# Removal of Micronutrients from High and Moderate Yielding Coconut Plantations in Sri Lanka

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## ABSTRACT

Coconut palms absorb large quantities of nutrients from the soil. A high proportion of these nutrients are removed from the soil along with the harvest and other plant components. The objective of this study was to determine the rate of metallic micronutrient removal from soil series belonging to highly suitable ($S_1$) and moderately suitable ($S_4$) land classes. This was done in order to assess the adequacy of the available heavy metallic micronutrients (Fe, Mn, Cu, and Zn) and to identify depletion of these reserves in the soil. Harvested nuts, fallen fronds and inflorescence parts were collected for a two-year period from each randomly selected 10 palms located in Madampe series ($S_1$) and Boralu series ($S_4$) at Bandirippuwa Estate and their micronutrient contents were determined. The reserves of micronutrients in the soil were determined by using representative soil samples taken from the manure circle and the center of squares at (0-25) cm and (25-50) cm depths. The annual removal of Fe, Mn, Cu, and Zn micronutrients from soil of Madampe series were 1.14, 0.63, 0.13, and 0.27 kg/ha/yr respectively. The Boralu soil series were 1.71, 0.88, 0.14, and 0.44 kg/ha/yr respectively. The soil reserves of available Fe in both soil series and Mn, Cu, and Zn in Boralu series were adequate for the coconut palm for a long period. It was estimated that Fe reserves could be used by the palms more than 300 years in Madampe series and for more than 500 years in Boralu series of which palms can utilize Cu and Zn for more than 250 years. However in Madampe series, Mn, Cu and Zn reserves in the soil were barely adequate to compensate the rate of removal. Hence, special attention may be needed for recycling components from the palm itself to improve the soil reserves of above nutrients.

**Key words:** *Depletion, metallic, micronutrients, reserves*

## INTRODUCTION

In coconut plantations, harvested nuts, as well as fronds and much of the other residues that are removed from the land for various purposes. This practice leads to gradual depletion of plant nutrients from the soil (Somasiri, 1987); furthermore, the nutrients stored in the trunk are not returned to the soil. Application of fertilizers containing N, P, K and Mg at the recommended rates only partially compensates for this depletion. Previous studies indicated that nuts remove a considerable quantity of major nutrients (Jeganathan *et al.*, 1977; Ohler, 1984; Jayasekara *et al.*, 1991).The current fertilizer recommendation of 800g of urea, 900g of Eppawala rock phosphate, 1600g of Muriate of potash per tree for Wet and Intermediate Zones (Adult palm Mixture-W) with 1 kg of dolomite palm/yr is aimed at meeting the demand of major nutrients for plantations yielding 7500 nuts/ha/yr. The recommendation for high yielding plantations is 1.5 times of the above rates (Mahindapala and Pinto, 1991). It would be sufficient for plantations yielding up to 11,250 nuts/ha/yr; nevertheless, plantations yielding 12,500-19,000 nuts/ha/yr as shown by land suitability studies (Somasiri *et al.*, 1994) removes higher quantities of nutrients than the above inputs (Somasiri *et al.*, 2000; Somasiri *et al.*, 2001).

According to yield potentials, coconut lands are categorized into five land suitability classes as follows: $S_1$, highly suitable (>15,000 nuts/ha/yr); $S_2$, suitable to highly suitable (12,500-15,000 nuts/ha/year); $S_3$, suitable (10,000-12,500 nuts/ha/year); $S_4$; moderately suitable (5,000 nuts/ha/year), and $S_5$; marginal suitable (2,500-5,000 nuts/ha/year). Information on the rate and amount of nutrient depletion in coconut lands of different yield potentials will be a useful input in developing more logistic approaches to coconut nutrition and soil management. The objective of this study was to determine the rate of micro nutrient removal from the field by *Typica x Typica* coconut palms, yielding an average of 17,380 and 13,438 nuts/ha/yr belongs to two land suitability classes $S_1$; Madampe soil series (Red Yellow Latosols) and $S_4$; Boralu soil series (Red Yellow Podzolic soils) (Somasiri *et al.*, 1994), in order to assess and identify depletion of the micronutrient reserves in the soil.

# MATERIALS AND METHODS

Two blocks of ten coconut palms each were selected from $S_1$ land suitability class; Madampe series soil and $S_4$ land suitability class; Boralu series soil at Bandirrippuwa Estate, Lunuwila. Coconut palms located in Boralu soil series were treated with recommended levels of 800 g urea, 900g Eppawela rock phosphate, 1600g Muriate of potash, and 1000g Dolomite once a year for the period of two years; coconut palms located in Madampe soil series were treated with 1.5 times of recomended fertilizers. Sampling was carried out once a month for a two-year period in each block. Mature nuts, fallen frond and residues of inflorescence of each plant component were collected and the volumes of nuts water were determined.

