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EFFECT OF PVA AS SOIL CONDITIONER ON POTASSIUM AND AMMONIUM FIXATION IN SOME REPRESENTATIVE SOILS OF BANGLADESH

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Abstract

Fixation of both native and added K^+ and NH_4^+ differed significantly among the soils. Potassium fixation increased significantly with increasing rates of K addition. Treating the soils with polyvinyl alcohol (PVA) prior to fixation experiment significantly decreased the rate of K-fixation in all soils except one at PVA application rate of 2000 $\mu g\ g^{-1}$. PVA did not have depressing effect on K-fixation when added at 1000 $\mu g\ g^{-1}$ rate in most cases. On the other hand, addition of PVA to the soils resulted not only in the decrease of ammonium fixation but also on the release of ammonium in most cases, which increased with increasing concentration of added NH_4^+ in soils, and the amount released increased with increasing concentration of PVA. Application of PVA or related high molecular soil conditioners could be used for better K^+ and $NH4^+$ fertilizer use efficiency.

Introduction

The soil conditioners, mostly polymers of organic origin, are likely to interact with clay minerals in a similar manner as organic matter and affect potassium and ammonium fixation in soils. Only limited information is available on the penetration of polymers in the interlayers of clay minerals and its effect on potassium and ammonium fixation (1). Since addition of organic matter to the soil tends to decrease potassium fixation in soils (2), and as high molecular weight polymers are like organic colloids, it is likely that the addition of soil conditioners e. g., polyvinyl alcohol (PVA) will also decrease the same in soil. Imamul Huq *et al.* (3) observed that addition of tamarind gum polymer was effective in reducing K-fixation in some representative Bangladesh soils. It has further been shown that addition of soil conditioners such as organic matter, polymer etc. improved the physical condition of soils (4) which might influence the NH_4^+ fixing capacity of the soils and increase NH_4^+ fertilizer use efficiency. The present work was aimed at studying fixation of K^+ and NH_4^+ as affected by polymer addition in three representative Bangladesh soils.

Materials and Methods

Soil samples were collected from a well represented catena, Sara series from ridge, Rathuria from the middle part and Ghior series from the basin. Some of the physical and chemical properties of the soils are summerised in Table 1.

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Table 1. Some physico-chemical properties of the soils under study.

Soil Properties	Sara series	Rathuria series	Ghior series
% Sand	13.9	15.9	11.0
% Silt	57.5	48.2	42.0
% Clay	28.6	35.9	47.0
Texture	SiCL	SiCL	SiC
pH	6.2	7.2	6.0
CEC, meq%	17.4	22.6	28.4
Organic C,%	0.97	0.62	0.92
Organic matter, %	1.7	1.1	1.6
Total K, meq%	12.3	14.3	17.9
Exchangeable K, meq%	0.3	0.4	0.6
Water soluble K, meq%	0.2	0.2	0.4
Total Nitrogen,%	0.07	0.10	0.14
Exch. NH_4^+, meq%	0.04	0.09	0.09
C:N ratio	14:1	6:1	6.5:1
Available P, $\mu g\ g^{-1}$	200	145	170
Total P, $\mu g\ g^{-1}$	710	680	590
Total Na, %	0.10	0.08	0.08
Total Mn, $\mu g\ g^{-1}$	680.9	876.5	727.9
Total Zn, $\mu g\ g^{-1}$	229.4	329.4	328.6

Polymer application. The water soluble polymer (polyvinyl alcohol - PVA, mol wt. about 30,000; BDH chemicals Ltd. England) was applied to the soils following the procedure as described in (3). Two rates viz., 1000 and 2000 $\mu g\ g^{-1}$ soil were used. The polymer treated soils were washed with distilled water, oven dried at 80°C for 48 h, ground and sieved through 100 mesh sieve. These soils were then used for the K^+ and NH_4^+ fixation studies.

Fixation experiment. The fixation study was made following the method as described in (3). Two sets of soils (one polymer treated and the other without polymer treatment) were used for the experiment. Potassium and NH_4^+-N were added at the rates of 50,100 and 150 $\mu g\ g^{-1}$ soils which were equivalent to 112.28, 224.55, 336.81 kg ha^{-1} and the salts used were of Analar grade KCl and NH_4Cl respectively. After completion of 5 cycles of alternate wetting and drying, the soils were extracted with 0.1N HCl and acidified with 1N NaCl (pH 3.0) for K^+ and NH_4^+ respectively. 10 ml portions of KCl and NH_4Cl solutions of the same concentrations as above were added to fresh 10g samples of the same soils and were immediately extracted. The difference between the amount of K and NH_4 extracted from these samples and the amounts of K and NH_4 extracted from

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the corresponding samples subjected to alternate wetting/drying cycles were taken as the amount fixed by the soils.

Results and Discussion

Potassium fixation in soils and effect of PVA. The soils differed significantly from one another in respect of their capacities for fixing potassium. Highest amount of K was fixed in the Ghior series soil when K was added at the rate of 150 µg g^{-1} (Table 2), the amount being 0.37 meq%. Significant amount of K was fixed by this soil when it was treated with 50 or 100 µg K g^{-1} soil. As expected, lowest amount of potassium fixation was noted in all the soils when no K was added. From correlation study it was observed that potassium fixation in soil increased significantly with increasing rates of K addition (Fig. 1). Similar observations were reported by others (3, 5, 6).

