Codling Moth Management Challenges

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The apple industry has been faced with increasing fruit injury due to codling moth (CM) in the last 5 years, and a direct result is more rejected loads of apple resulting in less profit for growers and packers alike. Historically, codling moth management programs have been effective due to the availability of good chemical controls. Recently, however, several factors have contributed to population increases and/or less than adequate control of this pest.

The chemical options available for codling moth control have changed. The Food Quality Protection Act (FQPA) has resulted in the loss of some insecticides, such as the use of Lorsban after bloom for control of CM. Organophosphates (OPs) are still available for CM control but with increased restrictions on the amount and times they can be used. In addition, reduced susceptibility to Azinphosmethyl, and to some degree Phosmet, has been reported in several apple-producing regions. Improper timing of chemical applications, use of low rates and less than adequate coverage have also contributed to poor CM management.

Insecticides that are providing less than 80% control, after assuming 90% natural mortality, are actually providing an opportunity for CM populations to build. Many of the new materials are at most 70 to 80% effective against CM. Several new chemistries have been registered that impact CM, but these are not merely plug-in replacements for older chemicals which are no longer available or have become less effective. In many cases, the efficacy of newer products is less than what we have experienced with the OPs during the last 40 years.

Timing of control measures is critical to prevent pest populations from building above economic thresholds. Calendar-based spray schedules are inadequate for proper CM management as chemical applications are frequently mistimed (Table 1). The CM degree-day model is very accurate and has become even more important because newer products are very specific to the life stage of the pest. Intrepid, an insect growth regulator, is active against CM during the egg and larval stage, while neurotoxins such as Assail and Spintor primarily target the larvae.

Each of these new insecticides has relatively good activity in reducing CM populations but, when used in combinations that target multiple life stages, might provide even greater levels of control. Integrating several products in a management program has the added benefit of reducing the likelihood of CM developing resistance to these materials.

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Codling moth generally has two full generations per season in the northern United States with up to 4 generations in southern areas. Each flight lasts for 6-8 weeks. Immediately following the decline in first flight moth activity is a second smaller but very distinct flight, often called the "b" peak. This activity can be overlooked if the decline in the first peak is misinterpreted as the end of the overwintering generation. This extended flight can allow CM populations to quickly build out of control and cause significant fruit injury. It is important to continue monitoring for these late emerging adults and respond accordingly.

As overwintering survival increases, codling moth populations increase. Many apple-growing regions have experienced mild winters during 2000 and 2001, resulting in greater CM activity during the spring. Another situation resulting in a greater potential for CM injury occurs when cold spring temperatures result in a reduced crop load. The potential level of fruit injury is artificially inflated under these conditions but is real nonetheless. An orchard that might typically have 1% fruit injury could experience 3.3% injury given a 30% crop reduction.

Recently abandoned orchards, or those not managed due to unfavorable economic conditions, can generate CM populations that lead to problems for nearby orchards. Codling moth females generally lay eggs in close proximity to where they are mated. However, when CM population densities increase, females are more prone to disperse before laying eggs. It is important to recognize that unmanaged areas such as abandoned orchards, bin piles and woodlots have the potential to quickly create pest populations that can impact nearby commercial orchards.

Pheromone mating disruption for CM is now a commonly used practice in many apple orchards. The success of mating disruption is influenced by factors such as orchard size, shape, pest pressure, dispenser release rate and number of point sources. Mating disruption works best in large (5+ acre), square blocks with uniformly spaced trees. Orchards with an uneven tree canopy, missing trees or steeply sloped terrain are less suitable for this technique.

Orchards with low to moderate CM populations benefit the most from mating disruption. Companion insecticide sprays are usually required and should be based on pest pressure. Mating disruption generally reduces the number of chemical applications required compared to non-disrupted orchards although, where CM pressure is high, more sprays are needed and the additional cost of pheromone application may not be justified.

Pheromone dispensers must be applied prior to first flight or the battle is an uphill fight. Pest pressure, level of fruit injury and the number of insecticide sprays required the previous season will help determine the appropriate number of dispensers needed (Table 2). Full rates of MD are warranted when beginning a pheromone program but may be reduced after several seasons of successive use as pest populations decline. Pheromone placement is critical to its performance. Female CM predominantly are active in the upper tree canopy and call for mates from that position, therefore dispensers must be applied within the top 2 feet of the tree canopy.

Codling moth is the "key" pest of apple in most regions, but the presence of other primary pests influences how or what kind of MD is employed. Leafrollers, in particular the obliquebanded leafroller (OBLR), *Choristoneura rosaceana*, is another candidate for MD. One of the most widely used mating disruption products, Isomate CM/LR, targets both primary pests. Some thought should be given to determine the best timing for the application of this dispenser.

The dispenser lasts approximately 120 days, not long enough to cover all of CM and all of OBLR flight. The dispenser will run out of pheromone for 2nd flight OBLR if it is applied early in the season targeting CM. Delaying the application a few weeks will ensure proper coverage for both OBLR flights but leaves the first half of overwintering CM flight untreated. There are many insecticides available which are very effective against leafrollers. If the orchard history indicates that CM is the major cause of fruit injury, then application of CM/LR should be timed for CM, and summer generation LRs can be managed with insecticides.

It is critical to monitor disrupted orchards on a weekly basis to determine the effectiveness of the pheromone as well as any supplemental sprays. A combination of sticky traps baited with high load (10x) and standard (1x) pheromone lures are required to properly trap CM under MD. Traps should be placed in the upper 1/3 of the tree canopy and the sticky insert should be cleaned regularly. The trap integrity needs to be maintained to function properly. Areas vulnerable to immigrating moths, including borders, woodlots and bin piles, require extra monitoring.

The cost of pest management programs has increased while the economic situation of the apple industry has declined. New insecticides cost more than older materials as companies attempt to recover the cost incurred during research and development. Pheromone mating disruption can be cost effective. Codling moth populations under mating disruption are reduced over time to sustainable levels, and the cost of these programs is similar to that of conventionally managed programs by the 2nd or 3rd year.

Codling moth management will continue to challenge growers today and in the future. Implementation programs have demonstrated that combining the use of new insecticides with pheromone mating disruption for codling moth control is effective and economical while conserving natural enemies and mitigating the development of insecticide resistance.

ADDITIONAL READING AND LITERATURE CITED

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TABLE 1

Example of degree-day (DD) model accuracy (adopted from Beers et al., 1993).

Year	DD model accuracy	Calendar accuracy	Days between biofix and first entry
1	0	4	24
2	-2	13	35
3	0	2	25
4	-1	8	25
5	0	18	33
6	-1	1	23
7	0	13	28

CM DD Model method: Spray 250 DD° after biofix.
Calendar method: Spray 21d after full bloom.
Accuracy: Difference, in days, between observed first larval entry in the field and predicted timing.
Negative numbers = too late, Positive numbers = too early.

TABLE 2

Example of integrated codling moth management based on previous injury (adapted from Gut and Brunner, 1996).

% injury previous year	0.1	0.5	2+
Anticipated # cover sprays	1-2	2-3	4+
# Dispensers per acre (rate)	200 (1/2)	300 (3/4)	400 (full)