Thresholds, Monitoring, and Sampling

Effectively monitoring codling moth with the DA lure

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Abstract: Codling moth (CM) continues to be managed with a suite of tools including the use of sex pheromones for mating disruption (MD) and a limited arsenal of insecticides. Predicting the beginning of moth activity, egg laying and egg hatch is an important consideration used by growers to target the codling moth population with sprays. The current model in conjunction with the use of Guthion cover sprays has served the industry well for nearly 25 years. The model was developed by matching the accumulation of degree-days from first male captures in a sex pheromone-baited trap (Biofix) with the observed timing of egg hatch. Over many years it was found that the accumulation of 250 degree-days after Biofix predicted the beginning of egg hatch. However, reports of the current model failing to accurately predict CM flight and subsequent egg hatch have increased over the past few years. The availability of new insecticides has elevated the importance of accurately predicting egg deposition and hatch. Efforts to reduce the use of insecticides will benefit from our ability to better time sprays for the major peaks in egg laying and hatch.

Report

Several problems exist with our current CM model. The model's "Biofix" or the start of adult emergence is often difficult to establish due to the low population density of CM in most orchards and the infrequent checking of traps. Confusion over the capture of a "sustained" number of moths versus a single moth can create errors in predicting egg hatch. Our previous study showed that predicting egg hatch from the capture of the first moth was typically much worse than from the beginning of a sustained catch. Combining data on both moth capture and daily maximum temperatures (three-day window with temperatures >72^{o}F) has been shown to be a more effective approach in establishing a Biofix.

Following the establishment of the Biofix the current model's prediction of emergence and egg hatch as a function of cumulative degree-days is "hard-wired." The model predicts a bell-shape emergence with a long extended tail of emergence and egg hatch will occur every year. Because the timing of egg hatch is based on the activity of female and not male moths the model had to be 'fit' to these data. The availability of the DA lure now allows us to fit the model to female emergence. In addition, female activities such as flight, calling, mating, and egg laying are influenced by seasonal, daily and hourly variations in temperature and wind patterns that vary continuously. The threshold for sexual activity is 10^{o}C higher than for egg or larval physiological development. Thus, degree-days can be accumulated without the occurrence of any sexual activity. The common occurrence of high wind speeds in central Washington in the spring can cancel moth flight and mating. A new more flexible model that can predict the cumulative

density of eggs laid and hatched during the season based on these factors would be an improvement.

The DA lure has been shown through extensive trials over the past four years to be an effective lure for monitoring both sexes of codling moth (CM) in walnuts and pome fruits. The DA lure has consistently caught more moths than high-load sex pheromone lures in orchards under mating disruption (MD), except in 'Bartlett' pear, and the two lures are nearly equivalent in 'Gala' apples. Use of the DA lure has revealed that a very high proportion of female moths are mated within MD orchards. Thus the value of assessing the mating status of female CM in these orchards appears to be minimal. However, the DA lure is extremely valuable in assessing both the population density and flight activity of female moths within an orchard. The correlation of female density trapped with the DA lure with nearby fruit injury is high. Predicting egg hatch from the beginning of sustained catch of female moths plus 155 degree-days (LT = 10^{o}C) is very effective.

Use of the DA lure has also been very effective in detailing the shape and breadth of the female flight and subsequent egg hatch period. Analysis of data from 2002 showed that the current model follows moth flight reasonably well except for a couple of points. It assumes a standard shape for population emergence over time (bell-shape with a greatly extended tail to the right). The DA lure shows that there are actually several major peaks in flight activity that occur during extended periods of suitable weather. The timing of these peak activity periods varies each year. Second, the DA lure allows us to more accurately view the occurrence of a late second peak in the first flight, which may contribute to a late period of egg hatch not currently included in the model. The failure to respond to this late peak can cause significant outbreaks of CM fruit injury within unprotected orchards. Third, the DA lure has allowed us to see that female activity continues uninterrupted all season in abandoned orchards. Immigration from these sites into commercial orchards threatens growers and suggests that season-long insecticide coverage may be needed. And finally, the use of the DA lure has shown that CM exhibits male protandry in the first but not in the second moth flight. The lack of this later protandry may be one reason why the current model does not predict the second-generation CM flight.

Objectives.

1. Establish the non-linear relationships between the daily accumulation of degree-days and female flight, mating, and egg laying.
2. Construct a new predictive model based on the captures of female CM in DA-baited traps plus the accumulation of 155 DD for egg hatch.
3. Use these data to establish a color-coded classification system to designate the occurrence of Biofix and the severity of female moth activity for each day.
4. Validate the efficacy of this modeling scheme versus the standard model to predict the actual curve of egg laying and egg hatch within five central Washington orchard sites.