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UNIVERSITY OF CALIFORNIA AGRICULTURE & NATURAL RESOURCES
UC IPM Online
Statewide Integrated Pest Management Program

How to Manage Pests

UC Pest Management Guidelines

Apple

Codling Moth

Scientific Name: ***Cydia pomonella***

(Reviewed 8/06, updated 12/09, corrected 8/11)

In this Guideline:

DESCRIPTION OF THE PEST

Codling moth has a 0.5 to 0.75 inch wingspan. The tip of each forewing has a coppery-tinged, dark brown band that distinguishes codling moth from other moths found in apple orchards. Females lay eggs singly on leaves and sometimes on fruit later in the season. The eggs are smaller than a pinhead, disk-shaped, and opaque white when first laid. Just before hatching the black head of the larvae becomes visible. Newly hatched larvae are white with black heads. Mature larvae are 0.5 to 0.75 inch long, pinkish white, with mottled brown heads. Depending on climatic conditions and location in the state, there are two to four generations of codling moth each year.

DAMAGE

Codling moth has the greatest potential for damage of any apple pest, yet it can be effectively controlled with properly timed treatments. It causes two types of fruit damage: stings and deep entries. Stings are entries where larvae bore into the flesh a short distance before dying. Deep entries occur when larvae penetrate the fruit skin, bore to the core, and feed in the seed cavity. Larvae may enter through the sides, stem end, or calyx end of the fruit. One or more holes plugged with frass on the fruit's surface are a characteristic sign of codling moth infestation. Calyx entries are difficult to detect without cutting the fruit.

MANAGEMENT

An IPM program uses a combination of tools for codling moth management, including insecticides, mating disruption, and cultural controls. Mating disruption is the preferred tool because of its low toxicity to people, natural enemies, and the environment, but it may need to be supplemented with insecticide sprays, especially

during the first few years. In orchards where codling moth is managed primarily with insecticides, alternate insecticides that have a different mode of action Group number to avoid the development of resistance. If you see trap catches increasing and suspect insecticide tolerance or resistance, combine the use of mating disruption with the insecticides. All codling moth management programs should be supplemented with cultural controls.

Biological Control
Alone, natural enemies are not able to keep codling moth populations below economic levels. Augmentative releases of the egg parasite *Trichogramma platneri* have been applied to reduce codling moth populations, but research has shown that this technique has limited effectiveness and is too expensive for practical use.

Cultural Control
Remove host trees in nearby abandoned orchards (apple, pear, and walnut) to destroy reservoirs of codling moth. Also remove props, picking bins, and fruit piles from the orchard. Proper pruning and orchard sprayer calibration will improve spray coverage. An option for small, organic orchards is hand thinning to remove all infested fruit during each generation, before worms leave fruit, and removal of dropped fruit.

Organically Acceptable Methods
Organically acceptable tools for the control of codling moth include cultural control in conjunction with mating disruption and sprays of approved oils, codling moth granulovirus (Cyd-X), the Entrust formulations of spinosad, and kaolin clay (Surround). Check with your certifier about the exact status of all materials.

MONITORING AND TREATMENT DECISIONS IN A MATING DISRUPTION ORCHARD

Mating disruption works best in large, uniform orchards that are relatively square in shape. It is not recommended for orchards less than 3-5 acres in size. The larger the contiguous block of mating disruption, the more effective it will be. In orchards with moderate-to-high populations of codling moth and/or in the first year of mating disruption, insecticides or other supplemental controls will likely be needed in addition to the mating disruption program. Using mating disruption successively over a number of years can effectively lower the codling moth population so that alternative, reduced-risk chemical treatments can be effectively used to supplement control when needed.

Setting Out Pheromone Dispensers. Pheromones are deployed as either hand-applied dispensers or in an aerosol canister (puffer). Sprayable pheromones are available but not currently recommended for pome fruit orchards because of their very short residual.

Using historical biofix dates to time the application, hang all pheromone products shortly before the first moth emergence in early March to early April. It is important to put out pheromone products early in order to disrupt the mating of overwintering moths as soon as they emerge. A late pheromone application will require supplemental spray treatment.

