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Microencapsulated Chlorpyrifos Distribution in Loamy Sand and Silty Clay Loam Soils When Applied with a Sub-Slab Injector for Subterranean Termite Control

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Subterranean termites infesting structures have been typically controlled by the creation of a continuous soil termiticide barrier proximal to the structures. The low cost of labor and insecticides, and extended insecticide persistence have made soil treatment the most popular technique used in termite control (Mampe 1982). Previously registered chlorinated hydrocarbon termiticides have provided 100% termite control for 20-30 years (Johnston et al. 1971; Mauldin et al. 1987). Currently registered organophosphate (OP) and pyrethroid insecticides generally provide 100% control for 5 years and 80-100% control for up to 10 years (Kard et al. 1989). The persistence of these termiticides can vary with soil and climatic factors. When applied at similar concentrations, the OP's and pyrethroids are not as persistent when compared with the chlorinated hydrocarbon termiticides. Controlled release technology may increase pesticide longevity (Tsuji 1986).

Of the currently registered termiticides, Dursban® TC (chlorpyrifos) has been the most widely used by commercial pest control operators (PCO's) (Mix 1991). A microencapsulated chlorpyrifos formulation may provide increased soil persistence compared with the emulsifiable concentrate of Dursban TC. Data on chlorpyrifos distribution in soil have been published (Davis and Kamble 1992). This research was undertaken to test the hypotheses that: a) microencapsulated chlorpyrifos will form a continuous barrier when injected beneath a concrete slab, and b) varying insecticide quantities and soil types will significantly affect termiticide distribution and penetration.

MATERIALS AND METHODS

All treatments included XRM-5160 (1% AI microencapsulated chlorpyrifos) and either a loamy sand (80.13% sand, 13.44% silt, 6.43% clay and 0.065% organic matter) or a silty clay loam (34.87% clay, 56.92% silt and 2.17% organic matter) soil. The soil pH of the loamy sand and silty clay loam soils was 8.25 and 5.63, respectively. Treatment variables included, application quantity (4.56 and 10.63 L) and soil type. An application pressure of 345 KPa was used in all treatments. The average flow rate was 15.19 L/min. There were four treatments and two untreated controls. The treatments were replicated three times and randomly assigned to the experimental units. Each experimental unit consisted of a plywood box (1.22 X 1.22 X 0.61 m) (Fig. 1). The soil was added to each box in increments of 18 cm. Each layer was hand tamped and lysed before succeeding increments were added. The process was continued until each box was filled to

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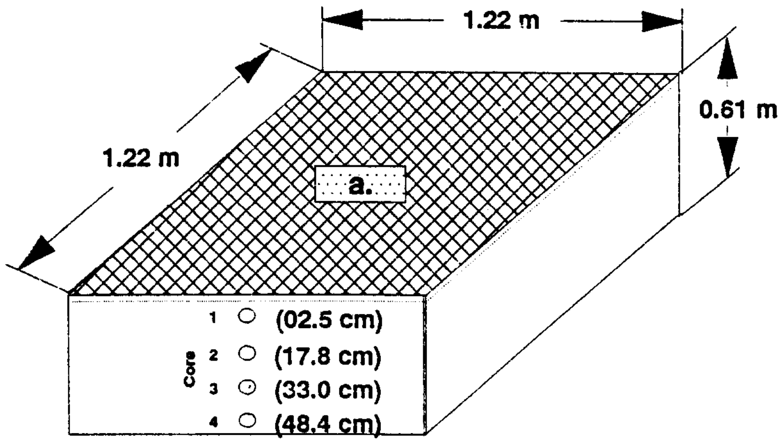

Figure 1. Experimental unit (plywood box) filled with soil, capped with concrete and with core locations specified (a. = injection point).

a soil depth of 53 cm. The soil was compacted to ca. 1.4 g/cm^3. After filling, each box was capped with a 7.6 cm #1 grade concrete slab. These conditions were selected to simulate conditions under a basement slab.

The soil was treated on 7/13/89. A 1.27 cm entry hole was drilled through the center of the concrete slab of each box. The termiticide was applied to the soil in each box via a B&G® sub-slab injector unit. The application pressure was monitored with a gauge mounted on the injector unit. A B&G®, 11.4 L, stainless steel spray tank was used as the termiticide reservoir. Termiticide quantity was measured with a tank-mounted sight gauge consisting of clear polyvinyl hose. The insecticide in the reservoir was frequently agitated to promote homogeneity. After treatment, the entry holes were sealed with concrete.

