Almond Board of California

Annual Report - 1983

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Project No. 83-F3 - Navel Orangeworm, Mite and Insect Research
Pest Phenology and Monitoring Techniques

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Objectives: (1) Evaluation of crude almond oil dispensers for use in egg traps. (2) Evaluation of inert carriers for almond oil sprays. (3) Re-evaluation of San Jose scale and peach twig borer pheromone cap longevity. (4) Optimum timings for SJS and PTB timings based on phenology model predictions (D°).

Interpretive Summary:

1. Crude almond oil was evaluated as an attractant and stimulant for navel orangeworm oviposition on egg traps by loading 2.0 ml of oil in 28 sq. cm. PVC pouches (Borregaard Industries, Ltd., Sarpsborg, Norway), and placing the pouches inside egg traps instead of almond press cake. Over a 4-wk period, standard egg traps with press cake collected an average of 8.4 eggs/trap/week, while traps containing almond oil in PVC pouches collected 0.1 egg/trap/week. Although the oil readily moved to the outside surface of the PVC pouch, apparently not enough attractant odors were released to attract female moths. The presence of free almond oil on the pouch surfaces also presented a handling and contamination problem.

2. A colloidal attapulgite clay material (Min-U-Gel 400, Floridin Co., Pittsburgh, Pa.) was added to crude almond oil to try to increase residual activity of the oil and improve disruption of NOW oviposition. Crude almond oil was applied at 12 gpa alone, and in combination with Min-U-Gel at 160 lbs./ac. Neither treatment significantly reduced NOW oviposition when compared to oviposition on standard egg traps in an untreated check.

3. Field longevities of pheromone caps (Zoëcon Corp., Palo Alto, Calif.) were re-evaluated for San Jose scale and peach twig borer. The results of these tests showed that the scale pheromone caps will last for 4 weeks before they should be changed. The peach twig borer caps, however, lasted only two weeks before requiring a cap change, which confirms observations made by UCR researchers in 1981-82.

4. Optimum timings for spray treatments directed against San Jose scale and peach twig borer in May were confirmed in 1983 field tests. For PTB, best timing is at 400-500 D° after first moths are collected in pheromone traps in April. Optimum spray timing for SJS is 600-700 D° after first male collections in pheromone traps in March, <u>or</u>, 200-300 D° after first crawler collections on sticky tapes in April or early May.

I. Evaluation of Borregaard PVC Pouches as Dispensers for Crude Almond Oil Attractants.

2.0 ml of crude almond oil was loaded into 28 sq. cm PVC pouches and the pouches then placed into standard Zoëcon NOW egg traps. Oviposition on these traps was compared to egg traps containing 15 gms almond press cake. One trap of each type was placed in each of five mature almond trees, with the traps ca. 3-4 ft. apart. Mated, pre-oviposition NOW females were released 2-3x/wk. in the orchard, as feral NOW populations were extremely low.

The results of these comparisons (Table 1) showed that use of standard dry almond press cake in traps was a much better method for measuring NOW oviposition than traps containing crude almond oil in PVC pouches.

Previous work has shown that crude almond oil is attractive and induces NOW oviposition. Apparently, the attractant odors from the oil are not released in sufficient quantities from the pouches to attract NOW females and cause them to lay on the egg traps.

Table 1. Comparison of Crude Almond Oil in PVC Pouches and Almond Press Cake for Inducing NOW Oviposition on Egg Traps

	Avg. No. NOW Eggs/Trap/Wk. 1/					
	Week					
Treatment	1	2	3	4	5	6
2.0 ml oil in PVC pouches 2/	0.2	0	0.2	0	0	0
15 g almond press cake	7.6	16.0	3.8	6.0	0	0

1/ 5 replicates per treatment, counted 2x/wk. No nuts on trees for competition.

2/ Borregaard Industries, Ltd., Sarpsborg, Norway.

II. Disruption of NOW Oviposition Using Crude Almond Oil Sprays With and Without Inert Extenders.

The concept of using sprays of crude almond oil and/or almond press cake to disrupt oviposition and host finding by NOW females has been discussed for several years. A test was made to measure the efficacy of crude almond oil sprays with and without an inert extender on NOW oviposition. Sprays of 12 gpa crude oil plus 1% Triton-363 emulsifier were compared to similar sprays also containing 160 lbs/acre of Min-U-Gel 400. Min-U-Gel 400 is a colloidal attapulgite clay material used as a spreader-sticker material in commercial paints, and as a component in bait-station spot-treatments for the oriental fruit fly.

