

EFFECT OF DOLOMITE ON SOIL REACTION AND NUTRIENT AVAILABILITY IN TEA SOILS

S. Krishnapillai, N. Jeyachandran and T. Balakrishnan
(*Tea Research Institute of Sri Lanka, Talawakele, Sri Lanka*)

Laboratory incubation studies were carried out to investigate the effect of incorporating different levels of dolomite in soils collected from different tea growing districts on soil pH, availability of Mg, Al and K. The results showed that the change in soil pH and the release of available Mg in the soil varied significantly with the levels of dolomite used, time of incubation and the type of soils. With increasing levels of dolomite there was a corresponding increase in total available Mg but the maximum Mg released differed with soil type and incubation time. Addition of dolomite decreased the availability of Al significantly in all the soils tested in this study.

INTRODUCTION

Tea grows well in soils in the pH range of 4.5 to 5.5. Since of late, the pH of tea fields in Sri Lanka have markedly declined to levels close to 4.0 and in some instances even close to 3.5. Having realised the need for improving the soil acidity for better nutrient retention and availability to plants, the Institute recommended, as a remedial measure, increased levels of dolomite to those fields with a pH of less than 4.0 (TRI Circular No F 12, 1986) to counteract the high soil acidity which is detrimental to soil and plant growth. Subsequently, Sivapalan (1988) outlined in greater detail some guidelines to estimate the lime requirements of tea soils, by taking into account their pH, total cation exchange capacity and per cent base saturation. It was also mentioned that the soil organic matter status of the fields should also be taken into consideration in determining the quantity of lime to be added to counteract soil acidity.

Based on the lime requirements of soils and on the actual removal of magnesium from tea fields, a recommendation on dolomite to replace the magnesium that is removed out from the field and to counteract acidity of tea soils was put out recently (TRI Circular No F 12, 1989; Sivapalan and Krishnapillai, 1989). This recommendation was also based on some results obtained from controlled laboratory incubation studies on dolomite use in tea soils.

In this laboratory incubation study, the effect of increasing levels of dolomite incorporated in soils from different agro-climatic regions on soil pH and the availability of soil nutrients such as potassium, magnesium and aluminium was investigated.

MATERIALS AND METHODS

This experiment was carried out in 1989 and the soils used in this study were obtained from the following locations:

1. Tea Research Institute, St Coombs Estate, Talawakele (Up country) where soils differing in texture and organic carbon from two fields were used.
2. TRI Low country Station, St Joachim Estate, Ratnapura (Low country).
3. TRI Advisory and Extension Centre, Passara (Uva district).

The chemical and physical characteristics of the above soils are presented in Table 1.

TABLE 1 – *Physical and chemical characteristics of tea soils*

Location	Physical Properties			Chemical Properties				pH
	Sand %	Clay %	Silt %	C %	Mg meq. %	K meq. %	Al meq. %	
St Coombs, Brown soil, Talawakele	48.0	22.0	24.0	2.41	0.24	0.17	2.20	4.35
St Coombs, Black soil, Talawakele	31.0	42.0	20.0	6.78	0.25	0.25	4.90	4.30
St Joachim, Ratnapura	81.0	12.0	7.0	1.85	0.34	0.13	0.55	5.00
Advisory & Extension Centre, Passara	57.0	28.0	15.0	2.57	0.26	0.18	1.85	4.30

The soils were collected from under tea bushes and after air drying (22°C), they were sieved through a 2 mm sieve. The moisture content of the sieved samples was adjusted to their respective moisture at field capacity. Portions of the moisture adjusted soils were treated with different levels of dolomite and the samples were thoroughly mixed and transferred to polythene bags and after firmly securing their open ends they were incubated on laboratory benches at 22°C. Each soil type at each level of dolomite was replicated twice.

Dolomite was incubated at the following rates:

- 1) 0.75 t ha⁻¹, 2) 1.5 t ha⁻¹, 3) 2.25 t ha⁻¹, 4) 3.00 t ha⁻¹,
- 5) 3.75 t ha⁻¹, 6) 4.50 t ha⁻¹, 7) 5.25 t ha⁻¹, 8) 6.00 t ha⁻¹,
- 9) 6.75 t ha⁻¹, 10) 7.50 t ha⁻¹, 11) Control (no dolomite)

The soil samples were drawn immediately after incubation and analysed for pH, K⁺, Ca²⁺, Mg²⁺ and Al³⁺ initially at weekly intervals but as the differences between weekly samples was not significant, the analyses after the 4th week was done monthly over a period of six months.

