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EFFECT OF POLYMER ON POTASSIUM FIXATION IN SOILS

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ABSTRACT

Water soluble polymer of tamarind gum isolated from the seeds of tamarind (Tamarindus indica)*, was used as a soil modifier on two soils: salt affected and normal, and its effect on K-fixation was studied. Polymer treatment was effective in decreasing fixation of both native potassium and added potassium in both the soils. However, when the soils were treated with the polymer after removing organic matter from them by H202 treatment, K-fixation was found to have increased in both soils. Attempt was made to correlate observed K-dynamics with the CEC of the soils and the polymer adsorbed on it.*

INTRODUCTION

The efficiency of K-fertilizer use in soils is determined, among others, by the extent the element gets fixed. Soil retains a certain proportion of added K in such a way that it becomes available to plant roots over a long period of time when the potassium status of the soil is sufficiently lowered (Arnold 1962). This behaviour of potassium in soils has been ascribed to fixation process which is primarily a function of the clay mineralogy of the soil (Rashid et. al 1973). Most of the K is fixed under moist conditions by illite while considerable portion of K is fixed by vermiculite or minerals containing expanded mica during drying of the soil. The wetting and drying tend to increase the fixation of fertilizer potassium (Karim 1980, Rashid et.al. 1973). However, factors like particle size, organic matter status and soil reaction are some other important parameters that affect K-fixation process in soils (Anon. 1988, Sparks and Huang 1985, Imamul Huq et.al. 1979). Addition of organic matter has been found to cause a decrease in K-fixation (Imamul Huq et.al. 1979, Zolataev and Bokter 1973) while removal of it from soil caused an increase in K-fixation (Imamul Huq et.al. 1976).

During the recent past much interest has been shown on the use of soil conditioners for improving soil physical properties (De Boodt and Gabriels 1973, Allison and Moore 1956). Most of the polymers used are water solubles like HPAN, IBMA, PAM, PVA, PVAc, VAMA, Starch etc. (De Boodt and Gabriels 1973, Allison 1956, Chepil 1954). Use of non- ionic aliphatic polymer (PVA), carboxylated aliphatic polymer (PAA), co-polymers (VAMA and HPAN) etc. on the swelling of montmorillonite is also in report (Emerson 1963). Informations regarding the effect of soil conditioners on nutrient interactions are quite limited (Haque 1987, Khan 1987, Jones et.al. 1957, Allison 1956).

It is expected that while improving soil physical properties, soil conditioners will also influence the K-fixing capacity of soils and increase K- fertilizer use efficiency. Keeping this fact in view, an attempt was made to study the effect of tamarind seed polymer as a soil conditioner on the K- fixation/release capacity of two different types of soils of Bangladesh.

MATERIALS AND METHODS

Two soil samples representing two soil series, viz., Amtali and Polashbari, were used in the experiment. The Amtali soil is salt affected while Polashbari soil is a normal one. Some of the soil characters are presented in table 1. The air dry soils were treated with 30% H202 to remove organic matter from them (Imamul Huq et.al. 1976).

Table 1: Some of the soils under study

Soils	Texture	PH	O.C.	O.M.	Total N	CEC me%	
			%	%	%	Normal	Polymer treated
Amtali	C	7.1	0.50	0.86	0.07	6.39	7.06
Polashbari	L	6.7	0.28	0.48	0.04	4.42	4.74

Water soluble polymers of tarmarind seeds were isolated and purified following the procedure developed by Rao and Srivastava (1973). This polymer gum was used to treat the soils. 1000 ml of 2500 ppm polymer solution was added to 100 g of soils before and after removal of organic matter. The suspension was stirred for about 15 minutes and was left for 24 hours. The supernatant was discarded and fresh portions of 1000 ml of the polymer solution was added to the soils to ensure the complete adsorption of the polymer on the soils. The polymer treated soils were washed with distilled water, oven dried at 80°C for 48 h, ground and seived through 90 mesh seive.

These polymer treated soils as well as the non-treated soils were then used for the K-fixation study. To each category of soils (normal soils, organic matter removed soils, polymer treated normal soils, polymer treated organic matter removed soils) K in the form of KCL solution at concentrations of 0, 125, 250 and 500 ppm were added. K-fixation in these soils were simulated in the laboratory and studied following the procedures described in Imamul Huq et.al. (1976).

