



Adult walnut husk fly.

*Bait spray applied to part of the tree canopy attracted husk flies and provided control for the entire tree.*

## Control of the walnut husk fly with pyrethroids and bait

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The first sign of attack by the walnut husk fly is a small egg-laying puncture, usually near the stem end of the walnut. Within hours after egg-laying, the puncture darkens. After the eggs hatch and as young larvae begin to feed, juice flows from the puncture, and often a characteristic "tearstain" forms and dries on the husk surface. Symptoms of larval feeding are small dark areas below the outer skin of the husk that are softer than surrounding healthy tissue.

As the larvae mature, these dark areas become larger, and eventually, the whole husk or a portion of it may turn black. The outer skin of the husk usually stays intact, holding the juices of the decaying husk that stain the walnut shell. Because this stain cannot be removed by normal bleaching, it is a serious quality defect when nuts are sold in-shell.

A second type of injury, damage to the kernel, occurs primarily in walnut orchards with early husk fly infestations. Early attack interferes with maturation of the kernel and may lead to shriveled kernels or even empty shells, induce mold growth, or discolor the kernel. Late infestations are usually less destructive, have no effect on kernel development, and may cause little shell staining when hulls split before larvae mature.

To prevent damage, growers traditionally

have relied on insecticides against the adult flies. In the 1930s, cryolite, a mineral desiccant, was recommended for control of the husk fly. Later, with the introduction of organophosphate insecticides, compounds such as parathion and malathion were used.

In the early 1950s, bait sprays were developed which contained a toxicant such as malathion and a protein hydrolysate bait. These sprays were more effective, because the protein hydrolysate bait (such as Staley's No. 7) attracted flies to treated foliage and caused

them to feed. With this bait, malathion remains today one of the best materials for control of the walnut husk fly.

More recently, in the early 1960s, the systemic organophosphate insecticide phosphamidon was developed for control of eggs and newly hatched larvae in the husk. This material is quite effective if spray applications are precisely timed.

Although organophosphate insecticides still provide good control, there is a real possibility that resistance to these compounds

TABLE 1. Nuts Infested with Walnut Husk Fly Larvae and Average Spider Mite Densities on Trees Sprayed with Fenvalerate Alone or Mixed with Bait, 1979

Treatment*	Spray coverage of canopy	Infested nuts†	Spider mites per 10 leaflets‡
		10/10	10/10
Fenvalerate 2.4EC	Full	29.2 a	3.9 a
Fenvalerate 2.4EC + bait	½	0.8 b	2.5 a
Fenvalerate 2.4EC + bait	¼	32.2 a	16.2 b
Check (untreated)	—	52.4 a	3.0 a

\*Fenvalerate 2.4 EC applied at 0.1 pound active ingredient per 100 gallons water. Bait = hydrolyzed protein bait (Staley's No. 7) at 1 quart per 100 gallons. Applied August 30, 1979.

†Means in each column followed by a different letter are significantly different at P = 0.05 according to Duncan's multiple range test.

‡Two-spotted and European red mites combined; all stages.



Nuts infested with walnut husk fly showing various stages of damage.

may develop because of their continuous use against this walnut pest for about 25 years. Therefore, it is important to have alternative controls available should the need arise.

Pyrethroids, a relatively new group of organic insecticides, have shown great promise against a number of key pests on tree fruits. The purpose of this field and laboratory study was to evaluate two pyrethroids—fenvalerate (Pydrin) and permethrin (Pounce)—applied with or without protein hydrolysate bait for control of the walnut husk fly and to determine the influence of these two compounds on abundance of secondary pests and natural enemies.

### Orchard tests

All tests were conducted in a 6-acre mature walnut orchard near Napa, California. Fenvalerate 2.4 EC was evaluated in 1979 and permethrin in 1980. The experimental setup and procedures were identical in both years.