Analysis

1. Soil pH

Ten g portions of the soil samples were stirred well in 25 ml distilled water and the contents allowed to stand for 30 mins and then read for pH.

2. Cations (potassium, magnesium, calcium and aluminium)

Weighed accurately 5 g portions of the soil samples and transferred to shaking bottles to which 50 ml of N NH_4Cl were added. The contents were mechanically shaken overnight in a reciprocative shaking machine and filtered through a Whatman No. 42 filter paper and the filtrate used for the estimation of K, Mg and Ca.

a) Potassium

Five ml of the filtrate was diluted to 25 ml with distilled water and the concentration of K^+ in the diluted solution was estimated by flame photometry using KCl as the standard.

b) Magnesium

Five ml aliquots were diluted to 25 ml with distilled water and the concentration of magnesium was read off directly in an atomic absorption spectrophotometer.

c) Calcium

Five ml aliquots were transferred into 25 ml flasks and added 10 ml of 0.15 % (w/v) lanthanum chloride and the contents diluted to 25 ml with distilled water. The concentration of the Ca^{2+} in the diluted solution was estimated by the EEL flame photometer using CaCl_2 as the standard.

d) Aluminium

Ten g portions of the soil samples were taken in a shaking bottle and added 100 ml 1N KCl. The contents were shaken for half an hour and filtered through Whatman No. 42 filter paper. Two drops of the indicator phenolphthalein were added to 50 ml of the filtrate and the contents titrated with 0.05 N NaOH. To the titrated portion in the conical flask 4 % 10 ml NaF was added and the contents titrated again with 0.1N HCl from which the amount of Al was calculated.

RESULTS AND DISCUSSION

Amendment of soil reaction is important for many reasons. Apart from making available to the plants bases such as potassium, magnesium and calcium, toxic effects of excessively present manganese, iron and aluminium are also removed when the soils are amended to the desired pH in the root zone. Tea soils which are acidic with a pH around 4.0 are unproductive and such soils need to be amended with appropriate quantities of dolomite.

In this study we observed that the soils from different agro-climatic regions reacted differently to the applied dolomite. Of the four types of soils used, three (brown and

black soils from St.Coombs and the soil from Passara) had an initial pH of about 4.3 while the soil from Ratnapura had a pH of 5.0 (Table 1).

Though the pH of the soils from St.Coombs and Passara were initially similar the pHs achieved for each increment of dolomite differed for the different soil types (Figs. 1-3). The Passara soil showed a relatively greater change in pH, but this increase was significant only above 4.5 t ha⁻¹ dolomite. At levels below 4.5 t ha⁻¹ the change in pH for both Passara and St.Coombs brown soil was almost similar (Figs. 2,3). In contrast, the St.Coombs black soil reacted differently. This soil had the highest content of clay and organic matter and therefore its increased buffering capacity resisted a large change in pH, compared to the other soil types. In the St.Coombs black soil the increase in pH for each successive level of dolomite was relatively small; indeed, to increase the pH from 4.3 to 5.2 about 7.5 t ha⁻¹ dolomite was needed (Fig. 1). It was interesting to note that in soils where the organic carbon content was low, the change in pH attained soon after incubation increased further with time, but with high organic matter there was a negligible change in pH with time at each level of dolomite. Thus, the soils from both St.Coombs (brown) and Passara produced an increase of 0.2 to 0.7 units, at the end of 6 months but in the case of the St.Coombs black soil the pH remained almost the same even after 6 months of incubation after the initial increase noted within about a month. The soil from Ratnapura had a high content of sand and its organic matter content was also very low. In the case of this soil the incorporation of dolomite elevated the pH significantly compared to those of the others (Fig. 4). At an application of 4.5 t ha⁻¹ the pH was raised to about 6.00 immediately after incubation which was further increased to about 7.00 at the end of 6 months. The rapid elevation of pH in the soil from Ratnapura could be due to the low organic matter content of the soil and consequently of its lower buffering capacity. From the pH changes attained for the soils obtained from the different districts, it is estimated that the following quantities of dolomite would be necessary to elevate the pH from 4.3 to about 5.00.

