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Investigations on Navel Orangeworm, Mites and Peach Twig borer in Almond Orchards

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Development of Insecticides for Control of Navel Orangeworm on Almonds

M. M. Barnes and E. F. Laird

When this project began, no insecticides were available for growers choice to use for navel orangeworm. This research has been instrumental in obtaining registration of Guthion, Imidan, Sevin, and a Section 18 exemption for Ambush and Pounce for navel orangeworm control and has described the characteristics of these materials for such use. In addition we have developed standards of sanitation and early harvest which can be used with minimal orchard use of insecticides. Several options need to be available to growers for choice depending on logistics, feasibility, preference, and cost.

We continue efforts in the development of insecticides seeking to improve the range and characteristics of performance of these compounds, and if possible the economy of control of this pest.

Methods

This trial was conducted in Kern County on Nonpareils. There is a great deal of tree to tree variation in navel orangeworm infestation, hence this trial was replicated 13 times, using single tree plots as replicates. Trees were hand sprayed at initiation of hullsplit in the tops of the trees. At the time of application (7/13/82) 6% of the nuts in the top fourth of the trees had hulls split, and there was no hullsplit below this area. This is the optimum time for treatment against this pest. Infestation begins in the tops of the trees and is initially heaviest there. Compounds must show residual action to protect the crop from newly hatched larvae. The emergence of the first brood of moths, those which develop in spring as mummies, as tracked by light traps, began during the week previous to treatment.

Adjacent to the replicated plots, a 20 row unsprayed area was used as a check or control.

Observations were made shortly after harvest on mite control.

At harvest, 300 nuts were sampled from each replicate, and from 10 trees in the check area, stored at 40°F and examined for navel orangeworm damage.

Four trees were separately sprayed with Mavrik (2.0 EC) at .05 lbs a.i./100 gal. using @ 430 gal. per acre. Application was made twice on 7/13 and 8/2/82. Samples were taken from these trees for residue analyses on 8/23/82.

Results and Discussion

All of the compounds are pyrethroids except Larvin, a carbamate. Results are found in Table 1. These provide information on residual larvicidal action, and where different rates were used of a given compound, provide comparisons of dosage. When applied over an area, however, effective dosages may be somewhat less than indicated for pyrethroids, which may, as in the case of Ambush, provide residual action and/or repellancy (see following report) for moths.

Based on data in Table 1, the following dosages (lbs. active/acre) are suggested for future trial: FCR-1271 - .05; Payoff - .075; HAG-107 - .03; Mavrik - .1; Ambush - .2; and Larvin - 2.

Mite populations were not severe in the plots, but there was no apparent suppression of mites from any of the treatments, as compared with untreated.

Table 1. Results of trial of insecticides for navel orangeworm control on Nonpareil almonds, Kern Co., 1982.

Treatment No.	Material		Dosage lbs. active ingredient per acre 1/	% Infestation Harvest 8/23 2/
10	FCR 1272	1.67E	.075	1.8
6	Payoff	2.5E	.1	1.9
2	HAG-107	0.3E	.04	2.1
9	Mavrik	2.0E	.1	2.2
5	Ambush	2.0E	.2	2.6
1	HAG-107	0.3E	.02	2.8
7	Payoff	2.5E	.05	3.2
4	Larvin	3.2E	1.5	3.4
8	Mavrik	2.0E	.05	3.6
3	Larvin	3.2E	1.0	3.7
Untreated	(Adjacent 20 row untreated area.)			7.3

1/ Applied 7/13/82 at initiation of hullsplit in tops of trees; 800 gal/acre, handgun application, 13 replicates, single tree plots.

2/ 300 nut samples from each replicate and from 10 trees in untreated area.

Application of permethrin plus acaricides by ground equipment vs. helicopter for navel orangeworm and mites

M. M. Barnes and E. F. Laird

Permethrin is the most effective insecticide for control of navel orangeworm. However, use of permethrin can result in devastating populations of mites. Its use can be considered when heavy losses from navel orangeworm would otherwise occur. When an orchard has a high load of mummies in June, and heavy infestations of navel orangeworm are therefore expected, can permethrin be used at hullsplit to halt infestation without creating a devastating mite problem? Heavy mite infestations result in loss of yield the year following infestation. And if permethrin is used, plus adequate use of acaricides, can the combination be applied by air with success against both types of pests?

And if both navel orangeworm and mites can be controlled by permethrin-acaricide combinations one season, do mites develop earlier the following season because of suppression of predators?

The following experiment was designed to provide information on these matters.

Methods

Four schedules were selected, each to be applied in 16 acre blocks replicated four times in a 4 X 4 Latin square. Two of the four schedules were applied by airblast sprayer and two by helicopter. In each permethrin (Pounce) was applied for navel orangeworm control. Two applications were made, the first at initiation of hullsplit in the tree tops, the second after 20 days.

Plictran was used for mite control in one of the airblast sprayer schedules and one of the helicopter schedules. In the other Omite was applied in the first application and Plictran substituted in the second as the interval to harvest was lower than allowed for Omite.

Further details of application e.g. dates, rates of use etc. are given in Table 1.

At harvest, samples of 200 nuts were taken from each of 15 trees in the center area of each 16 acre plot and examined for navel orangeworm. Some mite counts were made but were superseded by visual ratings as defoliation precluded counts in some plots.

Results

Excellent control of navel orangeworm was obtained in the permethrin schedules, whether applied by ground or helicopter (Table 1), with an overall average of 1.4% infested, and no difference among treatments. The area in which the trial was conducted (240 acres) averaged 3.3 mummies per tree in June. Based on past experience, this translates to a potential infestation of approximately 7%, with early harvest practiced. One check area 100 yards southwest of the trial area averaged 7.3%, and a northeast check area immediately adjacent to a helicopter plot averaged 2.3%.

Mite counts had been planned; however, so much defoliation from mite infestation occurred when permethrin plus acaricide was applied by helicopter, that it was necessary to use a visual rating system. There were 22 comparisons made between ground vs. air application in which the two were directly adjacent. In 16 out of 22, application by ground equipment was rated satisfactory and better than helicopter sprayed. The latter provided poorer to no adequate control. In six comparisons, both were rated equal and satisfactory.

When applied twice by ground with permethrin in the sequence Plictran-Plictran, or Omite-Plictran, mite control was consistently good, with little or no defoliation except adjacent to heavily travelled dusty roads. In contrast, when these schedules were applied by air, mite control was clearly unsatisfactory, ranging from fair to very poor control, varying with infestation potential.

When applied by ground, there was no difference between the two acaricide schedules, control was consistently good.

Table 1. Comparison of airblast sprayer and helicopter for control of navel orangeworm and mites, Kern Company, Experiment I, 1982.

Application Method	Material	Active Ingredient/lb/acre 7/13-15	8/3-4	% Infested Navel Orangeworm	Mite Control[2]
1. Ground	Pounce 3.2 E	.21	0.21	1.2	Good
(420 gal/acre)	Omite 6 E	3.1	--		
	Plictran 50 W	--	1.1		
2. Ground	Pounce 3.2 E	0.22	0.21	1.9	Good
(420 gal/acre)	Plictran 50 W	0.9	1.1		
3. Helicopter	Pounce 3.2 E	0.20	0.20	0.8	Fair to
(24 gal/acre)	Omite 6 E	2.5	--		very
	Plictran 50 W	--	1.0		poor
4. Helicopter	Pounce 3.2 E	0.21	0.20	1.6	Fair to
(24 gal/acre)	Plictran 50 W	0.7	1.0		very poor

[1]Based on 15 samples of 200 nuts each, 8/24-25. Potential infestation, 7%, see text.

[2]See text for further information on mite control.

Helicopter application, permethrin plus acaricide, one vs. two treatments, for navel orangeworm and mite control.

M. M. Barnes and E. F. Laird

This trial was carried out to provide information on one vs. two applications of permethrin and Plictran by helicopter for navel orangeworm and mite control. It was replicated three times in 15 acre plots. Permethrin (Pounce 3.5EC) was applied at 0.2 lb. active ingredient and Plictran 50W at 1 lb. a.i. in 23 gallons/acre by helicopter.

The first application, to both series of plots, was made on July 15, at initiation of hullsplit in the tops of Nonpareils. The second application for the double-treated series was on August 5.

Mite control was completely inadequate and premature defoliation by mites was extreme, virtually complete in some areas. Very little could be distinguished between one vs. two treatments with regard to mite control.

At harvest of Nonpareils (8/25), samples of 200 nuts were taken from 15 trees in each replicate. Following two applications there was 2.9% damage by navel orangeworm and 3.9% after one application.

Only one treatment of permethrin is warranted for navel orangeworm when, as in this case, the mummy population in June is less than four per tree and early harvest can be practiced. From a parallel trial, this application should be by ground equipment with thorough coverage and with an acaricide included.

Note: Observations will be made in the spring of 1983 comparing onset of mite infestations in blocks variously treated (in the same orchard) with permethrin, Guthion and Imidan in 1982.

Repellency of Permethrin to Female Navel Orangeworm Moths

M. M. Barnes and E. F. Laird

Previous data demonstrated that application of permethrin in a 5-acre block sharply reduced oviposition by navel orangeworm moths on egg traps freshly installed after treatment, as compared with pre-treatment counts and those in an unsprayed block. This reduction probably represents moth mortality as laboratory studies show that permethrin is very toxic to moths. Repellency was not shown as the traps were untreated.

Permethrin is the most effective insecticide presently available for navel orangeworm control. Because it creates severe mite problems, it should be applied with an acaricide and preferably by ground equipment.

The following trial demonstrated that permethrin is repellant to female moths.

Methods and Results

A set of 15 egg traps were dipped in the laboratory in an emulsion of permethrin (Ambush) in water at the dilution of permethrin which would be used applying 0.2 lb/400 gal/acre. These were installed (5/7) in comparison with an equal number of untreated egg traps, randomly paired in adjacent Nonpareil trees in Kern Co.

After a 4 day period, an average of 8.1 eggs/trap/night were deposited on the untreated traps, while only 2.0 eggs/trap/night were found on the traps treated with permethrin ($P<.01$). During a further 14 day period, the counts were 12.4 and 6.5, respectively ($P<.05$). On treated traps, there were fewer clusters of eggs, mostly singles and doubles. These data indicate short-term repellency of permethrin to moths attracted to oviposition traps.

Imidan by helicopter vs. ground sprayer for navel orangeworm control.

M. M. Barnes and E. F. Laird

A comparison was made between application of Imidan by helicopter vs. airblast ground sprayer. The trial was replicated twice using 15 acre plots. A single application was made at initiation of hullsplit in the tops of Nonpareil trees, July 14th.

Imidan 50 WP was applied in 500 gal/acre by ground and 25 gal/acre by helicopter and at the rate of four lbs. active ingredient/acre plus 1 lb. a.i./acre of Plictran 50 WP.

At harvest (8/25) samples of 200 nuts were taken from 15 trees in the center area of each of the four plots. There was no difference observed between treatments. Samples treated by airblast ground sprayer averaged 4.5% and by helicopter 4.0%. A 20-row-wide unsprayed area averaged 7.4%. This shows 40-45% control typical of one application of Imidan at hullsplit.

Mites were not a severe problem in this area of the orchard, even on untreated trees. However, neither did Imidan create a mite problem, when applied as described.

Evaluation of Pesticide Application to Late-Maturing Varieties Timed at Nonpareil Hullsplit

W. S. Seaman and M. M. Barnes

Almond trees require intervarietal pollination. Therefore, a typical almond orchard consists of two to several varieties interplanted in a particular scheme. One such planting common to Kern County is two rows of Nonpareils set off by alternating single rows of pollinator varieties, Texas Mission and Merced.

During the past 3 years, a series of field experiments have been carried out by S. C. Welter, examining the efficacy of selectively applying pesticides only to the Nonpareil variety trees. Because insecticide applications may affect spider mite populations, these studies have been concerned with the effect of a modified spray program on navel orangeworm infestation levels as well as spider mite population levels on Nonpareil and pollinator varieties. This project was continued in 1982.

Nonpareil trees typically begin hullsplit two to four weeks prior to Merced and Texas Mission variety trees. Harvesting schedules differ greatly between Nonpareil and pollinator trees. Pesticide application schedules should also be considered. Timing an application of an insecticide to control navel orangeworm at hullsplit is a common practice. Timing, however, is based on the condition of the Nonpareil trees which commonly comprise approximately 66% of the orchard. The remaining 33% of the orchard, Texas Mission and Merced, will not begin to hullsplit for an average of two to four weeks. It is questionable whether those compounds currently used to control navel orangeworm will remain effective through the period of pollinator hullsplit. This suggests the elimination of the "hull-split spray" to these pollinators or, if necessary, a second, more timely, application to the pollinators.

Methods and Materials

The experiment was carried out in a 13-year-old flood-irrigated almond orchard near McFarland, California and was comprised of a standard and a modified spray program. Each spray program was replicated in three pairs as 5-acre blocks. The standard program consisted of an application of Guthion 50WP and Omite 6E to all three varieties in the block, Nonpareil, Merced, and Texas Mission. 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 50WP and Omite 6E at the same rates but applied only to Nonpareil variety trees. Both spray programs utilized ground air-blast sprayers to apply the pesticides at 500 gal/acre.

Once the Nonpareil nuts had been shaken to the ground during normal harvest scheduling, 15 Nonpareil trees were selected from the center of each of four blocks. On 24 August, a 200-nut sample was collected from each of these trees and cracked out by hand to determine percent infestation by navel orangeworm.

Texas Mission and Merced trees were shaken 11 September in the experimental plot. On 14 September, 15 Texas Mission and 15 Merced trees were selected from the center of each of the six blocks. Again, a 200-nut sample was collected from each tree and hand cracked to determine percent infestation by navel orangeworm.

Five trees of each variety were selected from the center of each 5-acre block and marked. A leaf sample of 24 leaves per tree was taken from each marked tree every week beginning with a sample prior to the 15 July pesticide application date. Leaf samples were kept refrigerated until they could be examined for spider mites, predatory mites and predatory insects associated with spider mites and the results recorded.

A survey of 200 nuts of each variety was selected randomly from all blocks to determine percent hullsplit. Hullsplit surveys were recorded on 7/18, 7/28, 8/8, 8/20, 8/29, and 9/10.

Results and Discussion

The progression of hullsplit is shown for each variety in Fig. 1. Merced variety trees typically hullsplit just prior to Texas Mission trees. The delay in Merced hullsplit in Fig. 1 is most likely due to early water removal in preparation for harvest. Navel orangeworm infestation levels are recorded in Table 1. Nonpareil variety trees were given identical treatment in both spray programs and showed no difference in infestation level. Using a paired t-test, neither Merced nor Texas Mission varieties showed a significant difference ($P<0.05$) in infestation level between the standard and modified spray programs. Both Merced and Texas Mission varieties showed nonsignificant reductions in percent infested nuts in the modified spray program.

Spider mite population levels, as well as all other insect and mite species associated with spider mites, remained extremely low for approximately five weeks following the application of pesticides. The pre-application sample also showed near zero population levels for all recorded species and may be a result of an earlier Omite application. Spider mite populations were observed to begin increasing on both Nonpareil and pollinator varieties in the 23 August sample. Figs. 2 and 3 show spider mite population level development through time on Nonpareils and pollinators, respectively.

A paired t-test showed no significant difference ($P<0.05$) in the average number of spider mites per leaf between the two spray programs on Nonpareils at any of the sampling dates. These results would be expected considering Nonpareil trees received identical treatment in both standard and modified spray

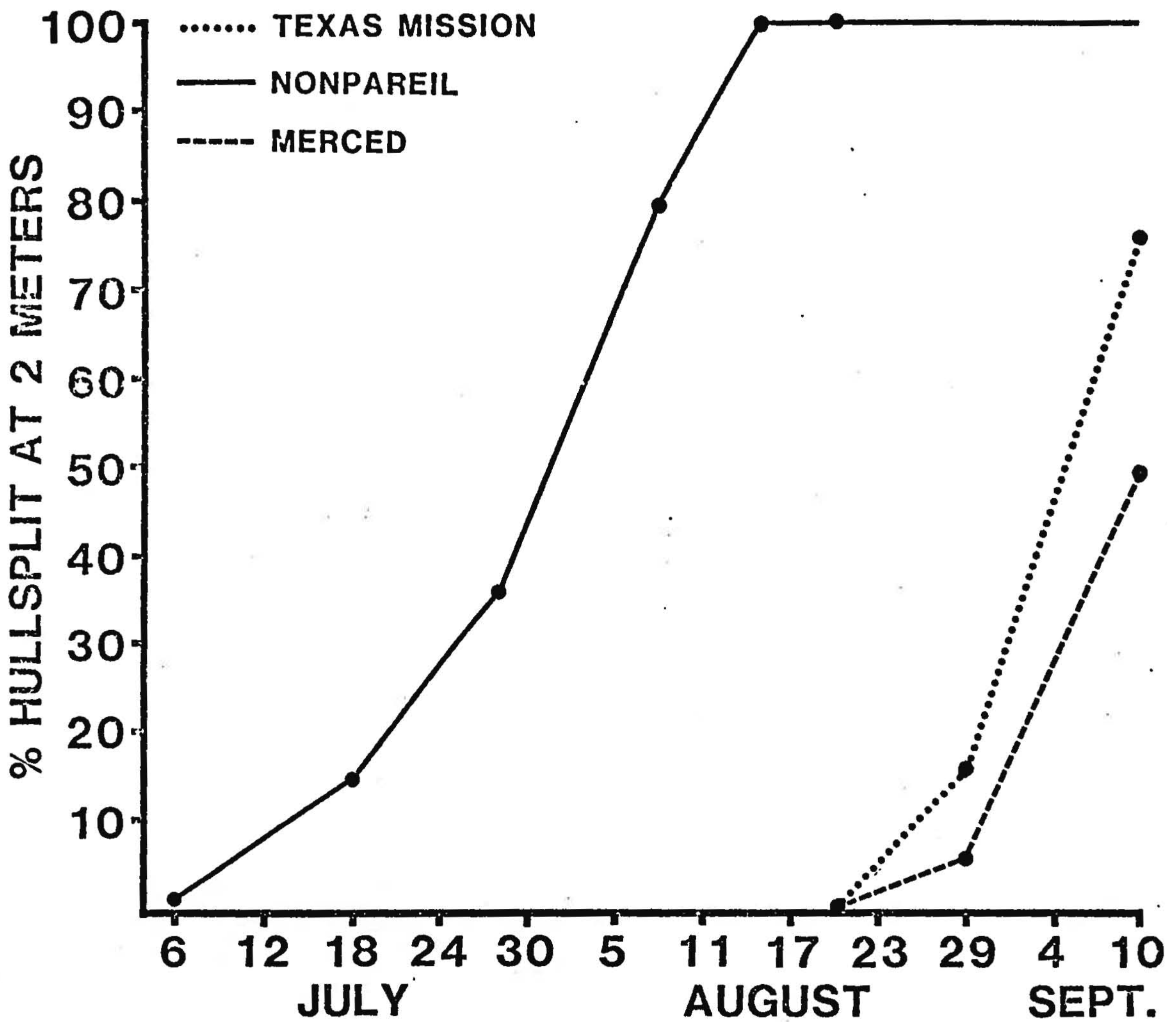

Fig. 1. Hullsplit recorded in three almond varieties, Kern County, California, 1982.

Table 1. Efficacy of Guthion applications timed at Nonpareil hullsplit on late-maturing almonds, Kern County, California, 1982.

Program	Pollinator treatment	Rate[1] 1 lb ai/acre	Average % infested by variety: Nonpareil[2]	Merced[3,4]	Texas Mission[3,4]
Standard Spray program	Guthion 50W	2.0	6.4	9.5	2.8
	Omite 6E	3.0			
Modified Spray program	Untreated	-	6.4	7.6	2.1

[1] Applied 15 July 1982 at 500 gal formulated spray/acre.

[2] Means based on a 6000-nut sample.

[3] Means based on a 9000-nut sample.

[4] Late-maturing variety.

