Dacca University Studies, B, XXVII (2) : 205—210, 1979, (July)

EFFECT OF ACID LEACHING, LIMING AND ORGANIC MATTER ADDITIONS ON POTASSIUM FIXATION IN SOME BANGLADESH SOILS

S. M. IMAMUL HUQ, M. H. RASHID and A. ISLAM
Department of Soil Science, University of Dacca, Bangladesh.

Abstract

Lowering of pH by acid leaching reduced the fixation of added K while the same was increased on liming the soils. Addition of organic matter to the soils decreased the fixation of K in all the soils excepting one.

Introduction

The rate and magnitude of potassium fixation in soils are affected by several factors. It has been reported that raising the pH of a soil by liming increases K fixation, and lowering the pH by acid leaching decreases the same (Karim and Malek 1956, McLean 1962, and Varbanova *et al.* 1975). That addition of organic matter to the soil decreased potassium fixation has been reported by Karim and Malek (1956), Hinman (1966) and Zolotaev *et al.* (1973). The present investigation was aimed at studying the influence of the above mentioned factors on potassium fixation in some representative soils of the country.

Materials and Methods

The soils included in the study were collected from different sites of Bangladesh following soil survey map published by the Soil Survey Department, Ministry of Agriculture, Govt. of the People's Republic of Bangladesh. Some of their physical and chemical properties are presented in Tables l-a and l-b respectively. The pH of the soils that have values higher than 5.5 (Table l-b) was lowered by leaching them with 0.0875 N and 0.175 N acetic acid for 10 days. The surface soils of the Borda, Tejgaon and Khilgaon series were treated with lime at the rates of 5,000, 10,000 and 20,000 pounds per acre. Organic matter from two different sources, *viz.*, glucose and starch was added at the rates of 100, 200, and 400 pounds per acre to the surface and sub-surface samples of all the soils. The fixation study was made following Volk's (1934) method as described by Jackson (1958) with slight modification. Potassium was added at the rate of 250 pounds per acre in the form of KCL solution.

Table 1a. Physical properties of the soils.*

Soil series	Area	Topography	Soil tract	Parent material	Drainage	Colour	Texture
Noadda	Savar, Dacca	Nearly level terrace	Madhupur	Tertiary and pleistocene sediments	Somewhat poor. Intermittently shallowly flooded for several days following heavy monsoon rainfall	Pale brown (10YR6/3, dry) to dark brown (10YR4/3, moist)	Loam
Borda	Chota Balakandi Dacca (near Meghna river)	Basin	Middle Meghna Meghna fflood plain	Young alluvium	poor to very poor. Seasonally flooded upto 10-12 feet for more than 6 months	Light grey (N7/, dry) to gray (NS/, moist)	Clay loam
Khilgaon	Joydebpur, Dacca	Level bottom of broad valley	Madhupur	Tertiary and pleistocene sediments	Poor; seasonally flooded upto about 10 feet about 6 months	Grey (N5/, dry) to dark grey (N/4, moist)	Clay
Tejgaon	Joydebpur, Dacca	Nearly level summit of gently rolling dissected terrace	Madhupur	Tertiary and pleistocene sediments	Well to moderately well; above flood level	Brown (7.5YR5/4, dry) to dark brown (7.5YR3/2, moist)	Clay loam
Demra	Joydebpur, Dacca	Nearly level terrace	Madhupur	Tertiary and pleistocene sediments	Poor; seasonally flooded upto 1 ft. for about 3—4 months	Light grey (N/7, dry) to grey (N/5, moist)	Clay
Fatki	Amla Experimental Farm, Kushtia	Nearly level basin sites to very gently undulating levees.	Gangetic alluvium	Gangetic alluvium	Not subjected to flooding during dry season, the internal drainage ranges from very slow in the basins to slow in the levees.	Dark greyish brown (2.5Y4/2, moist) to olive (5Y5/3, moist)	Clay

*Information collected through the courtesy of Soil Survey Dept., Ministry of Agriculture, Govt. of Bangladesh.

Table 1b. Chemical properties of the soils.

Soils (series)	Depth inches	pH	Org. Matter %	CEC meq/ 100g.	Total K %	Exch.K mg/ 100g.	Total N %	Clay Minerals
Noadda	0-6	6.6	1.19	15.93	0.48	3.47	0.12	IKH
	6-12	6.3	0.80	12.98	0.32	5.25	0.08	IKH DI
Borda	0-6	5.2	1.82	15.10	0.66	7.83	0.08	IK HM V
	6-12	6.3	0.71	13.45	0.66	2.91	0.07	IK HM V
Khilgaon	0-6	4.8	3.40	20.50	0.72	11.00	0.19	K H MH
	6-12	4.9	1.79	21.71	0.72	9.59	0.09	K H MH
Tejgaon	0-6	5.7	1.74	12.27	0.69	15.55	0.08	K I
	6-12	5.5	1.11	15.81	0.72	14.49	0.12	K I
Demra	0-6	7.0	1.87	18.92	0.69	7.28	0.18	I K M
	6-12	6.6	1.32	19.35	0.72	6.82	0.08	I K M
Fatki	0-6	7.7	1.51	29.26	0.77	13.59	0.13	I K V
	6-12	8.2	0.89	26.07	0.92	12.96	0.02	I K V

*I=illite; K=Kaolinite; H=Halloysite; M=Montmorillonite; V=Vermiculite; DI=Degraded illite; HM=Hydrous mica; MH=Metahalloysite (Rashid 1975).