- 1) Passara - 1.5 t/cycle
- 2) St.Coombs (Brown soil) – 2.25 t/cycle
- 3) St.Coombs (Black soil) – 4.5 t/cycle

For the soil from Ratnapura, which was already at a pH of 5.00 there was no need for any soil amendment with dolomite.

The cations such as magnesium and aluminium in the soils following dolomite application are presented in Figs 1-4.

The experimental data available do not furnish evidence that the soil reaction and increased concentration of Ca²⁺ and Mg²⁺ brought about by dolomite application has any great influence on the availability of exchangeable or water soluble potassium in the soil. It was observed that the soil exchangeable K⁺ did not show much variation with increasing rates of dolomite application; the same was true with the water soluble K⁺ as well (Table 2). This shows that the soil used (kaolinitic) in this study had a strong binding for K⁺ than Ca²⁺ or Mg²⁺ ions. The stronger binding of K⁺ over Ca²⁺ or Mg²⁺ may be attributed to the presence of specific K adsorption sites on the kaolinitic clay minerals. Similar observations were also reported by Jensen (1972) and Udo (1978) for kaolinitic clay minerals derived from strongly weathered tropical soils. Although the

TABLE 2 – Effect of dolomite application on water soluble K, Mg, Ca and exchangeable Ca²⁺ and K (ppm) in St. Coombs black (C% 6.78) and brown (C% 2.41) soils

Amount of dolomite applied	Brown soil					Black soil				
	exch. K ⁺	water K ⁺	exch. Ca ²⁺	water Ca ²⁺	water Mg ²⁺	exch. K ⁺	water K ⁺	exch. Ca ²⁺	water Ca ²⁺	water Mg ²⁺
Control	84.0	12.0	225.0	30.0	5.67	88.0	12.0	325.0	60.0	5.83
0.75	88.0	8.0	275.0	30.0	8.47	100.0	10.0	500.0	55.4	8.75
1.5	88.0	8.0	300.0	40.0	12.81	88.0	10.0	550.0	55.4	11.37
2.25	88.0	8.0	325.0	40.0	15.04	88.0	10.0	575.0	55.4	14.27
3.0	88.0	8.0	425.0	50.0	17.87	100.0	10.0	700.0	55.4	13.78
3.75	88.0	7.0	450.0	50.0	19.64	88.0	10.0	725.0	55.4	16.11
4.5	84.0	7.0	525.0	50.0	19.67	100.0	10.0	875.0	55.4	17.96
5.25	84.0	8.0	600.0	60.0	23.43	100.0	10.0	1000.0	55.4	18.26
6.00	84.0	8.0	725.0	60.0	35.12	100.0	10.0	1075.0	55.4	19.19
6.75	88.0	8.0	800.0	70.0	34.59	100.0	10.0	1150.0	55.4	26.72
7.5	88.0	8.0	850.0	80.0	36.7	88.0	10.0	1200.0	60.0	28.77

