Effect of anilofos and pendimethalin on the mineralization of carbon and nitrogen in a *Haplustept* soil of West Bengal

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ABSTRACT

An experiment was conducted under laboratory condition to investigate the effect of two systemic herbicides, viz. anilofos (S-[N-(4-chlorophenyl)-N-isopropylcarbamyl]-O,O-dimethyl phosphorodithioate) and pendimethalin (N-(1- ethylpropyl) -2, 6-dinitro-3,4-dimethyl aniline), either alone or in combinations, at their recommended field rates (400 g and 1.0 kg a.i./ha, respectively on the mineralization of carbon and nitrogen, and changes in total phosphorus content in a Haplustept soil of West Bengal. Application of herbicides in general, stimulated the mineralization of carbon and nitrogen in soil. Single application of anilofos and pendimethalin augmented retention of organic carbon and availability of exchangeable NH_4^+ *in soil. Application of herbicides either singly or in combinations retained 9% higher total nitrogen as compared to untreated control soil. Anilofos increased the availability of* NO_3^-*-N to the highest extent (36.3%). Incorporation of pendimethalin increased 20.7% exchangeable* NH_4^+ *in soil. The retention of total phosphorus was significantly increased (14.3%) due to the pendimethalin and its combination with anilofos.*

Key words: Anilofos, available nitrogen, herbicides and organic carbon

Soil is the repository of all types of chemical inputs including the herbicides applied in the form of “soil application” when incorporated to soil and in the form of “herbicidal fall-out” when applied on to the foliage. During the application of herbicides, a large portion of these chemicals accumulate in the top layer of soil (0-15 cm) where most of the microbiological activities occur. Microorganisms degrade a variety of carbonaceous substances including the accumulated herbicides in soil to derive their energy and other nutrients for their cellular metabolism (Debnath *et al.*, 2002; Das *et al.*, 2003). As a result amount of microbial biomass increases which favorably influence the transformations of plant nutrients in soil (Sandhu *et al.*, 1990, Das et al., 2003). Nongthombam, Nayek and Das (2008) have studied the effect of anilofos and pendimethalin on different useful microorganisms in soil. Moreover, the interaction between the herbicides and microorganisms vary depending upon the type of herbicides and microorganisms (Alexander, 1978). The present study was conducted to investigate the effect of two pre-emergence herbicides viz, anilofos (*S*-[*N*-(4-chlorophenyl)-*N*-isopropylcarbamyl]-*O,O*-dimethyl phosphor-rodithioate) (an organophosphate derivative) and pendimethalin [*N*-(1-ethylpropyl) -2, 6- dinitro -3, 4-dimethyl aniline] (a dinitroaniline derivative) at their recommended field rates (40 g and 1.0 kg a.i./ha. respectively) on mineralization and availability of carbon and nitrogen and total phosphorus in soil.

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MATERIALS AND METHODS

Experimental methods

An alluvial soil (*Typic Haplustept*) having the general characteristic as presented in table 1 was collected from the Instructional Farm of Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal by taking several thin slices from the surface soil layer (0-15 cm) by means of a spade as outlined by Jackson (1973). The composite soils were air dried in shade and passed through 2mm (4-8 mesh /cm) sieve. The processed soils were stored in screw-cap jar and were used for the experiment. Two pre-emergence herbicides viz. anilofos [30% active ingredient (a.i.) in emulsifiable concentrate formulation (Gharda Chemicals Ltd.)] and pendimethalin [30% a.i. in emulsifiable concentrate formulation (Rallis India Ltd.)] at rates of 40 g and 1.0 kg a.i./ ha, respectively were mixed thoroughly either separately or in combination with 250 g air-dried and sieved soil($\leq$ 2mm) and were placed in polyethylene pots. The water content of the soil was adjusted to 60% water holding capacity of the soil and it was maintained throughout the experiment by the periodic addition of sterile distilled water. To avoid photodegradation of the herbicides and evaporation loss of water from the soil, the pots were kept covered with black polythene sheet and were incubated in dark at 30 ± 1^0C for 60 days. All the treatments were replicated thrice and separate sets of treatments were maintained for each sampling date.

