Project Number 75-E

TITLE: Investigations on Navel Orangeworm with Emphasis on Insecticide Programs

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I. OBJECTIVES and GOALS: Development of control programs for navel orangeworm using insecticides. Investigations include selection of insecticides and biological studies which are fundamental to their proper use, e.g. process of infestation during hull-crack in relation to timing, effects of N.O.W. insecticides on other insects and mites, effects of mites on tree productivity, etc. Our goal is the development and maintenance of economical insect and mite pest management in almond orchards. The locale of these efforts is in Kern County where Pacific mite is severe, peach twig borer significant, and each must be managed in a total program.

II. ABSTRACT: Early season treatments: Two sprays of 2 lb actual Guthion using wettable powder in 400 gal/acre (5/22 and 6/12) gave 58% reduction of N.O.W. damage in a 40-acre block. One treatment (6/12) in a second 40-acre block gave 46% control. Untreated blocks averaged 22-24%. Late season treatments: One treatment at 49% hull-crack (7/15) of 8 lb actual Sevin using wettable powder in 430 gal/acre gave 52% reduction in damage, 40-acre block. Comparable untreated block was 29% infested. A second treatment at 70% hull-crack did not improve control. Mite control with Omite should be obtained before use of Sevin; otherwise, Sevin results in severe mite defoliation; but not if mites are well controlled. Adding Plictran to Sevin aids in mite control but may not be adequate in all situations. Addition of Omite to Sevin needs trial. Thirteen insecticides were compared in post-hull-crack treatments and promising results obtained with 2 new pyrethroids used at 1/40th the rate of Sevin, each gave 60% reduction. Orthene, Imidan WP, Monitor and Lorsban also showed promise. Dimilin, Zolone EC, and Plictran showed little effect. Cultural procedure: Windrowing in the sun (young orchard, east-west rows) right after knocking gave 60% more mortality of larvae than leaving nuts in shade, within 6 days after knocking. Egg placement: After hull-crack, 48% of eggs are placed on the outside of the hull, the rest on the inside of the hull or on the shell. Larval development: Larvae hatching soon after hull-crack tend to bore into the nut at once, later on they tend to feed more on the hull. Eggs laid on newly-opened hull develop to moths in time to reinfest: first moth 29 days; 50% to moth stage, 40-45 days. Potential Practical Applications: (Includes summary of 1975 trials of this project and others available, not recommendations) One spray of Guthion wettable powder at 2 lb active ingredient/acre directed against activity of overwintering generation (timing varies with season and latitude) resulted in 1975 (5 trials) in average of 59% reduction in damage from N.O.W. and gave promising results on peach twig borer. Two sprays (7 trials) gave 66% reduction of N.O.W. One spray of Sevin (8 lb a.i./acre) post-hull-split gave 52% reduction in damage. Application of Sevin must be preceded or accompanied by adequate use of acaricides. One early season spray of Guthion followed by a post-hull-split spray of Sevin gave 71% reduction. Tentatively, post-hull-split treatment should begin when hull-split is 5% in any part of orchard. Several other materials show promise at lower rates. Windrowing in the sun immediately after knocking gave 60% more mortality of larvae within 6 days, as compared with leaving nuts as knocked in shade. This practice should reduce pin-hole damage.

III. EXPERIMENTAL PROCEDURES: Two approaches to chemical control involve suppression of the population by 1) treatment(s) directed against the overwintering population in early season (May and/or June in 1975, but this varies with season and latitude) and 2) by treatment(s) after hull-crack begins.

Early season suppression trials are best carried out in large blocks as moths disperse from untreated areas and the results may be biased if moths re-infest the treated area before hull-crack. Use of large blocks takes advantage of partial control through moth kill as well as effects on eggs and newly hatched larvae. Late season (post-hull-crack) trials with insecticides conducted in large blocks also take advantage of effects on moths as well as on eggs and newly-hatched larvae. Post-hull-crack trials involving single tree plots replicated in randomized blocks measure effects on eggs and newly-hatched larvae only.

In 1975, large block suppression trials were carried out in both early season and post-hull-crack, and post-hull-crack treatments of 14 materials were compared in plots replicated 10 times.