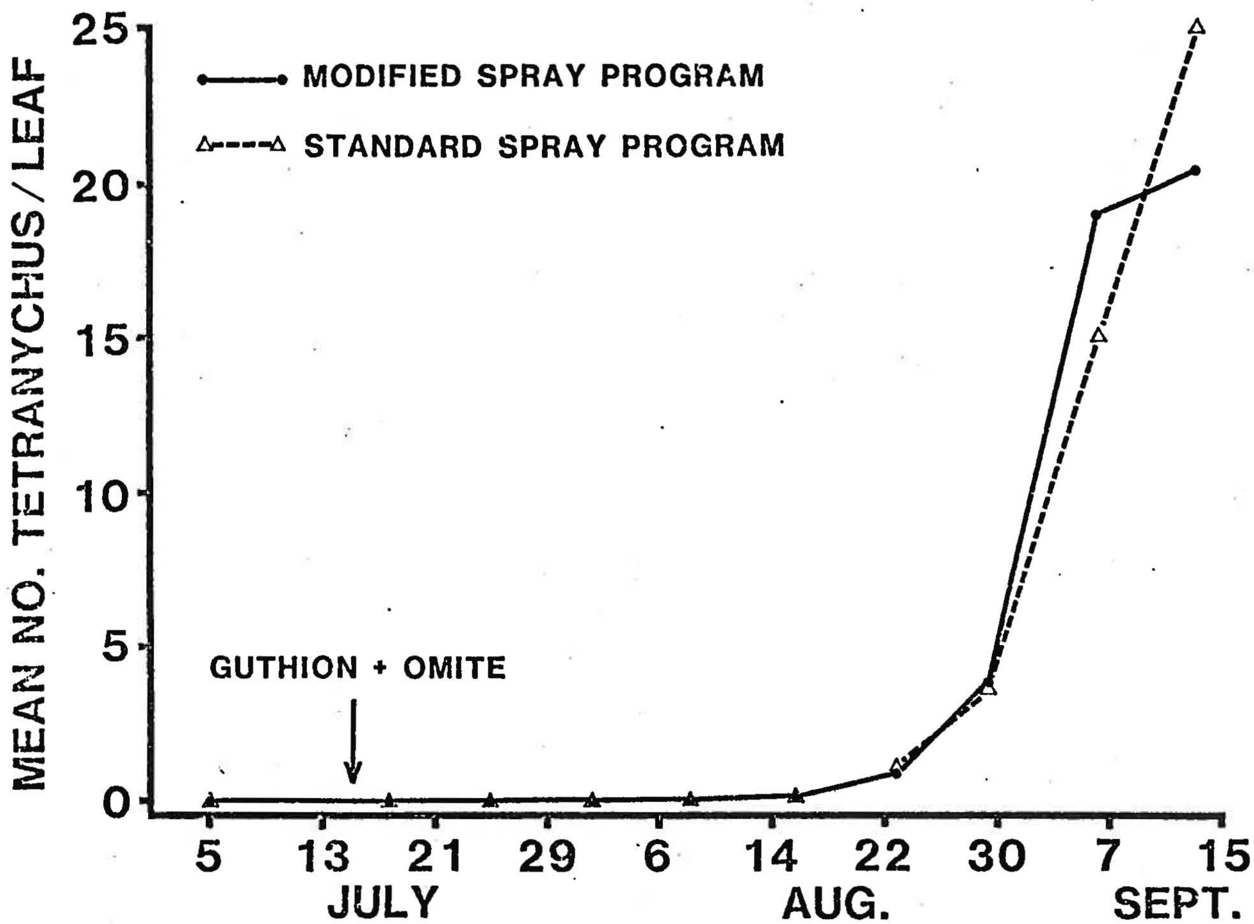

Fig. 2. Effect of standard and modified spray programs on <u>Tetranychus</u> mites in the Nonpareil variety.

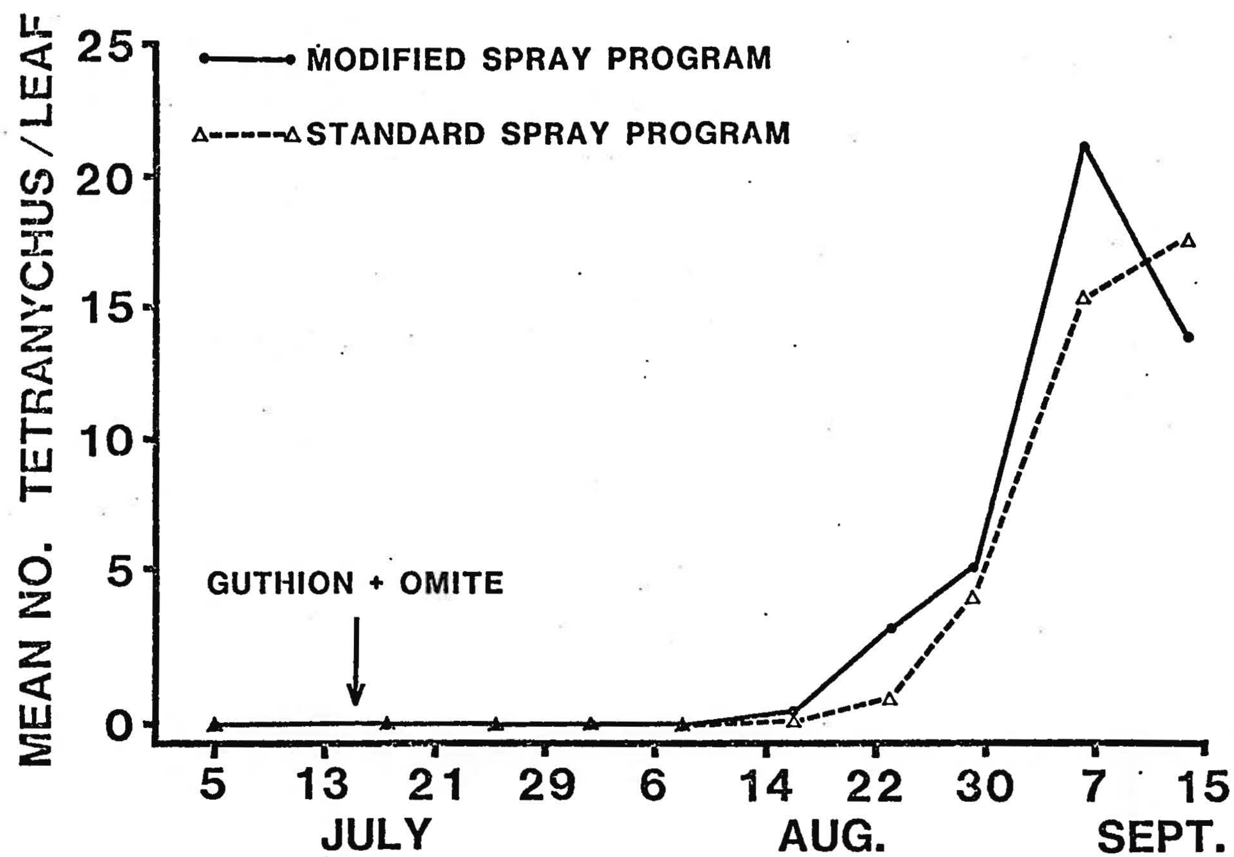

Fig. 3. Effect of standard and modified spray programs on Tetranychus mites in pollinator varieties.

programs. Pollinator spider mite levels between spray programs were found to be significantly different at two sampling dates. On 23 August, the modified program showed an average of 3.0 spider mites per leaf while the standard program showed an average of 1.1 spider mites per leaf. While these values are significantly different statistically, they are not likely to be biologically significant when the next sampling date, 29 August, is considered. At 29 August, the two programs again show nonsignificant differences in spider mite levels. The second sampling date to show significant difference was 6 September. The modified and standard spray programs showed an average of 21.3 and 15.3 spider mites per leaf, respectively. Here, again, statistical significance may not be biologically significant. A treatment decision based on 15 mites per leaf is most likely to be the same as a treatment decision based on 21 mites per leaf. Also, the following week showed a reversal in relative spray program position. The modified and standard programs on 13 September showed an average of 14.0 and 17.6 spider mites per leaf, respectively (Fig. 3). Determinations made from slide mounts showed spider mite populations to consist of 100% Pacific spider mite.

All leaf sampoes were examined for mite predators. Predator mite and insect levels were recorded as near zero in the pre-application sample as well as throughout the experiment. Again, this might be attributed to pesticides applied earlier in the season. One possible advantage to the modified spray program is a partial preservation of beneficial mites and insects living in the pollinator varieties. However, the complete lack of such beneficials in the experimental orchard either before or after the experiment was begun gives no positive nor negative evidence with respect to beneficial preservation.

This experiment suggests no significant differences in navel orangeworm infestation levels or spider mite population levels between the two spray programs on any of the three varieties studied. The primary advantage to using the modified spray program would be a reduction in actual pesticide material costs. By not spraying the late-maturing pollinator varieties during a normal "hullsplit application," 15-50% less pesticide is required, depending on the planting scheme, and hence a 15-50% pesticide material cost reduction. This modified spray program would only be practical for applications by ground and by equipment capable of being regulated to spray to one or both sides of the rig. If the decision is made to apply pesticides to pollinators, a modified spray program allows a more timely application, closer to pollinator hullsplit.

Application of nematodes for navel orangeworm control.

M. M. Barnes and E. F. Laird

The nematode *Neoaplectana carpocapsae* and its associated bacterium, *Xenorhabdus nematophilus* have been considered a possible control agent for many insects. The chief difficulty encountered has been the limitation of desiccation, as the nematode moves well and survives best in free moisture. Interest nevertheless persists in its possible use since the infective stage (dauer larvae) can be stored for long periods, they can be sprayed on plants, and they do not affect mammals.

Methods and Results

Flasks of nematodes were purchased in mid-July and stored in a refrigerator at 40°F and transported for field use in an ice chest. Six Nonpareil trees were sprayed by handgun on 8/3 at 75 lbs pressure using sufficient water for thorough coverage, 15 gallons per tree, and 1.5 million nematodes per tree. Three of the six were sprayed again on 8/10, using the same type of application but at the rate of 6.0 million nematodes per tree. Sprays were applied in early morning (@ 6 a.m.) and at 22°C to provide for the longest drying period possible at this time of year. Samples of the nematode lot used in the field were returned to the laboratory to check on viability after handling. After the first treatment, viability after transporting and handling as judged by larval movement was only fair. After the second application, excellent activity was noted in the sample after returning to the laboratory.

On 8/11, a sample of 32 almonds from the trees sprayed the previous day were dissected, nine larvae obtained, eight emerged as healthy adults, one died as a pupa, none being infested by nematodes.

At harvest (8/23) 200 nut samples were taken from each tree. The three trees sprayed twice were adjacent to the orchard border, which may be expected to be more heavily infested. They averaged 10.5% infested. The three trees sprayed once, located interiorly up the row from the others, averaged 4.3%. Check trees in the area averaged 4-7% infested.

There is no promise that mid-summer use of nematodes will result in suppression of navel orangeworm.

A Determination of Navel Orangeworm Ovipositional Activity On Grounded Mummy Nuts in "Clean" Almond Orchards

J. P. Sanderson and M. M. Barnes

The practice of removing and destroying mummy nuts from trees in winter has been established as an effective means of reducing a navel orangeworm population in an almond orchard. Therefore, in May there may be very few nuts remaining in the trees on which emerging NOW females may lay eggs. However, the presence of nuts on the ground could conceivably offer oviposition sites in which subsequent larvae could develop. Previous work by K. Andrews and R. Curtis appearing in the 1975 Annual Report demonstrated that no oviposition occurred on nuts which were shaken to the ground after harvest in August, although oviposition was heavy in the mummy nuts which remained in the trees. However, many more mummy nuts are available for oviposition after harvest than in May after winter cleanup has been accomplished. The present experiment sought to determine whether or not moths emerging in May in a "clean" orchard will lay eggs on grounded nuts since there are very few nuts in the trees on which to oviposit.

Methods and Materials

The experiment was conducted in three different orchards, one 7 mi. S.E. of Mettler, one 3 mi. N. of Arvin, and one 4 mi. N. of Shafter. Mummy counts made near the time of the experiment determined an average of 0.3, 0.16, and 1.2 mummies per tree, respectively, for these three orchards. In May, when egg trap data from other orchards detected increasing ovipositional activity, the experiment was initiated.

Two hundred mummy nuts were spread over a 5 X 4 ft plot on the berm beneath Nonpareil trees in five different areas scattered through each of the orchards.

In each orchard the five plots included one situated on the edge row of the orchard because navel orangeworm infestation is often higher on the edge. The mummies used were poled from Nonpareil trees in a separate orchard in early April and individually shaken by hand to screen out, to some extent, previously and presently infested nuts. Only uninfested mummy nuts were used. Also, a subsample of those nuts was examined to determine the proportion of nuts with eggs already present on them before they were placed in the experimental plots. No eggs were found on any of these nuts. An almond press-cake-baited egg trap was placed in a tree which was four trees to the west of each plot in order to demonstrate that ovipositional activity in the area around each plot was occurring in the trees.

The nuts remained in the orchards for 13 days. Thereafter they were brought back to the laboratory to be inspected for navel orangeworm eggs. A subsample of 50 nuts from each plot was examined carefully under a dissecting microscope for eggs. The egg traps were changed weekly and the eggs on them counted.

As a further measure of ground ovipositional activity, the experiment was repeated the following week in one of the orchards, except that an egg trap was placed on the ground in each plot where the experimental nuts had been, as well as in the trees as was done previously. After six days in the orchard the traps were taken back to the lab and the eggs on them counted.

Results and Discussion

The results of this experiment are presented below:

Site	Average no. mummies/tree	Average no. eggs/trap/day	No. eggs on nuts/ no. nuts sampled
Orchard 1	0.30	10.25	2/250
Orchard 2	0.16	1.50	0/250
Orchard 3	1.20	4.60	9*/250

*Only one of these eggs was fertile.

Only a total of three fertile navel orangeworm eggs was found on the 750 ground nuts sampled, although ovipositional activity was occurring in the trees according to the egg trap data. It is therefore concluded that navel orangeworm ovipositional activity on grounded mummy nuts in "clean" almond orchards is minimal. In addition, the subsequent experiment revealed that no eggs were were found on the egg traps which were placed on the ground, while the egg traps that were concurrently in the trees had an average of 1.63 eggs/trap/day. It should also be mentioned that the mortality of any eggs laid on ground nuts is probably significantly higher than those laid on tree nuts, therefore making the observed ovipositional activity on ground nuts inconsequential.

Preliminary Observations of the Parasite Complex of the Navel Orangeworm in Two Unsprayed Almond Orchards

J. P. Sanderson and M. M. Barnes

The parasite species that attack the navel orangeworm in two unsprayed orchards in August were determined. One of the orchards, located 3 mi. north of Arvin, Kern County, has not received in-season sprays against the navel orangeworm for 12 years. The other orchard, located 4 mi. north of Shafter, Kern County, has received no in-season sprays for 2 consecutive years.

A sample of nuts was collected at random throughout each of the two unsprayed orchards in late August. They were then taken to U.C. Riverside and placed in several sleeve cages labeled by orchard location in a room under conditions of 78±3°F and 24-h photoperiod. The cages were checked two or three times a week for emerging parasites that were then collected, killed and prepared for species identification.

The Shafter orchard yielded two parasite species, *Pentalitomastix plethoricas* and *Bracon hebetor*, both of which have previously been reported from navel orangeworm in California. The Arvin orchard also yielded *P. plethoricas* but, in addition, a recently introduced parasite species, *Goniozus legneri*, emerged from these cages. It is not known how *G. legneri* dispersed to this orchard from the areas of California where it had been released since, after checking with University of California personnel as well as all commercial insectaries that sell this species, the closest release site was determined to be near McFarland, Kern County, in 1979.

Thermal Accumulation Required for Development of the Navel Orangeworm in New Crop Almonds

W. S. Seaman and M. M. Barnes

During the winter and spring months the navel ornageworm develops on "mummy" almonds. Once the new crop nuts begin to hullsplit they, too, are susceptible to navel orangeworm attack. Establishment of a model describing navel orangeworm development on the new crop is an ongoing project. Thermal summation is a means to produce such a model and, once completed, this will enable the grower or pest control manager to predict accurately the major moth emergence that takes place after Nonpareil hullsplit. This knowledge can then be used to time control measures optimally with maximum efficacy.

Accuracy of the model depends primarily upon studies conducted under field conditions. A thermal summation field study was described in the 1981 Annual Report. A similar experiment was carried out during the summer months of 1982 for the purposes of comparison and verification. Both experiments were conducted in the same Kern County almond orchard. The primary information comes from determining developmental times of individual moths reared through on new crop nuts still attached to 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 thermal 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 caged fresh crop nuts, the total number of degree-days above the threshold temperature (55°F) for complete development may be obtained.

Methods and Materials

New crop Nonpareil variety nuts were caged individually prior to hullsplit, for later infestation with newly hatched larvae. Each cage consisted of a 8-oz plastic cup with the bottom cut out. Nylon netting was attached as a lid on the cup's top and as a sleeve on the cup's bottom. A cup could then be slid over an individual nut still attached to the tree and tied to the branch. These cages prevented oviposition on the nuts by wild moths and as well prevented moths emerging from artificial infestation from escaping.

During the first week in July 220 single nut cages were hung in a 13-year-old almond orchard near McFarland, California. Cages were hung in 11 trees at various heights in all 4 compass quadrants located in the interior, middle, and exterior positions of each tree. The caged nuts were allowed to mature naturally through hullsplit and drying until shaken from the trees. Statistical analysis from 1981 field data showed no significant difference in developmental time with respect to cage location in the tree.

Upon hullsplit initiation of caged nuts, numerous Zoecon egg traps baited with ground almond press cake were placed in nearby almond orchards known to support substantial navel orangeworm populations. As eggs deposited on the egg traps matured, the traps were removed from the field and held in the lab. As newly hatched 1st-instar larvae appeared they were removed from the traps and held for several hours at approximately 40°F on moist paper towels. Each afternoon, beginning 24 July, all newly hatched larvae were transported to the field where each caged nut was inoculated with 2 larvae. This process was continued until all 220 experimental nuts had been inoculated, 31 July.

Cages were checked periodically for damage and egg deposition on their outer surface from wild moths. Eggs were easily observed when present due to their orange color and were destroyed. A weather station containing a hygro-thermograph was located at the site of the experiment and supplied the necessary temperature data. Cages were checked daily for adult moth emergence. As adult moths emerged within the cages the cage number and date were recorded. In this way the number of degree-days required for development from 1st-instar larva to adult could be determined for any given individual.

Results and Discussion

Temperature comparisons between the field weather station and the plastic cage interior were made at various intervals during the day and found to be within 2°F.

The mean number of degree-days required for navel orangeworm development from newly hatched 1st-instar larva to adult moth was 774, using a lower developmental threshold of 55°F and no upper threshold. C. E. Engle determined egg development to require an average of 100 degree-days. Together, these data suggest a total developmental time from egg to adult of 874 degree-days.

Because this was the second season this project had been carried out, 1981 and 1982 results were compared. In 1981 the mean number of degree-days required to complete development from egg to adult was determined to be 1025. Average summer months' temperatures during 1981 were considerably higher than in 1982 in the Bakersfield area. This fact together with the degree-day results suggested the need for an upper developmental threshold in the navel orangeworm development model. The development data were analyzed again, using the same lower threshold of 55°F as well as adding an upper developmental threshold of 94°F. Thermal summation was carried out by triangulation with a vertical cutoff. Under these conditions, 1981 data showed an average of 763 degree-days required for development from egg to adult while 1982 data showed an average of 769 degree-days. These values are remarkably close, considering that a typical summer day accumulates approximately 20 degree-days. The pattern of adult emergence is shown in Figs. 1 and 2.

The primary benefits associated with a thermal summation development model are related to the model's predictive abilities. Therefore, there must be some standardized point where thermal summation begins in order to predict the moth population's development. Under normal conditions the navel orangeworm does not deposit eggs on fresh crop nuts until these nuts have begun hullsplit. This suggests hullsplit initation to be a likely biofix for degree-day accumulation.

