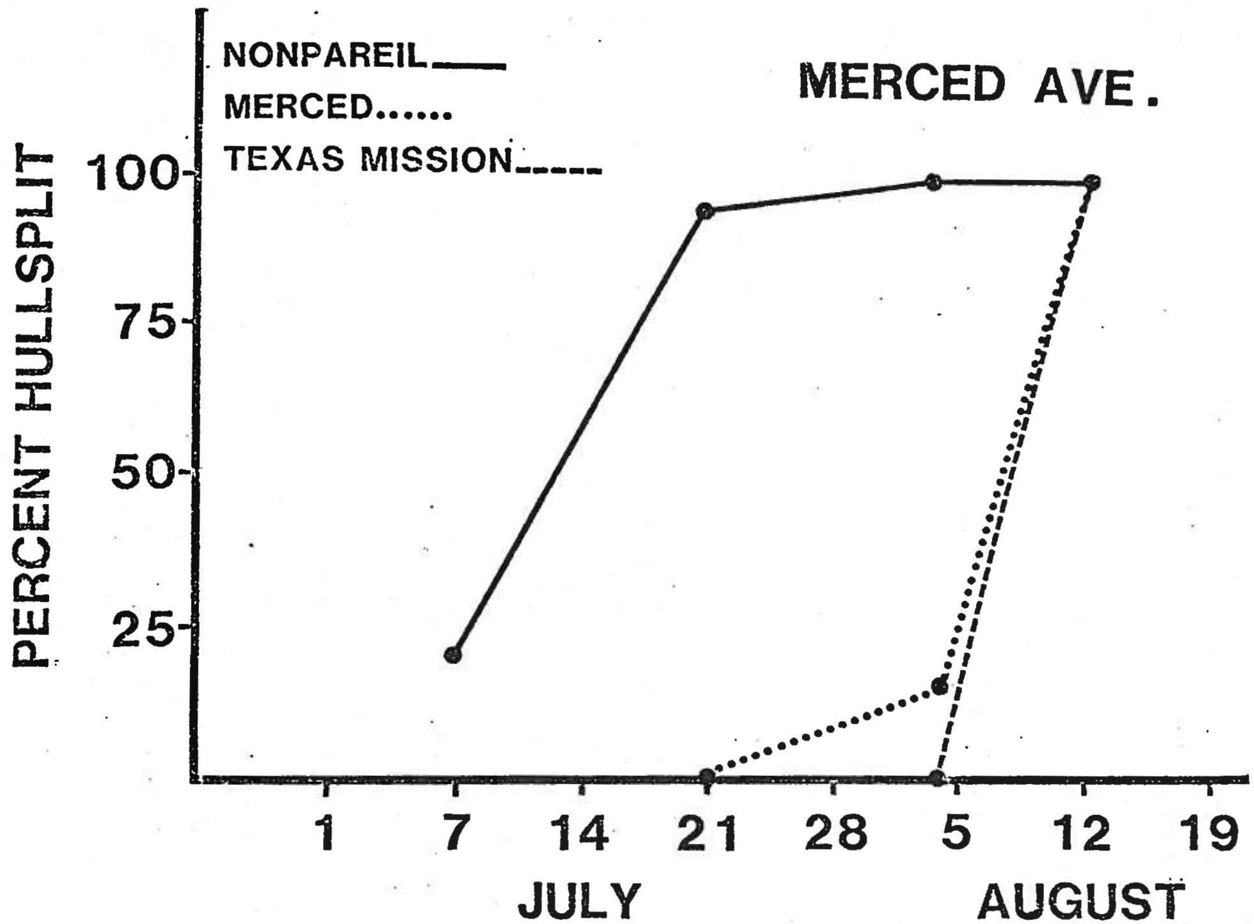

FIG. 6. Hullsplit recorded in three almond varieties, Ranch Merced Ave.

Table 2. Efficacy of Imidan applications at Nonpareil hullsplit for navel orangeworm control in late-maturing almonds.

Program	Pollinator treatment	Rate[1] lb a.i./acre	Avg. % infested by variety: Nonpareil	Merced[4]	Texas Mission[4]
Unmodified spray program	Imidan 50W	4.0	38.9 a[2,3]	44.8 a	2.6 a
	Omite 30W	2.7			
Modified spray program	Untreated	-	39.2 a	43.4 a	3.8 a

[1]Applied on 7/7/81 at 400 gal formulated spray/acre.

[2]Treatment replicated 3 times. Replicate consists of mean percent infestation of 10 center trees.

[3]Means in the same column followed by the same letter are not significantly different at $P < 0.05$ using Duncan's New Multiple Range Test.

[4]Late-maturing variety.

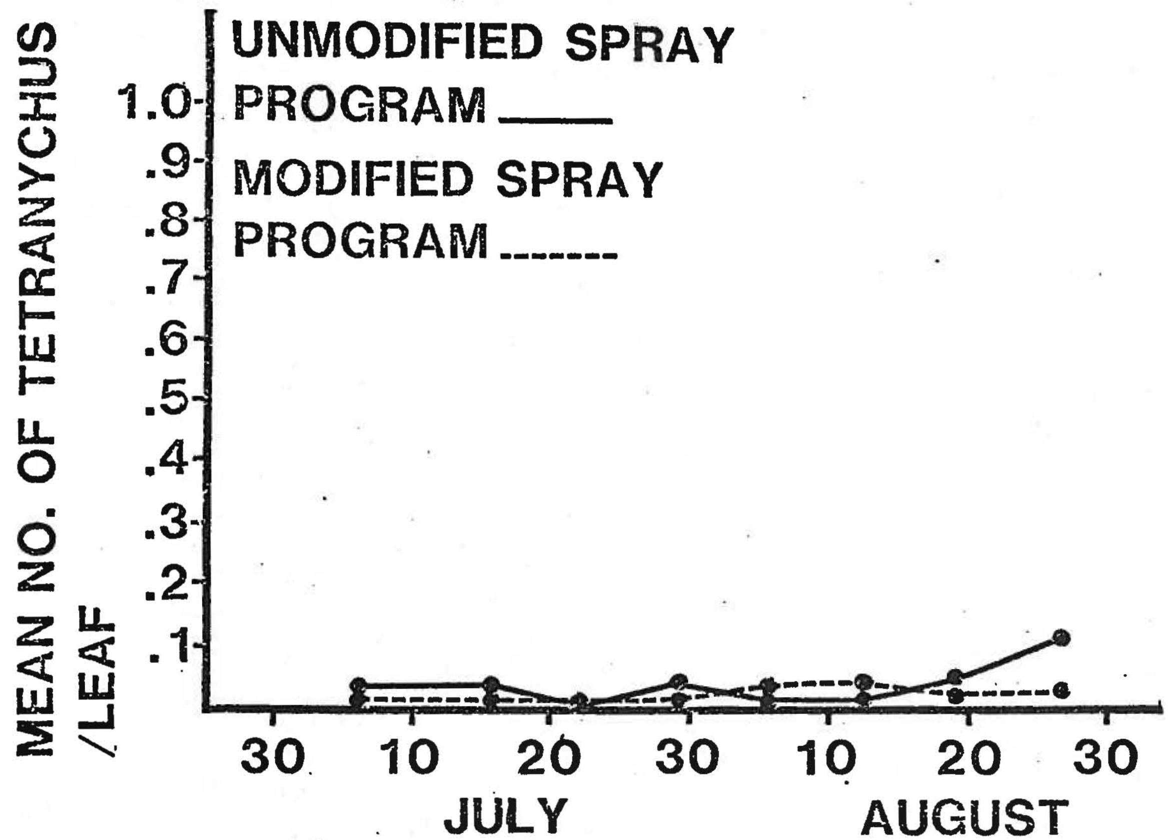

FIG. 7. Effect of modified spray program upon Tetranychus mites in the Nonpareil variety.

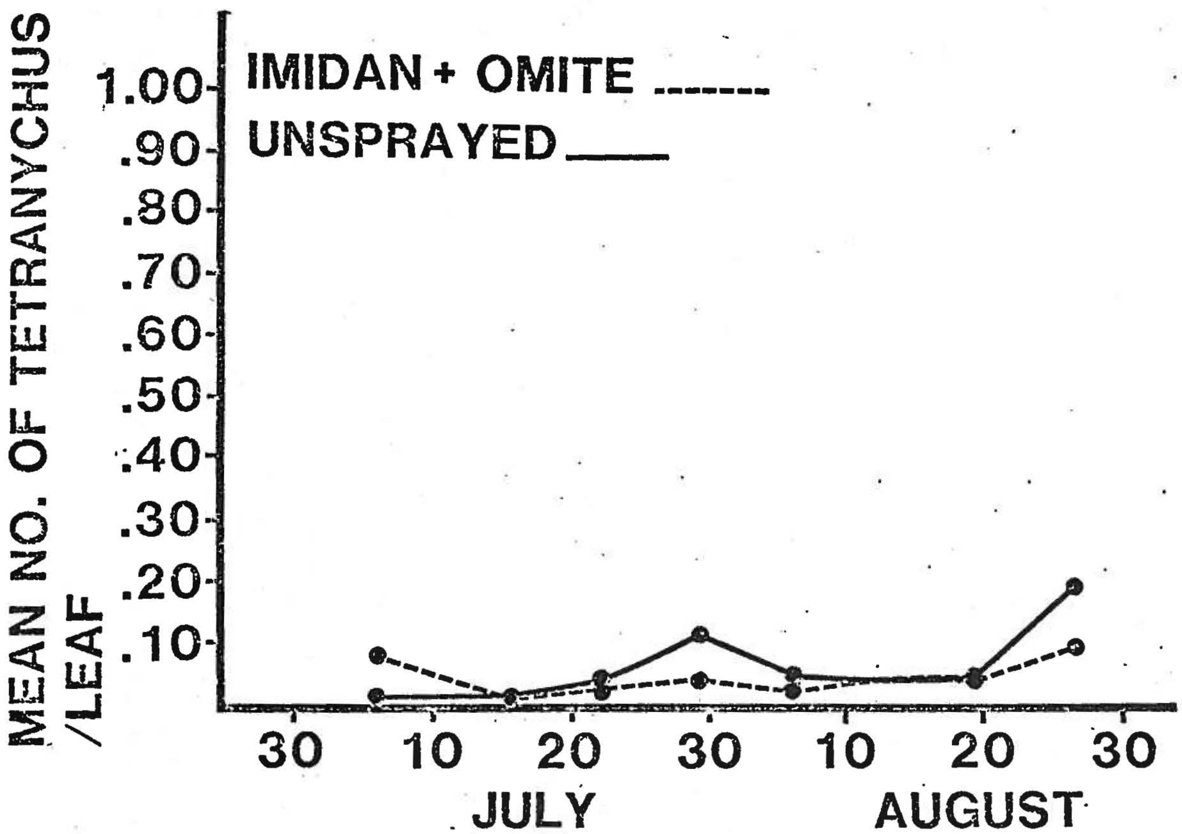

FIG. 8. Effect of Imidan and Omite upon <u>Tetranychus</u> mites in late-maturing pollinators.

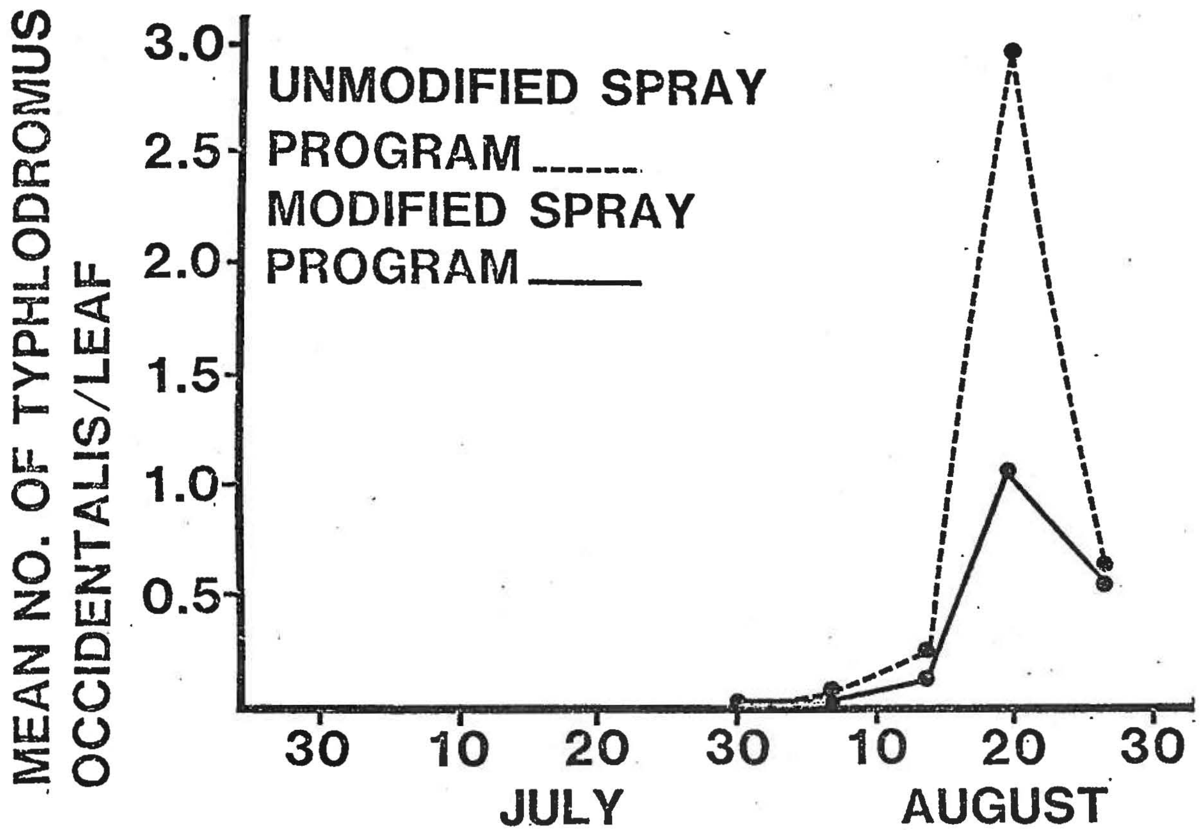

FIG. 9. Effect of modified spray program upon Typhlodromus occidentalis in the Nonpareil variety.

