Determining Impact of Third Generation Codling Moth, and Emergence Pattern of Overwintered Moths

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Abstract

Research conducted in 1989 indicate there is no direct relationship between pheromone trap catches and emergence of overwintered codling moth. It was also shown that overwintered larvae which receive the most chilling units emerged over a shorter period of time when compared to larvae exposed to less chilling units. In the laboratory codling moth females deposited at least some eggs when exposed to constant temperatures as low as 55 degrees F. No stings or larvae were detected on walnuts which averaged less than 21mm in diameter.

Introduction

Codling moth is the key pest in early bearing commercial varieties of walnuts. Early season treatments for this pest are disruptive to the biological control of walnut aphid and mites. This leads to secondary pest outbreaks and additional pesticide applications to prevent economic damage are often needed.

Pheromone traps are used to monitor codling moth in commercial orchards. Pheromone trap counts of overwintered moths often exhibit a bimodal flight pattern. This causes confusion among growers and PCAs and may lead to unnecessary treatments for this pest which further compounds the disruption of biological control of aphids and mites. It has been well documented that many factors such as temperature, wind, type of trap, trap height and care and maintenance of traps can impact pheromone trap catches. Because of these factors there is reason to question whether trap catch is a good indicator of the emergence egg laying and subsequent larval emergence of overwintered codling moth.

There are indications that the amount of winter chilling has an impact on the emergence of overwintered codling moth. If this is indeed true, and we could
forecast emergence patterns by looking at the amount of chilling we would be better able to determine the need for first generation treatments and more accurately time treatments aimed at first generation larvae.

It is widely believed that adult codling moth females only lay eggs if sundown temperatures are above 62 degrees F. Data to support this belief are sparse at best. Treatment timing decisions are often made taking into account the lower threshold for egg laying is 62 degrees. Validation of this belief would contribute substantially to understanding of the behavior of codling moth.

Objectives

The original objectives of this project were twofold. The first objective was to verify when during the growing season codling moth infested nuts could survive the harvest process and be scored as offgrade.

The second was to determine whether pheromone trap counts are a reliable indicator of the behavior of codling moth or whether the bimodal peak trap catches are an artifact due to other factors relating to the trapping of the moth.

Other objectives of determining the emergence pattern of overwintered larvae subjected to differing amounts of winter chilling, and determining the lower threshold for egg laying and minimum nut size for larval infestation were added after the project was initiated.

Methods and Procedures

Emergence of Overwintered Adults:

Corrugated cardboard bands were placed around the trunks or scaffolds of walnut trees to trap mature codling moth larvae as they crawled down the tree to spin overwintering cocoons. A minimum of 100 trees were banded in orchards located near Tulare, Winters and Gridley on August 1. Aluminum flashing was placed around the bands in the Winters orchard to prevent predation from birds. Many of the overwintering larvae trapped in the Tulare orchard were destroyed by birds. The bands in Butte county did not need to be covered because with only 2 to 4 larvae per band it was felt that the low population would be too low for birds to bother.

In Butte County bands containing codling moth were removed weekly, beginning with the first trapped adult moth. Bands were dissected and the percent of empty pupal cases was calculated. The percent emergence on each date and pheromone trap catches were recorded.

At Tulare all bands were removed when the first adult codling moth was caught in pheromone traps, placed in an emergence cage in the orchard, and adult emergence followed.

The orchard where the bands were placed near Winters had to be removed because of blackline. In order to save the experiment, orientation of the bands
was marked and bands and slabs of wood with the bands still around them were removed from the orchard using chain saws. The slabs were placed in emergence cages in a nearby walnut orchard oriented in the same direction as they were on the tree and adult emergence followed.

Determining Codling Moth Emergence After Different Amounts of Winter Chilling:

Cardboard bands containing overwintering larvae were collected at intervals throughout the winter from the Tulare site. Bands containing pre-pupae were brought into the laboratory and incubated at 70 degrees F. under natural light. The amount of chilling was calculated as chill hours below 45 degrees F. beginning on November 1, 1988. Collections were made after 911 chill hours (3/18), 1062 chill hours (2/1), 1333 chill hours (2/27) and 1414 chill hours (3/18). The first moth was caught in pheromone traps on 3/18. Emerged adults were collected daily, sexed, and the number recorded to determine emergence rates.

Codling Moth Infestation in Walnuts:

Nut infestation was followed in a mature Serr orchard in Tulare County. Beginning at 7mm nut size, four 50 nut samples were collected at random, and returned to the laboratory for examination. After measuring the diameter of each nut the number of eggs, larvae, stings, and entries was recorded. Live larvae were held for head capsule measurements to determine instars.

Codling Moth Egg Laying:

Adult moths were collected from the cages involved in the chilling project which were held in the laboratory at 70 degrees F. If at least 5 pairs were not available on one day, moths were held at 40 degrees F until 5 pairs emerged. After enough moths were collected five pairs were placed in battery jars near an east facing window overnight for mating. Mated moths were transferred to egg laying cages and placed in environmental chambers under constant light (one 25 watt incandescent light bulb) at 75% RH at 55, 59, 62 or 75 degrees F. Moths were left in the environmental chamber for two days then the number of eggs deposited on egg laying sheets counted.