Black light traps were used during the summer months of 1981 and 1982 to monitor navel orangeworm populations (Figs. 3 and 4). In each case the number of degree-days accumulated between hullsplit initiation at head high (5% in 1981 and 2-3% in 1982) and the peak black light catch was determined. If hullsplit initiation is to be considered as a biofix, the number of degree-days accumulated between hullsplit initiation and the black light peak catch should be approximately equal to the number of degree-days for development from egg to adult as determined in the caged field nuts experiments. Again, using an upper developmental threshold of 94°F, the 1981 and 1982 values for development from egg to adult were 763 and 769 degree-days, respectively. Using 94°F as an upper threshold, the number of degree-days accumulated between hullsplit initiation at head high and peak black light catch in 1981 and 1982 were 778 and 785 degree-days, respectively. These values show excellent agreement with the figures obtained from the caged nuts experiments (Table 1). These results indicate the success of adding an upper developmental threshold of 94°F to the model.

After further verification, the experimental value of 766 degree-days for navel orangeworm development from egg to adult may be used to maximize the

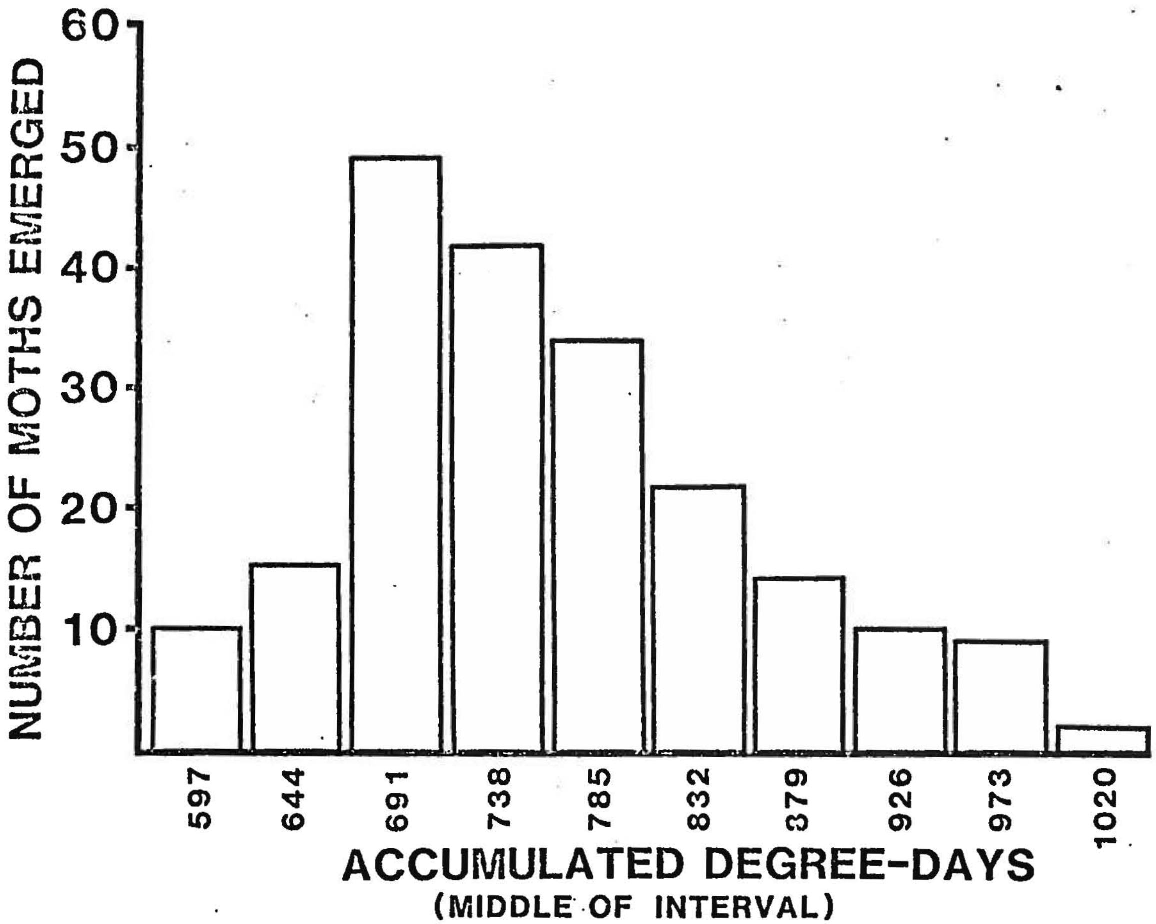

Fig. 1. Frequency histogram of summer moth emergence from caged field Nonpareil almonds, Kern County, California, 1981.

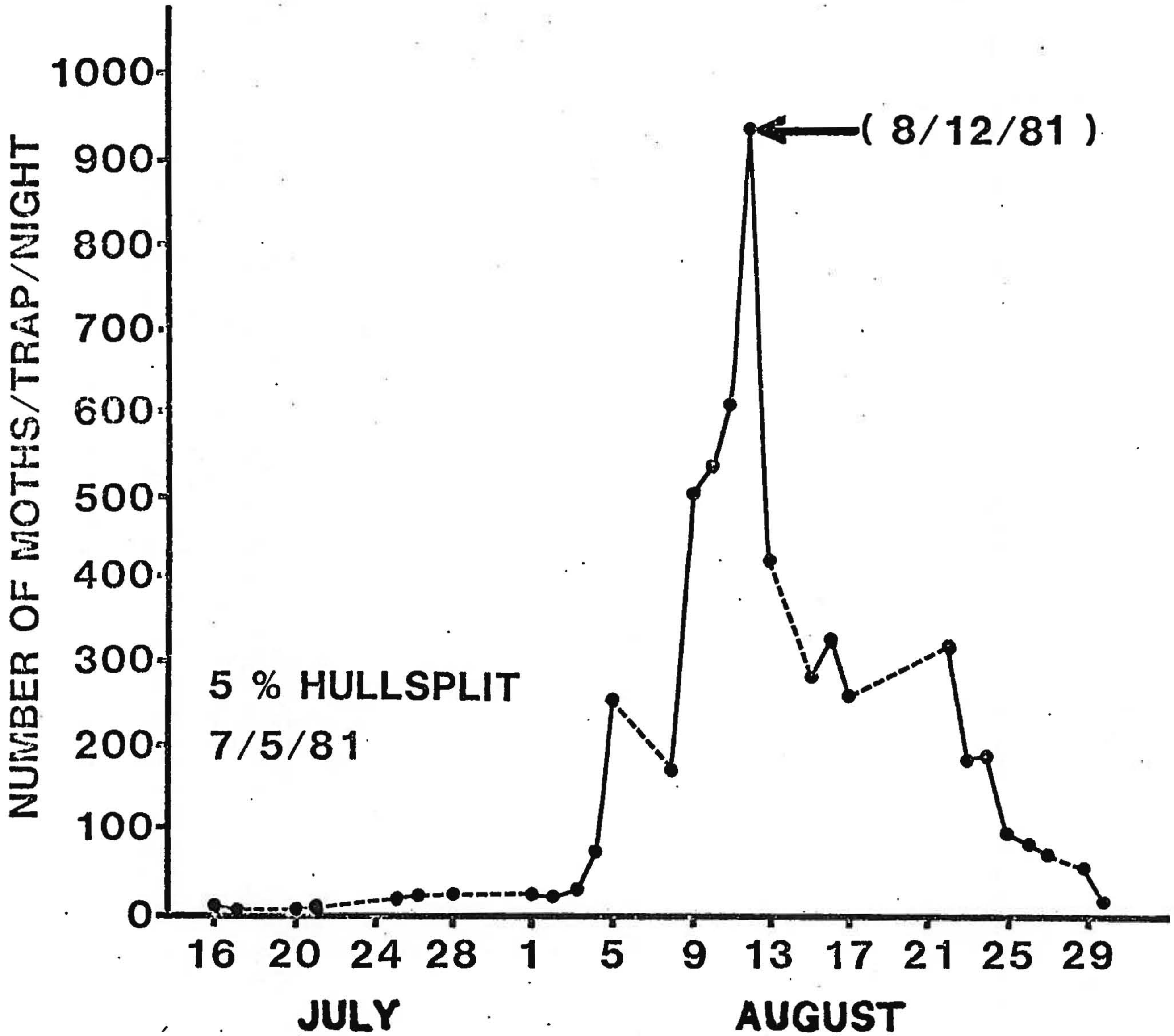

Fig. 3. Black light trap catch of navel orangeworm on almonds, Kern County, California, 1981.

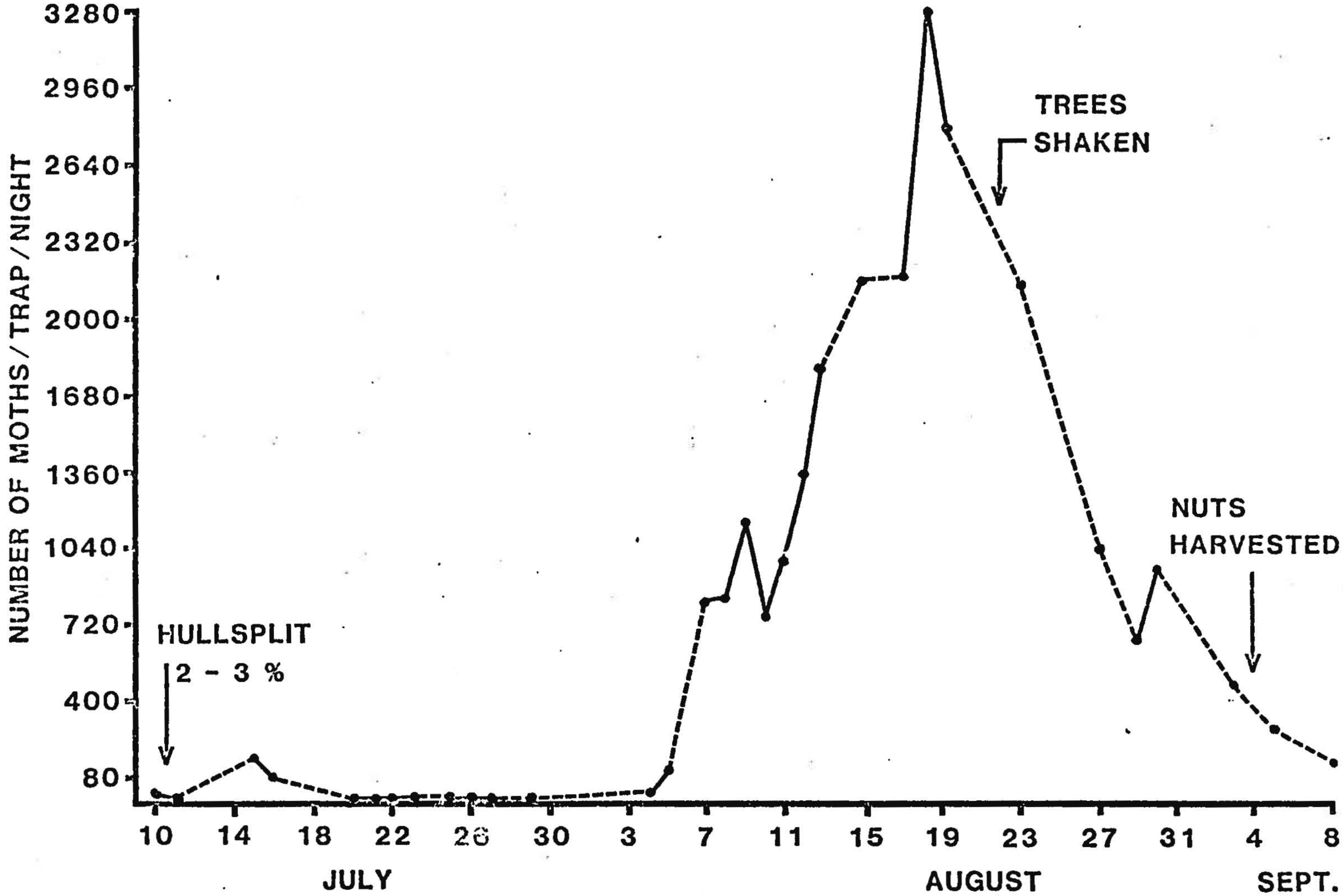

Fig. 4. Black light trap catch of navel orangeworm on almonds. Kern County, California, 1982.

efficacy of various control measures such as the timing of insecticide applications, biological control releases, and harvest practices as carried out agaisnt the navel orangeworm in almond orchards.

Table 1. Degree-days accumulated on new crop almonds using 55°F lower threshold, 94°F upper threshold, and vertical cutoff, Kern County, California.

Treatment	Accumulated degree-days
Inoculated caged nuts, 1981	763 1/
Inoculated caged nuts, 1982	769 1/
5% hullsplit at 2 m to peak blacklight catch, 1981	778
2-3% hullsplit at 2 m to peak blacklight catch, 1982	785

1/ Includes 100 degree-days required for egg development.

Thermal Summation for Navel Orangeworm Development on Mummy Almonds in the Field

W. S. Seaman and M. M. Barnes

Field experiments were carried out in 1981 and 1982 in a Kern County almond orchard to determine the relationship between navel orangeworm development and thermal summation. These experiments were centered around navel orangeworm development on new crop almonds in the field following hullsplit. Several researchers have shown diet to influence the time required for navel orangeworm development. Those diets with a higher moisture content allow a more rapid development.

New crop nuts have a far greater moisture content in both nut meats and hulls than do "mummies." It is well known that navel orangeworm can survive and develop on mummies during those periods when new crop nuts are absent. However, it was not known whether results obtained from development on new crop nuts in the field could be applied to development on mummies during the spring. If sufficient infromation regarding navel orangeworm development on mummies in the spring can be gained, it may be possible to use this data in a predictive manner toward more effective control.

Cages holding mummies inoculated with 1st-instar larvae were hung in a Kern County almond orchard during spring and early summer of 1982. Development on the mummies was recorded as well as temperature data for later thermal summation calculation. These thermal summation results could then be compared to values obtained from new crop nuts.

Methods and Materials

Nonpareil mummies were poled onto tarps in an almond orchard approximately 7 miles southeast of McFarland, California, on 14 April 1982. Non-infested nuts were separated out and stored at 40°F. On 26 April, 61 Zoecon navel orangeworm egg traps were hung in an orchard with a history of lar e navel orangeworm populations. The egg traps were collected 3 May and returned to the lab where they were held at 80°F. Mummies were inoculated with 2 newly hatched 1st-instar larvae and held at 80°F. Inoculation procedures were carried out over two days with a total of 400 mummies inoculated. Inoculated mummies were transferred to the field on 10 May where they were placed in cages and hung in an almond orchard near McFarland, California.

Cages were constructed from wire mesh screen and plastic petri dishes. The wire mesh was formed into a cylinder of 14-cm diameter and 7-cm length. Circles, 8.5-cm diameter, were burned out of each petri dish half and then covered with a piece of wire mesh secured with silicone rubber. The mesh cylinders were then capped at both ends with these modified petri dish halves. A wire hook was inserted in each cage for attachment to the tree so that the cage hung with the petri dish caps perpendicular to the ground. Ten inoculated mummies were placed on a wire mesh platform in each of the 40 cages. The platform raised the mummies above the cage bottom so wild moths would be unable to oviposit directly on the nuts. This cage design also prevented inoculated moths from escaping after emerging while allowing maximum air flow through the cage.

Cages were located at all 4 compass points and in interior and exterior positions. Cages were examined periodically for wild moth egg deposition and any eggs observed were destroyed. All cages were checked daily for adult emergence. Temperature data was recorded at the site of the experiment enabling thermal summation data to be calculated. The experiment was terminated 9 August.

Results and Discussion

Degree-day accumulation was calculated by triangulation with a vertical cutoff. The lower and upper developmental thresholds were 55° and 94°F, respectively. Fig. 1 illustrates the pattern of moth emergence. The mean number of degree-days required for development from 1st-instar larva to adult was 1022, based on 217 individuals. Addition of 100 degree-days for egg development produces a value of 1122 degree-days required for navel orangeworm development from egg to adult when reared on mummy almonds.

Experiments from 1981 and 1982, using new crop nuts for navel orangeworm, produced a value of 766 degree-days required for development from egg to adult. Temperature is a primary factor governing the rate of navel orangeworm development. However, the discrepancy in developmental time when rearing moths on spring mummies as opposed to summer new crop nuts cannot be explained by differences in daily temperatures. Thermal summation creates units in degree-days that are standardized regardless of temperature trends. The nuts themselves undergo a drastic change in the transition from a new crop nut to a mummy almond. Mummies have a much reduced water content in both the almond kernal and the hull, making them a poorer substrate for navel orangeworm development. Other researchers have reported media with a low moisture content to prolong developmental time compared to media with a higher moisture content. This fact is illustrated by navel orangeworm development on mummies and new crop nuts. The drier, poorer substrate of mummies requires an average of 1122 degree-days, while the substrate of new crop nuts, with a far greater moisture content, requires an average of 766 degree-days for egg to adult development.

These results indicate the need for separate degree-day development values when dealing with navel orangeworm development on mummies vs. new crop nuts. With further verification, it may be possible to use such a mummy development value in conjunction with spring egg trap data to optimally time late spring and early summer control measures such as an insecticide application.

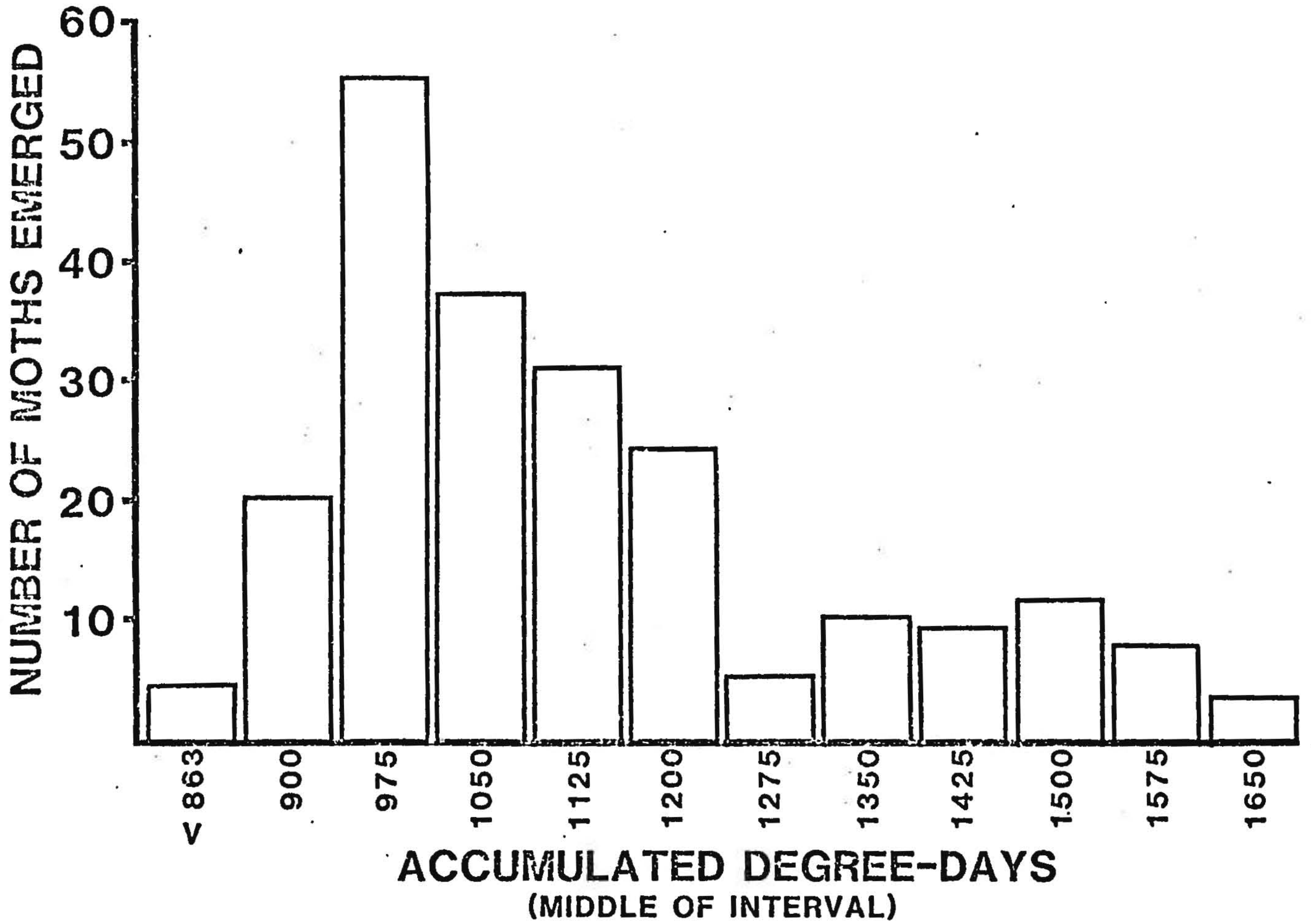

Fig. 1. Frequency histogram of spring moth emergence from caged Nonpareil mummy almonds, Kern County, California, 1982.