Analyticals: *pH of the soils was determined by a pH meter at a soil: water ratio of 1:2.5; total carbon by Walkley and Black(1947) wet oxidation method; total nitrogen by alkali distillation of the Kjeldahl digest (Black 1965). Organic matter was calculated by multiplying the % organic carbon with 1.72. CEC of the soils was determined by NH+-saturation method (Black 1965). Soil-K was extracted by shaking the soil for half an hour with 1N NH4OAc at pH 7.0. The soil: extractant ratio was maintained at 1:10. All experiments were done in triplicates and the results presented in the text are averages of three individual replicates.*

RESULTS AND DISCUSSION

In presenting the results, the legends A1,A2,A3,A4 and P1,P2,P3 and P4 have been used to indicate the soils of Amatali (all As) and Polashbari (all Ps) for soils with organic matter and not treated with polymer (A1,P1), soil with O.M. but treated with the polymer (A2,P2), soil without O.M. but treated with the polymer (A3,P3) and soil without O.M. but treated with polymer (A4,P4) respectively.

Fixation of available K: The available potassium in the two soils and its possible fixation in them when subjected to five cycles of wetting and drying are presented in table 2(a,b). Amtali soil was found to be richer in available K than Polashbari soil. On treating the soils with the polymer, 1N NH40Ac extractable K was found to have

Table 2: Fixation of available K in Amtali and Polashbari soils as affected by Polymer treatment. (a) in whole soil (b) in soils where O.M. has been removed.

a)

Soil	Potassium in mg 100^{-1} g soil		
	1N NH40Ac extractable K	1N NH40Ac extractable K after 5 cycles of wetting and drying	Amount of K fixed
A1	9.50	7.27	2.23
A2	11.50	10.83	0.67
A3	8.67	6.00	2.67
A4	6.17	4.83	1.34
b)			
A3	9.17	8.17	1.00
A4	10.67	9.17	1.50
A3	12.67	12.34	0.33
A4	7.83	7.17	0.66

increased in the saline Amtali soil while it showed a significant decrease (ca.28%) in the Polashbari soil. A similar situation was observed when the organic matter removed soils were considered. A higher content of 1N NH40Ac extractable K in the saline soil obtained for the polymer treated ones is probably an indication of the release of some non-exchangeable K from the interlayer of clay. The macromolecules like small organic molecules have a tendency to enter the interlayer of the layer expanding type of clays and inverse the d001 spacings which decrease the electrostatic interaction between the positively charged ions and negatively charged layers thereby facilitating the extraction of non- exchangeable ions. The reverse situation in Polashbari soil could be attributed possibly to its clay mineralogy and low organic matter content.

Amount of K fixed was higher in normal soils than in polymer treated soils in both the cases. The phenomenon is comparable to the effect of organic matter addition where K-fixation was found to have decreased (Imamul Huq et.al. 1979). It could be assumed that the watersoluble polymer blocks the interlayer position of clay in a similar way to that of organic colloids. This prevents the K ion to enter the inter lattices. However, the situation was reverse and remained somewhat unexplained when the organic matter removed soils were considered. It could be that during organic matter removal, which is a destructive procedure, the clay structures have collapsed.

Fixation of added potassium: 5 ml portions of 125, 250 and 500 ppm K+ (from KC1 solution) were added to the various soils, to 5 g each, giving additions of 62.50, 125.00 and 250 mg K per 100 g soil. Results on the fixation of these added K are presented in table 3(a, b).

Table 3: Fixation of added K in Amtali and Polashbari soils treated or not with tarmarind gum polymer. (a) Amtali soil (b) Polashbari soil

a)

K added, mg 100^{-1}g soil	1N NH_40Ac extractable K, mg 100^{-1}g soil												
	A1			A2			A3			A4			
	1	2	3	1	2	3	1	2	3	1	2	3	
0.00	9.50	7.27	2.23	11.50	10.83	0.67	9.17	8.17	1.00	10.67	9.17	1.50	
62.50	16.17	14.83	1.34	28.50	30.42	-1.92	21.17	18.17	3.00	23.17	20.83	2.83	
125.00	31.00	22.30	8.70	40.50	45.50	-5.00	41.00	34.67	6.33	48.17	36.67	11.50	
250.00	60.17	30.33	29.84	76.00	78.00	-2.00	82.50	71.50	11.00	96.77	68.33	28.44	

b)

