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Influence of long term manuring on cation exchange properties of soils *

by

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Synopsis: The influence of fertilisers with and without the basal dressing of cattle manure on the cation exchange capacity and exchangeable calcium and potassium were investigated in the soils of the New Permanent Manurials, Coimbatore. The basal dressing of cattle manure was found to have increased the cation exchange capacity. A correlation was found to exist between exchangeable calcium and cation exchange capacity. The application of potassic fertiliser was found to depress the exchangeable calcium.

Introduction: The phenomenon of cation exchange is one of the important properties which determine the fertility status of a soil. It is known that it can be modified by the application of bulky organic manures as well as by chemical fertilisers and soil amendments. But there is no agreed opinion regarding the influence of calcium on the release of exchangeable potassium in the soils. For example, Lawton (1957) found that more potassium was released from non-exchangeable form in the hydrogen saturated soil than in calcium-hydrogen saturated soil and least in calcium saturated soils. Dean (1936) found that application of lime to two Iowa soils actually reduced the content of exchangeable potassium. Allaway and Pierre (1939) and Stanford *et al.* (1941) noticed that high lime soils of Iowa contained less exchangeable potassium than adjacent soils low in lime and that high lime soils had a greater capacity to fix potassium in non-exchangeable form than neutral or acid soils. The observations of Kelly (1941) were also similar. But, the work of Ayres (1949), Merwin (1950) and York and Rogers (1947) indicated that addition of lime to hydrogen saturated clay increased the rate of release of potassium. It would appear from the above that the nature of colloids, both inorganic and organic present in the soil affect the amount of exchangeable potassium when lime is added.

Hence it was thought of interest to investigate the influence of continuous application of nitrogenous, phosphatic and potassic fertilisers, alone and in combinations, with and without basal application of oraganic manure on the amount of exchangeable cations present in the soils of New Permanent Manurials, Coimbatore, where crops are being raised on an intensive manner under irrigated conditions for the past 36 years.

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Materials and Methods: The New Permanent Manurial experiment was started in 1925. It consists of two series, one with basal dressing of cattle manure and the other without cattle manure. There are ten treatments in each series consisting of No Manure, Cattle manure, N, K and P individually and in combinations as detailed in the note in table I. The soil is calcareous sandy clay loam and crops are being raised under irrigated conditions intensively. Surface soil samples (0–9") collected from these plots after the harvest of cotton in 1958 were taken up for the studies.

Cation exchange capacity was estimated after leaching the soil with N/2 ammonium acetate solution adjusted to pH 7·0. As the soil was calcareous in nature, extraction with ammonium acetate (pH 8·4) was tried for estimation of exchangeable calcium (Menon and Sankaranarayanan, 1953), but as very high values were got even when the pH was raised to 8·6, Hissink's method was finally adopted.

Exchangeable potassium was estimated in the ammonium acetate leachate (pH 8·6) by a modified Cobaltinitrite method developed by the Chemistry section of the Madras Agricultural Department (unpublished) after removal of the ammonium salts. Magnesium was estimated in the leachate by the gravimetric method.

Results and Discussions: The results are presented in table 1

As can be seen, the cation exchange capacity of the soils in the western series (cattle manure basal dressing) is higher than the corresponding treatments in the eastern series. This is found to be statistically significant also. This might be due to the interaction of the applied fertilisers with the basal dressing of cattle manure which the plots in the western series are receiving at 2,000 lb. per acre regularly. But, within each series, the cattle manure treatment does not show higher cation exchange capacity than the chemical fertiliser plots. Also, the cation exchange capacities of the cattle manure plots are more or less identical with the mean cation exchange capacity of the respective series.

As regards exchangeable calcium there is a high degree of correlation between it and cation exchange capacity. It is significant at 5% level in the eastern series. Even though it is not significant in the western series, it is highly significant when the two series are taken together.

The application of potassium appears to depress the exchangeable calcium in both the series. The application of nitrogenous and phosphatic fertilisers also, either alone or in combination with potassium, depress the ratio of exchangeable calcium to cation exchange capacity. This is very marked in the western series. This is due mostly to the increase in cation exchange capacity of the western series on account of the basal dressing of cattle manure and to some extent possibly to the mobilisation of exchangeable calcium by the organic matter (in the cattle manure) and leaching it down to lower layers as postulated by Sanyasi Raju (1952) in the case of total calcium in the cattle manure treatment.

The exchangeable potassium figures are constant showing that the manurial applications (including potash, either alone or in combination with others) have not influenced the amount present in the soils. The absence of increase in exchangeable potassium even in the case of application of potassic fertilisers can be attributed to fixation of the applied potassium in non-exchangeable form as has been noticed by Stanford *et al.* (1941) and Kelly (1941). This is corroborated by the increase in total potassium of the treated plots noticed all these years. Besides the above, the higher uptake of potassium by the plants grown in the potassium plots (Table 2) might also account to some extent for this phenomenon.

The ammonium acetate solutions (pH 8·4 to 8·6) extracted very large quantities of magnesium from the soils. As the latter had been leached previously completely of soluble salts with 40% alcohol adjusted to pH 7·0, it appears likely that magnesium carbonate is also present in addition to calcium carbonate in the soils. Hence, ammonium acetate solutions do not appear to be suitable extractants for estimation of exchangeable magnesium in these soils.

