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Effect of Application of Different Rate of Dolomite on Soil and Plant Micronutrient Status of Tea, *Camellia sinensis* (L.) O.Kuntze

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ABSTRACT

This experiment was carried out to investigate the effect of dolomite application on micronutrients availability in soil and plants. The experiment was done under five treatments (0, 1000, 2000, 3000 and 4000 kg of dolomite/ha/yr) with three replicates. Soil and leaf samples were analyzed for zinc, copper, manganese, ferrous and boron. Diethylenetriaminepentaacetic acid (DTPA) extractable method and dry ashing method were used to determine trace elements in soil and leaf materials, respectively. The exchangeable magnesium and calcium in soil were increased significantly in dolomite applied plots with compared to the control. With the increase in dolomite rate, available manganese and copper concentration significantly decreased because of increase of soil pH. Increasing rate of dolomite did not show significant effect on available zinc, boron and ferrous concentration in soil. Increasing level of dolomite did not change leaf manganese, zinc, copper and ferrous content significantly.

KEYWORDS: Dolomite, Soil and leaf micronutrients, Soil pH, Tea

INTRODUCTION

Tea, *Camellia sinensis* (L.) O. Kuntze plant belongs to family Theaceae, and genus Camellia. Tea plays a major role in the economy of Sri Lanka because it is one of the major foreign exchange earners to the country. Sri Lanka is the oldest tea producing country, with the land extent of 221,969 ha and production of 290,000 MT and it contributes 1.7 % to the Gross Domestic Production (GDP) (Anon, 2009).

There are sixteen nutrient elements, which are recognized as essential for a satisfactory plant life. Among them, ten are classified as micronutrients or trace elements which are needed in minute quantities compared with the macro which are needed in large quantities. Micronutrients are Zinc (Zn), Manganese (Mn), Copper (Cu), Boron (B), Ferrous (Fe), Cobalt (Co), Chromium (Cr), Iodine (I), Selenium (Se) and Molybdenum (Mo).

When plucking, large amount of macro and micro nutrients are removed. Therefore, a huge demand is created in the plant for nutrition to offer flush yield at 5 to 7 days intervals. In addition to the major nutrients, micro nutrients are also required for better growth of the plant as well as to produce a harvestable crop. If fertilizer application is not done in correct time, the plants start to show symptoms of nutrient deficiencies.

In order to take care of micronutrient deficiencies, suitable micronutrient carriers are needed since they cannot be applied in elemental form. Although, these nutrients are not supplied to the field as regularly as major nutrients, long term negligence of micronutrients application and inherited low levels of micronutrients may lead to visible deficiencies in the tea fields.

Alternatively, tea plants prefer acidic soils, where pH ranges from 4.5 to 5.5. The soil pH should be checked prior to every prune, as high acidic conditions below the optimum would unable to give sustainable yields. Consequently, maintaining a favorable soil pH is undertaken as a desirable agronomic practice, in order to create a healthy environment for better growth of tea plants.

Dolomite limestone is applied in many countries to arrest increasing soil acidity. In Sri Lankan tea soils, acidification is a huge problem due to continuous application of nitrogen to the soil (Anon, 1989). Therefore dolomite application at each pruning is an important practice in Sri Lankan tea plantations. The beneficial effects of liming are improvement of soil pH suitable for nutrient availability and absorption, supply of an inexpensive source of magnesium (Mg) and calcium (Ca), reduction of possible toxicity by aluminium (Al) and Mn and improvement of soil physical and biological conditions.

The present micro nutrient recommendation of TRI is application of $ZnSO_4$ at the rate of 6 and 11 kg ha^{-1} yr^{-1}, for fields yielding less than, and above 2000 kg made tea $ha^{-1}yr^{-1}$ respectively, in 4 applications within 7 -14 days after soil fertilization.

Therefore, the aim of the present investigation is to study the effect of application of increasing rate of dolomite on micronutrient status, particularly Zn, Mn, Cu and B as they are considered as very important microelements in tea nutrition. Moreover, this seeks to develop micronutrient recommendations for mature tea.