Chemical analyses were performed on representative sub samples of each component of the each palm parts *viz.* perianth, husk, kernel, nut water of nut; ekel, leaf blade, petiole of fronds; spike, spikelet, green spathe, dry spathe, male flowers and button nuts of the inflorescence. The samples of the aforementioned components except nut-water samples were analyzed for Fe, Mn, Cu and Zn which were estimated by digesting plant samples in 4:1 $HNO_3$/ $HClO_4$ mixture (Tropical soil and leaf analytical methods,1982) followed by analysis using Atomic Absorption Spectrophotometer. Nut water samples were evaporated to dryness, ashed at 450°C and dissolved in 10% HCl followed by analysis using Atomic Absorption Spectrophotometer.

Two years after commencement of the experiment, soil samples were collected from the manure circle of each palm and the center of the coconut squares of each block at (0-25) cm and (25-50) cm depths for determination of available Fe, Mn, Cu, and Zn nutrients in the soil. Air-dried, 2mm sieved samples were used for analysis. Available micronutrients of soil were estimated by 0.005M DTPA-TEA extraction (Lindsay and Norvell, 1978) and followed by analysis using Atomic Absorption Spectrophotometer.

**Calculation**

The annual depletion of micronutrients from the soil in a hectare (a) was estimated by the equation $a = b + c - d$ (Somasiri *et al.*, 2003).

Where, b= quantity of available or exchangeable micro nutrients in the soil per hectare up to 1m depth

c= amount of the nutrient added contaminants with recommended fertilizer application per hectare per year

d= annual nutrient removal by the coconut palms per hectare per year

The time in the number of years taken for complete consumption of available nutrient reserves in the soil (t) was estimated by the formula $t = b/(d-c)$ (Somasiri *et al.*, 2003) while considering the depth of 1m.

Nutrient removal by nuts, fronds and residues of inflorescence of coconut palms were calculated per hectare (158 palms/ha) in a year. Averages of two years removal data were used (Somasiri *et al.*, 2003).

Nutrient content of the soil was calculated by summing up the quantities of available nutrients in the manure circle and the rest of the area together up to a 1 m of depth.

Quantity of nutrients supplied as contaminants by application of 3kg Adult Palm Mixture (APM) and 1kg dolomite per year, for ($S_4$) and 1.5 times for ($S_1$) were converted to the rate of ha/year (158 palms/ha) (Somasiri *et al.*, 2003).

# RESULTS AND DISCUSSION

Coconut plantations remove high proportion of nutrients through the harvest as well as the other plant components. These components are taken from the flied for various requirements. Table 1 shows that the nut weight contributes almost 60% from Madampe series ($S_1$) land suitability class and 56% from Boralu series ($S_4$) land suitability class to the total dry matter production of the coconut palm. The weight of fronds contributes to 26% and 33% respectively. If the nuts and fronds are totally removed from the field, more than 85% of the dry matter produced by the palms of two fields is removed from the field along with the nutrients.

Table 2 reveals that the total removal of micro nutrients except Zn from coconut palms grown in Boralu series $S_4$ land suitability class is higher than that of the coconut palms grown in Madampe series, $S_1$ land suitability class; furthermore, total Fe and Mn removal from palms grown in Boralu series ($S_4$) is 50% and 40% and is higher compared to the removal from palms grown in Madampe series ($S_1$) respectively. Both nuts and fronds remove higher quantities of micronutrients

**Table 1.** *The average (two years) dry matter of different components produced from two soil series belongs to two land suitability classes in a year*

| Plant component | Madampe series ($S_1$) kg/ha | Percentage of the total | Boralu series ($S_4$) kg/ha | Percentage of the total |
|---|---|---|---|---|
| Nut | 17200 | 60 | 7491 | 56 |
| Fallen fronds | 7514 | 26 | 4476 | 33 |
| Inflorescence | 4185 | 14 | 1421 | 11 |
| Total | 28899 | 100 | 13388 | 100 |

**Table 2.** *Micronutrients removed from the field by nuts, fallen fronds and inflorescences of palms grown in the two soil series of two land suitability classes*

| Parts of the palm | Removal of nutrients from two land suitability classes (kg/ha/yr) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Fe | | Mn | | Cu | | Zn | |
| | $S_1$ | $S_4$ | $S_1$ | $S_4$ | $S_1$ | $S_4$ | $S_1$ | $S_4$ |
| Nuts | 0.47 | 0.82 | 0.10 | 0.74 | 0.11 | 0.03 | 0.16 | 0.16 |
| Fronds | 0.61 | 0.70 | 0.50 | 0.11 | 0.01 | 0.10 | 0.15 | 0.09 |
| Inflorescence | 0.06 | 0.19 | 0.03 | 0.03 | 0.01 | 0.02 | 0.13 | 0.02 |
| Total | 1.14 | 1.71 | 0.63 | 0.88 | 0.13 | 0.15 | 0.44 | 0.27 |

compared to inflorescence from both soil series. With regard to the removal of four heavy metallic micronutrients, Cu was the lowest and Fe was the highest recording Cu from $S_1$ and $S_4$ land suitability classes 0.13 and 0.14 kg/ha/year respectively and Fe from $S_1$ and $S_4$ land suitability classes 1.14 and 1.72 kg/ha/year respectively.

