UTAH PESTS fact sheet

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Codling Moth (*Cydia pomonella*)

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Do You Know?

- Codling moth is the major pest of apple and pear in Utah.
- Damaging stage: larva tunnels into fruit
- Monitoring stage: adult moth
- Use of pheromone traps and the degree-day model (based on daily temperatures) are critical for determining optimal treatment timings.
- Insecticides and pheromone-based mating disruption are currently the main management tactics.
- Insecticides are targeted at newly hatched larvae and/or eggs.
- Mating disruption devices need to be applied immediately after biofix (first moth activity) to prevent or adequately delay moth mating.
- Biological control is minimally effective because larvae are protected inside fruit.
- Insect development and spray timing information are available on the USU Extension Integrated Pest Management (IPM) Pest Advisories Web page (http://utahpests.usu.edu/ipm/htm/advisories) or from your county USU Extension office.

Fig. 1. Codling moth adult[1]

Fig. 2. Codling moth larva[1]

Codling moth (*Cydia pomonella* – Family Tortricidae) is the most serious pest of apple and pear worldwide. In most commercial fruit producing regions and home yards in Utah, fruit must be protected to harvest a crop. Insecticides are a main control tactic. There are new insecticide compounds available, many of which are less toxic to humans and beneficial insects and mites than earlier insecticides. For commercial orchards with more than 10 acres of contiguous apple and pear plantings, pheromone-based mating disruption can greatly reduce codling moth populations to allow reduced insecticide use. Effective biological control has not been possible because fruit is attacked by newly hatched larvae, which are protected from natural enemies once inside the fruit. Sanitation methods can help reduce codling moth densities within an orchard but alone cannot provide satisfactory control.

In Utah, there are two to three generations of codling moth each year (Fig. 3). In northern Utah, there are typically two full generations and a partial third generation. In southern Utah, most or all of a third generation will occur. First generation moths begin to emerge about bloom time and peak in June in northern Utah. Second generation moths begin emerging in late June to early July and peak in late July to early August. Third generation moths are active from about mid August to mid September before declining day length induces the end of activity for the year.

HOSTS

apple, apricot, cherry, crabapple, English walnut, hawthorn, quince, pear

LIFE HISTORY

Pupa

- **Size and Color**: 1/2 inch long, brown
- **Where**: pupate inside silken cocoons under bark and in other protected sites
- 7 - 30-day development period depending on temperature

Adult – Monitoring Stage

- **Size**: 1/2 inch long
- **Color**: mottled gray and brown moth; bands of alternating gray and white on wings with a bronze to copper spot on the tip of each forewing (Fig. 1)
- **Where**: camouflaged against tree bark during the day with wings held tent-like over body
- Become active when evening temperatures exceed 55 - 60° F.
- After emerging, male moths can be caught in traps baited with sex pheromone (codlemone) and both sexes can be caught in traps baited with codlemone and pear ester
- Peak moth activity is a few hours before and after twilight
- Mated female moths can lay 30 - 70 eggs

Egg

- **Size and Shape**: pinhead sized, flat, oval
- **Color**: translucent when first deposited, later turning white; just before hatching, the black head of the larva is visible
- **Where**: laid singly on fruit or on upper surface of leaves near fruit; difficult to spot in the orchard
- Hatch occurs in 6 - 20 days depending on temperature

