CODLING MOTH FLIGHT PHENOLOGY AS IT RELATES TO POPULATION MONITORING, NADEL ORANGEWORM INFESTATIONS, MATING DISRUPTION, AND PESTICIDE APPLICATION COVERAGE

D. Flaherty, S. Sibbett, K. Kelley, J. Dibble, and R. Rice

ABSTRACT

Studies in 1988 and expanded in 1989 provide useful information about pest activity in tall walnut trees for the development of more effective pest management programs, including improving codling moth (CM) monitoring programs, assessing the potential of navel orangeworm (NOW) damage, evaluating spray coverage with various equipment, and laying the groundwork for studies on mating disruption of codling moth in walnut orchards.

OBJECTIVE

The study was designed to examine flight activity of male and female codling moths and the egg laying activity of navel orangeworm in relation to tree strata continuously during the season in Tulare and Stanislaus counties, two climatically different walnut growing areas. The studies in the Tulare grove near Poplar included evaluation of spray coverage at various tree heights with selected ground and air equipment. Codling moth mating disruption studies were also initiated in another Tulare County walnut orchard near Farmersville.

PROCEDURES

A. Procedures for monitoring studies.

1) Codling moth pheromone traps were monitored for male moths at 7 feet and 35 feet twice weekly. Winged or pherocon 1C traps with lures were placed in a randomized complete block design, with five replications for each trap height. The higher trap was raised and lowered by a fishing line through two eye screws which prevented trap entanglement with the line during windy periods. One gallon bait traps using terpinyl acetate and brown sugar mixed with water were maintained at the same heights and block design. Numbers of male and female CM caught in the liquid bait were recorded twice weekly. The Poplar and Stanislaus orchards are respectively Serr and Payne varieties, each about 40 acres of 50-foot trees.

2) Navel orangeworm egg-laying traps with almond presscake plus almond oil bait were monitored at 7- and 35-foot tree heights. These traps were hung from each high and low CM pheromone trap or hung singly at 7 and 35 feet, giving a total of 10 double traps and 10 single traps that were monitored for NOW eggs twice weekly.

3) A weather station was placed in each grove to record ambient temperatures and to calculate day-degree accumulations. Data pods (day-degree recorder) with thermocouples were used to accumulate day-degrees at 7- and 35-foot tree heights in the Tulare orchard.

B. Procedures for mating disruption studies.

In 1989 mating disruption studies were initiated in a 10-year old Ashley walnut orchard of 17 acres (20-foot trees with 40 x 20 spacing) near Farmersville in Tulare County. Because of limited availability of Shin-Etsu codling moth dispensers, this first-year trial was confined to treated and untreated plots of 12 trees, replicated four times in a randomized design within the 17 acres. On March 26, 1989, 15 dispensers were hung in each treated tree, 10 in the top and five in the bottom.
One winged or pherocon 1C trap with lure and one terpinyl acetate bait trap were placed in the top of two separate trees in each 12-tree replicate. The pheromone traps were placed March 26 and the bait traps March 29. These traps were monitored twice weekly and the number of moths recorded, males in the pheromone traps and females and males in the liquid bait traps.

CM females from all bait traps were dissected during the first flight for the presence or absence of spermatophores to determine if mating was affected by the confusion treatment. The number of infested nuts dropped during the first flight was recorded in each of the 12-tree replicates.

C. Procedures for spray application coverage studies.

Purpose: The degree of spray coverage in walnuts has been questionable for a number of years. This concern was thought to increase proportionately as the tree height exceeded 15 to 20 feet. Although larger sprayers and volute devices may have provided satisfactory results in some cases of taller trees, they also increase spraying costs and time. Their contribution to better coverage as well as those of newer type sprayers have not been comparatively measured. Recent evaluations of ground and air spray applications for blight control indicated a strong need for additional data, as did treetop codling moth trapping and control. Since all pest and disease control relies on satisfactory coverage, investigation of that obtained from typical and certain other available types of orchard air carrier sprayers was felt to be necessary.

