Nemacur residues in turfgrass

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Effectively controls nematodes but remains in soil many months

In 1981, a plant-parasitic nematode was found to be the cause of a yellowing, stunting, and dieback of golf greens in the San Francisco Bay and Monterey Bay areas. The nematode was later described and named *Anguina pacifica* by nematologists at the University of California, Davis. Annual bluegrass *(Poa annua)* appears to be the only turfgrass species affected by this nematode; individual plants have a prominent gall-like swelling on the stem crown and less obvious swelling on the roots.

Field and laboratory tests demonstrated that fenamiphos, formulated as Nemacur 15G, provides good control of the nematode with little damage to the turf. Its application to golf greens has improved the health and appearance of the turf and reduced disease incidence. Since fenamiphos has a relatively high mammalian toxicity (oral LD_{50} = 2 to 3 mg/kg [rat] and dermal LD_{50} = 200 mg/kg [rabbit]), concerns have been expressed about safety to golfers and golf course workers. Little information is available on residue levels and longevity of fenamiphos and its metabolites in golf greens; it has thus been difficult to assess the potential for exposure. We conducted this study to measure these levels on a treated golf green for a six-month period and to evaluate the residues in terms of human health risk.

Golf-green experiment

An unused but well-maintained golf green at the Olympic Club in San Francisco was used for the study. The green is predominantly annual bluegrass growing in a sandy soil. A 36-foot-square section of the green was divided into 12 plots, each 6 by 18 feet. Fenamiphos, formulated as Nemacur 15G, was evenly applied with a drop spreader at 3.1 pounds and 6.2 pounds per 1,000 square feet. Control plots received no treatment.

The maximum legal application rate of fenamiphos on turfgrass is 3 pounds of the formulated product per 1,000 square feet. The 3.1-pound rate resulted from a reproducible, but inaccurate, weighing of the formulation in the field. Applications at twice the legal rate were made to determine if an accidental application of excessive fenamiphos warranted any special precautions. Each treament was replicated four times. Immediately after the application, ½ inch of water was applied in accordance with label instructions. Subsequent irrigations amounted to approximately 1 inch per week.

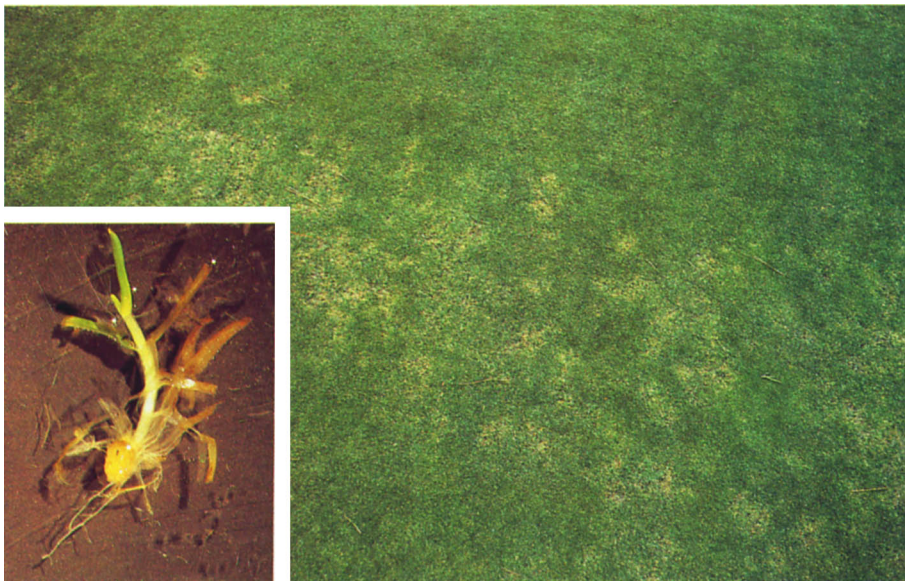

Photo of nematode infestation in a Bay Area golf green shows typical discoloration and dieback symptoms. A close-up of annual bluegrass plant shows light brown, shiny, bulbous gall at the shoot base caused by *Anguina pacifica* nematode.

Fenamiphos was applied on July 24, 1984, and all plots were sampled at intervals of 1 hour, 1, 7, 14, 30, and 60 days, and 6 months after treatment. Soil samples were taken at the first two intervals, turfgrass clippings, thatch, and soil samples thereafter.

