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FATE AND ACTIVITY OF TWO COTTON HERBICIDES IN SIX SOILS

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Abstract

Residual toxicity of prometryne and fluometuron was assayed in six different soils after three months of herbicidal treatment. The persistence of herbicides varied in different soils, fluometuron was more persistent than prometryne. Residual toxicity of prometryne was completely lost in heavy soil. In general, residual toxicity of the herbicides was inversely related to the amount of colloidal material in soil. Degradation of herbicides was also associated with soil pH. Formulae for the estimation of percentage residual activity (PRA) and loss of activity due to adsorption (LAA) have been adduced.

Introduction

Accumulation and persistence of herbicides in soils may have detrimental effects on current and/or subsequent crops. Beside photodegradation and volatilizations, reduction or disappearance of herbicide from a field is attributable to leaching (Burnside *et al*, 1963), chemical decomposition (Roadhouse & Birk, 1961; Obein & Green, 1969), biodegradation (Ragab & McColum, 1961; Harris, 1967) and irreversible adsorption on to the orgainc matter contents and clay (Dunigan & McIntosh, 1971; Gilmour & Coleman, 1971; Li & Felbeck, 1972; Yamane & Green, 1972).

In brown alluvial Neve-ya-ar soil, oat bioassay revealed a higher degree of persistence of fluometuron than prometryne over a period of five months (Horowitz, 1969). Walker & Crawford (1970) reported that small changes in triazine structure produce marked differences in selectivity between the adsorption by clay and organic matter. However, phytotoxicity of triazines is inversely proportional to the organic matter contents of soil (Hayes, 1970; Liu *et al*, 1970). Hance (1969) demonstrated that the adsorption of substituted urea herbicides was virtually independent of soil pH but that of prometryne was not.

This investigation attempts to evaluate the residual activity of prometryne and fluometuron herbicides for weed control in cotton crop. The role of some soil characteristics like pH, organic matter and soil texture on the residual activity of the two herbicides is also discussed.

Materials and Methods

The residual toxicity of prometryne and fluometuron in six soils of cultivated fields of Sind was assessed by bioassay method using *Sorghum bicolor* Pers. (var. White Hegari) as a test plant following Mirza (1968). The physical and chemical characteristics of the soils determined following Black (1965) are given in Table 1.

Fifteen cm diameter Petri plates (2.5 cm deep) containing 500 g soil were sprayed with aqueous suspensions of prometryne (6-methyl mercapto-2-4 *bis* isopropylamino-*s*-triazine) and fluometuron (3-m-trifluoro-methyl-phenyl-1, 1 dimethyl urea) at the rate of 2 and 4 kg (a.i)/ha. After thoroughly mixing the herbicides, the soils were kept at 28 ± 4°C in the laboratory for 3 months. Unsprayed soils were used as controls. Treatments and controls were replicated thrice. Soils were frequently sprinkled with distilled water.

Three months after the herbicide incorporation, lots of 15 seeds of *Sorghum bicolor* were sown in individual dishes. Six days after sowing, root and shoot length of the seedlings were measured. The same six soils were sterilized and treated with the same levels of the herbicides and the above bioassay procedure repeated to allow the evaluation of the residual activity of the herbicides and the loss of activity due to adsorption (LAA) by the soils. The determination of LAA also involved the test of seedling growth of *Sorghum* when exposed directly to the herbicide solutions. Fifteen seeds of *Sorghum* were placed on Whatman No. 1 filter paper in sterilized 15-cm diameter Petri plates and root and shoot growth were measured six days after treatment.

Percentage residual activity (PRA) of a herbicide at time t (viz. 3 months after application) was estimated using the following formula:

$$PRA = \frac{SL_c - SL_t}{SL_c - SL_f} \times 100$$

where: SL_c = seedling length of controls; SL_t = seedling length at time t subsequent to herbicide incorporation; SL_f = seedling length in soils freshly treated with herbicide.

Loss of activity due to adsorption (LAA) was ascertained employing the following expression:

$$LAA = \frac{\frac{SL_{ac} - SL_{ah}}{SL_{ac}} - \frac{SL_c - SL_f}{SL_c}}{\frac{SL_{ac} - SL_{ah}}{SL_{ah}}} \times 100$$

Table 1. The physical and chemical properties of the soils in which residual toxicity was tested.

Soil types	Loss on Ingition %	Soil pH	$CaCO_3$ %	Exchangeable Na ppm	Exchangeable K ppm	Maximum water holding capacity %
Fine sand	0.84	8.2	11.36	140	19	24.61
Sandy loam	1.45	7.9	10.37	155	32	33.33
Calcarious sandy loam	1.58	8.3	16.68	145	24	27.62
[illegible] loam	2.28	8.0	9.75	180	35	47.17
Clay loam [illegible]	11.99	7.5	8.04	215	41	49.24
[illegible]	1.21	8.6	7.04	470	28	35.71

where: SL_{ac} = seedling length in aqueous control: SL_{ah} = seedling length in aqueous herbicide solution; SL_c and SL_f as above.