Procedures: The thrust of this project was to evaluate the percent coverage obtained at different heights in 40- to 50-foot walnut trees. To obtain these data a standard and comparable spray monitoring system was used in each of three trees, each tree acting as a replication of the other. Also the targets necessary to catch the spray deposit were designed to be easily and fairly rapidly manipulated into and out of the trees. To accomplish this a nylon line was run through a pulley which was in turn attached to the top center structure of the tree. This placed the pulley at approximately 40 feet. Due, however, to some variation in height, targets placed on the nylon line varied slightly, but still allowed a low evaluation point of 4 to 5 feet above the ground and a high of 35 to 37 feet.

The technique used to determine spray coverage and deposit at the various tree heights involved using a water soluble food color dye (FDC Blue No. 1) and a fixed copper spray (Kocide 101). Three by five inch cards (Crown Zellerbach - Luster Kote) were attached at 2-foot intervals on the nylon line targets for the dye. A five-leaflet walnut leaf was also attached to the line at 2-foot intervals as a target for the copper. These cards and leaves alternated every foot so that there was a card, then a leaf, a card, a leaf, etc. Both target types were attached to the line by means of a "bulldog" type of clip. This setup was repeated in each of the three-tree replications. After each spray run the line and targets were hoisted down and the cards and leaves for that run catalogued. New targets were then attached, hoisted up and the next spray run was made. Eleven such tests were made in the mature 45-foot walnut trees planted in a 20x40-foot diamond. Such a configuration results in 20-foot rows.

Each ground application was made by spraying from both sides of the sprayer and along each side of the target trees as well as along these trees one row away. Therefore, spray coverage opportunities for both the dye and copper were possible twice on each row side of the target trees. This simulates the same initial and drift coverage that occurs in normal orchard spray applications. Helicopter runs (3) were made with: (1) a single pass on each side of the target tree; (2) each side plus an additional pass one row over; and (3) the latter plus a ground sprayer application.
The gallons of spray applied per acre were 250 gallons as a standard high volume rate and 40 gpa as the low volume rate—1.5 and 2.0 miles per hour were the travel speeds selected and pressure at the nozzles was either 100 or 200 psi. The air shear nozzled electrostatic sprayers—not depending on psi for droplet breakup—utilized a normal operating pressure of 21 to 38 psi. The variations in gpa, mph, and psi offered either the best operating range for the particular spray or allowed a more comparative and real world evaluation. Helicopter applications were made at 30 gpa, 35 mph, 75 psi, and a 40-foot spray boom.

In addition to these spray run tests conducted in a commercial walnut orchard, a series of non-crop spray coverage evaluations was set up in an open field. Here the nylon cord with clips were attached to a pulley at the top of a 50-foot crane. The purpose here was to demonstrate the height of sprayer coverage on unobstructed targets. Twenty different spray runs were made with essentially the same equipment used in the walnut orchard.

RESULTS AND DISCUSSION

A. Results and discussion of monitoring studies.

Figure 1 shows that low vs. high trap catches for codling moth in 1989 were similar to those in 1988 (see 1988 Walnut Research Reports, page 68), except that the high bait traps were more efficient in 1989. In fact, the high bait (HB) catches in the Poplar grove were two times higher than the low pheromone (LP) catches, and in the Stanislaus grove the HB trap catches were only slightly less than LP catches. To make it easier to see and count CM in the liquid, in 1988 small meshed screens were used to exclude larger moths and other insects from the liquid bait while allowing them free access in 1989. Evidently the screen somewhat hindered CM access to the liquid bait, making the traps less efficient in 1988.

Figure 2 shows that the number of eggs recorded on the NOW egg traps in Tulare grove was slightly greater for the low traps (5912 vs. 5361) while in Stanislaus the low trap numbers were about two times more (1202 vs. 616). Unlike codling moth, apparently the upper strata does not favor NOW activity. The greater difference between low and high traps in the Stanislaus grove may be caused by windy conditions. Helicopter treatments for CM may have affected the NOW egg-laying distribution in the Tulare orchard (see discussion below). No significant differences were noted in the number of eggs counted on double and single NOW traps.

