Use of soil and foliar nutrient levels to identify the nutritional limitations of two coconut growing soils in Sri Lanka

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Abstract

Nutritional status of soils with foliar nutrient levels of crops grown in the same soil is considered to be vital information in efficient management of plant nutrients. Among major coconut growing soils in Sri Lanka, Wariyapola series and Maho series cover a land area of about 66,400 ha. Nutrient levels of these soils have not been studied systematically. A study was conducted to evaluate soil and leaf nutrient levels of fertilized and unfertilized coconut lands in these two soil series. Soil samples were collected from the representative locations in two soil series separately from fertilized and unfertilized lands; leaf samples were also collected from the 14th leaf of the palm at the same locations. Collected samples were analyzed for macro and micronutrients.

Results showed that among major nutrients considered, soil total nitrogen levels were low (< 225 mg kg^{-1}) irrespective of fertilizer practice, but leaf nitrogen levels were above the critical level except unfertilized soils of Maho series. Soil exchangeable potassium levels were very low as less than 0.2 mq100g^{-1} and the leaf potassium levels were below 1% which is very much lower than critical level in both soil series even in the fertilized soils. Phosphorus levels in soils were moderate, and leaf phosphorus was above the critical level in both Wariyapola and Maho series. Soil calcium and magnesium levels were low in unfertilized lands; leaf nutrient levels indicate that calcium and magnesium levels were above the critical levels. Among micronutrients, Fe and Mn levels were high in both the soils series; accordingly, leaf Fe and Mn levels were also well above the critical levels. Leaf Cu levels were below the critical level of 5 mg kg^{-1} eventhough Cu levels in soils were moderate, indicating low plant availability of Cu in soils of Wariyapola and Maho series.

According to the results, main nutritional limitations for the production of coconut in Wariapola and Maho soil series were inadequate supply of potassium and plant availability of copper. Low soil nitrogen, magnesium and calcium levels indicate their potential to be limited, if they are not replenished adequately. The results of this study also highlight the need of further studies on the availability of copper for uptake by coconut in Wariapola and Maho soil series.

Key words: *Nutrient management, soil and foliar nutrients, soil series*

Introduction

Among coconut growing soils in Sri Lanka, Wariyapola and Maho series cover a considerable land area of about 66,400 ha. Both of these soils belong to the Non Calsic Brown Great Soil Group and mainly occur in low country Intermediate Zone (IL3) of Sri Lanka (Somasiri *et al.*, 2003). Maho series occur in upper and mid slope physiographic positions, while Wariayapola series occur in the lower positions of the undulating land form in the IL3 Agro-Ecological Region (Somasiri, 2005). Coconut is the main crop grown in these soils. According to the USDA soil taxonomy, Wariyapola and Maho series can be classified as Pasmmantic Hapludalfs coarse loamy, noncalcarious, isohyperthermic (Dassanayake *et al.*, 2005). Coconut had been grown on these soil series for more than 15 decades without adopting proper soil fertility management practices.

Physical properties of major coconut growing soils have been tested in the land suitability assessments (Somasiri, 2003); however, data on soil nutrient levels and foliar nutrient status of coconut is lacking in these soils. Therefore, this experiment was conducted with the objective of evaluating the soil and leaf nutrient levels of coconut in Wariyapola and Maho soil series in order to find out the nutritional limitations for the production of coconut in these two soil series.

MATERIALS AND METHODS

This study was conducted during 2005-2007, as a part of the project of soil mapping and assessing the nutritional levels in major coconut growing soils in Sri Lanka.

Sampling locations

Sampling locations were decided based on physiographic position of the landform and the area covered by each soil series. Samples were obtained at a frequency of one sampling location per about 500 ha. Samples were taken in two categories: fertilized, organically or chemically; and unfertilized. In sampling, lands which were fertilized within six months period were avoided. Representative locations were marked on the soil map of the area to represent three closely located sampling points (Fig. 1).

Soil sampling and analysis

Soil samples were collected from each location to represent the manure circle, (area of 1.6 m radius around the coconut palm) and centre of the square which is the middle position between four surrounding palms. Samples were collected at a depth of 0-25 cm after removing the topmost layer of organic materials. Samples were air dried and passed through a 2 mm sieve prior to analysis. Total nitrogen was determined by Kjeldhal digestion method (Bermmer and Malvaney, 1982). Available phosphorus was determined using bicarbonate extraction by Olson's method and exchangeable potassium by flame emission spectrophotometer. Exchangeable Ca, Mg and micro nutrients were determined using atomic absorption spectrophotometer (Thomas, 1982).

Leaf sampling and analysis

In order to determine foliar nutrient status, leaf samples were collected from four palms in one location; leaflets were collected from either side of the rachis of the 14th frond (selected by counting downward from the first fully opened frond as the 1st frond) and those four samples were bulked to obtain a representative composite sample. The collected leaf samples were washed, using distilled water and then, oven dried and powdered for determination of nutrients.

Fig.1. *Representative sampling locations of Wariyapola and Maho series in soil map of Wariyapola topographic area*

Nitrogen and Phosphorus were determined using auto analyzer. Potassium, calcium, magnesium and micronutrients were determined using atomic absorption spectrophotometer (Walsh and Beaton, 1973).