Sampling of soil

During incubation period, soil samples were collected at periodic intervals [i.e. 0 (1 hr), 15, 30, 45 and 60 days of incubation] from the replicated pots of each treatment earmarked for that particular sampling day following the method as described by Das and Mukherjee (2000).The sub-samples were immediately analyzed to determine organic carbon, total nitrogen, ammoniacal and nitrate form of nitrogen and total phosphorus. Soil moisture content was measured from the sub-samples.

Chemical analysis of soil

Soil samples were analyzed to estimate the changes of organic carbon, total nitrogen and total phosphorus following the methods described by Jackson (1973). Available nitrogen (exchangeable NH_4^+ and soluble NO_3^-) was measured using extractant 2N potassium chloride and following distillation technique (Mulvaney, 1996).

RESULTS AND DISCUSSION

Effect on organic carbon content

The results of the present investigation revealed that there was a significant rise in the retention of organic carbon content in the soil series treated with herbicides (Fig. 1). However, there was no significant change in the accumulation of organic carbon content among the herbicide treated soils. In general, organic carbon content in the soil was increased on 15th day of incubation. This was more pronounced with the herbicide treated soils indicating that microorganisms present in the soil degraded the herbicides to a greater extent and accumulated the carbon in to their cellular constituents during the course of metabolism. As compared to with 15th day of incubation, the highest amount of organic carbon mineralization was recorded with pendimethalin (19.1%) and the combined application of herbicides (19.1%) followed by anilofos (15.9%). The decrease in organic carbon content in the control soil series was due to the degradation of native organic matter by the autochthonous microorganisms in soil. These results were also supported by the earlier reports of Das and Mukherjee (1989) and Mukherjee et al.(1991).

Effect on total nitrogen content

Application of herbicides, either alone or in combination, accentuated the accumulation of total nitrogen content in soil and the stimulation was at par in all the treated soils (Fig. 2). The results indicated that the increased microbial activities accumulated more amount of organic nitrogen through immobilization in to their cellular components which were subsequently mineralized resulting in a decrease in total nitrogen content in the later stages of the incubation. The similar observation with herbicide (oxyfluorfen) was recorded by Ananthacumarswamy et al. (1987). At the end of the experiment, anilofos and pendimethalin separately mineralized 26.5% nitrogen as compared to 15th day of incubation while the combined application of herbicides mineralized 24.7%. The change of total nitrogen was significantly correlated ($r = 0.921$) with the mineralization of organic carbon in soil (Table 2).

Effect on ammoniacal nitrogen

Application of applied herbicides increased the availability of ammoniacal nitrogen in soil and the increment was more pronounced with pendimethalin followed by anilofos and the combined application of both the herbicides at their recommended field application rates (Fig. 3). In case of pendimethalin, the higher amount of ammonia formation was recorded on 30th day of incubation followed by a decrease on 45th day. Under anilofos treated soil series, a rise in the accumulation of ammoniacal nitrogen was recorded on 15th day of incubation followed by a gradual decrease up to the end of the experiment. This indicated that application of herbicides highly stimulated the activities of the soil microorganisms, which mineralized the organic nitrogen to a greater extent during the incubation period. These findings sustained the reports of earlier workers (Sinha et al., 1979; Das and Debnath, 2006) who pointed out that herbicides significantly stimulated the ammonification resulting in the accumulation of mineral nitrogen in soil.

Effect on soluble nitrate nitrogen

The results as presented in Fig. 4 pointed out that anilofos exerted greatest stimulating influence towards the accumulation of soluble nitrate nitrogen in the soil system as compared to pendimethalin and the combined application of the herbicides. This supported the earlier reports of Debnath *et al.* (2002). Among the treatments, on 15th day, anilofos exerted highest accumulation of soluble nitrate form of nitrogen followed by their combined applications. It was also revealed that the amount of exchangeable ammonium (Fig. 3) was greater than that of nitrate in soil. This supported the findings of earlier workers (Debnath *et al.*, 2002; Das and Debnath, 2006) that ammonification was highly stimulated than that of nitrification due to the application of herbicides (eg. Butachlor, fluchoralin, oxadiazon and oxyfluorfen). There was a significant positive correlation (r = 0.637) (Table 2) between the exchangeable ammoniacal nitrogen and soluble nitrate nitrogen in the soil.

