The Benefits of Insecticide Use: Pistachios

Split Hull and Shell

Navel Orangeworm Damage

Navel Orangeworm Hatching from Egg

Aspergillus fungi

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Key Points

- When the pistachio shell and hull split open, the nut is exposed to invasion by insects and molds.
- Each female navel orangeworm moth lays an average of 90 eggs in early split pistachios.
- Up to 20% of the pistachio nuts in some orchards have been damaged by the feeding of the navel orangeworm.
- Navel orangeworm-damaged kernels account for 84% of the aflatoxin in pistachios, which is produced by *Aspergillus* fungi.

Technical Summary

Pistachio has been grown for several thousand years. The pistachio is a native of Asia Minor and thrives in climates offering cool wet winters and long hot dry summers. In 1929 an American plant scientist spent six months in Persia (now Iran) and returned with twenty pounds of pistachio seed. The next year, experimental plantings were established in California, the perfect location with its desert-like climate. With pistachio trees requiring seven to ten years to mature, it was 1950 before one stand-out tree emerged. Additional years were spent in budding this variety (called Kerman) to heartier rootstocks. Plantings of pistachio trees expanded throughout California in the 1960s. California entered the world pistachio market in 1976 with its first commercial crop of 1.5 million pounds on 4,350 acres. This placed the U.S. fifth among pistachio producers behind Iran, Syria, Turkey, and Greece. Within a decade the California industry grew to become the second largest producer in the world after Iran [4]. Currently 136,000 acres are planted in California with 104,000 acres producing. The 2004 harvest set a record at 346 million pounds with a value of $465 million.

A small bushy tree, pistachio rarely grows more than 20 feet in height. The fruits are borne in grapelike clusters. A red-blushed fleshy hull surrounds the nut.

Normally as the nut matures, the hull separates from the shell and then the shell splits open. The hull does not split so the nut is protected. The shell splitting of the pistachio nuts is a very desirable feature because it allows the consumer to open the nut easily. Splitting of the shell is unique to pistachios.

A number of atypical pistachio nuts, known as “early splits”, also have the hulls split. With both the hull and the shell split, the nut is exposed to invasion by insects and molds [6]. The hull splitting that characterizes early splits can begin more than four weeks before harvest [9].

Initially, pistachios were relatively free of insect infestations, but as more orchards came into bearing, reports of nut meat damage by navel orangeworm (NOW) larvae became common [1]. NOW is considered the most important insect pest problem in pistachios. Pistachios are susceptible to NOW infestations for a very short period during August when the hulls begin to split, making an attractive place for the moths to lay their eggs [7]. The NOW moth seeks out and preferentially lays eggs on early split nuts.
NOW female moths deposit eggs on the outer hull of the developing pistachios. NOW larvae rarely feeds on any other plant parts exclusive of the nuts. Female moths will lay an average of 85 to 90 eggs in 2 to 3 days in summer. Upon hatching from eggs, the larvae will infest the nutmeats if there is a split hull. The larvae produce excrement (frass) and webbing in the nut. As worms grow in size, the entire nut is fed upon [8]. A single pistachio nut may often support several NOW larvae. Infestation levels of 19% of the nuts have been measured in some studies [2].

Even in the absence of a resident NOW population, pest damage can be substantial as a result of moths flying in from almonds [2]. Almond orchards often border pistachio plantings. Almonds are harvested a month earlier than pistachios and moth movement from orchard to orchard is common. Pistachio nuts begin to split open and become susceptible just as the moths of the large second generation emerge from the almonds [2]. NOW females locate pistachio nuts by following odor plumes emanating from the maturing nuts. Pistachios that have fallen on the ground and are not removed facilitate NOW infestation and increase the likelihood of aflatoxin contamination [19].

Infested nuts are prime sites for *Aspergillus* mold infections, which can produce aflatoxin contaminants. Navel orangeworms deposit their eggs in the split hull and the opening produced by their larvae allows *Aspergillus* growth to take place. The larvae immediately enter the nutmeat causing an opening in the surface of the nut meat that can allow *Aspergillus* sporulation and growth. Damage to the hull facilitates the entry of fungi into an environment where the moisture level is usually high enough to support the growth of the fungi. NOW-infested kernels account for 84% of the aflatoxins in pistachio nuts [13]. *A. flavus* spores can be detected in air samples collected in pistachio orchards in August, indicating a buildup of the fungus in the environment [14]. One infected nut can produce 10 million viable spores in seven days.

Aflatoxins are a group of closely related toxins produced by certain molds while these molds feed and grow in various crops. Research has suggested that three important factors affect aflatoxin contamination of pistachio nuts in California: early split nuts, the navel orangeworm, and the aflatoxin-producing fungi (*Aspergillus flavus* and *Aspergillus parasiticus*) typically found at very low levels in orchards in California [10]. Research has determined that these fungi were found on leaves in all tested orchards [11]. Any established infection of *A. flavus* will result in rapid accumulation of aflatoxin in the harvested nuts under warm temperatures and high humid conditions [15]. No aflatoxin has been found in healthy nuts with intact hulls before harvest [16].

Aflatoxins are among the most potent carcinogenic substances known. Extensive experimental evidence in test species shows that aflatoxins are capable of producing liver cancer in most species. The legal limit for aflaxoxins in the U.S. is 20 ppb while in the European Union the limit is 4 ppb. The aflatoxin limit for domestic shipments of California pistachios is 15 ppb under their marketing order.

Infestation of even 1% of the early splits can produce aflatoxin levels above the maximum 20 ppb allowed in pistachios in the U.S.
Egg traps are used to detect population trends for NOW. Insecticides are used based on the NOW population trends and the amount of hull damage. Often a single well-timed spray can reduce infestation by 65-75% [3]. Azinphos-methyl had been the primary NOW insecticide in part because of its long residual [3]. Phosmet has become more widely-used to control NOW remaining active for approximately 10 days [3]. [Methoxyfenozide is also used to control NOW larval populations, but two applications instead of one would be necessary to provide the same duration of NOW protection as azinphos-methyl. Permethrin is used to reduce NOW moth populations close to harvest.]

Approximately 80% of California pistachio acres are sprayed with insecticides for NOW control [3]. Insecticide applications for NOW in California pistachios is estimated at $42/A, which represents about 1% of the cost of growing pistachios [18].

Recent research indicated 4% NOW infestation in untreated trees which was reduced to 1% with applications of azinphos-methyl or phosmet [5][1].

NOW may have 3 or 4 flights in a pistachio orchard prior to harvest. Pistachios become susceptible to NOW infestations beginning in August and continuing through harvest. The best time for applying insecticides in pistachios is usually in August, just after the first hull split or at the appearance of stretch marks on pistachio hulls [12].

The parasite *Goniozus legneri* is available commercially and can reduce damage from navel orangeworm [8]. However, this parasite alone has not provided economical control of NOW [3]. *G. legneri* is a small parasitic wasp. It is an external parasite meaning that it stings the immature NOW larvae and lays its eggs on the outside of the host. The eggs hatch and the young feed on the host until they are ready to develop into mature adult wasps. At that time, they move off the hosts.

Research with pheromone mating disruption of NOW in pistachios has not achieved reductions in damage in comparison with the untreated check [17].

The Entrust formulation of spinosad is approved for organic pistachio growers to spray for NOW [8].

Prior to 1997, Iran provided nearly 100% of the EU pistachio market. However, due to repeated findings of aflatoxin in Iranian pistachios, consumers became alarmed and pistachio consumption fell to 60%. As a result, Iranian exports went from 100% market share to 50%. The reduction in Iranian imports opened the market to U.S. pistachios.

References


