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Influence of Calcium on the Physical properties of Soil *

By

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ABSTRACT

Forty soil samples were collected from various parts of South India and were subjected to the determination of important physical properties of soil and various forms of calcium. Exchangeable calcium exhibited high degree of correlation to the clay content. Total calcium and exchangeable calcium showed close correlation with volume expansion on wetting. Moisture constants like water holding capacity and sticky point were correlated with various forms of calcium. Black soils which contained high calcium were found to be extremely impermeable compared to red soils. Aggregate stability was observed to be markedly high in black soils, which were richer in calcium and clay.

INTRODUCTION

It is almost universally recognised that lime and organic matter improve the physical properties of soils. The beneficial effects of lime are due to its ability to flocculate the soil colloids by lowering the zeta potential, while the influence of organic matter has been traced to its cementing effects. An attempt has been made in this study to find out to what extent calcium content influences the various physical properties of soil which in turn affect the soil and water management.

MATERIALS AND METHODS

Forty surface soil samples (0-22 cm) were collected from all over South India comprising the States of Tamil Nadu, Kerala, Andhra Pradesh, Karnataka and Goa. These forty soils consisted of 10 black soils, 12 red soils, 8 alluvial soils and 10 laterite soils. The soil samples were air dried and gently powdered to pass through 2 mm sieve. The sieved material was taken up for analysis. The soils were subjected to the determination of various physical properties. Mechanical analysis was carried out by following International Pipette Method (Piper, 1950). Water holding capacity was estimated by using Keen-Raczkowski brass cups. Hydraulic conductivity was determined adopting the method of Dakshinamurthi and Gupta (1967) and using Darcy's law. Aggregate analysis was carried out following Yoder's modified wet sieving method (described by Biswas *et al.* 1961). The various forms of calcium such as total, exchangeable, water soluble and carbonate forms were estimated (Jackson, 1967 and Piper, 1950). Possible correlations between different forms of calcium and various physical properties of soil were worked out.

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RESULTS AND DISCUSSION

The data on the content of various forms of calcium are furnished in Table 1. The analyses on the physical properties of soil are given in Table 2.

1. **Soil texture:** In all fertile soils calcium formed 70 to 80 per cent of the exchangeable cations. Being an integral part of clay it is understandable that exchangeable calcium showed a high degree of correlation with clay. Chernov (1958) obtained a linear relationship between exchangeable calcium and the content of particles 1 μ in diameter. Pondel (1971) observed that total calcium was high in soils which were rich in the <0.02 mm fraction. In the present study clay and silt were correlated with some of the forms of calcium such as total, exchangeable and water soluble calcium which is in conformity with the above results.

TABLE 1. Content of different forms of calcium in soils

S. No.	Locality	State	Water soluble calcium (ppm Ca)	Exchangeable calcium (me/100 gm soil)	Calcium carbonate (per cent $CaCo_3$)	Total calcium (per cent Ca)
Black Soil						
1.	Virudhunagar	Tamil Nadu	72	22.85	1.10	1.48
2.	Peelamedu	,,	32	41.74	3.30	4.23
3.	Muthampatti	,,	120	20.82	2.40	2.85
4.	Kallakurichi	,,	80	14.40	1.80	2.11
5.	Chowtapally	Andhra Pradesh	64	21.41	2.40	2.85
6.	Podalakur	,,	104	18.08	1.20	1.58
7.	Nandyal	,,	24	18.71	4.00	4.43
8.	Medikerepura	Karnataka	104	32.78	4.80	5.50
9.	Yettinagadda	,,	80	24.34	2.60	2.94
10.	Hittanahalli	,,	120	20.73	2.00	2.42
Red Soil						
11.	Kovilpatti	Tamil Nadu	104	5.02	—	1.03
12.	Velampatti	,,	128	7.84	0.20	0.38
13.	Sathiamangalam	,,	208	5.59	—	0.28
14.	Thandarampet	,,	72	4.25	—	0.15
15.	Tirupathi	Andhra Pradesh	96	5.49	—	0.22
16.	Bucharayachatram	,,	96	6.12	0.20	0.35
17.	Mirialguda	,,	152	13.54	0.80	1.10
18.	Jadcherla	,,	128	6.84	0.20	0.30
19.	Gandhal	Karnataka	132	8.92	0.40	0.60
20.	Hebbal	,,	96	6.59	0.40	0.55
21.	Manvi	,,	128	6.49	—	0.16
22.	Trivandrum	Kerala	24	2.74	—	0.06

