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Movement of pendimethalin in saturated and unsaturated conditions in clay loam and sandy loam soils

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ABSTRACT

Movement studies were carried out using packed soil columns to know the distribution pattern of pendimethalin in clay loam and sandy loam under saturated and unsaturated conditions. Pendimethalin was applied at 20 mg/kg of soil and the soil columns were kept for movement studies at time intervals of 1, 3, 5, 7, 15, 22 and 37 days. The soils used in the study were clay loam and sandy loam. Pendimethalin remained primarily in the top soil layers. Under saturated conditions movement of pendimethalin was more in sandy loam as compared to clay loam. Under unsaturated conditions, pendimethalin showed more mobility in clay loam. The increase in herbicide movement was observed with increase in days. The factors that influence movement are the herbicide solubility, soil structure and texture and the amount of water passing through the soil profile influenced movement of herbicide. Pendimethalin moved up to 20-25 and 5-20 cm under unsaturated and saturated conditions at 37 days after application, respectively. In clay loam soil, under saturated and unsaturated conditions, pendimethalin moved up to 15-20 cm at 37 days after application.

Key words: Herbicide, Movement, Pendimethalin, Soil conditions

Movement of herbicide with water through soil profile also needs attention as herbicide leaching through soils may move to the root zone of sensitive non target crop resulting in crop injury besdes reducesing herbicide efficacy. The movement of herbicides in soil is an important process that determines their fate in both soil and aquatic environments. Herbicide leaching through soil may (a) move to the root zone of sensitive non target crop resulting in crop injury (b) move below the root zone thus reducing herbicidal efficacy and (c) may result in herbicidal transport to the ground water causing contamination (Jorden and Harvey 1980, Obrigawitch *et al.* 1981).The factors that influence movement are the herbicide solubility, soil structure and texture and the amount of water passing through the soil profile (Raj *et al*. 2003). Studies on the herbicide mobility can be done in soil columns (Weber and Whitacre 1982), and in the laboratory by using soil leaching column (Dovidson and Santetman 1968, Weber *et al.* 1986), soil thick layer trays (Gerber *et al.* 1970 Wu and Scentelman 1975) and soil thin layer chromatography plates (Helling and Turner 1968).

Pendimethalin [N-(1-ethylpropyl)–3,4-dimethyl-2,6-dinitrobenzenamine] is a selective herbicide, used as pre-emergence application for control of most of the annual grasses and broad-leaved weeds in most of the vegetables in Andhra Pradesh. But the information on movement of this herbicide is meager. Hence, present study was conducted in laboratory to understand the mobility of pendimethalin in clay loam and sandy loam soils under saturated and unsaturated conditions.

MATERIALS AND METHODS

Samples of clay loam and sandy loam soils (0.25 mm sieved) were used for movement study of pendimethalin. The study was conducted by taking soil columns as described by Harris (1996). An acrylic plastic tube of 5.5 cm internal diameter was used and sliced into 1 cm and 2 cm height rings. These rings were joined leak proof with the help of tape to get total height of 30 cm. These columns were filled with 4.50 kg soil up to 28 cm against the total height of 30 cm. The height of 2 cm served as water reservoir for addition of water. The column was closed at bottom with muslin cloth. Then herbicide was applied to top 1 cm. Then column was placed in a tray of water for saturation. Saturation from bottom will avoid air trapping pores thereby, forming pockets that may obstruct water movement.