Summary and Conclusions: The cation exchange capacity and exchangeable calcium and potassium in the surface soils of the New Permanent Manurial Experimental plots, Coimbatore, were estimated and the following conclusions are drawn.

1. The basal dressing of cattle manure has raised significantly the cation exchange capacity of soils as compared with no basal dressing, when fertilisers are super-imposed over them.

2. Within each series, cattle manure treatment has not resulted in increased cation exchange capacity.

3. Cation exchange capacity and exchangeable calcium are positively correlated and the application of cattle manure has not affected significantly the pattern of correlation.

4. The application of potassic fertilisers depresses the exchangeable calcium.

5. Nitrogenous and phosphatic fertilisers, either alone or in combination with potassic fertiliser, appear to depress the ratio of exchangeable calcium to cation exchange capacity i. e., the percentage of calcium saturation.

6. Exchangeable potassium is constant and is not affected either by the application of fertilisers or cattle manure due to fixation of the applied potassium and to some extent to the higher uptake of potassium by the crop from the treated plots.

7. The presence of free magnesium carbonate along with calcium carbonate in the experimental plots is inferred.

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TABLE I.

Cation Exchange Capacity and Exchangeable Calcium and Potassium of the surface soils (0·9") of New Permanent Manurial Plot, Coimbatore (1958) — (on oven dry basis).

Eastern Series							Western Series						
Lab. No.	Treatment	Cation Exch. capacity m.e./100 gm.	Exch. Ca m.e./ 100 gm.	% of Ca Satura-tion	Exch. K m.e./ 100 gm.	% of Exch. K to Exch. Ca	Lab. No.	Treatment	Cation Exch. capacity m.e./ 100 gm.	Exch. Ca m.e./ 100 gm.	% of Ca Satura-tion	Exch. K m.e./ 100 gm.	% of Exch. K to Exch. Ca
192	No Manure	15·8	11·7	74·0	0·2	1·7	202	No Manure	15·6	11·0	70·5	0·1	1·0
193	N.	16·0	10·4	65·0	0·2	1·9	203	N	18·1	11·6	64·1	0·2	1.7
194	NK.	15·5	10·8	69·7	0·2	1·9	204	NK.	17·4	9·0	51·7	0·2	2·2
195	NP.	15·8	11·8	74·7	0·2	1.7	205	NP.	19·0	10·9	57·4	0·2	1·8
196	NPK.	14·6	10·0	68·5	0·2	2·0	206	NPK.	17·6	10·4	59·1	0·2	1·9
197	PK.	16·6	10·6	63·9	0·3	2·8	207	PK.	15·1	8·5	56·3	0·2	2·1
198	K.	13·4	8·9	66·4	0·1	1·1	208	K.	15·4	8·7	56·5	0·2	2·3
199	P.	16·5	10·8	65·5	0·1	0·9	209	P.	18·3	11·3	61·8	0·2	1·8
200	CM.	15·5	11·3	72·9	0·1	0·9	210	CM.	17·1	12·9	75·4	0·2	1·6
201	CMR.	15·7	10·8	73·7	0·2	1·2	211	CMR.	18·3	10·7	58·5	0·2	1·9

Comparison of cation Exchange capacity between western and eastern series (Basal dressing versus No Basal dressing)

Analysis of variance:

Source		*D.F.*	*S.S.*	*M.S.*	*F.*
Between series	...	1	13·62	13·62	—
Within series	...	18	24·77	1·38	9·87 **
Total	..	19	38·39		

Summary of Results — *Comparison of Series*

		Mean cation Exch. capacity	S. E. of Mean	C. D. (P = 0·05)
Basal dressing	...	17·9		
No Basal dressing	...	15·54	0·37	1·10

Conclusions : Basal dressing. No Basal dressing (Cation Exch. capacity is significantly high in basal dressing series)

Correlations

		No Basal dressing	*With Basal dressing*
Value of r between cation Exch. capacity and Exch. Ca.	...	0·688 *	0·515

Joint estimate of r for both series 0·615 **

Table I — *(Continued)*

Note: *Details of Manurial Treatments*

N — 112 lb. of Ammonium sulphate / acre.
P — 336 lb. of single super phosphate / acre.
K — 112 lb. of Potassium sulphate / acre.
CM — Cattle manure at 5 tons / acre.
CMR — Residual effect of cattle manure applied some years earlier.
Eastern series — No basal dressing.
Western series — Basal dressing CM at 2,000 lb. / acre. (to all treatments except CM and CMR)
Size of plots — 5 cents.

Table II.

Percentage of Potash in Cotton Kapas and the amount of Potash removed per acre
New Permanent Manurials, Coimbatore (1957 — 58)

	Eastern Series										Western Series									
	Treatments										Treatments									
	No Manure	N	NK	NP	NPK	PK	K	P	CM	CMR	No Manure	N	NK	NP	NPK	PK	K	P	CM	CMR
K_2O % of kapas	1·18	1·22	1·55	1·31	1·35	1·44	1·36	1·31	1·72	1·15	1·64	1·59	2·27	1·48	1·62	1·61	2·30	1·46	1·54	1·37
Pounds of K_2O removed per acre by kapas	2·06	2·17	4·31	8·36	10·86	8·60	5·36	8·90	13·69	5·54	8·74	7·24	11·80	13·51	14·66	13·02	14·22	8·60	7·67	8·84