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Effects of pyrazosulfuron-ethyl on soil microbial biomass carbon and ammonification in a lateritic soil of West Bengal

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ABSTRACT

A laboratory experiment was conducted in the Institute of Agriculture, Siriniketan to study the effect of pyrazosulfuron-ethyl on microbial biomass carbon and ammonification using two levels of pyrazosulfuron-ethyl (0 and 20 g a.i. ha^{-1}), two nitrogen sources (urea and vermicompost supplying N @ 100 kg ha^{-1}). Soil was incubated for 50 days under saturates condition and analyzed for microbial biomass carbon and NH_4-N contents on 0, 5, 10, 15, 20, 30, 40 and 50 days. Soil microbial biomass carbon was increased with time. Vermicompost treated soils maintained much higher values than urea and control. Pyrazosulfuron-ethyl caused reduction in microbial biomass carbon and NH_4-N contents. The contents of NH_4-N were initially increased, reaching maximum values at 30 days and decreased afterwards. Urea treatments contained higher amounts of NH_4-N compared to others. There was a net mineralization of nitrogen from soils receiving urea. With vermicompost, there was a net immobilization of nitrogen.

Key words: Ammonification, microbial biomass carbon, pyrazosulfuron-ethyl

Herbicides are widely employed in both agriculture and forestry to control various weed species. Just as herbicides are toxic to plants they are toxic to many soil microorganisms (Roger *et al.*, 1994). Microorganisms are intimately involved in soil processes that determine soil fertility, upon which the continued existence of the human population on earth is dependent. Clearly, any possible side effect of herbicide application which disturbs the equilibrium has far-reaching consequences on the maintenance of soil fertility and our ability to grow healthy, productive crops and thus survive. Pyrazosulfuron-ethyl is one of the newly synthesized sulfonylurea herbicides that have been widely used. Dissipation behavior of this herbicide is widely studied from the point of view of environmental protection. However, information regarding effect of pyrazosulfuron-ethyl on microbial activity, and as a result, nitrogen transformation processes are very scanty. It is, therefore, a matter of priority to obtain adequate information on the effect of herbicides on soil organisms and their activities. Therefore, the present study was undertaken to study the effects of pyrazosulfuron-ethyl on soil microbial biomass carbon and ammonification in a lateritic soil of West Bengal.

MATERIALS AND METHODS

A laboratory experiment was conducted in the Department of ASEPAN, Institute of Agriculture, Visva-Bharati to study the effect of pyrazosulfuron-ethyl on soil microbial biomass carbon and ammonification in a lateritic soil of West Bengal. The treatments consisted of two levels of pyrazosulfuron-ethyl (0 and 20 g *a.i.* ha^{-1}). For each level of pyrazosulfuron-ethyl there were two nitrogen sources, *viz.*, urea (@100kg N ha^{-1}) and vermicompost (@ 1.14%, containing same amount of nitrogen as that in urea). A control was also maintained to compare the treatment effects. Each treatment was replicated thrice and each triplicate treatment set was again replicated eight times to facilitate exhaustive sampling in nine incubation periods. 25 g soil was taken in each of 144 test tubes and the soil was incubated for 0, 5, 10, 15, 20, 30, 40 and 50 days at room temperature. at what temperature?. After each incubation period soils from triplicate set of six treatments were taken out and analyzed for microbial biomass carbon and NH_4-N. For test of significance of different treatments, data were subjected to analysis of variance in completely randomized design with three factors using MSTATC data analysis package.