Soil samples were collected on 7/20/89-7/21/89. Four, 3.3 cm dia. sampling holes were drilled along a vertical line bisecting one of the plywood side panels of each box. The top hole was positioned 2.5 cm beneath the bottom of the concrete slab. The remaining three holes were located 17.8, 33.0, and 48.4 cm beneath the bottom of the slab. Four soil cores, 60.8 cm long and 2.5 cm in diameter were removed from each box via the sampling holes. The soil cores were removed using stainless steel probes 2.5 cm in diameter. Each soil core was divided into 4 samples, at 15.2 cm intervals with sample 1 located under the injection point and sample 4 proximal to the plywood sideboard. Each sample was placed in a separate, pre-labeled Ziploc® plastic bag and stored in a freezer at -20°C. The probes were triple rinsed with acetone prior to reuse.

Ten grams of soil were removed from each sample and placed in a 250 ml erlenmeyer flask with 50 ml of acetone. The flasks were stoppered, mounted on a wrist action shaker (Burrell® Model 75) and agitated for 180 min. After agitation, the acetone/soil slurry was filtered through #1 Whatman® filter paper into 250 ml boiling flasks. The flasks were mounted on a rotovapor (Buchi® RE110) and the filtrate was evaporated to near dryness. The concentrated residue was redissolved in 10 ml of hexane, decanted into 14 ml glass vials and stored in a freezer at -20°C until analysis. The residues were analyzed with a Varian® 6000 gas chromatograph equipped with a Varian® 4270 integrator, a Varian® 8000 autosampler and a Thermionic Specific Detector (TSD), adjusted for phosphorous selectivity. A 2 meter, 4% OV 101-6% OV 210 (Chromosorb® W-HP, 80/100 mesh) glass column was used. The oven temperature was stabilized at 210°C for 8 minutes and then increased to 250°C for a total run time of 12 min/sample. The injector and detector temperatures were 200°C and 300°C, respectively. Nitrogen, hydrogen and air flow rates were set at 30.0, 3.4 and 175.0 ml/min, respectively. The minimum detection limit was 0.05 μg(chlorpyrifos)/g(soil). The residues were analyzed using an external standard method. Analytical standards were provided by the Environmental Protection Agency (Research Triangle Park, North Carolina). The insecticide recovery efficiency of this process was 86.34 ± 11.05%. The mean chlorpyrifos recovery rate from fortified soil samples was 97.25 ± 11.81%, indicating an excellent storage stability. Data were analyzed with General Linear Models, Repeated Measures Analysis, SAS Institute 1982.

RESULTS AND DISCUSSION

The chlorpyrifos residues were significantly affected by the interactions of soil sample location and soil core depth (Pr>F = 0.0377), and soil sample location and soil type (Pr>F = 0.0001). The average R^2 for the repeated values was 0.58. Soil samples directly below the injection points in core 1 of all treatments had the highest concentrations (Fig. 2). Concentrations adequate to control subterranean termites (>5.0 μg of chlorpyrifos/g of soil, Su and Schefrahn 1990) were detected horizontally 45.8 and 15.3 cm in core 1 of the loamy sand and silty clay loam treatments, respectively (Fig. 2), and vertically 17.8 cm in core 2 in the loamy sand treatments (Fig. 3) and 33.0 cm in core 3 of the silty clay loam treatments (Fig. 4). Decreasing residues were generally found with increasing depth and horizontal distance (Figs. 2, 3, 4, & 5).

No residues greater than 5.0 μg/g were detected in core 4 (depth = 48.3 cm) (Fig 5). The greatest horizontal penetration of chlorpyrifos (15.3-45.8 cm) was detected directly beneath the slab along core 1 in treatments 1-4 and the greatest vertical penetration (33.0 cm) was detected in treatment 4 (Table 1).

Table 1. Penetration of microencapsulated chlorpyrifos (>5.0 μg/g) in either a loamy sand or a silty clay loam soil from the injection point.

Treatment[1]			Distance	
No.	Soil Type	Quantity (L)	Horizontal[2] (cm)	Vertical[3] (cm)
1	L. Sand	4.56	45.8-60.9	2.5
2	L. Sand	10.63	45.8-60.9	17.8
3	S. Clay L.	4.56	15.3-30.5	17.8
4	S. Clay L.	10.63	15.3-30.5	33.0

[1]1% AI chlorpyrifos was used in all treatments.
[2]In core 1 located 2.5 cm below the slab, distances from injection point.
[3]In a vertical line directly below the injection point.

