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Codling Moth Mating Disruption

Marion Murray, IPM Project Leader • Diane Alston, Entomologist

Do You Know?

- Codling moth is a key pest of apples and pears
- Mating disruption does not kill insects; it saturates the orchard with the female moth sex pheromone to delay or prevent mating
- At least 10 contiguous acres are required for codling moth mating disruption to be effective
- There are several different mating disruption products available; some are more effective than others
- In orchards with heavy codling moth pressure, supplemental insecticides are required for at least the first few seasons
- A regular monitoring program is essential for successful management of codling moth
- Long-term use of mating disruption can reduce insecticide exposure and codling moth populations
- Use of mating disruption is OMRI (organic) certified

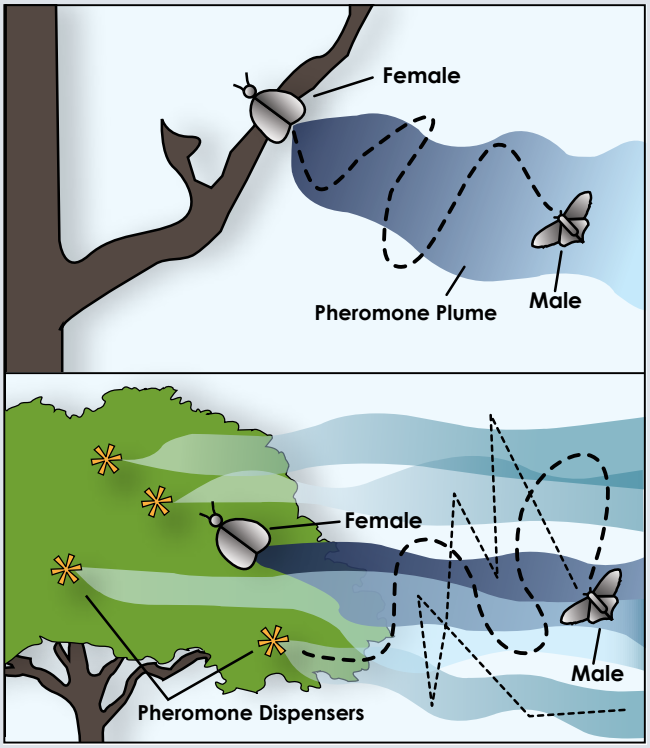


Fig. 1. Female moths emit a chemical blend (pheromone) that forms a plume. Male moths follow the plume to find their mates **(top)**. In the presence of mating disruption, the female moth's plume is mixed with the plumes of pheromone dispensers, which inhibits the male's ability to find the female **(bottom)**. The male may either fly randomly and not approach a moth at all **(thin dotted line)** or home in on a dispenser or even a female **(thick dotted line)**. The idea is that mating is either delayed or prevented.

Mating disruption became commercially available in the early 1990s, and was adopted by many Utah growers about a decade later. Use of this pest management technology can be daunting due to high up-front costs and monitoring requirements; however, after two to three seasons of use, the cost of mating disruption is the same or even less than conventional pest management. With the loss of Guthion, and pressure to reduce pesticide use, mating disruption is a viable and important alternative for larger-acreage orchardists.

HOW MATING DISRUPTION WORKS

Like many moth species, the female codling moth emits a species-specific pheromone (called codlemone), which attracts male moths for mating. Males easily follow the pheromone "plume" directly to the female. When an orchard is saturated with synthetic codlemone, mating is "disrupted" as the males are limited in their ability to find females (Fig. 1).

Two theories have been proposed to explain how mating disruption delays or prevents mating:

- "Competitive attraction," where males follow the false plumes at the expense of finding a mate
- The males' ability to find females has been blocked by the pheromone-saturated air, and they are unable to follow any plume

Entomologists at Michigan State University (MSU) suggest that the primary mechanism is competitive attraction. In their research, they repeatedly saw male moths approach pheromone dispensers reducing their success of locating female mates. The MSU research also showed a secondary response where males were unable to follow any pheromone plume due to sensory overload. They found that the males recovered the next day after flying out of the saturated orchard. The result of these two mechanisms is that mating is delayed. A female that has not mated after 3 days has half the number of viable eggs. As a result, mating disruption alone is not a successful pest control strategy in orchards with high moth populations. Chance encounters and mating are known to occur under mating disruption where pest pressure is high.

The good news is that, after several seasons of using mating disruption, the codling moth population declines, and mating and fruit injury are prevented.

WHO CAN USE MATING DISRUPTION

Before using mating disruption, be sure you have the time and resources for a proper monitoring program, and a source of information (consultant, agriculture company representative, Extension) when questions arise.

Codling moth mating disruption requires large, contiguous areas of orchard to work successfully.

- **Ten acres** of solid apple and/or pear trees is the minimum size.
- Ideally, border edges are minimized (i.e., mating disruption works better in a square-shaped orchard than in a long, narrow rectangular orchard).
- Expansion of mating disruption to cooperating, neighboring orchards (of the minimum size) will improve effectiveness.
- Newly planted orchards are not ideal for mating disruption because the pheromone quickly dissipates due to lack of foliage.