MATERIALS AND METHODS

Location

The soils and foliar samples were collected from long term field experiment on effect of levels of dolomite on soil and plant nutrient status and yield at Midland Estate, Rathtota.

The soil and leaf samples were analyzed at the Soils and Plant Nutrition Division, Tea Research Institute of Sri Lanka, Talawakelle.

Treatments

The treatments were used as follows.

T_1 - 0 kg of dolomite/ha/yr
T_2 - 1,000 kg of dolomite/ha/yr
T_3 - 2,000 kg of dolomite/ha/yr
T_4 - 3,000 kg of dolomite/ha/yr
T_5 - 4,000 kg of dolomite/ha/yr

Soil and Leaf Sampling

Soil samples were collected to a depth of 0-6" and 6-12", from experimental plots and collected samples were air dried in the laboratory. Then, they were passed through 2mm sieve for soil available nutrients analyses. The mother leaves were sampled from experimental plots, and leaves were oven dried at 80^0C and were grounded prior to analysis.

Analytical Procedure

pH was measured potentiometrically in a soil: 0.01M $CaCl_2$ solution suspension of 1:2.5. Available Mg and Ca concentration extracted by 1N NH_4Cl solution. Mg and Ca contents were determined by using the Atomic Absorption Spectrophotometer (AAS). DiethyleneTriaminePenta Acetic (DTPA) acid extractable method was used to extract trace elements. The Zn, Cu, Mn and Fe content were determined by AAS. Available B was extracted by hot water and B content was determined by colorimetric method. The leaf samples were digested by Dry ash method and analyzed for Zn, Cu, Mn and Fe content by AAS.

Statistical Analysis

The data collected from field experiments were tabulated and Analysis of Variance (ANOVA) was done by using Statistical Analysis System (SAS) Version 9.1

RESULTS AND DISCUSSION

Effect of Application of Dolomite on Soil pH

The changes in soil pH due to different rates of dolomite application are shown in Table 1. There was a significant increment of soil pH with increasing rate of dolomite application. Similar results were observed by Pathirana (2000) with addition of increasing amount of dolomite in tea soils.

Table 1. Soil pH at two depths with different rate of dolomite applications

Dolomite (kg/ha/yr)	Soil pH	
	Depth(0-6")	Depth(6-12")
0	4.23b	3.86b
1,000	4.29b	3.95b
2,000	4.44b	3.96b
3,000	4.45b	3.96b
4,000	5.02a	4.77a
LSD	0.4288	0.3801

Means followed by the same letters in each column are not significantly different at 0.05 levels.

Effect of Application of Dolomite on Soil Ca and Mg Concentrations

The increasing rate of dolomite application significantly increased soil Ca and Mg concentration as shown in Tables 2 and 3.

Table 2. Soil Ca concentration at two depths with different rate of dolomite applications

Dolomite (kg/ha/yr)	Soil Ca concentration (mg/kg)	
	Depth (0-6")	Depth (6-12")
0	80.60b	95.8b
1000	110.1b	116.5b
2000	142.7b	132.7b
3000	212.6ab	182.4b
4000	569.5a	526.4a
LSD	397.41	260.82

Means followed by the same letters in each column are not significantly different at 0.05 levels.

Table 3. Soil Mg concentration at two depths with different rate of dolomite applications

Dolomite (kg/ha/yr)	Soil Mg concentration (mg/kg)	
	Depth (0-6")	Depth (6-12")
0	14.12c	16.40b
1000	22.87c	19.06b
2000	41.09bc	42.60b
3000	70.02ab	57.27b
4000	108.45a	188.27a
LSD	39.941	71.585

Means followed by the same letters in each column are not significantly different at 0.05 levels.