Further GLM analysis indicated that insecticide quantity did not provide for a significant effect (Pr>F = 0.4858). However, the largest vertical insecticide

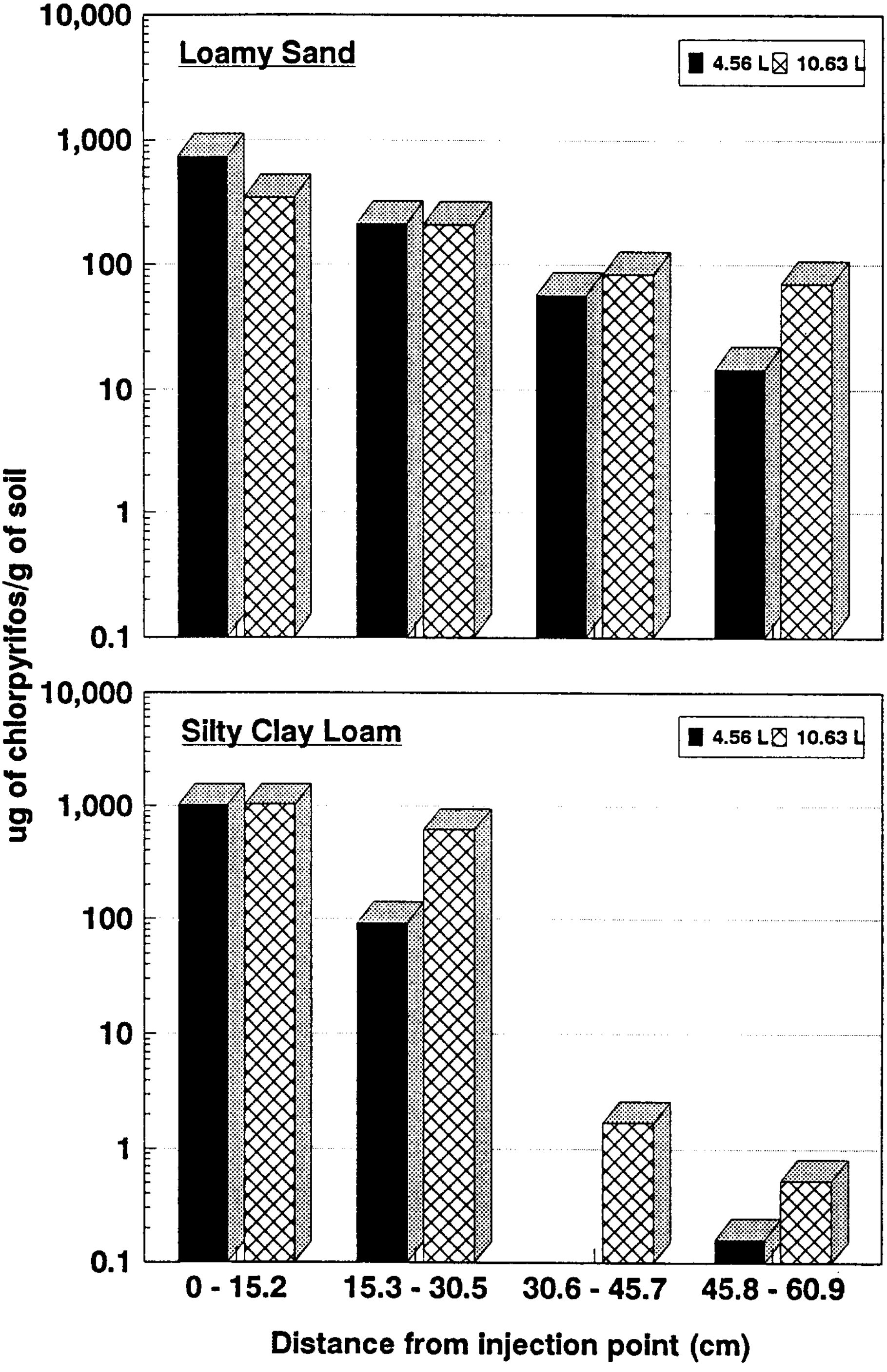

Figure 2. Mean chlorpyrifos residues in soil, at varying distances from the injection point in core 1 (2.5 cm below the slab) with all treatments