An experiment was also carried out with 8 replications on effects of different procedures in managing the crop after knocking on navel orangeworm mortality. An experiment with 23 replications was begun on effects of Pacific mite on almond tree productivity. Details of this and of methods used in other experiments are given in later sections.

IV. RESULTS: Large block trials.

Large block-early season suppression with Guthion.--According to current information, Guthion may not be applied within 60 days of harvest because of residue restrictions. One versus two treatments with Guthion were compared, treating 40-acre blocks in each, and comparing with adjacent, untreated 40-acre blocks. A 50% formulation as a wettable powder was applied in 400 gallons per acre at the rate of 2 lbs active ingredient (a.i.) per acre. The spray equipment provided only fair coverage, the infestation was heavy, and the results may be considered to be the minimum which can be expected under similar conditions. Results are shown in Table 1.

Table 1. Early season suppression of navel orangeworm infestation, Nonpareil almonds, McFarland, Calif., 1975.

Treatment[1]	Schedule	N.O.W. infestation at harvest (%) [2]	Comparable check (%)[3]	% Control
1. Guthion (WP) 2 lb a.i./A	May 22 & June 12	9.2	21.9	58
2. Guthion (WP) 2 lb a.i./A	June 12 only	13.1	24.1	46

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[1] Applied in 400 gal/A, air-blast sprayer; treated blocks and checks - 40 acres each.

[2] August 26. Average of 12 samples of 400 nuts each. Each sample was drawn from the composite harvest of 3 trees in the center area of the 40-acre blocks.

[3] Difference between treated and check significant at odds of 99:1.

<u>Large-block post-hull-crack treatments with Sevin</u>.--Sevin is less restricted as to residues and may be applied at hull-crack. A 40-acre block was treated using the 80% wettable powder at 47% hull-crack (later than desired) at the rate of 8 lb a.i. in 430 gal/acre. Ten rows in this block (approximately 5 acres) were treated again in this same manner after 2 weeks. The air-blast sprayer used provided only fair

coverage, the infestation was heavy, and the results may be considered to be the minimum which can be expected. Results are shown in Table 2.

Table 2. Suppression of navel orangeworm infestation by treatment at hull-crack, Nonpareil almonds, McFarland, Calif., 1975.

Treatment[1]	Schedule	N.O.W. infestation at harvest (%)[2]	Comparable check (%)	% Control
1. Sevin (WP) 8 lb a.i./A	July 15	14.0 ± 8	29.2 ± 8	52
2. Sevin (WP)	July 15 and 29	13.9 ± 4	29.2 ± 8	52

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[1] Applied in 430 gal/A, air-blast sprayer. Treatment 1, 40 acres; Treatment 2, 5 acres.

[2] August 26. Average of 12 samples of 400 nuts each. Each sample drawn from composite crop of 3 trees.

The lack of increased control by a second application may be due to 1) timing too late, 2) variation in infestation, or 3) inability to control larvae from eggs placed within open hulls.

The orchard in which the trial described in Table 2 was conducted had a moderate population of Pacific mites at the time of treatment. The Sevin treatment alone resulted in heavy mite damage and defoliation. Two blocks of 5 acres each, along each edge of the 40-acre block of this Sevin trial, were treated for mites by adding Plictran 50W at the rate of 10-3/4 oz a.i./acre on July 15 (treatment 1 in Table 2). This succeeded in suppressing mite populations satisfactorily in one of the 5-acre blocks, but not in the other which was subject to road dust from construction activity.

In 1974, Sevin was used in single and multiple applications in orchards (two varieties) in which mite populations had been suppressed with Omite, and no mite problem developed after the Sevin applications. Sevin is best employed in almond orchards where mite populations have been thoroughly suppressed by prior application of Omite or an equally effective acaricide. If this is not the case, then Plictran or Omite WP must be added. Restrictions with respect to interval between application and harvest must be observed with all materials.

Discussion of Large Block Trials: Results from individual large block trials expressed as percent control of navel orangeworm in Tables 1 and 2 should be interpreted in a conservative manner, since variation in infestation from one part of a large orchard to another blurs precision in results. It appears, however, that one application of Guthion in early season suppresses the damage by about 50%, and one application of Sevin at hull crack reduces infestation by about 50%. It seems reasonable to state, therefore, that if such applications were applied in sequence, they would control 75% of a severe infestation.