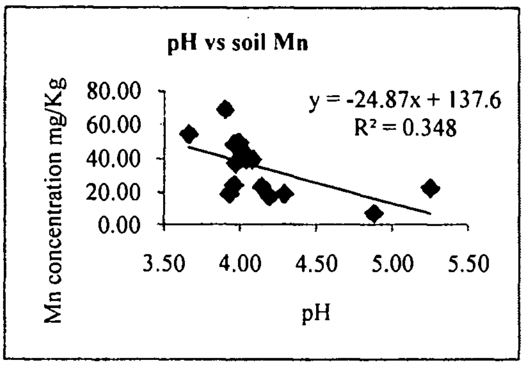
Effect of Application of Dolomite on Soil and Plant Mn Concentration

With increasing dolomite rate, Mn concentration was significantly decreased because of a negative correlation between Mn concentration and soil pH (Table 4 and Figure 1). The treatment without dolomite application had highest Mn value and lowest was recorded in 4000 kg of dolomite/ha/yr applied field. This indicates that dolomite application reduce the available Mn concentration in the soil.

Table 4. Soil Mn concentration at two depths with different rate of dolomite applications

Dolomite (kg/ha/yr)	Soil Mn concentration (mg/kg)	
	Depth (0-6")	Depth (6-12")
0	57.30a	48.37a
1000	36.27b	51.08a
2000	30.61b	28.90ab
3000	31.49b	33.98ab
4000	16.32c	13.17b
LSD	13.488	29.69

Means followed by the same letters in each columnare not significantly different at 0.05 levels.



Figurel. Correlation between soil Mn concentration and soil pH

The behavior of Mn in soils depends largely on pH and redox potential. All factors which influence oxidation-reduction influence Mn solubility and its availability to plants. Therefore, soil pH, dolomite, organic carbon, microbial activity and soil moisture have significant impact on Mn availability. High pH in soil increases oxidation of Mn whether, the process is chemical or biological. The reverse is true in acid soils (Tandon, 1995).

Increasing levels of dolomite application did not change leaf Mn content significantly (Table 5).

Table 5. Leaf Mn concentration with different rate of dolomite applications

Dolomite (kg/ha/yr)	Leaf Mn concentration (mg/kg)
0	3529
1000	2559
2000	2502
3000	2649
4000	3051
LSD	1398

Effect of Application of Dolomite on Soil and Leaf Zn Concentration

Increasing rate of dolomite application did not show significant effect on available Zn concentration in soil (Table 6). But decreasing trend was observed up to 3000 kg of dolomite/ha/yr applied fields.

Table 6. Soil Zn concentration at two depths with different rate of dolomite applications

Dolomite (kg/ha/yr)	Soil Zn concentration (mg/kg)	
	Depth (0-6")	Depth (6-12")
0	1.33	1.46
1000	2.20	1.19
2000	0.88	0.89
3000	0.84	0.98
4000	1.51	1.42
LSD	2.56	1.09

Means followed by the same letters in each column are not significantly different at 0.05 levels.

When soils pH is greater than 7, the availability of Zn becomes very low. Severe Zn deficiency is often associated with high soil pH. Under acidic conditions, Zn is most soluble and available for plants to absorb. Liming of acid soils to 5.6 and above reduced availability of Zn to forage crops (Gupta *et al.*, 1971).

Increasing level of dolomite did not change leaf Zn content significantly (Table 7).

Table 7. Leaf Zn concentration with different rate of dolomite applications

Dolomite (kg/ha/yr)	Leaf Zn concentration (mg/kg)
0	82.67
1000	57.33
2000	50.00
3000	62.00
4000	54.67
LSD	33.134

Effect of Application of Dolomite on Soil and Leaf Cu Concentration

Increasing level of dolomite rate significantly decreased, available Cu concentration in soil (Table 8). This was probably due to unavailability of Cu in high soil pH. In the present study a negative correlation was observed between soil Cu concentration and soil pH (Figure 2). The highest Cu concentration was observed in the treatment without dolomite when compared with dolomite applied fields. This indicates that dolomite application reduce the available Cu concentration in the soil.

Table 8. Soil Cu concentration at two depths with different rate of dolomite applications

Dolomite (kg/ha/yr)	Soil Cu concentration (mg/kg)	
	Depth (0-6")	Depth (6-12")
0	0.24a	0.20a
1000	0.04c	0.22a
2000	0.22ab	0.05a
3000	0.03c	0.39a
4000	0.09bc	0.10a
LSD	0.14	0.43

Means followed by the same letters in each column are not significantly different at 0.05 levels.