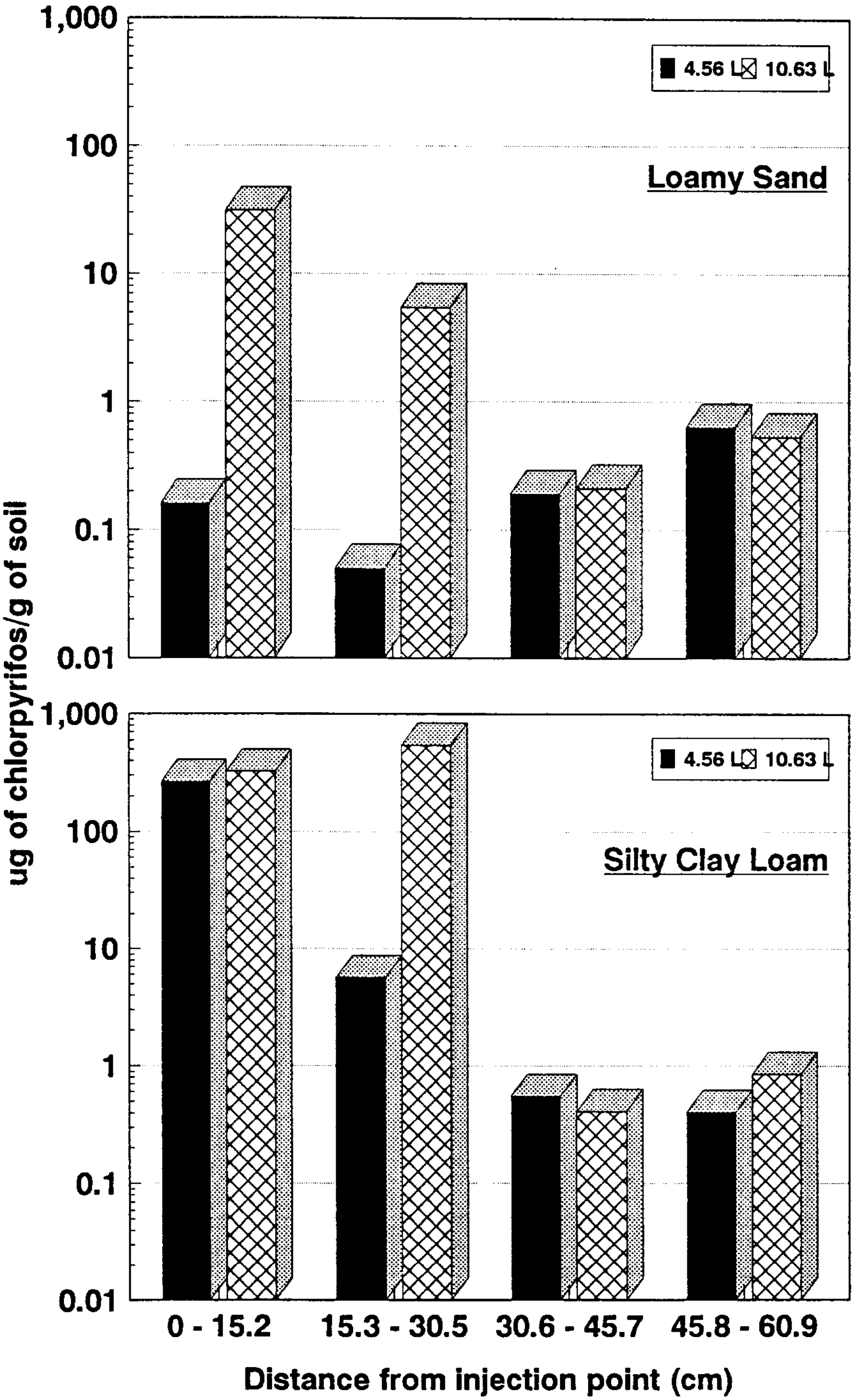

Figure 3. Mean chlorpyrifos residues in soil, at varying distances from the injection point in core 2 (17.8 cm below the slab) with all treatments