RESULTS AND DISCUSSION

Soil nutrient levels

According to the results, Wariyapola series showed higher values of exchangeable K, Ca and Mg than Maho series. As Maho series occur in upper and mid slope physiographic positions in the landform, it is well drained and there is a possibility for erosion and leaching loss of nutrients.

Major and secondary nutrients

Soil nutrient levels were higher in fertilized soils compared to unfertilized soils in both Wariyapola and Maho series (Table 1). In unfertilized lands, nutrient content in the center of the square showed higher values than in manure circle, especially macronutrients, due to heavy absorption of nutrients in active roots in manure circle (Table1). Despite fertilizer application, both Maho and Wariyapola soil series showed low total nitrogen content (< 250mg kg^{-1}) when compared with average tropical soil nitrogen levels (Landon, 1984). These values are low even when compared with the total nitrogen levels of coconut soils obtained by Amulu and Obigbesan (1990).

Soil P content is moderate in both Wariapola and Maho series according to the classification of Walsh and Beaton (1973). Eventhough, these two soil series are Alfisols, they have a moderate level of P content even in unfertilized soils. Brady (1990) pointed out that phosphate leaching was very little because it is quickly bound chemically in fine textured soils at the surface. This may be due to its low solubility and immediate fixation in the soil.

Soil exchangeable K levels were low in both soil series irrespective of fertilizer practice resulting low level of leaf potassium and the values were low as less than 0.2 meq100g^{-1} even in fertilized soils compare to average tropical soil levels

Table 1. *Soil nutrient levels (mean ±SD) of fertilized and unfertilized lands of coconut in two soil series*

Soil series/ Fertilizer practice	Position	Total N mg kg^{-1}	Av. Pmg kg^{-1}	Exch. Kmeq 100g^{-1}	Exch. Mgmeq 100g^{-1}
Maho Fertilized	MC	220.6 ± 32.1	16.6 ± 4.2	0.17 ± 0.05	0.89 ± 0.04
	CS	211.3 ± 26.8	10.3 ± 2.1	0.08 ± 0.01	0.71 ± 0.02
Maho Unfertilized	MC	150.4 ± 24.1	14.6 ± 3.4	0.08 ± 0.02	0.6 ± 0.02
	CS	156.5 ± 11.1	11.9 ± 2.9	0.12 ± 0.02	0.7 ± 0.1
Wariyapola Fertilized	MC	213.1 ± 41.3	19.4 ± 5.1	0.19 ± 0.06	1.2 ± 0.09
	CS	168.4 ± 23.4	11.6 ± 4.3	0.11 ± 0.03	0.9 ± 0.03
Wariyapola Unfertilized	MC	190.6 ± 31.2	9.3 ± 3.6	0.09 ± 0.05	0.7 ± 0.04
	CS	203.5 ± 29.8	9.1 ± 4.1	0.18 ± 0.01	0.8 ± 0.03

MC - Manure Circle CS – Center of the squire

(Landon, 1984). Soil Ca levels were above the average tropical soil Ca levels (3 meq100g $^{-1}$) in the fertilized sites of two soil series while unfertilized soils showed lower values. Irrespective of fertilizer practice, Mg levels were low (<1 meq100g $^{-1}$) in all the locations except fertilized lands of Wariyapola series (Table 1). It indicates that there is a risk of limiting Mg under current fertilizer practices especially in Maho series.

Soil micronutrient levels

Eventhough, micronutrients are not applied and not recommended with general fertilizer mixtures for coconut at present, all the micro nutrients considered were above the average tropical soil micronutrient levels.

Among micronutrients, Fe showed higher values in fertilized sites than others in both soil series mainly because some fertilizers like muriate of potash contain Fe as an impurity; however, the other micro nutrients did not show differences with fertilizer practices (Table 2). Mn levels of these two soils were also at higher level while Cu and Zn levels were moderate. Similar study conducted for Kalpitiya, Weliketiya, Andigama and Madampe series showed that Fe, Mn and Cu values in those soils were lower than those of Wariyapola series (Anon, 2001).

Leaf nutrient levels

Leaf nutrient levels showed similar pattern of variation as in fertilized and unfertilized soils, both in Wariyapola and Maho series. Fertilized palms showed higher leaf nitrogen values than the critical levels while the values of unfertilized palms were below or just at the critical level in both soil series. Leaf nutrient levels of unfertilized locations represent the nutrient supplying power of these soils to the coconut palm. Leaf phosphorous levels were higher than critical levels in both unfertilized and fertilized palms in these two soil series indicating ability of the soils to meet the P demand of the crop (Table 3).

