Adsorption and Leaching of Herbicides in a Soil

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1. INTRODUCTION

Trifluralin [2,6-dinitro- N,N- dipropyl-4- (trifluoromethyl) benzenamine], metolachlor [2- chloro- N- ethyl- 6- methylphenyl)- N- (2-methoxy-1-methylethyl) acetamide], and metribuzin [4-amino- 6-(1,1- dimethylethyl)-3-(methylthio)- 1,2,4,- triazin- 5(4H)- one] are selective herbicides used for preemergence control of annual grasses and broadleaf weeds in soybean, corn, cotton, and peanut production (Humbrug, 1989).

Soil-adsorbed herbicides are subject to leaching by water percolating downward in the soil profile. The extent of leaching is generally dependent on climatic, soils, herbicides, and management (Leonard, 1989). Several herbicide properties that influence leaching include partition coefficient, water solubility, vapor pressure, hydrophobic-hydrophilic character, ionic state, and chemical, photochemical, and biological properties (Himel et al., 1989). It is commonly accepted that herbicides which are strongly adsorbed to soil particles and have low water solubilities, are relatively immobile in soil (Kim and Feagley, 1996). The herbicides used in this study, (trifluralin, metolachlor and metribuzin) have different chemical and physical properties and thus, should have different mobilities in soil.

The objectives of this study were two-fold. The first was to evaluate the adsorption-desorption behavior and leaching properties of trifluralin, metolachlor and metribuzin in soil columns and the second was to predict their movement under natural conditions.

3. MATERIALS AND METHODS

3-1. Adsorption-Desorption Experiment

Adsorption isotherms were determined by placing 4 g of air-dried soil and 40 mL of standard solution (ranging from 1 to 50 mg/L herbicide) into

50 mL sealed centrifuge tubes. The samples were shaken (135 strokes per minute) for 24 hr, a period that preliminary studies had shown were sufficient to attain equilibrium. Samples were then centrifuged at 3000 rpm for 30 min and the supernatant was used for herbicide analysis. Differences between the added amounts of herbicide in standard solutions and the remaining amounts of herbicide in the supernatant were considered to be the amounts adsorbed. Desorption was determined on the same samples used for adsorption.

3-2. Leaching Experiment

Each column, which consisted of 13 stacked and taped steel rings (5.4 cm i.d. × 3 cm in length) was fitted with a Büchler funnel containing Whatman filter paper and mounted on a stand with a 500 mL Erlenmeyer flask for leachate collection (Smith and Willis, 1985). The columns were uniformly packed to a depth of 23 cm (bulk density 1.23 mg/m^3, soil porosity of 41.1%) with untreated soil and saturated with distilled water prior to applying the herbicide.

As the same rate of each herbicide applied in companion soybean field studies in Louisiana, amounts of each herbicide added to each column were 384 μg of trifluralin (1683 g/ha), 628 μg of metolachlor (2757 g/ha), and 137 μg (609 g/ha) of metribuzin, It was then covered with a depth of 3 cm (84.92 g) of soil treated 4521 mg/g of trifluralin, 7395 mg/g of metolachlor and 1613 mg/g metribuzin, respectively.

The soil column was leached with either 245 mL of distilled water (one pore volume) or 735 mL distilled water (three pore volumes). The 224 ± 6.76 mL of leachate from one pore volume of water was collected during 33.0 ± 8.8 hr (rate of 7.41 ± 1.98 mL/hr). The soil samples were divided into 0-5, 5-8, 8-11, 11-14, 14-20 and 20-26 cm after leaching. Each segments wear air-dried for one week and crushed for herbicide analysis.

4. RESULTS AND DISCUSSION

At a 1:10 soil/water ratio, the Koc values for trifluralin, metolachlor and metribuzin were 875, 135, and 96, respectively. Leaching of these herbicides was evaluated in soil columns (5.4 cm i.d. × 26 cm long).

Total recoveries of the herbicides applied to the soil column were 73.1% ±4.1%. When the soil columns were leached with three pore volumes of water, the distributions of trifluralin in soil and leachate were 99.993% and 0.007% of the total recoveries, respectively. The distributions of metolachlor was 65.27% in soil and 34.7 % in leachate. The distributions of metribuzin was 11.42% in soil and 88.58% in leachate. The results showed that metolachlor and metribuzin were readily leached, while trifluralin was strongly adsorbed to soil.

Leaching of three herbicides in the soil column followed the leaching trends of their calculated leaching indices 1.41×10^4, 4.18×10^6, and 3.38×10^8 for trifluralin, metolachlor, and metribuzin, respectively. The results of the study demonstrated the potential of pollution for metolachlor and metribuzin to be leached into the ground water in soils with shallow aquifer.

Metolachlor and metribuzin with solubilities of 10 ppm or higher are lost mainly in the water phase of runoff, and erosion control practices will have little effect on such losses. Trifluralin is strongly adsorbed by sediment, and erosion control can be important in controlling losses of trifluralin (Wauchope, 1978). Cohen et al.(1984) suggested that the potential of pesticide contamination of ground water was highest when pesticide characteristics was: water solubility- greater than about 30ng/mL; adsorptivity, Koc- less than 300 to 500; soil half life- greater than 2 to 3 weeks.

To evaluate the pollution potential for these herbicides, the water maximum contaminant level for trifluralin metolachlor and metribuzin in natural conditions need to be compared with levels of U.S Environmental Protection Agency health advisory level, which are 2.0 ng/mL for trifluralin, 10 ng/mL for metolachlor and 175 ng/mL for metribuzin.

The results of the present study showed the potential of pollution for metolachlor and metribuzin to be leached into the ground water in soils with shallow aquifer.

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