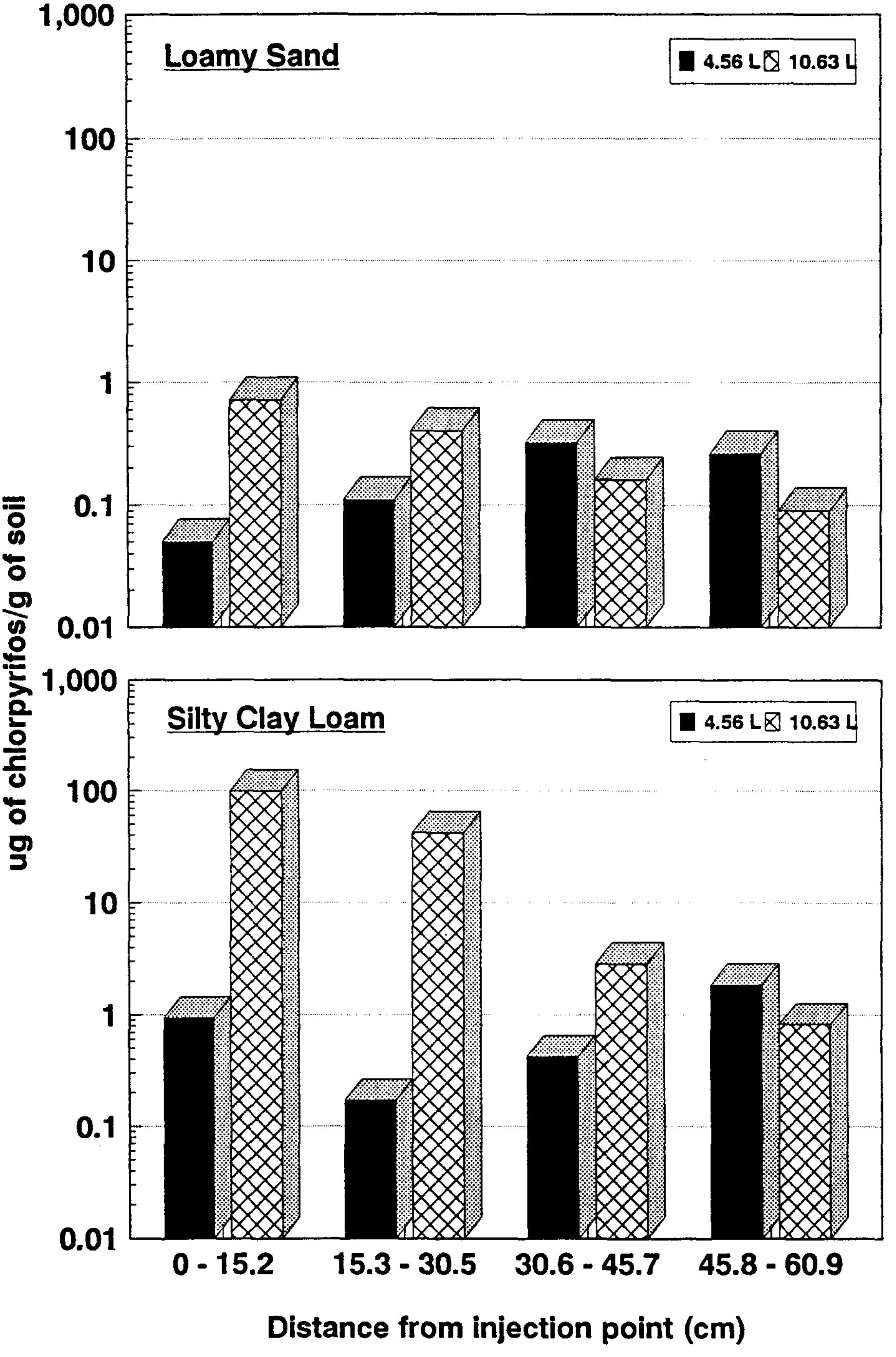

Figure 4. Mean chlorpyrifos residues in soil, at varying distances from the injection point in core 3 (33.0 cm below the slab) with all treatments.

