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EFFECT OF LIMING ON DISTRIBUTION AND MOBILITY OF MACRONUTRIENTS IN A RED LOAM SOIL OF BIHAR

G. SINGH[1], H. M. SINGH[2] and R. N. PRASAD[3]

The distribution and mobility of macronutrients were studied in five soil profiles from virgin, cultivated and lime applied equivalent to normal, 3 and 5 times of lime requirement from a red loam soil of Ranchi. Lime application increased the organic carbon, CEC, total N as well as Ca saturation of soil while decreased the Mg saturation. The mobility of Mg was slightly more than Ca. Content of total P was not affected by liming but had pronounced effects on available P. Limed series had higher total S than unlimed ones and was positively correlated with organic carbon (r=0.752**). Available S showed negative correlation with soil pH (r=0.503**).

The mobility of some elements has been found to be affected by liming (Robertson *et al.* 1954). Bhuiyan *et al.* (1961) reported uniform distribution of Ca in soil profiles while Mg increased with depth. Present investigation was undertaken to study the distribution and mobility of macronutrients under limed conditions in an acid soil of Chotanagpur (Bihar).

MATERIALS AND METHODS

Soil profiles were opened in 1972 in the farm of Ranchi Agricultural College receiving the following treatments in 1967 viz. Profile 1 - Control (virgin) Profile 2 - Control (cultivated) Profile 3 - Lime as per requirement, Profile 4 - Lime 3 times of its requirement Profile 5 - Lime 5 times of its requirement.

The soil of the experiment plot had good drainage. The colour of soil of layer 1, 2 and 3 varied from yellowish red (10 YR 5/4, yellow red 5 YR 5/8) to strong brown (7.5 YR 5/8) respectively and also strong brown in subsequent layers (4th & 5th). The texture of the surface soil was sandy loam to loam.

The soil were analysed for pH in 1:2.5 soil water suspension, organic C (0.4 N chromic acid), total N, CEC, exchangeable cations and different forms of available P (Bray-IP, Bray-II P and Olsen's P) by methods as described by Jackson (1958). HCl extract of the soil was used for determination of total Ca, Mg, K, P and S.

RESULTS AND DISCUSSION

A perusal of the data in Table-1 showed that there was considerable variation in soil reaction due to different treatments The soil pH in uncultivated control was higher than the cultivated control. This might be due to mining of the nutrients particularly Ca and Mg from the lower depths and their accumulation in the soil in the uncultivated plot. In cultivated control these nutrients were removed alongwith the biomass. The soil which received lime only as per its requirement (Profile 3), was

1) Scientist S-1 (Soil) CARI, Port Blair.
2) Joint Director (Biogas), Energy Department Patna, Bihar.
3) Scientist S-4 (Soil) ICAR, Research Complex for NEH Region Shillong-3.

depleted in exchangeable Ca by 57 .. The application of lime 3 or 5 times of its requirement has raised the pH beyond neutral range.

Data indicate further that lime application to soils had favourable effect on building up of organic C from 0.4 to 0.78% in the surface soils only. On the contrary, it was observed to decline in surface soil of profile-5, which might be attributed to the decomposition of organic carbon by soil micro-organisms in alkaline pH and in presence of high percentage of exchangeable Ca.

The content of organic C was found to decrease downward in profiles. Total N content of soil followed the trend of organic C distribution which was also evident from the positive relationship between them (r = 0.865**). Again the narrowest C/N ratio (6 : 9) in the surface soil of profile number 5 appeared due to the highest microbial activity.

An increase in CEC from 6.64 to 7.70 meq% due to lime application in the surface soils may possibly be due to increase in organic carbon and rise in pH. The data of Table-1 further, revealed low base saturation in the surface soil (38 5 to 51.4%).

The proportion of Ca and Mg on exchange complex of soil colloids was more or less equal in profile number 1 and 2. But the ratio of Ca/Mg fairly widened on liming indicating the replacement of Mg by the presence of large excess of calcium. The data of profile 4 & 5, further, showed a slow mobility of Ca and Mg. The maximum concentration of exchangeable Mg in 37-140 cm layer indicated that this element was prone to downward movement due to laeching and greater mobility than Ca. The distribution and mobility of K was not influenced by liming The percentage saturation of Ca on exchange complex was observed to increase linearly with doses of lime application.