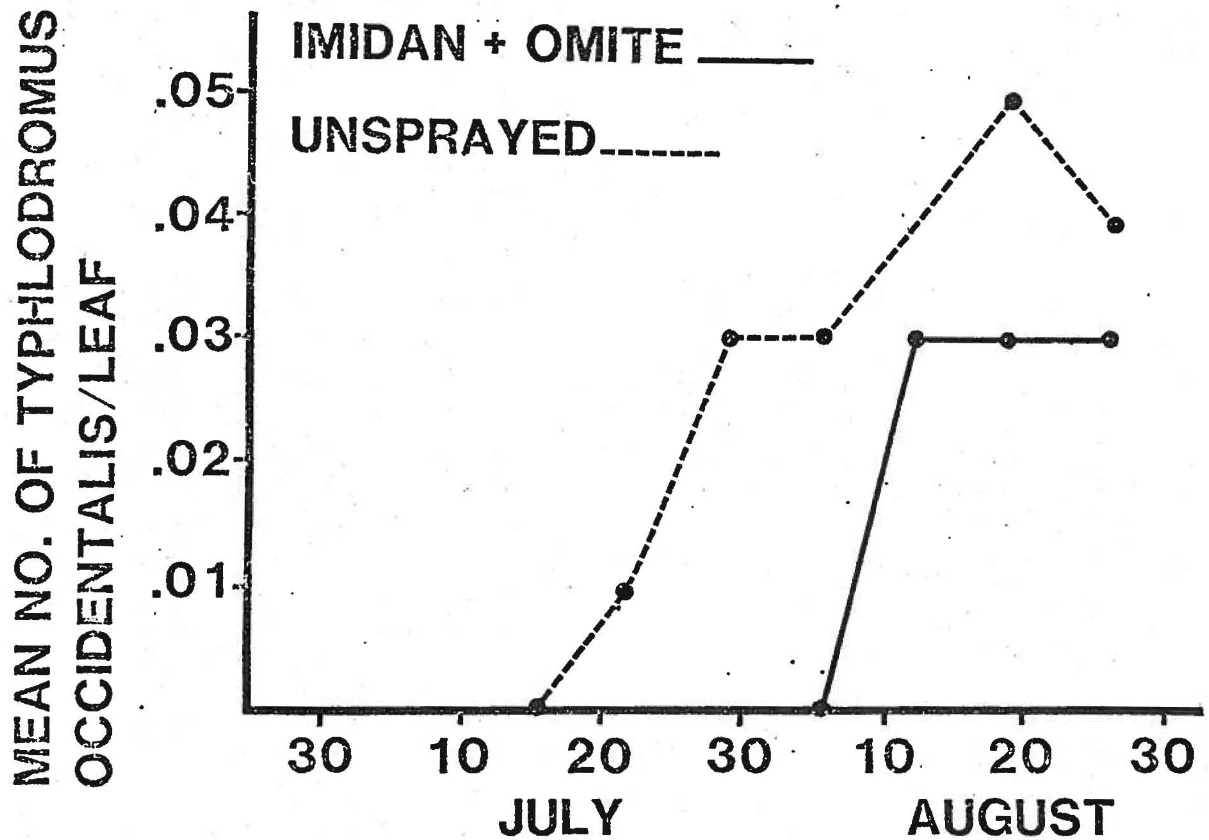

FIG. 10. Effect of Imidan and Omite upon Typhlodromus occidentalis in late-maturing pollinators.

The potential advantages of using the modified spray program are as follows: (1) reduction of both insecticide and acaricide costs at Nonpareil hullsplit by 15-50% (depending upon the planting scheme), (2) less fill-time due to a decrease in gallonage required per acre, and (3) potential enhancement of predator activity on the unsprayed pollinator.

If a grower decides to apply an insecticide to the late-maturing pollinators, then the application should be delayed until the pollinators initiate hullsplit. Previous research has shown that insecticide applications at pollinator hullsplit may in certain circumstances significantly reduce navel orangeworm infestations.

Efficacy of the Addition of Almond Press Cake to an Imidan Application at Hullsplit for Control of Navel Orangeworm

W. S. Seaman and M. M. Barnes

An experiment to determine the efficacy of ground almond press cake added to an Imidan application for control of navel orangeworm was conducted on a portion of a Superior Farms orchard in Kern County. The attractiveness of the almond press cake to the adult female navel orangeworm has been demonstrated with its successful use in Zoecon egg traps. The addition of the almond press cake to an insecticide application may show effects in several ways when applied at hullsplit. First, newly hatching larvae may be stimulated to feed by the presence of the press cake and in the process encounter lethal doses of the insecticide before entering the nut. Secondly, trees with the press cake may be more attractive to ovipositing females which may be confused by the presence of the press cake spread over the entire tree. The result could be eggs laid indiscriminately and therefore lower larval survival. Finally, trees with press cake may cause females to search longer for good oviposition sites, thereby contacting more treated portions of the tree and possibly picking up a lethal dose.

Methods and Materials

The experiment was carried out in the interior of a 12-year-old, sprinkler-irrigated orchard located about 3 miles SE of McFarland, Calif. Trees were in a 25X25 ft planting with double rows of Nonpareil variety adjacent to single rows of either Merced or Texas Mission varieties. The experimental plot consisted of 2 adjacent rows of 10 consecutive trees in each row. Each tree was paired to the closest tree in the adjacent row. One tree in each pair was randomly assigned a treatment and the remaining tree in each pair received the second treatment. In this manner, 10 replications of the 2 treatments were carried out. All trees used in the experiment were the Nonpareil variety.

One tree in each pair was treated with Imidan at 4.0 lb ai/acre plus 42 oz/acre Triton B-1956. The second tree in each pair received the same treatment but with the addition of 4.0 lb/acre ground almond press cake. The almond press cake was ground in a Wiley Mill using a sieve screen size of 13 holes to the inch. At this size, no clogging of the spray guns or other equipment was encountered. An average of 14 gal of formulated spray was applied to each tree with a high pressure handgun at 400 psi on 7 July 1981.

At harvest, all trees were mechanically shaken and nut samples were collected from each of the trees. Samples were stored at 40°F until the nuts were handcracked. Percent infestation per sample was based on the examination of 300 nuts per tree.

Results

The treatment using Imidan without addition of pressed almond cake showed an average of 6.3% infested almond meats. The treatment using Imidan with pressed almond cake showed an average of 6.7% infested almond meats.

The results show no effect on percent infestation by the addition of 4.0 lb/acre almond press cake compared to Imidan alone. Greater quantities of ground press cake may show differences but were not used in this experiment.

Reference Curve for Permethrin for Navel Orangeworm Moths

C. E. Engle and M. M. Barnes

Laboratory tests were conducted in the fall of 1980 to establish a reference curve of susceptibility of the navel orangeworm adult moth to permethrin. These laboratory experiments were conducted concurrent with the large scale introduction of permethrin into the almond orchard agroecosystem. With a reference curve, one can accurately determine if resistance to a specific insecticide is occurring.

Methods and Materials

Permethrin (97.5% technical) was dissolved in acetone and diluted to descending serial concentrations, beginning with a stock 1% solution.

Topically treated moths were treated with a hand-driven micrometer which delivered 0.5 oil droplets through a 250 µl Hamilton® syringe equipped with a 25-gauge needle.

Host material (150 lbs almonds) was collected from a Kern County orchard near McFarland, Calif., and placed in a 4 ft X 8 ft screen emergence cage in a glass house and held at temperatures ranging from 75-85°F. Moths (1-3 days old) of both sexes were gently collected and placed in a 1-gal ice cream carton with metal screen at each end. The moths anaesthetized with CO_2 were picked up (by the wings) with forceps, treated on the dorsum of the thorax with varied concentrations of permethrin in acetone and placed in a 3.5X5-in. wire mesh cage with a plastic lid at each end. The moths were held at 80°F with a constant photoperiod. Moths serving in the check treatment received only acetone on the thorax. Moth mortality was checked at 24 and 48 h and recorded. Each treatment (dilution) was replicated 5 times on 5 separate days, with 20 moths serving as

1 replicate. Mortalities were plotted at the different dosages on a logarithmic probability paper and a dosage mortality regression established. An LD_{50} and LD_{95} were then calculated from these data (fig. 1 and 2).

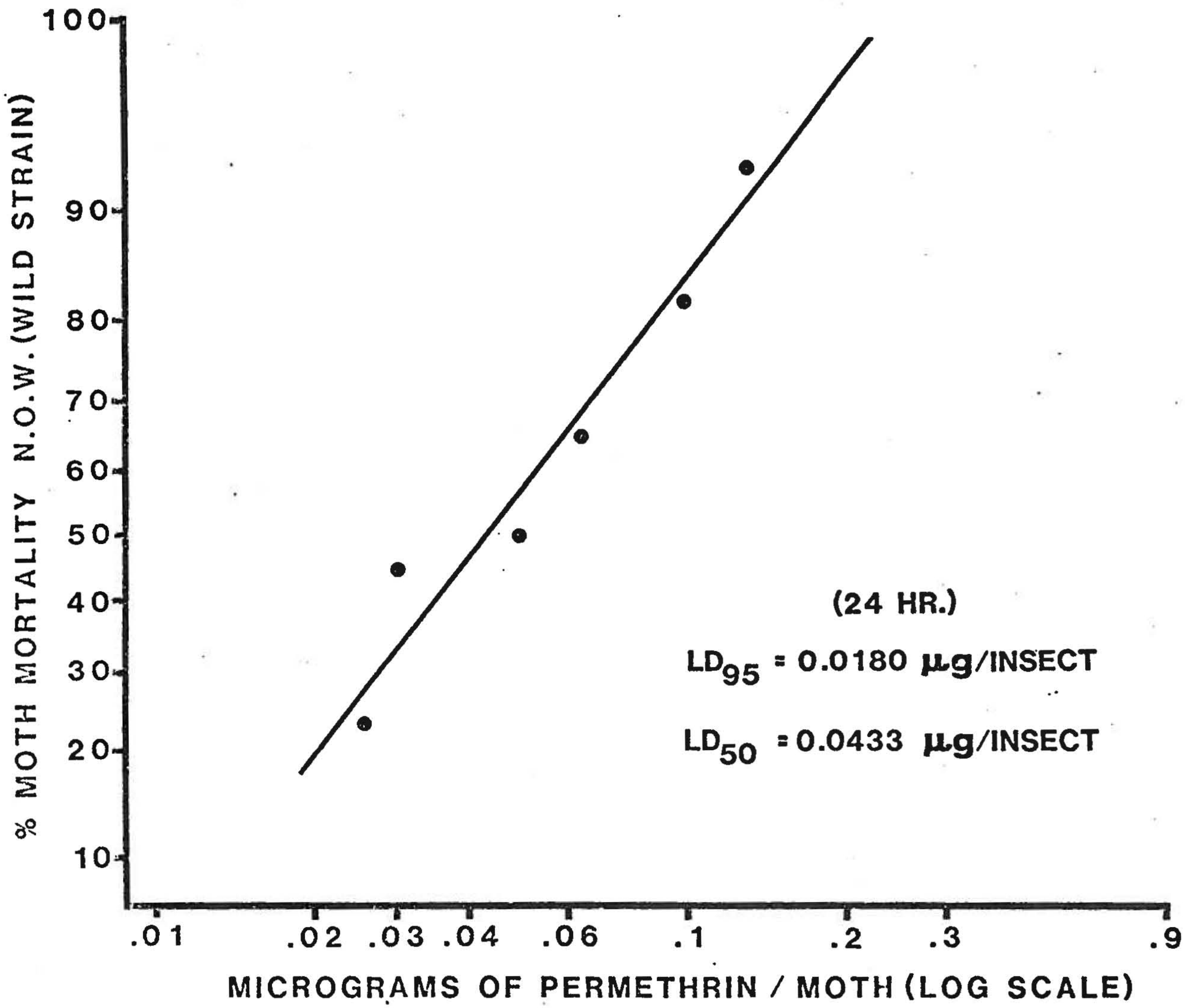

FIG. 1.--Baseline reference for navel orangeworm susceptibility to permethrin, 24 hours.

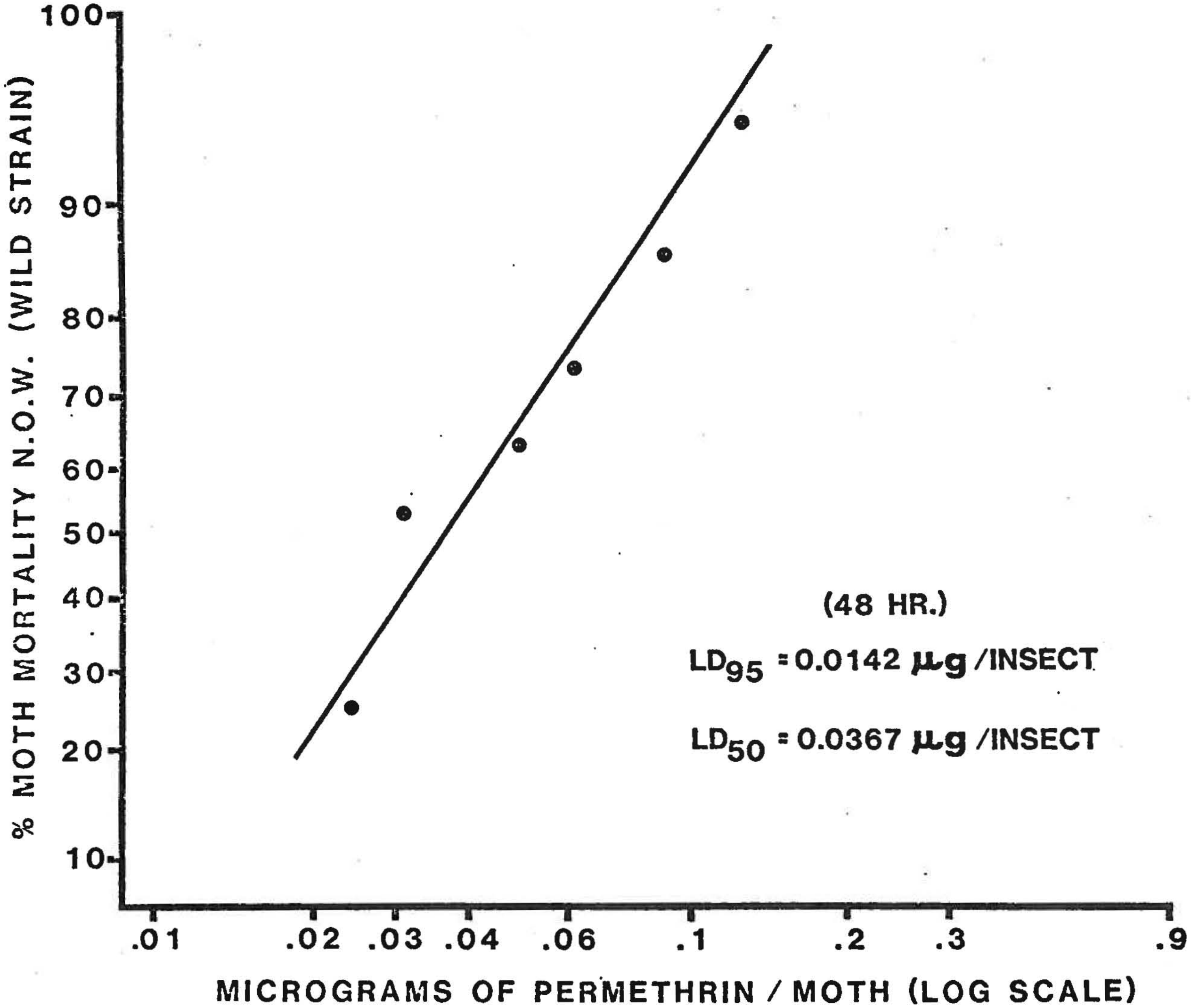

FIG. 2.--Baseline reference for susceptibility of navel orangeworm moths to permethrin, 48 hours.

Relationship Between Almond Orchard Mummy Sanitation and Navel Orangeworm Infestation

C. E. Engle and M. M. Barnes

The navel orangeworm overwinters in mummy almonds that remain in the tree after harvest. The larvae develop through the winter at a much reduced rate. In the spring, the adult moths emerge and females lay eggs on the mummy nuts which provide its major larval food source and shelter for the spring generation. The moths of this generation emerge to infest the current year's almond crop as hullsplit begins. When larvae are within the mummy nuts, they are inaccessible to insecticides.

Dr. Charles Curtis demonstrated that the practice of orchard mummy sanitation combined with relatively early harvest can reduce navel orangeworm infestation at harvest as much as 50%.

In 1980, we began an investigation to determine the quantitative aspects of orchard mummy sanitation, i.e. the relation between the number of mummies per orchard area and percent navel orangeworm infestation at harvest. The study reported herein is a continuation of trials to provide data on this matter. For convenience, the results of the 1980 study are also referred to by combining these with the results in 1981.

Methods and Materials

All investigations were conducted in the Shafter, Delano, and Richgrove areas of Kern County in 1980-81. Eight almond orchards were used in 1980 and 7 were selected for the 1981 experiment. The 1980 experiment contained 5 orchards planted with the hard-shell Mission variety as one of the pollinators.