Table 2. Amount of potassium fixed (meq%) in PVA treated and untreated soils.

Soil series	Amount of K added, µg g^{-1}	PVA untreated soil	1000 µg g^{-1} PVA treated soil	2000 µg g^{-1} PVA treated soil
	0	0.02	0.08	0.10
	50	0.08	0.13	0.13
Sara	100	0.17	0.15	0.17
	150	0.24	0.26	0.33
	0	0.10	0.10	0.09
	50	0.15	0.20	0.12
Rathuria	100	0.26	0.23	0.12
	150	0.29	0.31	0.18
	0	0.06	0.11	0.02
	50	0.28	0.12	0.03
Ghior	100	0.32	0.19	0.08
	150	0.37	0.20	0.11

Addition of PVA significantly decreased the rate of K-fixation in all soils except in the Sara series, at PVA application of 2000 µg g^{-1}. The decrease was maximum at K application rate of 150 µg g^{-1} in Ghior series, the amount being 0.26 meq%, as compared to soils without PVA treatment. The lowest decrease in fixation (0.03 meq%) over untreated soils was observed in Rathuria series at K application of 50 µg g^{-1} (Table 2). In all cases the magnitude of K fixation decrease was greater at 2000 µg g^{-1} PVA applications. Similar trends, with the exception of Sara, was observed for native K-fixation. Potassium fixation in PVA treated

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soils was found to correlate with the addition of K, the values for 'r' being 0.86** and 0.64* for 1000 and 2000 µg g^{-1} PVA, respectively (Fig. 1). These results agree with the findings of others (2, 3, 7, 8).

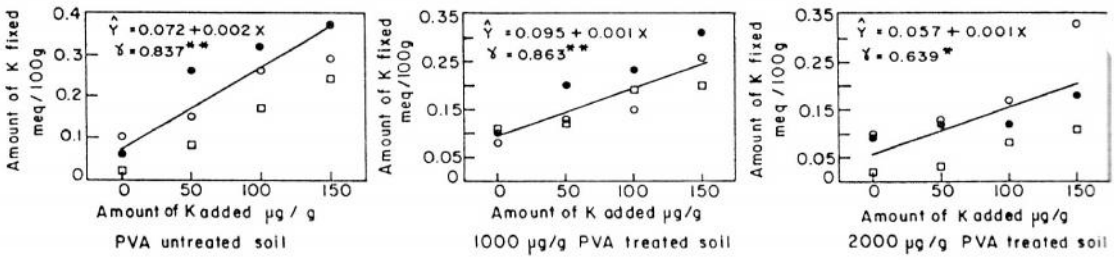

Fig. 1. Relationship between potassium added and potassium fixation in non-PVA and PVA treated soils.

Ammonium fixation in soils and effect of PVA. The soils varied much from one another in respect of their capacities for fixation of ammonium. Ammonium fixation in soils not treated with PVA increased significantly with increase in the amount of added ammonium in Sara and Rathuria series soils, whereas in Ghior series, though not significant, ammonium was found to be released after treating the soils with the compound. The highest amount of fixation was recorded in Rathuria soils when ammonium was added at the rate of 150 µg g^{-1} soil and the lowest fixation was noted in this soil when it was treated with 50 µg g^{-1} soil, the amount being 0.22 and 0.06 meq%, respectively (Table 3).

It was observed that with increasing addition the percentage of ammonium fixation decreased in most cases, the lowest percentage being recorded for Rathuria series soils when it was treated with 100 µg NH_4^+ g^{-1} soil, the amount being 14.3% and the highest percentage of fixation was noted in Sara series soil when it was treated with 50 µg NH_4^+ g^{-1} soil, the figure being 35.7% over control. Similar results were also reported by others (9,10).

Addition of PVA, not only decreased the ammonium fixation in soils, but also released ammonium in most cases, as compared to PVA untreated soils. The release of ammonium increased with increasing concentration of added NH_4^+, which ranged from 0.15 to 0.34 meq% in Sara, 0.04 to 0.17 meq% in Rathuria and 0.01 to 0.14 meq% in Ghior series soils. The highest amount released (0.34 meq%) was observed in 2000 µg g^{-1} PVA treated soils of Sara, when NH_4^+-N was added at the rate of 150 µg g^{-1} soil and the lowest (0.10 meq%) was recorded in 1000 µg g^{-1} PVA treated soils of Ghior series, when NH_4^+-N was added at 100 µg g^{-1}

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Table 3. Amount of ammonium fixed and/reseased (meq%) in PVA treated and untreated soils.