Distribution and mobility of macronutrients :

An appraisal of data of Table-2 did not show any change in the distribution of HCl extractable Ca, Mg, K and P in soil profiles. Considerably lower value of Ca, Mg and K in the surface soil might be attributed to the depletion by continuous intensive cultivation for 5 years.

Total P content was not influenced due to liming. However, its available forms exhibited considerable variation. Different forms of P were confined mostly in the surface soil which contained also fairly higher amount of organic carbon as compared to sub-soils Significant positive correlations were also obtained between Bray-I P (r = 0.735**), Bray-II P (r = 0.644**) and Olsen's P (r = 0.782**) to organic C which were in accordance with the earlier work of Singh (1972). An increase in available P (Bray I P from 4.5 to 18 ppm) only due to cultivation (Profile 1 & 2) may be explained due to increase in organic carbon and percentage base saturation of the surface soil. This might probably has rendered Fe, Mn and Al somewhat more unreactive. As expected, the content of Bray II P was found to increase due to liming in neutral range upto profile, number 4 whereas there was no change in the content of Olsen's P in these profiles. But Olsen's P increased substantially in the surface soil of profile number 5 in which the percentage Ca

Table 1 Chemical properties of soil profiles

Depth	pH	Org.C. %	Total N%	C/N ratio	CEC me/100g	Exchangeable cations Ca	Mg	K	Total Exch. bases me%	Saturation % of cations Ca	Mg	K	Total
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Profile-1 (Control uncultivated)													
0-10	5.6	0·40	0.06	7.2	6.5	1.8	0.6	0.1	2.5	27.4	9.6	1.5	38.5
10-46	6.5	0.32	0.04	7.3	7.5	2.9	2.7	0.2	5.4	39 2	36.0	2.0	77.2
46-87	6.6	0.13	0.04	3.5	7.4	2.9	3 4	0 2	6 5	39.7	46 5	2.2	88 4
87-140	6.7	0.10	0.03	3.6	7.9	2.8	3.2	0.2	6.1	34.8	40 9	1.9	87.6
140-183	7.0	0.06	0.02	6.2	6.2	2.8	3.1	0.2	6.1	44.4	50.5	2.7	97.6
Mean	6.5	0.20	0.04	4.9	7.1	2.6	2 6	0·2	5.4	37.1	36.7	2.1	77.9
SE (Mean)	.23	.067	.004	.1	.32	.51	21	.017	.72	2 86	7.20	.19	10.35
Profile No-2 (Control cultivated)													
0-10	0.8	0.59	0.07	8.0	6.6	2.5	0.8	0.2	3.4	37.7	11 3	2.4	51.4
10-46	5.8	0.53	0.05	10.4	7.2	2.9	2.4	0.2	5.4	39.6	33.3	2.1	75.0
46-87	6.2	0.28	0.05	5.5	7.7	2.6	3.4	0.2	6:1	34.2	43.4	2.0	79.5
87-140	6.2	0.11	0.04	3.1	7.8	2 8	3.4	0.2	6.3	35.3	44.1	1.9	81.3
140-183	6.1	0.08	0.03	2.5	6.3	2.6	2.9	0.2	5.7	41.4	46.0	2.7	90.1
Mean	6.0	0.32	0.05	5.9	7.1	2.7	2.6	0.2	5 4	37.6	35.6	2.2	75.4
SE (Mean)	.089	.10	.004	1.48	.29	.071	.48	0	.51	1.32	6.47	.14	6.49
Profile No. 3 (Limed as per lime requirement)													
0-10	6.3	0.71	0.07	9.7	7.1	3.4	0.5	0.1	4.0	48.3	6.9	2.0	57.1
10-46	6.4	0.30	0.05	6.5	7.3	3.4	2.0	0.1	5.5	46.9	27.0	1.9	75.9
46-87	6.4	0.44	0·04	11·0	7.6	3.1	3.1	0 2	6.4	40.7	41.2	2.0	83.8
87-140	6.3	0.20	0.03	7.1	7.9	3.1	3.0	0.2	6.3	39.6	38.2	2.3	79.1
140-183	6.4	0.10	0.02	5.0	6.1	3.2	2.0	0.2	5.5	55.3	33.1	3·3	89.7
Mean	6.4	0.35	0.04	8.0	7.2	3.3	2.1	0.2	5.6	45.8	29.3	2.3	77.1
SE (Mean)	.022	.10	.008	1.01	.30	.06	.46	.02	.42	2.53	6.09	.25	5.52