The columns were packed by taking 100 g of soil sample increments and by gentle tapping of the material. These were kept in tray for saturation, after saturation the

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excess water was allowed to drain off by keeping them overnight at room temperature. Unsaturated conditions were maintained by keeping the soil moisture content at its field capacity (36% for clay loam and 28% sandy loam soils). After saturating the column with water, herbicide was applied in top 1 cm of the soil column. Herbicide solution was prepared by dissolving the herbicide in methanol to give a concentration of 20 ppm for the entire weight of soil sample in the column. The columns were flooded with 1 cm water throughout the period of 1, 3, 5, 7, 15, 22 and 37 days. At each interval, column was removed and placed on smooth surface and with the sharp blade, the column was separated by removing the cello tape from the ring joints. After cutting the tape, the ring was gently sided from the column along with the soil taking care that the soil in lower ring did not get disturbed or lost. Then each ring was placed in moisture box, weighed again and dried for determination of moisture content. Before weighing, 25 g of sample from each segment was used for extraction of herbicide. Methanol was used as an extractant. Extraction was performed by shaking the soil with methanol for half an hour. 25 ml of methanol was used in each extraction and then filtered. The filtrate was made up to 50 ml with methanol. Pendimethalin concentrations in the extractant were determined using UV–Visible Spectrophotometer (GS 5701) at 420 nm.

RESULTS AND DISCUSSION

The pH of sandy loam and clay loam soil was 7.71 and 7.82, respectively. The pendimethalin moved up to 5–10 cm and the amount of pendimethalin extracted at this depth was 0.72 mg in sandy loam soil after 24 h of leachingin saturated conditions. At three days after leaching pendimethalin moved up to 10–15 cm and the amount extracted at this depth was 0.65 mg. At 5th, 7th and 15th day after leaching, pendimethalin moved up to 15-20 cm and the amount extracted was 0.66, 0.66 and 0.96 mg, respectively. The herbicide moved up to to 20-25 cm by 22nd day and the extracted amount of pendimethalin was 0.85 mg. At 37th day after leaching, 0.62 mg of pendimethalin was extracted at a depth of 20-25 cm. No pendimethalin was extracted at a depth of 25–30 cm at 37th day (Table 1).

In a clay loam after 24 hrs and 3 days of leaching under saturated conditions, pendimethalin moved up to 5–10 cm and the amount extracted was 0.58 and 0.68 mg respectively. At 5th, 7th, 15th and 22nd day after leaching, pendimethalin moved up to 10 -15 cm, and the amount extracted was 0.66, 0.64, 0.96 and 1.46 mg, respectively. At 37th day after leaching, herbicide moved up to 15-20 cm in soil column and the extracted amount was 0.92mg. There was no movement of pendimethalin at 20-25 cm and 25–30 cm of depth through out the study. Hence, it was inferred that distribution of leaching was higher in upper layers and decreased uniformly with depth (Table 2).

Table 1. Amount of pendimethalin extracted (mg) at different depths and different days of leaching in sandy loam under saturated conditions

Depth (cm)	Days						
	1	3	5	7	15	22	37
0-5	2.03	2.20	2.26	2.51	3.16	3.64	4.01
5-10	0.72	0.96	1.24	1.27	2.66	2.85	3.37
10-15	-	0.65	0.85	0.94	1.40	1.55	2.14
15-20	-	-	0.66	0.66	0.96	1.20	1.63
20-25	-	-	-	-	-	0.85	0.62
25-30	-	-	-	-	-	-	-

Table 2. Amount of pendimethalin extracted (mg) at different depths and different days of leaching in clay loam under saturated conditions

Depth (cm)	Days						
	1	3	5	7	15	22	37
0-5	1.85	2.16	2.26	2.58	2.98	3.28	3.68
5-10	0.58	0.68	0.84	1.36	1.88	2.24	2.44
10-15	-	-	0.66	0.64	0.96	1.46	1.68
15-20	-	-	-	-	-	-	0.92
20-25	-	-	-	-	-	-	-
25-30	-	-	-	-	-	-	-

Under unsaturated conditions, the leaching of pendimethalin in sandy loam after 24 hrs and 3 days of leaching was up to 5–10 cm, and the amount of pendimethalin extracted was 0.54 and 0.68 mg, respectively. Pendimethalin moved up to 10–15 cm and the amount extracted was 0.58 mg at 5th day after leaching. At 7th, 15th, 22nd and 37th day after leaching, pendimethalin moved up to 15–20 cm and the amount extracted was 0.82, 0.86, 0.89 and 0.91 mg, respectively. There was no movement of pendimethalin at a depth of 20-25 cm and 25-30 cm (Table 3).