Each nut was inoculated with 1 newly hatched larva and placed in a tray compartment. Two trays were placed in each of 4 constant temperature cabinets. The experiment was carried out at 70°, 80°, 85°, and 90°F. All nuts were examined daily for adult navel orangeworm emergence. A hygrothermograph was placed in each cabinet to record temperature and relative humidity throughout the experiment.

Results and Discussion

The number of degree-days required for development at each constant temperature is recorded in Table 1. These values include the 100 degree-days required for egg development. As the treatment temperature increases, the number of degree-days required for development increases. The use of thermal summation should allow the comparison of development at various temperatures while using a standardized unit, degree-days. Developmental values are expected to be approximately equal as long as constant temperatures are within the favorable range.

The moisture content of the nut is extremely important for navel orangeworm development. As observed in other studies this past year, new crop nuts allow a shorter developmental time than do mummy almonds. Almonds held at a constant 90°F will dry down much more rapidly than nuts held at a constant 70°F. This differential drying of the nuts would cause nuts at 90°F to become a poorer substrate more rapidly and, in the process, prolong developmental time. This would explain the trend in Table 1. However, this does not explain the extreme difference in developmental time in degree-days between development data from rearing at 70°F in the lab vs. field experiments.

Moisture is again likely to be the principal factor. In the field relative humidity rose and fell in a wave-like motion between approximately 25 and 80%

during a typical day between pre-hullsplit and harvest. Other workers have shown optimal navel orangeworm development occurs between 75 and 95% relative humidity in the lab. Relative humidity was recorded but not controlled in this experiment. Table 1 lists the average realtive humidity of each temperature chamber during the experiment. The low humidities recorded from the chambers were likely to have extended developmental time. Nut dry-down may also be significantly different between the field, where the nut remains attached to the tree, and lab storage in preparation for inoculation. In order to use lab studies as verification of field results, future experiments would have to be carried out at controlled and appropriate relative humidities.

Table 1. Number of degree-days required for development of navel orangeworm at indicated constant temperatures.

Treatment	Degree-days for Development	% completing development	Average cabinet relative humidity
70°	1041	69	60%
80°	1222	85	45-55%
85°	1465	69	40-50%
90°	1709	29	30-45%

Field Evaluation of Early Spring Aged Peach Twig Borer Pheromone Rubber Septa

R. R. Youngman and M. M. Barnes

Introduction

The 1981 pheromone cap aging experiment showed a significant decrease in trap catch between 2- and 4-week-old septa. These septa were field aged during the 1981 summer months of July and August. Based on the 1981 results, it was considered necessary to perform a second field trial investigating the cooler temperature effects of early season aging (April 23 to June 11) on the septa. Correct detection of first moth emergence and subsequent peak flight periods with pheromone traps enables accurate monitoring of the population. Therefore, it is particularly important to know how long the septa last in the cooler spring months.

Materials and Methods

In Kern County, on April 23 and continuing weekly until June 11, 5 peach twig borer pheromone rubber septa were set out to age in an almond orchard owned by Superior Farms. Each lot of 5 septa was put in a Pherocon® 1C pheromone trap that was hung on the northeast corner of a tree at a height of 5-7 ft. Field aging was done in this manner to expose the septa to conditions as near to those encountered from everyday exposure in field monitoring situations. To avoid fouling the septa and to facilitate handling ease, a sticky liner was not used. Instead, 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 septa were compared for male peach twig borer moth attractiveness in an almond orchard of approximately 140 acres. The orchard is located in Kern County about 3 miles north of Arvin. The experimental site consisted of 8.0 acres on the north end of the orchard that received no in-season pesticide applications.

In the experiment there were 8 treatment groups, replicated 5 times, that consisted of the control (fresh septa), and 1-, 2-, 3-, 4-, 5-, 6-, and 7-week-old septa. The septa were individually placed in 1C pheromone traps that were hung at a height of 5-7 ft on the northeast corner of the tree. The 40 1C traps were set in a 5 X 8 matrix separated by 100 ft from one another. Every day, each trap was completely re-randomized throughout the test site to remove any variation in local population density. The traps were allowed to catch moths over 7 consecutive days from June 12 to June 19. At the end of trapping period, 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 7 weeks of aging, the average temperature from week to week did not vary much from the overall mean of 66.8±3.95°F. Week 3 had the lowest mean temperature of 63.1°F and the highest mean temperature occurred in week 5 which was 75.1°F.

A one-way analysis of variance was performed on the raw data giving a significant F test between treatments ($P < 0.05$). Duncan's new multiple range test separated the treatments into 5 levels as may be seen in Table 1. Fresh septa were significantly higher in catch than all other treatments; 1- and 2-week-old treatments were not significantly different but they were higher than the others. The data represented on the graph of Fig. 1 clearly show that septa over 2 weeks old are catching very few moths proportionally. For example, 3-week-old septa caught only 34% as many moths as did 2-week-old septa.

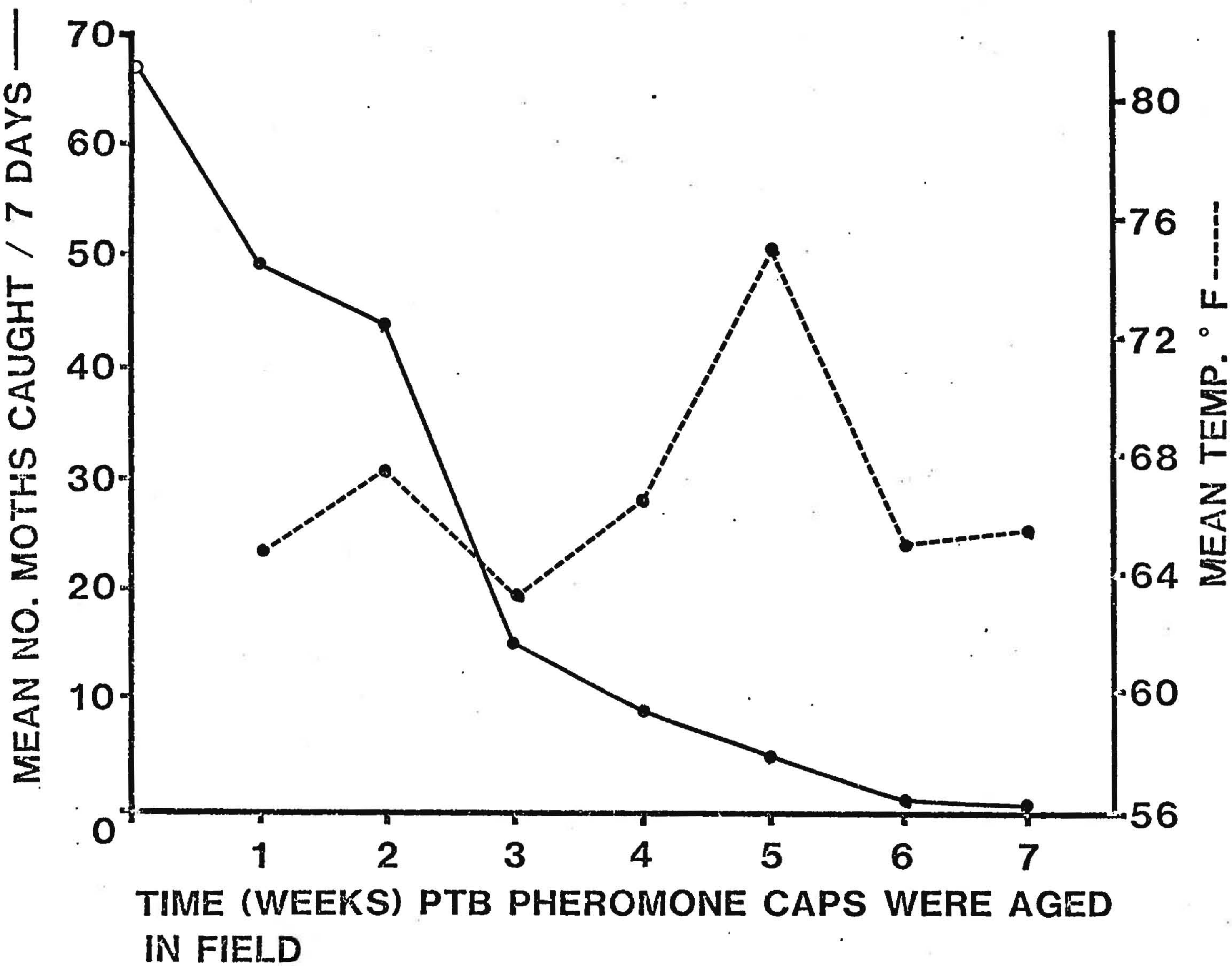

Fig. 1. Comparison of aged peach twig borer pheromone caps, spring 1982.

Table 1. Mean number of peach twig borer moths caught using commercial rubber septa at different age levels.

Treatment	Mean no. moths over 7 days
Fresh	67.20 a[1/]
1 week	49.00 b
2 weeks	43.20 b
3 weeks	14.80 c
4 weeks	8.60 d
5 weeks	4.20 de
6 weeks	0.60 e
7 weeks	0.40 e

[1/] Means in the same column followed by the same letter are not significantly different (P >0.05) as determined by Duncan's new multiple range test.

Conclusions

The two years in which this experiment was run give excellent information on effective longevity of commercial PTB pheromone cap life. Regardless of the time of year in which field monitoring of peach twig borer is being made with pheromone traps, the septa should be changed every two weeks. The results indicate that using septa which are older than two weeks may result in serious error in timing spray applications for this pest and in modeling the population.

Is the Peach Twig Borer Temperature Summation Model Valid for Almond Orchards?

R. R. Youngman and M. M. Barnes

Introduction

The method of modeling a pest insect population by accumulating its heat units is being used more frequently to base decisions on timing control measures.

The gelechiid moth, *Anarsia lineatella*, is a pest of almonds whose heat unit requirements have been proposed by R. E. Rice, F. G. Zalom, and J. F. Brunner in the Agricultural Sciences Division, University of California, Leaflet No. 21302 entitled "Monitoring Peach Twig Borer Development with Degree-Days".

An intensive monitoring program using pheromone traps in 2 large almond orchards was carried out on this pest to test the validity of this degree-day model.

Materials and Methods

Seasonal monitoring of peach twig borer flight periods was carried out in two Kern County orchards. One orchard is owned by Superior Farms and is located about 4 miles north of Shafter; it consists of 305 acres. The second orchard lies about 3 miles north of Arvin consisting of 140 acres and is owned by Dr. Williams. The two orchards have not received any spray applications except for a dormant oil and organophosphate treatment for control of San Jose scale and overwintering peach twig borer larvae. It should be noted that the Arvin orchard has not received any in-season pesticide treatments for the past 8 years.

Near the center of both orchards, 15 Pherocon® 1C pheromone traps were placed at a density of 1 trap to 2 acres. The traps were set out in the Arvin and

Shafter orchards on April 16 and 23, respectively. All traps were placed on the northeast side of the tree at an average height of 5' 10". The pheromone rubber septa were replaced every 2 weeks and the sticky liners were changed from 1-4 weeks depending on the number of moths caught. Monitoring was done every 7 days and the data are reported on Fig. 1 as mean number of moths caught per trap per night. Maximum and minimum temperatures were obtained from a continuously recording hygrothermograph, located in both orchards near the trapping site.

Degree-day summation was carried out according to the method and degree-day table mentioned in the introduction.

Results and Discussion

According to the work previously done, one complete generation requires approximately 1060 degree-days. This figure was used to compare the values in the total degree-day column on Tables 1 and 2. Table 1 values are based on the number of degree-days that occurred from 1 minimum flight period to the following minimum flight period (Fig. 1). Table 2 values were arrived at in exactly the same way except that they are representative of the peak-to-peak flight periods.

For either spring or summer periods, both orchards show fairly close agreement; however, none are close to the 1060 degree-day value. The average of the values for spring generations is 856; similarly, the average of the values for later generations is 1299. These averages are off from the 1060 degree-day estimate by more than 200 degree-days. Based on these results, it appears that additional work is needed on this model before it can be used to make decisions on timing applications for this pest.

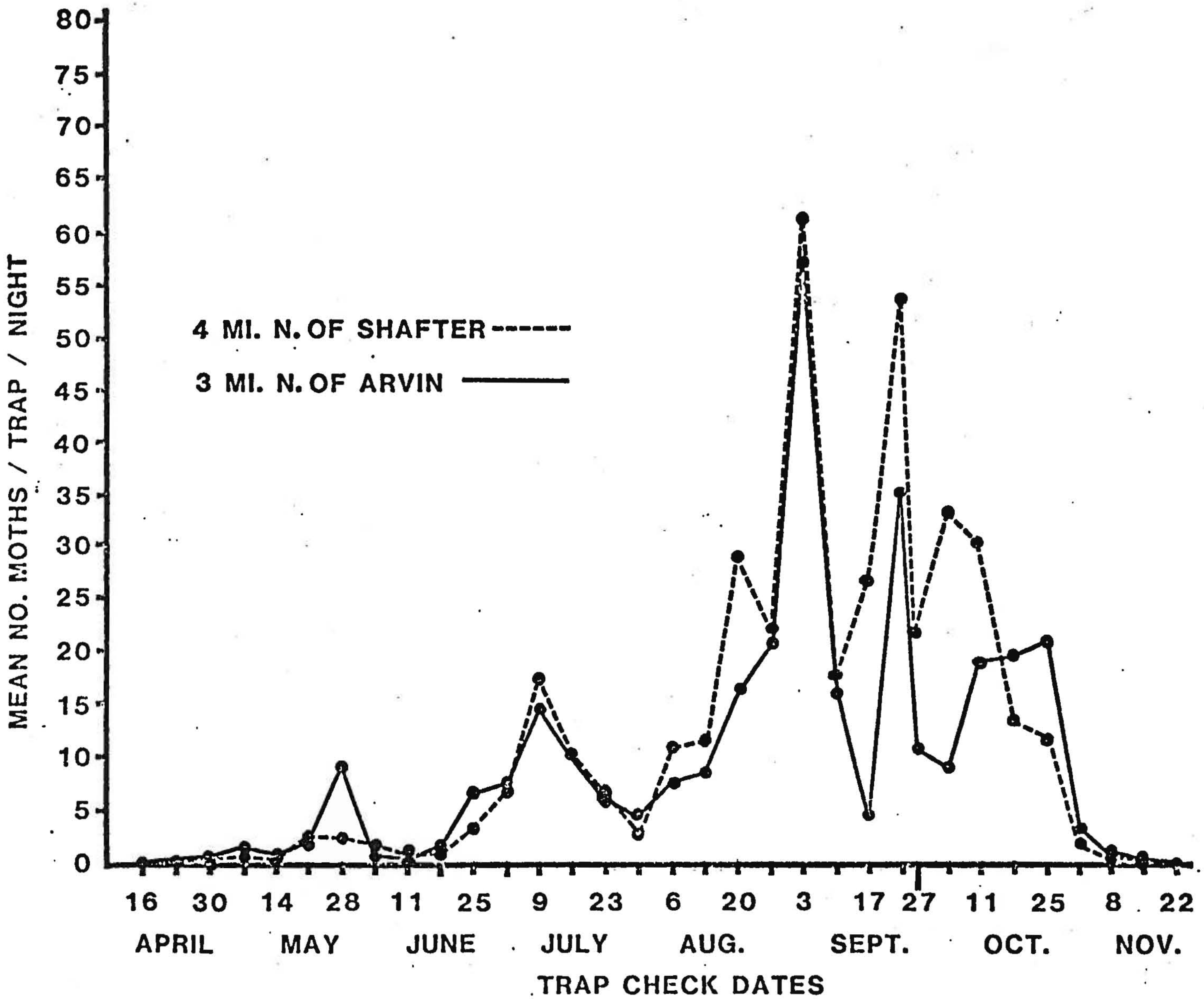

Fig. 1. Seasonal monitoring of peach twig borer with pheromone traps, 1982.

Table 1. Total degree-days from minimum to minimum trap catch.

Orchard location	Dates	Total degree-days
Arvin	4/17 to 6/11	896
Shafter	4/23 to 6/11	838
Arvin	6/11 to 7/30	1181
Shafter	6/11 to 7/30	1196
Arvin	7/30 to 9/17	1275
Shafter	7/30 to 9/10	1149

Table 2. Total degree-days from peak to peak trap catch.

Orchard location	Dates	Total degree-days
Arvin	5/28 to 7/9	843
Shafter	5/28 to 7/9	846
Arvin	7/9 to 9/3	1483
Shafter	7/9 to 9/3	1510

Relationship of Peach Twig Borer Infestation to Pheromone Trap Counts

R. R. YOUNGMAN and M. M. BARNES

Introduction

The peach twig borer, Anarsia lineatella, can cause considerable damage in almonds. In the early part of the season, larval damage is most apparent from the habit of the larvae boring into shoots, while in the latter part the larvae infest both hulls and nutmeats. Population levels of this pest may be routinely monitored throughout the season with the commercially available pheromone and pheromone traps. A grower may decide to control peach twig borer with an insecticide application based on trap counts which start to rise sharply during the first flight period.

An experiment was conducted to relate pheromone trap count data to peach twig borer infestation in an attempt to arrive at an economic threshold for Nonpareil almonds.

Materials and Methods

Seasonal monitoring of peach twig borer flight periods and infestation was carried out in two Kern County almond orchards. One orchard is owned by Superior Farms and is located about 4 miles north of Shafter; it consists of 305 acres and is referenced as R-88. The second orchard lies about 3 miles north of Arvin, is owned by Dr. Williams and consists of 140 acres. The two orchards have not received any spray applications except for a dormant oil and organophosphate treatment for San Jose scale that also offers suppression of peach twig borer. It should be mentioned that the Arvin orchard has not received any in-season pesticide treatments for the past 8 years.

Near the center of both orchards 15 Pherocon® 1C pheromone traps were placed at a density of one trap to two acres. The traps were set out in Arvin and R-88 on April 16 and 23, respectively. All traps were placed on the north-east side of the tree at an average height of 5'10". The pheromone rubber septa were replaced every two weeks and the sticky liners were changed from 1-4 weeks depending on the number of moths caught. Monitoring was done every seven days and the data are reported as mean number of moths caught per trap per night (Fig. 1). On May 28 Nonpareil trees in both orchards were sampled to determine the sticktight load. The data are presented in Table 1.

To assess infestation through time an average of 50 nuts was observed from either the N, S, E, or W side of four trees (average height of 5'8") at each pheromone trap location. Infested nuts were tagged but not removed from the branch; this began on April 21 in both orchards and continued at weekly intervals until harvest. In all, about 3000 nuts on 60 trees were observed in each orchard.

Prior to the grower-scheduled harvest the nuts were removed from the trees and cracked out by hand to determine the percent infestation of peach twig borer and navel orangeworm (Table 2).

Results and Discussion

Percent infestation by peach twig borer and navel orangeworm was extremely low in both orchards. Peach twig borer damage to the nutmeats in Arvin was 1.31% and in R-88 it was less than 0.5%. Similarly, for navel orangeworm it was 0.33 and 1.84%. Because the damage did not reach economic levels, no attempt was made to determine an economic threshold for peach twig borer based on number of moths caught.

