Cornell University
Cooperative Extension

Lake Ontario Fruit Program in
Wayne, Orleans, Niagara,
Monroe, and Oswego Counties

Are worms eating up your profits? Chewing holes through your returns?
A guide to reduce economic risk of fruit damage by internal lepidopteron pests.

Managing Codling Moth and Oriental Fruit Moth In Apples.

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If your packers and processors are reporting worm holes, or worms, it is likely you have a high population of codling moth (CM, *Cydia pomonella*) and/or oriental fruit moth (OFM, *Grapholita molesta*) that are causing economic losses in your fruit. It is time to take steps to prevent this damage. The tools that are used to control these pests include pheromone trapping, implementing mating disruption pheromones to prevent mating, improving spray timing using degree-day models and trap data, improving spray coverage, and using the most effective insecticides and viruses at the recommended timing.

Step 1: Identify the pest.

Is it codling moth, oriental fruit moth, lesser appleworm, or a combination? If you see that the larva has fed into the core and on the seeds, it is most likely codling moth. If the larva has fed into the core but not on the seeds, the larva must be identified by its physical characteristics: look for the presence or absence of an anal comb (present on the OFM or LAW), as shown in Figure 1, and presence or absence of speckles on the prothorax, as shown in Figure 2. If you only have sting damage from small larvae that are not present, you will need to rely on trap data for identification. See Figure 4.

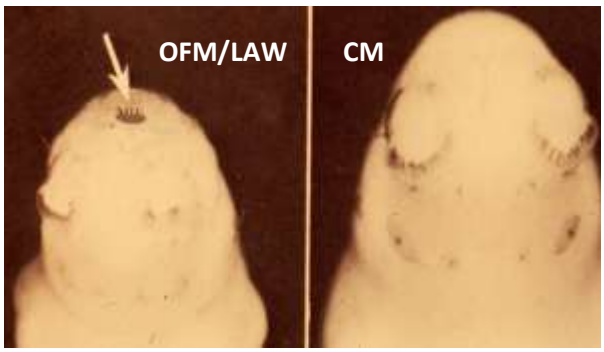

Figure 1. Anal comb present at end of abdomen of OFM and LAW. (Chapman and Link)

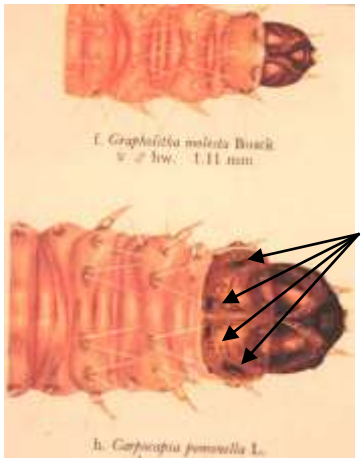

Figure 2. Four dark speckles present on prothorax of CM, not on OFM and LAW.

Step 2: Monitor moth flight for biofix, peak flights, and seasonal trap totals.
Monitor moth flight to mark biofix (first sustained moth catch) and identify when to start running degree-day developmental models. Use an appropriate pheromone lure for each insect species (CM or OFM).

If no mating disruption pheromones are being applied, use a standard lure for OFM, and use an L2 (long-life) lure for CM. There are several types of traps available including large delta, wing, and diamond shaped traps. The trap thresholds of the pests were based on traps the size of the small Pherocon IIB (see Figure 5). The bigger the trap, the more moths you will catch but there are no scientifically-based adjustments available if larger Delta traps are used, but they can be used.

Traps are best hung in trees at about 5-6 feet high in the tree canopy for CM and OFM. The OFM traps will also catch lesser apple worm (LAW) so it will be important to know how to distinguish between the two. A trap set at least every 10 acres is the minimum number recommended in orchards with a history of damage. A few traps should be placed around the edges to intercept moths immigrating into the orchard.