Table 2. *Soil micro nutrient levels (mean ±SD) of fertilized and unfertilized coconut lands in two soil series*

Soil series/ Fertilizer practice	Position	Fe mg kg $^{-1}$	Cu mg kg $^{-1}$	Zn mg kg $^{-1}$	Mn mg kg $^{-1}$
Maho Fertilized	MC	58.6 ± 12.1	1.36 ± 0.5	2.1 ± 0.6	41.2 ± 11.4
	CS	50.4 ± 10.6	0.87 ± 0.08	1.7 ± 0.5	31.1 ± 8.9
Maho Unfertilized	MC	31.3 ± 11.5	0.98 ± 0.06	2.4 ± 0.4	30.4 ± 6.9
	CS	29.6 ± 9.5	1.02 ± 0.7	2.1 ± 0.3	29.6 ± 8.6
Wariyapola Fertilized	MC	46.4 ± 10.3	1.67 ± 0.6	3.1 ± 0.4	34.5 ± 13.5
	CS	31.7 ± 9.5	1.02 ± 0.3	2.4 ± 0.6	41.6 ± 14.3
Wariyapola Unfertilized	MC	43.1 ± 10.3	0.84 ± 0.6	1.5 ± 0.4	42.3 ± 13.2
	CS	46.7 ± 6.9	0.91 ± 0.06	2.1 ± 0.2	40.2 ± 11.6

MC - Manure Circle CS – Center of the squire

In spite of fertilizer application, leaf K levels were below the critical levels in both the soil series with respect to the low soil K levels (Table 3). It revealed that fertilizer application for these two soils has not met the potassium requirement of the palm either due to low rate of application or due to not adopting proper method of application.

Potassium has become the most limiting nutrient for the growth and yield of coconut in these two soil series. Irrespective of fertilizer practice, leaf Ca and Mg levels were above the critical levels in both the soil series (Table 4), but similar studies conducted on Boralu and Pallama series have shown that irrespective of manuring, leaf Ca and Mg levels were below the critical level (Anon,2001). Supplies from parent material and from plant residue are the main sources of acquiring nutrients for unfertilized soils.

Leaf Zn levels do not vary with fertilizer application as it is not applied with commonly used fertilizer mixtures. The levels were just above or at the critical level in both the soil series. Leaf Cu levels were below the critical level in spite of fertilizer practice in both the soil series. However, the results obtained from a similar study conducted on Boralu and Pallama soil series have shown that the leaf Cu levels were well above the critical level (Anon, 2001). Eventhough, leaf Cu levels in Wariyapola and Maho series were lower than critical level, soil Cu levels were at moderate level indicating low

Table 3. *Leaf nitrogen, phosphorus and potassium levels (mean ±SD) of coconut grown in two soil series under different fertilizer practices*

Soil Series/Fertilizer practice		Nitrogen (%)	Phosphorous (%)	Exch. K (%)
Maho	Fertilized	2.11 ±0.14	0.14±0.06	0.81±0.28
Maho	Unfertilized	1.87 ±0.28	0.13±0.05	0.62±0.11
Wariyapola	Fertilized	2.13±0.15	0.15±0.03	0.94±0.23
Wariyapola	Unfertilized	1.91±0.11	0.14±0.10	0.66±0.31
Critical level*		1.9	0.11	1.2

* Critical nutrient levels as suggested by Loganathan and Athputharajah (1986).

Table 4. *Leaf nutrient levels (mean ±SD) of coconut grown in two soil series under different fertilizer practices*

Soil series/ Fertilizer practice	Ca (%)	Mg (%)	Zn mg kg $^{-1}$	Cu mg kg $^{-1}$	Fe mg kg $^{-1}$	Mn mg kg $^{-1}$
Maho Fertilized	0.41 ±0.1	0.39±0.06	29.5±1.2	3.5±0.7	110.8±20.2	107.8±20.2
Maho Unfertilized	0.39±0.06	0.31±0.03	31.5±3.4	2.8±1.2	79.6±15.3	86.91±10.11
Wariyapola Fertilized	0.59±0.11	0.43±0.05	30.2±4.7	3.8±0.8	89.8±15.6	140.5±20.2
Wariyapola Unfertilized	0.49±0.09	0.48±0.07	35.5±5.8	3.3±0.8	120.6±18.5	119.2±18.31
Critical level*	0.35	0.25	30	5	40	60

* Critical nutrient levels as suggested by Loganathan and Athputharajah (1986).

availability of Cu for uptake by coconut. However, there have been no any deficiency symptoms at the time of sampling. Fe and Mn levels were well above the critical level in fertilized and unfertilized palms of both soil series. The luxury level of Fe and Mn were also obtained in foliar nutrient level of coconut grown in Kuliyapitiya and Kurunegala soil series (Anon, 2001).

CONCLUSIONS

Results of this study revealed that the main nutritional limitations for the production of coconut in Wariapola and Maho soil series were inadequate supply of potassium and available copper. Low soil nitrogen, exchangeable magnesium and calcium levels indicate their potential to be limited with current management practices; therefore, special attention should be given to them in nutrient management practices.

As fertilized soils also showed lower nutrient levels, especially potassium, growers should be made aware about the importance of the application of recommended amount as well as proper method of fertilizer application while conserving the existing nutrient pool in these soils. Low leaf copper levels than critical levels in the soils having moderate copper levels highlight the need of further studies on availability of copper for coconut in soils of Maho and Wariyapola series.

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