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Investigation of Status of Sulfur in Coconut Lands in the Intermediate Zone of Sri Lanka

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ABSTRACT

Sulfur is one of the macronutrients which is necessary for the growth and development of the plants. However, as the continuous removal of sulfur from coconut growing soils without replenishment may cause depletion of soil sulfur. This study was focused to identify the status of sulfur in coconut growing soils in order to investigate the necessity of sulfur application for coconut plantations in Sri Lanka. Fifteen coconut estates were randomly selected in the intermediate zone of Sri Lanka and soil and leaf samples were collected from three coconut palms in each coconut land. Soils were analyzed for pH, available sulfur and total sulfur contents and leaf samples were assessed for total sulfur content using the standard methods. Soil available sulfur content of manure circle ranged from 2.35 mg/kg to 18.36 mg/kg in 0-20 cm depth and 2.05 mg/kg to 15.24 mg/kg in 20-40 cm depth. Higher sulfate content was observed in the sub soil compared to top soil and in center of the square compared to manure circles. Moreover, leaf sulfur contents of studied estates ranged from 0.07 to 0.29% and out of the studied samples 27% showed low sulfur content than the sufficiency range. In addition, 20% of the leaf samples were in the lower critical value of leaf sulfur, suggesting the need of external sulfur supplement for coconut growing soils prior to the depletion of sulfur pool in soil.

KEYWORDS: Available sulfur, Leaf sulfur, Manure circle, Total sulfur

INTRODUCTION

Coconut (*Cocos nucifera* L.) is one of the major plantation crops in Sri Lanka which has high economic value through its contribution of 0.8% for the gross national production of Sri Lanka (Anon, 2014). However, with the continuous withdrawal of nuts and other parts, majority of nutrients are removed from the coconut growing soils throughout its life cycle. Hence, the Coconut Research Institute recommends the application of nitrogen, phosphorus, potassium and magnesium fertilizers in order to compensate the nutrient loss while maintaining a sustainable crop production system.

Sulfur (S) is one of the macronutrients and it is considered as the fifth important nutrient for coconut (Jayasekara, 1990). Sulfur contributes for many functions in plants namely formation of chlorophyll, development and activation of certain enzymes and vitamins Jamall *et al.* (2010). Fazil *et al.* (2008) reported that lack of sulfur limits the efficiency of added nitrogen and therefore sulfur addition becomes necessary to achieve maximum efficiency of nitrogenous fertilizer. Furthermore, it has been found that lack of sulfur in coconut plantations cause to the strong yield reduction, copra quality deterioration and formation of rubbery copra.

Sulfur is added to soil through plant/animal residues, atmospheric fallout, fertilizers and pesticides. This S would transform into different forms and only about 5% of the total Sulfur pool will be in the form of available S. Plants usually take S as Sulfate (SO_4^{2-}) from the soil solution. Nevertheless, in addition to plant uptake, SO_4^{2-} can be removed from the soil solution through different processes namely immobilization, reduction and leaching (Anon, 2016) and this may cause inadequacy of available S to plants.

However, sulfur deficiency in coconut palms appears as light green to yellowish colour in leaves which is more or less similar to nitrogen deficiency (Anon, 2016), thus there is a possibility of misunderstanding S deficiency as the nitrogen deficiency. It has been more than two decades of discontinuation of ammonium sulfate addition to coconut cultivation which was a major source of S that contains 24% S. Moreover, due to the pressure on maximizing crop production through high yielding varieties; people tend to use high analysis fertilizers which are lack of sulfur without applying organic manure. In addition, rules and regulations have caused the reduction of SO_2 emission from industries. Therefore, all these factors have paved the way towards depletion of soil sulfur content as there is less replenishment compared to the continuous removal of soil sulfur in coconut plantations.

Hence, this study was focused on identifying the status of sulfur in coconut plantations in intermediate zone of Sri Lanka in order to investigate the necessity of applying Sulfur source for fertilizer recommendation in coconut.

MATERIALS AND METHODS

Experimental Sites

The study was carried out at the Soils and Plant Nutrition Division of the Coconut Research Institute of Sri Lanka. Soil and plant samples were collected from fifteen randomly selected coconut lands in Intermediate Zone of Sri Lanka during January to May 2016.