Four treatments, each consisting of four six-tree replicates, were arranged in a randomized complete block design. Treatments included full-tree coverage without bait, half-tree and quarter-tree coverage with bait, and an untreated check. Sprays were applied by hydraulic handgun until runoff (see tables for rates). Nuts were inspected (2,000 per treatment) shortly before harvest for husk fly eggs, larvae, and shell stains. In late summer, leaf samples (eight leaves per tree) were taken once in 1979 and twice in 1980. Leaves were brushed and counted for spider mites, walnut aphids, and their natural enemies (only spider mites were counted in 1979).

Fenvalerate without bait applied to the



Cache of walnut husk fly eggs and newly hatched larvae below skin of husk.

whole tree canopy provided no control, suggesting very low contact activity of this material on adult husk flies. When bait spray applications were limited to one-quarter of the canopy, control was also poor, and damage to the nuts was not significantly different from the check. However, the percentage of husk-fly-infested nuts on trees with half-canopy coverage of fenvalerate plus bait was significantly lower than in the other treatments, including the untreated check.

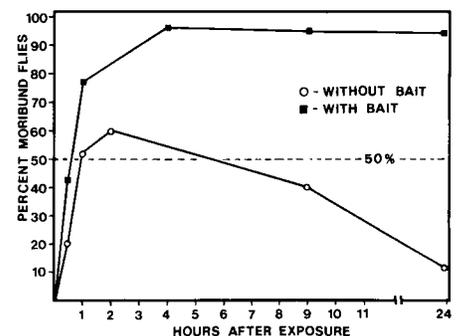
Significant red and two-spotted spider mite buildup in comparison with the check occurred only in the quarter-tree treatment.

In the trial with permethrin, the half- and quarter-canopy treatments with bait had the lowest husk fly infestations, but differences among treatments were not significant because of spotty distribution of the walnut

husk fly in the experimental orchard during 1980. Again, the treatment without bait applied to the full canopy appeared to have little effect on fly populations.

In September, walnut aphids, *Chromaphis juglandicola*, were significantly lower on all foliage treated with permethrin alone or with bait, when compared with the check. However, the lower number of aphid mummies on treated foliage indicates an adverse effect of this compound on parasitization by the braconid *Trioxys pallidus*.

Following the permethrin applications in early August, spider mites began to build up on treated foliage several weeks later during September. This increase was confined to the part of the canopy that actually received the spray. Phytoseiid mites, primarily *Amblyseius hibisci*, were adversely affected by the permethrin treatments and were significantly lower on foliage with residue. The reduction of predatory mites may have contributed to



Influence of hydrolyzed protein bait on toxicity of fenvalerate 2.4 EC residue to adult female walnut husk flies.

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TABLE 2. Nuts infested with Walnut Husk Fly Larvae and Walnut Aphid, Spider Mite and Natural Enemy Densities on Walnut Trees Sprayed with Permethrin Alone or Mixed with Bait, 1980

Treatment*	Spray coverage of canopy	Canopy region sampled	Infested nuts	Average number per leaflet†						
				Walnut aphids		Aphid mummies‡	Spider mites§		Predaceous mites	
				9/24	10/8	10/08	9/24	10/8	9/24	10/8
Permethrin 3.2EC	Full	Entire	8.6 NS	2.0 c	0.1 NS	0.08 NS	6.0 NS	4.7 bc	0.04 c	0.04 NS
Permethrin 3.2EC + bait	1/2	Sprayed	—	2.8 c	0.3	0.03	14.9	24.9 a	0.04 bc	0.10
		Unsprayed	—	11.1 ab	0.2	0.42	1.2	0.9 bc	0.80 a	0.17
		Entire	2.1							
Permethrin 3.2EC + bait	1/4	Sprayed	—	3.3 bc	0.1	0.05	13.6	8.1 b	0.03 c	0.16
		Unsprayed	—	6.9 bc	0.1	0.22	0.9	0.3 c	0.56 a	0.10
		Entire	2.5							
Check (untreated)	—	Entire	14.2	19.8 a	0.2	0.35	0.6	0.7 bc	0.68 a	0.17

\*Permethrin 3.2 EC applied at 0.1 pound active ingredient per 100 gallon water. Bait = hydrolyzed protein bait (Staley's No. 7) at 1 quart per 100 gallons. Applied August 8, 1980.