Soil reserves of available Fe of two soil series of two land suitability classes are much greater than the quantity of Fe annually removed by the palm (Table 3). The reserves of available Fe in the soil may be sufficient for more than 300 years of Madampe series soil ($S_1$) and more than 500 years of Boralu series ($S_4$) at the present depletion rate in the experiment sites. Table 3 and 4 revealed that

**Table 3.** *Quantities of micronutrients (i) lost from the site via removal of nuts and other plant components, (ii) as soil reserves in "available from" and (iii) supplied as impurities of fertilizer inputs*

| | Land suitability class | Fe | Mn | Cu | Zn |
|---|---|---|---|---|---|
| | | kg/ha/yr | | | |
| i. Nutrient removal by nuts, fronds and residues of inflorescence of coconut palms | $S_1$ | 1.14 | 0.63 | 0.13 | 0.44 |
| | $S_4$ | 1.72 | 0.89 | 0.14 | 0.27 |
| ii. Nutrient content of the soil at experiment site (up to 1m depth) | $S_1$ | 324.50 | 11.73 | 7.48 | 6.91 |
| | $S_4$ | 554.29 | 91.33 | 36.46 | 59.39 |
| iii. Nutrient added as impurities of fertilizer contaminants | $S_1$ | 2.82 | 0.36 | 0.02 | 0.05 |
| | $S_4$ | 1.88 | 0.24 | 0.013 | 0.03 |

**Table 4.** *Estimated of metallic micronutrients in two soil series for coconut palms grown in two soil series of two land suitability classes.*

| | Micro nutrients availability in years | | | |
|---|---|---|---|---|
| Soil series | Fe | Mn | Cu | Zn |
| Madampe series ($S_1$) | >300 | <45 | <70 | <20 |
| Boralu series ($S_4$) | >500 | <145 | >250 | >250 |

Table 3 shows that the availability of all four micronutrients in Boralu series soils ($S_4$) is higher than that of the Madampe series ($S_1$) and the estimated number of years of availability is shown in Table 4.

the availability of all four metallic micronutrients in Boralu series ($S_4$) sufficient for long period, but availability of Mn, Cu, and Zn in Madampe series ($S_1$) is low compared to Boralu series. Micronutrients are present in Adult Palm Mixture

(APM) fertilizer as contaminants. With APM application, the input of Fe is sufficient to make up for the removal and input of Mn would compensate for one third of the removal (Somasiri *et al.*, 2003). Input of Cu and Zn is very low compared to the removal. Considerable amount of micronutrient removed by coconut palm could also be returned to the land by using fronds, husks and inflorescence parts as mulch or manure. However, still there is a deficit between the removal of Cu, Zn from the field and the input by the mulch and contaminants in the fertilizer. Therefore, application of a maintenance doze of Cu and Zn to high yielding palms will be useful to conserve the reserves in the soil.

Apart from these the availability of micronutrients in the soil depends on the soil pH (Sauchelli, 1969). Soil pH is, most of the time, the main factor controlling Cu availability for plants, when pH increases the Cu availability decreases (Nascimento *et al.*, 2003).The electro negativity values of Cu (1.90), Zn (1.5) and Mn (1.55) explain the higher selectivity of the soil minerals for Cu and the high capacity for the adsorption of this element to soil, as compared to the others (Nascimento *et al.*, 2003) Cu deficiency was observed in Sumatra in 1988 after 8-10 months of planting coconut (Ohler,1984). It was revealed that normally after laying the seed nuts, it utilizes the stored nutrients from different parts of the nut up to 5 months (Perera *et al.*, 1996). Subsequently it uses nutrients from stored nutrients as well as soil up to 8-12 months. Micronutrient contents of root and shoot after 3 months of laying seed nuts was investigated by Silva *et al.*, (1974) and it was also revealed that the micronutrient contents in kernel and nut water was reduced as well as in the shoots and roots. Therefore, it utilizes micronutrients which is absorbed by the palm and stored in the seed nut affecting the growth of seedlings.

# CONCLUSIONS

The reserves of available Fe reserves in Madampe series and Fe, Mn, Cu, and Zn reserves in Boralu series were very high compared to removals by the palm. Therefore application of fertilizers containing micronutrients for Boralu series soil and fertilizer containing Fe for Madampe series would not be necessary. In the case of Cu and Zn in Madampe series the gaps between the inputs as the mulch and fertilizer residues and the removal from field appears to be low compared to the soil reserves but there may be a long-term depletion. However, the loss of Mn from the field is compensated by the inputs of fertilizer residues and the mulch. Therefore, application of Cu and Zn fertilizer to maintain the soil reserves in the fields containing high yielding coconut palms is recommended.

# ACKNOWLEDGEMENTS

Authors wishes to extend their sincere thanks the staff attached to the division of Soils and Plant Nutrition, Coconut Research Institute for their untiring support for the collection of data continuously for two year periods in each field.

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