Sprays were applied by handgun at 400 gpa and 100 psi to mature almond trees at Parlier, Calif. on 12 Sept. 1982. A standard NOW egg trap was placed in each tree to measure the amount of NOW egg-laying for several weeks after treatment.

The results of this test (Table 2) showed no significant differences in NOW oviposition activity between the sprayed trees and untreated check trees. The lack of statistical differences between these treatments is somewhat surprising, especially during the 2nd and 4th weeks. However, this is believed to be the result of inconsistent oviposition between traps in any treatment. Greatly increasing the numbers of replications per treatment may have alleviated this problem to some extent.

Table 2. Disruption of Navel Orangeworm Oviposition Using Crude Almond Oil and Min-U-Gel 400 1/

Treatment	Avg. No. NOW Eggs/Trap/Wk. 2/ 1	2	3	4	5	6
Untreated Check	7.6 a	16.0 a	3.8 a	6.0 a	0	0
Crude Almond Oil - 12 gpa + 1% Triton 363	10.8 a	3.6 a	1.6 a	0 a	1.2	0.2
CAO + Min-U-Gel 400: 12 gpa Oil + 1% Triton 363 + 160 lbs MUG/ac.	7.2 a	7.0 a	0.6 a	9.8 a	0	0

1/ Floridin Co., Pittsburgh, Penn.

2/ 5 press cake egg traps/trtmt. Traps out 9-12-83. No nuts on trees for competition.

III. Optimum Spray Timing for In-Season Control of San Jose Scale and Peach Twig Borer.

Sprays of diazinon 50 W at 2.0 lbs. a.i. per acre were applied by handgun at 400 gpa to mature plums and nectarines for determination of optimum timing to control crawlers of San Jose scale. These hosts are used for scale tests because of the relative ease of comparing treatments based on infested fruit. Timings of scale sprays were based on accumulated day-degrees (D°) after first male scales were trapped in pheromone traps.

Similar sprays of diazinon were applied to 3rd leaf almonds for optimum timing tests for control of peach twig borer. Almonds are the preferred test crop for PTB due to greater accuracy in identifying twig strikes, and the usual absence of interference from similar-appearing twig strikes caused by oriental fruit moth. The treatment timings for PTB were determined by accumulated D° after first PTB moth collections in pheromone traps.

The results of these tests (Tables 3 & 4) show that the optimum timing for sprays to control 1st generation San Jose scale crawlers is 600-700 D° after 1st males are trapped. The optimum timing for control of 1st generation PTB larvae is 400-500 D° after 1st male collections (Table 5).

TABLE 3. OPTIMUM TIMING FOR CONTROL OF SAN JOSE SCALE ON FRUIT. PARLIER, CALIF.

DAY-DEGREES > 1ST MALE	MEAN NO. SJS CRAWLERS PER REP. 1982[1]	1983[2]
CHECK	5.74 A[3]	3.63 A
300°	--	2.55 B
400°	4.85 AB	2.01 BC
500°	3.92 B	1.65 C
600°	3.84 B	1.60 C
700°	3.87 B	1.64 C
800°	--	1.83 C

1/ 4 REPLICATES, 100 FRUIT PER REPLICATE.
2/ 8 REPLICATES, 100 FRUIT PER REPLICATE.
3/ MEANS IN COLUMNS FOLLOWED BY THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT AT P = .05, DMRT. DATA TRANSFORMED TO $\sqrt{X+.5}$

R.E. RICE & R.A. JONES, KEARNEY AGRIC. CENTER, U.C. AGRIC. EXPT. STA.

TABLE 4. NUMBERS OF SAN JOSE SCALE CRAWLERS COLLECTED ON STICKY TAPES DURING AND AFTER CHEMICAL SPRAYS AT SELECTED INTERVALS. PARLIER, CALIF. 1983

TREATMENT - D° > 1ST MALE	MEAN NO. CRAWLERS PER TREATMENT TIMING: 1ST GEN. (TREATED)[1]	2ND GEN. (1ST POST-TRT.)[2]	3RD GEN. (2ND POST-TRT.)[3]
CHECK	15.4 AB[4]	22.8 A	79.0 A
300°	27.4 C	31.0 A	80.6 A
400°	19.1 ABC	22.0 A	58.4 A
500°	17.8 ABC	12.2 B	42.6 B
600°	11.3 B	3.1 C	31.3 B
700°	11.3 B	2.5 C	20.1 C
800°	24.4 A C	11.3 B	59.3 A

1/ MAR. 30-JUN. 15. 9 REPS PER TREATMENT.
2/ JUN. 22-AUG. 17. 9 REPS PER TREATMENT.
3/ AUG. 17-OCT. 5. 7 REPS PER TREATMENT.
4/ MEANS IN COLUMNS FOLLOWED BY THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT, P = .05 ANOVA AND DMRT.