RESULTS and DISCUSSION: Replicated trials.

Replicated comparisons of insecticides applied during the post-hull-crack period:--A comparison was made for larvicidal action among 14 materials. These were applied to Nonpareils in full-coverage sprays by handgun to 10 single-tree replications in randomized blocks. The first application was at 29% hull-crack (July 22) and the second 2 weeks later (August 4) at 71% hull-crack. A total of 4000 nuts (400/tree) were cracked from harvest samples from each treatment to determine levels of damage. Samples of hulls and nuts were also taken at harvest from several treatments for insecticide residue analyses. The results of these analyses are not available at this time.

Table 3 shows the rates of application and the resulting navel orangeworm infestation of almond meats.

Every effort was made to place this experiment in a relatively uniform stand of trees. Tree-to-tree variation for the same treatment schedule and among untreated trees was very large, however. Trees within 6-8 rows of the border showed higher infestation and variation of infestation among trees further within the orchard was excessive. For this reason, discrimination between treatments even with 10 replications was not as satisfactory as desired. Future comparisons of this sort should be located well within the orchard (at least 8 trees within) and involve fewer treatments with more replications. Timing should be at 1-5% hull crack.

Data from this trial (Table 3) show the best performance from Sevin, the synthetic pyrethroids (SD 43775, ICI PP 557, and FMC 33297) Orthene, Imidan wettable, Monitor and Lorsban in that order, though the differences are not significant at odds of 19:1. No control resulted from Plictran and Dimilin; and Zolone emulsifiable and Imidan emulsifiable were poor.

At the time the first treatment was applied, there was a significant Pacific mite infestation in the orchard. On August 20, each tree was rated visually as being in one of 3 categories as to mite damage: 1. good, 2. medium, and 3. severe. The results of this assessment are shown in Table 3. Monitor, emulsifiable Imidan or Zolone, and Plictran showed mite suppression.

An additional trial was conducted comparing several materials in replicated plots on Merceds. An infestation failed to develop in this block as water had been withdrawn and the hulls failed to open, and results from residue analyses are not yet available.

Table 3. Comparison of larvicidal action against navel orangeworm provided by full-coverage sprays in the post-hull-crack period, Nonpareils, McFarland, Calif., 1975.

Treatment[1]	Formulation	Active ingredient per acre (lb)[1]	% damage to kernels at harvest[2]	Average mite damage rating[3]
1. Shell SD 43775	2.4 EC	0.2	4.2	2.3 (7)
2. Sevin	80 W	8.0	4.4	2.9 (13)
3. Sevimol 4	4 E	8.0	5.0	3.0 (15)
4. ICI PP 557[4]	2 EC	0.2	5.2	2.9 (13)
5. FMC 33297	3.2 EC	0.2	5.3	2.7 (10)
6. Orthene	75 SP	4.0	5.5	2.7 (10)
7. Imidan	70 W	4.0	5.7	2.2 (6)
8. Monitor	4 S	4.0	6.3	1.4 (1)
9. Sevin, liquid	4 E	8.0	6.7	2.8 (12)
10. Lorsban	25 W	0	7.6[5]	2.1 (5)
11. Imidan	2 S	4.0	7.8	1.5 (2)
12. Zolone	3 EC	4.0	8.0	1.8 (3)
13. Plictran	50 W	2.0	9.3	1.9 (4)
14. Untreated	----	---	10.1	2.6 (9)
15. Dimilin	25 W	2.0	10.4	2.5 (8)

[1] Applied by handgun July 22 and August 4 in 800 gal/acre to 10 single-tree replications in randomized blocks.

[2] August 26. Average of harvest samples of 400 nuts from each of 10 trees.

[3] All trees rated on August 20 as to Pacific mite damage, -1, good; 2, medium; and 3, severe. Numbers in parentheses are the rank-order.

[4] Treatments 4 and 5 are the same compound, different formulations.

