

The Benefits of Insecticide Use: Walnuts



Codling Moth



Codling Moth Damage



Spraying Walnut Trees



Trichogramma Wasp Laying Egg in
Codling Moth Egg

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Key Points

- 60% of California walnut acres are at risk from codling moth
- The codling moth larvae bore through the husk and shell to feed on the nutmeat
- Insecticide sprays reduce the percent of damaged nuts from 15% to 1% (90% control)
- Although *Trichogramma* wasps parasitize codling moth eggs, they only provide 70% control and only in orchards with low codling moth populations

Technical Summary

Walnuts have been recognized as the oldest tree food known to man dating back to about 7000 BC. Today, they are commonly called “English” walnuts in reference to the English merchants who transported them for trade. Historians prefer the name “Persian” believing that walnuts originated in ancient Persia. The Franciscan Fathers are credited with bringing walnuts to California from Spain or Mexico. The first commercial planting began in 1867. Walnuts are commercially grown throughout the Central Valley of California. Current walnut acreage totals 216,000. California growers produce 692 million pounds of walnuts with a value of \$554 million annually accounting for 98% of the US crop and 2/3 of the worlds trade. The harvest begins in late August when the protective green hulls split, signaling that the nuts are ready to be removed from the tree.

The codling moth is the major insect pest of walnuts in California. Codling moths overwinter as full-grown larvae in thick, silken cocoons under loose scales of bark or in trash on the ground near the trunk [1]. They are inactive until spring. Moth emergence usually coincides with the leafing out of early walnut cultivars. The first flight of codling moth typically starts sometime from early to late March and is from the overwintered generation. These moths lay eggs that signal the beginning of the first generation. The second flight of moths results when the larvae of the first generation complete their development. When the moths in the second flight lay their eggs, this starts the second generation [1]. In most Valley locations they produce a third generation; in warmer locations a partial fourth generation may be produced in September.

Each overwintered female deposits about thirty eggs singly on leaves near nuts. Later generations of females lay an average of 60 eggs on leaves or nuts.

Young larvae penetrate directly through the husk and shell into the nutlets. The larvae remain in the nuts, on the average, about 35 days [2]. The larvae leave the nut after completing their development. The damage caused by the codling moth is different with each generation [1]. First generation larvae reduce yield directly by causing nutlets to drop from the tree. Nuts attacked by larvae from the last part of the first generation and from the second and third generations remain on the tree but are unmarketable due to the feeding damage to the kernel [1]. Even though only a portion of the kernel may be consumed, the remainder is practically worthless.

Damage is generally most severe on early season cultivars, although it has been increasing steadily over the years on late season cultivars such as Chandler [1].

The codling moth was introduced into California about 1873 and spread rapidly throughout the state where apples and pears were grown. The codling moth has been known to attack walnuts in California since 1909 [2]. At that time, less than 1% of the crop was affected. An increase followed with yearly fluctuations, and by 1918 the infestation had become serious. Growers placed the infestation as high as 50% in some orchards [2]. At the insistence of the California Walnut Growers Association, a special appropriation was made by the legislature. The Citrus Experiment Station undertook studies looking toward control of the pest [2].

The codling moth feeding on walnuts was originally considered to be a distinct species but later was determined as a variety of the codling moth species which attacks the apple. The insect undoubtedly came to the walnut from the apple [2]. Even though no differences have been found in the anatomy of the insect on apple and walnut, they are different biologically. A distinct race has evolved that prefers walnuts and has a life cycle well synchronized with the development of early walnut cultivars [11]. Observations have shown that the walnut is not as favorable a host as apple since only about 25% of the larvae bore into the nuts while on apple, 80% bore into the fruit [4]. Probably because walnut is not a favorable host, there is a tendency for the larvae to take a bite here and there before burrowing into the nut. By so doing, the opportunity of consuming a lethal dose of poison is increased greatly over that which would occur if the larvae burrowed directly into the husk [5].

Although a number of predators and parasites were found that attack the codling moth, it was determined in the 1920s that seldom, if ever, are these enemies of the codling moth important enough in themselves to effect a satisfactory control [2]. This conclusion regarding the ineffectiveness of natural predators was reaffirmed in research in the 1930s [4]. In the IPM manual for walnuts issued in 1987, the conclusion was that no adequate cultural or biological controls were available for codling moth so that management depended entirely on the use of insecticides [11].

The early research determined that there was but one thoroughly satisfactory method for controlling the codling moth: to coat the nuts with lead arsenate which destroys the larvae before they enter the husks [2]. The effective amount of lead arsenate per tree was determined to be 1.25 pounds in 25 gallons of spray [2]. The total amount of arsenic applied per acre was 21 pounds. The goal was to cover every nut on the tree with arsenic. Under this condition, there would not be a spot on any walnut where the larvae could bore into the green husk without taking some of the particles of poison into the mouth [3]. Under ordinary circumstances it was determined that one properly timed spray of arsenic usually afforded satisfactory protection throughout the entire season [4]. One factor that facilitated control was the general absence of rains to wash off the lead arsenate.

