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Influence of BHC and Fenvalerate on Mineralization and Availability of Some Plant Nutrients in Soil

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Insecticides are chemical inputs generally applied to the crop fields to combat insect pests for better crop growth. During application, a large amount of insecticidal residues eventually come ta the soil and accumulate in the surface soil (Harris and Sans 1967) where maximum microbiological activities occur. As organic substance of any kind cannot escape the onslaught of microbial degradation, insecticides are no exceptions. Generally, insecticidal residues are degraded by the microorganisms to utilize carbon and other elements for their metabolism (El-Shahaat et al. 1987) resulting in an increase in the population of active microorganisms which favourably influence the biological transformation of plant nutrients in soil (Rangaswamy and Venkateswarlu 1993). It was reported (Simon-Sylvestre and Fournier 1979) that the insecticidal effects on soil microorganisms and their associated transformations of nutrients are very specific since individual members within a group vary mainfold in toxicity. In the present study, an experiment was conducted to investigate the influence of BHC (1,2,3,4,5,6-hexachlorocyclohexane) and fenvalerate [(RS)-cyano(3-phenoxy phnyl (RS)-methyl-4-chloro-α(1-methyl) benzeneacetate] at their recommended doses on the mineralization and availability of C, N and P as well as the persistence of the insecticidal residues in soil.

MATERIALS AND METHODS

Two insecticides, viz. BHC (50 WP) and fenvalerate (20EC) @ 7.5 and 0.35 kg a.i. ha^{-1} respectively, were mixed thoroughly with 1 kg air dried and sieved (≤ 2 mm) alluvial soil (Typic *Fluvaquent*) collected from the top soil layer (0-10 cm) of the University (BCKV) farm at Mohanpur, India and having the general characteristics as : water holding capacity 50.5%, pH (1 : 2.5) 7.3, CEC 8.77 [cmol (p^+) kg^{-1}], organic C 5.85 g kg^{-1}, total N 0.57 g kg^{-1}, NH_4^+- N 54.2 mg kg^{-1}, NO_3^-- N 16.2 mg kg^{-1}, available P 5.75 mg kg^{-1}, sand 66.6%, silt 25% and clay 8.4%. After mixing the insecticides, the soils were placed separately in earthenware pots adjusting the water content to 60% of water holding capacity. To avoid photodegradation of the insecticides, the pots were covered with black polyethylene sheet and were incubated in dark at 30°C ± 1°C for 60 days. All the treatments were replicated thrice. After the incubation period of 0 (1 hr), 15, 30,

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45 and 60 days, soil samples were collected from the replicated pots of each treatment and were analysed for organic C, total and inorganic N following the methods as outlined by Jackson (1973). Available P was estimated in $NaHCO_3$ extract (Olsen et al. 1954) calorimetrically (Jackson 1973).

The soils were also analysed for the presence of insecticidal residues by drawing samples at different incubation periods and extracting the soils as outlined by Das et al. (1995). For both the insecticides, the residues were estimated by gas-liquid chromatography (GLC) using 5890A model (HP) gas chromatograph coupled with 3392A(HP) integrator and equipped with Ni^{63} electron capture detector and a glass column (180 cm x 2 mm) packed with 3% OV-17 on 80 to 100 mesh chromosorb-W. The operating temperatures of injector, column and detector were maintained for BHC and fenvalerate at 200°C, 160°C and 300°C, and 275°C, 225°C and 275°C, respectively. The flow rate of carrier gas (N_2) was adjusted to 37.5 mL min^{-1} for BHC and 70 mL mid^{-1} for fenvalerate. The recovery rates of BHC and fenvalerate were 90% and 98%, respectively.

For each insecticide the residue values were processed to calculate the half-life (T½ following the method of Hoskins (1961).