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TABLE 5. OPTIMUM SPRAY TIMING FOR CONTROL OF PEACH TWIG BORER.

DAY-DEGREES > 1ST MOTH	$\bar{X}$ NO. PTB STRIKES PER TIMING 1981	1982	1983
300 D°	3.8 AB[1/]	0.2 A	9.0 AB
400 D°	1.0 A	0.0 A	4.2 A
500 D°	0.8 A	0.1 A	7.8 AB
600 D°	5.4 B	3.6 B	9.1 AB
CHECK	15.6 C	8.1 C	16.8 B

1/ MEANS FOLLOWED BY THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT AT P = .05 DMRT.

R.E. RICE & R.A. JONES, KEARNEY AGRIC. CENTER, U.C. AGRIC. EXPT. STA.

IV. Evaluation of Pheromone Cap Longevities for Peach Twig Borer and San Jose Scale.

Research by Mr. Rod Youngman, UCR, in 1981-82 indicated that Zoëcon pheromone caps for PTB were not lasting as long as had been previously reported. Therefore, cap longevity tests for PTB and SJS pheromone were conducted during early season (cool weather) and late season (hot weather) in 1983.

The results of these tests (Tables 6 & 7) show that in both early and late season tests, commercial pheromone caps lost optimum attractancy after only 2 wks. field exposure. These data confirm the earlier data from UCR.

Longevity of the San Jose scale pheromone caps was shown to be ca. 4 wks., similar to earlier longevity tests.

Table 6. Pheromone Dispenser Longevity Studies - 1983
Peach Twig Borer, *Anarsia lineatella* (Zeller)

Treatments: Date of Cap Manufacture	Mean No. PTB Moths Collected 1/								
	Weeks Exposure								
	1	2	3	4	5	6	7	8	9
Test I: 4/20-6/23									
13 Dec. 81-AA	8.0ab	17.2a	17.0 b	15.2a	15.8a	1.0a	7.8ab	7.8a	13.3ab
28 July 82- A	12.5 b	24.5a	27.3 c	38.0 b	35.3 b	1.2a	20.5 b	14.5 b	20.0 b
22 Mar. 83- B	7.5ab	7.7 b	5.3a	7.7a	8.7a	0.5a	3.0a	4.3a	4.3a
22 Mar. 83- C	5.7a	7.5 b	14.5 b	12.2a	56.8 c	1.7a	72.7 c	29.7 c	94.8 c
Test II: 8/16-10/4									
13 Dec. 81-AA	39.3a	34.3a	43.2 b	15.3ab	4.0ab	5.0 b	0.5a		
28 July 82- A	37.5a	43.8a	45.3 b	24.2 b	10.5 b	8.2 c	2.0a		
22 Mar. 83- B	31.5a	33.2a	23.2a	8.8a	3.0a	1.8a	0.2a		
22 Mar. 83- C	37.0a	24.0a	78.3 c	23.0 b	50.8 c	30.3 d	15.0 b		

1/ ANOVA & DMRT @ p = .05. Means in columns followed by the same letter are not significantly different.

Peach Twig Borer Pheromone Dispenser Longevity Studies

Two weathering tests were conducted in 1983 with old and new commercial dispensers (caps) of peach twig borer (PTB) pheromone obtained from Zoëcon Corp., Palo Alto, Calif. The tests were placed in a 4th leaf almond orchard near Clovis, Fresno Co. from April 20 to June 23 (cool weather) and from August 16 to October 4 (hot weather). Plot designs in both tests were randomized complete block arrays with 4 treatments and 6 replicates. Pheromone caps in treatments AA, A, and B were not changed during each test, while treatment C caps were replaced with fresh caps every 2 wks. Caps were placed 100 ft. apart in Pherocon® I-C traps; moth collections were counted and traps re-randomized once each wk.

