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EVALUATION OF THE NITRIFICATION INHIBITOR (NITRAPYRIN) APPLICATION TO A SOIL-WATER SYSTEM FOR CONSERVATION OF AMMONIUM RELEASED UNDER WATER LOGGED INCUBATION OF SOILS

KEY WORDS: ammonification, nitrification-denitrification, anaerobic incubation.

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ABSTRACT

The nitrification inhibitor was added to a submerged soil system to check loss of the ammonified N through nitrification denitrification. The presence of nitrapyrin significantly raised the recovery of NH_4^+-N released during the 2 weeks of incubation at 30°C for soils having near neutral to alkaline pH probably by preventing nitrification. The levels of mineralizable NH_4^+ obtained using a modified version of the incubation method were comparable with those obtained by incubation of the submerged soil samples under an atmosphere of N_2. Our results emphasize the importance of exclusion of air from the soil-water system during waterlogged incubation of soils for preventing the loss of ammonified N by nitrification and denitrification. It is suggested that this can be achieved either by incubation of the soils under an atmosphere of inert gases such as N_2 or possibly by the use of a nitrification inhibitors such as Nitrapyrin.

INTRODUCTION

Incubation of soil samples under waterlogged conditions for short periods of 6 days to 2 weeks is generally used for measuring the N supplying capacity of wetland rice soils[6]. However, it has been observed that during soil laboratory incubation tests the pattern of soil N mineralization is such that the NH_4^+ after reaching a peak value starts to level off[4,10]. This has been attributed to the start of nitrification denitrification reactions[9]. Shiga and Ventura[14] reported that mineralization of soil N in a laboratory incubation test showed a similar pattern as observed under wetland field conditions if the soil samples were not dried and O_2 was excluded from the soil-water system. Broadbent[5] suggested that the waterlogged incubation test may give underestimation of the mineralizable N pool unless O_2 is excluded from the soil-water system.

Recently, Sahrawat[11] suggested that use of nitrification inhibitors could be effective in preventing nitrification and subsequent denitrification loss of NH_4-N if these chemicals are applied to the oxidised zone of a wet land rice soil where nitrification occurs. The objective of this study was to test the possibility of conserving NH_4-N released during water logged laboratory incubation by the application of Nitrapyrin (2-chloro-6- (trichloromethyl) pyridine) to the oxidized layer of the incubated soils and to compare these results with those obtained by following waterlogged incubation of the same soils under an atmosphere of N_2 after deaeration of the soil-water system.

MATERIALS AND METHODS

Soil samples used in the study were surface (0-15 cm) samples collected from the rice growing parts of the Philippines. The samples were air dried and ground to pass through a 2-mm sieve before use. The soils used were selected to provide a wide range in pH (4.4 to 7.9),

TABLE 1

Analysis of the soil used

Soil No.	Soil Texture	pH (1:1)	Organic C (%)	Total N (%)	C E C (m.e./100 g)
1	Clay	4.4	1.98	0.20	30.5
2	Clay	4.5	1.54	0.17	23.5
3	Clay	4.8	1.42	0.15	18.2
4	Clay	4.9	1.63	0.13	44.3
5	Loam	5.0	0.65	0.06	7.0
6	Clay	5.3	1.48	0.16	30.3
7	Silty clay	5.3	2.50	0.25	40.9
8	Silty clay loam	5.6	4.76	0.48	40.9
9	Clay	5.8	3.36	0.33	43.0
10	Clay	6.4	0.83	0.08	35.5
11	Silt loam	6.5	1.89	0.16	20.2
12	Clay loam	6.5	0.75	0.08	30.5
13	Clay	6.6	2.14	0.21	50.8
14	Silty clay	6.9	1.69	0.16	36.2
15	Clay	7.0	1.89	0.16	45.4
16	Silty clay loam	7.0	0.91	0.08	42.3
17	Silty clay loam	7.2	0.84	0.07	39.3
18	Silty loam	7.5	0.63	0.06	35.5
19	Silt loam	7.9	0.63	0.06	35.5

organic C (0.63 to 4.76%), total N (0.06 to 0.48%), cation exchange capacity (7.0 to 50.8 me/100 g soil) and texture (Table 1). For the soil analyses reported in Table 1, pH was measured by a glass electrode using soil to water ratio of 1:1, organic carbon was determined by the method of Walkley and Black[15], total N by the semi-micro-kjeldahl method of Bremner[2], CEC by the method described by Chapman[7] and particle size analysis was done as described by Day[8].

A ten g aliquot of soil was placed in a test tube (16 x 2-cm) containing about 15-20 ml of water to give a standing water layer of 2-3 cm, the transfer done carefully to minimize trapping of air. The incubation was carried out under each of the following environments: i) test tubes in air, ii) test tubes were deareated and incubated under an atmosphere of N_2 gas and iii) test tubes in air but the soil-water system was treated with 10 ppm of Nitrapyrin (2-chloro-6-(trichloromethyl) pyridine). Nitrapyrin was dissolved in 0.5 ml of pure acetone and applied to the surface of soil through flood water by a pipette. Appropriate controls were included to correct for the effect of acetone, if any on soil N mineralization.