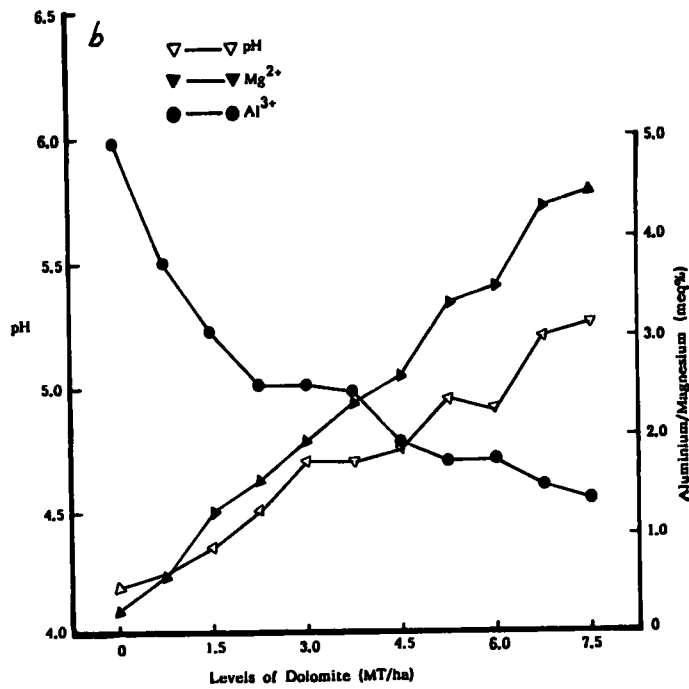
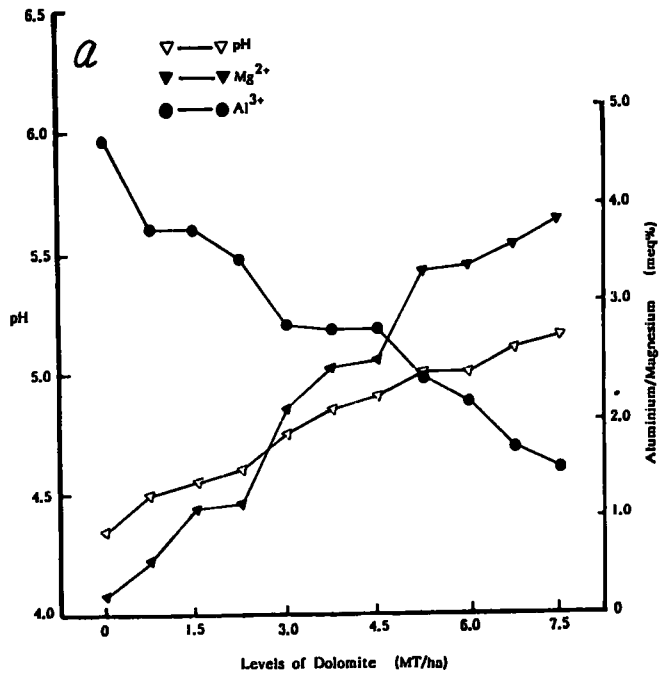


Fig. 1— Effect of levels of dolomite on pH, exchangeable Mg and Al in St Coombs black soil at a) zero time, b) after 6 months.

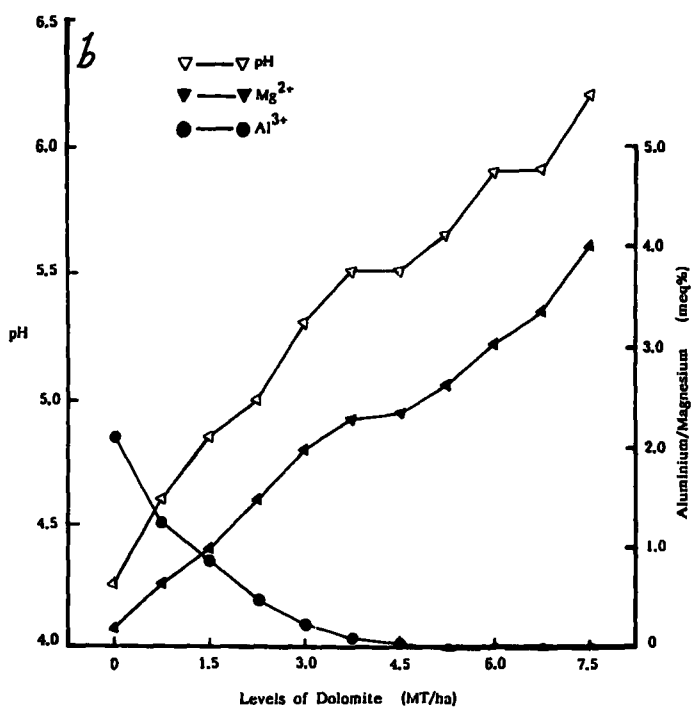
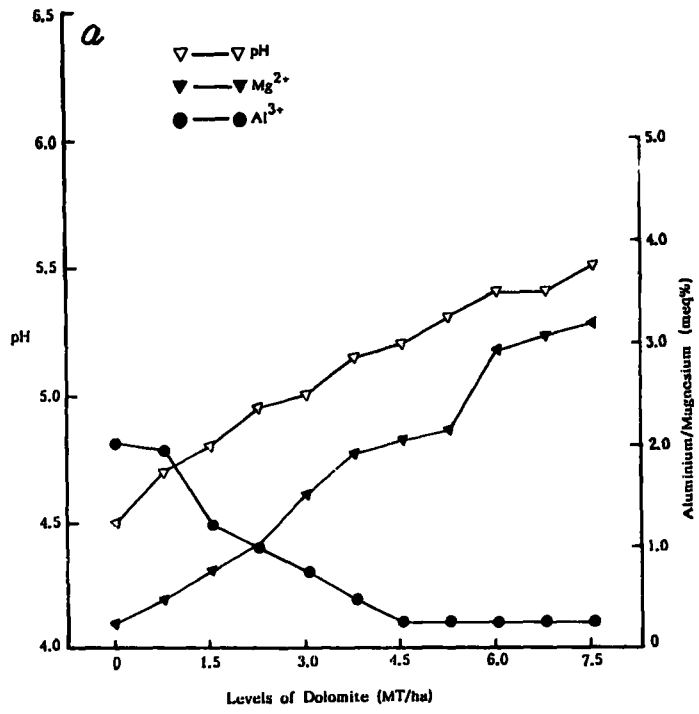