In 1981, 5 orchards were planted to the hard-shell variety Mission as 1 of the pollinators and 2 orchards contained only soft-shelled pollinators. All orchards were selected for their relative isolation (300-1200 ft) from potential, neighboring navel orangeworm sources. Within each orchard a 50-acre block was selected and within each block a subplot consisting of a 20-tree by 20-tree corner section totaling 3.5-5 acres (Fig. 1) was used for the experiment. The sub-plots received no sprays for navel orangeworm. The orchards were planted with 70-96 trees/acre. During February or March mummy nuts on every tree in each subplot were counted (excluding 94X in 1980, which was counted only in June) and recorded. The remaining 45 acres surrounding the subplot were handpoled below the level of mummies in the subplot to minimize the navel orangeworm immigration into the test plot. The subplots were examined for mummies 3 times; once in midwinter, again just prior to spring moth emergence and finally just preceding hullsplit in late June-early July. Mummy nut drop attributed to natural forces (wind, rain, birds), was recorded in 1980 for the period March through June, in 1981 nut drop was recorded for February through June.

In all orchards, navel orangeworm larvae were sampled at least once in midwinter. Larval and pupal counts were made by removing between 40-250 soft-shelled mummies per orchard, which were taken to the laboratory and examined.

Five navel orangeworm oviposition traps (baited with red wheat bran, glycerine and honeyin 1980, and almond press cake in 1981) were placed in every other tree in each of 2 rows per orchard. The 2 rows with traps were at least 50 ft apart and in the center of each subplot. The traps were placed from 4-6 ft in height on the NE corner of each tree canopy. All traps were replaced regularly on a 7-day schedule. The exposed traps were taken to the laboratory and examined for navel orangeworm eggs. The oviposition traps were in place

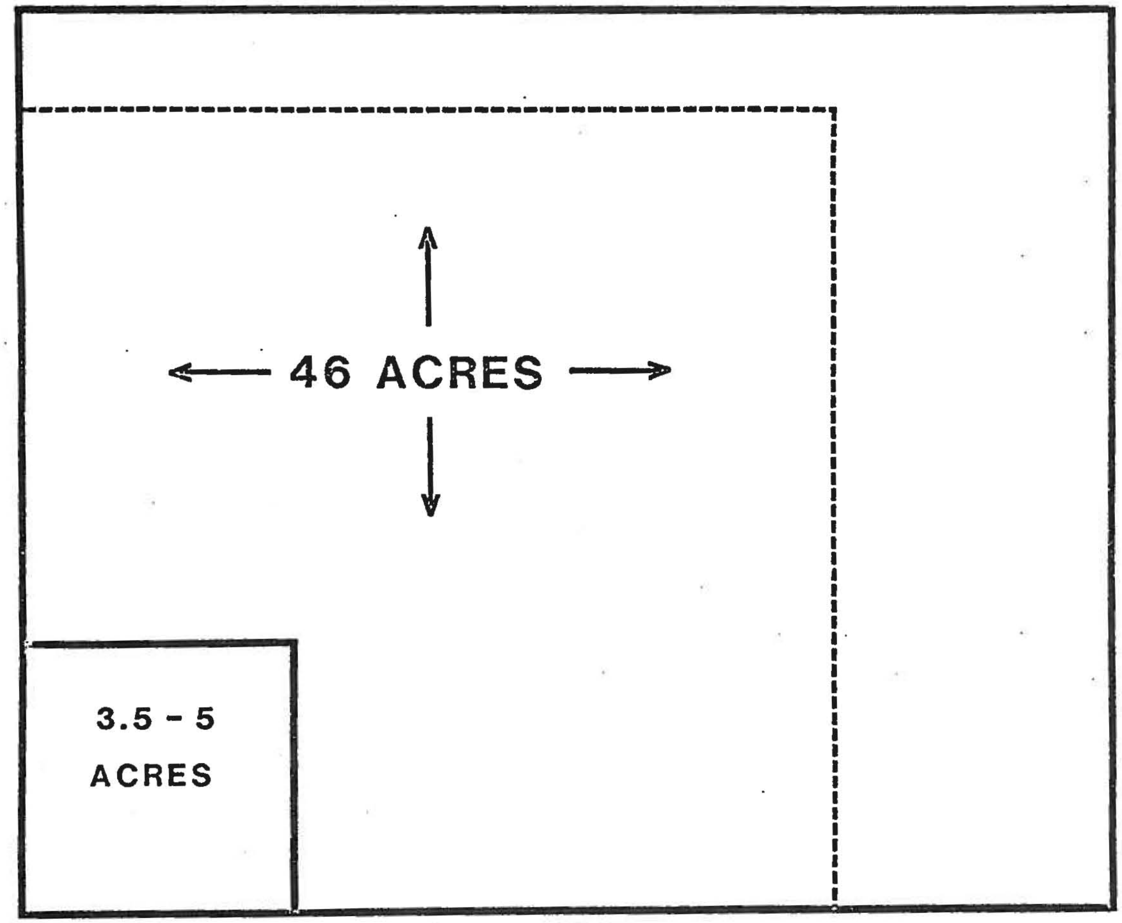

FIG. 1. Schematic representation of unsprayed sub-plot from which data were taken. Remainder of block cleaned of mummies somewhat below level of sub-plot.

during the entire season, terminating at harvest.

The harvest date for each plot was based on the physiological maturity of the nuts. Nuts were harvested when nut hullsplit averaged 95-100% hullsplit at the 4-6 ft level of the tree. Early harvest is important as delay results in increased navel orangeworm infestation. At harvest, 20 Nonpareil trees were sampled from the center of each subplot, 200 nuts were taken from each tree, totaling 4000 nuts/subplot. Nuts were knocked onto tarps prior to sampling and taken to the laboratory for examination. Infestation was determined by hand hulling as compared to commercial hulling; the latter underestimates field infestation.

Results and Discussion

For all 7 orchards (1981), the average mummy counts per tree taken in mid-winter were correlated with their respective larvae/acre estimates. The value $r = 0.94$ was significant ($P<0.05$). When these data were combined with the 1981 values, a significant correlation of $r = 0.82$ was established. Although variable, these results indicate the usefulness of taking only orchard mummy counts for estimating potentially destructive navel orangeworm larval populations.

Two variables among data reflecting navel orangeworm oviposition, determined using oviposition traps, were examined for their relationships to infestation at harvest. They were (1) total egg counts per trap per season and (2) eggs/trap/night at peak oviposition. In contrast to our 1980 data (using red wheat bran baited traps) a significant correlation was found for both variables when using almond press cake baited traps. Average egg laying for the season (based on $\bar{x}$ eggs/trap/night) vs infestation at harvest had a significant correlation $r = 0.89$ ($P >0.05$) (Fig. 2, Table 1), and peak oviposition (based on eggs/trap/

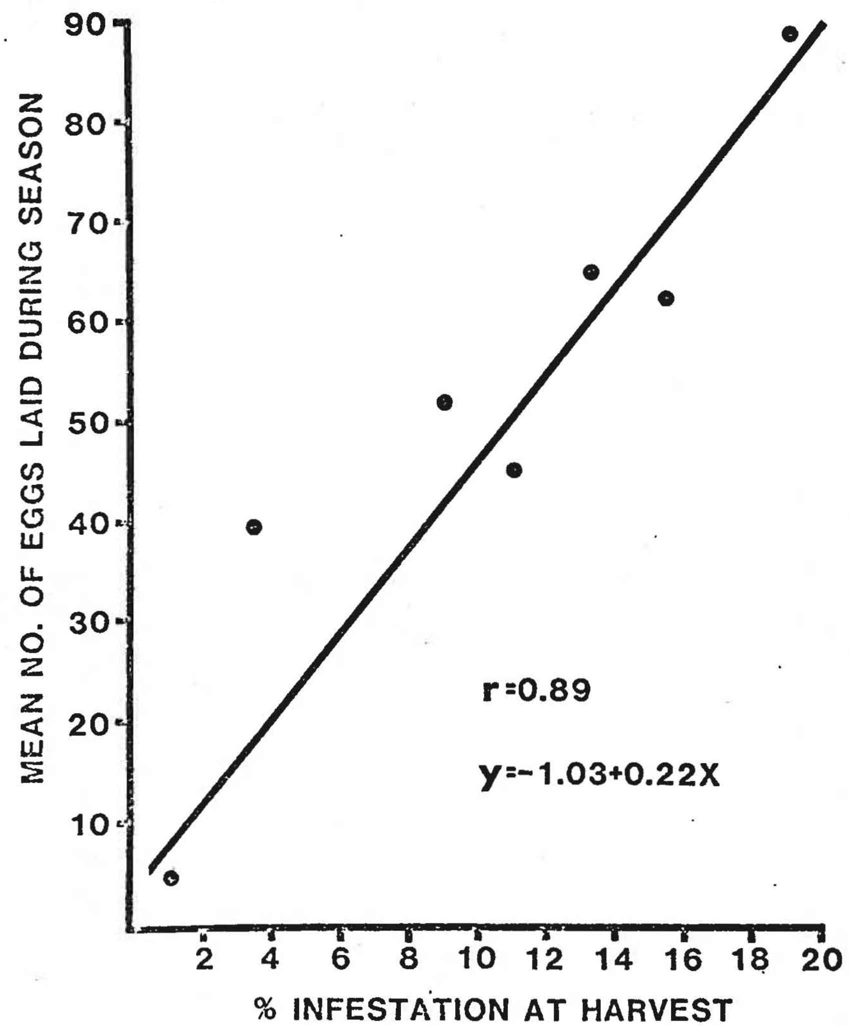

FIG. 2. Egg trap data in relation to infestation. Each point represents the sum of the mean number of eggs per trap per night from weekly records in sub-plots during the pre-harvest period. Based on 10 oviposition traps per sub-plot.

Table 1. Navel orangeworm oviposition[1/] taken from seven different almond orchards vs. percent infested almonds at harvest .

	Navel orangeworm oviposition 1981		
Orchard sample	Season total	Peak egg laying	% infested Nonpareil at harvest
194	41.6	7.3	3.5
65A	64.8	11.7	13.7
Lit Ark	56.1	9.9	9.2
R-88	48.2	7.8	11.2
R-95	90.4	14.3	19.6
65B	54.6	7.9	15.5
152	6.1	1.5	1.6

[1/] Oviposition based on data taken from 10 oviposition traps located in the center of each subplot.

night) vs infestation at harvest was also significant r = 0.83 (Fig. 3.). The high correlations may indicate that the almond press cake baited traps can aid in forecasting damaging navel orangeworm populations.

At harvest, average infestation per orchard (1980-81) was correlated with average numbers of mummies per tree in June. These data indicate that with an average of one mummy or less per tree in June a grower can expect a 1.6-4.5% infestation at harvest (Table 2). Average mummy drop on an individual orchard basis was tabulated from midwinter to harvest during both seasons. Average mummy drop in 1980 ranged from 29%-94% with a mean of 55%. In 1981 (Table 3) overall mummy drop ranged from 67%-86% with an overall mean of 80% drop from midwinter through June.

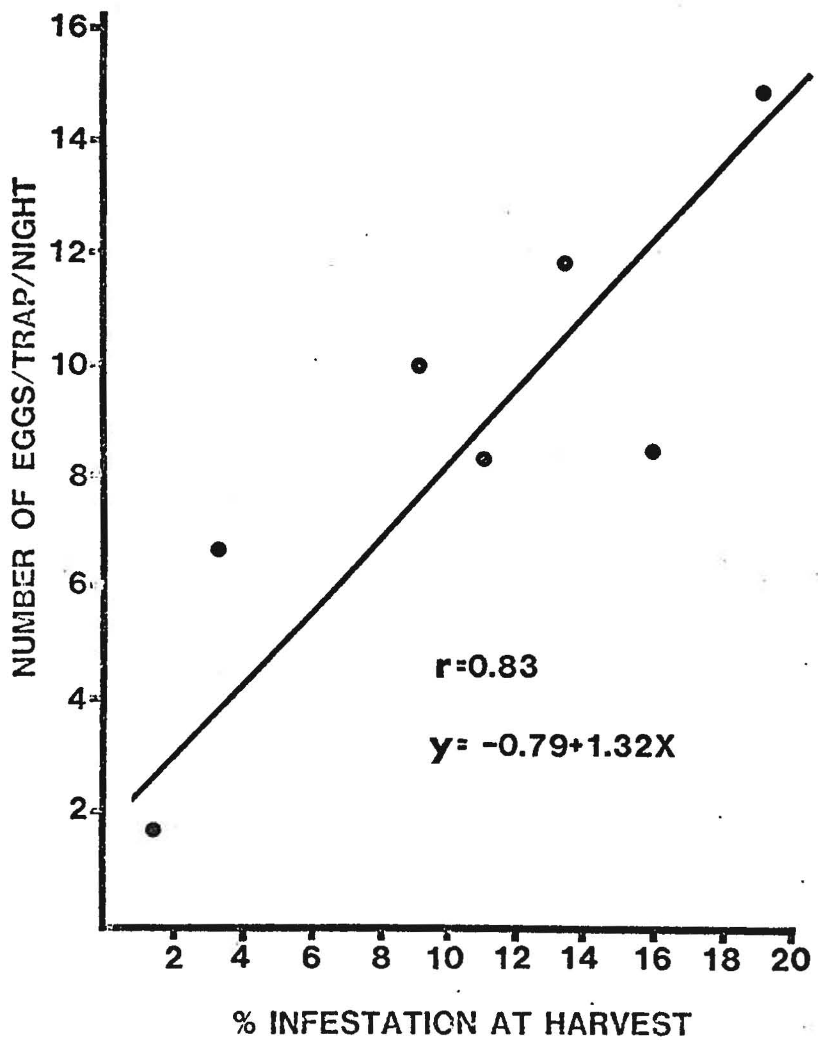

FIG. 3. Infestation in relation to egg trap data. Each point represents the maximum number of eggs/trap/night of the week of maximum spring oviposition.

Table 2. Distance from nearest potential navel orangeworm source, number of soft-shell mummy nuts in late June and final percent navel orangeworm infested Nonpareil almonds at harvest, 1980-1981.

Ranch no.	Year	Mean no. soft-shell mummy nuts/ tree in June	Distance from nearest potential NOW source (ft)	Harvest date	Percent[1] damaged nuts
C-152	1981	0.3	900	8/4/81	1.6
R-88	1980	0.6	1200	8/13/80	1.7
C-152	1980	0.3	900	8/12/80	2.3
R-15	1980	0.1	300	8/13/80	3.0
C-194	1981	8.3	1200	7/29/81	3.5
R-94A	1980	0.3	900	8/19/80	3.6
R-94B	1980	1.2	750	8/19/80	4.2
Mazy	1980	0.2	1200	8/25/80	4.5
2483	1980	1.9	1200	8/25/80	6.0
Lit Ark	1981	7.4	1000	7/29/81	9.2
R-94X	1980	20.1	300	8/14/80	10.9
R-88	1981	4.3	1200	8/3/81	11.2
65A	1981	3.4	1200	8/3/81	13.7
65B	1981	10.5	1200	8/17/81	15.5
R-95	1981	16.6	1200	8/4/81	19.6

[1]No insecticides applied. Infestation data based on samples of 200 nuts from each of 20 trees in the center of the block.

Table 3. Soft-shell mummy drop due to wind, rain, and other natural events occurring in the almond orchard, Kern County, CA, 1981.

Ranch no.	Mean no. soft-shelled mummy nuts/tree in February '81	Mean no. soft-shelled mummy nuts/tree in April '81	Feb. to April percent nut drop	Mean no. soft-shelled mummy nuts/tree in July '81	April to July percent nut drop	Feb. to July total mummy drop
194	46.2	22.0	52	8.3	62	82
65A	24.1	10.4	57	3.4	67	86
Lit Ark	34.3	16.2	53	7.4	54	78
R-88	24.4	7.8	68	4.3	45	82
R-95	105.6	38.0	64	16.6	56	84
65B	32.1	20.0	38	10.5	47	67
152	12.6	0.7	Na[a]	0.3	57	Na

[a] Trees mechanically shaken after initial count.