The results of these tests showed: 1) PTB pheromone caps manufactured in 1983 (Treatment B) became significantly less attractive than fresh caps (C) after only 2 wks. of field exposure in both cool and hot weather. This phenomenon was first noted by R.R. Youngman, Dept. of Entomology, U.C. Riverside, in similar tests conducted in 1981-82 (1981 Ann. Rept., Almond Board of Calif., pp. 57-60). These current tests confirm his observations. 2) Caps made in either 1981 (AA) or 1982 (A) and stored under refrigeration were as good or better than fresh 1983 caps (C) through 4 wks. of exposure. The only exception to this was in Test II, 3rd wk. 3) Beyond 4 wks. the 1982 caps (A) were still significantly more attractive than 1983 caps that were not replaced bi-weekly (B). These results strongly indicate that our recommendations for rotation or replacement of peach twig borer pheromone caps should be reviewed.

Table 7. Pheromone Dispenser Longevity Studies - 1983.
San Jose Scale, Quadraspidiotus perniciosus (Comstock)

Treatments: Date of Cap Manufacture	Mean No. SJS Males Collected 1/									
	Weeks Exposure									
	1	2	3	4	5	6	7	8	9	10
Test I: 6/2-7/28										
3 Apr. 81-AA	13.2a	26.2a	22.1ab	7.0a	6.3ab	6.3a	2.3 b	5.3a		
19 Mar. 82-A	19.7a	26.3a	20.0ab	15.0a	11.7ab	7.8a	2.0 b	4.3a		
18 Mar. 83-B	14.5a	27.8a	34.7a	17.5a	14.5a	11.7a	8.5a	11.0a		
18 Mar. 83-C	16.0a	23.0a	16.5 b	6.8a	5.0 b	6.2a	3.7 b	4.8a		
Test II: 8/18-10/27										
3 Apr. 81-AA	55.2a	30.8a	60.3a	24.5a	47.2ab	32.7ab	24.5a	25.3a	42.3a	99.5a
19 Mar. 82-A	54.0a	36.3a	31.7a	23.2a	57.7ab	37.8a	10.8a	41.7ab	60.7ab	68.0a
18 Mar. 83-B	61.5a	32.3a	36.7a	35.5a	65.5a	17.0 b	27.3a	51.2ab	37.3a	57.5a
18 Mar. 83-C	52.8a	29.7a	36.2a	27.5a	26.7 b	36.3a	60.0 b	96.8 b	87.7 b	194.8 b

1/ ANOVA & DMRT @ p = .05. Means in columns followed by the same letter are not significantly different.

San Jose scale pheromone dispenser longevity studies:

Two weathering tests were conducted in 1983 with old and new commercial dispensers (caps) of San Jose scale (SJS) pheromone. All dispensers were obtained from the Zoëcon Corp., Palo Alto, Calif. Both tests were conducted in a 3 acre block of mature mixed stonefruits at the Kearney Agricultural Center, Parlier. The 1st test was in place from June 2-July 28; the 2nd test was in place from August 18-October 27, 1983. Each test was comprised of 4 treatments (cap manufacture dates) and 6 replicates in a randomized complete block array. The cap manufacture dates in both tests were: AA-3 April 1981; A-19 March 1982; B and C-18 March 1983. Caps in treatments AA, A and B were not changed during either of the tests, while caps in treatment C were changed bi-weekly. All caps were placed in SJS tent traps; trapped male scales were counted weekly.

The results of the first test showed erratic performance of 1983 fresh (C) vs. unchanged (B) caps. The pattern of significant differences between these two treatments at 3, 5, and 7 wks. suggests some repellancy in fresh caps to responding male scale. There was a strong tendency for the unchanged 1983 caps to be more consistent in performance than the changed 1983 caps. With one exception (wk. 7), there were no significant differences between unchanged caps of any of the three dates of manufacture.

In Test II, there were no differences among treatments in male scale collections through the 4th wk. At wk. 5, the 1983 unchanged (B) caps were unaccountably better than fresh 1983 caps (C), while at wk. 6 and thereafter, the treatment C caps were better than treatment B. Again, with only 1 exception (wk. 6), there were no significant differences between unchanged caps of different dates of manufacture, which indicates a fairly good shelf life (± 2 yrs.) for these caps. Recommended cap change intervals for SJS caps will continue to be 4 weeks. ∞

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Oriental Fruit Moth

Distribution and Host Range

Oriental fruit moth, Grapholitha molesta (Busck) is a pest of deciduous fruits throughout most of the world. Its favorite host is quince, but the greatest economic losses from OFM occur on peaches and nectarines. Oriental fruit moth also attacks pear, plum, apple, cherry, apricot, and almond. This pest was first detected in the eastern U.S. in 1916, and, in spite of quarantine regulations and inspections, was found in southern California in 1942. However, serious outbreaks of OFM did not occur in commercial stone fruit orchards until 1954, in the San Joaquin Valley. It subsequently became the most important worm pest of peaches and nectarines throughout the state, but has been only occasionally mentioned as an incidental, minor pest in almonds.

