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Leaching and Movement of Carbofuran in Soils.

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Carbofuran movement in soils was studied by employing soil TLC technique with natural soil and alwin the soil in which organic matter was destroyed. The mobility, as Rf values, of 16 soils(Red, black, alluvial and laterite) showed that the movement in red, alluvial and black soils was rapid while in laterite soil it was slow. A striking increase in the mobility of carbofuran was recorded in soils in which the organic matter was oxidised.

Carbofuran leaching was high in red, alluvial and black soils and the effluents 55, 41.50 and 36.5 per cent of the added carbofuran, respectively. In laterite soils a major portion of the added toxicant was retained in the soil of the first column section and the effluents did not contain any residues. Both the soil TLC and leaching studies revealed that there was a general trend towards reduced mobility of carbofuran with increased organic matter content of soils.

Based on the Rf value recorded in red, black and alluvial soils with organic matter content below 1 per cent, carbofuran was classified under class IV and designated as 'mobile' insecticide while in respect of laterite soils with 1.50 to 4.29 per cent ogranic matter its mobility was moderate (class III).

INTRODUCTION

Carbofuran (2,3-dihydro-2,2-dimethyl-7-benzofuranyl methyl carbamate) is a broad spectrum insecticide and nematicide effective by contact, stomach and systemic action. Though, comparatively known to be less persistent, it is more toxic to animals than most of the organochlorine insecticides. Reported, oral LD 50 value for carbofuran is 8-11 mg/kg in rats. Few of its metabolites viz., 3-hydroxy Carbofuran and 3-Keto Carbofuran are also toxic to animals. It is therefore obvious that the effect of its residues and toxic metabolites is of great concern in the biological field.

Carbofuran being a soil insecticide, its uptake by the crop plants is mainly due to the solubility in water and movement in soils. The degree of leaching of chemicals through soil is important because of the possibility that they will reach the water table and contaminate the ground water. Leaching of an insecticide from soil is correlated with its water solubility but this is also modified by the capacity of the insecticide for adsorption on soil fractions (Edwards, 1973) The present investigation was designed to study the extant of leaching and movements of corbofuran in different types of soils. The basic data will help to regulate the insecticide application in respect of its dose, time and method of application.

MATERIAL AND METHODS:

The movement of the toxicant was studied by employing the soil TLC technique with natural and organic matter distroyed soil. The method was essentially the same as used by Helling and Turner(1968). Sixteen soils representing the major soil groups of Tamil Nadu (India) viz., red, black, alluvial and laterite were utilised for the studies. The soil was slurried with water until moderately fluid and applied to the clean glass plates of 20x20cm by using a TLC spreader. Thickness of 500μm for medium and fine textured soils and 750μm for coarse textured soils, was adopted. The plates were air dried and stored at room temperature.

Soils particles from the base of the plates to 1.5cm height were scraped out and a horizontal line scribed 11cm above the base line. Aliquots of carbofuran representing 50g/spot were spotted 1 cm above the base line. A long moist filter paper strip was placed at the base of the plate. The chromatograms were than developed with water, air dried and sprayed with 1.5N methanolic-KOH and after drying a saturated solution of p-nitrobenzene diazonium fluoborate was sprayed. The light red colour that developed was visible in soil plates. A masking technique developed by Helling and Thompson (1974) was also adopted to make the spots clearly visible. The developed plates were sprayed with a kaolinite slurry in 95 per cent ethanol, air dried and re-sprayed with chromogenic reagent as described early The spots were then distinctly visible and the Rf values recorded.

To find out the Rf values of carbofuran in organic matter destroyed soils, the natural soil coated glass plates were gradually heated to 350μC during a 24 h period and the organic matter was totally destroyed. After the oxidation of organic matter, the plates were then spotted, developed and sprayed with Chromogenic agents and the Rf values determined.

Leaching of carbofuran through soil columns.

Although soil TLC provided a good index of the relative mobility of carbofuran in different soil types, the quantities of Carbofuran moved to different depths could not be evaluated by this techniques. For this a leaching experiment, as described by Lafleur (1975 a) in soil columns was carried out. A detachable glass column consiting of 4 pieces of glass tubes(3.5cm i.d. and 10cm long) was used.

Four soils representing one each of red, black alluvial and laterite were utilised for the study. The glass columns were connected and they were filled with soils using a glass wool pack at one end. The tubes were tapped firmly against the floor with continued addition of soil until the tube was almost full. The weight of the soil added was noted. The soil in the column was made to near saturation with water. Small aliquots of Carbofuran dissolved in acetone representing 100μg for laterite and 150μg for red, black and alluvial (equivalent to 1.00 kg ai/ha) were added. After evaporation of the solvent, a filter paper disc was placed on the column surface and 250ml of water was added drop by drop to the top of the upright column. The column was gravity drained for 18 to 24 h and then suction drained to near equilibrium. The columns were then dismantled and the contents of Carbofuran in the soils of the different columns and leachate were determined colorimetically as described by Gupta and Dewan (1971).

RESULTS AND DISCUSSION

Soil TLC: The Rf values of Carbo furan for the 16 soils studied as measured by soil TLC are presented in Table 1. Movement was expressed by the conventional Rf designation although this referred to the front of the pesticide movement rather than its maximum concentration. The Rf value ranged from 0.75 to 0.80 for red soils, 0.74 to 0.70 for alluvial soils, 0.73 to 0.75 for black soils and 0.44 to 0.52 for laterite soils, indicating the rapid movement of Carbofuran in soils with low amount of organic matter. A striking increase in the movement of Carbofuran was observed in all the soils in general and laterite soils in particular when the organic matter of the soils was oxidised. The Rf values were 0.78 to 0.82 for red soils, 0.78 to 0.80 for alluvial soils, 0.75 to 0.78 for black soils and 0.75 to 0.78 for laterite soils confirming the importance of organic matter in the leaching and movement of Carbofuran in soils.