TABLE 1. (*Contd.*)

S. No.	Locality	State	Water soluble calcium (ppm Ca)	Exchangeable calcium (me/100 gm soil)	Calcium carbonate (per cent $CaCo_3$)	Total calcium (per cent Ca)
Alluvial Soil						
23.	Ambasamudram	Tamil Nadu	128	6.74	...	0.21
24.	Sirugamani	,,	168	10.66	0.60	0.83
25.	Aduthurai	,,	198	12.58	1.00	1.28
26.	Akuthotamalevada	Andhra Pradesh	176	6.57	0.60	0.73
27.	Tenali	,,	144	19.54	2.00	2.41
28.	Avanigadda	,,	176	20.31	2.80	3.21
29.	Bhimavaram	,,	216	11.94	0.80	1.04
30.	Chitwadgi	Karnataka	136	18.44	0.80	1.16
Laterite Soil						
31.	Kodaikanal	Tamil Nadu	16	1.88	...	0.05
32.	Nanjanad	,,	128	3.95	...	0.19
33.	Kudamalur	Kerala	48	3.49	...	0.09
34.	Pattambi	,,	32	2.10	...	0.05
35.	Kondotty	,,	32	2.04	...	0.06
36.	Mercara	Karnataka	40	3.60	...	0.09
37.	Karkala	,,	40	3.67	...	0.07
38.	Mugudthi	,,	48	2.59	...	0.08
39.	Amminalli	,,	56	2.27	...	0.05
40.	Mardol	Goa	40	4.14	...	0.11

2. **Physical constants:** Black and alluvial soils had high pore space percentage and the red soils registered the lowest. Black soils recorded a high percentage of volume expansion. Among the different physical properties studied, volume expansion on wetting was the only property correlated with total calcium ($r = 0.932^{***}$) and exchangeable calcium ($r = 0.865^{***}$). Black soils with high lime status showed a high degree of volume expansion.

3. **Moisture constants:** Black soils recorded high values for all the moisture constants. This may be due to high clay content. All the moisture constants showed a high degree of correlation with exchangeable calcium but only sticky point closely correlated with total calcium ($r = 0.764^{***}$). The samples that stood out from general relationship pattern belonged to the high level laterite group which were deficient in all forms of calcium. The findings of the present study were in conformity with the observations made by Raychaudhuri and Mazumdar (1940) who found that, in general, the the maximum water holding capacity

TABLE 2. Physical properties of soils

Soil Number	Mechanical analysis (Percentage)				Physical constants					Moisture constants		Aggregate stability (%)
	Coarse sand	Fine sand	Silt	Clay	Total porosity (%)	Non-capillary porosity (%)	Capillary porosity (%)	Hydraulic conductivity (cm/hr)	Volume expansion on wetting	Water holding capacity (%)	Sticky point (%)	
1	2	3	4	5	6	7	8	9	10	11	12	13
Black Soil												
1.	24.7	19.6	13.8	38.5	52	12	50	1.6	72.2	70.3	24.2	88.9
2.	21.9	38.3	9.3	28.4	51	5	46	3.1	80.1	74.1	28.4	64.3
3.	46.4	11.6	10.6	29.6	49	28	21	2.0	77.6	56.8	20.3	91.4
4.	21.8	34.4	15.5	26.9	35	6	29	1.5	48.4	48.4	18.2	77.1
5.	28.6	32.5	8.6	28.9	55	5	50	11.3	86.2	53.6	23.6	61.9
6.	28.9	25.9	9.8	31.1	58	29	29	2.8	40.3	46.2	12.8	81.6
7.	42.8	12.8	7.4	34.5	42	7	35	6.6	77.3	59.1	28.1	79.3
8.	24.0	20.6	12.5	36.6	49	17	32	3.0	88.4	72.6	29.3	69.7
9.	19.8	16.4	13.7	41.5	45	15	30	1.6	54.7	62.9	23.0	70.9
10.	31.0	14.2	11.6	35.3	63	42	21	12.5	45.8	50.9	17.0	79.6
Red Soil												
11.	62.5	11.5	4.1	20.8	51	20	31	16.0	21.2	29.3	10.4	64.5
12.	53.2	18.1	5.3	22.7	41	25	16	30.0	35.6	35.5	18.3	46.3
13.	50.7	23.6	6.1	18.2	46	24	22	21.3	30.4	20.7	17.6	47.6
14.	40.9	26.7	9.4	21.5	55	13	42	15.0	26.1	20.3	11.0	70.3
15.	58.2	26.7	2.3	14.8	53	26	27	21.3	35.9	26.1	16.7	35.4
16.	48.7	27.3	2.6	21.2	45	11	44	12.5	37.5	30.7	12.8	44.6
17.	44.7	16.1	5.3	28.6	48	16	32	7.5	34.3	48.6	26.0	69.4