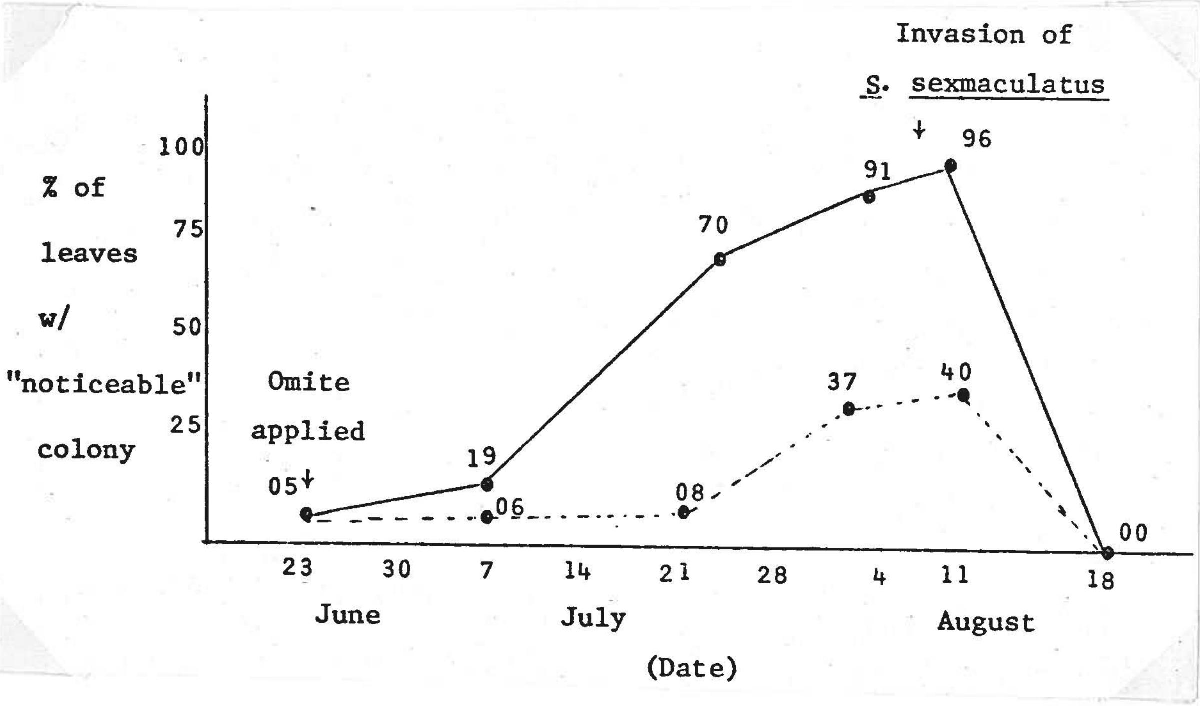
[5] Treatments 1-10 not different at 19:1.

Preliminary Report on
Effects of spider mite feeding on almond tree growth and yield

K. L. Andrews

A well-replicated study designed to assess the impact of spider mite feeding on tree growth and yield was initiated in June 1975. Pacific mite was the dominant species present. Twenty-three pairs of trees were selected and one of each pair treated with Omite 30W at 1.3 lb per 100 gal. Large numbers of sixspotted thrips invaded from an adjoining drying corn field in late July and nearly annihilated the mite populations in this experiment. Thus, less significant differences in infestation rates, feeding injury, and defoliation were recorded than would have been the case otherwise.

On six dates during the period June 23 to August 19, 24 leaves were selected at random from each of the 46 experimental trees. The numbers of those leaves that had at least one "noticeable" mite colony (i.e. had mites, webbing and stippling all present) are reported in the following figure as percentages of the total number of leaves checked.



The highest mites/leaf values were recorded on July 31. On this date there was an average of 27 mites/leaf on the infested trees and 8 mites/leaf on the control trees. By August 8 these values had declined to an average of about 8 per leaf on each set of trees and by August 19 mites were virtually nonexistent in the test area.

The infestations did persist long enough, however, to cause significantly (.01 level of certainty) greater defoliation of the infested trees than of the control trees (32.2 and 24.5%, respectively).

