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EFFECT OF PESTICIDES ON MINERAL NITROGEN CONTENT AND SOIL MICROBIAL POPULATION IN A LATERITIC SOIL OF WEST BENGAL

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ABSTRACT: A laboratory experiment was conducted in the Department of ASEPAN, Palli Siksha Bhavana, Sriniketan to study the effect of carbofuran and pendimethalin on mineral nitrogen content in soil, soil microbial biomass carbon and population of bacteria and fungi. The soil was collected from the Agricultural farm and treated with two sources of nitrogen, viz., urea and vermicompost and two pesticides, viz., carbofuran and pendimethalin. Soil samples were incubated for eight weeks and after every week these were analyzed for NH_4-N content and NO_3-N content. Total count of bacteria and fungi were taken after 2, 4, 6 and 8 weeks. NH_4-N content was found to increase with application of nitrogen as urea. Pendimethalin application decreased NH_4-N. However, pendimethalin application enhanced NO_3-N formation. Total mineral nitrogen content (NH_4-N +NO_3-N) was maximum with application of urea. Carbofuran application did not affect mineral nitrogen contents significantly but pendimethalin caused a decrease in the values. The rate of mineral nitrogen formation was faster with application of carbofuran compared to that of urea. Both the pesticides decreased population of fungi but pendimethalin was found to be more harmful. Carbofuran was found to be more inhibitory to bacterial population.

Key words: carbofuran, pendimethalin, fungi, bacteria, nitrogen

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INTRODUCTION

The addition of any chemical to the soil must be done with great care because it may disrupt the activities of the soil microflora. Before any chemical is used it is important to know what effects it may have on soil microorganisms and their activities. Pesticides are chemicals whose use is now-a-days unavoidable. Microorganisms are intimately involved in soil processes such as recycling of essential plant nutrients, trash decomposition and humus formation, soil structural stability, pathogen survival, pesticide detoxification and many others. The efficient functioning of these processes is the result of a delicate equilibrium between microorganisms, soil, and plants which is mediated by many environmental factors. The balance between all these factors and processes results in that state which is generally referred to as soil fertility, upon which the continued existence of the human population on earth is dependent. Clearly, any possible side effect of pesticide 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. Like other soil biochemical processes pesticide application may alter microbial transformation of nitrogen to its available forms. Therefore, the present study was undertaken to study the effects of pesticides on soil microbial population and mineral nitrogen content in a lateritic soil of West Bengal.

MATERIALS AND METHODS

An incubation study was conducted in the Department of ASEPAN, Palli Siksha Bhavana, Visva-Bharati, Sriniketan to study the effect of carbofuran on nitrogen transformation and microbial activity in a lateritic soil of West Bengal. The treatments consisted two sources of nitrogen (urea, and vermicompost, containing 1.14% N) and two pesticides, *viz.*,carbofuran (@ 25 kg/ha) and pendimethalin (@1 kg a.i.ha^{-1}). A control was maintained at both levels of two pesticides to study the nitrogen mineralization from these two sources with or without the presence of pesticides. All the treatments were replicated thrice, and each set of these six treatments in triplicate were again replicated nine times for exhaustive sampling in each incubation period. Hence, in total 162 test tubes were taken and in every test tube 25 gm soil was taken for application of different treatments. In control, only soil was incubated maintaining soil moisture level at field capacity. In urea treatments, urea was applied @ 100 Kg/ha and in each test tube, 2.47 mg urea was applied in solution form. In vermicompost treatments, 0.1136 gm vermicompost containing the same amounts of N as was applied through urea was applied. Moisture level at field capacity was maintained by weighing each of the test tubes every day for compensating the moisture loss, if required. Then all the test tubes were kept under aerobic condition for 8 weeks. The soil samples were analyzed for NH_4-N and NO_3-N contents at 0, 1, 2, 3, 4, 5, 6, 7 and 8th week of incubation and total count of bacteria and fungi were taken at 2, 4, 6 and 8 weeks.