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Profile No. 4 (Limed three times lime requirement)													
0-10	7.3	0.78	0.08	9.5	7.7	6.3	0.5	0.2	6.9	80.9	6.2	2.0	89.4
10-46	7.5	0.41	0.05	8.4	7.7	5.2	1.8	0.2	7.1	67.8	23.1	2.2	93.1
46-87	7.2	0.14	0.04	3.4	7.8	3.4	3.5	0.2	7.0	43.4	44.1	2.2	89.7
87-140	6.8	0.18	0.03	5.5	7.9	2.9	4.2	0.2	7.2	37.2	52.8	2.0	92.0
140-183	6.8	0.08	0.03	2.5	6.3	3.1	2.6	0.2	5.9	49.1	41.9	2.5	93.5
Mean	7.1	0.31	0.05	5.9	7.5	4 2	2.5	0.2	6.8	55.7	33.7	2.2	91.5
SE (Mean)	.13	.12	.009	1.36	.29	.7	.65	0	.24	8.14	8.34	.08	.84
Profile No. 5 (Limed five times lime requirement)													
0-10	8.4	0.56	0.08	6.9	7.2	6.4	0.5	0.2	7.1	88.2	7.1	2.1	97.4
10-46	8.2	0.31	0.06	5.2	7.3	5.6	1 3	0.2	7.1	76.9	17.4	2.1	86.3
46-87	7.9	0.14	0.06	2.5	7.8	4.4	3.0	0.2	7.6	55.9	38.6	2.9	96.4
87-140	7.4	0.18	0.04	5.0	8.0	3.1	4.2	0.1	7.4	39.2	52.3	1.8	93.2
140-183	7.0	0.16	0.04	4.4	6.1	2.7	3.1	0.7	6.0	44.9	50.3	2.5	97.7
Mean		0.27	0.05	4.8	7.3	4.5	2.4	0.2	7.0	61.0	33.1	2.1	94.2
SE	.28	.08	.009	.71	.34	.70	.67	.01	.27	9.36	8.99	.20	2.12
SE (Overall)	.046	.042	.004	.526	.13	.238	.232	.008	.246	3.08	3.10	.078	2.97

Table 2. HCl extractable Ca, Mg, K, P available S and available P by different methods