Summary

The following relationships were established in orchards receiving no navel orangeworm sprays. Orchard mummy cleanup can greatly reduce NOW infestation at harvest. There is strong evidence, supported by 2 seasons of data, that an almond orchard with an average of 0.1-1.2 softshell mummies/tree in June can expect a 1.6%-4.5% infestation at harvest. Orchards with an average of 1.9-8.3 softshell mummies/tree in June experienced a 6.0%-11.2% infestation and orchards with softshell mummy counts higher than 8.3 softshell mummies/tree ranged from 13.7%-19.6% infestation at harvest. These data indicate a grower would benefit greatly if orchard trees were clean in winter to a sufficient degree such that natural fall would result in below 1 mummy/tree in June. From midwinter to June the average number of mummies per tree declined 55% in 1980 and 80% in 1981.

To provide for management of NOW based solely on orchard sanitation and early harvest, the following tentative standards, based on 2 seasons' experience, are suggested.

A. Use orchards that are at least .25 miles from external source of infestation.

B. Clean orchard in midwinter to an average of 2 mummies per tree.

C. Estimate mummy density in orchard in winter by tabulating mummies from at least 2 softshell trees per acre chosen at random. This provides a 90% confidence level of being within 20% of the mean.

D. Blow mummies off berm and flail prior to March 15.

E. Harvest promptly at 95-100% hullsplit measured below 6 feet. If all requirements cannot be met, the NOW control program should be supplemented by the use of insecticides.

The Development, Age Distribution, and Abundance of the Navel Orangeworm in Mummy Almonds

C. E. Engle and M. M. Barnes

The navel orangeworm was first reported as a pest of walnuts and almonds in the late 1940s. Following almond harvest, the navel orangeworm utilizes mummy nuts as feeding and overwintering sites. In early spring, emerging navel orangeworm moths oviposit on remaining mummies resulting in a resident population for larval infestation of the new crop.

Navel orangeworm growth and development has been examined under laboratory conditions and on freshly hullsplit (dehisced) nuts. Wade in 1961 and Curtis in 1977 constructed frequency histograms of larval headcapsule width and reported distinct gaps between all instar categories. Falcon in 1964 studied a laboratory strain of navel orangeworm and reported distinct stages of growth except between the 4th and 5th instars. Wade sampled navel orangeworm populations on IXL variety mummy almonds in 1952. Wade's age classification of the orchard population was based on data obtained from a laboratory strain of navel orangeworm. Since Wade's work, there have been no field studies of immature navel orangeworm development or population trends on mummy nuts in the orchard. The study reported herein investigated methods of determining (a) growth and development of an orchard population of navel orangeworm on mummy almonds, (b) age distribution and abundance of immature navel orangeworm on orchard mummies through time, and (c) spring adult emergence from orchard mummies.

Materials and Methods

A 12-year-old, flood-irrigated almond orchard (25 acres) was selected for navel orangeworm population studies. The study was conducted near McFarland, California. The experimental orchard was planted with three soft-shelled almond varieties, Nonpareil, Sauret I and II. Mummy nuts were sampled at intervals during two seasons, winter and spring, of 1979 and 1980. Trees were sampled at different heights, taking one or two mummies/sampled tree. Mummies were bagged and refrigerated for laboratory inspection.

Larvae were removed from infested mummies and grouped into their respective instars. The procedure for assignment to instars was based on the work of Dyar (1890) and was similar to those used by Wade, Falcon, and Curtis for immature navel orangeworm populations. A dissecting microscope fitted with a calibrated micrometer was used to measure head capsule widths. Measurements were taken at the widest margins of the larval head capsule.

Prepupal stages, indicated by the spinning of a cocoon, did not have their head capsule measured and were placed into the 6th instar group. Head capsule measurements from each sample period were combined, totaling 3780 larvae, and plotted as a frequency histogram. Age groups were arbitrarily identified from the range and means of the larval head capsule distribution and by comparisons with previous researchers' data. The natural log of mean head capsule width was plotted to aid in predicting navel orangeworm instar groups.

Navel orangeworm colonization of mummy nuts was indicated by oviposition in the orchard. Oviposition was determined using red wheat-bran baited ovipositional traps. Ten traps were placed, one/tree, in the center of the experimental plot. Traps were checked weekly and hatched and unhatched eggs were recorded.

Results and Discussion

Head capsule measurements proved to be useful for determining orchard navel orangeworm instar category. Classification by head capsule width of the orchard population was not as distinct, however, for most instars when compared to the non-overlapping larval categories of Wade and Curtis and Barnes. Falcon's 1964 classification of larvae by head capsule width was more comparable to data found in the present study (Table 1).

There are several possible explanations for the relatively non-distinct grouping of larval growth on mummy almonds. This variation in growth (overlap) can probably be attributed to the lengthy sampling periods (ca. 5 mo/season), the extremes of a changing nutritional substrate, and the environmental fluctuations encountered during the sample period. Additionally, Wade stated that

> The data obtained for each instar under a given set of constant conditions were fairly uniform. However, some differences could be detected between given instars when reared under different sets of constant conditions, although in most cases these were not too great.

Dyar stated that "the widths of the head of the larva in its successive stages follow a regular geometric progression." A graph of the natural log of mean head capsule width in relation to instar group demonstrates a close approximation to "Dyar's Law" (Fig. 1). The mean rate of head capsule increase (growth ratio) between means of navel orangeworm head capsule instar widths was 1.48. Curtis and Barnes in 1977 found a similar growth ratio of 1.4 from larvae removed from new crop almonds.

Table 1. Head capsule width of an orchard population of navel orangeworm larvae compared to *A. transitella* diets and head capsule measurements of previous investigators.

Instar	No. collected	Width mean (mm)	Width range (mm)	Range (mm)		
				Wade (1961)	Falcon (1964)	Curtis & Barnes (1977)
1	425[a]	0.20 ± 0.01	0.18 - 0.22	0.20 - 0.20	0.19 - 0.21	0.20 - 0.23
2	391	0.28 ± 0.02	0.24 - 0.32	0.25 - 0.32	0.24 - 0.31	0.30 - 0.38
3	771	0.43 ± 0.06	0.34 - 0.55	0.33 - 0.43	0.38 - 0.55	0.48 - 0.58
4	882	0.71 ± 0.11	0.57 - 0.95	0.53 - 0.67	0.59 - 0.92	0.68 - 0.88
5	636	1.16 ± 0.12	0.98 - 1.36	0.80 - 0.93	0.95 - 1.25	0.90 - 1.13
6	675	1.55 ± 0.10	1.38 - 1.90	0.97 - 1.07	1.28 - 1.73	1.40 - 1.75
			<u>Diet</u>:	(Almond meats)	(Walnut meats)	(New crop almonds)

[a] Collected from overwintering mummy Nonpareil and Sauret I and II almonds for the seasons of 1979 and 1980, McFarland, Calif.

Age distribution through time of A. transitella populations was similar in some aspects for both 1979 and 1980 (Figs. 2 and 3). In late-January-early-February, there were virtually no 1st or 2nd instars found in mummy nuts. The majority of the population (ca. 70%) was grouped into the 4th, 5th and 6th instars, with fewer numbers occurring in the 3rd instar and pupal stage. Although during the initial samples, navel orangeworm was grouped primarily in the 4th, 5th and 6th instars for both seasons, there were differences between the population age structures. The 1980 population had fewer 3rd instars and a greater number of 6th instars compare to the 1979 population. Although this was a marked contrast in age structure between the two populations, the initial detection of spring oviposition was virtually identical for both seasons (Figs. 4 and 5). As the season progressed, the population age structure changed and fewer 3rd and 4th instars were found in the mummies. By April, over 80% of the immature population structure had shifted into the last three stages of development during both seasons. Wade reported a similar, but lesser degree of compacting in his navel orangeworm studies.

In late April (24th-27th), 1st instars were initially observed in sample nuts. After this period, the population age structure shifted to include an abundance of early stages (1st, 2nd and 3rd instars). By the first week in June, the population was more evenly distributed among the various stages and emergence of the overwintered population from pupae was virtually complete.

The number of immature navel orangeworms per infested nut is presented in Figs. 4 and 5. A decreasing trend in navel orangeworms per infested nut was evident in the first two months of each sampling season. However, three weeks after the initiation of oviposition, the abundance of navel orangeworm per infested nut began to increase and continued to rise during the sample period as a result of newly-hatched larvae.

Wade indicated that complete navel orangeworm larval development could occur either in the almond kernel or hull. In the present study, the greatest ratio (37% in 1979 and 34% in 1980) of navel orangeworm found feeding in the hull occurred in the initial samples. In the following samples the ratio of navel orangeworm in the hull gradually decreased (1979, 0.9% and 1980, 0.0%). This ratio reduction may be attributed to hull non-preference by larvae because of an apparent progressive, decreasing moisture content and resulting unsuitability of the hull as a food source.

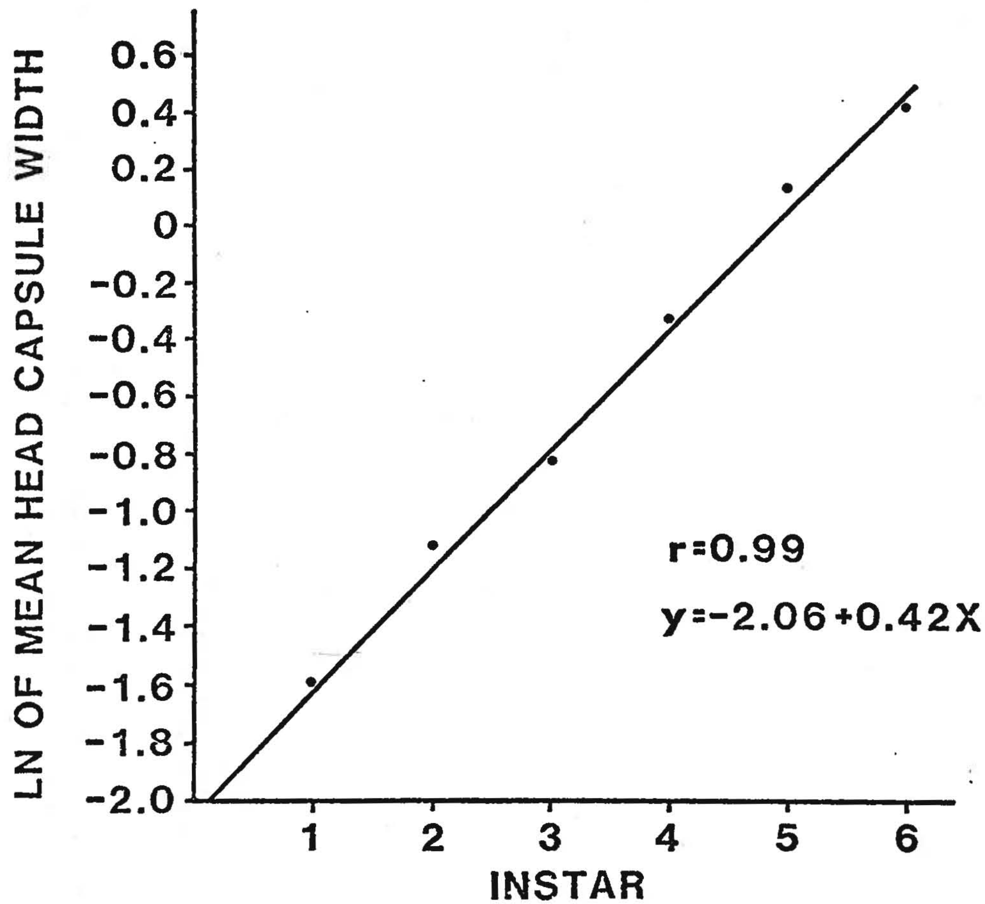

FIG. 1. Natural log of mean head capsule width in relation to instar larvae collected from soft-shelled mummy almonds, McFarland, Calif., 1979-1980.

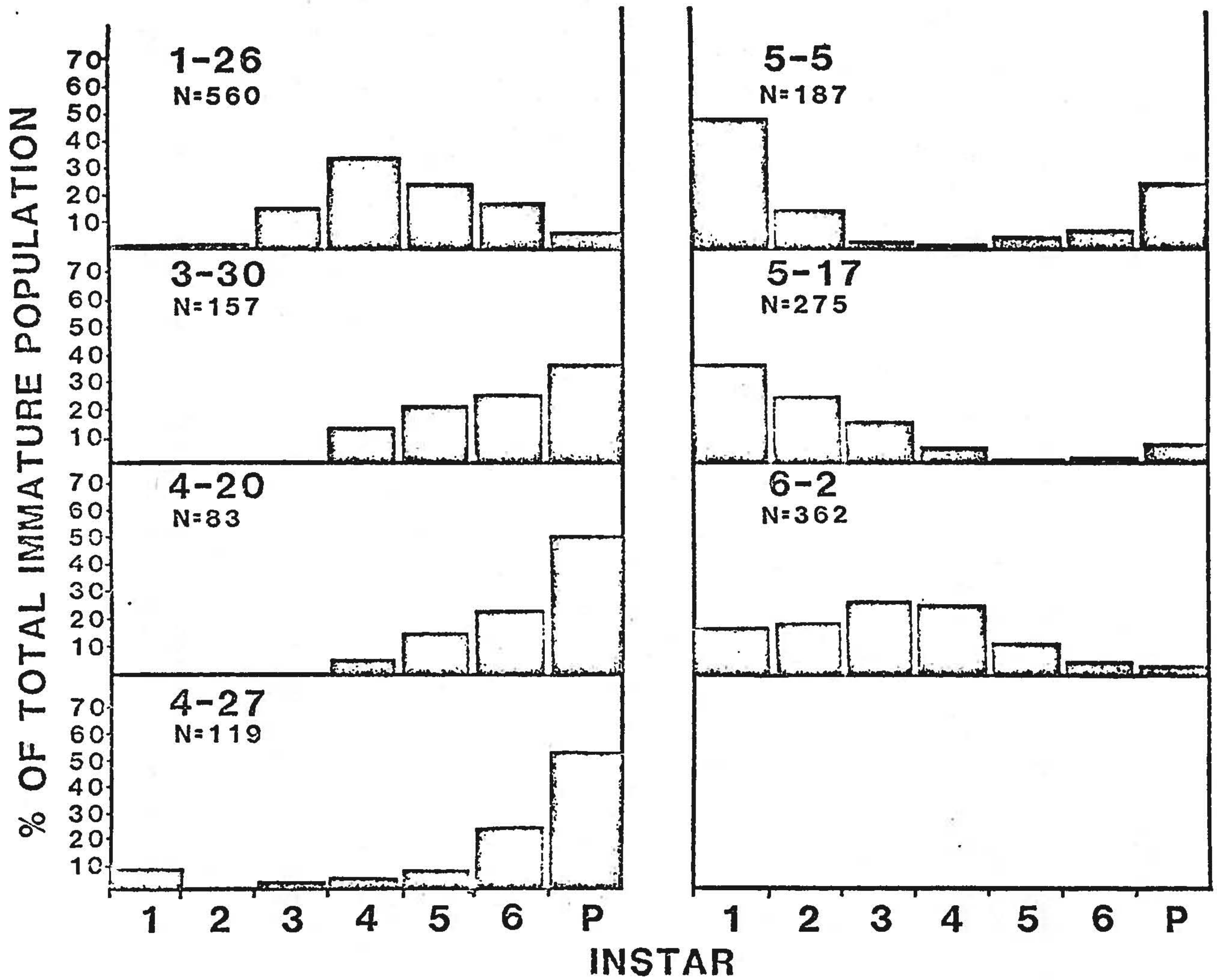

FIG. 2. Frequency histogram of immature Amyelois transitella population occurring at different dates on mummy almonds. McFarland, Calif., 1979.