Place hand-applied pheromone dispensers in the upper third of the tree canopy. When placing puffers, put them on the inside of the canopy of edge trees or on the outside of trees in the second row. Upwind placement is one puffer every 50 to 65 feet, and downwind placement is one every 100 to 130 feet, or an average of 20 units per quarter mile. For large blocks, also place a few puffers towards the middle of the orchard on the upwind side. Reapply the dispensers according to the manufacturer's guidelines if the product residual will not last through harvest or through the end of the last generation.

Monitoring with Traps. Monitor pheromone-treated orchards with traps carefully to help ensure that mated moths have not moved in from adjacent orchards and that the pheromone is successfully disrupting mating.

Supercharged (10 mg) pheromone traps. Place pheromone traps with supercharged (10 mg) pheromone lures in the orchard when pheromone dispensers are set out. Put these traps in trees at the same level as the pheromone

dispensers. These traps serve to help set the biofix point for degree-day accumulation, which is used to time both fruit sampling and supplemental treatments. Check traps one to two times a week until biofix is set and once a week thereafter. Biofix is the first date that moths are found in traps for three consecutive checks and sunset temperatures have reached 62°F. (Replace lures at the frequency recommended by the manufacturer.)

Supercharged traps do not attract moths from far, so place as many traps as you can monitor in areas of the orchard that are known hot spots and areas vulnerable to wind where pheromone concentration is likely to be reduced. Examples include high spots and orchard edges; five to six rows inside the orchard is a good location. If the supercharged traps consistently catch high numbers of moths, monitor fruit in the surrounding area for eggs and damage to determine if a supplemental treatment is necessary. No thresholds have been established for these supercharged traps but 5 moths/week can be considered a relatively high trap count.

Regular (1 mg) pheromone traps. Another tool in a mating disruption program is the use of pheromone traps with the regular (1 mg) lures to verify the effectiveness of the mating disruption dispensers. A good idea is to pair a 1 mg trap with a supercharged one. Check traps weekly and replace lures at the frequency recommended by the manufacturer. *The supercharged traps should catch a few moths, but the 1 mg traps should not catch any.* If moths are caught in the 1 mg traps, check the fruit in the surrounding area. If eggs or damage are found, apply a supplemental treatment to prevent further damage. Traps with regular lures can also be used in upwind border trees (placed in trees in the second row) to monitor the influx and development of codling moth. When moths are caught in these edge traps, it signals the need to monitor fruit.

DA lures. A plant-derived chemical (kairomone) lure has been developed to assist in monitoring codling moth populations. This lure is sold commercially as the "DA" lure and is available alone and in combination with pheromone ("combo lure"). The DA lure has been shown to catch both female and male moths, whereas pheromone lures catch only male moths. The sex of moths caught in traps using the DA lure can be determined by observing the tip of the abdomen. If the moth is female, the abdomen can be squeezed to eject the bursa pouch and give some idea of whether the moth is unmated, mated once, or more than once. Generally, if the female's abdomen feels hard to the touch, the moth is most likely mated.

The DA lure appears to work best in mating-disrupted apple orchards early in the season. The DA and DA/pheromone combo lure may also be used to assess the success of mating disruption in an orchard, similar to using a supercharged (10X) pheromone lure. Because these lures are relatively new to the market and there appears to be some variability in these lures from one season to the next, use them in conjunction with standard 10X and 1X pheromone lures in order to become familiar with them.

Fruit Sampling. Fruit damage can occur even when no moths are caught in traps, so always check fruit for damage towards the latter half of each generation (900 to 1000 degree-days from biofix) and whenever moths are being caught in traps. Examine at least 200 fruit from throughout the orchard as well as in known hot spots and areas vulnerable to wind (edges, high spots), which can reduce pheromone concentration.

If fruit damage exceeds 0.5%, supplemental sprays should be used for the next generation. If the damage is quite light and very localized along a border, treating five to ten rows along the problem border may be adequate. However, if damage is not clearly localized, or is localized but more than a few percentages, then a larger area or the entire orchard may need to be sprayed.

Supplemental Treatments. *First generation.* In orchards with moderate-to-high codling moth populations or if the orchard is in the first year of mating disruption, supplement the mating disruption with an insecticide spray of Altacor, Delegate, Assail, Imidan, Guthion, or Warrior at 250 degree-days after the biofix to target hatching eggs from the first peak of the overwintered moth flight. If monitoring indicates continued flight, apply a second application about 600 to 700 degree-days from the biofix to suppress egg hatch from the second flight peak of the overwintered moths.

