

## AMMONIUM FIXATION IN SOME BANGLADESH SOILS

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### Abstract

The soils varied appreciably from one another in fixing added ammonium and it ranged from 0.00 to 181.96 lbs/A in the surface and 21.24 to 165.52 lbs/A in the sub-surface layers. Soils containing illitic mineral fixed the highest amount of ammonium followed by soils containing vermiculite while, kaolinite containing soils fixed the least. Soils containing montmorillonite fixed appreciable amount of added ammonium. Multiple correlations co-efficient between ammonium fixation and the sand, silt, and clay contents; pH; organic matter contents; exchangeable ammonium and CEC of the soils was  $+0.58(0.05)$ . A linear relationship was obtained between ammonium and potassium fixation, the equation being  $y = 34.68 + 1.17x$ , where, y is the amount of ammonium fixed in lbs/A and x is the amount of potassium fixed in lbs/A.

### INTRODUCTION

As early as 1917, McBeth established that soils possess the property of fixing added ammonium which was later on substantiated by workers like Allison *et al.* (1953, 1955); Young and McNeal (1964) and Raju and Mukhopadhyay (1974). Fixation of ammonium has an important bearing on its availability to plants. Although it limits the nitrogen availability status of soils yet, it may possibly be beneficial also as it retards the leaching loss of this ion by holding it in the clay mineral lattice, which takes part in the biological cycling and contributes to the balance of available nitrogen in soils (Mogil-evkina, 1974). Clay minerals like vermiculite, illite, biotite and halloysite are found to be effective in fixing added ammonium (Allison *et al.*, 1953, 1954; Young and McNeal, 1964;

Raju and Mukhopadhyaya, 1974). Organic matter has been found to play a positive role in the fixation of added ammonium (Mukhopadhyay and Das, 1973) but, Rajkovic and Ubavic (1974) observed inverse relationship between the two. Contrasting views exists in the literature as regards the role of soil pH on the fixation of added ammonium (Bower, 1950 and Allison *et al.*, 1953).

With these views in mind a study was made to ascertain the capabilities of some soils of Bangladesh for fixing added ammonium. An attempt was also made to relate fixation of ammonium with certain soil properties.

### MATERIALS AND METHOD

The soils included in the study represented six soil series of Bangladesh at two different depths (0-15 and 15-30 cm from surface) varying in their physical and chemical

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properties (Table 1). Mechanical analyses of the soils were done by hydrometer method as outlined by Piper (1966), and the textures were determined by using a pye glass electrode pH meter at a soil: water ratio of 1:2.5. The CEC was determined by using neutral N  $\text{NH}_4\text{OAc}$  as described by Jackson (1965). Organic matter of the soils were determined volumetrically by wetoxidation method of Walkely and Black (Jackson, 1965). Exchangeable  $\text{NH}_4^+$  was extracted with 10% acidified NaCl ( $\text{pH}_{2.5}$ ) solution and determined by steam distillation (Jackson, 1965).

**Ammonium fixation :** Ammonium fixation was studied with modification of the method described by Allison and Roller (1951). 10 ml of  $\text{NH}_4\text{Cl}$  solution containing 125 ppm of  $\text{NH}_4^+\text{-N}$  (equiva-

lent to 250.00 lbs/A) was added to 10g of each soil. The soils were then subjected to alternate wetting and drying (24 hrs each of drying and wetting) cycles over a period of 10 days. The drying was done on a water bath at a temperature of  $70^\circ\text{C}$ . The ammonium was extracted with neutral N KCl solution. Freshly treated samples of the same soils were immediately extracted with neutral N KCl solution. The difference of the amounts of ammonium between these two soils were taken as the amount of ammonium fixed by the soils during that period.

## RESULTS AND DISCUSSION

The values for ammonium fixation are presented in Table 2. The soils varied greatly (LSD = 2.059 at 1% level) from one another in fixing added ammonium, ranging from 0.00