TABLE 2 — (*Contd.*)

1	2	3	4	5	6	7	8	9	10	11	12	13
18.	50.1	20.6	3.1	24.1	45	14	31	21.3	27.7	36.8	17.5	61.3
19.	46.4	17.2	5.6	27.4	36	8	28	8.1	25.6	39.6	10.3	48.2
20.	43.1	22.8	6.3	26.7	43	21	22	18.3	29.5	20.2	14.6	60.1
21.	68.5	18.3	9.4	29.0	41	14	27	7.2	24.8	22.3	12.1	59.6
22.	59.8	21.7	2.3	14.6	45	19	26	1.0	15.2	20.1	8.5	47.4
Alluvial soil												
23.	33.8	36.8	2.9	23.4	43	15	28	0.3	35.9	20.6	16.0	90.4
24.	28.0	19.6	15.8	34.2	49	12	37	0.6	40.7	43.6	20.6	67.3
25.	17.2	23.4	10.0	45.7	38	11	27	0.5	40.6	44.8	16.7	74.5
26.	41.8	18.5	9.0	29.8	55	16	39	0.5	33.4	32.4	14.3	79.6
27.	21.3	29.8	12.7	31.7	57	11	46	0.5	45.9	51.6	28.2	69.4
28.	22.2	20.7	10.6	42.9	45	8	37	1.9	50.5	58.9	30.1	73.1
29.	24.6	21.3	12.5	40.6	53	11	42	24.4	32.8	45.0	22.4	48.4
30.	31.1	20.5	9.1	38.1	49	10	39	1.1	30.1	59.2	16.1	59.5
Laterite soil												
31.	22.4	20.1	10.7	38.5	45	7	38	6.4	12.6	20.3	8.6	50.3
32.	29.2	19.0	5.6	43.6	42	5	37	5.0	32.5	28.1	16.5	49.6
33.	39.2	37.0	7.3	21.6	38	8	30	9.0	20.3	26.8	18.4	44.6
34.	46.7	25.9	8.1	18.4	50	18	32	1.6	15.4	22.5	6.7	51.3
35.	41.7	27.6	7.5	21.3	56	16	40	4.0	19.8	27.5	10.3	47.6
36.	47.8	31.4	3.6	15.1	57	20	37	1.0	28.2	22.5	15.2	49.4
37.	38.1	29.7	4.4	25.5	54	18	36	9.0	22.9	30.1	13.9	46.4
38.	38.8	26.3	6.0	28.2	51	30	21	1.0	26.6	20.7	15.6	51.3
39.	37.3	30.6	5.1	24.2	49	28	21	6.3	15.4	18.3	5.8	47.6
40.	29.3	32.2	7.5	29.3	52	27	25	5.2	29.7	32.6	16.1	48.3

and maximum xylene holding capacity increased on saturation with lime. Prasad *et al.* (1973) reported that liming acid soils increased water holding capacity.

4. **Hydraulic conductivity at minimum bulk density:** Red soils registered remarkably high values, thereby indicating that they were highly permeable to water. Clay content adversely affected permeability. Black and alluvial soils with comparatively high content of calcium are extremely impermeable when compared to other groups. Laterite soils recorded intermediate values. It could be seen from the data that clay impeded the conductivity of water in soil. High content of sand in red soil might have contributed to larger conductivity in red soils.

5. **Per cent aggregate stability:** Black soils showed strikingly higher aggregate stability than other soils, followed by alluvial, red and laterite soils. Since flocculation preceded cementation in forming soil aggregates, calcium rich soils were found to possess high aggregate stability because of the profound influence of calcium on soil flocculation. Black and alluvial soils were found to possess highly stable aggregates. The value for this property varied from 35.4 to 91.4 per cent. Black soils in addition to high clay content contained appreciable amount of exchangeable calcium. Clay particles through the medium of calcium ions influenced granulation and formation of stable aggregates (Selvakumari, 1971). Per cent aggregate stability was found to be closely correlated with exchangeable calcium ($r = 0.801^{**}$).

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