Description

The adults of OFM are small, grey to brownish-white moths with bodies about 1/4 - 3/8 in. long (6-10 mm). The moths normally fly in the evenings after sunset, or on warm mornings for brief periods between daybreak and sunrise. Adult moths live for 2-3 weeks in mid-summer, and longer during cool weather.

Eggs of OFM are creamy white, slightly convex discs about 1 mm in diameter. They turn dark just prior to hatching, or if they have been parasitized by small wasps. Eggs are laid on either surface of leaves at or near terminal growth points, near ripening fruit, or sometimes directly on the fruit. Eggs hatch in 4-6 days when high temperatures are in the 95°-100°F range, but may take up to 3 weeks to hatch with cool temperatures in March and early April.

Larvae of OFM are at first very small (1/16 in. long), and white, with a black head. They progressively grow and molt through 5 larval instars, gradually turning to a uniform pink color with a light brown head as they mature. The larvae reach a length of 3/8 - 1/2 in., and take 11-35 days to develop.

The pupae of OFM are small, brown, and oblong, about 3/8 in. long. The pupae are found inside tough silken cocoons that are spun by the mature larvae in rough bark cracks or scars, curled leaves, or ground trash and litter. Pupae are not usually found in fruit or twigs where the larvae have fed.

Field Biology

There are normally 3 to 4 generations of oriental fruit moth in the northern peach producing areas of the United States, while 5 to 6 generations occur in the southern states. Central and northern California routinely observe five generations and occasional years with six generations (Fig. 1-3). The OFM larva is the only stage of the insect that produces direct injury to hosts, attacking either the fruit or terminal growth. Oriental fruit moths overwinter as mature diapausing larvae within cocoons in soil debris or trash, or under the rough bark on the larger trunk and limb areas of the tree. A few larvae enter their overwintering state during the 3rd generation in June or the 4th generation in July-August. All of the larvae from the 5th generation in September-October enter diapause. Overwintered larvae pupate in February and March, and adult moths first appear in late February or early March in central California. First larval damage to twigs is observed in April and early May. The larvae of each generation feed and bore into the xylem tissue of the terminals and may cause extensive twig and terminal dieback (often referred to as "flagging" or "strikes"). This type of injury can be particularly damaging to young trees up to 5 or 6 years old, primarily through the loss of developing fruit wood and in causing misshapen or deformed trees. Excessive twig and terminal losses from oriental fruit moth result in the need for additional pruning and labor costs in shaping younger trees. The damage to twig terminals by OFM is identical to that caused by the peach twig borer.

The second type of injury from oriental fruit moth larvae is caused directly to host fruit. Although most fruit moth eggs are laid on the leaves, eggs are also commonly found on maturing fruit about 3 to 4 weeks prior to harvest. Oriental fruit moth larvae normally are not found in green fruit of most hosts. The larvae enter the fruit at any point on the surface and usually move directly through the flesh and feed primarily in the pit area of the ripening fruit.

Until recently oriental fruit moth was not considered a serious pest of almonds, although high numbers of moths have been routinely collected in pheromone traps in the San Joaquin Valley from ca. 1972 on. During this time, populations developed in almond twigs and in the soft, fleshy hulls after hullsplit, but OFM larvae were not causing significant direct damage to the nut meats. During the 1980-82 crop seasons, growers and fieldmen in the Fresno-Madera County area began to report instances of suspected OFM damage to almond nut meats. In 1983 this was confirmed in several orchards, particularly in the Fresno, Madera and Merced areas. OFM infestations in nuts were first observed in late May-early June, which is unusual, since OFM normally prefers ripening fruit. At hullsplit, OFM larvae were found entering nuts primarily through splitting sutures and at the point of stem attachment. Some field-run nut meat samples of Nonpareil and NePlus varieties in early September were 15-19 percent infested with OFM. Oriental fruit moth has also been found infesting Carmel, Thompson, Milow and Merced cultivars. Another interesting observation about these infested nuts was that many had several (5-6) larvae in a single nut, which is unusual for oriental fruit moth.