In mid-September defoliation counts were made at 48 different sites on each experimental tree. The limbs checked were equally distributed around the trees at heights of about 6, 9, and 13 ft. At each site branches were selected randomly until one with at least 26.7 cm of first- or first- and second-year growth was found. Counts were made on 25 cm of the 1st- or 1st- and 2nd-year wood beginning 1.7 cm from the distal tip. The number of leaves on 1st-year wood plus the number of vegetative spurs w/at least one leaf on 2nd year wood gave a value for "number of undefoliated leaf sites". The number of leaf scars on 1st-year wood, plus the number of leafless vegetative spurs on 2nd-year wood produced a value for "defoliated leaf sites".

By plugging these values into the following formula, a value for the % defoliation of each monitored limb was obtained:

$$\%\ \text{defoliation} = \left(\frac{\#\ \text{defoliated leaf sites}}{\#\ \text{defoliated leaf sites} + \#\ \text{undefoliated leaf sites}}\right)$$

Then, by taking an average of the 48 values obtained for each tree, an estimate for % defoliation of each tree was made.

The amount of stippling as determined by a reflectance meter (manufactured by Ennis & Assoc.) was significantly greater (at odds of 99:1) on leaves from the infested trees than on those from control trees. Leaves from the infested trees had an average reflectance reading of 59.1 while the control trees' leaves had an average reading of 54.2. These readings are in the process of being related to mite feeding areas.

The uniformity of this year's yield data shows that the trees were well paired. The yields of dry nut meats per tree averaged 13.4 and 13.7 lb for the infested and control trees, respectively. This uniformity was as expected since mite populations do not build up until the current year's crop is well on its way to maturity; effects of mite feeding, if they develop, would be expected to appear in the year following infestation.

The average weight of 100 normal kernels was 115.3 g for the infested trees and 113.9 g for the control trees. These values are not significantly different. The small numbers of blanks and doubles encountered did not differ significantly for the two treatments.

Several of this year's observations are not yet completed. Trunk girth measurements will be made after all leaves have fallen. Determinations of the carbohydrate content of limbs and the numbers of sticktights remaining in the trees will also be made at this time.

Development of a method for quantifying defoliation using photography was begun in the fall, and tests of the method indicated its feasibility.

Preliminary Report on
A Method for Monitoring Female N.O.W. Moth Movement

K. L. Andrews

Of the approximately 80 dyes that have been tested in this laboratory, two have been found which result in internally-marked adult females that lay colored eggs. They are Calco Oil Red N-1700 and B.A.S.F. oil soluble deep black B.B. The former results in newly-laid eggs that are uniformly pink while the latter produces turquoise-colored eggs. Deleterious effects on development time, behavior, or morphology have been associated with the introduction of 0.025% (by weight) red dye into larval media. Laboratory tests are currently underway to determine if concentrations of the black dye can be found which always produce marked eggs but do not induce deformed or sluggish adults; this tye at 0.05% produces significant numbers of adults that either have unextended wings or are uncommonly small, while dye at half that rate leaves a proportion of the eggs unmarked.

A small scale test was conducted in mid-September that showed the feasibility of tracing moth movement by releasing Calco oil red marked ♀ moths in the center of an area which was surrounded by trees in which egg traps had been hung. For the first 24 hours the eggs from the marked females could be readily distinguished from the cream-colored freshly-laid eggs of the wild females. After 24 hours, however, eggs from both sources had turned the orange-red color characterisitic of maturing N.O.W. eggs. This means that in future tests either 1) traps will have to be replaced daily or 2) a dye giving very different colored eggs (say, blue or green) will have to be used.

A Procedure to Minimize Navel Orangeworm Larval Feeding During the Period Between Shake and Pickup

Keith Andrews and Robert Curtis

Feeding by larvae in the interim between shaking and harvesting (pickup) can result in significant nut meat damage, especially if this period of time is prolonged as frequently may be the case. A mid-August test in a young Kern County orchard with a history of severe NOW damage was undertaken to determine which of two procedures is more effective in minimizing damage occurring during this time.

The two procedures tested are 1) leaving the nuts scattered, i.e. delaying sweeping and windrowing until just before pickup, and 2) windrowing the nuts as rapidly after shaking as possible and leaving them in these windrows until they can be picked up.