Under unsaturated conditions the leaching of pendimethalin in a clay loam, at 24 h and 3 days after leaching pendimethalin was moved up to 5–10 cm and the amount of pendimethalin extracted was 0.63 and 1.46 mg respectively. At 5th, 7th and 15th day after leaching, pendimethalin was moved up to 10–15 cm and the amount

Table 3. Amount of pendimethalin extracted (mg) at different depths and different days of leaching in Sandy loam under unsaturated conditions

Depth (cm)	Days						
	1	3	5	7	15	22	37
0-5	1.46	1.80	2.05	2.19	2.64	3.12	3.45
5-10	0.54	0.68	1.06	1.28	1.36	1.96	2.41
10-15	-	-	0.58	0.86	0.92	1.13	1.28
15-20	-	-	-	0.82	0.86	0.89	0.91
20-25	-	-	-	-	-	-	-
25-30	-	-	-	-	-	-	-

Table 4. Amount of pendimethalin extracted (mg) at different depths and different days of leaching in clay loam under unsaturated conditions

Depth (cm)	Days						
	1	3	5	7	15	22	37
0-5	2.08	2.48	2.88	3.04	3.28	3.64	3.88
5-10	0.63	1.46	1.56	1.66	1.85	2.15	2.65
10-15	-	-	0.77	0.97	1.57	1.65	1.97
15-20	-	-	-	-	-	0.92	1.58
20-25	-	-	-	-	-	-	-
25-30	-	-	-	-	-	-	-

extracted was 0.77, 0.97 and 1.57, respectively. At 22nd and 37th day after leaching, pendimethalin moved up to 15-20 cm, and the amount of pendimethalin extracted was 0.92 mg and 1.58 mg, respectively (Table 4). There was no movement of pendimethalin below 20 cm depth. It was observed that amount of pendimethalin extracted in Clay loam under unsaturated conditions was more where compared to saturated conditions.

It was evident that herbicide movement depends on soil properties and water content. In saturated conditions in sandy loam at 37 days after application, pendimethalin moved up to 20-25 cm while it moved only up to 15-20 cm in unsaturated conditions. In clay loam, under saturated conditions, pendimethalin moved up to 15-20 cm and under unsaturated conditions, it moved up to 15-20 cm at 37 days after application. Similar findings were also reported by Raj *et al.* (2003) and Devi *et al.* (2000). In contrast to the results under saturated conditions, the movement of herbicide under unsaturated conditions was more in case of clay loam. It was also reported that water movement and herbicide movement was greater in fine textured soil than in coarse textured soils under nsaturated flow conditions (Goetz *et al.* 1986, Madhuri 2003). Negative correlation of movement of pendimethalin with depth (r=-0.981) and a positive and significant correlation (r=0.880) with time (days) was observed under saturated condition in clay loam soil. Similarly under unsaturated conditions, negative correlation of movement of pendimethalin with depth (r=-0.978) and a positive and significant correlation (r=0.851) with time (days) was observed (Table 5).

Table 5. Correlation and regression coefficient for movement of pendimethalin under saturated and unsaturated conditions in clay loam and sandy loam soils

Treatment	ClaylLoam		Sandy loam	
	Saturated	Unsaturated	Saturated	Unsaturated
Correlation coefficient				
Time (days)	0.880	0.852	0.932	0.976
Depth (cm)	-0.982	-0.978	-0.991	-0.981
Regression coefficient				
Time (days)	0.775	0.726	0.869	0.953
Depth (cm)	0.964	0.957	0.991	0.963

In sandy loam soil under saturated conditions, negative correlation of movement of pendimethalin with depth (r=-0.995) and a positive and significant correlation (r=0.932) with time (days) was observed. Similarly under unsaturated conditions, negative correlation of movement of pendimethalin with depth (r=-0.984) and a positive and significant correlation (r=0.976) with time (days) was observed (Table 5).

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