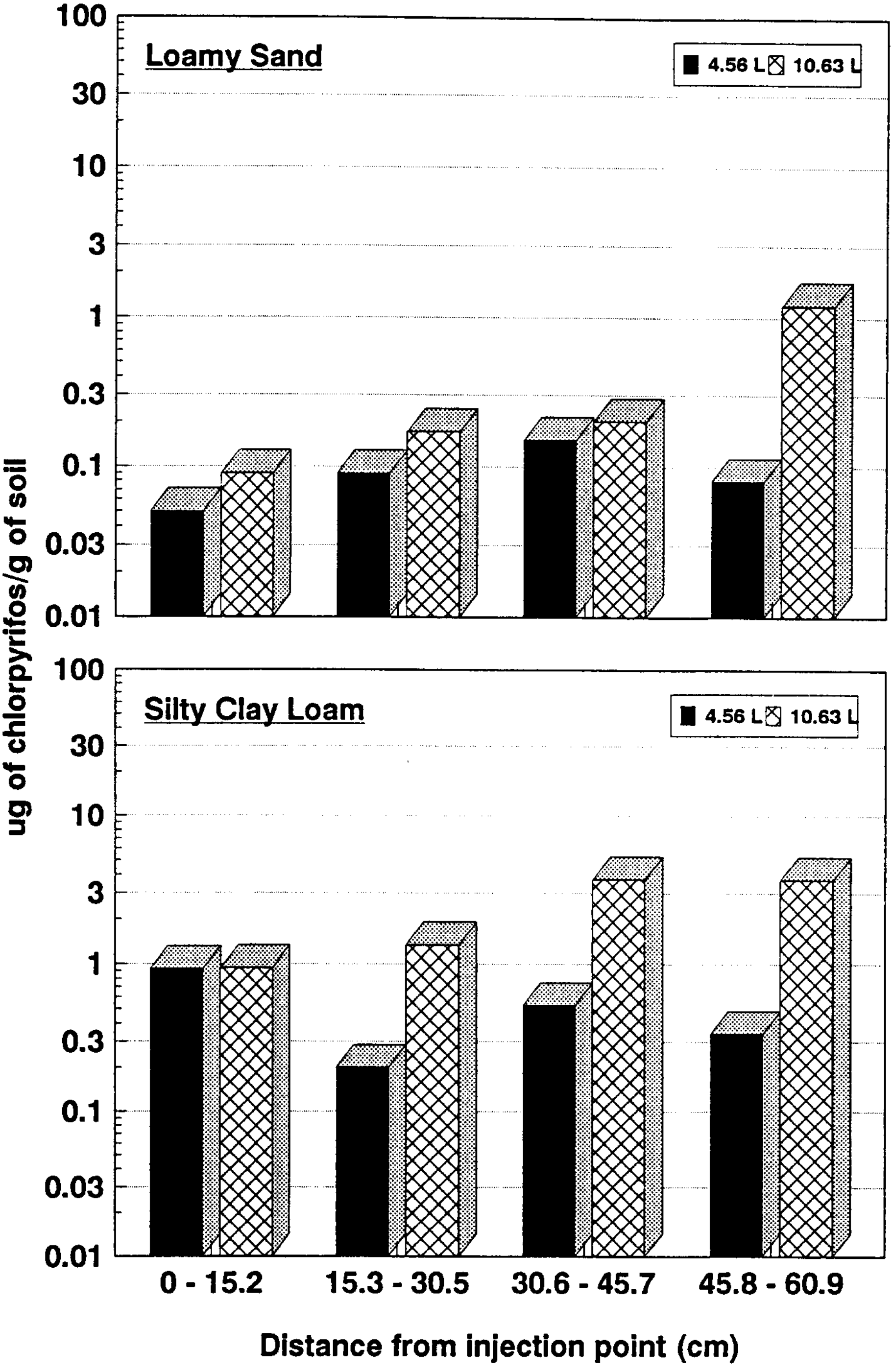

Figure 5. Mean chlorpyrifos residues in soil, at varying distances from the injection point in core 4 (48.4 cm below the slab) with all treatments.

penetration was evident with the treatments utilizing the largest quantities (Treatments 2 & 4). The greatest horizontal penetration was observed with the treatments consisting of the loamy sand soil (Treatments 1 & 2), (Table 1).

Termiticide applicators can be reasonably assured that sub-slab injected microencapsulated chlorpyrifos will be initially placed 0-18 cm (loamy sand soil) or 0-33 cm (silty clay loam soil) beneath the concrete slab and that decreasing concentrations will be present vertically and horizontally from the point of injection. This is consistent with reported Dursban TC (Davis and Kamble 1992), and chlordane and dieldrin distribution patterns (Bennett et al. 1974). This microencapsulated formulation only remained in a homogeneous solution during application with frequent agitation. This could be a difficulty for termiticide applicators. Insecticide placement can be affected by soil type. Greater horizontal penetration can be expected in sandy soils with greater vertical penetration expected in clay soils. Increased insecticide quantity may allow for larger amounts within 61 cm of the injection point. Therefore, applicators should allow for differences in termiticide distribution that may occur due to soil type in order for the structure to be protected from subterranean termite infestation.

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