Soil Column studies: The observed distribution of added Carbofuran in saturated soil columns due to leaching with 250ml of water is shown in Table 2. In black, alluvial and red soils, the movement of Carbofuran was repid and the effluent contained as much as 36.50, 41.59 and 55.00 per cent added Carbofuran raspectively. But in laterite soils, eventhough the applied water moved through the soil column, most of the added carbofuran was retained in the soils of first column section(0.10cm). Carbofuran was not detected in the effluent and the movement was found only with in 3 column section(0-30cm)

The quantitative estimation of leaching of pesticides though not possible under field condition for different types of soils under varying climatic conditions, the laboratory testswould help to compare the degree of leaching of one compound with another. The laboratory tests viz., layer chromatography and soil soil thin columns were utlised in the present investigations to study the leaching and movement Carbofuran in soils.

The mobilities of 16 soils, as Rf values, showed that the movement in red, alluvial and black soils was rapid whilein laterite soil it was slow. The difference Rf values between laterite and other soils may be due to the presence of higher amounts of organic matter in aterite soils than the rest. A striking increase in the mobility of Carbofuran was recorded in the soils in which organic matter was destroyed. Quite interesting observation was that the laterite soils which registered low Rf values before destruction of organic matter exhibited almost equal Rf values as that of other soils when the organic matter was destroyed. The leaching studies with soil columns also reavealed a similar trend. Carbofuran leaching was high in red, alluvial and black soils and the effluents contained 55, 41.50 and 36.5 per cent of the added carbofuran respectively. However, in laterite soils a major portion of the added toxicant was retained in the soils of the first column section and the effluents did not contain any residue. Carbofuran was not detected in soils beyond third column section (20-30 cm). The results revealed that there was a general trend towards reduced mobility of Carbofuran with increased organic matter content of soils. All these observations suggest that soil organic matter is quite important in preventing leaching of Carbofuran. Helling (1971 a,b) reported that the mobility of non-ionic pesticides was inversely related to the organic mattar and clay contents. He also observed a spectacular increase in the mobility of chloroprophan, propham and many other pesticides when the organic matter of soils was oxidised. Laflour (1976 a, b) opined that organic matter of the soils was largely responsbile for the greater retention of carbaryl and promotryne in soil column studies.

The mobility of Carbofuran was generally high in red, alluvial and black soils than the other soils. Similar trend was also observed in soil column leaching studies. As discussed earlier, the black soils contained higher amounts of clay fraction (Table 1) than red and alluvial soils, and dominated by montmorillonite clay minerals. Hence these would have contributed to the low mobility of Carbofuran in black soils. This is in close agreement with the reports of many investigators (Harris, 1964 Kearney *et al.* 1965). Helling (1971 a) proposed five mobility classes for pesticides based on the Rf values in a standard soil which contained 24 per cent organic matter to compare the leaching of pesticides. Based on the Rf values recorded in red, black and alluvial soils with organic matter content below 1 per cent. Carbofuran was classified under class IV and designated as 'mobile' insecticide while in respect of laterite soils with 1.50 to 4.29 per cent organic matter its mobility was moderate (Class III).

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Table. 1.
Mobility of Carbofuran in soils.

Soil No.	Soil Group.	Mean Rf values		Organic matter content (%)	Clay Content (%)
		Natural soil.	Organic matter oxidised soil		
S1	Red	0.79	0.79	0.55	16.95
S2	Red	0.78	0.80	0.26	13.30
S3	Red	0.80	0.82	0.48	8.87
S4	Red	0.75	0.78	0.42	23.10
S5	Black	0.73	0.76	0.76	40.90
S6	Black	0.73	0.75	0.57	53.00
S7	Black	0.75	0.76	0.72	43.00
S8	Black	0.74	0.78	0.76	32.80
S9	Alluvial	0.78	0.80	0.83	20.87
S10	Alluvial	0.79	0.80	0.55	18.10
S11	Alluvial	0.79	0.79	0.83	38.20
S12	Alluvial	0.74	0.78	0.83	15.80
S13	Laterite	0.54	0.76	3.63	25.25
S14	Laterite	0.57	0.78	2.72	25.80
S15	Laterite	0.62	0.75	1.48	14.60
S16	Laterite	0.44	0.76	4.29	22.43

Table-2. Distribution of carbofuran in soils of different column-sections after leaching

Column section (cm)	S1 (Red) Concentr-ation (ppm)	%	S8 (Black) Conc. (ppm)		S11 (Alluvial) Conc. (ppm)	%	S16 (Laterite) Conc. (ppm)	%
0-10	18,00	12,00	32.62	21.75	26,25	17.50	63.65	63.95
10-20	15.80	10.50	16.50	11.00	14.25	9.50	21.75	21.75
20-30	18.79	12.50	13.13	8.75	17.25	11.50	7.30	7.30
30-40	10.49	7.00	18.00	12.00	21.75	14.50	ND	ND
Effluent	82.24	55.00	54.75	36.50	62.25	41.50	ND	ND
Total Recovered	145.32	97.00	135.00	90.00	141.75	94.50	92.70	92.70
Total added	150.00	100.00	150.00	100.00	150.00	100.00	100.00	100.00