Fig. 2 – Effect of levels of dolomite on pH, exchangeable Mg and Al in St Coombs brown soil at a) zero time, b) after 6 months.

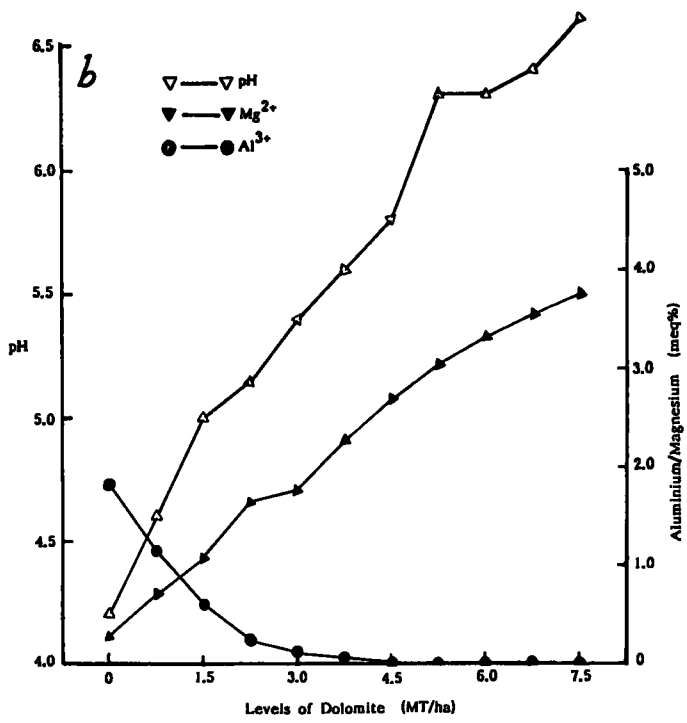
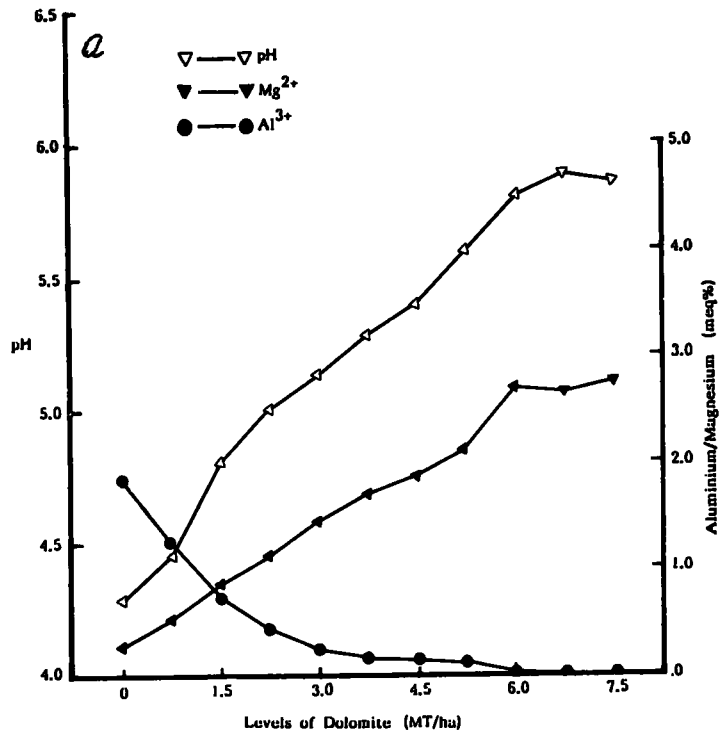


