Journal of Tropical Agriculture 31 (1993) : 131 - 136

# REDISTRIBUTION OF EXCHANGEABLE CALCIUM, MAGNESIUM AND ALUMINIUM FOLLOWING APPLICATION OF DIFFERENT LIMING MATERIALS IN COMBINATION WITH GYPSUM IN A LOW ACTIVITY CLAY SOIL OF KERALA

Laterite soils covering 60 per cent of the area of Kerala are predominant in low activity kaolinite and hydrous oxide clays. These soils are inherently acid and contain small amounts of exchangeable Ca and Mg, high levels of exchangeable Ai and possess low CEC. The practice of surface incorporation of lime in the upper 15 cm of the soil often reduces only the surface acidity and toxic factors. Thus subsoil acidity and low calcium concentration continue to exist as a problem below the plough depth. Incorporation of lime to the subsoil is not feasible in general because of the cost of deep ploughing. Alternatively, Reeve and Sumner (1972) recommended surface application of gypsum and dolomitic lime (combined) for Natal Oxisols to neutralise exchangeable Al while increasing the level of exchangeable Ca and Mg in the subsoil. The rainfall is to be sufficient to dissolve enough of the amendments and promote movement of Ca salts into the subsoil. Kerala receives an annual rainfall of approximately 3000 mm which would facilitate deep leaching of gypsum and movement of Ca to the subsoils.

A study was initiated on the leaching and mobility of Ca and Mg using different liming materials in combination with gypsum, to study its impact on reducing subsoil acidity. Soil samples from a profile of Vellanikkara series were collected at five depths viz., 0-20, 20-40, 40-60, 60-80 and 80-100 cm. Relevant physical and chemical properties of soil are given in Table 1. The bulk samples from each layer were collected separately, air dried and ground with wooden mallet. Samples were filled up in PVC columns of 1 m length and 10 cm diameter, maintaining a bulk density of 1.5 $g/cm^3$ to simulate a soil profile.

The filled up PVC columns were fixed vertically in the green house using wooden stands and supports. Drainage was provided by a funnel and tube arrangement at the bottom of each column. The experiment was conducted during February to April 1991 in the Department of Soil Science, College of Horticulture, Vellanikkara. Lime application was done at the rate to neutralise 1.5 times KC1 extractable AI, which worked out to 1680 kg/ha. The treatments were as shown below.

TO : No lime

T1 : $CaCO_3$ at the rate of 1.5 times exchangeable Al content

T2 : $CaCO_3 + CaSO_4.2H_2O$ (25 per cent of total lime requirement)

T3 : $CaCO_3 + CaSO_4.2H_2O$ (50 per cent of total lime requirement)

T4 : $CaCO_3 + CaSO_4.2H_2O$ (75 per cent of total lime requirement)

T5 : $MgCO_3$ at the rate of 1.5 times exchangeable Al content

T6 : $MgCO_3 + CaSO_4.2H_2O$ (25 per cent of the total lime requirement)

T7 : $MgCO_3 + CaSO_4.2H_2O$ (50 per cent of the total lime requirment)

T8 : $MgCO_3 + CaSO_4.2H_2O$ (75 per cent of the total lime requirment)

T9 : $CaSO_4.2H_2O$ at the rate of 1.5 times exchangeable Al content.

Table 1. Physical and chemical properties of the soil used for the column study

| Horizon cm | pH | Exchangeable, cmol (+)/kg Al | Ca | Mg | K | Na | CEC (sum of cations) | Al saturation % |
|---|---|---|---|---|---|---|---|---|
| 0-20 | 5.31 | 1.30 | 1.76 | 0.66 | 0.11 | 0.17 | 4.00 | 32.50 |
| 20-40 | 5.10 | 1.43 | 1.54 | 0.66 | 0.12 | 0.16 | 3.91 | 36.57 |
| 40-60 | 5.07 | 1.69 | 1.54 | 0.66 | 0.13 | 0.11 | 4.13 | 40.92 |
| 60-80 | 5.03 | 1.82 | 1.76 | 1.10 | 0.12 | 0.22 | 5.02 | 36.25 |
| 80-100 | 5.16 | 1.30 | 2.64 | 1.32 | 0.14 | 0.18 | 5.58 | 23.30 |

Location : Vellanikkara, Type : Laterite
Column length : 100 cm, Diameter: 10 cm, Surface area : 78.5 $cm^2$
Volume : 7850 $cm^3$, Bulk density : 1.5 $g/cm^3$, Moisture : 2.5%

The treatments given were applied to the surface layer of the column and mixed well with 2 cm of the soil. Prior to application of treatments the soils were brought to field capacity. The soils were irrigated for 45 days with 150 ml water using a rose can to simulate the daily rainfall at Vellanikkara. The soil columns were cut horizontally at different depths by a hack saw after the above period. The soil samples from each depth were dried and the2 mm sieved samples were utilised foranalysisbystandardmethodsoutlined by Hesse (1971).