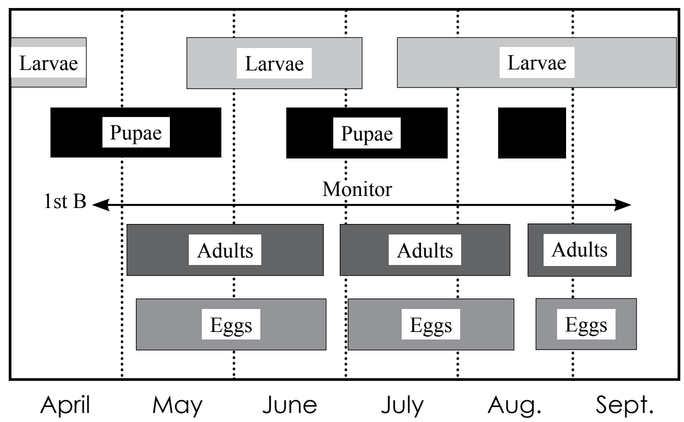
Larva – Overwintering Stage

- **Size and Color**: 1/2 - 3/4 inch long when full grown, creamy-white to tan
- **Where**: in silken cocoons under loose bark on tree, in protected areas at base of tree, in fruit bins, or in orchard trash piles
- Develop to pupal stage when spring temperatures exceed 50° F in late February and early March

Larva – Damaging Stage

- **Size and Color**: 1/10 inch long upon hatching, pale white with a black head; 1/2 - 3/4 inch long when full grown, tan to pink with a brown head (Fig. 2)
- **Where**: occasionally feed on terminal leaves and bore into shoots before seeking fruit
- Bore into fruit within 24 hours after hatching, then tunnel to core where they feed on developing seeds
- Pass through five instars inside fruit in 3 to 5 weeks
- Fruit attacked early in the spring often drops; larval development can be completed in the fallen fruit
- After completing development, larvae exit from fruit by entry hole or by a new exit hole and crawl to a protected site for pupation
- Entrance and exit holes are filled with frass (excrement) and are usually conspicuous (Fig. 4)
- Larvae may pupate and emerge as second- or third-generation adults in 10 - 20 days, or enter diapause and remain larvae until the following spring (Fig. 3)

Figure 3. Life history of codling moth. In Utah, there are three generations per year.



- The arrow indicates when adults should be monitored with pheromone traps (1st B=first bloom).

HOST INJURY

Deep Entries

- Larvae tunnel to center of fruit to feed on seeds (Fig. 2)
- Brown frass (excrement) extrudes from entry and exit holes (Fig. 4)
- Fruit attacked during the first generation often drops prematurely

Fig. 4 Frass from codling moth exit[1]

Stings

- Stings are healed shallow or aborted entries that occur due to larvae death or when larvae exit the feeding area and tunnel into fruit elsewhere

TIMING CONTROL

Monitoring with Pheromone Traps

Trap Placement

- Delta or wing style pheromone traps can be used to monitor adult activity (Fig. 5).

Fig. 5 Delta trap[1]

- Sex pheromone (codlemone) lures are used in traps to attract moths. There is a choice of lures available, in a rubber septum or membrane:

Lure Type	Sex Attracted	Orchard Type	Lure Longevity
1X (codlemone)	Males	Non-mating disrupted (MD)	30 or 60-day
10X (codlemone)	Males	MD	30-day
CM-DA combo (codlemone + pear ester)	Both	Both; primarily MD	60-day

- Place traps in orchards by first bloom or based on degree-day (temperature) accumulations (Table 1).
- Place traps within the upper third of the tree canopy (preferably 6 - 7 ft. high) making sure the trap entrance is not blocked and that it is parallel to the prevailing wind direction (Fig. 6).
- A minimum of two traps should be placed in each orchard. For orchards greater than 10 acres, place one trap for every five acres.
- Hang at least one trap on the edge and at least one near the center of the orchard to determine if moths are immigrating from outside sources and/or over wintering within the orchard. Suspected "hot spots" within the orchard should be monitored separately.
- Check traps every 1 - 2 days until the first moth is caught.

Biofix

- Biofix is a biological marking point from which the rest of an insect's development is measured. It is the beginning of consistent moth flight, or where at least two moths are trapped on consecutive nights.
- It is imperative to determine the date on which biofix occurs to accurately initiate the codling moth model.