Effect on total phosphorus

The change of total phosphorus in soil system was highly influenced due to the application of herbicides (Fig. 5). In general, it was revealed that the content of total phosphorus was increased on and on with the age of incubation periods under the untreated control soil series. Similar trend was also recorded by the herbicide treated soils, more so on 15th and 60th days of incubation. This pointed out that enhanced microbial population received more phosphorus due to higher multiplication of their cells, which was caused by the greater utilization of anilofos and pendimethalin as well as their degraded products. As compared to control, the highest stimulation of total phosphorus content was recorded by anilofos on 30th day (20.9%), by pendimethalin on 30th day (26.0%) and by the combined application of the herbicides on 15th day (23.0%) of incubation. At the end of the experiment, anilofos, pendimethalin and their combined application retained 5.6%, 11.3% and 16.2% respectively more total phosphorus as compared to the untreated control soil.

The results of the present investigation revealed that the mineralization of organic carbon and total nitrogen was significantly stimulated with the application of the herbicides, more so with single application of anilofos and pendimethalin. The single application of anilofos and pendimethalin highly increased the availability of nitrogen in soil and this stimulation was more pronounced with pendimethalin for exchangeable NH_4^+ and with anilofos for soluble NO_3^- content in soil. Herbicides, in general augmented the content of total phosphorus in soil solution and the augmentation was more conspicuous when pendimethalin was applied either singly or in combination.

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Table 1: General characteristics of the soil used in the experiment

Soil characteristics	:	Results
1. Soil taxonomy (USDA, 1975)	:	*Typic Haplustepts*
2. Texural class	:	Clay loam
3. Sand (%)	:	27.7
4. Silt (%)	:	40.7
5. Clay (%)	:	31.6
6. Bulk density (g / cm^3)	:	1.04
7. Water holding capacity (%)	:	53.1
8. pH (1:2.5 w/v) in water	:	6.4
9. Cation exchange capacity [cmol (p^+) /kg]	:	11.15
10. Electrical conductivity (dS /m)	:	0.21
11. Organic carbon (%)	:	0.60
12. Total nitrogen (%)	:	0.072
13. C : N ratio	:	8.33
14. Exchangeable NH_4^+ (mg /kg)	:	97.7
15. Soluble NO_3^- (mg / kg)	:	43.9
16. Available phosphorus (mg /kg)	:	25.0
17. Total phosphorus (g /kg)	:	0.525

Table 2 : Linear relationships (r values) among different parameters studied for determining the effect of herbicides in soil

Parameters	Total nitrogen	Exchangeable NH_4^+	Soluble NO_3^-	Total phosphorus
Organic carbon	0.921**	0.720**	0.850**	0.331
Total nitrogen	--	0.642**	0.829**	0.504*
Exchangeable NH_4^+		--	0.637**	0.116
Soluble NO_3^-			--	0.444*