RESULTS AND DISCUSSION

The organic C content of the soil, in general, decreased gradually with time (Table 1). This was due to the greater utilization of organic carbonaceous materials by the increased microgoranisms, resulting in higher breakdown of organic matter with a subsequent loss of CO_2 from soil (Debnath et al. 1994). In accord with the earlier report (Murthy et al. 1991), the mineralization of organic C

Table 1. Influence of insecticides on organic C and total N in soil

Incubation days	Treatments		
	Control	BHC	Fenvalerate
	Amount of organic C (g kg^{-1} soil)		
0 (1 hr)	5.78 ± 0.07	5.80 ± 0.07	5.82 ± 0.07
15	5.65 ± 0.04	5.47 ± 0.07	5.62 ± 0.05
30	5.62 ± 0.22	5.47 ± 0.04	5.51 ± 0.08
45	5.55 ± 0.04	5.40 ± 0.08	5.47 ± 0.14
60	5.54 ± 0.29	5.29 ± 0.07	5.36 ± 0.11
	Amount of total N (g kg^{-1} soil)		
0 (1 hr)	0.57 ± 0.02	0.58 ± 0.01	0.56 ± 0.02
15	0.54 ± 0.01	0.52 ± 0.02	0.51 ± 0.04
30	0.53 ± 0.01	0.50 ± 0.02	0.52 ± 0.01
45	0.52 ± 0.03	0.48 ± 0.01	0.49 ± 0.01
60	0.52 ± 0.02	0.44 ± 0.03	0.46 ± 0.02

Means ± SD

was highly increased due to the application of BHC (8.8%) and fenvalerate (7.9%) as compared to that of control (4.2%). A similar trend was recorded for total N (Table 1), since the stimulating influence of the insecticides on microbial mineralization of organic N brought about a significant reduction in total N in soil (Rangaswamy and Venkateswarlu 1993). Between the insecticides, application of BHC resulted higher reduction of total N content (24.1%) as compared to that of fenvalerate (17.9%) in soil.

The greater mineralization of N following the application of the insecticides brought about a significant increase in $NH4^{+}$- N and NO_3^{-}- N in soil (Table 2) and it was more prominent for NH_4^{+} - N under BHC and fenvalerate up to 30th and 15th days of incubation respectively, followed by a steady decline. NO_{3-}- N, on the other hand, was progressively increased up to 60th day. This indicated that the applied insecticides increased the growth and activities of both ammonifying and nitrifying bacteria responsible for the conversion of organic N to NH_4^{+} and oxidation of NH_4^{+} to NO_3^{-}, respectively (Rangaswamy and Venkateswarlu 1993). In general, the soil retained more amounts of NH_4^{+}- N than NO_3^{-}- N, indicating that the process of ammonification was faster than that of nitrification. Between the two insecticides, BHC released higher amount of mineral N into the soil. The availability of soluble P in soil treated with insecticides was also increased

Table 2. Influence of insecticides on the inorganic N and available P in soil

Incubation days	Treatments		
	Control	BHC	Fenvalerate
	Amount of NH_4^+ - N (mg kg^{-1} soil)		
0 (1 hr)	53.8 ± 2.0	52.8 ± 3.9	52.5 ± 4.3
15	52.5 ± 1.4	63.2 ± 5.6	53.5 ± 4.3
30	47.1 ± 2.5	63.2 ± 6.4	51.8 ± 6.4
45	43.0 ± 5.4	61.8 ± 4.5	49.2 ± 3.6
60	43.6 ± 4.6	52.4 ± 3.2	43.8 ± 3.3
	Amount of NO_3^- - N(mg kg^{-1} soil)		
0 (1 hr)	17.1 ± 1.7	18.1 ± 3.2	17.8 ± 2.1
15	20.2 ± 1.6	28.3 ± 2.7	25.6 ± 2.2
30	21.5 ± 3.2	29.6 ± 4.3	28.0 ± 3.2
45	22.9 ± 1.3	29.6 ± 3.2	28.3 ± 1.4
60	25.6 ± 2.1	34.9 ± 2.0	30.1 ± 2.3
	Amount of available P (mg kg^{-1} soil)		
0 (1 hr)	5.36 ± 0.19	5.38 ± 0.48	5.46 ± 0.38
15	5.38 ± 0.29	6.92 ± 0.32	5.77 ± 0.17
30	5.22 ± 0.16	7.46 ± 0.46	5.38 ± 0.42
45	5.96 ± 0.18	7.23 ± 0.31	7.69 ± 0.48
60	5.49 ± 0.48	7.84 ± 0.22	7.61 ± 0.29