Figure 3 shows a number of interesting CM and NOW activities with regard to one another and to the treatments in the Tulare orchard. First, note the active NOW egg-laying during and immediately after the first CM flight (4/8 to 5/10), indicating that damage as a result of the first CM flight probably greatly accentuates NOW infestations in orchards. Also note that during the first CM flight the high NOW egg traps had as many or more eggs than the low traps. However, following the start of the second CM flight through the third flight (about 6/18 until harvest), when two Lorsban and two Guthion treatments were needed in the grower’s attempt to control CM by helicopter rather than by ground equipment, the low NOW traps consistently had more eggs than the high traps. Perhaps very poor coverage in the lower strata by air applications (see later discussion) compared to the upper strata resulted in higher number of eggs laid on the low NOW traps. It is noteworthy that laboratory and orchard studies by J. Dibble have shown that navel orangeworm moths are highly susceptible to the Lorsban compound.

It is also noteworthy that figure 3 indicates that female CM activity was disrupted only for short periods by the treatments, again indicating poor coverage by the helicopter treatments. That is, the population in the upper strata quickly surged because of the tendency of
surviving and newly emerged moths to move to the upper strata. In 1988, the grower treated with a combined air (Guthion) and ground application (Lorsban) on July 6, and CM activity remained very low through the third flight. Perhaps the thorough coverage treatment in 1988 accounted for the very low percentage of worm-infested nuts at harvest in 1988 compared to the high infestation of 1989. We emphasize that good codling moth and NOW control go hand in hand.

B. Results and discussion of mating disruption studies.

In the pheromone confusion studies, figure 4 shows that from March 26 to August 31, traps in the untreated plots caught significantly more male moths (991) than the traps in the treated plots (15), indicating that the dispensing rate of the pheromone dispensers is highly effective over a long period of time. However, dissection of females for presence or absence of spermatophores and infested nut counts both showed no significant differences between treated and untreated plots. The data indicate that the males had trouble finding the pheromone traps but no difficulty in finding virgin females, or that the plots were too small to discourage moth movement between treated and untreated trees. Moreover, the untreated bait traps caught 279 females and 324 males (=603 moths) while the bait traps in the treated plots caught 319 females and 234 males (=553 moths), indicating little meaningful differences in moth activity between treated and untreated trees.

The bait trap data in figure 4 only include the catches for the first CM flight, March 29 to May 31, after which the traps in the treated plots were taken down. However, bait traps were maintained in the untreated plots through July 16 (figure 5) to develop information on their possible use in treatment decisions. For example, when comparing the male catches in the pheromone traps with the female catches in the bait traps, it appears that the delayed female activity is a better indicator for timing a treatment. After all, it is the onset of egg laying that should be of prime interest according to some authorities. It would seem that the activity of females measured in the upper strata bait traps is a better indicator of egg laying than the easier to use pheromone traps that catch only the males. Perhaps we have been locked into the use of a pheromone trap that does not adequately mirror codling moth population activity, particularly in tall walnut trees. Studies on female CM attractants and traps have been initiated by R. Rice.

It is interesting that figure 5 indicates excellent seasonal control of codling moth with one ground application of Zolone in the Farmersville grove and apparently that treatment resulted in less than 1 percent worm infestation at harvest. Evidently the spray coverage in this orchard of 20-foot trees was quite adequate in contrast to the coverage in the Poplar orchard which had four treatments by helicopter (figure 3) and about 4.5 percent infested nuts at harvest.

C. Results and discussion of spray application coverage studies.

In order to relate comparative performance results, table 1 lists the make and model of those sprayers used in the walnut orchard tests. Dye/card coverage determinations, although made a 2-foot intervals are presented as average percent coverage in quarter of tree height.

The two somewhat comparable standard type air carrier power take-off orchard sprayers, Turbomist 30P and FMC 360 (runs No. 1 & 3 in table 1), showed no difference at 250 gpa and 1.5 mph (figures 6 & 7). Very good coverage was achieved up to 27 feet (three-quarters of the tree height) and approximately 50 percent coverage in the top one-fourth of the tree.

The FMC 360 (runs No. 2 & 3), at 250 gpa and compared at 2.0 vs. 1.5 mph (figures 7 & 8) showed a substantial dye coverage difference—with the slower travel speed performing better.
in the top one-half of the tree. This same unit (run No. 4) operated at 40 gpa and 1.5 gave equally as good coverage at this low volume rate as it did at 250 gpa (figure 9).