Soil Series	Amount NH_4^+ added, μ/g	PVA Untreated soils	1000 μg g^{-1} soils	2000 μg g^{-1} soils
	0	0.03	- 0.09	- 0.10
	50	0.10	- 0.13	- 0.09
Sara	100	0.12	- 0.03	- 0.11
	150	0.15	- 0.13	- 0.19
	0	0.03	- 0.02	0.09
	50	0.06	0.02	0.10
Rathuria	100	0.08	0.08	0.15
	150	0.22	0.05	0.16
	0	0.02	- 0.04	- 0.07
	50	- 0.09	- 0.15	- 0.12
Ghior	100	- 0.14	- 0.15	- 0.08
	150	- 0.04	- 0.18	- 0.05

'-' signs indicate release, other denote fixed.

soil rate (Table 3). A study of the Table 3 reveals that addition of PVA at different concentrations released the native ammonium in soils. In most cases, the amount of ammonium released increased with increasing concentration of PVA compared to PVA untreated soils. The maximum release was observed in 2000 μg g^{-1} PVA treated soils of Sara and the minimum in 1000 μg g^{-1} PVA treated soils of Rathuria series, the amounts being 0.10 and 0.02 meq%, respectively.

From the above results it is clear that, addition of PVA at different concentrations caused release of native as well as added NH_4^+ from the soils. It has been reported that both K^+ and NH_4^+-fixation in soils are directly related (11). Imamul Huq *et al.* (3) working with one salt-affected and one normal soil of Bangladesh observed that addition of ploymer reduced K-fixation in soils. As the addition of polymer to the soils reduced K-fixation in soils and since the mechanism of fixation of both K^+ and NH_4^+ in soils are more or less similar (12), it is quite likely that the observed decrease/release in the fixation of added as well as native ammonium in soils was due to polymer addition. Polymer might have blocked the entry of NH_4^+ to the fixation sites or prevented collapse of the basal spacing of the minerals as does organic matter in similar situations (13). Working with some Canadian soils, Hinman (13) found destruction of organic matter with H_2O_2 resulted in an increase in NH_4^+- fixation. Agrawal and Kumar (4) reported that the addition of 0.5% PVA improved soil structure of surface

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0-15 cm layer. They applied NH_4NO_3 to a field at a rate of 100 kg ha^{-1} and submerged the field and observed that in all cases, NH_4^+- N levels were highest in 0-10 cm layer, indicating that PVA was effective in reducing NH_4^+ fixation.

References

1. Jones, M. B., P. F. Pratt and W. B Martin. 1957. The effect of HPAN and IBMA on the fixation and availability of potassium in several Ohio soils. Soil Sci. Soc. Amer. Proc. **21**: 95-98.
2. Imamul Huq, S. M., M. H. Rashid and A. Islam. 1979. Effect of acid leaching, liming and organic matter additions on potassium fixation in some Bangladesh soils. Dacca Univ. Stud. B., **27** (2): 205-210.
3. Imamul Huq, S. M., H. Khatun and H. Ahmed. 1990. Effect of polymer on potassium fixation in soils. Bangladesh J. Soil Sci. **21** (1): 1-7.
4. Agrawal, R. P. and R. Kumar. 1978. Nitrogen movement as influenced by initial soil wetness, soil texture and soil structure of the surface layer. Proc. Nat. Symp. Hissar, India, Oct. 1976 (Sen, S. P., Y. P. Abrol, S. K. Sinha, eds.) New Delhi. Associated Publishing Company pp. 260-268.
5. Mathur, S. K., N. K. Goswami and N. R. Talati. 1981. Fixation of potassium in north west Rajsthan soils. Trans. Indian Soc. Desert Technology and University Center of Desert Studies. **6** (2): 29-32.
6. Sahu, S. and S. K. Gupta. 1987. Fixation and release of potassium in some alluvial soils. J. Ind. Soc. Soil Sci. **35**: 29-34.
7. Chakrovorti, S. P. and S. Patnaik. 1980. Fixation and release of K in flooded rice soils. J. Ind. Soc. Soil Sci. **38** (2): 243-247.
8. Khan, A. H., M. Billah. 1987. Studies on the effect of adsorbed water soluble polymers on soil properties. M. Sc. Thesis. Dept. of Chemistry, Dhaka University.
9. Opuwaribo, E. and C. T. I. Odu. 1978. Ammonium fixation in Nigerian soils: 4. The effect of time, potassium, and wet and dry cycles on ammonium fixation. Soil Sci. **125** (3) : 137-145.
10. Juang, T. C. and C. C. Tann. 1989. Effect of drying-wetting treatment of expanding clay minerals on ammonium fixation in soils. J. Chin. Agric. Chem. Soc. **27** (4): 505-514.
11. Imamul Huq, S. M., A. Islam and M. H. Rashid. 1978. Ammonium fixation in some Bangladesh soils. Bangladesh J. Agric. **3** (3): 343-347.
12. Nommik Hans and Kaarel Vahtras. 1982. Retention and fixation of ammonium and ammonia in soils. In: *Nitrogen in Agriculture* (Frank J. Stevenson, ed.). pp. 123-171. 2nd edition. ASA-CSSA-SSSA, 677 South Segoe Road, Madison, WI 53711, USA.
13. Hinman, W. C. 1966. Ammonium fixation in relation to exchangeable K and organic matter content of two Saskatchewan soils. Can. J. Soil Sci. **46**: 223-225.

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