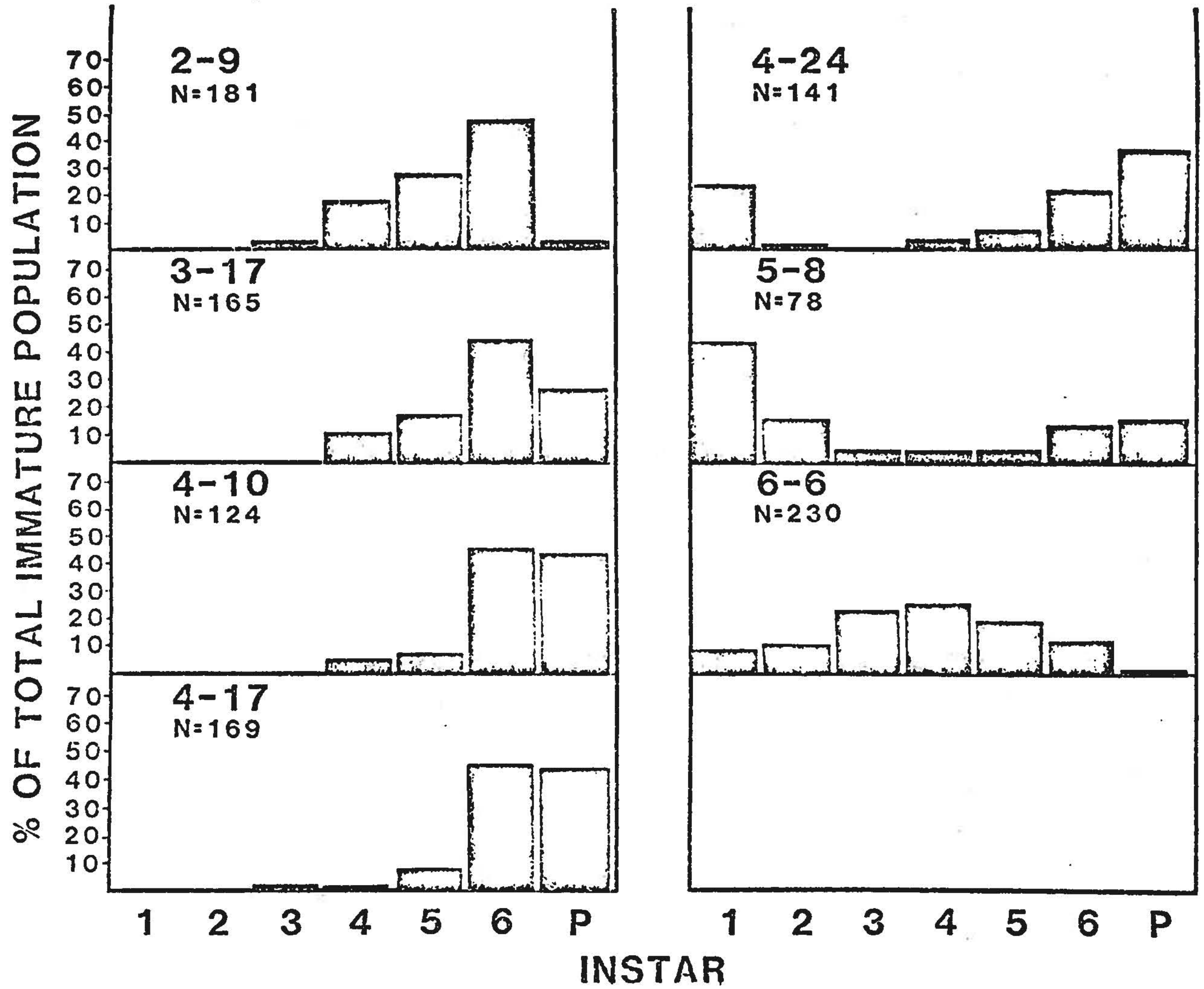

FIG. 3. Frequency histogram of immature Amyelois transitella population occurring at different dates on mummy almonds. McFarland, Calif., 1980.

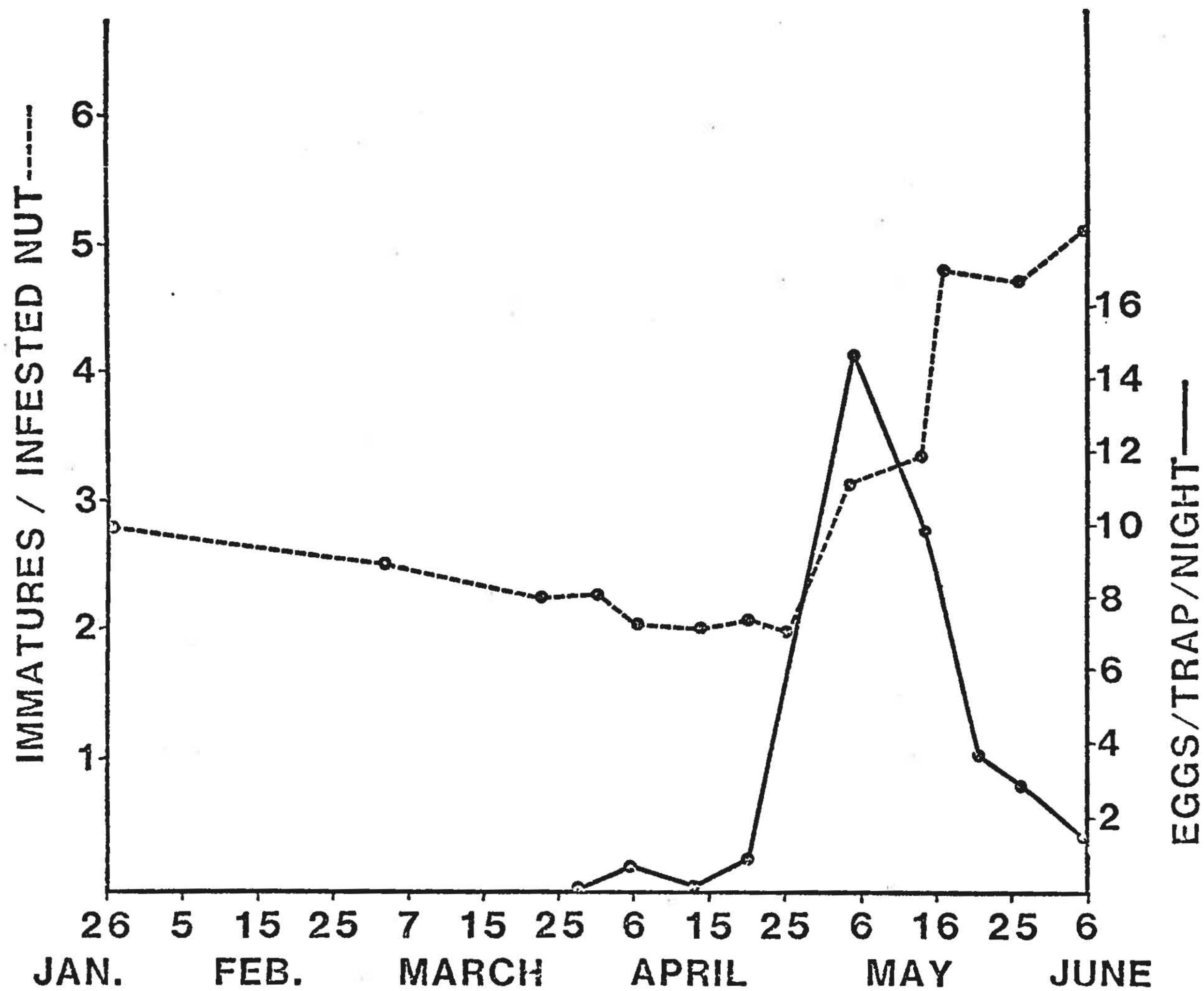

FIG. 4. Abundance of immature Amyelois transitella per infested mummy almond in relation to adult oviposition. McFarland, Calif., 1979.

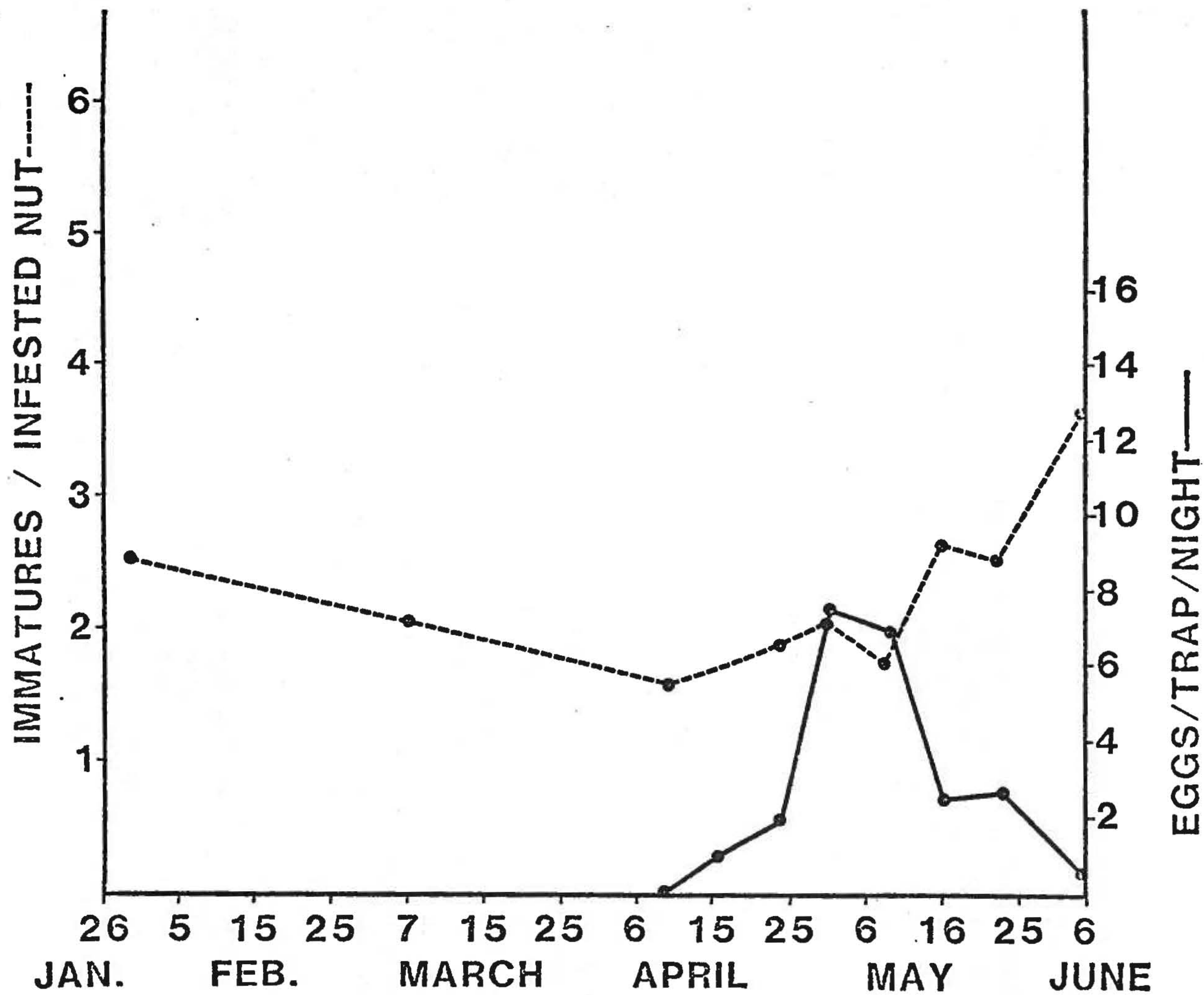

FIG. 5. Abundance of immature *Amyelois transitella* per infested mummy almond in relation to adult oviposition. McFarland, Calif., 1980.

Field Study of Temperature Summation for the Development of Navel Orangeworm from Larva to Adult in the New Crop

W. S. Seaman and M. M. Barnes

Establishment of a temperature summation model for navel orangeworm is an ongoing project. A principal segment of this model concerns the time for development from first-instar larva to emerged adult in the new crop. Accuracy of the model depends primarily upon studies conducted under field conditions. This information will enable the grower or pest manager to accurately predict the major moth emergence which takes place after Nonpareil hullsplit and enables optimal timing of harvest or use of an insecticide application.

Field tests were conducted during the summer months of 1981 in an almond orchard located in Kern Co. The primary information for the model comes from determining developmental times of individual moths reared through on new crop nuts present in the trees. Recording these data for a large number of moths and combining this information with temperature data recorded at the same site produces the desired temperature summation data required for implementation. By combining the known degree-day value for egg development with the accumulated degree-days established for larval and pupal development and moth emergence from fresh crop nuts in the tree, the total number of degree-days for complete development may be obtained.

Methods and Materials

Individual nuts were caged just prior to hullsplit to eliminate the possibility of oviposition on experimental nuts. Each cage consisted of a 10-oz plastic cup with the bottom cut out. Nylon netting was used to cover both ends of the cup as well as to aid in fastening each cage to the branch. This enabled single nuts to be isolated while still attached to the tree.

Early in July, 378 cages were set out in a 12-year-old almond orchard ca. 4 miles SE of McFarland, CA. Cages were hung in 53 trees included in 8 different rows of the Nonpareil variety. Positioning of cages included interior, middle, and exterior branches located in all 4 compass quadrats and at varied heights from the ground. Nuts were then allowed to go through hullsplit naturally.

On July 15, 62 Zoecon egg traps baited with almond press cake were set out in a nearby almond orchard with a history of high navel orangeworm infestation. Five days later, traps with eggs were taken to a temporary lab and stored outside where they were allowed to continue development but could be observed for egg hatch. As newly hatched 1st-instar larvae appeared during the day, they were removed with a fine brush and placed in containers on moist paper towels. These larvae were stored at ca. 40°F for several hours and taken back to the orchard as a group. One or two larvae were then placed on each nut in its plastic cage. This inoculation took place over 6 days and was completed on 26 July 1981. Newly hatched larvae for inoculation were obtained each day from the eggs which continued to hatch during this period.

Once inoculation was complete, cages were checked daily for damage and, as time went on, adult navel orangeworm emergence. Emerged adults were trapped inside the cage and were recorded by emergence date and sex. The experiment was terminated 14 Sept. 1981. Temperature data were recorded at all times by field weather stations and observations were made to determine whether temperatures inside the cages closely approximated temperatures recorded by the weather stations.

Results

Temperature comparisons between the field weather station and inside the plastic cages run at various intervals during the day were found to be within 2°F.

Temperature summation data for the development of navel orangeworm from newly hatched larvae to adults is illustrated in figure 1. The mean number of accumulated degree-days for emergence, using 55°F as a threshold, is 929. Earlier work by C. E. Engle appearing in the 1979 Annual Report, gives average degree-day summation data for navel orangeworm egg development as approximately 100 degree-days above 55°F. These egg development data, added to the temperature summation data from this experiment, give a preliminary mean total developmental value of 1030 degree-days above 55°F. After further verification, the value for total development may be used in a predictive manner to determine navel orangeworm development and proper timing of preventive action during the post-hullsplit period, provided that observations on initiation of hullsplit have been made. At hullsplit oviposition turns from mummy nuts almost entirely to the new crop. Treatment may be applied at any desired level of adult emergence (see Fig. 1) to obtain optimal results with the particular means of treatment.