RESULTS AND DISCUSSION

Microbial biomass carbon

Data on microbial biomass carbon are presented in table 1. Microbial biomass carbon was increased with time up to 40 days of incubation and then attained a steady value. Application of the herbicide reduced the mean value from 54.62 to 45.91 μg g^{-1}. The reduction in values indicates inhibitory effect of the herbicide on microbial populations. The negative impact was observed throughout the incubation period in all the treatments. This inhibitory effect of pyrazosulfuron-ethyl on microbial biomass carbon was more pronounced in the urea treated soils where it was drastically reduced from 52.34 μg g^{-1} to 37.86 μg g^{-1}. In these soils microbial biomass carbon contents were lower than vermicompost treated soil and even control throughout the entire incubation period. Soils treated with vermicompost harbored (try to use some other word) maximum microbes as reflected by higher values of microbial biomass carbon even with the application of the herbicide. The highest value (82.33 μg g^{-1}) of microbial biomass carbon was recorded in soils treated with vermicompost without the application of the herbicide at 40 days of incubation.

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Irrespective of the herbicide application the mean values of microbial biomass carbon contents were much higher in the vermicompost treatments. Control and urea treatments recorded more or less similar microbial populations. Soils treated with organic amendments generally harbour higher populations of soil microflora. Similar result was also reported by Devi *et al.* (2007).

As herbicides are toxic chemicals they may have inhibitory effect on microbial community. In an earlier study on the effects of several herbicides (butachlor, pretilachlor and 2,4-D) Devi *et al.* (2007) showed inhibitory effects on total soil microflora and the effect was more on soil bacteria than fungi and actinomycetes. However, with the application of chlomazone, Ghosh *et al.* (2007) observed an inhibitory effect on soil bacteria. In the same study they observed a stimulatory effect of 2,4-DEE on soil bacteria. Shetty and Magu (1996) also reported increased microbial population due to application of pendimethalin @1.5-3ppm up to 4^{th} week of incubation. In another study Lin *et al* (2003) reported increased respiration rate due to application of pendimethalin at lower rates of application (1 and 5 mg kg^{-1}). These studies support enhanced activity of microorganisms due to application of pendimethalin.

NH_4-N contents in soils

Data on NH_4-N contents in the soil samples are presented in Table 2. The results revealed that soils treated with urea maintained higher levels of NH_4-N content throughout the incubation period. It was followed by the control where no nitrogen was applied. When vermicompost was applied as the nitrogen source, lower values of NH_4-N were recorded irrespective of the herbicide application which indicates a net immobilization of nitrogen as a result of vermicompost application. Overall, pyrazosulfuron-ethyl inhibited the rate of ammonification which was reflected by the lower mean values of NH_4-N contents in all the treatments due to the herbicide application. Ammonification rate was slow during the initial days, increased steadily up to 30 days, thereafter, decreased afterwards and reached a minimum value at 50 days of incubation. When pyrazosulfuron-ethyl was not applied, the mean NH_4-N contents in all the treatments were higher compared to the treatments receiving the herbicide in every incubation period. It clearly indicates the detrimental effect of the herbicide on proliferation of microbes, especially on ammonifiers which was also reflected by reduced microbial biomass carbon in the soils treated with the toxicant.

Soils receiving urea as nitrogen source maintained a very high level of NH_4-N contents throughout the incubation period. The values were more than two-fold compared to that of control and vermicompost treatments except at the very beginning and at 50 days. Up to 20 days vermicompost treatment was at par with control but after that the release of NH_4-N from vermicompost treatments decreased and the values were even lower than control.

A critical appraisal on the rate of ammonification as a result of various treatments revealed that rate of NH_4-N formation was very high during first 5 days (Table 3). After that it was decreased remarkably. After 20 days rate of ammonification was decreased sharply and ultimately attained negative values indicating net immobilization. Increase in ammonification rate was due to increased microbial activity just after incubation. Afterwards, the substrates, i. e., organic proteinaceous compounds, become limiting for the increased microbial population and ultimately, they will be forced to consume mineral nitrogen from soil for the growth and proliferation resulting in net immobilization. These are statement of the results but where are the discussion with results? Application of pyrazosulfuron-ethyl significantly reduced ammonification rate. This inhibitory effect of the herbicide was observed after 30 days of incubation. Mean ammonification rate was highest when the soil was treated with urea irrespective of herbicide application. With vermicompost lower rates of ammonification were recorded compared to control. In control the decrease in ammonification rate due to application of the herbicide was not statistically significant.