The results of the study indicate that the $CaCO_3$ and $MgCO_3$ treatments raised the pH only in the surface 10 cm layer of the soil. Beyond 10 cm no change in pH was observed. The $CaSO_4.2H_2O$ treatment and combination treatments also showed reduction in pH.

The mobility of applied calcium resulting from $CaCO_3$ treatments was restricted to the surface 10 cm of the profile (Table 2). In marked contrast to this the application of $CaSO_4.2H_2O$ has resulted in a relatively high accumulation in the 0-40 cm depth and a general increase in the remaining part of the profile. The combination treatments of liming materials with gypsum also brought about substantial movement of calcium to lower depths. The movement of calcium was found to increase as the proportion of gypsum was increased. This is possibly due to the role of stable $SO_4$ anion present in gypsum which has enhanced the mobility of Ca. The same pattern of distribution holds good for $MgCO_3$ treatments also in combination with gypsum (Table 3).

Table 4 presents the relationship between treatments and the distribution of exchangeable Al in the soil column. The $CaCO_3$ treatment reduced exchangeable Al to a depth of 25 cm, $MgCO_3$ treatment to a depth of 30 cm and $CaSO_4.2H_2O$ treatment to a depth of 50 cm. Combination treatments of $CaCO_3$ gypsum also showed reduction in Al concentration to a depth of 40 cm while $MgCO_3$ gypsum combination showed decrese in Al concentration throughout the depth of the soil column. The decrease in the exchangeable Al may be due to

Table 2. Downward movement of applied Ca as influenced by various treatments, **cmol(+)/kg**

| Depth cm | Treatments T0 | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | T9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0-5 | 1.98 | 11.77 | 12.10 | 13.09 | 16.72 | 1.21 | 2.31 | 6.49 | 9.02 | 17.71 |
| 5-10 | 1.65 | 1.76 | 2.75 | 3.96 | 4.29 | 1.65 | 1.43 | 1.21 | 2.75 | 5.39 |
| 10-15 | 1.54 | 1.43 | 2.64 | 3.85 | 4.07 | 1.54 | 1.54 | 1.32 | 2.64 | 5.17 |
| 15-20 | 1.54 | 1.54 | 2.64 | 3.63 | 3.85 | 1.54 | 1.76 | 1.65 | 2.64 | 5.06 |
| 20-25 | 1.54 | 1.43 | 2.09 | 3.52 | 3.74 | 1.54 | 1.87 | 1.87 | 2.42 | 4.73 |
| 25-30 | 1.54 | 1.54 | 1.76 | 2.75 | 3.08 | 1.65 | 1.76 | 2.31 | 2.42 | 4.62 |
| 30-40 | 1.42 | 1.65 | 1.43 | 2.09 | 2.20 | 1.65 | 1.54 | 1.98 | 2.42 | 3.63 |
| 40-50 | 1.54 | 1.76 | 1.54 | 1.87 | 1.87 | 1.54 | 1.65 | 1.65 | 2.42 | 1.87 |
| 50-60 | 1.54 | 1.54 | 1.32 | 1.76 | 1.87 | 1.65 | 1.54 | 1.65 | 2.09 | 1.98 |
| 60-70 | 1.65 | 1.54 | 1.54 | 1.76 | 1.76 | 1.87 | 1.76 | 1.54 | 1.98 | 1.98 |
| 70-80 | 1.87 | 1.76 | 2.09 | 2.09 | 2.20 | 1.87 | 2.20 | 2.20 | 2.09 | 1.98 |
| 80-90 | 2.42 | 2.09 | 2.20 | 2.20 | 2.53 | 2.20 | 2.64 | 2.53 | 2.75 | 2.42 |
| 90-100 | 2.64 | 2.53 | 2.64 | 2.64 | 2.64 | 2.53 | 2.86 | 2.75 | 2.86 | 2.75 |

Table 3. Downward movement of applied Mg as inflluenced by various treatments, **cmol(+)/kg**