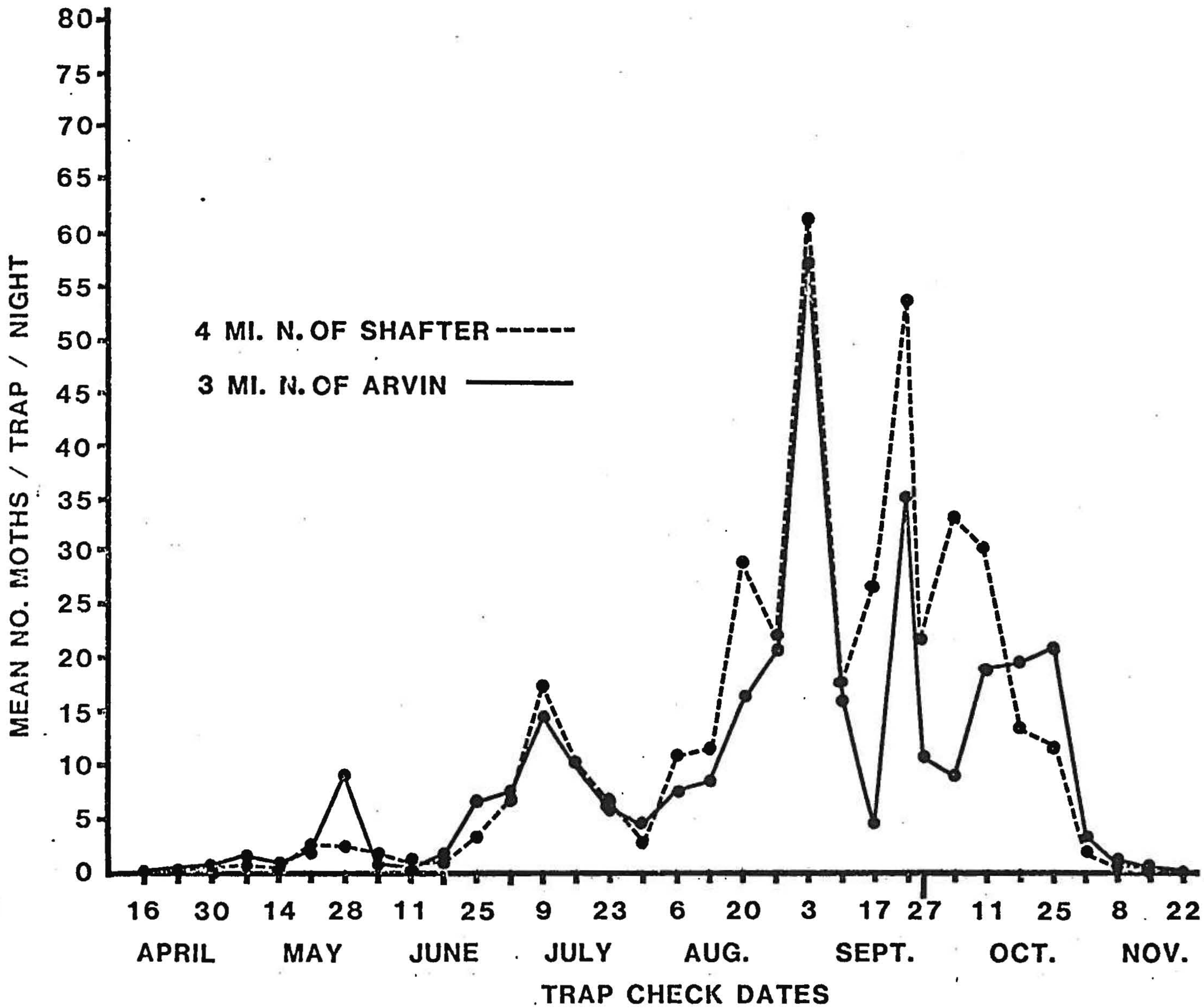

Fig. 1. Seasonal monitoring of peach twig borer with pheromone traps, 1982.

Table 1. Average number of sticktights per tree.

Orchard location	Sample date	No. trees observed	No. sticktights per tree
3 mi. N of Arvin	5/8	87	0.2
4 mi. N of Shafter	5/8	112	1.1

Table 2. Average percent infestation.

Orchard	Harvest	Peach twig borer		Navel orangeworm		PTB + NOW
location	date	Nutmeat only*	Hull only**	Nutmeat only*	Hull only**	Total nutmeats
3 mi. N of Arvin	8/13	1.31	5.71	0.33	3.36	1.64
4 mi. N of Shafter	8/11	0.46	3.76	1.84	3.07	2.30

$$* \ \frac{\text{(nutmeats infested) + (nutmeats and hulls infested)}}{\text{Total nuts in sample at harvest}} \times 100$$

$$** \ \frac{\text{Infested hulls only}}{\text{Total nuts in sample at harvest}} \times 100$$

Sampled nuts were removed from R-88 and Arvin on August 11 and 13, prior to the third generation peak flight period which occurred on September 3. The first and second generation peak flight periods were much lower and averaged 9.1 and 14.3 moths per trap per night in Arvin. In R-88 it was 2.3 and 17.3 moths per trap per night for the same flight periods. The dormant insecticide treatment may have killed enough overwintering peach twig borer larvae to prevent the remaining population from attaining sufficient numbers to cause economic damage.

Probably the main factor responsible for the low percent infestation by navel orangeworm was the low sticktight load in the two orchards. On May 28 the Arvin orchard had 0.2 sticktights per tree and on the same date R-88 had 1.1 per tree.

No noticeable infestation occurred from either pest until July 30 when percent hullsplit was 94% in Arvin and 85% in Shafter.

Investigation of the Interaction of Spider Mite Feeding and Water-Stress on Fifth Leaf Almonds

R. R. Youngman and M. M. Barnes

Introduction

It has been previously established on almonds and other crops that high levels of spider mite feeding can cause a significant decrease in transpiration, photosynthesis and yield. Similarly, water-stress has been shown to have much the same effects. The physiological effect which these two stresses have on a plant are primarily stomatal closure. Generally, the stomate is one of several thousand microscopic pores located on the leaf underside. It is through these pores that critical gas exchange of water and carbon dioxide takes place.

Therefore a field experiment was made on almonds to study the interaction of mite feeding and water-stress. The objectives were three-fold: the first was to obtain significant levels of spider mite densities and artificially induced water-stress. The second objective was to quantitatively measure through time the stress effects on plant photosynthesis, stomatal conductance and leaf water potential. This was carried out using the Riverside dual isotope porometer and a PMS pressure bomb. The third objective was to investigate what impact water-stress would have on spider mite densities, both in terms of number of eggs and motile stages per leaf.

Materials and Methods

The orchard used in this study is located in southern Tulare County on the north side of County Line road about 6 miles east of Hwy. 99. The orchard consists of a 10-acre block in its fifth leaf that was generously donated for use by the owners of Pandol and Sons. With the exception of the 3 N and S end rows exclusively of the Price variety, the planting mix consisted of Price to Nonpareil in a 2:2 ratio.

Up until the spring of 1982 the block was flood irrigated; it was then changed to a fixed sprinkler system using FAN-JET^{TM} emitters, one between each tree in a row. The row-tree planting scheme is 24' X 18'.

Two adjacent rows of 10 trees each of the Price variety were selected near the S side of the block for the test plot where the soil consists of a sandy loam type. A 2 X 2 factorial design was used in which the 4 treatments - replicated 5 times - consisted of 2 non-water-stressed, one of which was allowed to develop mites, and 2 water-stressed where, again, one was allowed to develop mites. The other trees were kept mite-free by spraying until run-off with Plictran 50W at the rate of 6 oz a.i. per 100 gal on June 16 and July 16.

Due to the impracticability in attempting to water-stress individually isolated trees, one row was selected to receive water as normal and the other was cut off from July 1 through August 19 (the end of the experiment). It should be noted that the non-water-stressed (NWS) trees were also cut off from water on July 30 through August 19 due to harvest.

To prevent run-off water from moving to trees in the water-stressed (WS) row, basins were formed around the base of each tree normally receiving water, with a FAN-JET emitter placed inside it using extension tubing. Water was cut off to the trees in the WS row by simply plugging off the neighboring FAN-JET emitters.

An initial mite sample was taken on July 1 and beginning July 6 mites were sampled weekly through August 17. The tree was divided into upper and lower halves with each half subdivided into four cardinal point quadrants. Four leaves were randomly selected within each of the 8 quadrants, making up a total sample size of 32 leaves per tree. These samples were refrigerated until they could be observed under a dissecting microscope.

Pre-dawn and mid-day measurements of leaf water potential were taken every 7 days on all 20 trees in order to establish the level of water stress. This was done from July 6 through August 17 using a PMS pressure bomb. Four leaves per tree were randomly selected at eye level from each of the cardinal points. A reading was made on each leaf as soon as it was removed from the tree.

A second instrument used in this study was the Riverside dual isotope porometer. It is completely field portable and was used to quantify the interaction effects of mite feeding and water stress on stomatal conductance and photosynthesis. The porometer functions on the principle that radioactive isotopes of H_2O and CO_2 are taken up by the leaf's stomates in direct relationship to stomatal conductance and photosynthesis.

As in the mite sampling, the tree was divided into 8 quadrants with 2 samples taken from each one for a total sample size of 16 per tree. All samples were kept on dry ice until taken back to the lab in Riverside where the radioactivity in each leaf sample could be determined on the liquid scintillation counter.

Results and Discussion

A 2-way analysis of variance was performed on the raw pressure bomb data for each sample date. Statistical separation ($P<0.05$) occurred on July 27 and on all sample dates thereafter between the NWS and WS treatments. Although there was a trend toward a negatively greater leaf water potential in the WS vs. NWS treatments when mites were present on the former, it did not prove to be statistically significant. Therefore, the mite effects are not presented separately in Fig. 1. It should also be noted on Fig. 1 that a certain degree of water stress also occurred in the control or NWS treatment, especially on the latter dates. This was partially due to the July 30 water cut-off for harvest and the method used to water the control trees as explained in the materials and methods section.

The mite population consisted of two species, Tetranychus pacificus and Panonychus citri. In the NWS treatment the ratio of T. pacificus to P. citri motile stages was 77-23% whereas in the WS treatment it was 87-13%. Eggs were also counted and in the NWS treatment the respective ratio was 54-46% and, similarly, in the WS treatment it was 55-45%.

A 2-way analysis of variance was performed on each sample date on transformed data ($\log_e + 1$). Both mean number of eggs and mean number of motile stages per leaf were analyzed. The two speices were not separated in the analyses.

Referring first to Fig. 2, the number of phytophagous mite eggs per leaf on August 3 was significantly higher ($P<0.05$) on the WS treatment than on the control treatment. The same occurred between the phytophagous mite motile stages on August 3 as seen on Fig. 3. No other dates proved to be significantly different for either eggs or motile stages. This data suggests that water-stressed almond trees may influence spider mite fecundity and lead to greater population densities.

The porometer was used every 2 weeks starting July 7 to obtain measurements on photosynthesis (PS) and stomatal conductance to H_2O (SC). The raw data were analyzed in a 2-way analysis of variance for each sample date and is graphically represented as relative percent of the control. This was done because the NWS trees, as mentioned earlier, were subjected to some degree of water stress. Figs. 4 and 5 show all 4 treatments for PS and SC which are: no mites plus

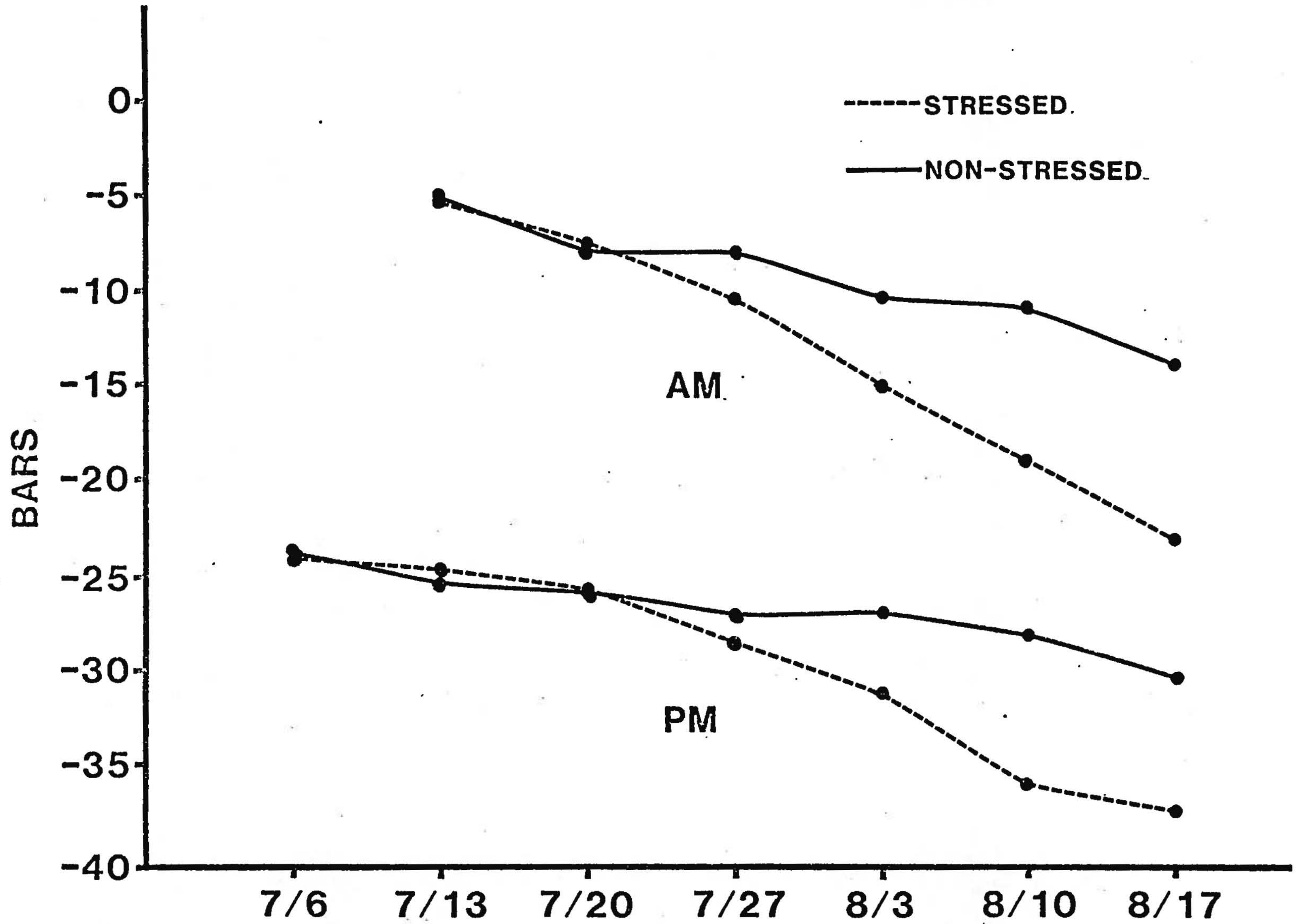

Fig. 1. Drop in leaf water potential in water-stressed vs. non-water-stressed almonds.

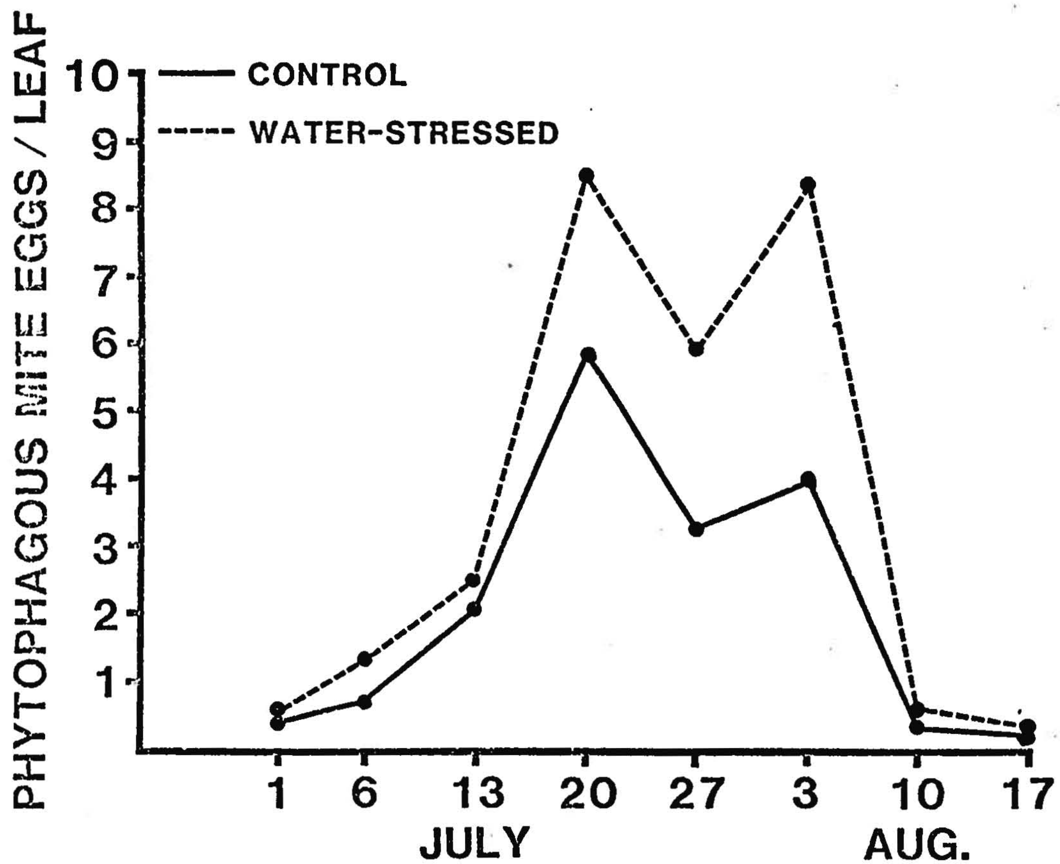

Fig. 2. Mite egg density on water-stressed vs. non-water-stressed trees.

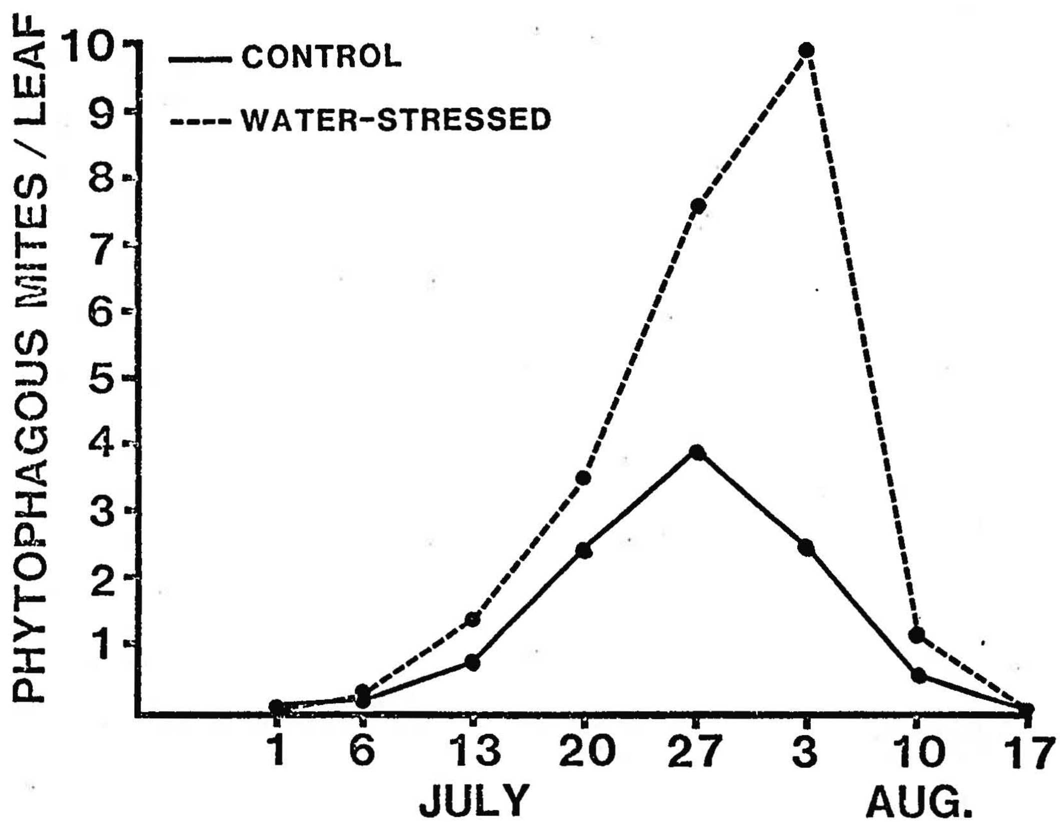

Fig. 3. Mite motile stages on water-stressed vs. non-water-stressed trees.