As evidenced by reduced microbial biomass carbon due to application of herbicides it is also expected to have reduced population of ammonifiers due to herbicide application. Shukla and Mishra (1997) also reported inhibition of the rate of ammonification of urea when butachlor was applied. However, in another study, using butachlor, fluchloralin, oxadiazon and oxyfluorfen, Debnath *et al.* (2002) showed higher release of mineral nitrogen (NH_4-N as well as NO_3-N) due to addition of herbicides.

A study on the apparent net mineralization (mineral N in treated soil – mineral N in control at the same incubation period) of nitrogen in different incubation periods showed that the release of mineral N from added urea was always higher than that from vermicompost (Fig. 1a and 1b). In vermicompost treatment negative values were recorded after 30 days of incubation indicating a net immobilization due to the addition of vermicompost. Similar immobilization of native soil nitrogen with the application of farmyard manure has been reported by Gill *et al.* (1991) and with application of biogas slurry by Gupta *et al.* (2003). Singh and Aulakh (2001) reported immobilization of native soil nitrogen when the soil was amended with crop residues.

The study revealed that microbial biomass carbon increased with time. Application of pyrazosulfuron-ethyl significantly reduced the microbial biomass carbon contents. Soil treated with vermicompost maintained higher levels of microbial biomass carbon throughout the incubation period. Ammonification was also hampered by the herbicide application. NH_4-N contents were increased up to 30 days in all treatments and then showed a sharp decline. Soils treated with urea released higher amount of NH_4-N compared to vermicompost and control throughout the entire period. However, rate of ammonification was decreased with time. Application of vermicompost caused a net immobilization.

Table 1: Effect of urea, vermicompost and pyrazosulfuron-ethyl on microbial biomass carbon (μg g^{-1} soil)

Treatments	Incubation period (day)								Mean
	0	5	10	15	20	30	40	50	
Without herbicide									
Control	27.08	31.25	40.45	46.75	53.56	60.24	60.45	60.13	47.49
Urea	31.70	35.73	42.45	49.67	55.45	67.00	68.14	67.98	52.34
Vermicompost	41.60	45.56	52.06	59.06	69.09	81.48	82.38	81.13	64.04
Mean	**33.46**	**37.51**	**44.99**	**51.83**	**59.37**	**69.72**	**70.31**	**69.74**	**54.62**
With herbicide									
Control	25.45	27.34	35.21	41.93	47.62	55.87	56.17	55.17	43.10
Urea	22.43	25.44	30.37	35.76	42.86	48.43	49.16	48.46	37.86
Vermicompost	37.17	41.02	48.88	53.51	61.53	72.24	72.29	67.43	56.76
Mean	**28.35**	**31.27**	**38.15**	**43.73**	**50.67**	**58.85**	**59.20**	**57.03**	**45.91**
Control	26.26	29.30	37.83	44.34	50.59	58.05	58.31	57.65	45.29
Urea	27.06	30.58	36.41	42.72	49.15	58.72	58.65	58.22	45.06
Vermicompost	39.39	43.29	50.47	56.29	65.31	76.86	77.31	74.28	60.40
Mean	**30.90**	**34.39**	**41.57**	**47.78**	**55.02**	**64.30**	**64.76**	**63.39**	

	Time	N source	Herbicide level	Time x N source	N source x herbicide level	Time x herbicide level	Time x N source x herbicide level
SEm(±)	**0.05**	**0.03**	**0.16**	**0.01**	**0.04**	**0.06**	**0.11**
LSD (0.05)	**0.13**	**0.08**	**0.44**	**0.02**	**0.11**	**0.18**	**0.31**