| Depth cm | Treatments TO | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | T9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0-5 | 0.66 | * | * | - | * | 13.97 | 11.66 | 5.64 | 1.65 | * |
| 5-10 | 0.66 | 0.66 | 0.22 | • | * | 2.75 | 2.53 | 2.09 | 1.10 | » |
| 10-15 | 0.77 | 1.10 | 0.66 | 0.33 | * | 0.99 | 1.87 | • 1.98 | 1.10 | • |
| 15-20 | 0.88 | 0.88 | 0.88 | 0.44 | 1.10 | 0.77 | 1.65 | 2.20 | 1.43 | * |
| 20-25 | 0.88 | 0.99 | 1.54 | 1.65 | 1.10 | 0.99 | 1.54 | 2.20 | 1.76 | 0.44 |
| 25-30 | 0.77 | 0.88 | 1.21 | 1.09 | 1.87 | 0.77 | 1.54 | 1.54 | 1.98 | 0.66 |
| 30-40 | 0.66 | 0.66 | 0.88 | 0.55 | 1.54 | 0.77 | 0.99 | 1.32 | 1.98 | 1.21 |
| 40-50 | 0.77 | 0.55 | 0.99 | 0.77 | 1.32 | 0.88 | 0.88 | 1.32 | 1.21 | 1.10 |
| 50-60 | 0.66 | 0.88 | 1.10 | 0.99 | 0.99 | 1.10 | 0.88 | 0.99 | 0.77 | 0.88 |
| 60-70 | 0.99 | 0.88 | 1.10 | 1.10 | 0.99 | 1.21 | 1.10 | 1.21 | 0.66 | 0.88 |
| 70-80 | 1.10 | 1.21 | 1.32 | 1.10 | 1.21 | 1.32 | 1.10 | 1.32 | 1.32 | 0.88 |
| 80-90 | 1.32 | 1.43 | 1.54 | 1.54 | 1.32 | 1.32 | 1.21 | 1.21 | 1.32 | 1.21 |
| 90-100 | 1.32 | 1.43 | 1.32 | 1.32 | 1.32 | 1.76 | 1.32 | 1.54 | 1.32 | 1.54 |

* Traces

Table 4. Depthwise distribution of exchangeable Al as influenced by various treatments, cmol(+)/kg

| Depth cm | Treatments | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | TO | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | T9 |
| 0-5 | 1.00 | 0.20 | 0.10 | 0.15 | 0.10 | 0.55 | 0.30 | 0.15 | 0.10 | 0.40 |
| 5-10 | 1.60 | 1.15 | 1.00 | 1.10 | 1.20 | 0.60 | 0.65 | 0.45 | 0.75 | 0.95 |
| 10-15 | 1.60 | 1.20 | 1.15 | 1.25 | 1.15 | 1.25 | 1.15 | 1.15 | 0.95 | 1.10 |
| 15-20 | 1.55 | 1.20 | 1.10 | 1.25 | 1.15 | 1.10 | 0.80 | 0.95 | 0.85 | 1.35 |
| 20-25 | 1.60 | 1.45 | 1.60 | 1.15 | 1.25 | 1.20 | 1.05 | 1.15 | 1.05 | 1.00 |
| 25-30 | 1.55 | 1.55 | 1.55 | 1.10 | 1.25 | 1.35 | 1.15 | 0.90 | 1.10 | 1.10 |
| 30-40 | 1.40 | 1.45 | 1.45 | 1.30 | 1.35 | 1.45 | 1.35 | 1.15 | 1.10 | 1.25 |
| 40-50 | 1.35 | 1.45 | 1.35 | 1.50 | 1.35 | 1.50 | 1.15 | 1.25 | 1.20 | 1.10 |
| 50-60 | 1.35 | 1.25 | 1.30 | 1.45 | 1.30 | 1.40 | 1.15 | 1.00 | 1.10 | 1.45 |
| 60-70 | 1.30 | 1.40 | 1.20 | 1.50 | 1.35 | 1.55 | 0.85 | 1.20 | 0.95 | 1.40 |
| 70-80 | 1.25 | 1.05 | 1.30 | 1.30 | 1.25 | 1.15 | 0.60 | 0.75 | 0.35 | 1.00 |
| 80-90 | 1.35 | 0.75 | 0.80 | 0.60 | 0.80 | 0.40 | 0.20 | 0.60 | 0.25 | 0.35 |
| 90-100 | 0.40 | 0.50 | 0.70 | 0.65 | 0.35 | 0.25 | 0.20 | 0.35 | 0.25 | 0.35 |

polymerization of Al into insoluble forms (Pavan *et al.*, 1984). The patterns of mobility of Ca to the lower depths by the different treatments brought about increase in the calcium saturation and concomitant decrease in the Al saturation in the lower depths.

The study brings out the possibility of utilisation of gypsum as a liming material for correcting subsoil acidity in the upland laterite soils especially for perennial crops.

College of Horticulture
Vellanikkara 680 654, Trichur, India

Tessy Jacob
V.K. Venugopal

REFERENCES

Hesse, P.R. 1971. *A Text Book of Soil Chemical Analysis.* John Murray Publishers Ltd., London, p. 520

Pavan, M.A., Bingham, F.T. and Pratt, P.F. 1984. Redistribution of exchangeable calcium, magnesium and aluminium following lime or gypsum applications to a Brazillian Oxisol. *J. Soil Sci. Soc. Am.* **48** : 33-38

Reeve, N.G. and Sumner, M.E. 1972. Amelioration of subsoil acidity in Natal Oxisols by leaching surface applied amendments. *Agrochemophysica* 4 : 1-5