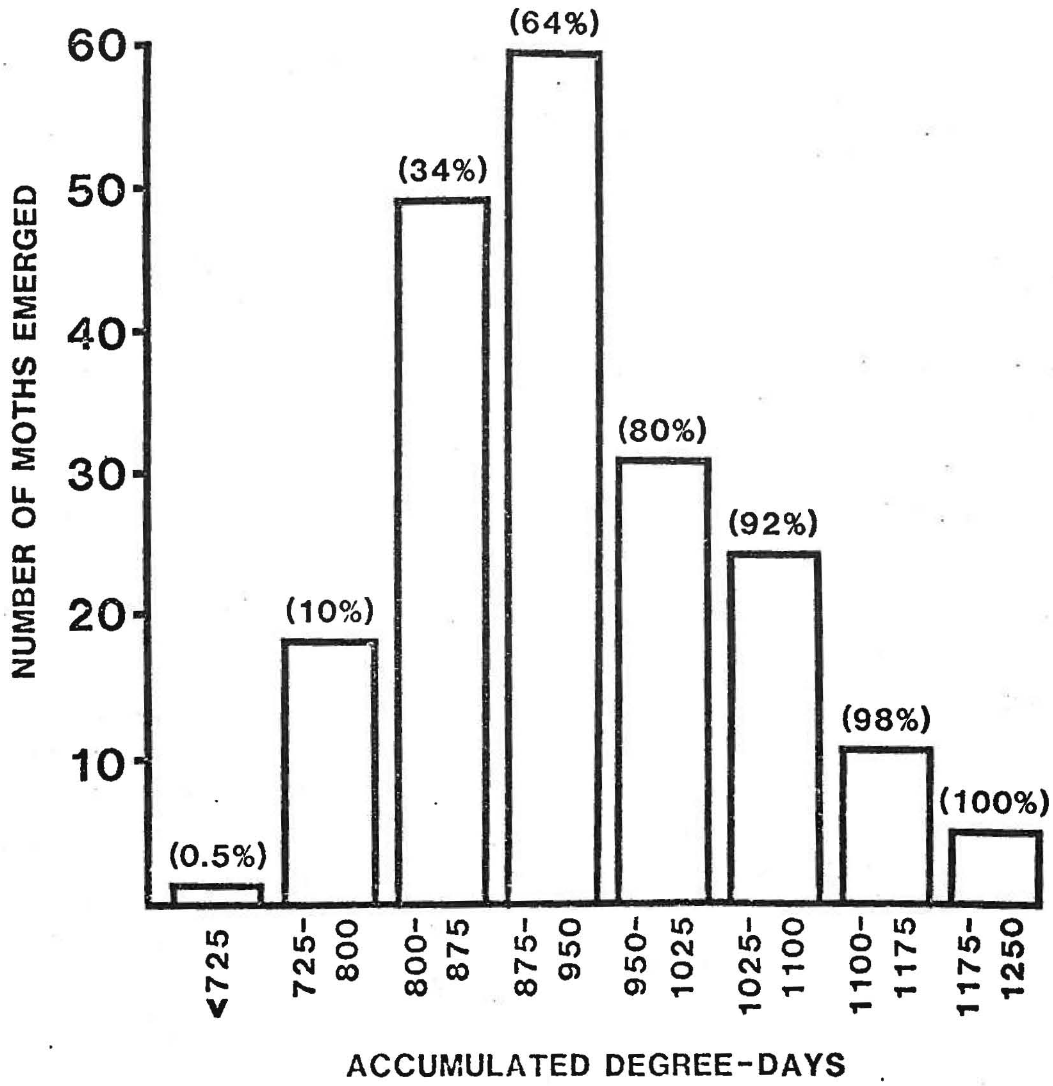

FIG. 1.--Emergence of moths following larval hatch in the new crop in terms of degree-days above 55°F.

Peach Twig Borer Male Flight Periodicity

R. R. Youngman and M. M. Barnes

Introduction

A late season flight study on male peach twig borer moths was made in an almond orchard using the synthetic pheromone. Information was sought on the flight period, peak flight occurrence and possible temperature influence. Work of this nature has been done before on peach twig borer (Rice et al. 1975), but during the spring months. It was felt that the data from this study would be valuable in supplementing the previous work.

Methods and Materials

An almond orchard owned by Tenneco West near the city of Caruthers was used in an experiment to obtain data on male peach twig borer flight periodicity.

The monitoring site was located on the S side next to a vineyard, 5 rows in from the edge. Extensive plantings of almonds were on the other 3 sides. The orchard consists of 50% Nonpareil, 25% Ne Plus Ultra and 25% Milow varieties that are about 16 years old.

Four Pherocon® 1C pheromone traps were set 120 ft apart on the NE side of the tree at a height of 5-7 ft. Fresh peach twig borer pheromone rubber septum were used and monitoring began Sept. 16 and continued for 3 consecutive nights. A thermometer was hung on a tree in the monitoring area for temperature records to be made.

During the flight period, the temperature and number of moths caught were recorded every hour followed by removing all moths present.

Results and Discussion

Male moths did not begin to fly until 1 AM or shortly thereafter (63.3±1.5°F) with the peak number of males trapped at 4 AM (60.0±1.0°F) on all 3 nights. After the peak, flight activity fell off abruptly with very few males caught after 5 AM (58.3±0.6°F) (Fig. 1).

Conclusion

Late season male flight periodicity is similar to the previous study made in the spring months (April and June). In both, peak flight activity occurs quickly, followed by a rapid decline. The temperatures ranged from about 66° to 60°F in the spring to about 63° to 57°F in Sept.

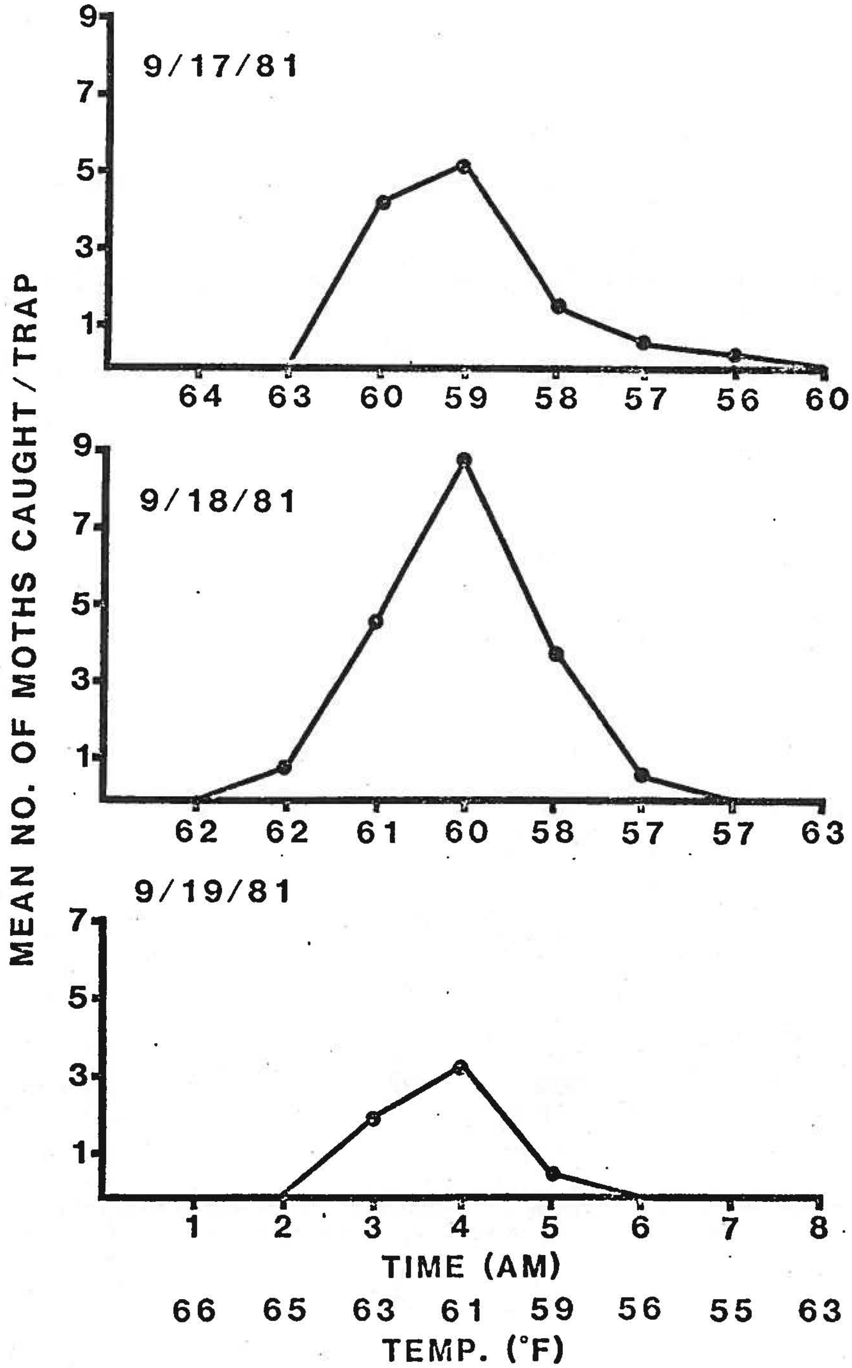

FIG. 1.--Flight periodicity of male peach twig borer moths.

Field Evaluation of Aged Peach Twig Borer Pheromone Rubber Septa

R. R. Youngman and M. M. Barnes

Introduction

Since volatility of chemicals in pheromone rubber septa (RS) is directly related to temperature, an experiment was conducted to determine the effective monitoring life of the commercial peach twig borer (PTB) RS. Once the optimum attractive period under these conditions is known, the maximum use of RS could be made with regard to more accurately monitoring PTB populations.

Peach twig borer pheromone RS were field-aged under summer temperature extremes and then used to attract males to a standard pheromone trap. Aged pheromone RS were evaluated on the basis of number of moths caught.

Methods and Materials

In Madera County, on July 15 and continuing weekly until Sept. 16, 10 PTB pheromone RS were set out to age in an almond orchard owned by S and J Ranch. Each lot of 10 RS was put in a Pherocon® 1C pheromone trap that was hung on the NE corner of a tree at a height of 5-7 ft. Field aging was done in this manner to expose the RS to conditions as near to those encountered from everyday exposure in field monitoring programs. Such extrinsic physical conditions are daily high and low temperature extremes, fluctuating humidities and possible ultraviolet light degradation.

To avoid fouling the RS and to facilitate handling ease, a sticky liner was not used. An inverted 1C top was used in place of the sticky liner. Daily records of temperature and relative humidity were recorded by a hygrothermograph placed near the aging site.

After aging, the RS were tested to determine male PTB moth attractiveness in an almond orchard owned by Tenneco West, near the city of Caruthers on Chestnut and Kamm Avenues. The experimental site consisted of 2 1/3 acres and was located near the center of the 493-acre planting.

In the experiment, there were 6 treatment groups, replicated 7 times, that consisted of the control (fresh RS), 2, 4, 6, 8 and 9-week-old RS. The RS were individually placed in 1C pheromone traps which were hung at a height of 5-7 ft on the NE corner of the tree. The 42 1C traps were set in a 6X7 matrix separated by 120 to 100 ft, respectively, from one another. Each trap was re-randomized daily throughout the test site to remove any variation in population density in the orchard. The experiment lasted for 5 consecutive days from Sept. 16 to Sept. 21. At the end of the 5th day, counts were made of trap catches and mean trap counts were plotted along with mean weekly temperatures on Fig. 1.

Results and Discussion

During the 9 weeks of aging, the average temperature from week to week did not vary much from the overall mean of 83.6±2.7°F. Week 6 had the lowest mean temperature of 78.4±2.1°F. and the highest mean temperature occurred in week 4 which was 87.4±3.4°F. Daily high temperatures of over 100°F were not uncommon.

From the analysis of variance performed on the treatment groups, a highly significant F test among treatments at P=0.05 was obtained. Duncan's New Multiple Range Test divided the treatments into 3 distinct classes: fresh and 2-week-old RS; 4-week-old RS; and 6, 8, and 9-week-old RS. After 2 weeks (Fig. 1), the attractiveness fell off dramatically; note that 4-week-old RS caught only 33% as many moths as did the fresh or 2-week-old RS. After 6 weeks of field aging, the RS were spent and attracted on the average less than 1 male per trap during the 5 days.

Conclusion

Based on the outcome of this experiment, under warm summer temperatures PTB pheromone rubber septa should be replaced every 2 weeks preferably, and every 3 weeks maximally. This will enable more accurate records to be made from monitoring PTB populations.

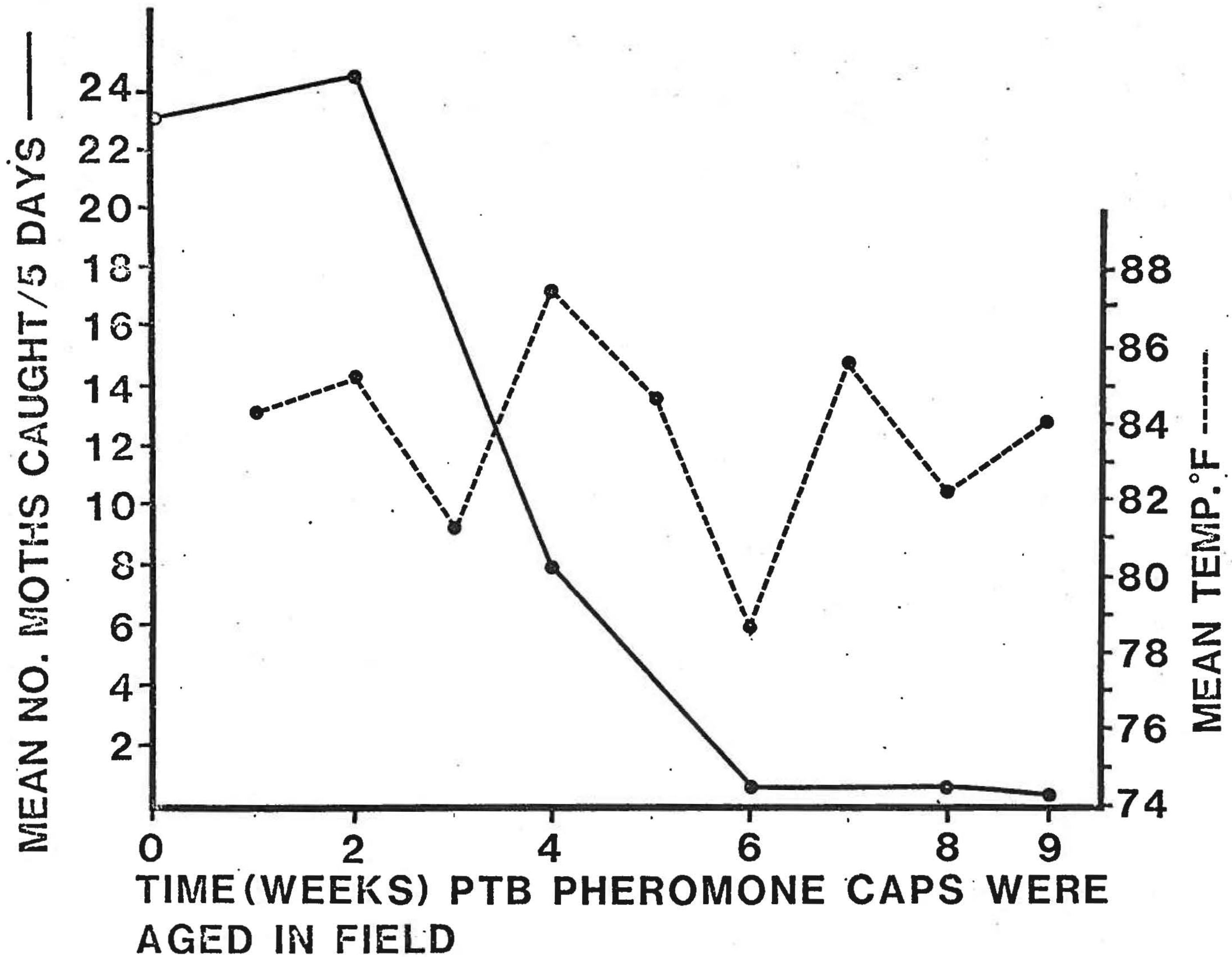

FIG. 1.--Comparison of aged peach twig borer pheromone caps, 1981.