Means ± SD

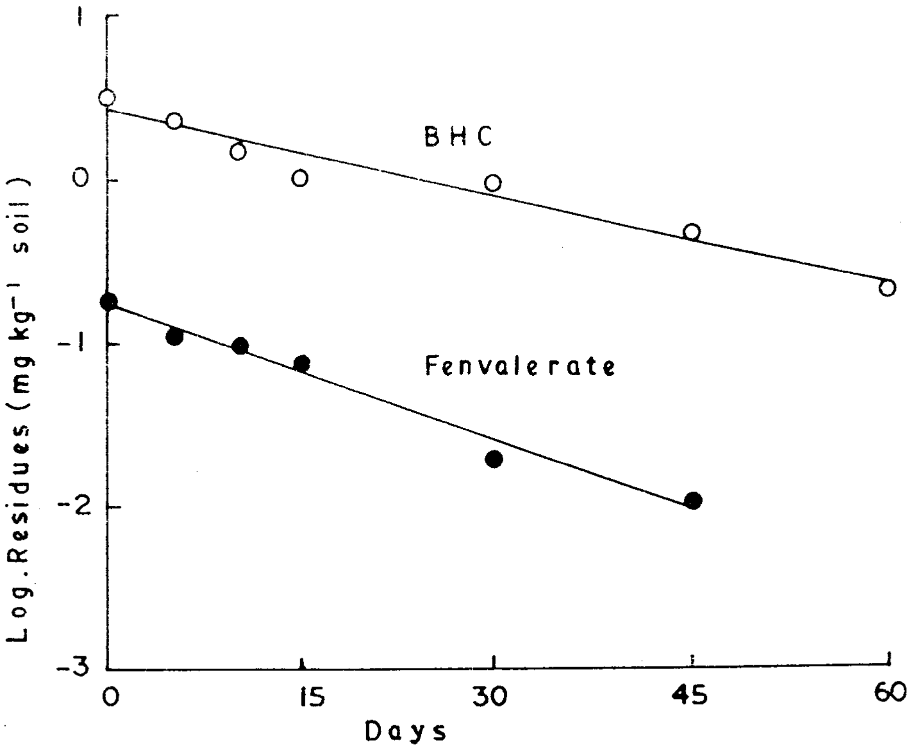

Figure 1. Linear regression of first order reaction kinetics of the insecticidal residues in soil

Table 3. Persistence of the insecticides in soil

Incubation days	BHC		Fenvalerate	
	Residues (mg kg^{-1} soil)	Dissipation (%)	Residues (mg kg^{-1} soil)	Dissipation (%)
0 (1 hr)	3.22 ± 0.04	-	0.17 ± 0.02	-
5	2.47 ± 0.02	23.29	0.12 ± 0.01	29.41
10	1.65 ± 0.04	48.76	0.09 ± 0.01	47.06
15	1.02 ± 0.03	68.32	0.07 ± 0.01	58.82
30	0.89 ± 0.02	72.36	0.02 ± 0.01	88.24
45	0.47 ± 0.02	85.40	0.01 ± 0.003	94.12
60	0.22 ± 0.01	93.17	ND	-
DL	0.01		0.002	
$T_{(1/2)}$	16.72 days		10.75 days	
r	-0.981		-0.996	

Means ± SD, ND = not detected, DL = detection limit, $T_{1/2}$ = half-life, r = correlation coefficient

(Table 2). This could be due to the stimulation of growth and activities of phosphate mineralizing/solubilizing microorganisms in soil (Arora and Gaur 1979) which in turn, utilized the insecticides as well as their degraded products for growth and metabolism (Matsumura and Boush 1971).

The persistence of the insecticides in soil varied (Table 3). It was observed that the rate of dissipation of fenvalerate was higher than that of BHC, depicting the half-lives ($T_{1/2}$) 10.75 and 16.72 days, respectively. The long persistence of BHC, as also investigated by earlier workers (Kawano et al. 1992), could be attributed to its resistance to biodegradation (Kahlon et al. 1990) and/or its ability to form recalcitrant molecules (Edwards 1966) in soil. The degradation of both the insecticides were very rapid during early days of incubation and fenvalerate could not be detected after 45 days. BHC, on the other hand, persisted up to 6.38% even after 60 days of incubation. The logarithm plots of the insecticidal residues (Fig. 1) indicated that the dissipation of the insecticides in soil followed first order reaction kinetics which was also evident from the significant correlation coefficient (Table 3).

The results of the present investigation thus clearly indicated that application of insecticides at their recommended doses stimulated the microbial activities due to the rapid utilization of the insecticides, which in turn increased the availability of nutrients in soil.

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