The test tubes in duplicate with the soil samples under the above described three incubation environments were covered with aluminium foil and incubated at 30°C for 2 weeks in an anaerobic incubator.

After the incubation period, the soil samples were extracted with 2 N KCl keeping a final ratio of soil to KCl solution at 1:10. A 20-ml of the filtered extract was distilled with MgO to determine the amounts of NH_4^+ produced during incubation[3]. Direct distillation of the incubated soil samples with MgO as suggested by Waring and Bremner[16] was not followed because it inflated the values of NH_4^+-N as compared to the distillation of the filter extract (Sahrawat and Ponnamperuma[13]).

RESULTS AND DISCUSSION

The quantity of NH_4^+ found following incubation of the soil samples under the three environments showed that treatment with Nitrapyrin or incubation under N_2 gas was greater in soils that had near neutral or alkaline pH as compared to soils having pH's less than 5.3 (Table 2). These results indicate that incubation of the soil samples under N_2 gas or after treatment with Nitrapyrin checked nitrification of the ammonified N and thus reduced its subsequent loss through denitrification. This is mainly because nitrification is active in soils having near neutral or alkaline pH. The application of nitrapyrin did not affect the recovery of NH_4^+ produced during

TABLE 2

Effects of three treatments on the ammonium coment of 19 soil submerged under 2-3 cm water in test tubes and incubated at 30°C for 2 weeks.

		NH_4^+ produced (ppm of soil)		
No.	pH	Incubated in air	Incubated in N_2 gas	Incubated in air with 10 ppm Nitrapyrin
1	4.4	82 a	82 a	82 a
2	4.5	63 a	63 a	64 a
3	4.8	39 a	39 a	38 a
4	4.9	41 a	42 a	42 a
5	5.0	41 a	44 a	42 a
6	5.3	73 a	74 a	74 a
7	5.3	169 b	176 a	173 a
8	5.6	315 a	314 a	315 a
9	5.8	279 a	282 a	281 a
10	6.4	49 a	54 a	54 a
11	6.5	28 b	34 a	33 a
12	6.5	54 b	62 a	60 a
13	6.6	52 b	56 a	54 ab
14	6.9	50 b	56 a	55 a
15	7.0	47 b	53 a	54 a
16	7.0	21 b	30 a	22 b
17	7.2	17 b	21 a	20 ab
18	7.5	17 b	24 a	25 a
19	7.9	20 b	35 a	32 a

In a row, means followed
at the 50% level by DMRT.

incubation in acid pH soils probably because nitrification was at low ebb in these soils.

It was also observed that in general the soils with acidic pH released greater quantitites of NH_4^+ and this was mainly associated with the higher contents of organic C and total N in these soils. Our earlier studies have shown that the ammonification of organic N in waterlogged soils is highly correlated to organic C and total N contents but is not related to pH, CEC and clay content (Sahrawat[12]). The results of the study further emphasize the importance of exclusion of air from the soil-water system during waterlogged incubation of soils for checking possible losses of the ammonified N due to nitrification-denitrification. This can be achieved either by incubation of the soil samples under the atmosphere of an inert gas such as nitrogen or possibly by the use of nitrification inhibitors as suggested by these results.

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REFERENCES

1. Present address: International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), ICRISAT Patancheru P.O, A.P. 502324, India

2. J.M. Bremner, J. Agric. Sci. 55, 11 (1960)

3. J.M. Bremner, In C.A. Black (Ed), Methods of Soil Analysis, Part 2. Agronomy 9, 1179. Amer. Soc. Agron. Madison, Wisconsin (1965).

4. F.E. Broadbent, In International Rice Research Institute. Soils and rice. Los Banos, Philippines, 543 (1978).

5. F.E. Broadbent, In International Rice Research Institute, Nitrogen and rice. Los Banos, Philippines, 105 (1979)

6. S.C. Chang, In International Rice Research Institute, Soil and Rice, Los Banos, Philippines, 521 (1978).

7. H.D. Chapman, In C.A. Black (Ed), Methods of Soil Analysis, Part 2. Agronomy 9, 891, Amer. Soc. Agron. Madison, Wisconsin (1965).

8. P.R. Day, In C.A. Black (Ed), Methods of Soil Analysis Part 1. Agronomy 9, 562, Amer. Soc. Agron, Madison, Wisconsin (1965).

9. W.H. Patrick, Jr. and K.R. Reddy, J. Environ. Qual. 5, 469 (1976).

10. K.L. Sahrawat, Agrochimica 24, 149, (1980 a).

11. K.L. Sahrawat, Plant Soil 57, 335 (1980 b).

12. K.L. Sahrawat, Soil Sci. (submitted)

13. K.L. Sahrawat and F.N. Ponnamperuma, Soil Sci. Soc. Am. J. 42, 282 (1978)

14. H. Shiga and W. Ventura, Soil Sci. Plant Nutr. 22, 387 (1976)

15. A. Walkley and I.A. Black, Soil Sci. 37, 29 (1934)

16. S.A. Waring and J.M. Bremner, Nature 201, 951 (1964).