Table 2: Effect of urea, vermicompost and pyrazosulfuron ethyl on NH_4-N content (μg g^{-1} soil)

Treatments	Incubation period (day)								Mean
	0	5	10	15	20	30	40	50	
Without herbicide									
Control	5.74	7.52	12.29	18.38	19.04	29.20	20.64	8.25	15.13
Urea	3.79	47.76	47.65	58.24	57.75	53.95	50.73	8.25	41.02
Vermicompost	3.79	10.49	15.42	18.18	19.04	21.58	14.60	1.90	31.12
Mean	**4.44**	**21.92**	**25.12**	**31.60**	**31.94**	**34.91**	**28.67**	**6.14**	**23.09**
With herbicide									
Control	1.88	9.46	9.58	18.12	17.77	17.77	24.12	4.44	12.89
Urea	3.84	46.54	47.57	47.62	48.23	50.77	35.54	4.44	35.57
Vermicompost	8.63	7.64	13.39	17.16	18.41	8.89	10.79	3.81	11.09
Mean	**4.78**	**21.21**	**23.51**	**27.63**	**28.14**	**25.81**	**23.48**	**4.23**	**19.85**
Control	3.81	8.49	10.94	18.25	18.41	23.49	22.38	6.35	14.01
Urea	3.82	47.15	47.61	52.93	52.99	52.36	43.14	6.35	38.29
Vermicompost	6.21	9.06	14.40	17.67	18.72	15.23	12.69	2.85	12.11
Mean	**3.81**	**8.49**	**10.94**	**18.25**	**18.41**	**23.49**	**22.38**	**6.35**	**14.01**

	Time	N source	Herbicide level	Time x N source	N source x herbicide level	Time x herbicide level	Time x N source x herbicide level
SEm(±)	**0.31**	**0.19**	**0.16**	**0.56**	**0.28**	**0.45**	**0.77**
LSD(0.05)	**0.89**	**0.55**	**0.45**	**1.58**	**0.78**	**1.27**	**2.19**

Table 3: Effect of urea, vermicompost and pyrazosulfuron-ethyl on rate of ammonification (µg g^{-1} day^{-1})

Treatments	Incubation period (day)							Mean
	5	10	15	20	30	40	50	
Without herbicide								
Control	0.361	0.954	1.217	0.135	1.016	-0.854	-0.903	0.275
Urea	8.927	-0.153	2.184	-0.350	-0.380	-0.317	-12.730	0.810
Vermicompost	1.340	0.986	0.356	0.173	0.254	-0.697	-3.800	0.164
Mean	**3.543**	**0.595**	**1.252**	**-0.014**	**0.296**	**-0.622**	**-2..138**	**0.416**
With herbicide								
Control	1.516	0.023	1.374	-0.067	0.127	0.634	-1.897	0.244
Urea	8.540	0.205	0.077	0.003	0.254	-1.497	-9.310	0.640
Vermicompost	-0.197	1.152	0.755	0.250	-0.950	0.190	-2.094	0.072
Mean	**3.286**	**0.460**	**0.735**	**0.062**	**-0.190**	**-0.224**	**-1.899**	**0.319**
Control	3.036	0.453	1.283	-0.027	0.254	-0.309	-4.833	0.373
Urea	5.081	0.265	0.998	-0.060	0.064	-0.469	-6.934	0.468
Vermicompost	2.800	0.592	0.641	0.090	-0.079	-0.343	-4.275	0.280
Mean	**3.415**	**0.528**	**0.994**	**0.024**	**0.053**	**-0.423**	**-2.019**	

	Time	N source	Herbicide level	Time x N source	N source x herbicide level	Time x herbicide level	Time x N source x herbicide level
SEm(±)	**0.05**	**0.04**	**0.16**	**0.09**	**0.04**	**0.06**	**0.11**
LSD(0.05)	**0.13**	**0.106**	**0.44**	**0.28**	**0.11**	**0.18**	**0.31**

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