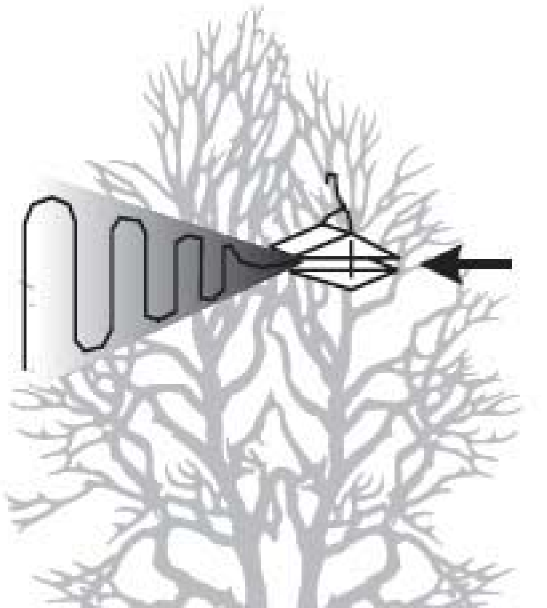


Fig. 6. Diagram of trap placement within tree. Arrow indicates direction of prevailing wind, dark line indicates moth flight trail up the pheromone plume to the trap.

- Hang traps within the upper third of the tree canopy, parallel to the prevailing wind direction, and with an unobstructed entrance.

Trap Servicing

- Trap catch data can be used to monitor moth emergence to start degree-day accumulations, to assist with determining optimal spray timings, to determine the relative size of the moth population, and to help in evaluating the success of your management program.
- Check traps weekly and record the number of moths caught (see Codling Moth Sampling Form, ENT-13SF-06). After recording, remove moths from trap.
- Change pheromone caps based on manufacturer's recommended product longevity and change sticky trap panels after catching 20 - 30 moths or after debris has collected on the surface.
- Zero trap catch does not necessarily mean there are no moths in the orchard. Evening temperatures below 60° F are not conducive to moth flight, and a lack of wind in the evening means the trap cannot create a pheromone plume, which lures moths inside (Fig. 6). Also, old or ineffective lures can cause zero trap catch.
- Do not cross-contaminate lures or traps between insect species. Do not handle or store unsealed pheromone lures together from more than one species. Do not reuse a trap that contained a pheromone lure from another species.
- Plan to use the same type of trap and lure from year to year so that you can compare results.

Degree-day Model

The Degree-day Method

- The development of codling moth, like all insects, can be predicted based on accumulated heat over time, called degree days (DD). Use of the codling moth phenology model based on DD will help to more accurately time insecticide applications and reduce the number of applications to a minimum.
- Codling moth development occurs between the lower and upper temperature thresholds of 50° F and 88° F.
- Starting March 1 in northern Utah or January 1 in southern Utah, begin accumulating DD for an individual location by:
    - collecting representative daily maximum and minimum air temperatures and using the DD look-up table (Table 2), or
    - obtaining the information provided by USU Extension on the IPM Pest Advisories Web page (http://utahpests.usu.edu/ipm/htm/advisories) or from your county extension office.
- Place pheromone traps in orchards when 100 DD have accumulated. The first moths are expected by 150 - 200 DD.
- Once biofix (first consistent moth catch) has occurred, accumulated DD are reset to zero (Table 1).

Timing Sprays

- If mating disruption (MD, see page 6) is used in an orchard, dispensers should be hung immediately after biofix to prevent mating and egg-laying. Supplemental insecticide treatments are usually necessary even when MD is used. The first cover spray is often the most important to apply as this timing should suppress the first generation and thus the following generations.
- Depending on the type of insecticide used, the first cover spray should be applied as follows:

DD after biofix	Timing/Target	Examples
50 - 75	pre-egg-laying	Rimon
100 - 200	early egg-laying	Horticultural oil, Esteem, Intrepid
220 - 250	first egg hatch (emergence of larvae)	Assail, Asana, Calypso, Carbaryl, Diazanon, Guthion, Codling Moth Granulosis Virus, Imidan

- Reapply insecticides based on the residual period (i.e., protection interval) of the product used. Keep fruit protected throughout each generation (Table 1).
- As harvest date approaches, consider the pre-harvest interval (required time interval between insecticide application and harvest) in planning late season treatments.