Field samples and analytical method verification samples were analyzed by capillary gas chromatography for residues of fenamiphos and its two major oxidative metabolites, fenamiphos sulfoxide and fenamiphos sulfone, following solvent extraction and separation from unwanted sample coextractives. The method was sensitive to levels of fenamiphos and its major metabolites at 0.01 to 0.05 ppm, depending on chemical and sample matrix. Most samples had residue levels well above these limits.

Residue levels

Residue patterns for fenamiphos and metabolites in turfgrass clippings (reported on a dry weight basis) at the two treatment rates were very similar (fig. 1). The highest levels of fenamiphos-related pesticide residue occurred by 14 days at both treatment rates. At that time, the total residue, including the oxidized metabolites, was 1,059.6 ppm at the 3.1-pound rate and 2,199.3 ppm at the 6.2-pound rate. Unchanged fenamiphos residues peaked at both treatment rates at 7 days and were declining rapidly with a half-life of 4 days. Unchanged fenamiphos was not detectable in the 6-month turfgrass samples at either treatment rate.

The turfgrass residue data for unchanged fenamiphos at both application rates are similar to data previously reported for fenamiphos at a rate of 2.3 pounds per 1,000 square feet. The observed fenamiphos half-life was 4 days at 3.1 and 6.2 pounds per 1,000 square feet and 5.7 days at 2.3 pounds.

The major metabolite found in turfgrass clippings was fenamiphos sulfoxide, which reached 849 ppm at the lower rate and 1,617 ppm at the higher rate in 14 days and represented 70 percent of the total residue at that sampling. Fenamiphos sulfone residues in turfgrass peaked at 14 days but represented only 17 percent of the total residue. At 30 days, the sulfone represented 30 to 43 percent of the total residue.

Previous turfgrass work reported that residues of the metabolites peaked at 7 days. This difference from our findings of a peak at 14 days may be due to differences in soil type, irrigation regime, or temperature. It is also possible that the metabolite levels actually peak between 7 and 14 days.

Fenamiphos sulfoxide was the principal metabolite in turfgrass during our study, which was somewhat different

from published residue data for turfgrass. These results, however, are consistent with published data for crops and soils. A previous turfgrass study found the sulfone to be the major metabolite residue.

In the soil cores (1- to 4-inch depth), total fenamiphos-related residues (dry-weight basis) gradually increased after application, reaching a maximum by 7 days (17.3 ppm) at the high treatment rate, but not peaking until day 30 (6 ppm) at the lower rate (fig. 2). The reason for this phenomenon is not clear. At both treatment rates, fenamiphos-related residues declined after 30 days but were still detectable after 6 months.

At the 3.1-pound rate, unchanged fenamiphos reached a maximum concentration of 1.78 ppm 14 days after application. The major metabolite in soil was fenamiphos sulfoxide, with a peak concentration of 3.77 ppm after 30 days. Residues of fenamiphos sulfone peaked at 14 days but never accounted for more than 20 percent of the total residue.

Fenamiphos soil residues in plots treated at 6.2 pounds per 1,000 square feet generally followed a dissipation pattern similar to those in plots treated at the lower rate. The sulfoxide residues, however, did not show as uniform a dissipation pattern at the higher rate as at the lower application rate. Levels of the sulfoxide although somewhat variable, appeared to be disproportionately higher at the 6.2-pound rate, possibly because of a toxic effect on the microorganisms responsible for degradation.

In thatch samples, at the lower application rate, maximum levels of fenamiphos (65 ppm), fenamiphos sulfoxide (42.2 ppm), and total residues (140.3 ppm) occurred on day 7, which was the first thatch sampling date, but declined rapidly after that (fig. 3). Unchanged fenamiphos was usually the greatest residue component in the thatch samples at all intervals; these residues decreased from 65 ppm at seven days to less than 5 ppm at 30 days and were barely detectable after two months.

The major metabolite was fenamiphos sulfoxide at all sampling times. Fenamiphos sulfone residues peaked at 14 days but contributed less than 14 percent of the total residue at all intervals.

As total residue levels in the thatch layer decreased, total residue levels in the turfgrass and soil increased during the 7- to 14-day interval, indicating significant movement of the pesticides out of the thatch.

Conclusions

Fenamiphos is effective in the control of a variety of turfgrass nematodes, including *Anguina pacifica*. Application to turfgrass in accordance with label directions results in fenamiphos-related residues that are detectable in turfgrass clippings, thatch, and soil up to six months after treatment.