The large engine-driven air carrier FMC 1087 sprayer (runs No. 5 & 6) gave excellent dye coverage results at 2 mph and both at 250 and 40 gpa (figures 10 & 11).

The two air shear type nozzle sprayers Kinkelder and Windmill (runs 7 & 8) showed good to excellent coverage (figures 12 & 13). The Kinkelder unit tested performed at 40 gpa as well as both the Turbomist and FMC 360 did at 250 gpa, which was equally as well as the latter at 40 gpa. Both of these air shear sprayers featured electrostatically charged droplets. The charge on the Kinkelder, however, may not have been performing during the test. Windmill dye coverage results were very good and equivalent to those of the FMC 1087. This sprayer model is a substantially larger capacity unit than the Kinkelder model.

Helicopter coverage was disappointing (run No. 10), showing approximately 50 percent coverage in the top one-fourth of the tree and 34 percent in the bottom three-fourths (figure 14). Combined with a ground application (run No. 11), this gave substantially better coverage than the helicopter alone, but only slightly better performance than a similar ground application alone (run No. 2).

Although the copper deposit results showed differences between spray runs, these were not as graphic as the dye data. These differences were greatest up to 15 to 20 feet. After this height, all runs were similar in that they ranged from approximately 50 to 250 parts per million, the greatest deposit recovered from the FMC 1087 and Windmill applications.

The non-crop tests were interesting in that they allowed more varied spray runs over a longer and more controlled period of time, table 2. These tests showed generally that some sprayers can reach heights of 47 to 50 feet (Kinkelder and large Windmill and FMC 1087) and still show very good to excellent coverage. The others appear to maximize out—probably because of air pattern characteristics at 28 to 41 feet. Increased travel speed curtailed coverage as height increased.

In summary, the two PTO conventional sprayers performed very good at either high volume (250 gpa) or low volume (40 gpa) sprays when operated at 1.5 mph. Excellent coverage was obtained up to 27 feet, but was only 50 to 60 percent in the top one-fourth of the tree. When the travel speed was increased to 2.0 mph, the top one-half and especially the top one-fourth of the tree received poor coverage. The engine-driven FMC performed very well as did the Windmill even though the FMC traveled at 2.0 mph vs. 1.5 for the electrostatic Windmill. Kinkelder performance at 40 gpa was equally as good as that of conventional PTO sprayers at 40 gpa. Helicopter coverage was poor and at best no better than the worst ground sprayer rating.

Dye coverage evaluated from semi-fixed target cards appears to be a more sensitive technique than copper residues. It is possible that the differences in copper deposits may have been somewhat masked due to the mechanics of handling samples in the field, storage, and lab because of contamination. However, since two methods of evaluating help to verify results better than one, the copper technique is still valid provided the mechanics of handling are improved.
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<th>Sprayer</th>
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<th>MPH</th>
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California Walnut Board

Walnut Research Reports 1989
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FIGURE 1

CODLING MOTH vs TREE STRATA
Tulare County - 1989
Tot. Mths/5 Traps (2/28-9/1)

Stanislaus County - 1989
Total # Moths/5 Traps
FIGURE 2

NOW vs TREE STRATA
Tulare County - 1989
Total # Eggs/10 Traps (2/28 - 9/1)

Stanislaus County - 1989
Avg. No. Eggs/Trap (2/28 - 9/8)
FIGURE 3

CODLING MOTH vs TREE STRATA
Tulare County - 1989

Total Moths/5 High Bait Traps

NOW vs TREE STRATA
Tulare County - 1989

No. Eggs/Trap/day

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FIGURE 4

Pheromone Confusion Studies
Tulare Co. - 1989

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Pheromone Confusion Studies

Tulare Co. - 1989

Total Moths/Trap/Day

- PT
- PUT
- BT
- BUT

Date


Zolone 6/20
FIGURE 8

Height (ft)

20-23

20-27

12-19

4-11

Average %Coverage

21

73

100

100

FMC-PTO, 750 rpm, 2.0 mph

FIGURE 9

Height (ft)

20-23

20-27

12-19

4-11

Average %Coverage

57

81

100

100

FMC-PTO, 40 gpa, 1.5 mph