An Attempt to Control Peach Twig Borer in a Commercial Organic Peach Orchard Using the Male Mass Trap-Out Technique

R. R. Youngman, E. F. Laird, and M. M. Barnes

Mass trap-out or male annihilation was studied using standard pheromone traps for the control of peach twig borer (PTB) in a small commercial peach orchard near Beaumont, Calif.

This peach orchard was chosen for several reasons: it is a small planting; it has received no insecticide or acaricide applications for over 5 years; it has sufficient isolation; and it has a history of high PTB infestation.

It was felt that the information gained from this experiment in peaches would be beneficial in its relation and possible application toward control of PTB in a commercial almond orchard. Male annihilation of PTB, if successful, could complement a standard spray program or function as the sole means of control of a PTB pest population.

Methods and Materials

The trap-out block consists of 2.23 acres and is separated from the SE corner of the main orchard by about 330 ft. Directly to the N side of the trap-out block is a straw field. To the E and S sides are an open field and a private residence, respectively, and to the W are new plantings of apricots, cherries and plums. In the small block, there are 126 trees of Fay Elbertas and 144 trees of Rio Oso Gems totaling 270 trees that were planted in 1965. The Fay Elbertas are planted in the first 7 rows on the E side and the other 8 rows to the W have all Rio Oso Gems. There are 18 trees per row and the row-tree spacing is 20X18 ft. The orchard is furrow-irrigated and has been under the same management for the past 5 years without the application of any insecticides or acaricides.

It should be noted that ca. 80,000 trichogrammatid parasites were purchased weekly from a commercial insectary and released during the growing season in proportional amounts throughout the trap-out block and main orchard. This has been done in an attempt to control PTB for the past 5 years, but no study has been made on the impact of the parasite in this orchard.

We felt that it was important to initiate the trap-out program prior to the first PTB seasonal flight activity. Therefore, on April 17, at late budswell, 90 Pherocon® 1C pheromone traps were placed 6 to a row, 3 trees apart and staggered by 1 tree from row to row, 40 traps per acre. All traps were hung on the NE corner of the tree (Rice et al. 1975) at a height of 5-7 ft. The traps were checked the following day and found to contain no moths. After the first day, traps were checked weekly, all insects were removed, and records were kept of individual trap catch and location. Every 4 weeks all sticky liners and pheromone rubber septa were replaced. In addition, five 1C pheromone traps were placed ca. 150 ft apart in the main orchard for routine monitoring purposes. They were inspected and serviced in the same manner as the other 90 traps. Data are reported in weekly mean trap catches represented in Fig. 1. Trap monitoring lasted from April 17 to Sept. 4.

Determination of PTB fruit infestation at harvest was done by sampling the culled peaches from each picking in order to ultimately determine the actual percent PTB infestation (see Table 1). The grower recorded the cull rate. Percent actual infestation was determined in the following manner:

$$\% \text{ Actual Infestation} = \text{Cull Rate} \times \% \text{ Culls Infested by PTB}$$

The grower does his own culling and kept the culled samples in cold storage until they could be inspected. Each culled peach was thoroughly inspected for evidence of frass and PTB feeding scars. The peach was labeled either as infested or not infested.

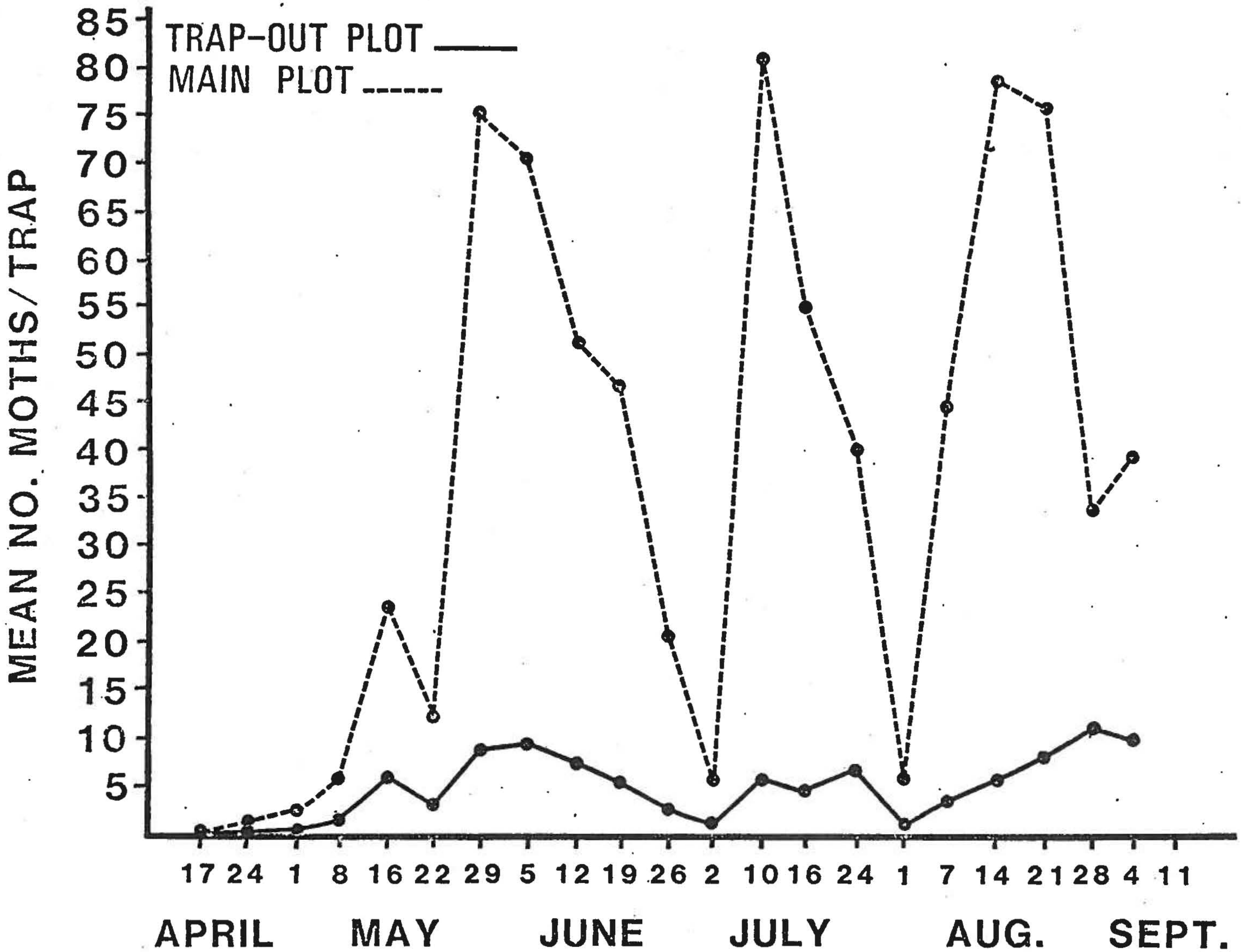

FIG. 1.--Peach twig borer males per trap in trap-out block vs. main plot (control). Forty traps/acre in trap-out block, 1 trap/2.6 acres in control.

Table 1. Peach twig borer infestation of peaches at harvest in male trap-out trial, Beaumont, 1981.

Treatment	Variety	Harvest date	Percent cull rate	No. lugs sampled	Tot. no. sampled	PTB-infested peaches	Percent culls infested	Percent[1] actual infestation
Trap-Out	Fay Elberta	8/21	38	6	337	80	23.7	9.0
Trap-Out	Fay Elberta	8/28	47	6	453	102	22.5	10.6
Trap-Out	Fay Elberta	9/1	50	5	388	115	29.6	14.8
Control	Fay Elberta	9/1	55	9	765	380	49.7	27.3
							Difference =	15.8%
Trap-Out	Rio Oso Gem	8/29	53	5	272	66	24.3	12.9
Trap-Out	Rio Oso Gem	9/3	54	4	186	104	55.9	30.2
Trap-Out	Rio Oso Gem	9/6	61	5	298	153	51.3	31.3
Trap-Out	Rio Oso Gem	9/10	66	5	313	77	24.6	16.2
Control	Hale	9/1	60	6	368	225	61.1	36.7
Control	Cal Red	9/6	37	2	119	76	63.9	23.6

[1]Percent actual infestation found from: (Cull Rate) X (Percent Infested Culls)

Results and Discussion

Promising results were obtained from this study. From Table 1, the "Percent Actual Infestation" (AI) in the Fay Elberta variety from the main block (nontrap-out block) had an AI of 27.3%. This was 2.4 times greater than the mean AI of 11.5% from the same variety in the trap-out block.

The Rio Oso Gem variety in the trap-out block had a mean AI of 22.6% which was almost twice that of the Fay Elberta variety from the same block. Unfortunately, since the Rio Oso Gem is only grown in the trap-out block, no direct comparison is available. However, from a general varietal comparison, the Rio Oso Gem AI of 22.6% was lower than samples from the main block. The Hale and Cal-Red varieties had AI levels of 36.7% and 23.6%, respectively.

Conclusions

The high cull rates on Table 1 can be attributed to fresh marketing consumer demands. Only top quality "fancy" peaches are accepted. A large part of the cull rate is caused by factors other than PTB damage. A peach is culled if it bears a cosmetic injury such as a twig scar or is deformed in any way. The "fresh market" cull rate can be partially reduced by lowering PTB infestation, and a higher percentage of culls can be sold for processing.

From the results obtained in this experiment, there are good indications that a significant reduction in PTB infestation levels can be obtained by using the method of male annihilation. Further studies need to be made using fewer traps per acre.

The Effects of Water-Stressed Almond Trees on Peach Twig Borer Feeding Habits and Phytophagous Mite Density Levels

R. R. Youngman and M. M. Barnes

Introduction

The peach twig borer is a pest of considerable importance on almonds. Not only will it attack developing leaf and fruit buds, but it also directly attacks the nutmeat. A developing larva, however, will often feed entirely in the hull or on the exterior of the shell, never becoming established on the nutmeat. The purpose of this experiment was to seek a possible reason as to why a large proportion of the peach twig borer population will in some years prefer the nutmeats over the hull. Also, it was done to investigate and determine if there is a physiological need for a moist food source which induces the peach twig borer to move from the hull into the nutmeat. The factor considered to be the most important cause of this was hull moisture content. Therefore, this part of the experiment attempted to show that a water-stressed tree has a significantly lower hull moisture content which causes the larva to move from the hull into the nutmeat.

The other part of this experiment investigated the relationship between water-stressed trees and phytophagous mite density levels. High populations of phytophagous spider mite levels on almonds seriously affect yield for the following season. It has been indicated (previous unpublished studies, S. C. Welter) that equivalent mite-days on well-irrigated and water-stressed trees, causes a more significant reduction in almond yield of the latter. Differences of opinion exist as to whether a water-stressed almond tree has a significantly higher phytophagous mite density level than a nonwater-stressed almond tree.

Therefore, sampling was done to determine if significant differences actually exist in density levels between a control and a water-stressed treatment.

Methods and Materials

The almond orchard in which this field study was made is located in Madera County, 6.5 miles E of Hwy. 99 and about 0.5 miles S of Ave. 9 and Rd. 38. This orchard is referenced as 26-3 and was graciously donated for this study by S and J Ranch. The orchard consists of 80 acres of an equal planting mix of Nonpareil, Mission and Ne Plus Ultra varieties in a row ratio of 1:1:1. The orchard was planted in 1975 incorporating a row-tree spacing of 23X23 ft. The orchard is bordered on the E and W sides by open fields and extensive plantings of pistachios to the N and S sides. Since its planting, the orchard has received drip irrigation on a regularly scheduled basis (see Table 1 for 1981 records). The only insecticide treatment the experimental plot received was on Jan. 18 and consisted of a dormant oil plus parathion 8E.

The Nonpareil variety was used in this experiment since the softshell is highly susceptible to attack by both the peach twig borer and navel orangeworm.

A randomized complete block design was used to pair off neighboring Nonpareil rows in order to minimize any existing soil moisture variation running from N to S. There were 9 blocks containing 10 trees, 5 in each of 2 neighboring rows. One row received regularly scheduled irrigation and the other row received no water at all from July 16 to Aug. 4. This schedule was terminated at harvest and removal of the nuts (Aug. 4). The 5 trees in each water-stressed row were bordered by an area free of water which extended 96 ft to the E, 72 ft to the W and 23 ft to the N and S. Small tree size and isolation made it unlikely that a water-stressed tree would take up enough water from a neighboring row to significantly affect the results. Hullsplit at the start of the experiment was 72 percent.

Nut samples were taken each week by removing 20 nuts per tree at head height, 5 from 4 quadrants of each tree, for determining hull moisture content. At harvest, 100 nuts/tree were removed from windrows. Each hull and nutmeat were inspected for peach twig borer and navel orangeworm larvae or evidence of infestation which was based on frass type. Records were also kept on the location of feeding damage (see Table 2). Immediately after the samples were hulled, a triple beam balance was used to weigh 100-hull lots from each treatment row to obtain the wet weight. The hulls were then dried at 110°F in a forced air oven for at least 4 days and then re-weighed. This moisture weight enabled us to determine percent moisture in the hulls.

For the mite part of the experiment, 1 tree per row was sampled every 4 days during the entire water-stress period beginning July 16. A total of 24 leaves per tree, 6 from each of 4 quadrants were randomly removed at a height of 5-8 ft. These samples were refrigerated until they could be observed under a dissecting microscope. Data were analyzed using an unpaired t-test.

Routine monitoring of male peach twig borer flight activity was done weekly within the experimental plot using Pherocon® 1C standard pheromone traps (see Fig. 3). Ten traps were placed ca. 200 ft apart at a height of 5-7 ft on the NE side of the tree. Every 4 weeks fresh liners and pheromone rubber septum were replaced.

Results and Discussion

An analysis of variance on the data of percent water weight per hull was performed at each of the 3 sample points. There were no significant differences found at P=0.05 between the 2 treatments. The graph on Fig. 1 depicts

Table 1. Irrigation schedule - 1981.

	Month							
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
Avg. daily no. gal/tree	8.5	0.0	1.2	18.2	50.3	67.4	57.3	27.5

Table 2. Average percent infestation.

		PTB					
Treatment	Harvest	Total	Nutmeat only	Hull only	Combined hull+nut	NOW in nut	Ants
Control	8/4[1]	0.82	0.31	0.58	0.07	0.29	1.07
Water-stressed	8/4[1]	0.87	0.38	0.56	0.07	0.22	1.40

[1]Samples based on 100 nuts/tree, 5 trees/treatment.