RESULTS AND DISCUSSION

NH_4-N contents

NH_4-N contents were found to increase initially (Table 1) and afterwards decreased gradually, reaching the minimum at 6th week and again increased afterwards up to the end of incubation period. The much higher values of ammonium nitrogen in the initial period may be due to hydrolysis of urea. Urea treated soils recorded the maximum values of NH_4-N throughout the incubation period irrespective of pesticide application. Vermicompost treated soils recorded the minimum values throughout the incubation period except the initial value. When carbofuran was applied, vermicompost treated soils released more NH_4-N compared to control. With the application of carbofuran the mean NH_4-N content (87.29 mg kg^{-1} soil) was at par with that recorded in samples receiving no pesticide (87.49 mg kg^{-1} soil). However, with application of pendimethalin, the mean value (81.51 mg kg^{-1} soil) decreased significantly. This may be due to the adverse effect of the herbicide on ammonifying bacteria which was recovered after complete degradation of the pesticide and hence, beyond 6th week, the herbicide did not show any significant effect. Another reason may be its stimulating effect on nitrifying bacteria. Immediate formation of nitrate might have caused a reduction in NH_4-N content of soils. This type of differential response of pendimethalin on ammonifying and nitrifying bacteria in the initial period was also reported by Lin *et al*., [1] also reported inhibitory effect of pendimethalin on the ammonification in the beginning of incubation.

NO_3-N contents

Nitrate nitrogen content was nearly half of NH_4-N content (Table 2). Formation of nitrate nitrogen was not hampered significantly by the application of carbofuran while it was found to be enhanced with pendimethalin application. Nitrate-N content was found to increase up to 6th week and afterwards decreased. This increased nitrification may be the reason for decreased NH_4-N content during this period. When no pesticide was applied, soils with no nitrogen application released more NO_3-N compared to urea and vermicompost treated soils. However, with application of pesticide, the mean values at control were lower compared to soils receiving either of the nitrogen sources. With application of carbofuran vermicompost treated soils released maximum amount of NO_3-N (48.80 mg kg^{-1} soil) and with application of pendimethalin, urea treated soils recorded the highest value (51.45 mg kg^{-1} soil). Decreased nitrification activity by the application of insecticides was observed by [2] only when pesticide application rates exceeded the recommended doses. However, enhanced nitrification due to herbicide application was reported by Debnath *et al*. [3].

Total mineral nitrogen content

Total mineral nitrogen content (table 3) was highest (149.02 mg kg^{-1} soil) when the soils received urea as their source of nitrogen. Vermicompost treated soils contained total mineral nitrogen content (121.44 mg kg^{-1} soil) that was at par with that observed in control (123.04 mg kg^{-1} soil). Total mineral nitrogen content was found to increase at the first week and decreased gradually up to the end of incubation period. Carbofuran application did not affect mineral nitrogen content significantly but with application of pendimethalin there was a slight drop in the mean value (128.32 mg kg^{-1} soil). When no pesticide was applied vermicompost treated soils released lesser amount of total mineral nitrogen compared to that in control.

Population of fungi

Number of fungal colonies was increased with application of nitrogen and fungi preferred vermicompost to urea as the nitrogen source (table 4). With the application of pesticides population of fungi decreased drastically. Pendimethalin was found to be more harmful compared to carbofuran. The mean fungal population remained more or less constant with time. Maximum population of fungi (18.70) was observed in the urea treated soils with no application of pesticides and the minimum value (1.33) was recorded in soil receiving pendimethalin without any addition of nitrogen. In carbofuran treated soils the inhibitory effect of pesticide could be checked, to a lesser extent, with the application of vermicompost as the nitrogen source.

Table-1: Effect of urea, vermicompost and pesticides on NH_4- N content (mg kg^{-1} soil)

Treatment	Incubation period (weeks)									Mean
	0	1	2	3	4	5	6	7	8	
	No pesticides									
Control	26.61	59.04	60.00	63.80	45.71	46.70	42.85	57.09	51.43	50.35
Urea	38.50	40	40	51.43	39.04	40	77.14	40	40	45.22
Vermicompost	30.79	54.28	45.71	32.38	42.85	37.14	47.62	42.85	38.11	41.31
Mean	31.96	51.11	48.61	49.22	42.53	41.31	55.91	46.65	43.49	
	With carbofuran									
Control	31.97	51.43	39.04	41.90	51.43	53.33	52.40	34.33	34.28	43.34
Urea	33.99	34.28	42.85	40	41.90	40.95	62.85	42.85	40	42.19
Vermicompost	34.74	48.57	45.71	43.81	56.19	55.24	58.57	41.90	54.28	48.80
Mean	33.60	44.76	42.53	41.90	49.84	49.84	57.93	39.70	42.85	
	With pendimethalin									
Control	31.42	45.71	42.85	34.30	45.71	47.61	51.43	43.81	48.57	43.49
Urea	62.10	37.14	41.90	41.90	52.38	58.08	54.28	59.04	56.19	51.45
Vermicompost	32.45	51.43	43.81	31.43	53.33	51.43	56.20	43.81	45.71	45.51
Mean	41.99	44.76	42.85	35.90	50.50	52.40	53.93	48.90	50.15	
Grand mean	35.84	46.80	44.65	42.32	47.61	47.83	55.92	45.02	45.50	
CD(0.05)	Nitrogen source	Pesticide	Nitrogen source×pesticide	Time	Nitrogen source ×Time	Pesticide×Time	Nitrogen source× Pesticide×Time			
	1.106	1.106	1.915	1.915	3.314	3.314	5.744			