Monitor traps 2-3 times per week until biofix is set. Record first moth capture and mark biofix after catching more than 1 moth two weeks in a row (sustained trap catch). Trap supplies can be purchased from many agricultural suppliers. Follow manufacturers' guidelines for proper trap and lure maintenance and replacement.

Pheromone traps used when mating disruption pheromones require a different trap set up, since the key to mating disruption is to prevent the male from finding the female or lure by saturating the orchard canopy with the female lure. When using CM mating disruption pheromones, the CM-DA combo lure (using a combination of CM sex pheromone and pear ester) is more attractive to both male and female moths increase the sensitivity of the traps to detect CM activity. The standard lure for OFM can be hung 5-6 feet high in the canopy. The same traps are used but some researchers think that the large Delta trap hung in top third of the tree canopy will increase the chances of catching a moth if present in a disrupted orchard. In mating disrupted orchards, CM traps should be hung in the top third of the tree canopy attached to a bamboo pole. An effective trap distribution pattern is 1 trap per species for about every 5 acres in the disrupted orchard. Adding a few traps in orchards outside the disruption area has proven to be a good indicator of the outside population pressure if suitable locations exist, preferably upwind of the disrupted area. Traps hung downwind of disrupted acreage will be less accurate. Do not hang these traps in the same tree as the pheromone dispensers.

Trap Thresholds: What they are and how to use them.

A trap threshold is the number of moths captured in a trap indicating a population size at which economic damage will likely ensue if control methods are not implemented. These numbers are suggested thresholds and will be influenced by lure type and trap size.

OFM suggested trap thresholds: If apples have > 30 oriental fruit moths per trap per week for the first flight, and >10 moths per week for the 2^{nd}-4^{th} flights, there is a potentially treatable population. In peaches, if there are >15 moths per trap per week for the first flight, there could be potential fruit

infestation problems if control steps are not taken. The suggested trap threshold for OFM in peaches for 2nd-4th flight is 10 moths per trap per week.

CM suggested trap thresholds: If > 5 codling moths are caught per trap per week using standard lures, there can be problems in fruit from future generations. High trap counts are a warning to prepare for an application in 5-7 days. If trap counts continue to exceed threshold throughout the season, maintain insecticide coverage on a 2 week interval.

Step 3. Review insecticide choices and timing.

Ask your consultant or extension specialist for a review of spray timing and insecticide choices. Spray timing for these pests is directed at newly hatched larvae since most insecticides are not effective at controlling adults. High trap counts do not trigger an immediate insecticide application; there is a lag period for egg hatch after the moths fly. Regional trap counts for the past season will show trends in when egg hatch of these pests was expected based on trap biofix (first sustained trap catch) and degree-day accumulations. The first oriental fruit moth capture is usually noted in late April to the first week of May, or when peaches are at pink bud. The first codling moth emergence typically occurs during bloom in apples. The higher the population of overwintering CM or OFM, the earlier first trap catch can be expected.

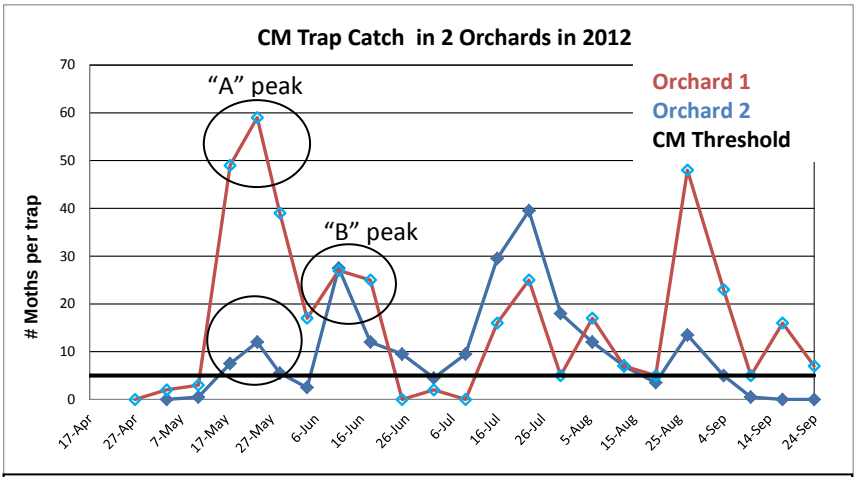

Figure 3. Trap catch data showing multiple peak flights of CM .