For low populations, applying a supplemental spray to the first generation may not be necessary. Use trap catch information and monitor fruit to determine if a spray is needed. Using a reduced risk material such as the IGRs (methoxyfenozide-Intrepid) or an organically acceptable alternative (oil, spinosad-Entrust, or codling moth granulovirus – Cyd-X) may be sufficient for control of low populations.

Second and third generation. To determine if treatment is needed for subsequent generations, careful trap and fruit monitoring is essential. If treatment is needed, use the guidelines in the section below to determine the best time to spray.

MONITORING AND TREATMENT DECISIONS IN A CONVENTIONAL ORCHARD

In orchards where codling moth is managed primarily with insecticides, pheromone traps, in conjunction with degree-days and sunset temperatures, are used to determine egg hatch and proper spray timing. When using pheromone traps, keep in mind the many factors, such as tree size, trap density, type of trap, trap placement, brand of pheromone, as well as climatic conditions, that can affect trap counts.

Establish First Biofix and Begin Accumulating Degree-days. Hang 1 mg pheromone traps in the orchard in mid-March (or at bloom in foothill orchards) about 6 to 7 feet high, with one trap every 10 acres and at least two traps per orchard. The first date that moths are found in traps for three consecutive trap checks and sunset temperatures have reached 62°F is first biofix. (Service traps one to two times a week until biofix is set and once a week thereafter. Replace lures at intervals specified by the manufacturer.)

Spray Timing. Once biofix is reached, calculate degree-days using a lower threshold of 50°F and an upper threshold of 88°F.

The most effective spray timing for each generation is outlined below. For all generations, if high levels of moths are being caught in traps, do not wait until 200–250 degree-days to treat, but apply the first spray at *the beginning* of egg hatch (160 degree-days).

Codling moth has two to four generations each season. Continue to monitor the generations with traps and accumulate degree-days until the crop is harvested or populations decline below damaging levels in September.

First generation egg hatch. Two to three sprays may be necessary to adequately control the first generation particularly if the population is high or a short-residual insecticide is used. In addition, if rainfall exceeds 0.5 inch or an irrigation with overhead sprinklers is scheduled within 2 weeks after treatment, a second spray will be needed. Apply the first spray when 250 degree-days have accumulated from the first biofix, unless high levels of moths are being caught, in which case spray at 160 degree days.

Make the second and third, if needed, application when the residual effectiveness of the previous spray has ended; this will vary, depending on the chemical used. If trap catches are low or the weather turns too cool for moth activity, you can delay treatment, but continue to monitor.

Second generation egg hatch. Use pheromone trap catches to detect an increase in moth flight activity around 1060 degree-days from the first biofix, which signals the start of the next flight and is the second biofix. For low moth populations, a single application may be sufficient; make this application when 200 to 250 degree-days have accumulated from the second biofix. If you are catching high levels of moths per trap per week, spray at 160 degree-days. If needed, apply a second spray when the residual of the previous spray ends. These two sprays should provide control during the entire egg hatch period.

Third generation egg hatch. A third generation of codling moth eggs does not occur every year in every location. Codling moth larvae normally go into diapause (winter dormant state) around August 22, but in warm years and warm locations they will have already started pupation before August 22, and these pupae will soon

emerge as adults to produce a third generation. If 650 degree-days have accumulated between the peak of the second generation flight and August 22, most of the codling moth will not go into diapause but will pupate and emerge in August to early September, depending on climate.

If degree-day accumulation data indicates a third generation will occur, use pheromone traps to establish a third biofix point around 1100 to 1200 degree-days from the second biofix. Apply a spray when 200 to 250 degree-days have accumulated from the third biofix unless trap catches are high, in which case treat at 160 degree-days. If needed, apply the second spray when the residual of the previous spray ends.

Fourth generation egg hatch. In the hottest growing regions of the state, such as the southern San Joaquin Valley, a fourth or partial fourth generation may occur in some years. When flight activity increases around 1100 to 1200 degree-days from the third biofix, establish the fourth biofix. Apply a spray when 200 to 250 degree-days have accumulated from the fourth biofix and, if needed, a second spray when the residual of the previous spray ends.

Common name (trade name)	Amount to use** (conc.)	(dilute)	R.E.I.+ (hours)	P.H.I.+ (days)

When choosing a pesticide, consider information relating to the impact on natural enemies and honey bees and environmental impact. Not all registered pesticides are listed. Always read label of product being used.