Fig. 3 – Effect of levels of dolomite on pH, exchangeable Mg and Al in Passara soil at a) zero time, b) after 6 months.

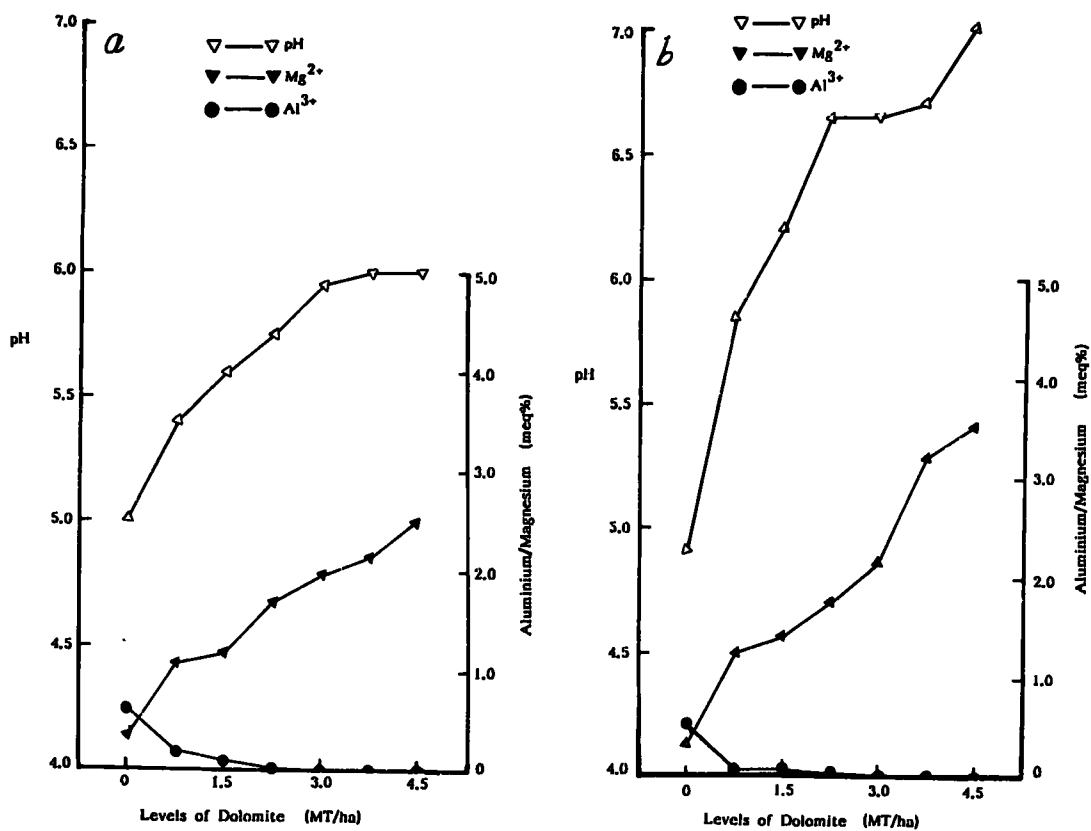


Fig. 4 – Effect of levels of dolomite on pH, exchangeable Mg and Al in Ratnapura soil at a) zero time, b) after 6 months.

application of 2.0 t ha⁻¹ of dolomite to soils in North India, decreased the acidity by 0.7 unit it did not change the exchangeable K (ammonium acetate extractable) in the soil.