Table-2: Effect of urea, vermicompost and pesticides on NO_3- N content (mg kg $^{-1}$ soil)

Treatment	Incubation period(weeks)									Mean
	0	1	2	3	4	5	6	7	8	
				No pesticide						
Control	73.33	88.56	88.56	89.52	89.52	90.47	85.71	88.56	85.71	86.66
Urea	86.81	120.93	114.28	118.09	105.71	108.56	86.66	105.71	99.98	105.19
Vermicompost	81.30	82.85	62.85	85.71	69.51	73.32	57.14	54.14	68.60	70.61
Mean	80.84	97.45	88.56	97.77	88.24	90.78	76.50	82.85	84.85	87.49
				With carbofuran						
Control	81.35	74.33	69.52	71.42	73.33	85.71	60.00	68.56	79.99	7379
Urea	85.33	111.42	100	95.23	112.40	117.14	86.70	102.85	114.25	102.80
Vermicompost	83.80	91.42	95.23	99.97	80.95	70.50	66.70	97.13	81.90	85.28
Mean	83.49	92.37	88.25	88.87	88.88	91.90	71.11	89.51	92.05	87.29
				With pendimethalin						
Control	85.71	80.95	71.42	71.42	65.69	65.31	58.57	72.37	71.42	71.47
Urea	92.48	105.70	112.37	117.14	92.40	93.33	84.80	113.30	90.47	100.21
Vermicompost	84.93	88.56	85.71	81.90	65.71	63.80	62.85	61.90	60	72.85
Mean	87.70	91.73	89.83	90.15	74.56	74.28	68.72	82.52	73.96	81.51
Grand mean	83.89	93.85	88.88	92.26	83.90	85.29	72.11	84.96	83.28	

CD(0.05)	Nitrogen source	Pesticide	Nitrogen source ×pesticide	Time	Nitrogen source ×Pesticide	Pesticide×Time	Nitrogen source×Pesticide×Time
	1.646	1.646	2.854	2.854	4.943	4.943	8.562

Table 3-Effect of urea, Vermicompost and pesticides on total mineral N (NH_4-N+NO_3-N) content (mg kg^{-1} soil)

Treatment	0	1	2	3	4	5	6	7	8	Mean
				No Pesticides						
Control	99.9	147.6	148.5	153.3	135.2	137.1	128.6	145.7	137.14	137.02
Urea	125.3	160.9	154.3	169.5	144.7	148.6	163.8	145.71	140.93	150.42
Vermicompost	112.1	137.1	108.6	118.1	112.4	110.5	104.8	97.13	106.66	111.92
Mean	112.4	148.6	137.1	146.9	130.8	132.1	132.4	129.5	128.24	
				With Carbofuran						
Control	113.3	125.7	108.6	113.33	124.77	139.04	112.38	102.85	114.28	117.14
Urea	119.3	145	142.8	135.23	154.27	158.09	149.52	145.71	154.25	144.99
Vermicompost	118.6	140	141	144	137.14	125.8	125.23	139.04	136.19	134.06
Mean	117.1	137.1	130.7	130.78	138.72	140.95	129.05	129.2	134.9	
				With Pendimethalin						
Control	117.13	126.66	114.28	105.71	111.41	113.32	110	116.18	119.99	114.96
Urea	154.58	142.81	154.28	159.04	144.76	151.41	139.04	172.34	146.66	151.66
Vermicompost	117.39	139.99	129.52	113.33	119.04	115.23	119.04	105.71	105.71	118.33
Mean	129.69	136.49	132.69	126.02	125.05	126.66	122.69	131.41	124.12	
Grand mean	119.73	140.73	133.54	134.59	131.52	133.22	128.04	130.05	124.09	