Table 1. Major events in a codling moth management program, based on accumulated degree days

Degree Days	% Adults Emerged	% Egg Hatch	Management Event
100 *	0	0	• Place traps in orchards
150 - 200	First moths expected	0	• Check traps every 1-2 days until biofix is determined
First Generation			
0 (biofix)†	First consistent catch	0	• Reset degree days to 0
50 - 75	5 - 9	0	• First eggs are laid • Apply insecticides that need to be present before egg-laying
100 - 200	15 - 40	0	• Early egg-laying period • Apply insecticides that target early egg-laying period
220 - 250	45 - 50	1-3	• Beginning of egg hatch • Apply insecticides that target newly hatched larvae
340 - 640	67 - 98	12 - 80	• Critical period for control, high rate of egg hatch • Important to keep fruit protected during this period
920	100	99	• End of egg hatch for 1st generation
Second Generation			
1000 - 1050	5 - 8	0	• First eggs of 2nd generation are laid • Apply insecticides to target early egg-laying
1100	13	1	• Beginning of egg hatch • Apply insecticides that target newly hatched larvae
1320 - 1720	46 - 93	11 - 71	• Critical period for control, high rate of egg hatch
2100	100	99	• End of egg hatch for 2nd generation
Third Generation			
2160	1	15	• Beginning of egg hatch • Keep fruit protected through September 15 • Check pre-harvest interval of material used to ensure that final spray is not too near harvest.

*Begin accumulating degree days after daily temperatures begin to exceed 50°F, typically on January 1 for southern Utah or March 1 for northern Utah.

† Biofix is when at least 2 moths are caught on consecutive nights.

Table 2. Degree Day Look-Up for Codling Moth*

Lower threshold: 50° F Upper threshold: 88° F

Maximum Temperature \ Minimum Temperature	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63	66	69	72	75	78	81
51	0	0	0	0	0	0	0	0	0														
54	1	1	1	1	1	1	1	1	1	1	1	2	3										
57	1	1	1	1	1	2	2	2	2	2	3	3	4	5									
60	2	2	2	2	2	3	3	3	3	3	4	4	6	7	9								
63	3	3	3	3	4	4	4	4	4	5	5	6	8	9	11	12							
66	4	4	4	4	5	5	5	5	6	6	7	7	9	10	12	13	15						
69	5	5	5	5	6	6	6	7	7	7	8	9	11	12	14	15	17	18					
72	6	6	7	7	7	7	8	8	8	9	10	10	12	13	15	16	18	19	21				
75	8	8	8	8	8	8	9	9	10	10	11	12	14	15	17	18	20	21	23	24			
78	9	9	9	9	10	10	10	11	11	12	13	13	15	16	18	19	21	22	24	25	27		
81	10	10	10	10	11	11	12	12	13	13	14	15	17	18	20	21	23	24	26	27	29	30	
84	11	11	11	12	12	12	13	13	14	15	16	16	18	19	21	22	24	25	27	28	30	31	33
87	12	12	13	13	13	14	14	15	16	16	17	18	20	21	23	24	26	27	29	30	32	33	35
90	13	14	14	14	15	15	16	16	17	17	18	19	21	22	24	25	27	28	30	31	33	34	35
93	14	14	15	15	16	16	17	17	18	18	19	20	22	23	25	26	28	29	30	31	33	34	36
96	15	15	15	16	16	17	17	18	19	19	20	21	23	23	25	26	28	29	31	32	34	35	36
99	16	16	16	16	17	17	18	18	19	20	21	21	23	24	26	27	29	30	31	32	34	35	36
102	16	16	17	17	18	18	19	19	20	20	21	22	24	25	27	27	29	30	32	33	34	35	36
105	17	17	17	18	18	18	19	20	20	21	22	23	24	25	27	28	30	30	32	33	35	35	36
108	17	17	18	18	19	19	20	20	21	21	22	23	25	26	27	28	30	31	32	33	35	35	36
111	18	18	18	19	19	20	20	21	21	22	23	24	25	26	27	29	30	31	32	34	35	36	37
114	18	18	19	19	20	20	21	21	22	22	23	24	25	26	28	29	30	31	33	34	35	36	37