Table 1. Some of the soil properties

Soils (Series)	Depth (cm)	Texture	pH	Clay* minerals	CEC (meq/100g)	Exch. $\text{NH}_4^+$ (meq/100g)	O.M. (%)
NOADDA	0-15	CL	6.6	I K H	15.93	0.18	1.19
	15-30	CL	6.3	I K H DI	12.98	0.12	0.81
BORDA	0-15	CL	5.2	I K H M V	15.10	0.24	1.12
	15-30	CL	6.3	I K H M V	13.45	0.19	0.72
KHILGAON	0-15	CL	4.8	K H M H I	21.71	0.14	3.40
	15-30	C	4.9	K H M H I	20.50	0.11	1.79
TEJGAON	0-15	CL	5.7	K I	12.27	0.11	1.74
	15-30	C	5.5	K I	15.81	0.20	1.11
DEMRA	0-15	C	7.0	I K M	18.92	0.17	1.87
	15-30	C	6.6	I K M	19.35	0.19	1.32
FATKI	0-15	C	7.7	I K V	29.26	0.33	1.51
	15-30	C	8.2	I K V	26.07	0.24	0.89

\*I Illite, K Kaolinite, M Montmorillonite, V Vermiculite, DI Degraded illite, HM Hydrous mica, MH Meta halloysite.

to 181.96 lbs/A in the surfaces and 21.24 to 165.52 lbs/A in the sub-surface layers of the soils studied. When considered as per cent of the added ammonium the corresponding values were 0.00 to 72.78 and 8.50 to 66.21 respectively. The soils fixed in general higher amounts of the compound in the surface than the sub-surface layers except in the Tejgaon and Demra series. It is of interest to note that the Tejgaon series which failed to fix any ammonium in its surface, fixed 21.24 lbs/A in the sub-surface. Allison *et al.*, (1953) reported that the amount of ammonium fixed from ammonium salts by soils of the humid regions was less than 360 lbs/A. The greater fixation in the surface soils was probably due to the higher amounts of organic matter in them because, the fixation was positively correlated with the organic matter contents of the soils (Tables 1

and 3). Mukhopadhyay and Das (1973) observed that the reaction between ammonium ion and soil organic matter resulted in the formation of a chemical complex in which nitrogen was not susceptible to removal by leaching with N KCl. Nevertheless, greater fixation in the sub-surface has also been reported (Singh and Dixit, 1972). Allison and Roller (1951) opined that if, (i) the organic matter content of soils is already saturated with ammonium and, (ii) K-saturation of soils is higher, then the fixation of ammonium may be blocked. This may probably explain the higher fixation of ammonium in the sub-surface layers of the Tejgaon and Demra series. These soils had higher K-saturation in their surfaces (Rashid, 1976).

The soils were grouped into three classes according to the amounts of ammonium they fixed. Class I included the soils that fixed

Table 2. Fixation of ammonium in the soils

Soils (Series)	Depth (cm)	NH <sub>4</sub> <sup>+</sup> fixed lbs/A	Percentage of added NH <sub>4</sub> <sup>+</sup> fixed
NOADDA	0-15	181.96	72.78
	15-30	157.88	63.15
BORDA	0-15	174.32	69.73
	15-30	165.52	66.21
KHILGAON	0-15	106.20	42.48
	15-30	54.72	21.89
TEJGAON	0-15	0.00	—
	15-30	21.24	8.50
DEMRA	0-15	63.72	25.49
	15-30	127.44	50.98
FATKI	0-15	166.92	66.77
	15-30	130.44	52.18

L.S.D. = 2.059(0.01)

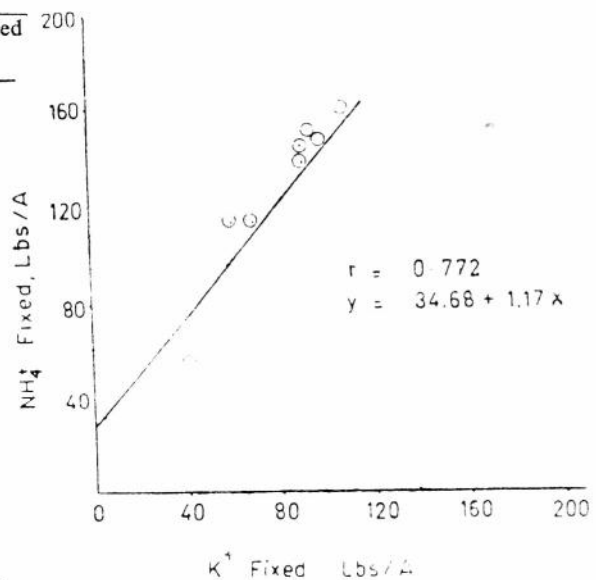


Figure 1. Relationship between Potassium and ammonium fixation in Soils.