Results

a) Fate and activity of fluometuron

The toxicity of 2 and 4 kg/ha of fluometuron in terms of reduction in shoot and root growth of *Sorghum bicolor* is presented in Fig. 1. It is apparent that seedling growth was much more adversely afected in soils freshly treated with fluometuron than those incorporated with the herbicide three months prior to the determination of residual activity

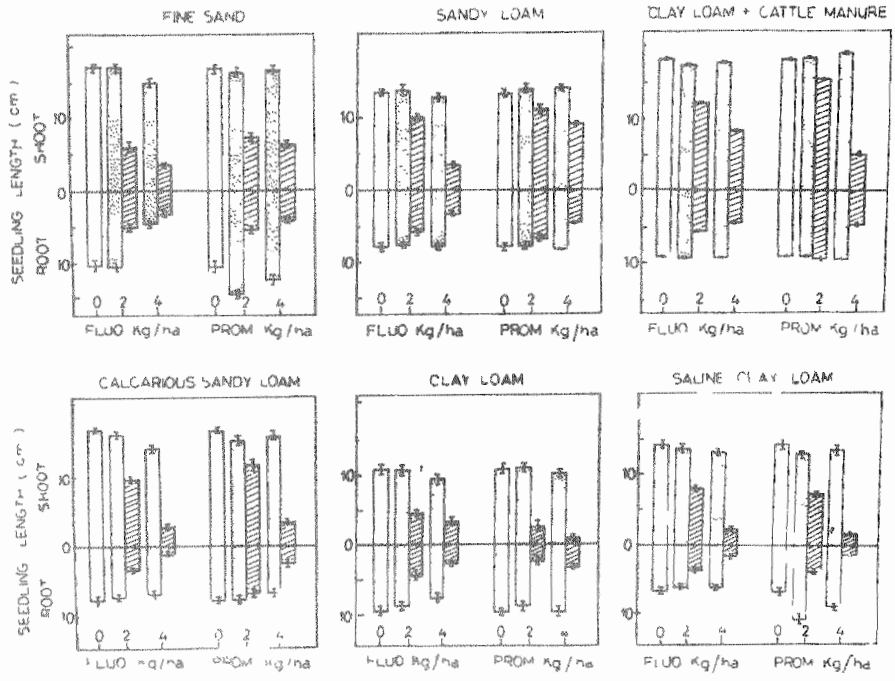

Fig. 1. Response of *Sorghum bicolor* seedlings to 2 & 4 kg/ha application of fluometuron (FLUO) and prometryne (PROM) in six soils

Growth of control seedlings

Growth of seedlings in freshly treated soils

Growth of seedlings in soils three months after herbicide incorporation

Table 2. Percentage residual activity (PRA) of prometryne and fluometuron in six different soil types after three months.

Soil Types	Fluometuron 2kg/ha	Fluometuron 4kg/ha	Prometryne 2kg/ha	Prometryne 4kg/ha
Fine sand	4.30	37.14	23.29*	10.56*
Clay loam	3.54	4.80	12.35*	12.64*
Calcarious	7.04	16.64	24.43	9.70
Saline	9.21	8.48	28.07*	10.24*
Sandy loam	6.66	25.19	4.29	3.36
Clay loam + cattle manure	6.17	0.88	12.69*	7.93*

*SL_t SL_c ; hence promotion in treatment after time t.

The phytotoxicity of fluometuron at a rate of 2kg/ha, when freshly applied to various soil types was in the order: fin sand > saline clay loam > calcarious sandy loam> sandy loam> clay loam > clay loam with added cattle manure. The percentage residual activity (PRA) of herbicides in various soil types after three months of herbicide incorporation is presented in Table 2. The PRA at 2 and 4 kg/ha showed considerably simular values in most soil types, the exceptions being fine sand and sandy loam which had substantially higher PRA at 4 kg/ha than at 2 kg/ha. In general, the order of residual toxicity of fluometuron in various soil types was in the order: fine sand > sandy loam > calcarious soil> saline clay loam> clay loam with added cattle manure.

b) Fate and activity of prometryne:

Data presented in Fig. I reveal that the phytotoxicity of prometryne @ 2 and 4 kg/ha in terms of *Sorghum* seedling growth response was significantly lost in all the soils after three months of incroporation. The percentage residual activity (PRA) of prometryne in 3 out of six soils shows similar values at the two dosages (Table 2). Herbicidal residue becomes non-toxic in four out of six soils after three months of degradation Only the sandy loam and calcarious soils show some residual toxiciry; the latter indicating higher PRA at both the dosages than the former. The loss of activity due to adsorption (LAA) of prometryne, as in the case of fluometuron, was higher at kg/ha than at 4 kg/ha. The LAA of prometryne in various soils varied as follows· sandy loam > saline> fine sand> calcarious> clay loam> clay loam with added cattle manure.