Know your initial codling moth population. If you have never used mating disruption, the orchard may have high codling moth pressure. In this case, be prepared to apply well-timed insecticide treatments as you would without mating disruption for the first one to two seasons. Once the population declines, it is possible to use mating disruption with few, or even without, supplemental treatments.

MATING DISRUPTION PRODUCTS

Growers in Utah have used both hand-applied and puffer dispensers, and sprayable codlemone. Hand-applied dispensers are applied at a rate of 150 – 400/acre, and puffers at 1-2 canisters/acre.

Hand-Applied Dispensers

Currently, the following brands are most commonly used in Utah:

Isomate-C Plus is a polyethylene tube twist-tie dispenser loaded with pheromone. This dispenser is considered the industry standard to which others are compared.

Cidetrak CM is a clip-on dispenser ("puzzle piece") that uses a novel packaging of the pheromone in an internal and external shell that is said to prevent oxidation.

Isomate-CTT is similar to Isomate-C Plus, but is formed of "twin tubes" (TT) that contain double the volume of pheromone, and are applied at half the rate of C Plus.

Checkmate CM-XL 1000 is a clip-on, flat membrane dispenser.

NOTE: Dispensers in the images above are shown clustered on branches for demonstration, but should be hung according to the directions for actual applications.

Table 1. Characteristics of common hand-applied dispensers

Dispenser	Codlemone Load ((E,E)- 8,10 dodecadien-1-ol)	Minimum Application Rate (dispensers/acre)	Product Cost/acre	Manufacturer /Distributor
Cidetrak CM	2.0% (120 mg)	400/acre	$110	Trécé, Inc., Adair, OK
Isomate-C Plus	53.0% (205 mg)	400/acre	$100	Pacific BioControl, Vancouver, WA
Isomate-CTT	53.0% (382 mg)	200/acre	$100	Pacific BioControl, Vancouver, WA
Checkmate CM-XL	17.5% (250 mg)	200/acre	$110	Suterra LLC, Bend, OR

To be effective, each hand-applied mating disruption dispenser should release a small amount of pheromone over approximately 140 days. Recent research at USU (2009) compared the pheromone release rate of each of the above dispensers (Table 1) and found that they were all releasing pheromone after 140 days in the test orchard; however, there were notable differences between the products (the final report can be found here):

Cidetrak:

- This product had the lowest pheromone release rate and lowest amount of codlemone within the dispensers
- Field testing in Michigan and Washington have shown this product is effective in preventing injury

Isomate-C Plus:

- Showed the most constant release rate through 1st and 2nd generations of codling moth
- This product was the second highest in release rate after 140 days
- Field testing in other states have shown excellent results with this product

Isomate-CTT:

- Initially, release rate was twice that of Isomate-C Plus but dropped to similar levels as C Plus after 90 days; because this product is applied at half the rate of C-Plus, orchards with CTT would have less protection from disruption later in the season
- After 140 days, the release rate was the highest, suggesting product longevity
- This product had the greatest amount of codlemone remaining within the dispensers after 140 days

Checkmate:

- This product had the second lowest pheromone release rate after 140 days
- Results showed that it was the least efficient product; it lost the greatest amount of pheromone, but had lowest release rate into the air, suggesting that pheromone was degrading on the dispenser surface

Puffers

The Checkmate Puffer (Suterra, shown at right) is an aerosol device that releases a small spray of pheromone every 10 to 15 minutes. The aerosol canister is housed in a reusable cabinet that controls the spray. One canister lasts approximately 200 days. The initial cost to purchase the aerosol devices is higher than for hand-applied dispensers, but aerosol devices can be reused for years. Over several years, the price/acre for product is similar to hand-applied dispensers, however, the labor costs are much less because the rate is 1-2 puffers/acre as opposed to up to 150-400 hand-applied dispensers/acre. Puffers have not been researched in Utah; however some apple growers in Utah, and most walnut growers in California, have had good success.

Sprayable Pheromones

Microencapsulated pheromones are enclosed in a polymer capsule which adheres to the crop canopy and controls the pheromone release rate. Sprayable formulations are mixed with water and applied with traditional sprayers, such as the orchard airblast. Existing products have a short residual (1 to 2 weeks or less) and have shown inconsistent results. They may have a fit for short-term disruption, such as late in the season when dispenser release rates have declined.

APPLYING MATING DISRUPTION PRODUCTS

Whichever product you choose, mating disruption dispensers should be placed in the orchard at or shortly before biofix (first male flight) to prevent/delay mating. Ideally, a biofix for each orchard should be determined in a nearby, non-mating disrupted site. (You cannot get an accurate biofix within an orchard that has been historically using mating disruption due to the low moth population.)