Depth in cm	Ca	Mg	K	P	S (ppm) Total	S (ppm) Avl.	Available P (ppm) Bary P_1	Available P (ppm) Bary P_2	Olsen P
			Profile No. 1 (Control uncultivated)						
0—10	0.12	0.11	0.15	0.25	190	24.4	4.21	14.04	10.0
10—46	0.22	0.23	0.34	0.25	150	52.4	0.77	22.46	2.5
46—140	0.22	0.18	0.25	0.23	60	18.4	1.40	18.25	2.5
87—140	0.22	0.18	0.25	0.25	50	18.4	1.40	18.25	2.5
140—183	0.18	0.85	0.25	0.25	50	9.4	0.77	11.23	4.0
Mean	0.19	0.17	0.26	0.24	122	29.6	1.58	16.85	4.0
SE (Mean)	.01	.01	.03	.004	27.38	7.65	.28	1.93	1.4
			Profile No. 2 (Control cultivated)						
0—10	0.15	0.12	0.19	0.25	150	24.4	18.25	37.89	28.5
10—86	0.21	0.13	0.28	0.25	190	92.9	0.77	27.37	10.0
46—87	0.22	0.30	0.29	0.23	120	105.4	0.77	22.46	2.5
87—140	0.20	0.14	0.29	0.23	120	43.4	1.40	15.14	2.5
140—183	0.18	0.11	0.26	0.23	120	18.4	0.77	20.35	2.5
Mean	0.19	0.13	0.26	0.24	140	56.8	4.39	24.89	4.0
ES (Mean)	.01	.008	.01	.004	29.56	11.70	2.59	3.72	5.04
			Profile No. 3 (Limed as per lime requirement)						
0—10	0.13	0.08	0.18	0.25	280	9.40	14.40	24.56	28.5
10—46	0.18	0.13	0.29	0.25	170	67.9	0.77	14.04	2.5
46—87	0.20	0.17	0.33	0.25	150	55.4	0.77	31.58	2.5
87—140	0.20	0.15	0.30	0.23	120	46.4	0.77	33.68	2.5
140—183	0.18	0.12	0.25	0.23	120	12.4	2.11	22.46	2.5
Mean	0.18	0.13	0.27	0.24	168	38.3	3.69	25.26	7.7
SE (Mean)	.01	.01	.02	.004	29.56	11.70	2.59	3.50	
			Profild No. 4 (Limed three times lime reuirement)						
0—10	0.13	0.09	0.16	0.23	220	9.4	12.63	53.33	28.5
10—46	0.13	0.09	0.16	0.23	220	9.4	12.63	53.33	28.5
46—87	0.21	0.19	0.36	0.23	140	21.4	0.77	24.56	2.5
87—140	0.20	0.17	0.29	0.22	50	46.4	0.77	22.46	2.5
140—183	0.17	0.18	0.26	0.26	50	24.4	0.77	7.02	2.5
Mean	0.18	0.16	0.26	0.23	116	26.4	3.14	25.12	7.7
SE (Mean)	.01	.01	.02	.004	31.71	6.05	2.37	5.81	
			Profile No. 5 (Limed five times lime requirement)						
0—10	0.14	0.13	0.09	0.23	190	9.4	19.64	20.35	42.0
10—46	0.20	0.18	0.30	0.23	120	9.4	0.77	22.46	2.4
46—87	0.21	0.21	0.31	0.23	150	12.4	0.77	22.46	2.5
87—140	0.18	0.19	0.25	0.23	30	12.4	0.77	16.84	2.5
140—183	0.17	0.13	0.26	0.25	60	12.4	1.40	27.37	10.4
Mean	0.18	0.16	0.26	0.23	110	11.2	4.67	21.90	10.4
SE	.01	.01	.02	.004	29.15	.07	3.74	1.7	7.89
SE (overall	.006	.008	.012	.002	11.888	5.286	1.16	1.574	2.23

saturation (97%) and soil reaction (pH 8) was recorded to be maximum. Fairly higher amount to Bray II P as compared to Bray I P may be attributed to more acidic extractant. The data of Table-2 further, revealed that phosphate was not at all mobile and its mobility was not affected due to liming.

Total S content in these profiles varied from 30 to 280 ppm and showed a decreasing tendency with increase in depth. Similar results were also observed by Kanwar and Takkar (1963) for some acid soils. Total sulphur was found to be positively correlated with organic carbon ($r = 0.752^{**}$). The content of available sulphur ranged from 9.4 to 105.4 ppm. Jha (1964) also reported similar value of sulphur in such soils. Upward movement of sulphur was noticed due to cultivation (Profile - 2) while it was dramatically reduced on liming. This reduction might possibly be due to formation of $CaSO_4$. It showed negative correlation with soil reaction ($r = 0.503^{**}$).

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REFERENCES

BHUIYAN, S. J., M. ZACHARIA and F. RAHAMAN, 1961. Soils of Khaiyae tract of East Pakistan. *Soil Sci. 91* : 369-370.

EVANS, C. A. and C. O. ROST 1945. Total organic sulpher and humus sulphur of Minnesota soils. *Soil Sci. 59* : 125-133.

JACKSON, M. L. 1958. Soil chemical analysis. Const. & Co. Ltd., London.

JHA, K. K. 1964 Review of work on micronutrients in Bihar *Indian Soc. Soil Sci. 12* (4) : 235-241.

KANWAR, J. S., and P. N. TAKKAR 1963. Sulphur, phosphorus and nitrogen deficiency in tea soils. *Indian J. agric. Sci. 33* : 291-4.

ROBERTSON, W. K., J. R. NELLER & F. O. BARTLET, 1954. Effect of lime on availability of phosphorus in soils of high to low sesquioxide content. *Soil Sci. Soc. Amer. Proc. 18* (2) : 194.

SINGH, B. P. 1972. Studies on distribution of zinc and copper in Bihar soils. M. Sc. (Ag.) Thesis, R. A. U.