CD(0.05)	Nitrogen source	Pesticide	Nitrogen sourcexpesticide	Time	Nitrogen source xTime	Pesticide x Time	Nitrogen source x Pesticide x Time
	2.18	2.18	3.78	3.78	6.55	6.55	11.36

Table-4 Effect of urea, vermicompost and pesticides on total number of fungi (colony forming units g^{-1} dried soil x 10^5)

Treatment	Incubation period (weeks)				Mean
	2	4	6	8	
No pesticide					
Control	8.66	9.33	8.66	6.70	8.33
Urea	10.00	9.66	11.66	7.70	9.75
Vermicompost	14.00	16.00	18.70	16.70	16.33
Mean	10.90	11.70	13.00	10.33	
With carbofuran					
Control	5.00	2.00	3.33	1.70	3.00
Urea	6.00	8.33	4.33	5.70	6.08
Vermicompost	9.00	4.33	8.70	7.70	7.41
Mean	6.70	4.90	5.44	5.00	
With pendimethalin					
Control	2.33	1.70	2.33	1.33	1.91
Urea	4.00	4.33	5.70	5.30	4.83
Vermicompost	4.33	5.33	6.00	7.00	5.70
Mean	3.55	3.70	4.70	4.50	
Grand mean	7.03	6.80	7.80	6.70	

CD, P=0.05	Nitrogen source	Pesticide	Nitrogen source ×Pesticide	Time	Nitrogen source×Time	Pesticide×Time	Nitrogen source ×Pesticide Time
	1.56	1.56	2.71	1.81	3.13	3.13	5.43

Population of bacteria

Bacterial population (table 5) showed similar trend as that observed in case of fungi but here carbofuran was found to be more inhibitory compared to pendimethalin. Bacterial population also remained constant with advancement in incubation period. Nitrogen application enhanced bacterial population and application of vermicompost as the nitrogen source increased the value to nearly two-fold compared to control. Bacterial population reached to its maximum value (68.35) in soils treated with vermicompost without any addition of pesticide and the minimum value (9.66) was recorded in soils receiving carbofuran and no addition of nitrogen. In all the soils vermicompost application increased bacterial population to nearly two-fold. Pesticide application decreased bacterial population to nearly half of that observed without addition of any toxicant. Magnitude of this decrease was more with addition of carbofuran.

This decreased microbial population by application of pesticides was also observed in a recent study by Durga Devi *et al*. [4]. They showed inhibitory effect of herbicides (butachlor, pretilachlor and 2,4-D) on soil microflora in rice-rice system. They observed that the inhibitory effect of herbicides was more on soil bacteria than soil fungi and actinomycetes. They also observed that treatments with farmyard manure had higher population of microflora at all the sampling intervals.

Table-5: Effect of urea, vermicompost and pesticide on bacterial population (colony forming units g^{-1} soil x 10^5)

Treatment	Inoculation period (weeks)				Mean
	0	1	2	4	
				No pesticide	
Control	38.70	40.33	33.70	30.00	35.70
Urea	44.66	52.66	38.33	35.66	42.83
Vermicompost	66.66	68.35	60.66	62.66	62.08
Mean	50.00	53.80	44.22	39.44	
With carbofuran					
Control	9.66	12.66	17.66	17.66	14.41
Urea	18.66	15.33	22.66	29.00	21.41
Vermicompost	22.66	26.70	29.30	23.70	25.60
Mean	17.00	18.22	23.22	23.44	
With pendimethalin					
Control	18.00	19.33	23.66	15.33	19.08
Urea	22.66	21.66	25.33	27.66	24.33
Vermicompost	33.70	35.33	41.00	43.00	38.25
Mean	24.80	25.44	30.00	28.70	
Grand mean	30.60	32.50	32.50	30.51	30.60

CD,P=0.05	Nitrogen source	Pesticide	Nitrogen source×Pesticide	Time	Nitrogen source×Time	Pesticide×Time	Nitrogen source×Pesticide×Time
	2.80	2.80	4.81	3.20	5.60	5.60	9.62

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