To find the total degree days for a day, locate the low and high temperatures and follow the rows to where they intersect. For temperatures between those listed, use the nearest shown.

*Adapted from: Beers, E.H, J. F. Brunner, M. J. Willett, and G. M. Warner. 1993. **Orchard Pest Management: A Resource Book for the Pacific Northwest**. Good Fruit Grower. 276 pp.

MANAGEMENT

Insecticides

Synthetic insecticides have been the major control tactic used since the 1940s. Current insecticide choices include synthetic materials, microbial and botanical insecticides, and petroleum oils. The choice depends on numerous factors including commercial versus home orchard production, the crop's market destination, grower preferences, size of orchard, codling moth pressure in the area, and the surrounding habitat. Select insecticides with the desired modes of action and apply them at optimal timings to coincide with key development periods (Table 1). Use of pheromone trapping in combination with the degree-day model is highly recommended to accurately determine codling moth development for your location. (For more information, see the Degree-day Method above.)

If the orchard is large (more than 10 acres) and moths are only found in border traps, treating 4 - 5 border rows may markedly reduce the amount and number of insecticide applications. This tactic is primarily used after first and second cover sprays have been applied or in conjunction with mating disruption.

Rotate among insecticide classes (see list of insecticides below) to prevent development of resistance to insecticides in the codling moth population.

*Synthetic Insecticides**

Chloronicotinyls:

- acetamiprid (Assail)
- clothianidin (Clutch)
- thiacloprid (Calypso)

Insect Growth Regulators:

- azadirachtin (Aza-Direct, Azatin)**
- methoxyfenozide (Intrepid)
- novaluron (Rimon)
- pyriproxyfen (Esteem)
- tebufenozide (Confirm)

Organophosphates:

- azinphosmethyl (Guthion)
- chlorpyrifos (Lorsban), apples only
- diazinon (Diazinon)
- dimethoate (Dimethoate)
- malathion (Malathion)**
- phosmet (Imidan)

Carbamates:

- carbaryl (Sevin)**
- indoxacarb (Avaunt)

Synthetic pyrethroids:

- esfenvalerate (Asana)
- fenpropathrin (Danitol)
- lambda-cyahalothrin (Warrior)

*Lower Toxicity Insecticides**

Use of lower toxicity insecticides alone has not generally provided satisfactory control of codling moth. However, intensive use of combinations of soft pesticides has proven adequate in some cases. Combinations of soft chemicals and pheromone-based mating disruption have proven effective.

Horticultural mineral oils**:

Highly refined, superior-type petroleum oils can prevent egg hatch by suffocation. Apply at beginning of early egg-laying (100 - 200 and 1000 - 1050 DD after biofix). There are concerns about negative effects on fruit finish following use of high rates and multiple applications.

Microbial insecticides:

Bacillus thuringiensis (Dipel**, Javelin, Biobit, Crymax), codling moth granulosis virus (Virosoft, Cyd-X, Carpovirusine)**, and spinosad (Success, Entrust)** generally must be applied every 3 - 10 days to be effective.

- **Particle films:**
  Kaolin clay (Surround**), when maintained as a complete barrier on fruit surfaces, can reduce codling moth infestations.

- **Botanical insecticides:**
  Rotenone**, pyrethrum**, and ryania** (apples only) have variable control effectiveness. They may provide satisfactory control of low codling moth population levels but can be harsh on beneficials, thus allowing other pest insect populations to increase.

