COMMUN. IN SOIL SCIENCE AND PLANT ANALYSIS, 10(7), 1015-1023 (1979)

AMMONIUM FIXATION IN SOME TROPICAL RICE SOILS

KEY WORDS: Ammonium fixing capacity, ammonium fixation and soil properties, active iron

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ABSTRACT

The NH_4^+ fixing capacity of 12 tropical rice soils was studied by treating 10 g soil samples with 50 mg NH_4^+ as $(NH_4)_2$ SO_4 dissolved in 20 ml of water, equilibrating for 2 h by continuous shaking and then extracting NH_4^+ with 2 M KCl. The portion of NH_4^+ added which was not extracted by KCl was termed fixed.

The NH_4^+ fixing capacity of the soils studied ranged from 3.8 to 7.7 m.e./100 g of soil. NH_4^+ fixation in soils was not related to pH, organic matter or clay content but correlated with the amount of active iron in the soils. The results of the study suggest that because of the reversible oxidation and reduction of iron oxides in rice soils, this mechanism of NH_4^+ fixation may be of special importance in sorption and desorption of NH_4^+ - N.

INTRODUCTION

It has been observed by many workers that in some soils, quantitative recovery of added NH_4^+ is sometimes not possible even when soils are extracted immediately after addition of ammonium nitrogen. The pioneering work of Mc Beth[2] on NH_4^+ fixation demonstrated that, in some soils, the added NH_4^+ could not be completely recovered by extraction with hydrochloric acid solution or by distillation with alkali. He concluded that the various anions associated with NH_4^+ did not affect fixation, that fixation is greater at 100°C than at 5°C and that NH_4^+ retention or adsorption was due to clay fixation. Since then, the subject has been investigated by many workers and reviewed by Nommik[3].

There are several kinds of mechanisms or bo nding which may be implicated in the adsorption of the NH_4^+ on clay minerals[4]. It has been shown that NH_4^+ fixation is due to trapping of NH_4^+ was within the lattice of montmorillonite and vermiculate minerals and also to the tie up by soil organic matter[5,6,7]. However, in some soils, NH_4^+ fixation has been attributed to adsorption on the amorphous soil materials like colloidal hydrated oxides of aluminum and iron or allophanic materials. There is paucity of data on NH_4^+ fixation in tropical rice soils and most of the literature on the subject pertains to upland soils.

This study was undertaken to investigate the NH_4^+ fixing or adsorbing capacity of some tropical rice soils and the soil properties affecting it. Our interest in this subject was also as a result of the preliminary observations in laboratory that some soils had the ability to fix NH_4^+ in such a manner that it was not easily replaced by cations like Na^+ or K^+ even shortly after (1-2 h) application of NH_4^+ to these soils.

MATERIALS AND METHODS

The soils (Table 1) used for the NH_4^+ fixing capacity experiments, except Aggaie sandy loam (from Nigeria) and Silo silty loam (from Taiwan) are Philippine wetland rice soils. The soil samples were air dried and ground to pass a 2-mm screen before use. For the analyses

TABLE 1

Analyses of soils used

Soil	pH (1:1)	O.M. (%)	Clay (%)	ActiveFe (%)
Aggaie sandy loam	7.4	1.0	17	0.22
Buenavista clay loam	6.3	1.1	33	1.71
Calalahan sandy loam	3.4	2.7	5	1.44
Paete clay loam	5.3	10.4	12	1.52
Luisiana clay	4.8	2.6	44	3.12
Pila clay loam	7.5	3.9	39	0.86
Quingua silty loam	6.5	2.2	18	1.94
Lipa loam	7.0	4.3	23	0.72
Maahas clay	6.5	1.6	46	1.55
Bani clay	6.1	2.4	46	0.55
Silo silty loam	7.7	2.0	26	1.02
Tiaong loam	7.1	3.9	20	0.46

reported in Table 1, pH of soil suspension (soil:water 1:1) was determined with a glass electrode, organic matter by the method of Walkley and Black[9], active iron content by the method of Asami and Kumada[10], and particle size analysis was made using the hydrometer method[11].

