Because the orangeworm-infested almond is not penetrable by most insecticides, a better solution to NOW infestation might be a biological control method: application of an entomophagous nematode.

Parasitic nematode seeks out navel orangeworm in almond orchards

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The navel orangeworm (NOW), *Paramyelois transitella* (Walker), is a serious multi-million-dollar pest of almonds. As hull split of the nut occurs in the orchard, the adult NOW female deposits eggs close to the suture. The newly hatched NOW larva then invades the almond interior where it feeds on the hull and kernel. Once the larva has penetrated the almond, it is protected from most insecticides.

The moist almond interior provides a favorable environment not only for the NOW larva but also for the entomophagous nematode, *Neoaplectana carpocapsae* Weiser. When applied as a biological agent to newly split almonds, this nematode actively seeks out and parasitizes NOW larvae and pupae within the nuts (fig. 1). Nematodes have been observed moving through the interstitial tissue at the site of future hull and shell separation and, even in the absence of a suitable host, may remain active and viable inside the almond for 10 days or more after application.

The strain of *N. carpocapsae* used in these field applications was originally found parasitizing codling moth, *Laspeyresia pomonella* (L) larvae in northern Mexico. This species has an extensive host range. Consequently, it has been applied as a biological insecticide to a variety of crops. However, treatment of almond orchards for the control of NOW larvae and pupae is a new application of this nematode, as is its use as an adulticide for lepidopteran insect pests. Therefore several techniques have been developed for monitoring the effectiveness of these new nematode applications.

Monitoring methods

Post spray NOW larval mortality and the distribution of the entomogenous nematode were measured by baiting ten hull split almonds per tree with two colony-reared NOW larvae per almond (fig. 2) eight hours before the nematode spray application. Baited almonds were collected the following morning and held at about 27° C for six days; then dead NOW larvae were examined microscopically (20 ×) for nematode parasitic stages.

The mortality produced by the nematode in adult NOW was monitored by the following method: Ten colony-reared NOW adults were placed on the sticky surface of a 9-cm-diameter cardboard disc coated on one side with Stikem Special (fig. 3). For transporting to the field, the disc was placed inside a plastic petri dish containing moist filter paper. Before nematode application, three discs were hung in the canopy of each target tree, two at about 8 feet and one at 16 feet above the ground (fig. 4).

Field application

Initial studies were made in 1976 by treating individual almonds in the field to determine the biological control potential of the Mexican strain of *N. carpocapsae* invasive-stage nematodes Results indicated that total suppression of a NOW larval population was possible if the quantity of nematodes applied was sufficient (see table)

A larger test was conducted in 1977 to determine the host-parasite response to a spray application of this nematode. Spray applications were made in the evening when the relative humidity was at least 60 percent.

A total of eight 'Nonpareil' almond trees was used in this experiment (four treatment and four control). Three separate applications were made to the test trees with a Solo Port 423 backpack sprayer at seven-day intervals. These applications corresponded to 20, 80, and 100 percent hull split. Three million *N. carpocapsae* invasive-stage nematodes were applied to each almond tree. Two 1-pound samples of almonds (about 285 nuts) were taken from each tree 28 days after the initial spray application. One sample was examined for live NOW larvae; the other was commercially examined for determination of percentage nutmeat damage caused by NOW larvae. Test results indicate a 55 percent reduction of live NOW larvae and a 34 percent reduction in nutmeat damage at harvest.

These tests indicate that *Neoaplec-*

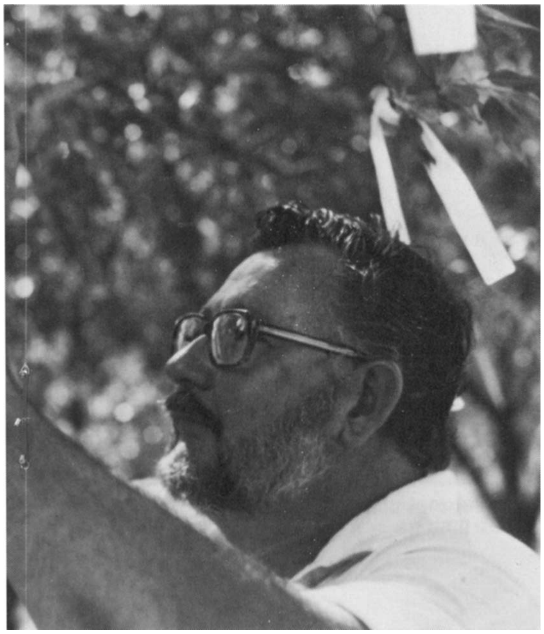

Fig. 1. Left: Invasive stage N. carpocapsae nematodes emerging from parasitized NOW larva.

Fig. 2. Above: Baiting newly-split almond with colony-reared NOW larvae.

Fig. 3. Sticky disc with 10 NOW adults for monitoring adulticide activity of the nematode.

tana carpocapsae does have potential as a biological control agent of NOW in almond orchards and that further studies are warranted.

Control of the Navel Orangeworm in Newly-Split Almonds* in the Field by the Spray Application of *Neoaplectana carpocapsae* (Mexican strain), 1976

No. nematodes/ almond	Percent larval mortality
1,500	100.0
483	100.0
218	97.7
150	95.0
108	91.6
46	23.5

*8 hrs. before the nematode application, 2 14-day-old colony-reared NOW larvae were placed into newly-split almonds. 10 almonds per tree were selected in each of 3 treatment trees and 3 control trees. Baited almonds were sprayed individually with .8 ml nematode suspension. Almonds were harvested and examined for NOW larval mortality 4 days after nematode application.

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This research was supported in part by a grant from the Almond Board of California. The authors thank Darlene F. Hoffmann, Biological Laboratory Technician (Micro), SEA, USDA, Stored-Product Insects Research Laboratory, Fresno, and Abdul R. Chauthani, Head, Entomological Research Dept., Nutrilite Products, Inc. for the production of nematodes used in the 1977 tests. Thanks also to the California Almond Growers Exchange for their evaluation of NOW-caused almond nutmeat damage.

Fig. 4. Placement of sticky discs in tree canopy.