Furthermore, to make the results of the test applicable both to older orchards with shaded floors and to young orchards in which the ground surface receives much direct sunlight, windrows were constructed in two different places. First, to simulate conditions found in old, shady orchards, windrows were built on the north sides of trees near the trunk base so that they were well protected from direct sunlight during the hottest part of the day. Second, to simulate conditions found in young orchards, windrows were constructed midway between adjacent rows so that they would receive direct afternoon sunlight (rows were running east to west). In summary, three treatments were analyzed in this experiment: 1) leaving nuts scattered, 2) windrowing in the shade on the north side of trees, and 3) windrowing midway between rows and open to sun.

The experimental layout consisted of 8 randomized blocks, with the 3 treatments outlined above, yielding a total of 24 experimental units. To insure identical initial infestation rates for the 3 treatments within each block, the nuts from 3 trees were hand-knocked onto a canvas, thoroughly mixed, and then divided equally among the 3 treatments. The nuts in the unwindrowed treatment were scattered under the trees by hand. The windrows were made with leaf rakes and were approximately 3 in. deep and 12 in. wide.

The nuts were left in the field for 6 days. At the end of this period samples were scooped at random out of each of the 8 replicates of the differently exposed windrows, sampling equally from all depths. The unwindrowed nuts were also sampled at random, taking one subsample from the ground under the southern half of the tree canopy, and another from under the northern half. The samples were immediately put into cold storage and cracked out within a 2-day period. The number of live NOW larvae in 35 damaged nuts was recorded in each of the 8 samples from each treatment.

To better understand differences in heat-mortality of larvae in the different treatments, temperature readings were taken with a YSI Telethermometer Thermistor during the 4 hottest days of the 6-day test. The localities monitored included: internal temperature of infested nuts in 10 different locations, ground surface temperatures readings, and ambient air temperature readings. Values for the first 2 days of the test were not recorded, as they were unseasonably low.

On the final day of the test, observations were made to assess the amount of egg laying occurring during the test period. The number of fresh NOW eggs on 100 nuts in each of the 3 treatments and on 108 sticktight nuts of the new crop in the test trees were recorded. The results of the oviposition counts are summarized in Table 1.

Table 1. Number of fresh N.O.W. eggs found on nuts in 4 different locations at end of 6-day period after shake.

Location of nuts	No. nuts checked	No. fresh NOW eggs
1. Shaded windrows	100	0
2. Windrows exposed to sun	100	0
3. Scattered on ground	100	0
4. New crop sticktights in trees	108	86

No oviposition occurred on grounded nuts, while heavy oviposition continued on sticktight nuts of the new crop.

Table 2 presents the total and average number of live NOW larvae found in each treatment at the end of the 6-day exposure period. Tukey's w - procedure was used to analyze differences between treatment means.

Table 2. Number of live NOW larvae found at the end of the 6-day exposure period after shake in each of the 3 treatments.

Treatment	Total no. living NOW larvae in 8 replicates		Average no. living NOW larvae per 100 damaged nuts	
1. Scattered under tree				
North canopy	61		43.6	
South canopy	18		12.8	
Total		79[1]		28.2
2. Shaded Windrows		118[1]		42.1
3. Windrows exposed to sun		31[1]		11.1

[1] Total sample = 280 NOW damaged meats.

At odds of 99:1, there were significantly (60%) fewer live larvae in nuts in the windrows exposed to direct afternoon sunlight than in those windrowed in the shade or left scattered. At the .05 level of certainty there were fewer living larvae in the scattered nuts than in nuts in the shaded windrows.

Table 2 also summarizes the total number of live NOW larvae found in each subsample of the unwindrowed nuts. At the end of the 6-day period a t - test for paired data was used to analyze differences between subsamples. At odds of 99:1, nuts scattered under the southern half of tree canopies, and thus more exposed to the sun, had fewer living larvae than nuts scattered under the northern canopies.

Table 3 presents both average and extreme maximum daily temperatures for each area monitored during the hottest 4 days of the test.

Table 3. Average and extreme maximum temperatures for various locations during 4 hottest days during period of August 17-22, 1975.