	P1			P2			P3			P4			
	1	2	3	1	2	3	1	2	3	1	2	3	
0.00	8.67	6.00	2.67	6.17	4.83	1.34	12.67	12.33	0.34	7.83	7.17	0.66	
62.50	19.67	10.83	8.84	24.67	11.33	13.34	26.83	24.34	2.49	18.00	23.00	-5.00	
125.00	30.33	19.83	10.50	43.50	19.50	24.00	39.00	36.00	3.00	33.00	35.67	-2.67	
250.00	47.67	34.17	13.50	86.67	34.33	52.34	78.33	71.67	6.66	53.00	85.00	-32.00	

In an ideal situation where there is no K-soil interaction, total extracted K is simply the algebraic sum of available K of the soil and the added K which could be represented by the equation $Y = a + IX$, where Y is the total K extracted, 'a' is available K, 'X' is the added K, 'I' is a measure of clay-K interaction. If there is no K-soil interaction, 'I' will be equal to unity. 'I' less than unity means a positive K fixation in which case the amount of K extracted will be less than the algebraic sum of 'a' and 'X'. The value of 'I' could also be negative in which case no fixation occurs.

It is apparent from table 3 that there is a fixation of added K even when the soil is shaken for only half an hour with KC1 solution, the proportion of extracted K and added K remaining almost static in all additions of K for both soils. However, the amount of extracted K decreased when the soils were subjected to five cycles of wetting and drying leading to fixation in both the soils. In the polymer treated whole soil (no organic matter removal) the amount of extracted K after half an hour shaking increased dramatically in both the soils. The amount of K extracted after five cycles of wetting and drying was almost double the amount when the soils were not treated with the polymer for Amtali soil indicating a negative fixation (table 3a) while it remained almost the same for polymer treated samples of Polashbari soil. In the organic matter removed soil of Amtali, polymer treatment resulted in a higher amount of extracted K after half an hour shaking while the K extracted after wetting and drying cycles was almost the same in both polymer treated and untreated soils.

1,2,3 indicate respectively K extracted after half an hour shaking with 1N NH4OAc, K extracted after 5 cycles of wetting and drying of the soils and then shaken for half an hour with 1N NH4OAc and amount of K fixed.

The situation was a bit different for Polashbari soils.

The amount of K apparently fixed by the soils are obtained as:

K apparently fixed = (K-extracted after 30 min.shaking + amount K added) - K extracted after alternate wetting and drying cycles.

The calculated amount of K thus fixed are presented in table 4. It is apparent that polymer treatment in the whole soils of both Amtali and Polashbari had negative effect on K- fixation. The polymer caused reduction in K-fixation, being more in Amtali soils than in Polashbari soils at all levels of K additions. The K fixation was also reduced in soils where no K was applied. An average of about 20% less fixation for any level of K addition was noted for Amtali soils and about 5% less for Polashbari soils when the soils were treated with the tamarind gum polymer. The differences in the magnitude of K desorption could be attributed to the differences in organic matter content, CEC and clay contents of the individual soils.

Table 4: Amount of K apparently fixed in soils treated with TG polymer (a) Amtali soil (b) Polashbari soil

a)

K added mg 100^{-1}g soil	Amount of K fixed mg 100^{-1}g soil			
	A1	A2	A3	A4
0.00	2.23	0.67	1.00	1.50
62.50	57.17(91.47)	43.58(69.78)	50.00(80.80)	52.34(83.74)
125.00	112.20(89.76)	91.00(72.80)	99.50(79.60)	98.00(78.40)
250.00	229.17(91.67)	183.50(73.40)	187.67(75.00)	192.34(76.94)

b)

	P1	P2	P3	P4
0.00	2.67	1.34	0.33	0.66
62.50	60.34(96.54)	57.34(91.74)	50.83(81.30)	47.33(75.73)
125.00	113.84(91.07)	111.67(89.33)	101.67(81.30)	97.16(77.73)
250.00	224.50(89.80)	221.84(88.74)	191.00(76.40)	172.83(69.13)

Figures in parentheses indicate the percent of added K fixed

The soil conditioners, mostly polymers of organic origin, are likely to interact with clay minerals in a similar manner as organic matter and effect K fixation in soils. It is known, however, that these polymers interact in a significantly complex way. Polymer adsorption is irreversible and molecular weight dependant. Only limited information is available on the penetration of polymers in the interlayers of clay minerals and its effect on K fixation (Clapp et.al. 1968, Jones et.al.1957). K fixation in modified soil could be related to the extent of adsorption of the gum which is again related to the clay complex present in the soil samples. Detailed investigation with model clay systems needs to be done to elucidate the effect of polymer induced modification on K- fixation phenomena.

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