more than 100 lbs of ammonium/A. Both the surface and sub-surface of the Noadda, Borda and Fatki series, surface layer of the Khilgaon and sub-surface of the Demra series fall in this group. With the exception of the Khilgaon series the other soils of this class contained illite as the predominant clay mineral (Table 1). They also contained vermiculite and montmorillonite as minor clay minerals. Class II consisted of the soils that fixed between 100.00 and 50.00 lbs of ammonium/A which included the surface layers of the Demra and sub-surface of the Khilgaon series. The Khilgaon series soil contained halloysite as a minor mineral. Class III included the Tejgaon series soil (both surface and sub-surface) that fixed less than 50.00 lbs of ammonium/A. Kaolinite is the predominant mineral in this soil. It contained illite as a minor mineral (Table 1). Illite was attributed the main cause for higher fixation of ammonium in the soils. Kaolinite containing soils fixed the lowest amount of ammonium. The relatively higher amounts of ammonium fixation in the Khilgaon series soil, was attributed to its halloysite contents although kaolinite was the predominant mineral in this soil. Raju and Mukhopadhyay (1974) observed that illite and vermiculite contributed to the ammonium fixation in soils. Allison and Roller (1955) considered halloysite to be capable of fixing ammonium.

The pH of the soils though not very noticeable, had some contribution to the fixation of ammonium. The soils with pH above 6.0 generally fixed comparatively higher amounts of the compound and the fixation was positively related to the soil pH (Table 3). Singh (1971) stated that raising the pH of a soil increases the ammonium fixation. Exchangeable ammonium was found to be

effective in the fixation process. Ammonium fixation was positively related to the CEC and the exchangeable  $\text{NH}_4^+$  of the soils (Table 3). The soils with relatively high amount of exchangeable  $\text{NH}_4^+$  were also high in their capabilities for fixing added ammonium. This is an indication that the exchangeable ions are the seats of fixation reaction (Bower, 1950). The effect was similar to the addition of greater amounts of ammonium; and it is a well known fact that upto a certain limit, determined by the nature of the soil, the magnitude of the ammonium fixation increases with the increase in the addition of ammonium (Grewal and Kanwar, 1967). Insignificant positive relationship between ammonium fixation and the silt and clay contents and inverse relationship between ammonium fixation and the sand contents of the soils were obtained (Table 3).

It is of interest to note that while no significant relationship existed between the amount of ammonium fixed and the individual variables a better relationship was obtained when all those factors were collectively considered, the value being + 0.58(0.05). This

Table 3. Co-efficients of correlation between ammonium fixation in soils and some soil properties

Variables	r
Ammonium fixation and per cent sand	- 0.526
Ammonium fixation and per cent silt	+ 0.042
Ammonium fixation and per cent clay	+ 0.393
Ammonium fixation and pH	+ 0.088
Ammonium fixation and organic matter	+ 0.167
Ammonium fixation and exchangeable $\text{NH}_4^+$	+ 0.197
Ammonium fixation and CEC	+ 0.435
Multiple correlation co-efficient	+ 0.580*

\* Significant at 5 per cent level

suggested that these factors were probably responsible for the variation in the ammonium fixing capabilities of the soils. Relationship between ammonium and potassium fixation in soils. Potassium fixation was also studied with these soils (Rashid, 1976). A correlation study was made between ammonium and potassium fixation in the soils to see whether similar mechanism existed for the both. The correlation study between them ( $r = +0.772$  at 1% level of significance) revealed that similar mechanism existed for fixation of both the ions. Barshad (1951) stated that a wide variety of soils have the ability to fix alike  $\text{NH}_4^+$  and  $\text{K}^+$ .

To observe more specifically their relationship amongst individual soils, a regression line was drawn (Figure 1). The calculated prediction equation is,

$$y = 34.68 + 1.17x, \text{ where,}$$

$y$  = amount of ammonium fixed in lbs/A  
 $x$  = amount of potassium fixed in lbs/A

A comparison of the amounts of potassium and ammonium fixed by the same soils showed that in most cases ammonium was fixed in greater amounts. While ammonium fixation was positively related to the organic matter content of the soils, potassium fixation (Rashid, 1976) was not. It was, therefore, concluded that ammonium fixation was caused not only by the clay minerals alone as in the case of potassium but also by the organic matter reserve of the soils as well.

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