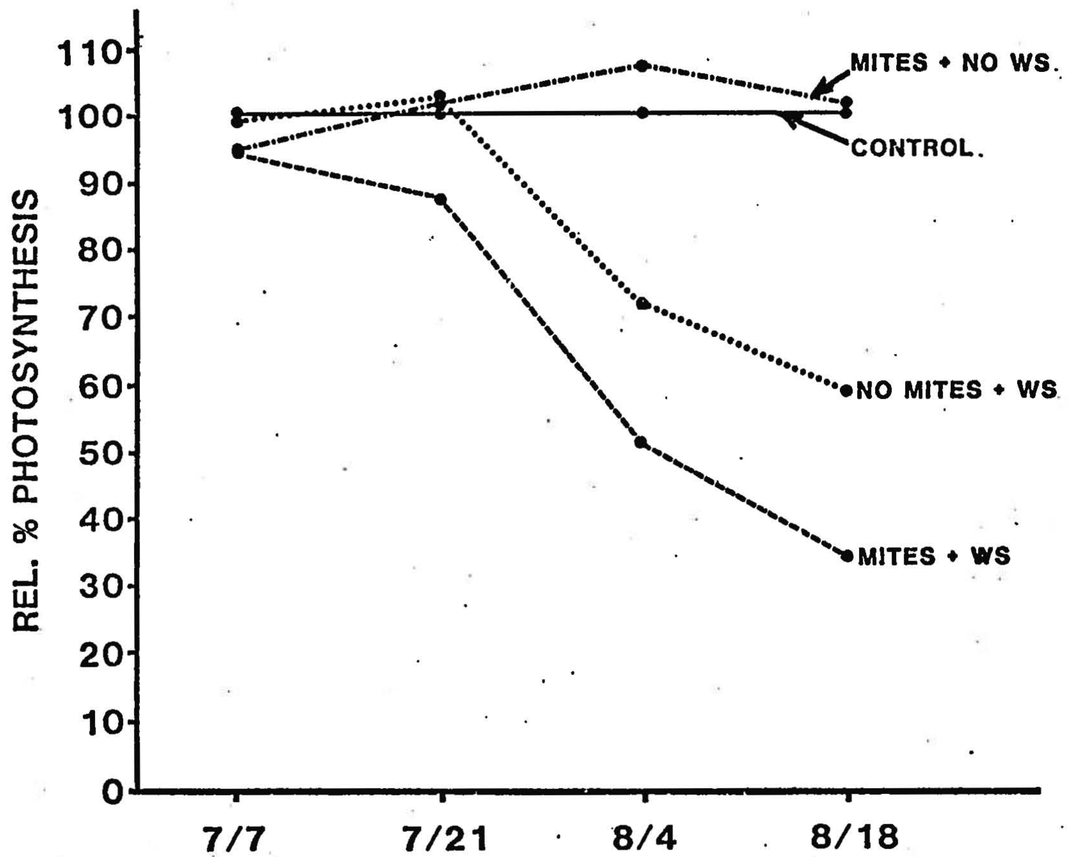

Fig. 4. Photosynthetic rates of all treatments relative to the control.

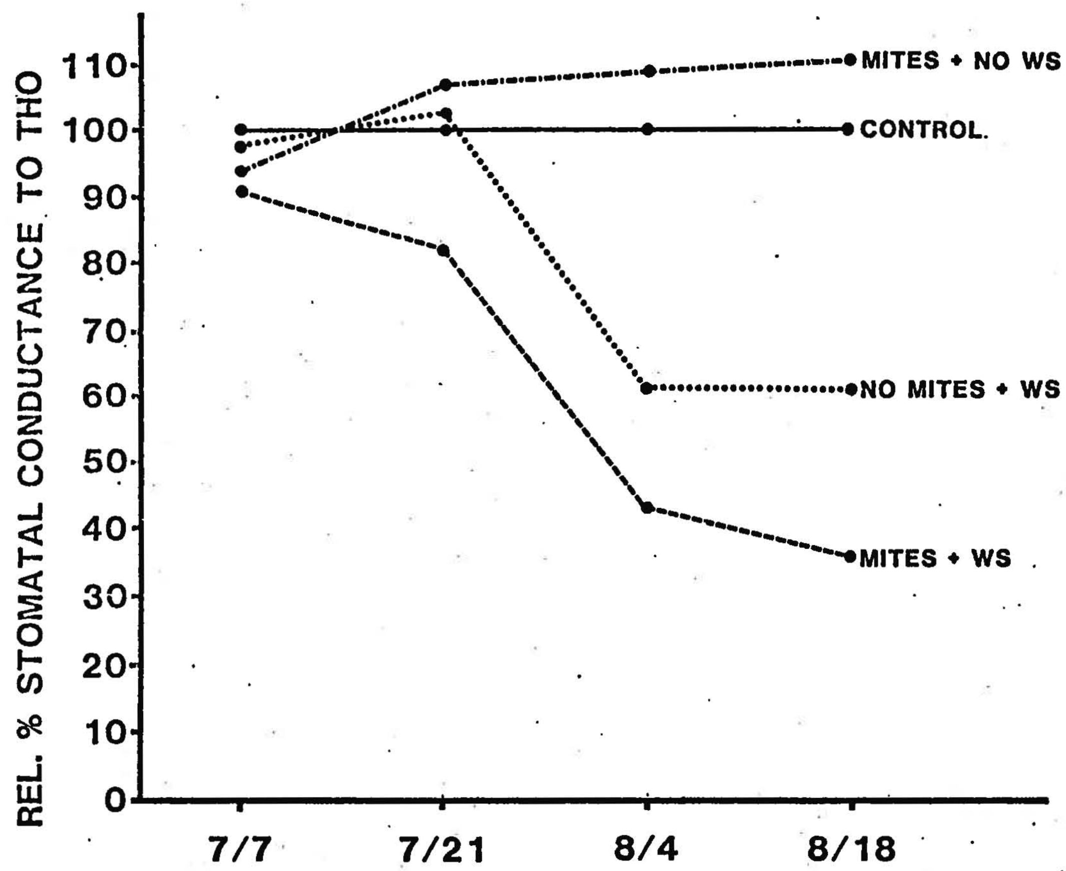

Fig. 5. Stomatal conductance to THO of all treatments relative to the control.

water stress (NM+WS), mites plus no water stress (M+NWS), mites plus water stress (M+WS), and the control consisting of no mites plus normally watered trees. There was obtained good agreement in the results from the pressure bomb and the porometer with respect to the NM+WS treatment compared to the control. There was a significant decrease ($P<0.05$) in PS by about 30% on August 4 and 40% on August 18 (Fig. 4). The same was true of SC for the same dates; it was decreased by about 40% (Fig. 5).

Referring to the M+NWS treatment, it was slightly greater than the control for both PS and SC (Figs. 4 and 5). However, it was not statistically different from the control at any of the sample dates. It is important to note that the number of accumulated mite-days at the end of the season was less than 90 for this treatment. Also, there were just under 200 mite-days in the M+WS treatment at season's end. It is felt that detectable differences in PS and SC as measured with the porometer do not begin to show up until greater than 100 mite-days have been accumulated.

The most important aspect of this study is the combined interaction effects of M+WS as compared to the control. Beginning on July 21, the main effect of mites and the main effect of WS were not significantly different from their controls; however, the interaction was. In essence, this says that given a very low level of mite-days, when combined with a moderate level of WS, a significant reduction in PS and SC will result. Referring still to Figs. 4 and 5, note that by August 4 the main effect of mite feeding was not significantly different from its control, but the main effect of WS was. The interaction was also significant with a 49% drop in PS and a 57% drop in SC. By the August 18 sample date the main effect of WS was highly significant ($P<0.01$); however, the main effect of mites as well as the interaction was not. It is thought that by this late date in the experiment, water stress was the dominating factor masking the effects of mite feeding.

Further investigation into the interaction of M+WS vs. WS alone showed that mite feeding contributed to a significantly lower photosynthetic rate and stomatal conductance to water (Figs. 6 and 7). This occurred on both the July 21 and August 4 sample dates. The effects of mites on PS and SC were not significant on August 18, presumably for the same reason mentioned earlier, the severe level of WS was masking the effects of the mites.

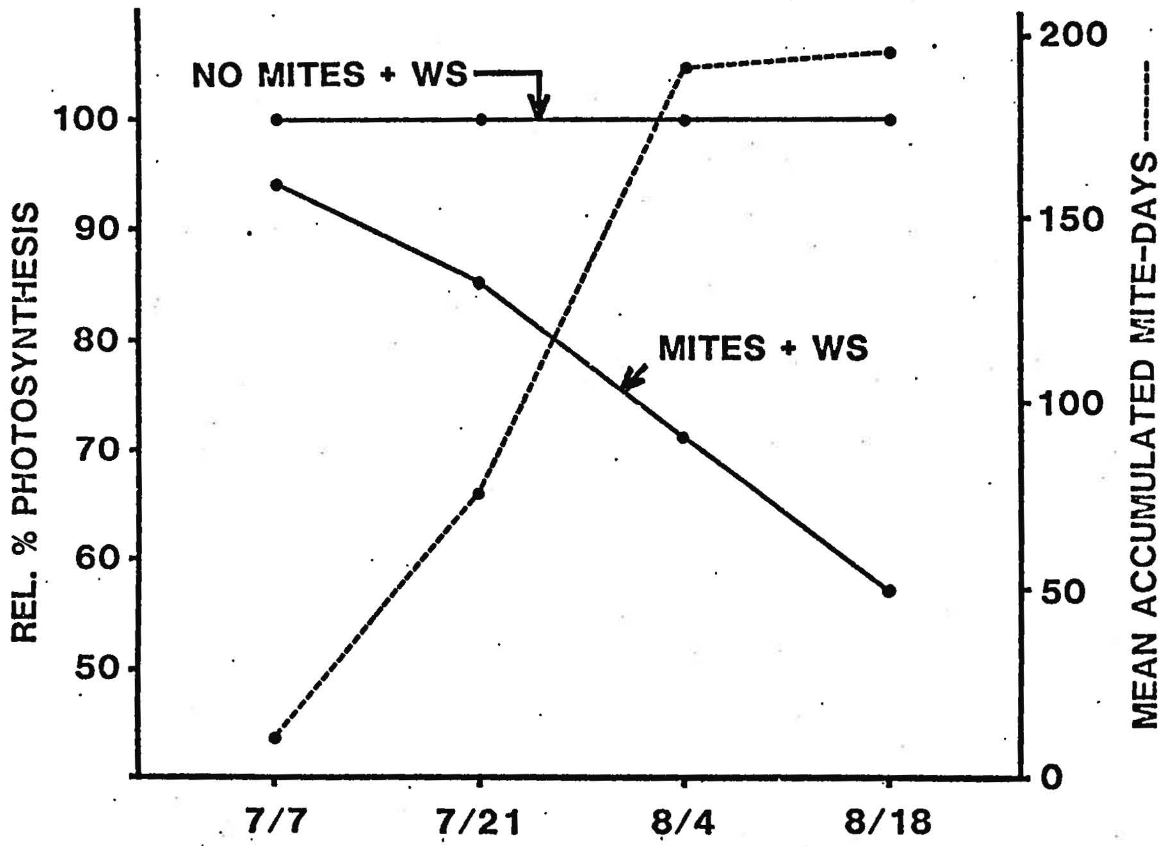

Fig. 6. The photosynthetic rate of the combined stresses relative to water-stressed (mite-free) trees.

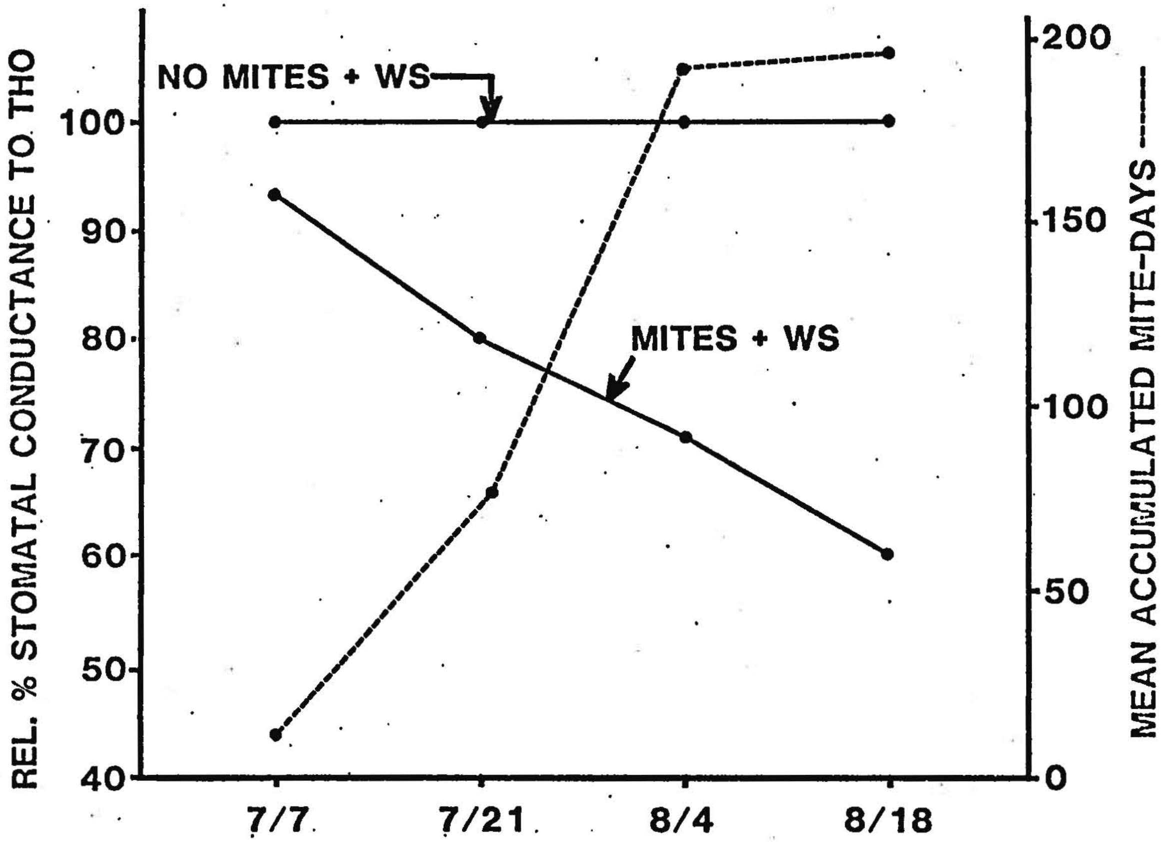

Fig. 7. Stomatal conductance to THO of the combined stresses relative to water-stressed (mite-free) trees.

Field Trial of Experimental Acaricides for Control of Spider Mites on Almonds, 1982

J. P. Sanderson and M. M. Barnes

Field experiments involving experimental compounds are an essential step in the development of new and possibly more effective acaricides for use against spider mites on almonds. In this experiment the efficacy of 9 acaricide treatments was evaluated during July and August of 1982. Permethrin plus synergists, permethrin alone, Avermectin with and without oil, and SLJ 0312 were compared to a currently registered acaricide, Omite, as well as to a water check. The effects of the treatments on the population levels of both the phytophagous and predatory mites as well as the predatory insects were examined.

Methods and Materials

The experiment was conducted on 2-year-old Nonpareil trees in a drip-irrigated orchard approximately 7 mi. east of Shafter, Kern County. A randomized block design composed of 12 blocks was established in the orchard. Each block contained 1 replicate of each of the 10 treatments.

The treatment applications were made on 23 July 1982, with a high pressure hand gun which delivers a fine spray at 400-450 psi. The trees were sprayed with an average of 7.5 gal of dilute spray per tree, resulting in an application rate of approximately 700 gal/acre.

Five sample leaves were taken from each of the 4 compass quadrants of each tree, inside and outside of the canopy at heights of 3 to 6 ft, for a total of 20 leaves per tree. The leaves were placed in moistened paper bags and refrigerated until counts were made under a dissecting microscope. Only the active stages of the mites and predatory insects were recorded. Samples were taken 0, 1, 6, 13, 20, 27, 34, and 48 days after the treatment date. Due to time constraints, only 6 of the 12 blocks were sampled on the pretreatment and 1 day posttreatment sample dates. Also, no insect predator data were taken for the 1-day posttreatment sample. Data for all other sample dates are based on counts from 12 blocks.

Thirty male spider mites from the leaves of the pretreatment sample were slide-mounted for identification and all were found to be the Pacific spider mite, Tetranychus pacificus. The predaceous mites consisted entirely of Metaseiulus (= Typhlodromus) occidentalis, as determined from slide-mounted females. The most abundant insect predators were the sixspotted thrips, Scolothrips sexmaculatus, and the larvae of a Cecidomyiid fly, probably Feltiella sp.

Results

Table 1 presents the spider mite data for all 10 treatments on all 8 sample dates.

A vigorous population of spider mites was present on all trees prior to the application date. The population was greatly reduced on all trees 24 h after treatment, although the population on the water-sprayed trees was significantly higher than the other treatments. Avermectin plus oil caused the greatest population reduction at this time, although trees treated with the double rate of GFU 152, GFU 151, oil alone, and SLJ 0312 were not significantly different.

Six days after the treatment date it was obvious that the treatments containing permethrin (GFU 152 at both rates, GFU 151, and Ambush) were not holding the mites, as they were all significantly different from the rest of the treatments, including the water check.

By the 13th day, the population levels of the treatments containing permethrin were unacceptable and were subsequently sprayed-out. Omite and Avermectin appeared lower than the check trees but higher than Avermectin plus

Table 1. Average number of active stages of Pacific mite per leaf,[a] Kern County, Calif., 1982.[b]

	Compound	Rate[c]	Sample date 7/22 Pretrt.	7/24 1 day	7/29 6 days	8/5 13 days	8/12 20 days	8/19 27 days	8/26 34 days	9/9 48 days
1.	Omite 30WP	3 lb AI/acre	14.5a	0.37bc	2.90b	1.80b	11.60a	18.80a	-	-
2.	GFU 152		11.80a	0.15bc	18.30a	40.00a	-	-	-	-
	1.0EC permethrin	0.2 lb AI/acre								
	4.0EC piperonyl butoxide	0.8 lb AI/acre								
3.	GFU 152		15.00a	0.13c	17.90a	46.30a	-	-	-	-
	1.0EC permethrin	0.4 lb AI/acre								
	4.0EC piperonyl butoxide	1.6 lb AI/acre								
4.	GFU 151		22.50a	0.10c	17.80a	38.20a	-	-	-	-
	0.5EC permethrin	0.2 lb AI/acre								
	4.0EC piperonyl butoxide	0.8 lb AI/acre								
	8.0EC "X"	1.6 lb AI/acre								
5.	Ambush 2.0EC	0.4 lb AI/acre	10.20a	0.45ab	18.6a	46.30a	-	-	-	-
6.	Avermectin 0.03SL	0.1 oz AI/100 gal	16.20a	0.28bc	1.00b	1.50b	10.20a	9.10b	4.30b	0.10a
7.	Avermectin 0.03SL + 60 sec 415 NR oil	0.1 oz AI/100 gal 1 qt/100 gal	12.20a	0.05c	0.80a	0.30b	0.90b	1.60c	1.30b	0.10a
8.	60 sec 415 NR oil	1 qt/100 gal	12.40a	0.12c	0.80b	0.30b	2.30b	4.00bc	9.30b	0.10a
9.	SLJ 0312 50WP	8 oz AI/100 gal	12.30a	0.07c	0.80b	0.20b	1.00b	9.10b	30.00a	-
10.	Water	-	19.20a	0.72a	5.90b	4.00b	6.10ab	1.80c	0.40b	0.10a

[a] Means of sample dates 7/22 and 7/24 are based on 6 replicates of 20 leaves/tree. All other sample dates are based on 12 replicates of 20 leaves/tree.

[b] Means in the same column followed by the same letter are not significantly different at the P = 0.05 level using Duncan's new multiple range test.