Damage to almond nut meats by OFM larvae may be similar to that caused by peach twig borer and navel orangeworm. However, webbing is not produced, and the frass is a fine textured, uniform light brown in appearance. In contrast to PTB injury, OFM larvae tend to feed at any point on the nut meats, and feeding channels or holes are usually deeper than PTB feeding, sometimes extending into the meat centers.

Control

Unlike peach twig borer, overwintering OFM larvae cannot be controlled with dormant or delayed dormant sprays. Chemical controls for OFM on almonds have never been required or established, therefore the following discussion is based on OFM controls developed on peaches and nectarines. The first opportunity to control OFM is in late March or April after the first generation eggs have hatched. However, this is not a preferred timing because it is difficult to apply sprays during windy or wet spring weather. The first good opportunity to apply chemical controls for OFM comes during the second moth flight in late May or early June. If additional treatments are required, they can be applied during each subsequent moth flight until harvest. Sprays should be optimally timed using OFM pheromone traps and the OFM phenology model (Table 8).

Although there are several parasites and predators that attack OFM larvae or eggs, these beneficial species have never been shown to control OFM to satisfactory levels in orchards that are routinely sprayed.

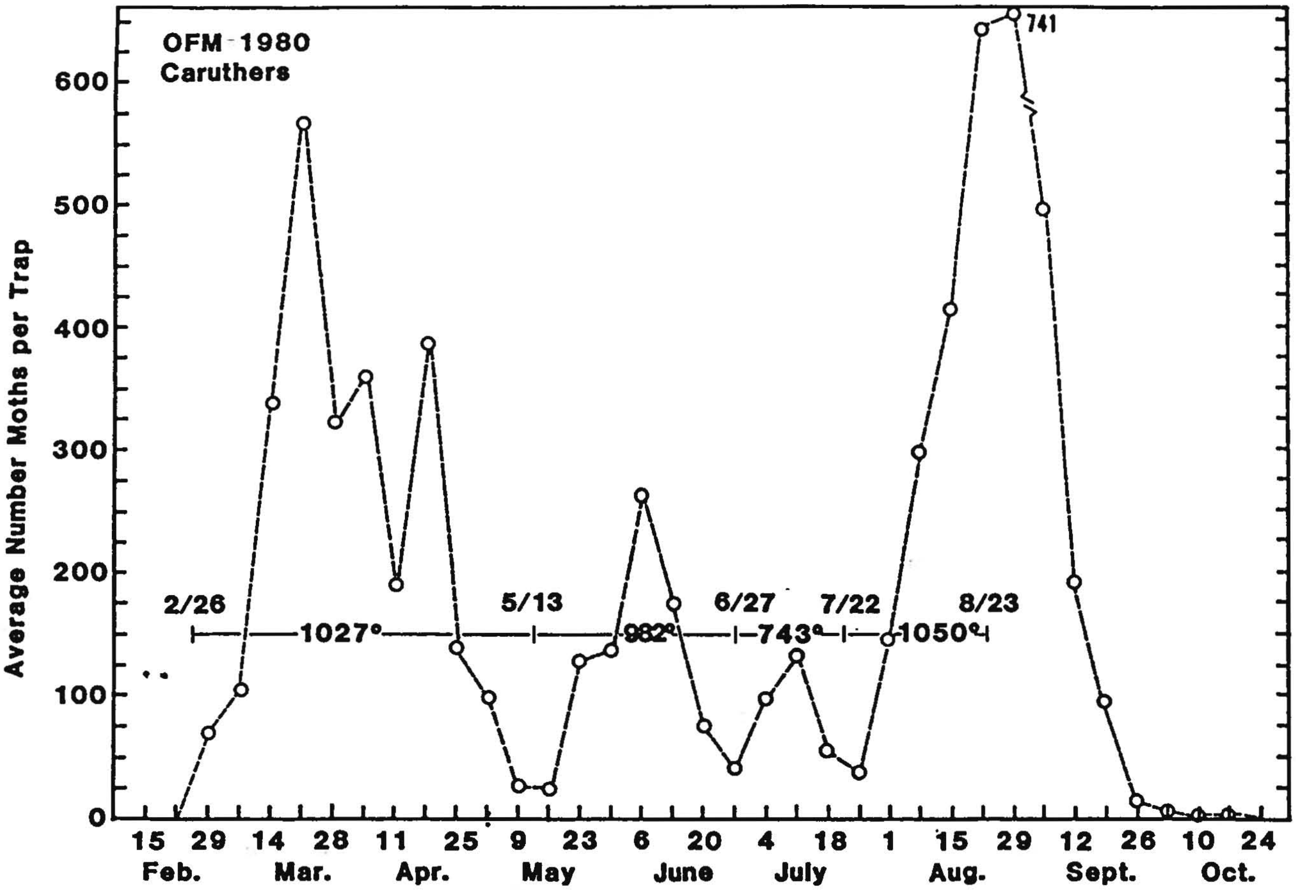
OFM-1980
Caruthers
Average Number Moths per Trap
0
100
200
300
400
500
600
741
2/26
1027°
5/13
982°
6/27
743°
7/22
1050°
8/23
15
29
14
28
11
25
9
23
6
20
4
18
1
15
29
12
26
10
24
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.