Results and Discussion

The pattern for pheromone trap counts were similar for Tulare and Yolo counties, Fig. 1 & 2. Each had 3 peaks, the first two at 200 and 500 degree days after biofix. The third peak occurred 800 degree days after biofix at Tulare and 900 in Yolo County. Trap counts in Butte County showed 2 peaks, Fig. 3, one at 200 and a second at 900 degree days after biofix. In Butte County the lowest counts experienced during emergence of the first generation occurred at about 500 degree days, the time of the second peak in Yolo and Tulare counties.

Although degree days differed, adult emergence patterns from cardboard bands in Tulare and Yolo Counties was similar. In both orchards, Fig. 1 & 2, emergence from bands was not detected until well after moths had been caught in pheromone traps. In Tulare County there was a constant emergence from 100 to 300 degree days after biofix. Emergence declined after 300 degree days and by
700 degree days was essentially complete. No further emergence occurred until 800 degree days when emergence resumed and was constant until 1000 degree days after biofix when 100% had emerged.

In Yolo County, Fig. 2, emergence began between 100 and 200 degree days after biofix and peaked at 500 degree days. Emergence declined rapidly after the peak until 1000 degree days. Moths continued to emerge until over 1200 degrees after biofix.

Figure 3 shows the emergence pattern in Butte County differing significantly from the other two orchards. After beginning at the same time as pheromone trap biofix the rate of emergence was more or less constant until about 300 degree days when it decreased slightly until 400 degree days. After 400 degree days the emergence rate was more or less constant until 100 percent emergence at a little over 1000 degree days.

As can be seen from the graphs, there appears to be little or no direct relationship between the pattern of pheromone trap counts and adult emergence from overwintering sites. Although the data are somewhat variable if anything there appears to be a reverse correlation with peak emergence occurring between 300 and 500 degree days after biofix. This points out the importance of using other observations in addition to trap counts when making recommendations for treatments. In fact one could make the case for not using trap counts for treatment decisions because so many factors, many of which are probably not known influence the number of moths caught in pheromone traps.

Figure 4 shows the results of the impact of winter chilling on the emergence of overwintering codling moth. As suspected the moths left in the field the longest and receiving the most chilling generally emerged earlier until about 85 percent emergence was completed. When comparing those moths collected after 1062 chill units to those collected after 1414 chill units 60% emergence occurred almost 300 degree days earlier in those receiving the most chill units. This could contribute to extended emergence and poor control experienced during some seasons. This should be researched further to determine if extended overwintered emergence could be forecast which would allow growers to adjust their control program during those years when normal treatment timing does not fully cover the emergence.

Results of laboratory experiments to determine the lower threshold for egg laying by codling moth is shown in Fig. 5. From this test it is obvious that after mating codling moth oviposition takes place at a much lower temperature than previously thought. Although the number of eggs was low, there was some egg laying at 55 degrees, with the number of eggs deposited increasing with temperature until 62 degrees when the rate of egg laying in response to increased temperature remained constant. The small amount of egg laying as low as 55 degrees could account for the second generation consistently starting at about 1060 degree days after biofix even in years when sundown temperatures are below 62 degrees. It appears from these data that the importance of having 62 degrees at dusk has been overstated and unless prolonged cold temperatures are experienced, sundown temperatures after mating are probably not as important as previously thought and for the most cases can be ignored.
It has been thought for many years that codling moth does not attack walnuts unless nuts average at least 3/8th inches in diameter. Consequently the 3/8th inch average nut size has been widely recommended as the time to apply chemicals for control of first generation larvae. Field observations over the years indicated this timing may be too early. In order to determine the minimum nut size which a codling moth larva would attack we followed first generation nut infestations in a Serr orchard in Tulare County. As can be seen in Table 1 the first stings were not observed until nut size averaged 21mm in diameter which was over 500 degree days after biofix with pheromone traps. Even then only stings were observed and only one live first instar larva was found, Table 2. A week later on May 1, 600 degree days after biofix, nut size averaged almost 26mm diameter. Only three live first instar larvae were found in the 200 nut sample. If one assumes, with good coverage, first instar larvae inside the nut can be killed, it appears the first treatment should have gone on about May 1, almost 3 weeks after nut size averaged 3/8 inch diameter and a month after 225 degree days from biofix. Although these data are preliminary they indicate recommendations for timing first generation sprays are 2 to 4 weeks earlier than they should be. Future research should include timing experiments to determine optimum timing for first generation sprays.
Fig. 4

EMERGENCE OF OVERWINTERED CODLING MOTH
1989

Date Collected (Chill Units)
- 1/18 (911)
- 2/1 (1062)
- 2/27 (1333)
- 3/18 (1414)

% Emergence

Degree Days

Data collected at various dates and chill units:
- 1/18 (911)
- 2/1 (1062)
- 2/27 (1333)
- 3/18 (1414)
Table 1.

Codling Moth larvae and damage in 200 nut sample Tulare County, 1989

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(dead)

(from biofix)
Table 2.

Number and size of live Codling Moth larvae in 200 walnuts. Tulare County, 1989

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