*All brand names are registered trademarks. Examples of brands may not be all-inclusive, but are meant to provide examples of effective insecticides registered on apple and pear in Utah. The availability of insecticides is changing rapidly. Always check the label for registered uses, application and safety information, and protection and pre-harvest intervals.

**Insecticide products that may also be available for use on home fruit trees.

Mating Disruption

Detailed knowledge of insect biology, development timings, and limitations of mating disruption are needed to use it successfully. Substantial fruit damage could result from improper use. The size of orchard, proximity to outside sources of codling moth, and dispenser placement and application rate can all influence the success of this tactic. The typically small size of apple and pear blocks in Utah (less than 10 acres) and the high codling moth populations reduce the effectiveness of mating disruption in Utah as compared to other areas of the Northwest. Mating disruption is not effective in home yards or orchards smaller than 10 acres.

- Place small dispensers containing the female sex pheromone (Isomate C+, Isomate CTT, No Mate, CheckMate) at 200 - 400 dispensers per acre (follow product label directions) throughout the orchard immediately after biofix. Place dispensers within 2 feet of the top of the canopy. Sprayable formulations and aerosol devices (also called puffers) for releasing pheromones are available, but experience with these products is limited.
- Research in Utah and other locations has demonstrated the importance of continual monitoring of adult populations with traps in mating disrupted (MD) orchards. The dual gender lure (CM-DA Combo®, Pherocon) has proven more effective than the 10X codlemone lure in catching moths in MD orchards.
- If the orchard has a history of codling moth problems, use one or two applications of insecticides against the first generation. If a codling moth source exists nearby, use border sprays (5 - 6 rows) of insecticides to prevent fruit damage on edges from immigrating mated moths.

- Be aware that if insecticide applications are reduced substantially, populations of other pests (e.g., leafrollers, piercing-sucking bugs, aphids, scale, etc.) can increase.

Fruit Thinning

Newly hatched larvae often seek out protected sites for entry, and thinning fruit to just one apple/cluster can limit successful entries. Fruit thinning also allows for improved insecticide coverage on the entire fruits.

Sanitation

- Remove or treat host trees within a quarter mile (450 yards) of orchards to destroy outside codling moth sources, including abandoned orchards and wild hosts.
- Strip fruit remaining after harvest in young, unharvested orchards or on pollinator trees.
- Remove or destroy piles of culled fruit in orchards.
- Remove additional pupation sites from orchards such as fruit bins, brush, woodpiles, and other debris.
- Fruit infested during the first generation typically drop to the ground in June or July. Remove or destroy (e.g., flail) dropped fruit to reduce second generation densities.

Trunk Banding

- Place corrugated cardboard bands (2 - 3 inches wide) around trunks of trees in May to collect first generation larvae or in August to collect overwintering larvae that are moving to the trunks to pupate.
- Remove and destroy bands before moths emerge in mid- to late June (for first generation) or in late October to November (for overwintering generation).
- This method is most effective on smooth-barked varieties and in smaller, isolated orchards without nearby sources of codling moth.

Biological Control

Use of more selective and lower toxicity insecticides enhances populations of beneficials (predaceous and parasitic arthropods). Native enemies alone, however, do not provide satisfactory control. Recent efforts to introduce parasitoids from native habitats of codling moth in Eurasia are promising. The egg parasitoid, *Trichogramma*, has shown potential especially in combination with other lower toxicity tactics.

[1]Images courtesy of Shawn Steffan, Utah State Universtiy Extension

Precautionary Statement: All pesticides have benefits and risks, however following the label will maximize the benefits and reduce risks. Pay attention to the directions for use and follow precautionary statements. Pesticide labels are considered legal documents containing instructions and limitations. Inconsistent use of the product or disregarding the label is a violation of both federal and state laws. The pesticide applicator is legally responsible for proper use.