Discussion

The response of the test plant *S. Bicolor* in soils incorporated with herbicides disclosed that the extent of phytotoxic residues of both fluometuron and prometryne vary

from soil to soil and that the urea derivative fluometuron is relatively much more persistent compared to the triazine compound prometryne which, in most soils, completely loses its phytotoxic activity in 3 months duration. This is in agreement with the findings of Horowitz (1969) who in his study of the persistence of herbicides in brown Neve-ya-ar soil found prometryne to be less persistent than fluometuron. In four soil types viz., clay loam with added cattle manure, clay loam, saline clay loam and fine sand, the residue of incorporated prometryne was so low at the end of 3 months that it caused a slight promotion in the growth of the test plant. The stimulation of seedling growth at subherbicidal concentrations of triazines has been widely reported (Pilet & Gaschen, 1962; Copping, *et al*, 1972; Wideman & Appleby, 1972). The soils in which phytotoxic activity of prometryne was completely lost had either high clay content or were rich in organic matter. Sandy loam and calcarious sandy loam, where residual phytotoxic activity was detected after three months of treatment, were poor in colloidal material and had relatively higher proportion of sand. However, the reason for the disappearance of toxic activity in fine sand, remains obscure.

Table 3. Percentage loss of activity due to adsorption (LAA) of prometryne and fluometuron in six different soil types.

Soil Types	Fluometuron 2kg/ha	4Kg/ha	Prometryne 2kg/ha	4kg/ha
Fine sand	27.20	11.73	33.65	24.46
Clacarious	43.27	02.35	69.80	09.87
Clay loam	67.99	19.94	81.02	56.25
Saline	45.74	04.69	41.13	04.89
Sandy loam	28.67	16.42	06.18	03.67
Clay loam + cattle manure	56.87	36.36	90.73	23.23

It has been demonstrated that increase in clay content decreases the persistence of triazine herbicides (Talbert & Fletchall, 1965; Bryant &Andrews, 1967; Liu *et al*, 1970). Organic matter content has also been shown to be inversely related with the degree of persistence of triazines (Walker & Crawford, 1968; Hayes, 1970) and that the adsorption by organic matter is chiefly affected by the humic acid fraction of organic matter (Gilmour & Coleman, 1971; Li & Felbeck, 1972). A comparison of PRA values (Table 3) and the characteristics of soils (Table 1) indicates that soil pH bears a direct relationship with the degree of residual activity of prometryne which is in accordance with the results of Hance (1969). Sandy loam and calcarious sandy loam soils, which retained phytotoxic activity after 3 months, had comparatively higher percentage of $CaCO_3$ than the rest of the soil types suggesting that high $CaCO_3$ content of these soils could be direc-

tly or indirectly responsible for the greater persistence of prometryne in these soils. Other soil variables seem to have no relationship with the residual activity of prometryne. The high LAA of prometryne in clay loam and clay loam + cattle manure clearly suggests that the loss of activity in these soils is primarily due to their increased ability to adsorb prometryne, rendering a substantial proportion of the herbicide inactive, immediately after application.

The residual activity of fluometuron after 3 months of degradation was low in soils rich in clay and organic matter and high in soils poor in colloidal material. Higher levels of colloidal material have been shown to alleviate the dissipation of urea derivatives (Sheets, 1964; Scheweizer & Holstum, 1966; Mikailcheno *et al.* 1969). Residual phytotoxicity of fluometuron appears to be lesser at lower soil pH which contrasts with the findings of Hance (1969). Other soil characteristics appear to be uncorrelated with the residual activity of fluometuron. Loss of activity due to adsorption (LAA) of fluometuron was higher for clayloam + cattle manure and clay loam soils providing evidence that high colloidal content decreases the activity of fluometuron owing presumably to irreversible adsorption of the herbicide on colloidal particles (Hays, 1970; Gilmour & Coleman, 1971; Khan, 1972).

Anwar-ul-Haq (1974) studied the effect of pre-emergence application of prometryne and fluometuron at doses of 2 and 4 kg/ha on weed composition and cotton yield and obtained an effective control of weeds as well as increased yield of commercial cotton by prometryne, particularly at 2 kg/ha. Since the present study has disclosed a more rapid decline in the residual activity of prometryne in comparison to fluometuron, it is concluded that prometryne is more beneficial and safer of the two herbicides and with its application in the cotton fields in Sind region (on loam to clay loam soils) chances of injury to the subsequent crop can safely be eliminated even if the next crop is sown immediately after the harvest of cotton.

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