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Effects of oxamyl and chlordane on the activities of nontarget soil organisms

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Summary. The effect of two pesticides, oxamyl and chlordane, on nontarget soil biota were examined in microcosms. Neither oxamyl nor chlordane had an effect on rates of litter decomposition or soil and litter respiration. There were differences in numbers of nematodes and protozoans and in biomass of bacteria and fungi in microcosms with and without chlordane on some sampling dates. One of the nematodes, *Pelodera* sp., died out in all of the microcosms within 30 days. Although the pesticide chlordane had no measurable effect on the activities of the soil biota as measured by respiration and mass loss, it did affect the population sizes and biomass of some grazers of soil biota.

Key words: Microcosms – Microflora – Nematodes – Soil-litter respiration – Soil Nitrogen

Pesticides, even though selective, may affect beneficial species closely related to the pest and/or other nontarget organisms that may belong to other orders or even other phyla. The importance of nontarget organisms in nutrient cycling may be a factor in crop production where various agrochemicals are used to control arthropods, plant parasites, or pathogens. Recent research has shown that arthropods and nematodes are important rate regulators of nutrient cycles through predation on the soil microflora (Coleman et al. 1978; Santos et al. 1981; Elkins and Whitford 1982; Parker et al. 1984) and can affect plant growth (Coleman et al. 1984). An understanding of the role that these organisms play in nutrient cycling and the effect pesticides have on these soil organisms is important.

There has been considerable interest in the application of pesticides to eliminate or reduce the activity of nematodes and microarthropods in order to examine their role in ecosystem processes (Witkamp and Crossley 1966; Macauley 1975; Malone and Reichle 1973; Fowler and Whitford 1980; Santos et al. 1981; Elkins and Whitford 1982; Parker et al. 1982; Parker et al. 1984). Two pesticides, oxamyl and chlordane, have shown promise for studying the role of predators in nutrient cycling processes in soil systems. Oxamyl is used for the control of nematodes and arthropods and has a short persistence (DT_{50} = 2 weeks) (Bromilow 1973). Chlordane is a highly persistent insecticide (DT_{50} = 8 years) (Nash and Woolson 1967).

Studies testing the effects of pesticides on nontarget organisms in pure culture or in intact soil have disadvantages. With the former, the responses may be entirely different from those in soil, where numerous interactions between soil taxa occur. In the latter, it is difficult to discern whether responses stem from removal of a target organism (predator) or effects on nontarget organisms (prey) (Thompson and Edwards 1974). Recently, Coleman et al. (1984) have developed a filtering method for removing predators (organisms larger than protozoa, i.e., mites and nematodes) while still maintaining a high diversi-

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ty of bacteria, fungi, and protozoa. Using this method, it is now possible to obtain a more representative mix of soil microflora for use in microcosms.

In order to evaluate the results of earlier research and to test the feasibility of using selected chemicals in future studies, we used microcosms to examine the effects of oxamyl and chlordane on nontarget organisms, mass loss of creosote bush litter (*Larrea tridentata*), and carbon and nitrogen dynamics in the absence of the target organisms. Hypotheses tested were: (1) neither oxamyl nor chlordane affect nontarget organisms or nutrient cycling processes and (2) nematodes overgraze bacteria and fungi and reduce mass loss in the absence of mites.

Materials and methods

The above hypotheses were tested in two experiments, one experiment for each pesticide. The design for the oxamyl study employed two treatments: with and without oxamyl. The chlordane study was a complete factorial design consisting of four treatments: with and without chlordane by with and without nematodes. In both experiments, we collected data on litter and soil respiration, microbial biomass, and nontarget soil fauna. The respiration data provide an integrated measure of the activity of the entire soil biota. The population and biomass data indicate the status of populations but not their activity. Used together these data should provide an effective measure of effects on nontarget organisms.

Forty-five microcosms were used in the oxamyl study. Thirty-six microcosms consisted of 50-ml Erlenmeyer flasks containing 25 g soil and 1 g creosote bush (*Larrea tridentata*) leaf litter enclosed in a 2 × 2-cm nylon mesh litter bag. The soil used in the microcosms was a Berino series soil classified as a Typic Haplargid, fine loamy, mixed, thermic soil. This soil has a pH of 8.4, 0.4% organic matter, 4.7% $CaCO_3$; with 13.7% clay, 12.1% silt, and 74.3% sand. The remaining nine microcosms contained only soil and were used for soil respiration. Flasks and contents were sterilized by gamma irradiation (2.72 MR). The flasks containing leaf litter and six containing soil alone were inoculated with a mixed inoculum containing bacteria, yeast, fungi, and protozoans. The inoculum is described later. The remaining three flasks were sterile controls. After inoculation the microcosms were brought to field capacity with either sterile distilled water or filter-sterilized oxamyl solution. The application rate for oxamyl was 7 μg a.i. g^{-1} soil. Microcosms were incubated at 22°C in individual 0.5–1 respiration chambers (Coleman et al. 1978).

In the chlordane study, 0.5 g litter was used and an extra 0.5 ml water was added to account for absorption by the litter. A total of 159 microcosms were used (144 containing litter and soil and 15 with soil alone). Three soil-only microcosms from each treatment were used to measure soil respiration and the remaining three were left as sterile controls. The microcosms were inoculated as in the oxamyl study and treated with autoclaved sterilized chlordane at 25 μg a.i. g^{-1}. Autoclaving was at 100°C and 689 N • m^{-2} for 10 min; after autoclaving the solution was then submerged in cold water. The insecticidal activity of the chlordane was not reduced by this protocol.

Bacteria, fungi, yeasts, protozoans, and nematodes were isolated from buried litter bags containing creosote bush litter after 1, 2, and 3 months in the field and from surface litter after 6 months in the field. Bacteria, fungi, yeasts, and protozoans were isolated by the filtering method developed by Coleman et al. (1984). Ten grams of litter were added to 400 ml sterile distilled water and shaken for 24 h. This suspension was blended for 1 min and then filtered through 8 μm filter paper. Five-milliliter aliquots of the filtrate were added to sterile soil microcosms containing 0.25 g creosote bush litter.

Fungi were isolated by removing 1 ml of the blended litter suspension just prior to filtering, serially diluting the sample, and inoculating six different agars (littman oxgall, potato dextrose, milk, malt extract, malt salt, and cornmeal). All fungal colonies with different morphological characteristics were added to microcosms that were maintained for fungal inocula. The fungal inocula were prepared by blending one of the inoculum microcosms in 100 ml sterile water for 1 min and then adding 1 ml of the suspension to each experimental microcosm.

Nematodes were extracted from soil and buried creosote bush litter by centrifuge flotation (Jenkins 1964) and identified. Selected genera were maintained for use as inocula. *Pelodera* sp. was cultured on bacterial colonies on dilute cornmeal agar. *Aphelenchus avenae* were grown on *Rhizoctonia solani* colonies maintained on potato dextrose agar. Members of the Cephalobidae (primarily *Paracephalobus* spp.) were grown on decomposing leaf litter buried in pots of steam-sterilized soil.

Nematode inocula for microcosms were prepared by transferring individuals from their respective cultures into sterile water. The nematodes were combined in a 3:1:1 ratio (cephalobids:*Pelodera* sp.:*Aphelenchus avenae*). That ratio was similar to that observed in buried litter in the field. Inocula were pipetted volumetrically into microcosms at double the rate recovered from soil to minimize any effects due to nematodes injured during micromanipulation.