Soil Sampling and Analysis

Soil samples were collected from the manure circle (MC) of three representative coconut palms and center of the square (CS) in each selected location at two depths; 0- 20 cm and 20- 40 cm representing the top soil and sub soil respectively.

Soils were air dried and analyzed for pH (1:2.5 soil: solution ratio), available Sulfur content (Klimer and Nearpass, 1960) and total Sulfur content (Tabatabai, 1982).

Leaf Sampling and Analysis

Leaf samples of 14^{th} leaf were collected from the same palms from which soil samples were obtained and they were extracted by digestion with nitric, perchloric and hydrochloric acid (Miller, 1998) and assessed for total sulfur content turbidimetrically (Garrido, 1964).

Statistical Analysis

One sample t-test was conducted using the SAS 9.1.3 statistical package in order to identify the difference between the leaf S contents of studied samples and sufficiency range of leaf S in coconut.

RESULTS AND DISCUSSION

Variation in Soil pH

The pH values of top soil of manure circle ranged from 5.21 to 7.25 whereas in center of the square varied from 5.27 to 6.93. The higher pH values of manure circle than center square is explained by the application of dolomite to the coconut palms as a magnesium fertilizer.

Variation of Soil Available and Total Sulfur Contents

Soil available Sulfur content of manure circle ranged from 2.35 to 18.36 mg/kg in 0-20 cm depth and 2.05 to 15.24 mg/kg in 20- 40 cm depth. Moreover, the available Sulfur content in center of the square varied from 2.44 to 16.55 mg/kg in 0- 20 cm depth whereas 2.07 to 15.38 mg/kg in 20- 40 cm depth. In addition, a relative increase was observed in the Sulfate content of sub soil compared to top soil, may be due to the leaching of sulfate through the soil profile. Plant uptake may have caused lower available Sulfur contents in manure circles of studied sites compared to the center of the square (Table 1).

However, there are many factors that influence the availability of sulfate in soil, including soil minerology, organic matter content and type of organic matter, pH and the presence of other ions (Lavorenti and Alves, 2004). In this study, a low positive relationship was observed between soil pH and available sulfur contents in manure circle (r^2=0.20) and center of the square (r^2=0.06) indicating a slightly increased SO_4^{2-} contents with the increase of soil pH. Mattson (1927) found that a considerable amount of SO_4^{2-}-S was absorbed by soil colloids with increasing acidity and it becomes negligible in soils above pH 6.5 (Scherer, 2001). Furthermore, it has been proved that soil pH is inversely correlated to sulfate adsorption (Marsh *et al.*, 1987; Zhang and Yu, 1997).

Nevertheless, in most soils organically bound sulfur act as the major sulfur reservoir and organic sulfur accounts for more than 95% of the total sulfur pool in soil (Gunaratne *et al.*, 2008). However, organic sulfur must undergo mineralization to sulfate before it is used by plants (Khalid *et al.*, 2011). The total sulfur content of the top soil of studied coconut growing estates varied from 21.4 to 227.91 mg/kg in manure circles and 7.14 to 235.69 mg/kg in center of the squares. However, a significant positive relationship (r^2=0.96) was observed between the total sulfur content and plant available sulfur content.

Variation of Leaf Sulfur Contents in Coconut

Leaf sulfur contents of studied estates ranged from 0.07 to 0.29% and out of the studied samples 27% showed low sulfur content than the sufficiency range i.e. 0.15- 0.20% (Manciot *et al.*, 1980). However, none of the analyzed soil parameters showed a significant correlation with leaf sulfur levels. Moreover, 20% of the leaf samples were in the lower margin of the critical level of leaf sulfur indicating the risk of falling them in to deficient levels in future (Figure 1).

CONCLUSIONS

The levels of leaf sulfur in the studied locations suggest that there is a possibility of having a high risk in sulfur deficiency in future and therefore, it is important to monitor the sulfur dynamics and identify the requirement of external application of Sulfur before palms start to suffer from deficiencies.

