Biology/Phenology

Improving the Codling Moth Biofix-based Spray Timing Model

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The codling moth timing model is widely used by growers throughout North America and Europe to time spray applications. The model adopted by growers in Washington is based on spraying 250 DD after biofix, defined as the first sustained moth catch. Degree days are a convenient measure of cumulative temperature effects. Codling moth eggs, larvae, and pupae develop above a lower temperature threshold of 50°F. However, adult flight, female calling, mating, and oviposition events occur above a much higher threshold, ca. 60°F. These adult activities also have fairly defined time periods. For example, egg laying occurs before, during, and after dusk. Flight, calling and mating occur during dusk. In most fruit producing areas in the western U.S. there can be quite a drop in temperatures from the heat of the day (ca. 4PM) until dusk (we determined the mean drop in the Yakima Valley to be 12°F during April-June). Thus if a number of days occur in which the high is well in excess of 50°F but the temperature falls below 62°F by dusk then the model will start accumulating DD and begin to predict egg laying and hatch while the moths in the field are inactive and have not mated.

Improvements in the current codling moth model may be needed for two reasons. First, in the past, applications of Guthion were highly effective for 21 d, but now with low levels of resistance, growers have to reapply every 10-14 d to maintain adequate levels of control. Second, the new insecticides that will soon be available to apple growers such as Comply and Confirm are active against the egg stage and sprays need to be timed for periods of peak egg laying and subsequent egg hatch.

One solution that has been proposed to fine tune the model is to establish a biofix only if a sustained catch of moths occurs and temperatures during dusk are warm enough for adult activities. In California a model (BUGOFF 2) uses an activity threshold of 62°F and a biofix is established only if dusk temperatures exceed this temperature for three nights during a week. This approach has never been adopted or evaluated in Washington.

Another factor that can limit adult codling moth activity is high wind speed. The literature shows that at speeds above 2.2 mph codling moth adults become inactive. Measurements of wind speed at PAWS sites outside of the orchard canopy will likely be higher than speeds occurring inside the canopy where the moths are active. Measurements by Dr. Steve Welter (UC-Berkeley) found that speeds declined about 60% from outside to inside the canopy. Thus wind speeds measured above 5 mph may affect moth behavior.

Starting in 1996 we initiated a project to evaluate whether the current model could be improved if temperature and wind speed were considered in establishing a biofix date. Fortunately the spring weather in 1996 was unusual (as it is every year) and we were able to test the models under exceptional conditions. The first catch of codling moth in my experimental orchard occurred on 6 May and I established the Biofix on 9 May. Following this date the weather cooled until 23 May. I used sticky interception traps to monitor the female moth population and found that the first mated moths were not present until 31 May. Leaf sampling for codling moth eggs detected oviposition on 31 May as well. Analysis of the temperature and wind data from 9 to 31 May showed that on the one night clearly warm enough for moth activity the wind speed was very high during dusk. On several other nights the suitability of dusk temperature and wind speed were marginal but no eggs or mating occurred. Following 31 May temperatures warmed and mating and egg laying increased.

Based on the BUGOFF 2 model the biofix date would have been delayed from 9 to 24 May. Timing spray applications 250 DD after biofix would have moved the recommended spray date from 4 June to 11 June. This later date coincided approximately with egg hatch.

A useful insight that may improve our management of codling moth was derived from these analyses. We examined how far apart were time intervals of at least three days where the maximum daily temperature was >74°F (62°F plus the 12°F difference between the daily maximum and dusk temperatures in Washington orchards). In 1996 once the temperature warmed it remained warm through June. However, in other years such as 1995 there was a 20 d gap between the first warm period and the next. We observed a clear split peak in moth flight and resulting egg hatch in our areawide site in Oroville during 1995. It appears that if warm periods (maximum temperature >74°F) of 3 or more days are separated by more than 7 days then growers may want to time a second spray from the second warm period. In Oroville, growers who did not apply a second cover suffered high levels of fruit injury in 1995.

Implementation of these modifications to the current model should be easy. Biofix will be based on the first sustained catch of moths followed by three days of temperatures >74°F and with average dusk wind speeds <5 mph. Further validation of this model will be conducted during the next two years. The efficacy of timing Guthion and Confirm from the new and old model for codling moth will be evaluated.