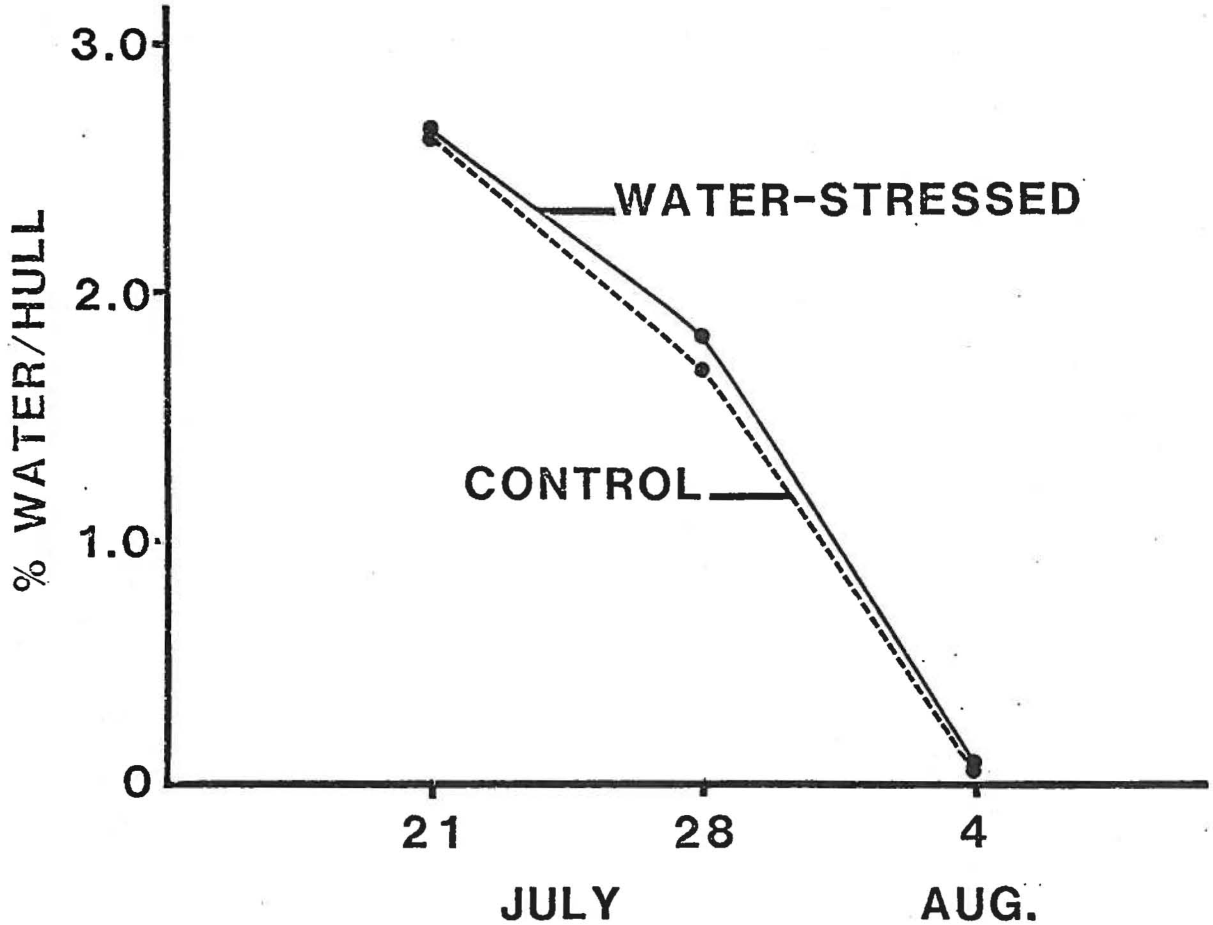

FIG. 1.--Water loss in hulls of water-stressed vs. irrigated trees.

how closely water loss was in the 2 treatments over time. Also, no significant differences could be found to indicate that the effect of water stress had any influence on peach twig borer larval distribution in the hull or the nutmeat. This is in light of the fact that during the water-stressed period, beginning July 16 to July 27 (July 27 was normal harvest irrigation cut-off date), control trees on the average received 630 more gallons of water than the water-stressed trees - recalling that water-stressed trees received no water at all during this period.

The results of the effects of water-stress on spider mite density levels proved interesting. It was observed that water-stressed trees, after about 9 days, dramatically began to lighten in color and lose their leaves. However, the important aspect to note was that there were no significant differences ($P = 0.05$) found in spider mite densities between treatments. The graph on Fig. 2 clearly indicates the similarity in density levels between the 2 treatments. It should be noted that combined predators (phytoseiid and sixspotted thrips) had no significant differences in density levels as well.

Conclusion

Termination of orchard irrigation at a point when 72% hullsplit had occurred did not have an affect on the feeding habits of peach twig borer larvae under the conditions of this experiment. Once hullsplit had occurred, the rate of hull water loss was not compensated for by the tree even though it was still attached.

The evidence from the mite studies reveals that severely water-stressed trees did not numerically affect spider mite or predator density levels. It does lend support, however, that severity of feeding impact by spider mite infestations is greater on water-stressed trees.

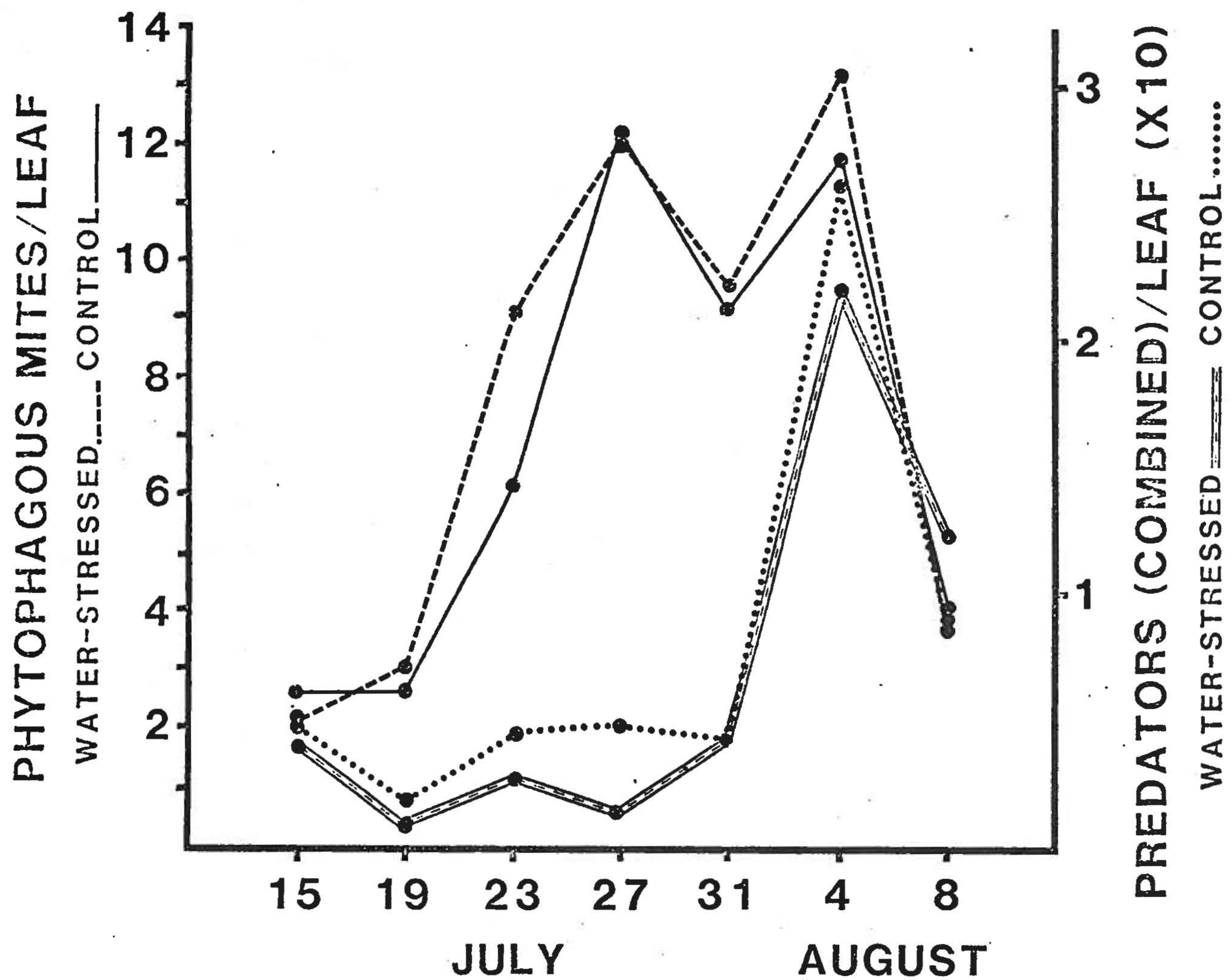

FIG. 2.--Mite density and predator density on water-stressed vs. irrigated trees.

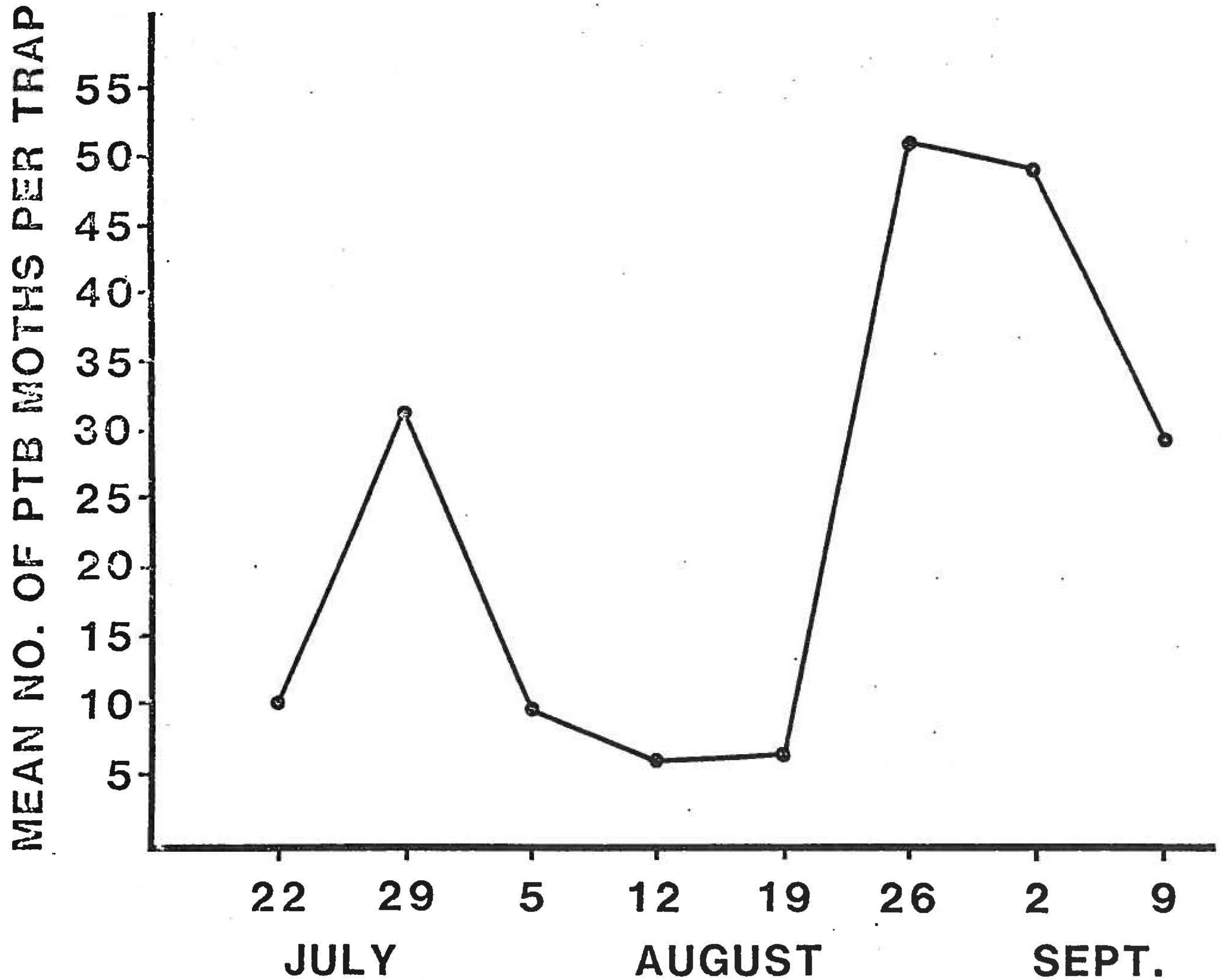

FIG. 3.--Peach twig borer moth catch in experimental orchard.

Acaricide trial for Pacific mite on almonds, Kern Co., CA, 1981

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The efficacy of 14 acaricide treatments was evaluated in an 8-year-old flood-irrigated almond orchard. The compounds UC55248, Mitac, NC21314, Avermectin and SLJ0312 were compared to the three currently registered acaricides Omite, Plictran, and Vendex, as well as to a water check and unsprayed check. The application was made on 6/3/81 to the orchard which was located 7 miles west of Wasco, Kern Co.

Materials and Methods

Applications were made with a handsprayer which delivered a fine spray at 400-450 psi. The trees required an average of 11 gal of formulated spray per tree which corresponds to an application rate of 800 gal per acre.

A completely randomized block design was established within 2 rows of the Mission variety. Each treatment was replicated 5 times.

Twenty-five male spider mites were mounted for species identification. The population consisted entirely of the Pacific mite, *Tetranychus pacificus*.

Twenty-four leaves were collected from each tree at a height of 1.5-2.0 m. The leaves were kept refrigerated until counts were made under a stereoscope.

Results

Despite an adequate pre-sample population size, the spider mite populations declined rapidly after 1 day in all treatments. The two check treatments also showed significant declines after 1 day. The reason for this general decline in mite populations is not known. The trees were monitored throughout the season in case the check treatments started to rise again (Table 1).

No phytotoxicity was observed associated with any compound.

Table 1. Mean number of mobile stages of Pacific mite per sample,[1/] Kern Co., CA[2/]

Compound	Rate	Presample 6/22	3-day 6/26	6-day 6/29	14-day 7/7	21-day 7/14	28-day 7/6	42-day 8/4
1. UC55248 4EC	4 oz a.i./100 gal	26.0	0.0	0.0	0.0	0.4	0.2	0.8
2. UC55248 4EC	8 oz a.i./100 gal	4.6	0.0	0.0	0.0	0.0	0.0	0.6
3. Mitac 1.5EC	15 oz a.i./acre	36.6	0.2	0.0	2.2	2.8	0.6	2.2
4. Mitac 1.5EC	24 oz a.i./acre	11.6	0.0	0.0	0.0	0.0	0.0	0.6
5. NC 21314 80WP	8 oz a.i./acre	13.4	0.8	0.2	0.0	0.0	0.0	0.0
6. NC 21314 80WP	16 oz a.i./acre	65.4	0.4	0.4	0.0	0.2	0.0	0.2
7. Avermectin 0.03EC	0.1 oz a.i./100 gal	13.2	3.2	4.4	1.6	0.2	0.0	0.6
8. Avermectin 0.03EC+ 60 sec 415 NR oil	0.1 oz a.i./100 gal 1 qt/100 gal	16.0	0.8	0.2	0.2	0.2	0.0	0.2
9. Avermectin 0.03 EC+ 60 sec 415 NR oil	0.04 oz ai/100 gal 1 qt/100 gal	28.4	0.6	0.8	0.0	0.6	0.0	1.0
10. 60 sec 415 NR oil	1 qt/100 gal	17.2	0.6	0.0	1.6	0.0	0.2	7.8
11. Plictran 50WP	3 oz a.i./100 gal	13.0	0.0	0.0	0.0	0.0	0.2	0.0
12. Omite 30WP	7.2 oz a.i./100 gal	19.8	1.0	0.2	0.0	0.0	0.0	0.2
13. Vendex 50WP	3 oz a.i./100 gal	12.4	0.4	0.0	0.2	0.0	0.2	0.4
14. SLJ0312 50WP	8 oz a.i./100 gal	11.6	0.0	0.0	0.0	0.0	0.0	0.2
15. Water	--	39.6	3.8	1.2	0.8	1.0	0.0	3.4
16. Check (no spray)	--	11.6	1.0	2.0	6.0	0.0	0.0	1.8

[1/] Based on 24 leaves/tree.

[2/] Applied with a handsprayer at high pressure at 800 gal/acre.