For determining the NH_4^+ fixing capacity of soils, the following method was adopted: To 10 g soil samples placed in 200 ml conical flasks, 50 mg NH_4^+ as $(NH_4)_2SO_4$ dissolved in 20 ml of distilled water was added. The soil suspension was equilibrated for 2 h at the room temperature by shaking it continuously in a wrist action shaker. After 2 h, the NH_4^+ in the soil sample was extracted with 2 M KCl solution by shaking for 1 h keeping a final soil to KCl ratio of 1:10. The soil suspension after shaking with KCl was filtered through a Whatman filter paper No.40. Twenty ml aliquots of the extracts were distilled with MgO and the ammonia was absorbed in 2% boric acid with mixed indicator. The NH_4^+ was determined by titration with 0.01 N H_2SO_4 (Bremner[12]). The amount of NH_4^+ not extracted by KCl from the total NH_4^+ added was deemed fixed or adsorbed by the soil. Blanks were run to correct for the amount of NH_4^+ originally present in the soil samples. All the determinations were done in duplicate.

In another experiment with Maahas clay, the NH_4^+ fixing capacity was studied by varying the amounts of NH_4^+ added from 1 to 100 mg NH_4^+/10 g soil.

The correlations between NH_4^+ fixing capacity of soils and other soil properties were calculated.

RESULTS AND DISCUSSION

Table 2 shows that the NH_4^+ fixing capacity of soils varied from 3.8 to 7.7 m.e. NH_4^+/100 g of soil, the maximum being with Buenavista clay loam and the lowest with Tiaong loam. The results on NH_4^+ fixation in Maahas clay with increasing levels of NH_4^+ application (1 to 100 mg NH_4^+/10 g of soil) showed that the recovery of NH_4^+ added remained more or less same and ranged from 85.7 to 88.1% of the NH_4^+ added.

The results further indicated that the amounts of NH_4^+ fixed increased with the increase in rate of NH_4^+ added (Table 3).

TABLE 2

NH_4^+ fixing capacity of soils

Soil	NH_4^+ fixing capacity (m.e./100 g soil)
Aggaie sandy loam	4.9
Buenavista clay loam	7.7
Calalahan sandy loam	5.2
Paete clay loam	5.9
Luisiana clay	7.3
Pila clay loam	5.7
Quingua silty loam	7.2
Lipa loam	6.3
Maahas clay	4.4
Bani clay	5.7
Silo silt loam	4.0
Tiaong loam	3.8

TABLE 3

Ammonium fixation in Maahas clay with increasing rates of NH_4^+ added

NH_4^+ added (mg/10 g of soil)	NH_4^+ recovered (%)	NH_4^+ fixed (m.e./100 g soil)
1	87.0	0.07
5	85.7	0.40
25	86.6	1.86
50	88.1	3.31
100	88.0	6.67

Another important observation was that the amount of NH_4^+ fixed in Maahas clay increased from 6.67 to 12.9 m.e./100 g soil when the organic matter in the soil was completely oxidized by hydrogen peroxide treatment and NH_4^+ was added at 100 mg/10 g soil. The increase in NH_4^+ fixing capacity may be due to more number of NH_4^+-fixing sites being exposed by hydrogen peroxide treatment.

The correlations of NH_4^+ fixing capacity of soils with other properties (Table 4) revealed that the NH_4^+ fixation was not significantly related to pH, clay content or the organic matter content but significantly correlated with the active iron content of the soils. The results of this preliminary study on NH_4^+ fixation bring out the importance of amorphous soil materials like free iron oxide in adsorbing or retaining NH_4^+ ions. Because of reversible oxidation

TABLE 4

Correlation of NH_4^+ fixation in soils with other soil properties

Soil property	Correlation cooefficient (r)
pH	-0.31 ns
O. M.	0.006 ns
Clay	0.15 ns
Active iron	0.61*

ns = not significant

* = significant at the 5% level

and reduction of iron oxides in rice soils, this mechanism is of special interest in sorption and desorption of NH_4^+ in rice soils and there is an obvious need for further elucidation on this aspect. According to a recent report[13], the amount of fixed NH_4^+ in 16 Philippine soil profiles ranged from 7 to 428 ppm and the proportion of soil nitrogen in the form of fixed NH_4^+ varied from 1 to 56% when measured by the hydrogen flouride extraction procedure. This report, along with the results from our study, indicates the importance of ammonium fixation in some tropical rice soils but its implications for the residual effect of NH_4^+ fertilizers on long term basis and its availability to plants are still not well understood.

ACKNOWLEDGEMENTS

The work reported was carried out under a postdoctoral research fellowship at the International Rice Research Institute. The author is highly appreciative of the valuable suggestions made by Dr. F.N. Ponnamperuma, Principal Soil Chemist during this study and also for critically going through an earlier manuscript of the paper.

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