Indian Journal of Weed Science 40 (1&2) : 29-31, 2008

Evaluation of leaching potential of oxyfluorfen in clay soil under field conditions

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ABSTRACT

An experiment was conducted during July to September 2007 to determine leaching behaviour and movement of oxyfluorfen in clay soil under natural rainfall conditions in PVC columns which received 830.5 mm rainfall. Oxyfluorfen was applied in the soil column at 200 and 400 g/ha. After every rain leachates were collected and analyzed for oxyfluorfen residues. Oxyfluorfen movement was evaluated in the soil at various depths at the interval of 10 cm *viz*, 0-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70 and 70-86 cm depths. A total of 0.226 µg/g of oxyfluorfen was recovered after 850 mm rainfall. The data indicated that oxyfluorfen may move up to 90 cm in soil profile under continuous and high rainfall conditions and thus may have potential to contaminate ground water.

Key words : Clay soil, Leaching, Movement, Oxyfluorfen, Rainfall

Oxyfluorfen is a selective pre and post emergent herbicide used to control certain annual broadleaf and grassy weeds in vegetables, fruits, cotton, ornamentals and on non-crop areas. It is a contact herbicide and light is required for it to affect target plants (USDA 1990). Oxyfluorfen has a strong tendency to adsorb to soil particles. It is therefore, unlikely to leach downward or to, contaminate groundwater under normal conditions. Herbicide leaching through soil is particularly important due to environmental and agronomic problems (Yen *et al.* 2003). Leaching is considered as main cause of ground contamination by herbicides (Walker 1989, Sondhia 2008).

Oxyfluorfen has the potential to affect terrestrial plants and aquatic ecological systems at all levels as it is toxic to plants, invertebrates, fish and has been shown to drift from application sites to nearby areas. Birds and mammals may also experience subchronic and chronic effects from oxyfluorfen use. In India, despite the extensive use of oxyfluorfen in a variety of field crops (Thakare *et al*. 2002, Shrefler *et al*. 2004, Sondhia and Dixit, 2007) very little is known about its leaching potential to contaminate ground water under tropical high rainfall conditions. Thus, the present study was undertaken with the objective to study the mobility and leaching potential of oxyfluorfen under natural rainfall conditions.

MATERIALS AND METHODS

Surface soil samples (0-20 cm) from the surrounding area of the National Research Centre for Weed Science farm, Jabalpur that was never treated with any herbicide were collected, air-dried and passed through a 3 mm sieve. The soil was clay (clay, 35.47; silt, 12.45; sand, 52.09 %) with 7.2 pH and 0.81% organic carbon.

The leaching experiment was done as described by Sondhia and Yaduraju (2006) at ambient temperature (27 to 32^{0}C) in a completely randomized design with three replications. From the bulk soil samples, 9 sub-samples of approximately 9 kg each were placed in PVC column of 10 cm internal diameter and 90 cm length. Columns were sequentially filled with soil from the bottom with 3 cm of sand and 86 cm of dry soil. The surface of each column was then covered with sand (3 cm) and filter paper disks were placed on top of the each column to assist uniform dispersion of the water across the column surface. Oxyfluorfen was applied to the surface of the column at 0, 200 and 400 g/ha. The columns were arranged under field conditions and allowed to receive approximately 850 mm rain water during the experimental period (*viz.*, July 2008 to September 2008).Water eluting from the column was collected in flask and stored at 4^{0}C for herbicide analysis. After three months, the soil columns were than cut into two equal halves and the soil was sampled in 10 cm segments in the respective segments from all replicates, which were pooled for analyzing residues.

Oxyfluorfen residues from soil were extracted as described by Sondhia and Dixit (2007). Ten g soil was transferred to 250 ml flasks and extracted with 30 ml of methanol: acetonitrile (2:1) in a mechanical shaker for two hours and filtered. Additional 10 ml methanol: acetonitrile (2:1) was used as washing solvents. They were taken in 250 ml separatory funnel and partitioned with chloroform

(40 ml). Chloroform layer was collected and evaporated on a rotary vacuum evaporator. It was dissolved in methanol (5 ml) and analyzed by Shimadzu HPLC. The analysis was carried out at 205 nm using acetonitrile: water (70: 30) as mobile phase. Quantification of oxyfluorfen residues was accomplished by comparing the peak response for samples with peak area of the standards. The retention time of oxyfluorfen was 3.51 minutes.

Leachates were filtered through Whatman filter paper No 5. 25 ml of samples were taken in separatory funnel and partitioned with chloroform (15 ml). Chloroform layer was collected and evaporated in a rotary vacuum evaporator to dryness. It was dissolved in methanol (5 ml) and used for HPLC analysis.

RESULTS AND DISCUSSION

Oxyfluorfen residues at different soil depths are presented in Table 1. Results revealed that oxyfluorfen was mobile in soil columns and can leach by high rainfall. The highest concentration of oxyfluorfen was found at 0-10 cm depth in both the application rates and was higher in 200g/ha as compared to 400 g/ha rate.