Results and Discussion

The amount of added potassium fixed after acid leaching of the soils, lime treatment and organic matter additions are presented in Tables 2, 3 and 4(a, b) respectively.

Acid leaching : A study of the Table 2 indicates that the decrease in pH produced by acid leachihg of the soils caused a decrease in K fixation in them. The lowering of K fixation was observed in two of the three soils, the values being 7.09 and 17.64 per cent for the 0.0875 N acetic acid and 11.02 and 44.16 per cent for the 0.175 N acetic acid treatment in the Noadda and Demra soils respectively over the untreated ones. The Fatki series soil did not show any decrease in K fixation. The clay minerals of this soil contain vermiculite in addition to illite (Table 1b). Moreover, the soil has some degraded open mica from which potassium was not removed by acid treatment. This might have caused to fix added potassium subsequently when subjected to fixation treatment. The decrease in pH and potassium fixation was found to be positively correlated. The decrease in K fixation due to lowering of pH by acid leaching has been attributed to the release of aluminium (Page and Ganje 1964) which occupied the interlayer position usually occupied by potassium. It seems from the critical examination of the data that soil reaction might have played a role in the potassium fixation though the influence of the other factors can not be overruled.

Table 2. Potassium fixation in the acid leached soils.

Soils (series)	pH	Treatment with Acetic Acid	pH after treatment	Fixation of added potassium		Decrease %
				Before acid leaching lb/A	After acid leaching lb/A	
Noadda	6.6	0.0875N	4.9	119.93	111.43	7.09
		0.175 N	4.4		106.70	11.02
Demra	7.0	0.875 N	4.9	78.53	64.67	17.64
		0.175 N	4.4		43.84	44.16
Fatki	7.7	0.875 N	5.0		119.00	—
		0.175 N	4.7	111.20	113.70	—

L. S. D. s at 0.1 per cent level for Noadda and Demra soils are 2.00449 and 2.44291 respectively.

Liming : Liming the soils increased the fixation of added K in all the soils studied (Table 3). Liming increased the potassium fixation significantly in the Borda (significant at 0.1 per cent level) and in the Khilgaon series (significant at 1 per cent level) soils. The increase in fixation in the Tejgaon series soil was not significant. It is interesting to note that the Khilgaon series soil, which did not fix potassium in its original reaction, acquired the property of K fixation. Moreover, it was observed that the increased rate of liming caused an increase in potassium fixation. De *et al* (1972) suggested that with an increase in calcium content of the minerals, their ability to fix potassium from solution increased. The effect of liming in increasing the potassium fixation is indirect. The increase in pH with the addition of lime is generally thought to be the principal cause of increased potassium fixation (Joffe and Levine 1947, Kaila 1965).

Table 3. Potassium fixation in lime treated soils.

Soils (series)	pH	Lime added lb/A	pH after liming	Fixation of added potassium		
				Before liming lb/A	After liming lb/A	Increase %
Borda	5.2	5,000	6.8	102.33	124.04	21.22
		10,000	8.0		131.31	28.25
Khilgaon	4.8	10,000	6.9	0	16.81	—
		20,000	8.3		49.65	—
Tejgaon	5.5	5,000	6.9	28.93	29.09	1.05
		10,000	7.6		33.95	17.36

L. S. D. s for Borda, Khilgaon and Tejgaon soils at 0.1 per cent level are 1.3883, 0.7921 and 2.2023 respectively

POTASSIUM FIXATION

Organic matter : Addition of organic matter significantly decreased the rate of potassium fixation in all the soils except in the Khilgaon series soil (Tables 4a and 4b). Among the two sources of organic matter, glucose was found to be more effective in reducing potassium fixation. The organic colloid of low moleculer weight (glucose) may be stored in the interlayer position or may block the layers by being adsorbed on lateral surfaces, thus reducing the accessibility of the potassium ion into the interlayer position (Scheffer and Schachtschabel 1967).

Table 4. Fixation of added potassium as affected by different treatments of organic matter in the form of (a) Glucose and (b) Starch.