†Means in each column followed by a different letter are significantly different at P = 0.05 according to Duncan's multiple range test. NS = not significant.

‡Parasitized by *Trioxys pallidus*.

§Two-spotted and European red mites combined; all stages.

||Mostly *Amblyseius hibisci*.

the buildup of spider mites in the various treatments.

### Laboratory tests

Assays were carried out in the laboratory to help explain results of the field tests and to determine the effect of protein hydrolysate bait on the toxicity of fenvalerate and permethrin to female husk flies. Fifty two- to four-week-old flies were allowed to walk on the inside of a cardboard cube whose interior surfaces were treated with 0.4 milliliter per 100 square centimeters of a 0.24 percent insecticide emulsion. In the experiment with bait, protein hydrolysate (Staley's No. 7) was added to the emulsion at a rate of 50 milliliters per liter. Exposure time was one minute.

After exposure, the effect of the toxicant was assessed at frequent intervals during a 24-hour period by counting the number of moribund flies. Flies were classified as "moribund" when they were lying on their backs and were not able to right themselves.

Results for the two pyrethroids were similar; only those for fenvalerate are shown in the graph. Fifty percent of flies exposed to fenvalerate residue without bait were moribund after one hour. The number of moribund flies peaked at 60 percent after two hours. However, most of the flies that were initially affected by the toxicant had recovered after 24 hours, and only 15 percent had actually died. By comparison, residues of fenvalerate with bait were considerably more toxic to adult female husk flies than those without. The addition of bait also achieved a quicker knock-down and 50 percent of the exposed flies were moribund after 40 min-

utes, 95 percent after four hours. Very few of the flies that displayed symptoms after four hours were able to recover, and actual mortality was 95 percent after 24 hours.

The high survival of flies exposed to fenvalerate residues that were 10 to 20 times higher than in field applications suggests that this compound has very low contact activity on the walnut husk fly. The addition of bait markedly increased the toxicity of fenvalerate, apparently because flies were actually feeding on the bait-toxicant residue. Field observations with treated, visually attractive yellow rectangles suggested that husk flies spend 95 seconds ( $\pm 14$  SE—standard error) on boards treated with bait while continuously feeding on the surface as opposed to 31 seconds ( $\pm 4$  SE) on unbaited boards without attempting to feed. Neither fenvalerate nor permethrin residues had a repellent effect on husk flies.

### Summary

In summary, pyrethroids fenvalerate and permethrin were effective against adults of the walnut husk fly when applied with a protein hydrolysate bait. Without bait, these two compounds failed to provide control. Laboratory assays confirmed field observations that both compounds had low contact activity but were very toxic when ingested. Because husk flies search on leaf surfaces for food, such as honeydew from aphids, they are susceptible to residues of baited insecticides even if contact activity is low.

Bait spray applications confined to part of the tree canopy provided control for the entire tree. Apparently, husk flies readily

disperse to foliage treated with a bait and feed on it, since protein hydrolysates act as feeding attractants as well as a food source.

Limiting spray coverage to part of the tree canopy may be not only more economical than full coverage because of considerably lower insecticide use per tree, but also a useful strategy with broad-spectrum insecticides that induce secondary pest problems. Experience with pyrethroids on pears and apples has shown that these compounds can cause severe outbreaks of spider mites when applied during the foliar period. According to the research reported here, the same can be expected on walnuts. However, when used with bait, spray coverage can be reduced to one-half or perhaps even one-quarter of the tree canopy, resulting only in localized outbreaks of spider mites. The untreated part of the canopy could then serve as a refuge for natural enemies, from which they can spread to sprayed foliage once enough of the residue has dissipated.

Spider mite population increases induced by pyrethroid application during August may not reach the levels that generally occur after late-spring or early-summer applications, because the food value of the foliage is declining (hardening off) and spider mites are becoming dormant during the fall. However, any spider mite buildup in late season must be closely watched, since it can cause serious problems the following spring.

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