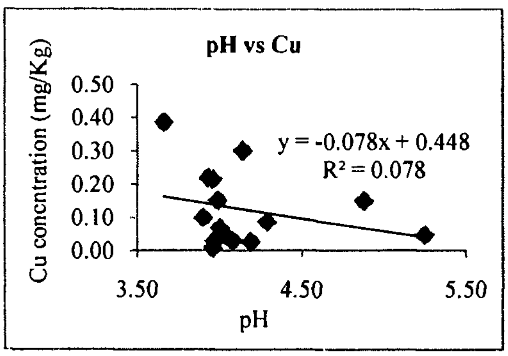


Figure 2. Correlation between soil Cu concentration and soil pH

Copper is tightly held on the soil exchange complex but is prone to leaching in coarse-textured soils. The major factors which control the transformation of Cu are the soil pH, $CaCO_3$, organic matter and clay content. Even the nature of clay minerals and presence of oxides of Fe and Al are important in regulating the behavior of Cu in soil (Tandon, 1995).

Increasing level of dolomite did not change leaf Cu content significantly (Table 9).

Table 9. Leaf Cu concentration with different rate of dolomite applications

Dolomite (kg/ha/yr)	Leaf Cu concentration (mg/kg)
0	82.67
1000	57.33
2000	50.00
3000	62.00
4000	54.67
LSD	33.134

Effect of Application of Dolomite on Soil and Leaf Fe Concentration

No significant difference was observed in Fe concentration under the different rate of dolomite in depth of 0-6" (Table 10). However, there was a significant different in Fe concentration in depth of 6-12". The highest value was recorded with dolomite rate of 4000 kg/ha/year.

Table 10. Soil Fe concentration at two depths with different rate of dolomite applications

Dolomite (kg/ha/yr)	Soil Fe concentration (mg/kg)	
	Depth(0-6")	Depth(6-12")
0	4.54 a	4.46ab
1000	4.45 a	3.86b
2000	3.89 a	3.03b
3000	4.34 a	4.28ab
4000	4.47 a	6.72a
LSD	1.38	2.77

Means followed by the same letters in each column are not significantly different at 0.05 levels.

In spite of high iron concentration in soils, its availability to the crops is a major problem in many soils. Usually, crops absorb iron as Fe^{2+} form. In the soil Fe^{2+} oxidizes to the unavailable Fe^{3+} form. Soil pH is the major factor which governs the solubility and consequently availability of iron to plants. Each unit of increment in pH decreases solubility of divalent and trivalent cations by 100 and 1000 folds respectively (Tandon, 1995).

Increasing level of dolomite did not change leaf Fe content significantly (Table 11).

Effect of Application of Dolomite on Soil B Concentration

No significant differences were observed in B concentration under the different rate of dolomite in both soil depths (Table 12). However, the lowest B concentration was observed in the treatment without dolomite when compared with dolomite applied fields.

Table 11. Leaf Fe concentration with different rate of dolomite applications

Dolomite (kg/ha/yr)	Leaf Fe concentration (mg/kg)
0	101.00
1000	90.00
2000	91.33
3000	84.67
4000	88.67
LSD	31.919

Table 12. Soil B concentration at two depths with different rate of dolomite applications

Dolomite (kg/ha/yr)	Soil B concentration (mg/kg)	
	Depth (0-6")	Depth (6-12")
0	0.75	1.09
1000	2.16	1.58
2000	1.59	2.18
3000	1.15	1.23
4000	1.92	2.38
LSD	1.79	1.55

The B supplying capacity of soil to the growing plants is a function of B content in soil solution which is controlled by texture, pH, electrical conductivity and organic carbon contentin soil. Most of added B gets fixed and only a small fraction gets transformed into different forms like water soluble, leachable and acid soluble B (Tisdale, 1985).

CONCLUSIONS

The exchangeable Mg and Ca in soil were increased significantly in dolomite applied plots compared to the control. With the increase in dolomite rate, Mn and Cu concentrations in the soil significantly decreased. However there was no significant effect of dolomite application on concentrations of available Zn, Fe and B in the soil.

Increasing level of dolomite did not change leaf Mn, Zn, Cu and Fe contents significantly.

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