Soils (series)	Depth inches	Amount of glucose added	Fixation of added potassium (lb/A)	100 (lb/A)	200 (lb/A)	400 (lb/A)	L.S.D. at 0.1% level
Noadda	0-6		119.93	111.53	109.50	103.78	2.246
	6-12		90.80	85.60	74.60	73.90	1.609
Borda	0-6		102.33	100.43	96.53	91.93	3.175
	6-12		101.80	95.80	93.40	90.30	2.540
Tejgaon	0-6		28.93	16.91	15.35	12.22	1.018
	6-12		53.53	34.91	33.90	26.63	1.574
Demra	0-6		78.53	67.17	65.61	52.31	1.224
	6-12		44.87	41.80	38.50	32.30	1.294
Fatki	0-6		110.80	95.40	94.60	93.50	1.250
	6-12		66.93	43.53	42.89	41.33	0.560
Khilgaon	0-6		—12.13	1.20	3.00	1.75	—
	6-12		—6.27	2.00	5.00	5.50	—

Soils (series)	Depth inches	Amount of starch added	Fixation of added potassium (lb/A)	100 (lb/A)	200 (lb/A)	400 (lb/A)	L.S.D. at 0.1% level
Noadda	0-6		119.93	115.43	113.83	108.43	1.283
	6-12		90.80	86.38	82.47	81.69	1.266
Borda	0-6		102.33	98.23	92.12	89.53	1.925
	6-12		101.80	100.40	99.60	97.30	1.074
Tejgaon	0-6		28.93	23.93	23.13	20.73	0.886
	6-12		53.53	48.80	44.00	39.40	0.483
Demra	0-6		78.53	63.26	60.93	57.73	2.480
	6-12		44.87	40.50	37.50	32.00	1.478
Fatki	0-6		110.80	94.20	91.50	89.40	0.831
	6-12		66.93	54.47	52.81	52.03	0.882
Khilgaon	0-6		— 12.13	2.30	8.85	13.00	—
	6-12		—6.27	4.75	10.70	14.25	—

It was observed that the decrease in potassium fixation was more or less gradual in all the soils except in the Khilgaon series soil with the increasing rate of organic matter addtions. The trend was similar for both the sources of organic matter. This is in agreement with the observations of Karim and Malek 1956, Hinman 1966, and Zolotaev *et al.* 1973.

With decrease in soil pH fixation of added potassium also decreases. Low soil pH has a bearing on the availability of other nutrient elements. It is not always practically feasible to lower the soil pH below certain limit. In general, the soils need to be limed at the cost of potassium availability. However, to get maximum benefit, counter cross interaction between lime and soil pH, factors which can overweigh the back trend availability of potassium may be compensated if the soil is properly manured with easily decomposable organic matter. In short, the present findings indicate that liming coupled with manuring can create an environment conducive for the retardation of potassium fixation and perhaps it would not be detrimental to the availability of other nutrient elements too.

References

De, S. K., Gupta, A., Srivastava, P. C. and Jain, R. K. 1972. Association of potassium by clay minerals. Ind. J. Agri. Chem. **5(2)** : 115-124.

Hinman, W. C. 1966. Ammonium fixation in relation to exchangeable potassium and organic matter content in two Saskatchewan soils. Can. J. Soil Sci. **44** : 151-157.

Jackson, M. L. 1958. *Soil Chemical Analysis.* Prentice Hall Inc. Englewood Cliffs N. J. U.S.A.

Joffe, J. S. and Levine, A. K. 1947. Fixation of potassium in relation to exchange capacity of soils. III. Factors contributing to the fixation process. Soil Sci. **63** : 241-247.

Kaila, A. 1965. Fixation of potassium in Finnish soils. Maataloust Aikak **37** : 116-126.

Karim, A. Q. M. B. and Malek, M. A. 1956. Potassium fixation in East Pakistan soils under different conditions. Soil Sci. **83** : 227-237.

Mclean, A. J. 1962. Fixation of potassium in some Canadian soils. Can. J. Soil Sci. **42** : 96-104.

Page, G. B. and Ganje, T. J. 1964. The effect of pH on potassium fixed by an irreversible adsorption process. Soil Sci. Soc. Amer. Proc. **25** : 199-202.

Rashid, M. H. 1975. Fixation of potassium and ammonium in some representative soils of Bangladesh. M. Sc. Thesis. Soil Science Department, Dacca University.

Scheffer, F. and Schachtschabel, P. 1967. Plant nutrients in soil : Potassium. Potash Review. Int. Pot. Inst. Berne. Jan. 1967.

Varbanova, N. Z. and Bache, B. W. 1975. Effect of pH on adsorption and desorption of potassium in granitic soil. J. Sci. Food and Agric. **26(6)** : 129-134.

Zolotaev, S. A. and Boktor, Samir. 1973. Potassium fixation by clays of Ukranian Chernozem soils. Pochvovendenier, **2** : 129-134.