Though increased application of dolomite increased the water soluble Ca²⁺ ions in the St.Coombs brown soil there was no change in the water soluble Ca²⁺ ions in the black soil which contains relatively high carbon content. It is probable that the high content of colloidal complex ions in the black soil could have chelated the free Ca²⁺ ions derived from the applied dolomite preventing them from coming into solution.

The soil exchangeable magnesium showed an increasing trend with the progressively higher rates of dolomite (Figs. 1-4). Soon after incubation, in all the soils the soil magnesium increased with increasing applications of dolomite but the amount varied from soil to soil. The Passara soil contained about 0.26 meq % Mg but at an application rate of 7.5 t, the amount increased to 2.78 meq % soon after incubation, while at the end of 6 months there was a gradual build up of magnesium at each level of dolomite used (Fig. 3). A similar trend was observed in the brown soil from St.Coombs (Fig. 2). The St.Coombs black soil behaved differently. Although this soil without any incorporation of dolomite contained similar quantities of magnesium as the Passara and St.Coombs brown soil the amount detected soon after incubation, in the St.Coombs black soil was significantly more for each level of dolomite used (Fig. 1). In this soil, with an application rate of 7.5 t the available Mg was 4.08 meq % soon after incubation but it rose gradually to 4.45 meq %. It is also to be noted that in the St.Coombs black soil, the change in magnesium content with time was small (Fig.1). In fact, up to 4.5 t there was no change in soil magnesium with time and the change above this level was also relatively small. The soil from Ratnapura contained about 0.34 meq % Mg and with the first level of dolomite (0.75 t) the available Mg rapidly rose to 1.00 meq % – a change that was not detected in the other soil samples (Fig. 4). Similar increases were noticed with the other levels of dolomite as well.

At the pHs favourable for tea growth (4.5 to 5.5), the magnesium content of the different soil types tested in the study remained above 0.8 meq % (i.e. 100 ppm). For the Passara soil, to increase the pH from 4.3 to a pH range of 4.5 to 5.0, it was necessary to incorporate about 0.75 to 1.5 t of dolomite and with this addition the soil Mg improved from 0.5 to 0.8 meq % (i.e. 60 to 100 ppm). For the St.Coombs black soil, the soil amendment with dolomite to the desired pHs resulted in the soil having 1 to 2.5 meq % (i.e. 120 ppm to 300 ppm Mg). The Ratnapura soil without amendment with dolomite contained about 0.35 meq % (i.e. 40 ppm) Mg and in this case, as the soil was already at the desired pHs, soil amendment with dolomite was not required.

However, to bring the soil magnesium to the desired levels as seen in the other soils, it may be necessary to use other sources of magnesium that would have little effect on soil pH. In this case the use of Kieserite is beneficial.

The effect of pH on soil available aluminium was interesting (Figs.1-4). Among the soils tested, the Ratnapura soil contained the least aluminium (Fig. 4) and the St.Coombs black soil the most (Fig. 1). The low quantity of aluminium in the Ratnapura soil could be due to its high initial pH (5.0).

In all soils the soil aluminium dropped markedly as the pH increased with increasing application of dolomite. At the end of 6 months, in the Passara soil, aluminium content dropped from 1.85 meq % to about 0.05 meq % at 3.75 t dolomite (Fig. 3) while in the St.Coombs black soil, it dropped from about 5 meq % to 1.35 meq % at 7.5 t dolomite (Fig. 1). The other soils too showed a similar trend. The increasing doses of dolomite caused immediate reductions in the aluminium content of the soils after incubation in the same manner in which it caused increases in soil pH. With time further reductions in aluminium content were noted in all the soils. In sandy soils with less organic matter, as in the case of the soil from Ratnapura there was a marked disappearance of aluminium with dolomite application (Fig. 4).

This study shows the advantage of incorporating dolomite which helps to adjust the pHs to desired ranges (4.5 - 5.5) as well as to supply the soil with adequate quantities of available magnesium and at the same time to reduce the concentration of aluminium and to eliminate possible toxic effects of aluminium, manganese and iron in tea soils; the reduction in the aluminium content is another desirable effect to increase the efficiency of phosphates in our acid tea soils. The amount of dolomite to be applied is related to the soil conditions and as is evident in this study, consideration of the soil organic matter is also vital.

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