MATING DISRUPTION

A.	**MATING DISRUPTANTS#**			
(Isomate-C Plus, Isomate-C TT) (CheckMate CM) (Suterra Puffer)	Label rates		0	0

COMMENTS: Apply at biofix just before moth emergence in spring. Hang dispensers high in the tree canopy, about 2 to 4 feet from tree top. If necessary, reapply once at the interval recommended on the label. Monitor weekly with pheromone traps and check fruit after each generation. Most effective on larger blocks of 5–10 acres with trees of uniform size; not effective on smaller irregularly shaped orchards or orchards with varying tree heights. In sites with medium-to-high population levels of codling moth, supplement the pheromone with insecticide treatments.

INSECTICIDE CONTROLS

A. CHLORANTRANILIPROLE				
(Altacor)	3–4.5 oz	—	4	5

MODE OF ACTION GROUP NUMBER[1]: 28

COMMENTS: Do not apply dilute applications of more than 200 gal/acre; use 100–150 gal/acre for best results.

B. SPINETORAM				
(Delegate) WG	4.5–7 oz	—	4	7

MODE OF ACTION GROUP NUMBER[1]: 5

C.	**ACETAMIPRID**			
(Assail) 70 WP	1.7–3.4 oz	—	12	7

MODE OF ACTION GROUP NUMBER[1]: 4A

COMMENTS: Larvicide; use in orchards with moderate-to-high populations. Begin applications 250 DD after biofix. Residual at 3.4 oz/acre rate is about 14 days. May cause outbreaks of mites, especially in orchards with chronic mite problems; addition of 1% oil (volume by volume) and limiting applications to a single application may help mitigate mite problems. Otherwise, to help prevent the development of insect resistance, limit applications to one generation/year. Repeat applications of *any* neonicotinoid insecticide (acetamiprid-Assail; imidacloprid- Provado; and thiacloprid-Calypso) can lead to resistance to *all* neonicotinoids. Alternate neonicotinoids with an insecticide that has a different mode of action Group number to help delay the development of resistance. To help prevent development of resistance, do not use for both codling moth and aphid control.

D. PHOSMET

(Imidan) 70WP	3.5–5.33 lb	0.875–1.33 lb	3 days	7

MODE OF ACTION GROUP NUMBER[1]: 1B

COMMENTS: Larvicide; use in orchards with high populations. Make applications 250 after biofix. Residual at the 5.33 lb/acre rate with a pH of 5.5 is about 14 days.

E. AZINPHOSMETHYL*

(Guthion Solupak) 50WP	1–3 lb	0.25–0.75 lb	14 days	14–21

MODE OF ACTION GROUP NUMBER[1]: 1B

COMMENTS: Larvicide; use in orchards with high populations. Make applications 250 DD after biofix. Check label for restricted entry intervals, which vary according to activity. Early in the season, azinphosmethyl applied at the low rate is not very disruptive to beneficials; after May, however, this is no longer true. Use the low rate when no more than 2 weeks residual control is required, or no more than 10 moths/trap have been caught before first moth treatment and seasonal trap catches the previous season did not exceed 30 moths/trap. In areas where resistance to azinphosmethyl is present in the codling moth population, even high label rates of this material may not be effective. If the last application is greater than 2 lb/acre, the preharvest interval is 21 days; if it is less than or equal to 2 lb/acre, it is 14 days.

F. LAMBDA-CYHALOTHRIN*

(Warrior with Zeon)	2.56–5.12 fl oz	—	24	21

MODE OF ACTION GROUP NUMBER[1]: 3

COMMENTS: Larvicide; use in orchards with moderate-to-high populations. Make applications 250 DD after biofix. Residual at the 5 oz/acre rate is about 21 days.

G. THIACLOPRID

(Calypso)	6–8 fl oz	1.5–2 fl oz	12	30

MODE OF ACTION GROUP NUMBER[1]: 4A

COMMENTS: Larvicide; use in orchards with moderate populations. Make applications 250 after biofix. Residual at the 8 oz/acre rate is about 14 days. May cause outbreaks of mites, especially in orchards with chronic mite problems; addition of 1% oil (volume by volume) and limiting applications to a single application may help mitigate mite problems. Otherwise, to help prevent the development of insect resistance, limit applications to one generation/year. Repeat applications of *any* neonicotinoid insecticide (acetamiprid-Assail; imidacloprid- Provado; and thiacloprid-Calypso) can lead to resistance to *all* neonicotinoids. Alternate neonicotinoids with an insecticide that has a different mode of action Group number to help delay the development of resistance. To help prevent development of resistance, do not use for both codling moth and aphid control.