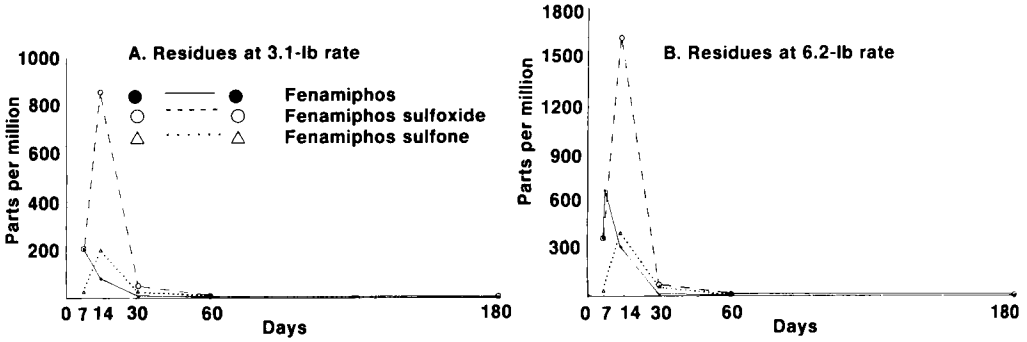

Fig. 1. Total residues of fenamiphos and its metabolites in turfgrass clippings were highest 14 days after application, then declined to nearly nondetectable levels.

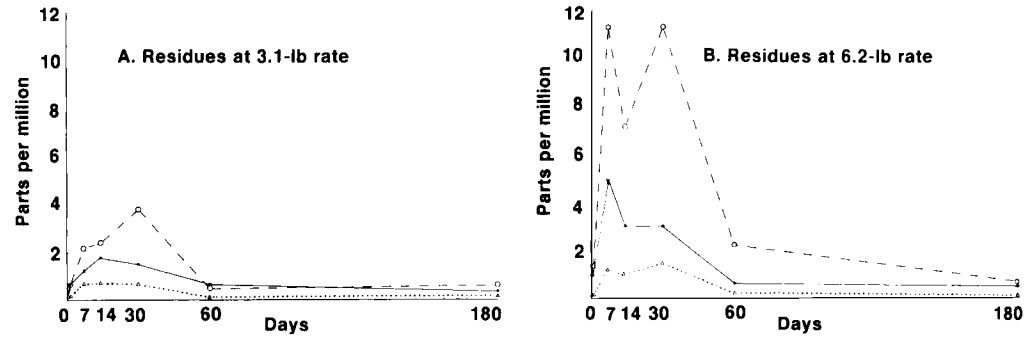

Fig. 2. Soil residues, at 1 to 4 inches deep, peaked at 7 or 30 days, then declined slowly, remaining well above the detection limit at 6 months.

In our study, the highest residues occurred in turfgrass clippings 14 days after application and declined rapidly to nearly nondetectable levels by six months. Residues in the thatch layer peaked at 7 days (the first sampling interval for this fraction) and rapidly declined to levels close to the detection limit by six months. Soil residues peaked at 7 or 30 days, depending on treatment rate, and declined slowly. Fenamiphos residues in soil were well above the detection limit at the six-month sampling, indicating slow dissipation from this layer. The major metabolite of fenamiphos in all sample types was fenamiphos sulfoxide.

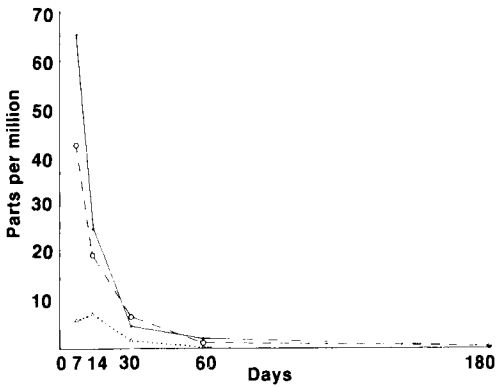

Fig. 3. Residues in the thatch layer peaked at 7 days, then rapidly declined.

The levels we detected in turfgrass clippings are not likely to represent a hazard to golfers or golf course workers, because most of the residues would be within the grass blade and not available for contact with the skin. Since the fate of these chemicals in compost is not known, however, compost from the golf course should not be used in growing edible crops or be made available as feed for domestic animals or wildlife. The fenamiphos registration states that animals must not be allowed to feed on turfgrass clippings following fenamiphos treatment.

The fenamiphos residues found in soil or in the thatch layer would not present a health threat to golf course workers or golfers, since the levels are low and the pesticide is not easily contacted in these layers.

According to the label, fenamiphos controls nematodes for up to six months in turfgrass. In this study, however, little pesticide remained after two months. The lengthy control might be explained by the existence of persistent fenamiphos metabolites not measured in this study or by thorough initial nematode control followed by slow reinfestation.

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