It is reported that at high temperature, oxyfluorfen dissipated rapidly and there is almost no dissipation at 10^0C (USDA 1984). During experimental period the temperature was between 27- 32^{o}C and that might be the reason for slow degradation and thus increase the residue content in soil profile at various depths. Yen *et al.* (2003) also reported similar findings and found that oxyfluorfen was not very mobile in soil and may not contaminate groundwater under normal conditions. But in soil of extremely low organic carbon content and coarse texture, oxyfluorfen has the potential to contaminate groundwater less than 3 m deep

Table 1. Oxyfluorfen content at different soil depth at two application rates

Soil depth (cm)	Oxyfluorfen residues (µg/g)*	
	200 g/ha	400 g/ha
0 -10	0.099±0.003	0.144 ±0.005
10-20	0.075±0.002	0.097±0.004
20-30	0.071±0.007	0.084±0.011
30-40	0.069±0.003	0.077±0.011
40-50	0.068±0.007	0.074±0.009
50-60	0.055±0.005	0.070±0.003
60-70	0.047±0.005	0.061±0.006
70-80	0.038±0.003	0.047±0.004

* Mean of three replications

(Ying and Williams 2000).

Downward herbicide movement is influenced by characteristics of the soil. In addition, certain soil microorganisms and living weeds can sometimes metabolize adsorbed herbicides, rapidly or gradually altering those to non-phytotoxic forms that may have different leaching characteristics. Sondhia (2008) reported that in clay loam, 82% of applied oxyfluorfen remained in the top 50 mm soil and did not leach below 100 mm soil. In soils, oxyfluorfen is not subject to microbial degradation and is not subject to hydrolysis at pH 5, 7 or 9 (Flury 1996). It is therefore highly resistant to degradation in the soil environment. During rainy season decomposition by light occurs slowly. Walker *et al*. (1989) also reported slow degradation of oxyfluorfen with half-lives of generally over two weeks in nonsterile sediment.

Downward movement is most likely with chemicals that do not degrade quickly and do not adsorb strongly to clay or organic matter. The potential for phytotoxicity or groundwater contamination is more with such chemicals when heavy rain occurs soon after application.

Recovery of oxyfluorfen from 0- 90 cm depth was between 46-54% in both application rates (Fig. 1). Residues of oxyfluorfen were also analyzed in the leachates coming after each rainfall. Results indicate that concentration of oxyfluorfen after first and second rainfall was between 0.05-0.066 µg/g. Increasing the time interval between herbicide application and the incidence of rainfall reduced the amounts of herbicides found in the leachates. Pesticide leaching from zone of the soil application is also dependent on amount of rainfall or irrigation received (Savage 1977, Sondhia and Parmar 2008). In this study, soil columns received approximately 850 mm rain fall that may be the reason that oxyfluorfen could leach even upto 90 cm depth. The presence of organic matter constitutes an impediment for oxyfluorfen movement because of its high adsorption capacity. Therefore, in this leaching study maximum amount of applied oxyfluorfen was recovered

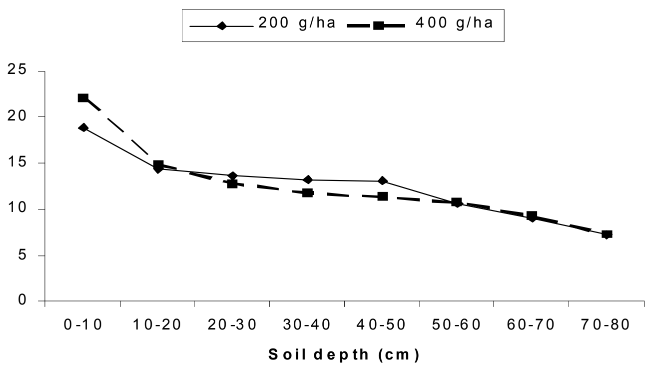

Fig. 1. Distribution of oxyfluorfen at 0-90 cm soil depth at different application rates

from 0-10 cm depth due to high organic carbon content (Fig. 1).

The proportion of oxyfluorfen in the top 0-10 cm soil zone was 13.30 % whereas it was 12.25, 12.89, 12.54, 12.15, 11.96, 12.86 and 12.08% in 10-20, 20-30, 30-40, 40-50, 50-60, 60-70 and 70-86 cm soil profile, respectively. A total of 0.266 and 0.310 μg/g of oxyfluorfen was recovered from leachates after 850 mm rainfall. Low recovery of oxyfluorfen from soil and water may be due to formation of bound residues, secondary metabolites and dissipation of oxyfluorfen from soil.

Results indicate that oxyfluorfen could leach in clay loam soil up to the depth of 90 cm at more than 850 mm rainfall. The data generated indicated that oxyfluorfen can move up to 90 cm in soil profile under continuous and high rainfall conditions and may have potential to contaminate ground water.

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