**Correlation is significant at 0.01 level of significance
 * Correlation is significant at 0.05 level of significance

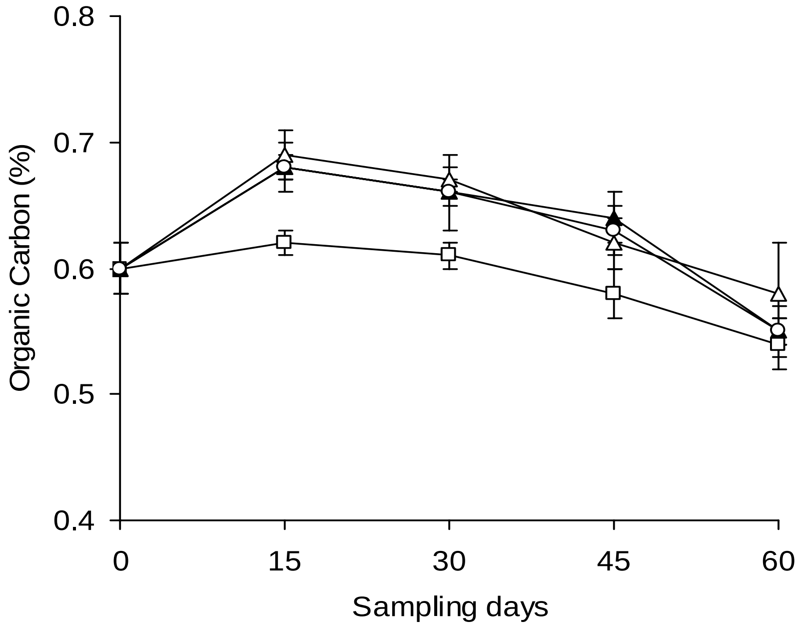

Figure 1 : Effect of herbicides on the changes of organic carbon content in soil. Treatments: □, control (untreated); △, anilofos; ▲, pendimethalin; ○, anilofos + pendimethalin. (Values are ± SE)

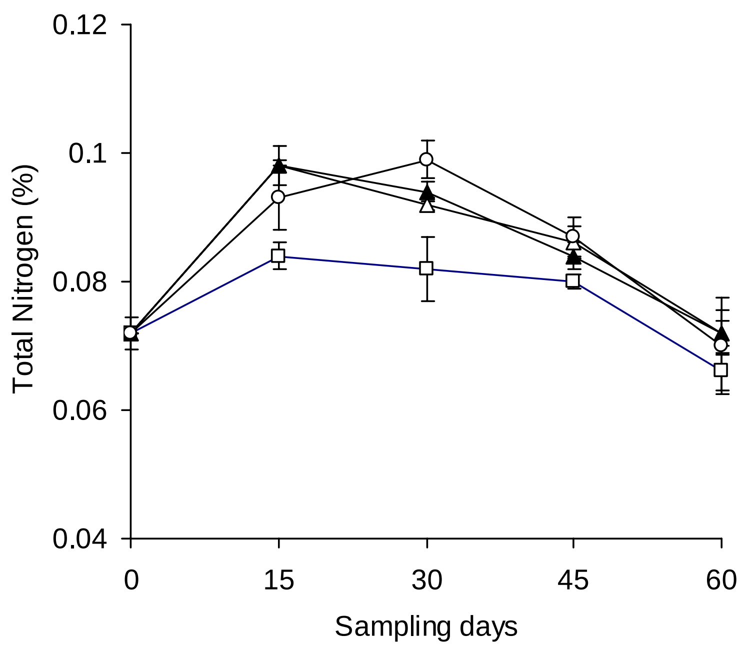

Figure 2 : Effect of herbicides on the changes of total nitrogen content in soil. Treatments: □, control (untreated); △, anilofos; ▲, pendimethalin; ○, anilofos + pendimethalin. (Values are ± s.e.)

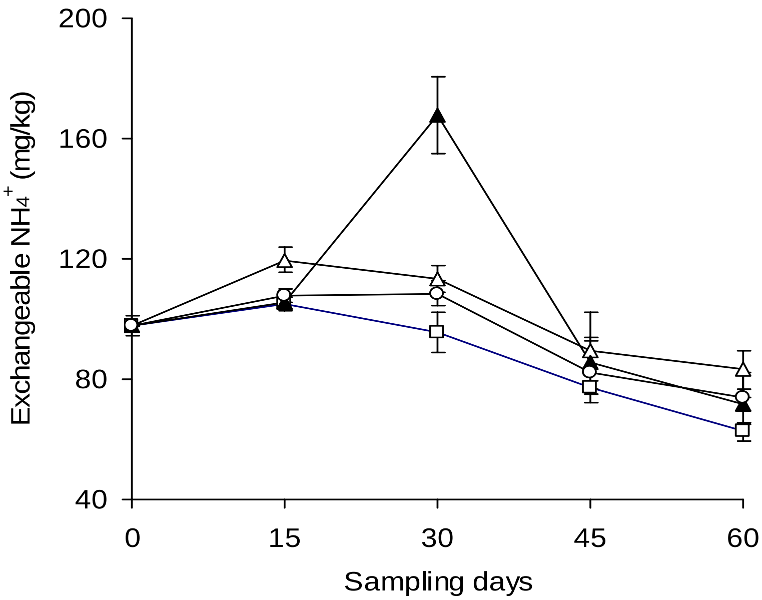

Figure 3 : Effect of herbicides on the changes of exchangeable NH_4^+ content in soil. Treatments: □, control (untreated); △, anilofos; ▲, pendimethalin; ○, anilofos + pendimethalin. (Values are ± SE.)