[c] Applied with high pressure handgun at 700 gal/acre.

oil, oil alone, and SLJ 0312, although they were not statistically different.

At 20 days posttreatment the mite levels on Omite and Avermectin trees were higher than those of the water check. Avermectin plus oil, oil alone, and SLJ 0312 were still providing good control as compared to the check trees.

At 27 days posttreatment the Omite-treated trees were significantly higher in mites than the other treatments and were subsequently dropped. The population level of the SLJ 0312-treated trees rose considerably on this date compared to the level of the previous week and was for the first time statistically higher than the check trees.

By the 34th day the trees treated with SLJ 0312 had developed a very high mite population and were no longer sampled. Except for the population level on the trees sprayed with oil alone and SLJ 0312, it appeared that mite levels were declining on all the remaining treatments.

The population levels of all remaining treatments had become equal by the 48th day after treatment.

Tables 2 and 3 present the data for predatory mites and insects, respectively, for all 10 treatments on all 12 sample dates.

Statistical differences in the predatory mite populations were present between treatments in the pretreatment sample for some reason but 1 day after application of the sprays the predatory mite population of all treatments dropped substantially and was no longer statistically different.

Six days after the treatment date the check trees had significantly more predatory mites as well as insect predators than those of any of the other treatments. The sudden rise of the spider mite population after 6 days in the trees treated with formulations containing permethrin cannot entirely be explained on the basis of predator elimination. Omite, GFU 152 (single rate), GFU 151, Ambush, and Avermectin plus oil all had statistically equivalent

Table 2. Average number of active stages of predatory mites[a] per leaf,[b] Kern County, Calif., 1982.[c]

			Sample date							
			7/22	7/24	7/29	8/5	8/12	8/19	8/26	9/9
	Compound	Rate[d]	Pretrt.	1 day	6 days	13 days	20 days	27 days	34 days	48 days
1.	Omite 30WP	3 lb AI/acre	0.70b	0.01a	0.05bc	0.04b	0.22abc	1.16a	-	-
2.	GFU 152		0.80b	0.00a	0.14b	0.12b	-	-	-	-
	1.0EC permethrin	0.2 lb AI/acre								
	4.0EC piperonyl butoxide	0.8 lb AI/acre								
3.	GFU 152		1.10ab	0.08a	0.02c	0.08b	-	-	-	-
	1.0EC permethrin	0.4 lb AI/acre								
	4.0EC piperonyl butoxide	1.6 lb AI/acre								
4.	GFU 151		1.40a	0.00a	0.01c	0.13b	-	-	-	-
	0.5EC permethrin	0.2 lb AI/acre								
	4.0EC piperonyl butoxide	0.8 lb AI/acre								
	8.0EC "X"	1.6 lb AI/acre								
5.	Ambush 2.0EC	0.4 lb AI/acre	0.90ab	0.00a	0.06bc	0.08b	-	-	-	-
6.	Avermectin 0.03SL	0.1 oz AI/100 gal	0.90ab	0.02a	0.04bc	0.08b	0.29ab	1.22a	0.95a	0.03a
7.	Avermectin 0.03SL + 60 sec 415 NR oil	0.1 oz AI/100 gal 1 qt/100 gal	0.80b	0.00a	0.04bc	0.04b	0.08cd	0.14c	0.19b	0.01a
8.	60 sec 415 NR oil	1 qt/100 gal	0.80b	0.06a	0.14b	0.06b	0.14bcd	0.50bc	1.02a	0.03a
9.	SLJ 0312 50WP	8 oz AI/100 gal	0.80b	0.06a	0.01c	0.00b	0.00d	0.01c	0.34b	-
10.	Water	-	1.30ab	0.08a	0.61a	0.40a	0.38a	0.91ab	0.38b	0.02a

[a] Family Phytoseiidae: _Metaseiulus occidentalis_.

[b] Means of sample dates 7/22 and 7/24 are based on 6 replicates of 20 leaves/tree. All other sample dates are based on 12 replicates of 20 leaves/tree.

[c] Means in the same column followed by the same letter are not significantly different at the P = 0.05 level using Duncan's new multiple range test.

[d] Applied with high pressure handgun at 700 gal/acre.

Table 3. Average number of active stages of predator insects[a] per leaf,[b] Kern County, Calif., 1982.[c]

	Compound	Rate[d]	Sample date 7/22 Pretrt.	7/29 6 days	8/5 13 days	8/12 20 days	9/19 27 days	8/26 34 days	9/9 48 days
1.	Omite 30WP	3 lb AI/acre	0.09a	0.04bcd	0.02c	0.17a	0.32a	-	-
2.	GFU 152		0.07a	0.03bcd	0.33a	-	-	-	-
	1.0EC permethrin	0.2 lb AI/acre							
	4.0EC piperonyl butoxide	0.8 lb AI/acre							
3.	GFU 152		0.12a	0.01cd	0.42a	-	-	-	-
	1.0EC permethrin	0.4 lb AI/acre							
	4.0EC piperonyl butoxide	1.6 lb AI/acre							
4.	GFU 151		0.13a	0.06bcd	0.28ab	-	-	-	-
	0.5EC permethrin	0.2 lb AI/acre							
	4.0EC piperonyl butoxide	0.8 lb AI/acre							
	8.0EC "X"	1.6 lb AI/acre							
5.	Ambush 2.0EC (permethrin)	0.4 lb AI/acre	0.08a	0.02bcd	0.32a	-	-	-	-
6.	Avermectin 0.03SL	0.1 oz AI/100 gal	0.06a	0.10bc	0.02c	0.11a	0.24a	0.11a	0.01a
7.	Avermectin 0.03SL + 60 sec 415 NR oil	0.1 oz AI/100 gal 1 qt/100 gal	0.08a	0.05bcd	0.00c	0.00b	0.01b	0.01b	0.00a
8.	60 sec 415 NR oil	1 qt/100 gal	0.10a	0.11b	0.02c	0.02b	0.02b	0.11a	0.01a
9.	SLJ 0312 50WP	8 oz AI/100 gal	0.08a	0.00d	0.00c	0.00b	0.03b	0.07ab	-
10.	Water	-	0.08a	0.24a	0.10bc	0.13a	0.08b	0.00b	0.00a

[a] Thysanoptera: Thripidae (Scolothrips sexmaculatus), and Diptera: Cecidomyiidae (probably Feltiella sp.).

[b] Means of sample date 7/22 are based on 6 replicates of 20 leaves/tree. All other sample dates are based on 12 replicates of 20 leaves/tree.

[c] Means in the same column followed by the same letter are not significantly different at the P = 0.05 level using Duncan's new multiple range test.

[d] Applied with high pressure handgun at 700 gal/acre.

predatory insect levels on this date, although no dramatic increase in spider mites occurred with Omite or Avermectin plus oil. Similarly, statistically similar predatory mite levels existed on trees treated with Omite, GFU 152 (single rate), Ambush, Avermectin, Avermectin plus oil, and oil alone, although spider mite levels increased dramatically only on trees treated with GFU 152 (single rate) and Ambush. SLJ 0312 appeared to greatly reduce the population levels of all predatory species.

At 13 days posttreatment the check trees still possessed a significantly higher predatory mite population than the rest of the treatments. However, the predatory insect population had increased greatly on the trees treated with permethrin formulations, probably in response to the large spider mite populations on these trees, and were significantly higher than all the other treatments.

At 20 days posttreatment, differences in insect predator levels were highest on trees treated with Omite, Avermectin, and the water check trees. Predatory mite levels were also highest on these trees. These same trees also had statistically similar spider mite populations on this day. SLJ 0312 again had the lowest number of predatory species.

With the increased spider mite levels on Omite- and Avermectin-treated trees at 27 days posttreatment, a corresponding predator increase occurred. The spider mite population of trees treated with SLJ 0312 began to rise at this time but the corresponding increase in predators was only rather slight.

At 34 days posttreamtnet the predatory species decreased on the Avermectin and check trees and increased on oil alone and SLJ 0312. The predatory mites were highest on the trees treated with Avermectin and oil alone while the insect predators were high on the trees treated with Avermectin, oil alone, and SLJ 0312.

Very low levels of predatory species existed at 48 days posttreatment due to the decline in spider mite levels.

In general GFU 152 (both rates), GFU 151, and Ambush did not perform well as acaricides. Avermectin was similar to Omite, both compounds appearing to lose their effectiveness between 13 and 20 days posttreatment. The addition of oil greatly increased the performance of Avermectin against spider mites, yet it did not devastate the predatory species. SLJ 0312 provided good control for at least 20 days but appeared to be the most detrimental compound to the beneficial species.

No phytotoxicity was observed associated with any treatment.

Investigation of the Effects of In-Season Pesticide Sprays on the Population Trends of Phytophagous Mites and their Predators in Two Unsprayed Almond Orchards

J. P. Sanderson and M. M. Barnes

Since spider mites are important pest of almonds, investigations of the effects of pesticide sprays on them and their predators are necessary. If cultural control methods against the navel orangeworm eliminate the need for in-season sprays in some orchards, it is important to assess the population trends of spider mites and their predators in unsprayed orchards. A comparison of the population trends between a sprayed and an unsprayed orchard would be interesting but the many uncontrollable differences that exist between separate orchards would complicate the interpretation of the results of the experiment. Therefore it was decided to apply commercially-used sprays at hullsplit to trees in two unsprayed orchards in order to observe their effects on the population trends of phytophagous mites and their natural enemies as well as the species composition through time. The data on the species composition are not yet available. This report only concerns the effect of sprays on the population trends of these arthropods.

Methods and Materials

Two unsprayed almond orchards were used for this experiment. One was a 120-acre orchard located 3 mi. north of Arvin, Kern County, consisting of 12-year-old, flood-irrigated trees. No pesticide sprays had ever been applied to this orchard except for a dormant spray of Imidan and oil applied every other year. The other was a 500-acre orchard in which 300 acres received no in-season sprays this year for the second year in a row. It was located 4 mi. north of Shafter, Kern County, and contained 9-year-old, flood-irrigated trees. Sixspotted thrips were being released in both of these orchards up until July, 1982, by a commercial insectary.

Twenty leaves were sampled from all experimental trees in both orchards by taking 5 leaves from each of the 4 compass quadrants, inside and outside of the canopy at heights of 3 to 6 ft. The leaves were placed in moistened paper bags and refrigerated until they could be counted under a dissecting microscope. Only the active stages of the mites and insects were recorded. Spider mite males and females as well as predatory mites were picked off the leaves at random and preserved in 70% ethyl alcohol until they could be mounted on microscope slides for species identification in order to determine the species composition through time.

Arvin Experiment

Four Nonpareil trees, spaced 6 trees apart in each of 4 rows spaced 6 rows apart, were selected in a corner of the Arvin orchard, making a square configuration containing 16 trees, each spaced 6 trees apart from each other. This design allowed an ample buffer zone between trees. Eight of the 16 trees were randomly assigned to be sprayed, the other 8 remained unsprayed as a check.

On 16 July, 1982, at roughly the beginning of hullsplit, the treatment trees were sprayed with a mixture of Guthion 50WP and Omite 30WP at a rate of 2 and 3 lb ai/acre, respectively. The spray was applied with a high pressure hand gun that delivers a fine spray at 400-450 psi. Approximately 12 gal of dilute spray was applied to each tree, resulting in an application rate of approximately 800 gal/acre.

The trees were sampled 12 times between 6/5/82 and 9/1/82. Due to the variability in samples, the raw data was first transformed using a log transformation and then analyzed using t-tests.

Shafter Experiment

A randomized block design composed of 6 blocks was established on the Nonpareil trees in a corner of the Shafter orchard. Each block contained one replicate of each of the 3 treatments plus 1 unsprayed check. All experimental trees were spaced 3 trees apart, again to allow for a buffer zone between trees.

On 16 July, 1982, the trees received a treatment spray of either a mixture of Guthion 50WP and Omite 30WP, a mixture of Ambush 2.0EC and Omite 30WP, Ambush 2.0EC alone, or no spray at all. The application rates were 2.0, 3.0, and 0.2 lb ai/acre for Guthion, Omite, and Ambush, respectively, based on 12 gal/tree and approximately 800 gal of dilute spray/acre. The sprays were again applied with a high pressure hand gun to individual trees.

The trees were sampled 15 times between 6/28/82 and 10/18/82. Due to the variability in sample counts, the raw data was first transformed using a log transformation and then analyzed for significance using a 2-way analysis of variance procedure.

Results

Arvin Experiment

Preliminary species identification revealed *Tetranychus pacificus* McGregor, the Pacific spider mite, as the most common phytophagous mite in this orchard, although *Panonychus citri* (McGregor), the citrus red mite, was also found in low numbers. The most common predatory mite was *Euseius* (= *Amblyseius*) *hibisci* (Chant). *Scolothrips sexmaculatus* (Perg.), the sixspotted thrips, was found in very low numbers, and the larvae of the green lacewing, *Chrysopa* sp., were only rarely encountered.

Tables 1 and 2 present the average number of phytophagous mites per leaf and average number of mite predators per leaf, respectively. Unusually low populations of phytophagous mites were observed in this orchard this year, although last year (1981) this orchard was observed with significant mite damage. One possible explanation for the low spider mite population in June could be due to the commercial sixspotted thrips releases which occurred at this time. Thrips were the most common predator encountered in June but they were seldom seen thereafter, probably due to the paucity of spider mite prey. However, thrips were also released in June of 1981, yet mite levels still developed which eventually visibly damaged the leaves. Other environmental factors such as the lower temperatures of the 1982 season were probably related to the low spider mite levels.

The application of Guthion plus Omite on 7/16 maintained the spider mites at a very low level until 8/25, when a slight increase can be discerned. The spider mites on the check trees were slightly more abundant although not statistically different from the sprayed trees.

A slight increase in the predatory mite population occurred on the unsprayed trees on 7/28 and remained higher than that of the sprayed trees for the duration of the experiment. It can be be seen that the number of spider mites per leaf and the number of predatory mites per leaf on the unsprayed trees were roughly equivalent from 8/11 to 9/1. Since the predatory mite, E. hibisci, is not an obligate predator, it can utilize other food sources such as pollen or nectar when mite prey is scarce. On avocado and citrus in southern California, it is not uncommon for E. hibisci to be more numerous than its prey, P. citri. The most common predatory mite in most commercial almond orchards is Metaseiulus (= Typhlodromus) occidentalis (Nesbitt). Since this species is an obligate predator, it is not surprising that it was not found in this orchard.

Table 1. Average number of active stages of spider mites per leaf,[a] Arvin, 1982.[b]

	Sample date											
Treatment	6/5	6/18	6/29	7/7	7/15	7/21[c]	7/29	8/4	8/11	8/18	8/25	9/1
Guthion + Omite	0.00	0.02a	0.04a	0.04a	0.01a	0.00a	0.01a	0.01b	0.01b	0.04a	0.25a	0.33a
Check	0.00	0.00a	0.04a	0.02a	0.08a	0.06a	0.16a	0.34a	0.25a	0.21a	0.20a	0.20a

[a] Based on 20 leaves per tree, 8 trees per treatment.

[b] Means presented are re-transformed from log-transformed data. Means in the same column followed by the same letter are not significantly different at the P = 0.05 level using t-tests.

[c] Threatened spray was applied on 7/16/82 with high pressure handgun.

Table 2. Average number active stages of predatory species[a] per leaf,[b] Arvin, 1982.[c]

Treatment	Sample date											
	6/5	6/18	6/29	7/7	7/15	7/21[d]	7/28	8/4	8/11	8/18	8/25	9/1
Guthion + Omite	0.01a	0.01a	0.01a	0.01a	0.00a	0.00a	0.00a	0.00b	0.00b	0.01b	0.00b	0.01b
Check	0.02a	0.01a	0.01a	0.00a	0.01a	0.01a	0.05a	0.16a	0.26a	0.22a	0.15a	0.15a

[a] Phytoseiidae: *E. hibisci*, Thripidae: *S. sexmaculatus*.

[b] Based on 20 leaves per tree, 8 trees per treatment.

[c] Means presented are re-transformed from log-transformed data. Means in the same column followed by the same letter are not significantly different at the P = 0.05 level using t-tests.

[d] Treatment spray was applied on 7/16/82 with high pressure handgun.

This experiment will hopefully be repeated in 1983, and hopefully a more substantial mite population will develop in order to observe, among other things, whether E. hibisci or M. occidentalis is the dominant spider mite predator on sprayed or unsprayed trees in the unsprayed orchard .

Shafter Experiment

A preliminary examination of some collected specimens revealed that T. pacificus also was the most common phytophagous mite in the Shafter orchard, with the European red mite, Panonychus ulmi (Koch), and the citrus red mite present in low numbers. M. occidentalis was the most common predatory mite, although E. hibisci was also present. Common insect predators again included the sixspotted thrips and an occasional lacewing larva. At high spider mite population levels, very low numbers of eggs and larvae of the predatory cocinellid beetle, Stethorus picipes Casey, were encountered, as well as larvae of a cecidomyiid fly, probably Feltiella sp.

Fig. 1 graphically demonstrates the trends in the spider mite population levels of each of the 3 spray treatments compared to those of the check trees through time. Figs. 2-4 individually compare the population levels of mite predators of each of the spray treatments with those of the check trees through time. Tables 3 and 4 present the statistical comparisons of the average numbers of spider mites per leaf and mite predators per leaf, respectively, for all sample dates.

Low levels of spider mites were present on the trees prior to the treatment date of 7/16/82. The predatory species were also low on all trees and, although Figs. 2-4 indicate fluctuations in the predator levels, no statistical differences existed.

After the sprays were applied, the spider mite populations on all the sprayed trees at first declined. Subsequently the mite population on the trees

Table 3. Average number of active stages of spider mites per leaf,[a] Shafter, 1982.[b]

Treatment	Sample date														
	6/28	7/5	7/12	7/19[c]	7/26	8/2	8/9	8/16	8/23	8/30	9/6	9/13	9/27	10/4	10/18
Guthion + Omite	0.46a	0.29a	0.21a	0.08b	0.06c	0.02c	0.09c	0.09c	0.13c	1.98c	3.71b	5.46a	0.96a	0.90a	0.02ab
Ambush + Omite	0.22a	0.20a	0.28a	0.03b	0.06c	0.01c	0.04c	0.18c	0.72b	3.82b	8.17a	7.21a	1.50a	1.28a	0.05ab
Ambush	0.34a	0.15a	0.25a	0.05b	0.49b	6.19a	15.06a	27.01a	19.08a	12.18a	10.62a	7.04a	1.17a	0.77a	0.07a
Check	0.22a	0.26a	0.20a	0.66a	1.09a	1.24b	1.58b	1.39b	0.72b	1.46c	2.05b	1.80b	0.08b	0.00b	0.00b

[a] Based on 20 leaves per tree, 6 trees per treatment.

[b] Means presented are re-transformed from log-transformed data. Means in the same column followed by the same letter are not significantly different at the P = 0.05 level using Duncan's NMRT.

[c] Treatment sprays were applied on 7/16/82 with high pressure handgun.

Table 4. Average number of active stages of mite predators[a] per leaf,[b] Shafter, 1982.[c]

Treatment	Sample date														
	6/28	7/5	7/12	7/19[d]	7/26	8/2	8/9	8/16	8/23	8/30	9/6	9/13	9/27	10/4	10/18
Guthion + Omite	0.03a	0.00a	0.03a	0.00a	0.00b	0.00a	0.00b	0.01b	0.00b	0.07a	0.08a	0.07a	0.10ab	0.15a	0.00
Ambush + Omite	0.06a	0.00a	0.02a	0.00a	0.01ab	0.00a	0.00b	0.00b	0.00b	0.10a	0.09a	0.17a	0.12a	0.14a	0.00
Ambush	0.06a	0.00a	0.02a	0.00a	0.02ab	0.00a	0.02b	0.06ab	0.06a	0.13a	0.17a	0.11a	0.14a	0.04a	0.00
Check	0.02a	0.01a	0.01a	0.02a	0.06a	0.03a	0.16a	0.13a	0.04ab	0.13a	0.14a	0.16a	0.01b	0.06a	0.00

[a] Phytoseiidae: M. occidentalis, E. hibisci. Thripidae: S. sexmaculatus.

[b] Based on 20 leaves per tree, 6 trees per treatment.