In orchards with high codling moth populations, we typically see 2 peak moth flights emerging from the overwintering larvae; the first is a normal "A" peak, about mid-late May, and the second "B" peak occurs mid-late June and can be a smaller or larger peak than the "A" peak. Both cases can be seen in Figure 3. The second flight typically begins in mid-late July.

The PETE (Predictive Extension Timing Estimator) degree-day model suggests the best spray dates for the first generation should be about 200-250 DD (base 50°F) after first sustained catch, with a second application about 2 weeks later (or one week if using pyrethroids). But this spray timing does not provide sufficient residual insecticide to last through the time when we would have significant egg hatch from the "B" peak of the first flight usually early July. So under very high populations, a third insecticide spray is necessary to prevent larval penetration of the fruit. If this late flight goes uncontrolled, it will contribute to multiple peaks for the second flight in late August and September. It is critical to use the more effective insecticides (rated as a "3" in Table 2) for internal lep pests at these timings to prevent future generations that will infest the fruit closer to harvest. The 2nd generation CM sprays should be applied 1260 DD (base 50°F) after biofix and 2 weeks later. However, 3 sprays may be needed if the first

generation was not well controlled and trap counts continue to exceed threshold. Under low to moderate population pressure, 1-2 sprays will be necessary to control the second generation.

If OFM larvae are identified as the main internal-feeding species found in fruit at harvest, there was likely a late flight of OFM, which is common in early September if early season OFM generations are not controlled, or if apples are located near harvested peach plantings. High trap numbers will predict infestation, especially in later harvested apple varieties.

If spray timings were close to those predicted by the combination of trap catch and degree days, then consider the possibility of inadequate spray coverage, or resistance to organophosphates, or a weakness in residual protection using pyrethroids.

Time insecticide applications based on trap data and degree day (DD) models for egg hatch.
Spray timing for these pests is directed at newly hatched larvae, since most insecticides are not effective at controlling adults. There is a lag period for egg hatch after the moths fly.

The first spray for CM is recommended at first egg hatch, which occurs 220-250 DD (base 50°F) after sustained trap catch. But the timing depends on insecticide choice. Rimon (which is more ovicidal) should be applied at 75-100 DD 50°F after CM biofix; for Calypso, Assail, Delegate, Altacor, Belt, or Voliam Xpress or Voliam Flexi, 200-250 DD 50°F after biofix. An additional option is to apply a granulosis virus formulation at 200-250 DD 50°F. High moth pressure requires 2-3 sprays for the first generation, but in lower pressure orchards (with counts of less than 5 moths per trap per week), you can control CM with a single spray timed at 350 DD 50°F. Research in Washington and Michigan has shown that codling moth mating and egg laying activities take place primarily during a four-hour period, beginning around dusk, if temperatures are above 60°F during that period. Temperatures below 60°F impede male activity and prevent mating, so a cooler spring will delay significant egg hatch for the first generation. If weather data is available to predict this, it can be incorporated into the degree day model as egg hatch will occur 220 DD 50°F after the first flight when evening temperatures >60F.

The first insecticide spray for OFM in peaches is recommended at 175 DD (base 45°F) after biofix (petal fall) and a second spray 10-14 days later, until trap counts subside; in apples, 1st generation OFM can be controlled with the petal fall spray. In summer, sprays for OFM in apples are applied 3-4 days after peak trap catch, or 7 days after the start of the 2nd flight.