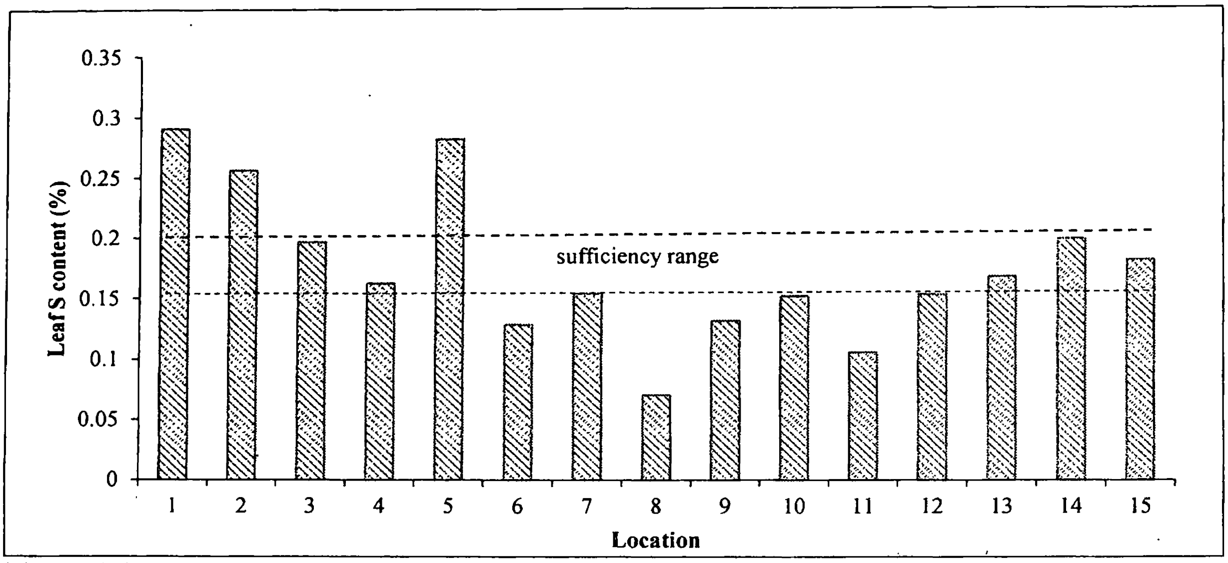

Figure 1. Leaf Sulfur contents of studied coconut estates

Table 1. Soil pH, available Sulfur and total Sulfur contents of studied coconut estates

Location	pH		Available S (mg/Kg)				Total S (mg/Kg)	
	MC	CS	MC		CS		MC	CS
	0- 20 cm	0- 20 cm	0- 20 cm	20- 40 cm	0- 20 cm	20- 40cm	0- 20 cm	0- 20 cm
1	6.54	5.95	4.25	3.60	2.50	3.06	26.67	21.67
2	7.26	5.27	2.82	4.03	2.64	2.07	33.33	33.33
3	6.25	6.14	2.36	2.05	2.45	2.33	27.50	21.67
4	5.91	5.51	8.93	7.47	7.13	7.52	85.71	21.43
5	6.16	5.39	10.64	11.40	10.80	13.50	107.14	121.43
6	6.00	5.58	6.77	7.13	4.11	4.21	75.00	21.43
7	5.71	5.59	6.95	6.31	8.11	7.49	71.43	7.14
8	5.51	5.71	1.33	1.21	6.31	7.44	21.43	92.86
9	6.18	5.31	5.43	5.78	15.42	14.11	35.71	121.43
10	5.77	5.63	7.41	8.99	8.54	9.67	78.57	95.02
11	5.21	5.47	5.11	5.14	17.11	18.32	60.71	157.14
12	6.08	5.99	5.28	5.97	4.78	5.33	52.38	21.43
13	6.79	6.75	12.11	12.07	14.11	15.38	141.89	123.17
14	7.14	6.93	18.36	15.24	12.13	13.11	227.91	235.69
15	6.78	6.59	14.11	9.63	16.55	12.32	148.91	120.75

MC- Manure Circle, CS- Center of the square

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