[c] Means presented are re-transformed from log-transformed data. Means in the same column followed by the same letter are not significantly different at P = 0.05 level using Duncan's NMRT.

[d] Treatment sprays were applied on 7/16/82 with high pressure handgun.

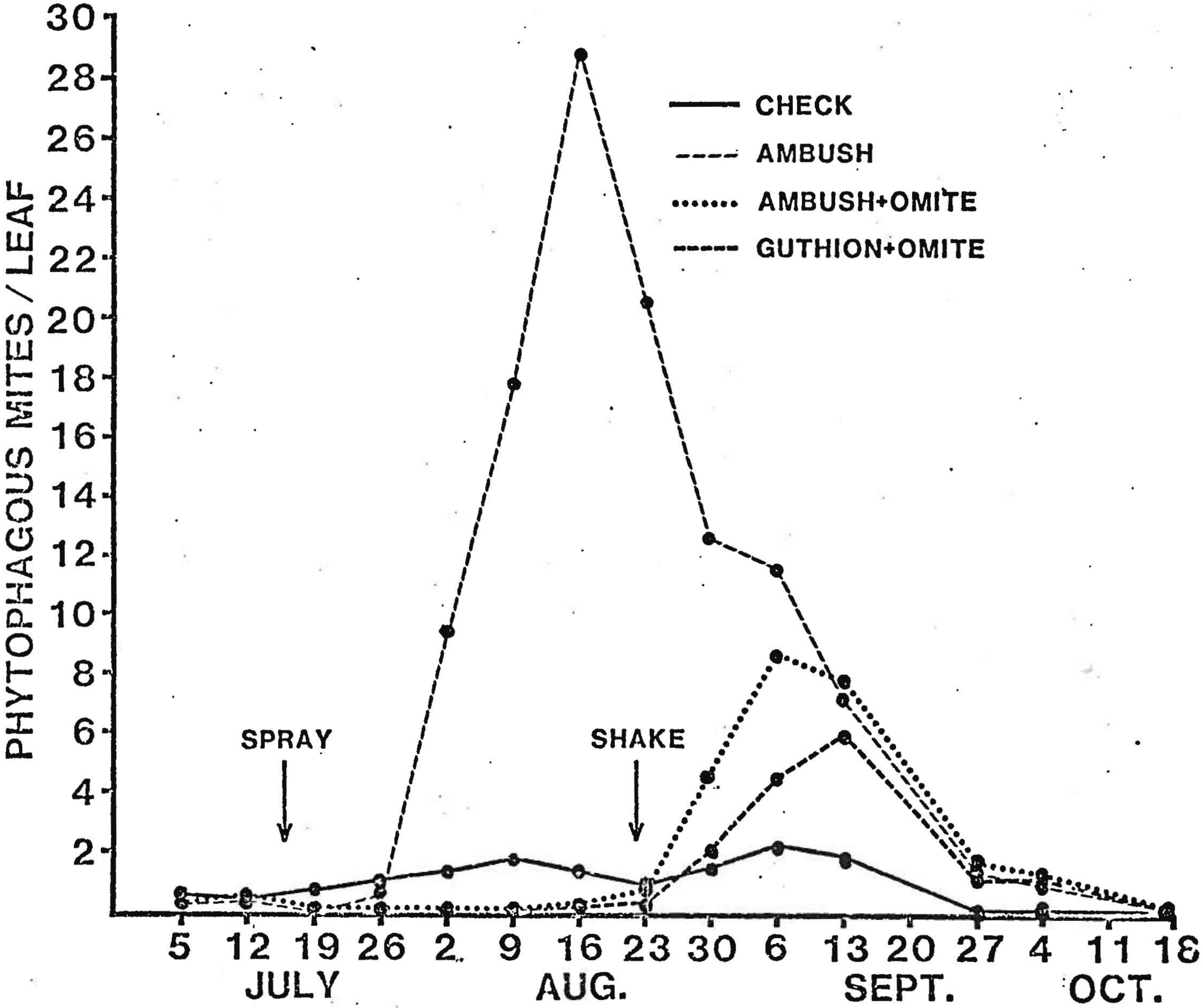

Fig. 1. Spider mite population trends in trees treated with 3 pesticide treatments vs. unsprayed trees, Shafter, Kern County, 1982.

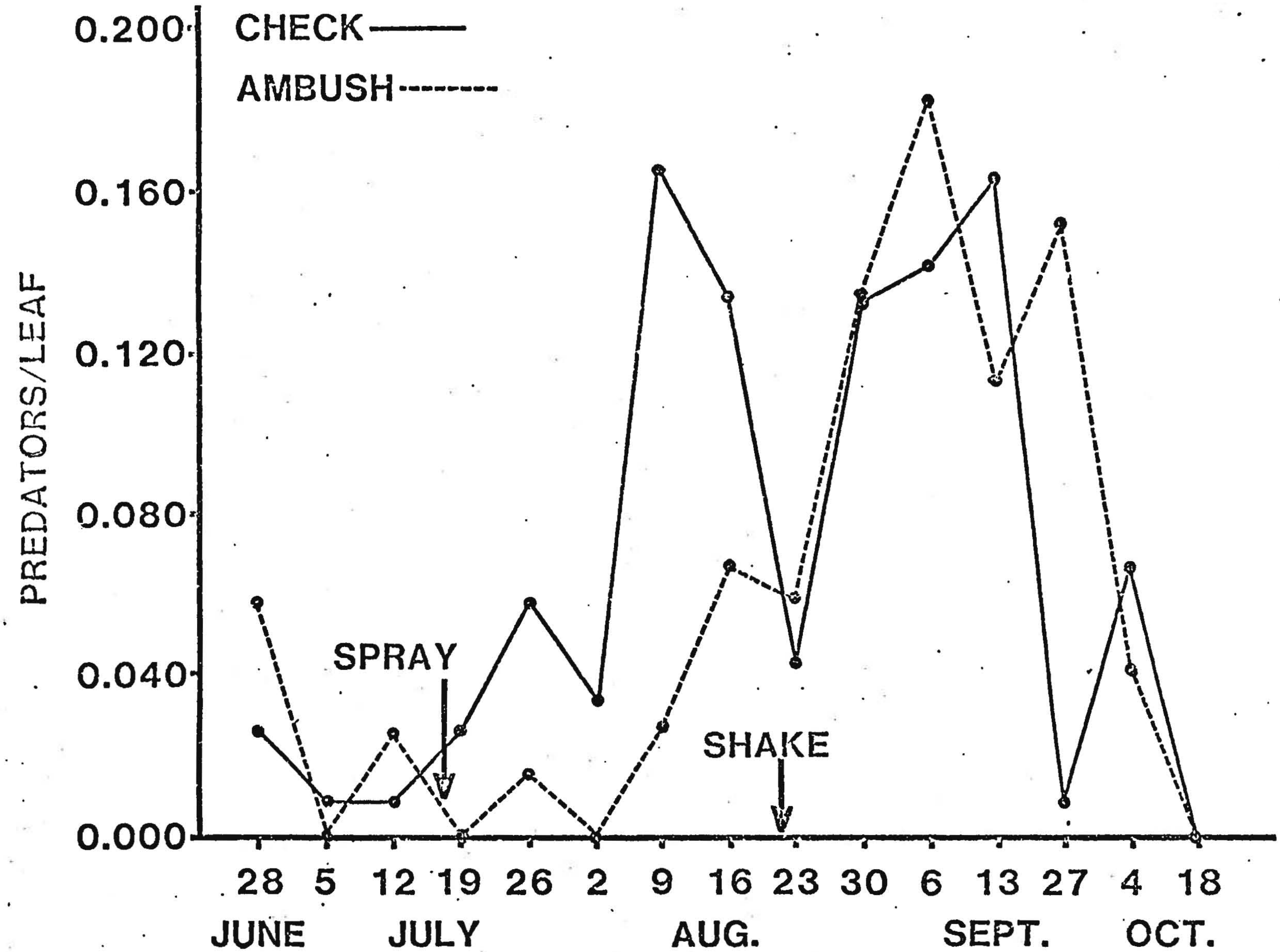

Fig. 2. Predator population trends in trees treated with Ambush vs. unsprayed trees, Shafter, Kern County, 1982.

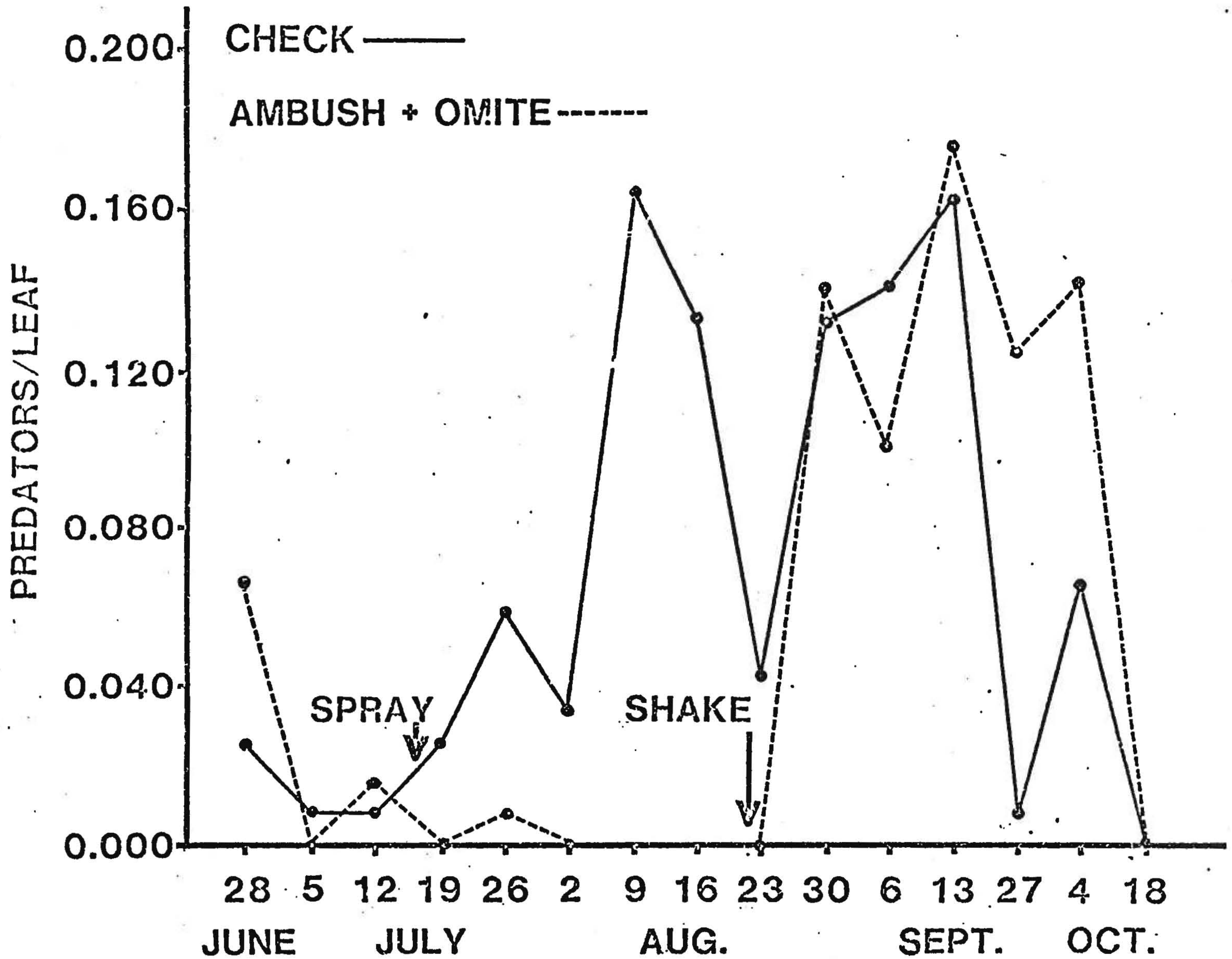

Fig. 3. Predator population trends in trees treated with Ambush + Omite vs. unsprayed trees, Shafter, Kern County, 1982.

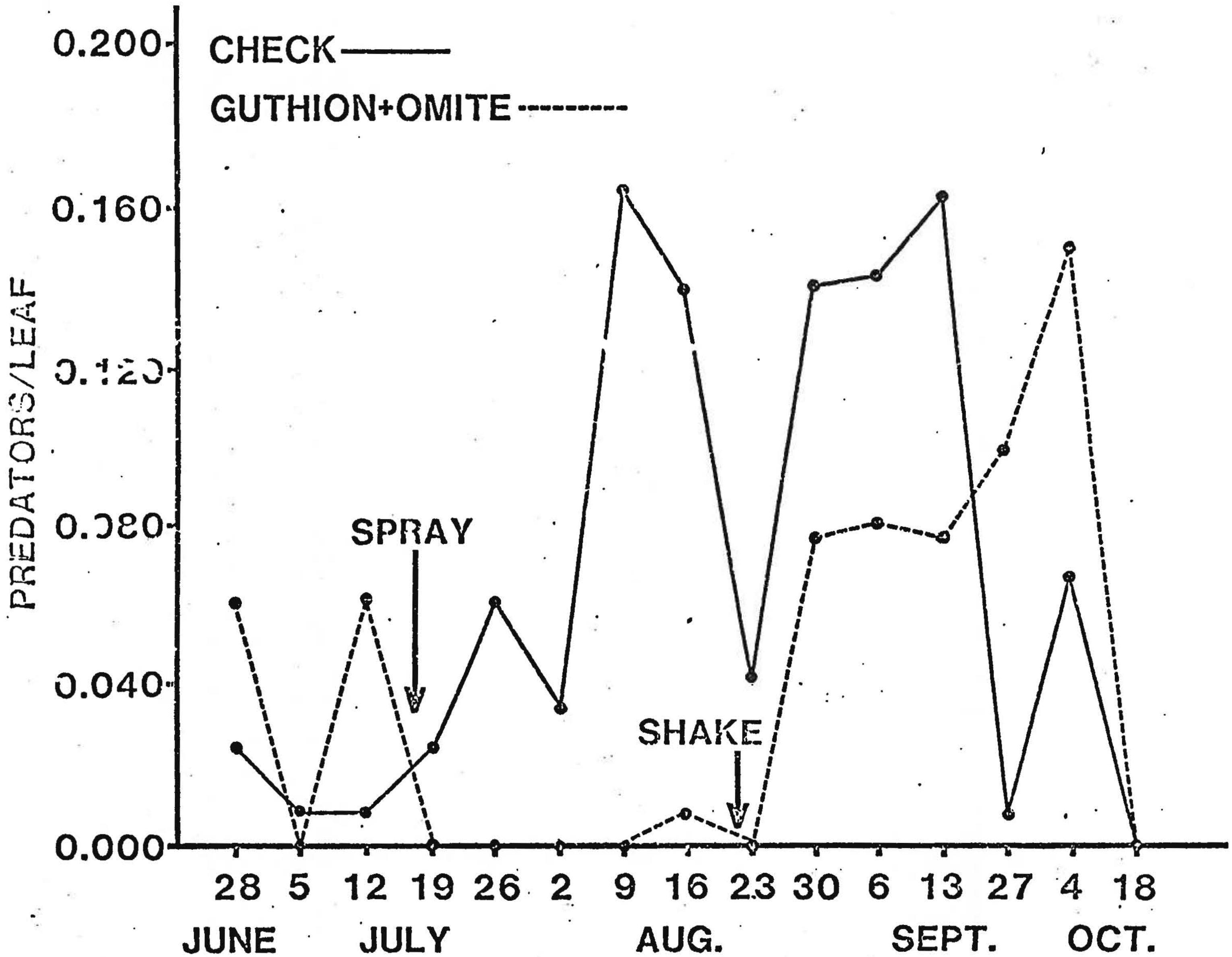

Fig. 4. Predator population trends in trees treated with Guthion + Omite vs. unsprayed trees, Shafter, Kern County, 1982.

sprayed with Ambush alone began to increase to an extremely high level. Concurrently the mite levels of the trees sprayed with treatments containing Omite remained low until 8/23, when the mite level of the Ambush-treated trees began to drop. In comparison a very slight, gradual peak occurred on the check trees during this time.

The trends in the predator population levels help explain these results. Compared to the check trees, the sprays eliminated much of the predators immediately after the sprays were applied, although there was little statistical difference in the averages. With no predators nor acaricide residue present to prevent an increase in spider mite levels, the Ambush-treated trees developed a huge population. [It must be mentioned, however, that this explanation may not be the complete reason for the dramatic increase. Other factors that play a part in pest resurgence (e.g. hormolygosis) may also be important]. The subsequent gradual decline in this spider mite population might be explained by a corresponding gradual increase in the predator population, although even the highest level the predator population attained was still rather low.

The increase in spider mite levels after 8/23 corresponded with the advent of harvest activities. By this date the acaricide residues would no longer have been effective. It is possible that the increased dust levels on the leaves stimulated a spider mite population increase that was then followed by an increase in the predator levels.

Finally, the mite levels on the check trees indicate that unsprayed trees had overall lower spider mite levels than sprayed trees in this orchard, even if trees were sprayed with an acaricide.

It has been reported that orchards treated with permethrin compounds for one year developed high mite populations early in the season the following year. This phenomenon, as well as others, will be investigated in 1983.

Trial of a Granular Systemic Insecticide, Aldicarb 15G (Temik), Applied to the Soil for Control of Mites on Almonds, 1982

J. P. Sanderson and M. M. Barnes

The purpose of this experiment was to evaluate the efficacy of aldicarb (Temik) 15% granular formulation in controlling spider mites on almonds when applied at 0.6 lb ai/acre 60 days prior to anticipated harvest. Samples were also taken for residue analyses but these data are not yet available.

Methods and Materials

The experiment was conducted in an orchard approximately 7 mi. SE of Mettler in the southern part of Kern County. Eight-year-old Nonpareil trees, planted in a 24 X 24 ft diamond configuration and irrigated by a Rainbird sprinkler system, were used. Six adjacent trees in each of 4 rows were selected, with 2 of the 4 rows being contiguous. Three adjacent trees in each row were treated with granular aldicarb, with the remaining 3 adjacent trees serving as controls. On 23 June, 1982, aldicarb 15G was applied at a rate of 0.6 lb ai/acre to the soil under the drip line of each side of the treatment trees by means of a commercial rig calibrated for granular aldicarb application and equipped with 2 shanks spaced 12 in. apart. The soil was somewhat moist on the day the aldicarb was applied, but the treatment date was taken to be 1 July, 1982, as this was the date the orchard was irrigated.

Mites from leaf samples were slide-mounted for identification and were determined to be *Tetranychus pacificus*. Leaves were sampled beginning with the pretreatment sample on 6/23 and subsequently on 1, 6, 16, 23, 30, 37, 44, and 58 days after the treatment date. Five leaves were taken from 4 quadrants of each tree at a height of 3 to 6 ft and from inside and outside the canopy.

The leaves from each tree were placed in labeled, moistened, paper bags and placed in an ice chest until they were counted under a dissecting microscope. Only active stages of the mites were counted.

Results

Table 1 presents the mean number of spider mites per leaf for each of the sampling dates.

It was necessary to inititate the experiment in June in order to allow for the 60-day pre-harvest application date. At this time a low level of mites was present on the trees but it was anticipated that the population would increase on the check trees with time. However, this was not the case and the mites remained at extremely low levels throughout the season. No significant difference (5% level) between the average number of mites per leaf on the aldicarb-treated trees and that of the check trees existed for any of the sample dates.

No phytotoxicity was observed associated with the aldicarb-treated trees.

Table 1. Aldicarb 15G efficacy trial. Average number of spider mites per leaf* for each sampling date.

	Sample date								
	6/23	7/2	7/7	7/17	7/24	7/31	8/7	8/14	8/28
Treatment	(Pretrt)	(1 day)	(6 days)	(16 days)	(23 days)	(30 days)	(37 days)	(44 days)	(58 days)
Aldicarb	0.15**	0.10	0.17	0.00	0.03	0.01	0.02	0.20	0.26
Check	0.07	0.06	0.17	0.10	0.09	0.26	0.13	0.22	0.24

* Samples based on 12 replicates of 20 leaves each per treatment.

** None of the means are significantly different at the 5% confidence level as determined by a paired t-test.