Step 4: Check spray coverage and insecticide resistance.
Spray coverage or insecticide resistance should be considered as contributing factors if spray timing was good. Spray coverage tests can easily be conducted using Surround kaolin clay – if you do not see residue in the top third of the tree canopy and on the fruit in the tops of trees, this is a primary weak point in your spray program that cannot be overcome with more sprays of expensive insecticides. Much of the egg laying activity happens in the tree tops, and research shows that lack of pruning contributes to poor spray coverage; consequently most of the damage occurs in the tops. If you are still relying on organophosphates and pyrethroids, there may also be some resistance to these insecticides in the insect population.

Step 5: Consider whether or not to use mating disruption pheromones.

Should you use mating disruption (MD) or not? We have seen cases where the cost of mating disruption is made back many times over in high pressure orchards that would otherwise suffer damage of more than 5% in high value varieties having a yield of 1000 bushels per acre. Mating disruption pheromones are very effective tools for cleaning up an infested orchard. Several pheromone products are available for disrupting the mating behavior of codling moth and oriental fruit moth. We've experienced the most success with time-release products such as Isomate CM/OFM TwinTube dispensers at 200 per acre, or Checkmate Duel CM/OFM at 200 per acre. A third option is the Suterra Checkmate Puffer, deployed at 1 unit per acre, with 1-2 rows of hand-applied dispensers around the outside edges of the orchard. Although some growers have shown success using sprayable pheromones to avoid the labor of installing hand-applied dispensers, this is very management-intensive, is ineffective with rainfall, and growers tend to wait to see moth flight before planning an application. The delay between first moth catch and applying pheromone allows a period of time when mating will occur; consequentially, we see egg laying and larval fruit penetration when sprayable pheromones are applied after the flight. For assistance in designing a dispenser distribution plan for your farm, feel free to call Debbie Breth.

How do I adjust insecticide timings when using MD pheromones ?

When pheromone products are implemented at the proper rate under high overwintering insect pressure, the same DD timings will be used and it will still be necessary to apply 2-3 well timed sprays for the first generation of CM, and 1-2 for the second generation, so as to result in no fruit damage during the first season. The impact of the first season of MD under high pressure is the elimination of September insecticides targeting these pests. In the second season, if no damage occurred during the first season, continue using pheromones at the same rate, but you should be able to reduce insecticide applications to 2 for the first generation and 1 for the second generation. In the third season with mating disruption, our experience has shown we can reduce insecticides that target CM to 1 per generation and reduce the pheromone rate by 25% of Isomate CM/OFM from 200 to 150 dispensers per acre and Suterra Puffers from 1 puffer per acre to 1 puffer per 1.25 acres.

If there is a high pest population outside your orchard that you are unable to control due to land ownership or other issues, you may want to consider a protective edge spray program based on trap catch and DD timing of the traps outside of your orchard. But beware, your pheromones will travel downwind and disrupt flight resulting in no moths caught in traps downwind from the disrupted area, misleading you to believe there are no moths in the neighborhood.

Control recommendation based on damage levels suffered the previous season:

More than 5-10% damage? Starting with a high overwintering population of codling moth and oriental fruit moth.

1. Hang MD pheromones for CM/OFM during pink bud in apples.
2. Hang pheromone traps at pink bud for CM in top 1/3 of tree canopy and mark biofix date for CM. Hang OFM traps in late April, 5 feet off ground in the tree canopy and mark biofix for OFM.

3. Spray the most effective insecticides for the first generation starting at first egg hatch, and follow up with 1-2 more biweekly sprays. Do not rely on pyrethroids for this generation. When trap numbers start to increase again for the second flight, add 200 DDF to the date of increase, or treat 5-7 days after a high trap catch using another effective insecticide class and apply a second spray in 2 weeks.
4. Monitor fruit for damage in July to assess control of the first generation and again in late August.
5. If apples have less than 2% damage after the first high pressure season, the second season insecticide load can be reduced to 1-2 per generation, but decisions must be made based on trap data and monitoring for damage in fruit.
6. Do not reduce the MD pheromone disruption rate until after 2 seasons with no damage.