H. METHOXYFENOZIDE

(Intrepid) 2F	16 fl oz	—	4	14

MODE OF ACTION GROUP NUMBER[1]: 18A

COMMENTS: Use only in orchards with low-to-moderate populations. Functions both as an ovicide (when applied to eggs and when eggs are laid on residues) and as a larvicide (larvae must ingest it for it to be

effective). Apply at 100 DD from first biofix and again in 10 to 18 days if flights are extended.

I. SPINOSAD

(Entrust) #	2–3 oz	0.5–0.75 oz	4	7

MODE OF ACTION GROUP NUMBER[1]: 5

COMMENTS: Use only in orchards with low-to-moderate populations or as a supplement to mating disruption. Tank mixing with 1% oil (volume by volume) increases efficacy: oil suppresses egg hatch and spinosad kills young larvae that ingest it. Apply 200 DD from first biofix, and reapply at 10-day intervals if continued coverage is needed. Do not apply more than 9 oz/acre/season.

J. CYDIA POMONELLA GRANULOVIRUS#

(Cyd-X)	1–6 fl oz	—	4	0

COMMENTS: Use only in orchards with low-to-moderate populations or as a supplement to mating disruption. A larvicide; larvae must ingest to become infected by this virus. Make first application at 200 to 250 DD. Make a second application 7 to 10 days later, a third application at 600 DD and a fourth 7 to 10 days later for a total of 4 applications per flight. The use of oil will help to provide increased control by distributing the virus better over leaf surfaces and serving as an ovicide by suffocating eggs. May also be tank-mixed with acetamiprid (Assail) for increased efficacy of both materials. For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum a.i. on any label when tank mixing products that contain the same a.i.

K. KAOLIN CLAY#

(Surround)	25–50 lb	—	4	0

MODE OF ACTION: Unknown. An inorganic insecticide.

COMMENTS: Best used as a supplement to mating disruption and where population pressure is quite low. Serves primarily as a barrier to oviposition and/or to prevent larvae from entering the fruit so early application and good coverage are important. Make the first application at 100 DD after the biofix, and reapply in 7 to 14 days in 100-200 gal water/acre or sufficient water for complete coverage. A total of 3 treatments per generation may be required to keep fruit completely covered during the egg-laying period. Because of potential for interfering with fruit finish in some varieties, this material may not be the best choice for later generations.

L. NARROW RANGE OIL# — 1–1.5 gal 4 when dry

MODE OF ACTION: Contact including smothering and barrier effects.

COMMENTS: Best used as a supplement to mating disruption and where population pressure is quite low. Functions as both an ovicide and larvicide. Oils are mildly effective against codling moth eggs and work by smothering them; they need to be reapplied frequently during egg-laying period, which is anytime moths are flying. Begin oil applications at 100 to 200 DD after the biofix. Reapply every 7 to 10 days as long as significant flight is occurring. Good coverage is essential. Effectiveness may be enhanced with more dilute applications (i.e., 200–400 gal water/acre). Oils may be phytotoxic if used within a few weeks of a sulfur or captan spray or if applied at higher rates during hot weather (above 90°F). May be used to maintain lower populations in mating-disrupted orchards. May cause a greasy appearance to some fruit if applied close to harvest or with high seasonal volumes. Check with certifier to determine which products are organically acceptable.

** For dilute application, rate is per 100 gal water to be applied in 300–500 gal water/acre, according to label; for concentrate applications, use 80–100 gal water/acre or lower if the label allows.

+ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

* Permit required from county agricultural commissioner for purchase or use.

Acceptable for use on organically grown produce.
— Not recommended or not on label.
[1] Rotate chemicals with a different mode-of-action Group number, and do not use products with the same mode-of-action Group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a Group number of 1B; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode of action Group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their Web site at http://www.irac-online.org/.

IMPORTANT LINKS

- Degree-day table
- Degree-day calculator
- Sunset temperatures

PRECAUTIONS

PUBLICATION

UC PEER REVIEWED

UC IPM Pest Management Guidelines: Apple
UC ANR Publication 3432
Insects and Mites
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