Product labels will instruct on placement in the orchard, but in general:

- Hang dispensers singly, and evenly, in the top third of the orchard canopy (do not bunch many in fewer locations)
- Choose sturdy branches for hanging so that dispensers remain attached even in high winds
- Dispensers last just one season; a fresh batch should be reapplied each spring
- Store leftover dispensers in the freezer for up to one year
- Use disposable latex gloves when applying to prevent the possibility of a skin rash (rare)
- For new mating disruption orchards, consider doubling the application rate on the borders and at problematic "hot spots" for injury
- As moth population decreases, you can consider lowering the application rate within the orchard (not on the borders) to save costs. Monitor moth population and injury carefully to assess effectiveness

MONITORING

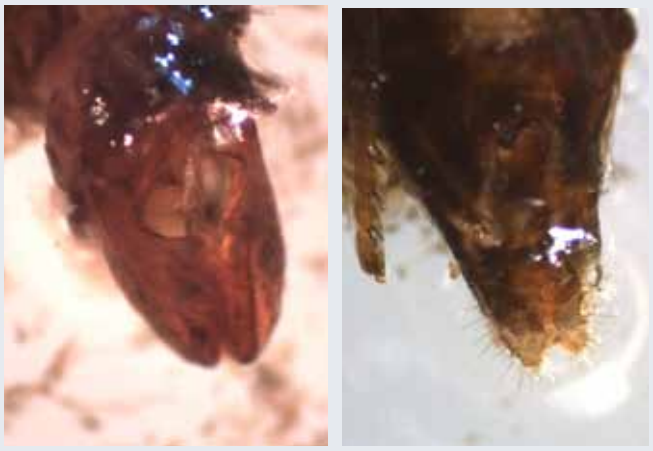
Monitoring codling moth populations using pheromone traps in disrupted orchards is essential to determine pest pressure and need for supplemental insecticide. Specialized codling moth lures must be used because the high concentration of pheromone in disrupted orchards masks traps with the standard lures. A high-load codlemone lure (mega, or 10X) has been the traditional grower standard. The newer lures, DA and DA-Combo, contain a chemical extracted from ripe pears to attract male and female codling moths, and show promise in improved trapping effectiveness. We compared the new lures to the 10X lure in apple orchards in Utah County in 2006-2009, and developed trap thresholds.

The Utah study found that action thresholds for the DA-Combo lure were the most accurate in predicting apple fruit injury and the need for supplemental insecticide treatments. Use of both total moth and female moth thresholds combined resulted in only one false prediction for the full season in 20 apple orchards in a 2009 validation study (Table 2). The DA lure thresholds were too low, and resulted in numerous false positive predictions (recommended treatment when it wasn't necessary). For the 10X lure, the relationship between fruit injury and trap catch was inconsistent at higher moth densities. The DA-Combo thresholds in Table 2 are recommended for use in disrupted orchards.

Table 2. Action thresholds for the DA-Combo lure (Trece, Inc.) to prevent fruit injury. Cumulative moth counts begin at zero for each codling moth generation and are reset to zero following an insecticide application. Use of both thresholds (i.e., total and female moth thresholds must both be reached) provides greater accuracy than use of either threshold alone.

CM generation	Total moths per trap	Female moths per trap
1st	10	0.5
2nd/3rd	10	1

Identifying Female Moths



Male and female moths can be discerned by looking at the tip of the abdomen (body behind the wings) with a 10-20x hand lens. The abdominal tip of the male (left) has a pair of claspers which are used to hold the female during mating. The female abdominal tip (right) has a heart-shaped pad used for laying eggs. Probe the abdominal tip of the moth caught on the sticky liner with a blunt object to extend the claspers or pad for better viewing.

CAUSES OF FAILURE

- Use of mating disruption (MD) in a small area (less than 10 acres) or use in an orchard with a high ratio of border to interior trees
- Not increasing MD dispenser rates in "hot spots" such as along borders with external moth sources (e.g., backyard trees) or along upwind borders of strong prevailing winds
- Not applying supplemental insecticides when necessary
- Not monitoring and detecting increased moth populations and fruit injury

- Applying MD dispensers after biofix
- Not applying MD dispensers according to labeled recommendations
- Not maintaining sanitation practices (e.g., removing cull piles and bins)

SUMMARY

Mating disruption can be a highly effective method to lower codling moth populations and reduce insecticide usage, and is organic approved. It is only appropriate for use in contiguous apple and/or pear blocks of 10 acres or more. Mating disruption needs to be applied just before or at biofix (first consistent moth activity) for full effectiveness. The method does not kill moths, but prevents or delays mating. There are a number of pheromone disruption products available. Hand-applied dispensers have been used the most in Utah. It is critical to prevent high populations of codling moth from building up in a disrupted orchard; otherwise, fruit injury is likely to occur. Transition of orchards from traditional codling moth management to mating disruption is most successful if a complete or nearly-complete spray program is used in combination with mating disruption for the first season or two to lower moth populations. Thorough monitoring of moth populations and use of action thresholds to determine the need for supplemental treatments are essential for successful implementation of mating disruption.