Fig. 1

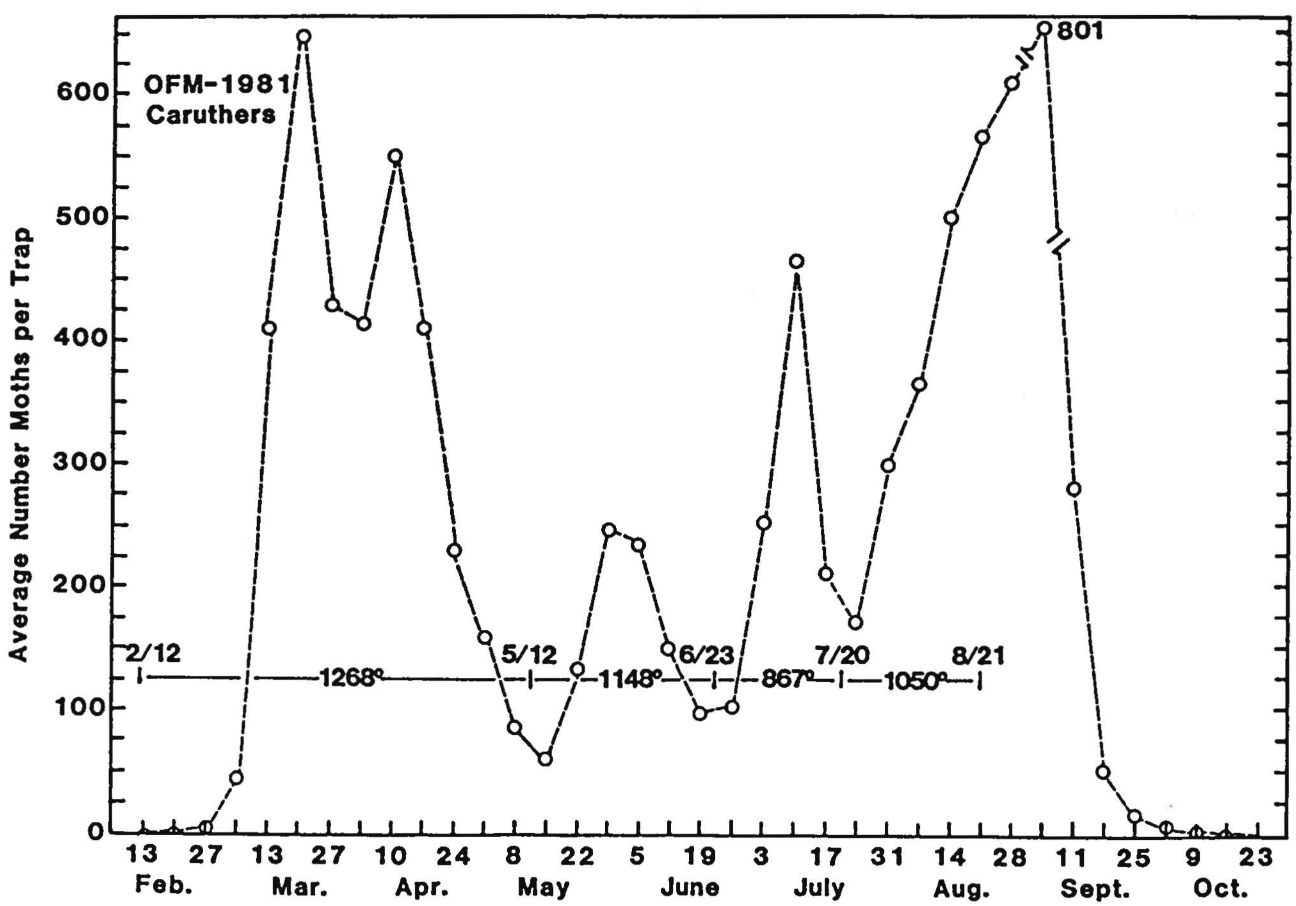
OFM-1981
Caruthers
Average Number Moths per Trap
0
100
200
300
400
500
600
801
2/12
1268°
5/12
1148°
6/23
867°
7/20
1050°
8/21
13
27
13
27
10
24
8
22
5
19
3
17
31
14
28
11
25
9
23
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.