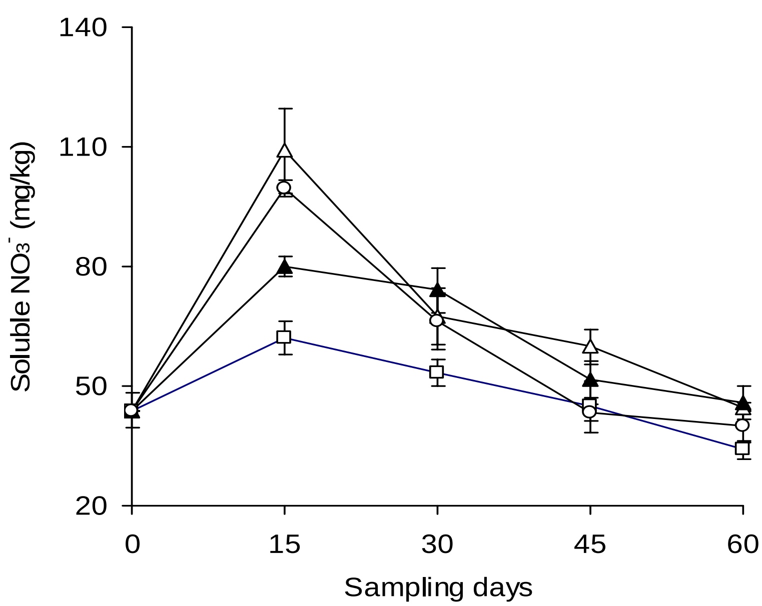

Figure 4 : Effect of herbicides on the changes of soluble NO_3^- content in soil. Treatments: □, control (untreated); △, anilofos; ▲, pendimethalin; ○, anilofos + pendimethalin. (Values are ± s.e.)

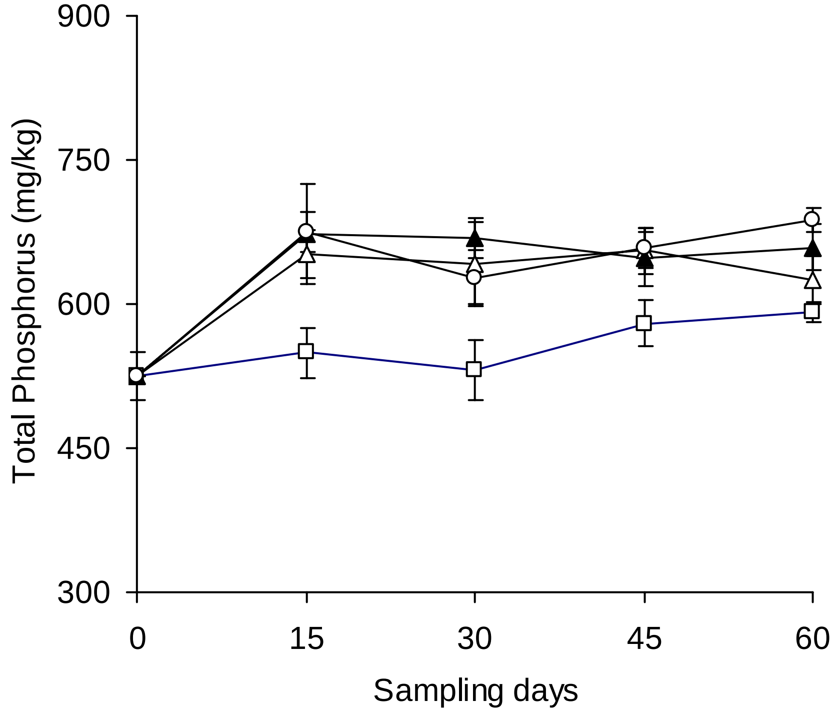

Figure 5 : Effect of herbicides on the changes of total phosphorus content in soil. Treatments: □, control (untreated); △, anilofos; ▲, pendimethalin; ○, anilofos + pendimethalin. (Values are ± S.e.)