Are Moderate CM/OFM populations or hot spots causing economic losses in fruit?

Identify pests and monitor moth activity with traps to improve timing of insecticides based on thresholds and degree-day models described above. Check spray coverage especially in trees taller than 15 feet. Consider mating disruption: formulations of Checkmate or Isomate dispensers or Puffers would work well in these cases; these are easily applied once in the spring (pre-bloom) with a little labor, and then can be left to work for the whole season with no additional applications.

Low to nonexistent CM/OFM populations?

If you see no fruit damage and low trap counts without mating disruption, consider yourself lucky! Keep up the good work, and review the above guidelines for trap monitoring, thresholds, and DD model timing, to ensure your continued success.

Figure 4. Identifying moths in traps.

Oriental fruit moth

Codling moth

Lesser apple worm

Figure 5. (Left) Pherocon IIB trap with Trece standard OFM lure. (Right) Hang CM traps in top of tree canopy when using mating disruption pheromones.

Figure 6. (Left) Isomate CM/OFM Twin Tube on PVC hoop for installing in tree top (200/acre). (Center) Checkmate Duel CM/OFM membrane pheromone dispenser (200/acre). (Right) Suterra Puffer, aerosol can of pheromone in cabinet – 1/acre.

Figure 7. (Left) Shoot tip infested with OFM larva. (Right) CM or OFM newly hatched larva penetrated the skin to cause a "sting."

Table 1. Codling moth degree-day model and insecticide timings for control.

GDD° base 50 (Post Biofix)	Event	Action
Pink bud	Development of overwintering larvae.	Set traps.
0 GDD° = Biofix (~200 DD° after Jan 1)	1st sustained moth captures	Set DD° = 0
100 GDD°	1st generation egg laying (oviposition).	Timing for ovicide materials.
250 GDD°	Start of 1st generation egg hatch.	Timing for larvacide materials.
350 GDD°	1st generation egg laying & hatch.	Delayed timing if pest pressure is low, or for 2nd treatment if an ovicide was applied at 100 DD°.
500-650 GDD°	Peak of 1st generation egg hatch.	Timing for additional larvacide if monitoring of CM activity indicates a treatment is needed.
1260 GDD°	Start of 2nd generation egg hatch	Timing for additional larvacide if monitoring of CM activity indicates a treatment is needed.

Table 2. Chemical class, activity and timing of insecticides used for CM control. (Wise, MSU)

Compound trade name	Chemical class	Life-stage activity	Optimal spray timing for codling moth	Activity: best = 3 good = 2 some = 1
Asana, Warrior, Danitol, Decis, Baythroid XL	Pyrethroids	Eggs, Larvae, Adults	Biofix + 250 DD	2
Rimon	IGR (chitin inhibitor)	Eggs, Larvae	Biofix + 100 DD Residue under eggs	3
Delegate	Spinosyn	Larvae	Biofix + 250 DD	3
Altacor, Belt	Diamide	Eggs, Larvae	Biofix + 200-250 DD	3
Assail, Calypso	Neonicotinoid	Larvae, Eggs & Adults (limited)	Biofix + 200-250 DD Residue over eggs	3
Intrepid	IGR (MAC)	Eggs, Larvae, Adults(sublethal)	Biofix + 150-200 DD Residue over eggs	2
Avaunt	Oxidiazine	Larvae	Biofix + 250 DD	2
Esteem	IGR (juvenoid)	Eggs, Larvae	Biofix + 100 DD Residue under eggs	2
Proclaim	Avermectin	1st generation larvae	Biofix + 200-250 DD	2
Granulovirus	Biopesticide	Eggs, Larvae	Biofix + 250 DD Residue over eggs	2
Voliam Xpress	Diamide + Pyrethroid	Eggs, Larvae	Biofix + 200-250 DD Residue over eggs	3

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