Fig. 2

TABLE 8, OFM PHENOLOGY & EFFICACY TEST
PARLIER, CALIF. 1983

TREATMENT - D° > BIOFIX	RATE A.I./ACRE	$\bar{X}$ NO. TWIG STRIKES	
300°	DIAZINON 2.0 LBS.	30.0	D[1/]
400°	DIAZINON 2.0 LBS.	20.3	C
500°	DIAZINON 2.0 LBS.	8.1	B
600°	DIAZINON 2.0 LBS.	1.6	A
700°	DIAZINON 2.0 LBS.	8.9	B
600°	FMC .04	2.3	A
600°	FMC .06	1.6	A
600°	FMC .08	1.8	A
CHECK	--	35.6	D

1/ 5% DMRT; TRANSFORMED TO $\sqrt{x + 0.5}$

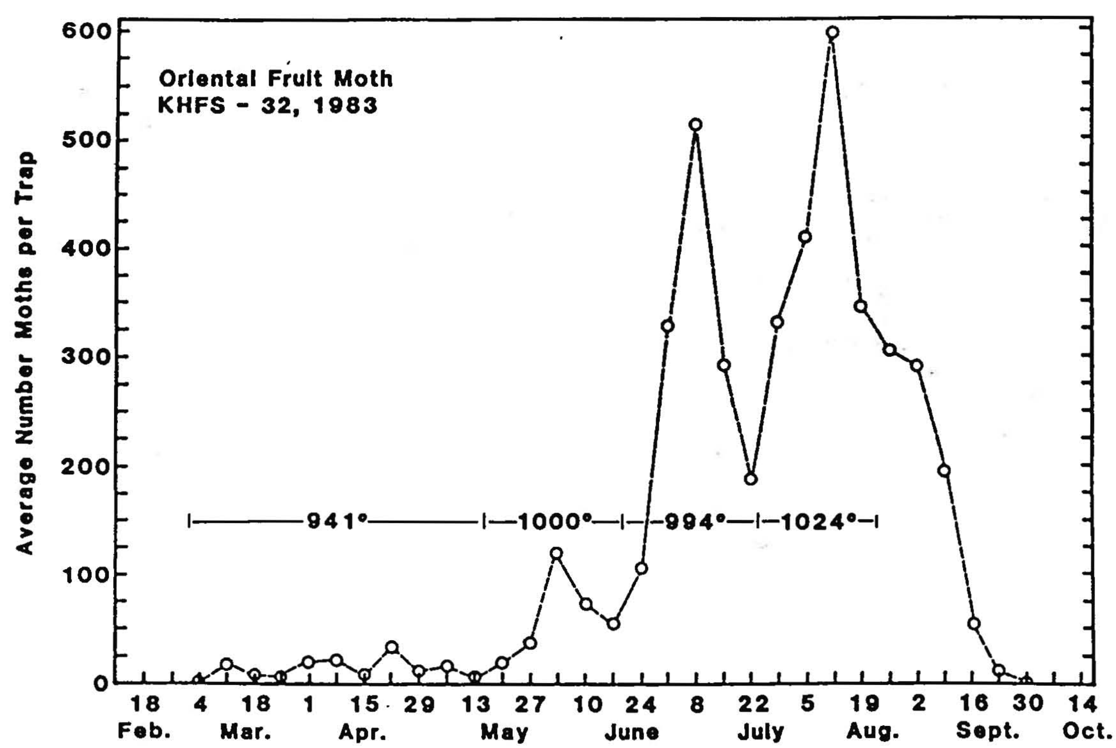

Fig. 3