Location		Average maximum temperature (°F)	Extreme maximum temperature (°F)
Air		91	96
Ground surface in sun		116	120
Ground surface in shade		93	102
Windrow exposed to sun:	Top	132	136
	Middle	108	115
	Bottom	95	96
Shaded Windrow:	Top	110	116
	Middle	100	102
	Bottom	91	94
Single nut on ground in sun		116	124
Single nut on ground in shade		91	93
Single new crop sticktight in sun		96	101
Single new crop sticktight in shade		90	92

Nut temperatures on top of windrows exposed to afternoon sunlight were 40°F hotter than ambient air temperatures during the hottest part of the day.

Two factors contribute to decreased NOW damage in the interim between shake and harvest: 1) movement of larvae out of nuts in contact with the hot ground surface,--such hurried exits were observed in the field on several occasions, and 2) direct mortality because of excessive heating and/or desiccation.

At the time of shake, almonds may have unhatched eggs and very small newly hatched larvae, as well as older larvae that have already caused considerable damage. It follows from this trial that, in young sunny orchards, rapid windrowing of nuts into areas exposed to direct afternoon sunlight will stop some feeding damage before it becomes economically significant. However, some nuts are so badly damaged at the time of shake that continued NOW feeding is of no consequence. In commercial situations where the windrows would be less than 3 in. deep, mortality would be expected to be higher than in this trial; no insulation of nuts deep in the pile could occur.

Rapid windrowing is apparently not a useful tactic for operations in older completely shaded orchards; NOW mortality in windrows on shaded orchard floors cannot be expected to exceed mortality occurring in shaded scattered nuts.

Development of the Navel Orangeworm on Nonpareil Almonds in the Field After Hull-Crack

R. K. Curtis

A study following the larval development and adult emergence of the navel orangeworm reared on Nonpareil almonds after hull-crack in the field was conducted in a Superior Farms, Famoso (Kern County) orchard from July 24 to September 22, 1975.

Three groups of newly-cracked fruit confined by nylon netting bags were artificially infested with eggs laid on paper toweling by field-collected females. Starting four days after infestation and continuing for 38 days, 2 infested nuts were collected every 4 days from each group of nuts. The stadium and feeding sites of larvae within these nuts was recorded. In each bag, adult emergence was also noted.

From this study, the stage of development of the navel orangeworm in nutmeats in relation to nights elapsed after oviposition was determined. Moth emergence began 29 days after oviposition and continued for more than 30 days. Fifty percent emergence occurred on the 43rd night after oviposition.

Navel Orangeworm Oviposition and Larval Feeding on Maturing New Crop Nonpareil and Merced Almonds

R. K. Curtis

Nut sampling studies were conducted during the period of hull-crack initiation to harvest for both Nonpareil and Merced variety almonds during the summer of 1975 in two Kern County orchards. The objectives of this study were to determine 1) at what stage of new crop maturation will oviposition commence, 2) where oviposition occurs on the almond fruit, 3) whether oviposition preferences exist--such as preference for previously infested nuts over uninfested nuts, and 4) the location of larval feeding, in hull or nutmeat, with respect to larval age and nut maturation.

Samples from each orchard were taken approximately every 4 days during the course of the study. The maturity of nuts collected was recorded. Almond fruit were inspected for eggs and larvae using either a Luxo illuminated magnifier or a dissecting microscope.

This study demonstrated that 1) eggs laid just prior to hull-crack initiation will give rise to larvae which will successfully invade nutmeats, 2) after fruit are open, approximately 50% of the eggs are laid within the dehisced area between the hull interior and the shell,--an area which is difficult to reach with insecticide deposits unless systemic activity is present,--while the other 50% are laid on the hull exterior, 3) in the early stages of fruit dehiscence, the majority of NOW larvae will establish immediately in nutmeats (this was also verified by the above development study), and 4) female moths will preferentially oviposit on already infested fruit rather than on uninfested fruit.

Based on the above observations, the most critical and advantageous timing of hull-crack sprays which will suppress NOW larval feeding in nutmeats appears to be the period just prior to and during hull-crack initiation.

More detailed reports of the above two studies will follow. In addition, more on trap development will be reported.