The average increase in the yield of sound nuts per tree as a result of one lead arsenate spraying in four orchards was 7.4% [2]. The average cost of spraying one tree was \$.48 or \$9.00 per acre. The net difference per acre in favor of the spray was \$12.00 [2]. By 1926, spraying was the commercial practice employed in all of the codling moth infested groves [2].

In the late 1940s research was begun with DDT for codling moth control on walnuts. Research in 1948 demonstrated that one spray of DDT reduced codling moth infested nuts from 44% in the check to 2.6% while 4.9 % of the nuts were infested in the lead arsenate treatment [5]. Although effective against the codling moth, DDT was not immediately recommended for use since its use resulted in an increase in other destructive pests [5]. In particular, DDT destroyed the natural predators of walnut aphids, frosted scale and orchard mites [5]. Further research indicated that a lower rate of DDT (3.0 lbs/A) did not seriously increase the frosted scale or mite populations and maintained effective control of the codling moth [5][6][9].

It was noted that the DDT sprays were effective in killing the walnut aphid but the aphid predators (lady bird beetles, lacewings, syrphid flies) were also killed. Observations indicated that the spray remained effective against the predators for a longer period than it did against the aphid [7]. As a result, the aphids were able to reestablish themselves in the trees ahead of the predators. This allowed them to build up in destructive numbers before the controlling influence of the predators could come into play. Research indicated that uncontrolled walnut aphids could reduce walnut yield by 10-26% [10]. This led to the recommendation that an aphicide should always be added to the DDT spray for codling moth [5]. Nicotine was first recommended and at 1.25 pounds per acre provided effective control [9]. Parathion at .3 pounds per acre supplanted nicotine due to its superior effectiveness essentially killing all the aphids [9].

During the period 1968-1970, a wasp, *Trioxys pallidus*, which is parasitic on walnut aphid was introduced to Central Valley walnut orchards. The parasite spread rapidly throughout most of the Central Valley. Use of a short residual insecticide for codling moth minimizes disruption of the aphid parasite.

Alone, natural enemies are not able to keep codling moth populations below economic levels [1].

In the 1940s researchers examined the impact of parasitism of codling moth by *Trichogramma* wasps [8]. It was determined in an experimental orchard that approximately 50% of the eggs were parasitized—a level insufficient for successful control [8]. A total of 12 weekly releases of *Trichogramma* wasps has provided 70% control of codling moth when the populations are low to moderate [1]. This level of control is not adequate to prevent a buildup over time and economic damage in most walnut orchards in California [12]. Twelve weekly releases of 150,000-200,000 wasps per acre were made. They are most effective when codling moth populations are low [1].

Although over 250 biological control organisms have been shown to attack codling moth, none are capable of keeping populations below that which causes economic damage [12]. Codling moth granulosis virus has been shown to be somewhat effective (60-80% control) [17]. It must be eaten by larvae and from 9 to 12 applications are needed each year to cover the long generation time. Timing these treatments is very difficult because irrigation scheduling prevents growers from getting into orchards in a timely manner [12]. Also, because walnut trees are large, it is not possible to get the thorough spray coverage with the virus for reliable control.

A classical biological control program for codling moth was initiated in California walnut orchards in 1992 [16]. Following an initial survey for parasitoids of codling moth in Central Asia, three species were selected for importation and release in California. The introduced parasitoids were released in 72 walnut orchards. The most successful parasitoid was *M. ridibundus*, a cocoon parasitoid, which parasitized 9% of the cocoons in walnut orchards [16].

Codling moth mating disruption is not effective in walnut orchards with tall trees with a large codling moth population history [1]. Codling moth mating disruption works best in isolated orchards with low populations. The edges of orchards under mating disruption may become infested by in-migration of mated codling moth females and require insecticide sprays [1].

Approximately 60% of the walnut acres planted in California are susceptible to damage from codling moth and require from one to three treatments every year to prevent serious economic damage [12]. Insecticide tests have shown that untreated walnuts incur about 15-18% codling moth damage at harvest while insecticide-treated walnuts incur less than 1% damage [13][18]. The cost of two insecticide sprays for codling moth control in walnuts is estimated at \$51/A, which represents about 2% of the cost of growing walnuts [14].

Organic walnut growers usually grow late-blooming walnut varieties such as Chandler and Hartley which avoid the first flight of codling moth [15]. There are indications that codling moth is adapting to these cultivars. Organic growers are also permitted the use of the Entrust formulation of spinosad for codling moth control [1].

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