# An Estimate of the Optimum and Critical Levels of Leaf-Sulfur Concentration in Bearing Coconuts (Local Tall)

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**Data on yield and leaf nutrient contents from a gypsum-fertilization experiment were analyzed statistically to determine the response-curve to sulfur and the latter's critical and optimum levels in the reference leaf. A quadratic equation was derived where 74.6% of the variation in yield of nuts per tree was accountable to the level of leaf-S. The critical and optimum level of leaf-S in the reference leaf were 0.12% and 0.19%, respectively. These values are important if foliar diagnosis is used as guide to fertilizer application.**

Key Words: sulfur deficiency; gypsum fertilization, leaf-S

## INTRODUCTION

Coconuts suffering from sulfur deficiency exhibit yellowing leaves (with lower or older leaves hanging down the trunk), few and small nuts, and rubbery copra with low oil content (about 40%). Sulfur deficiencies have been observed by Southern (1969) in New Guinea, Ollagnier and Ochs (1972) in Madagascar, and Magat et al. (1981), in the Philippines.

In Papua, New Guinea, the application of either elemental S, ammonium sulfate, or potassium sulfate checked the yellowing of coconut leaves and made them green again in 6 months; increased the number of leaves from 14-15 to 21; increased nut production to 100% over the control a year after initial fertilization; and the copra produced was no longer rubbery (Southern 1969). While in Madagascar, the correction of S deficiency was observed to be faster with the addition of N and S as $(NH_4)_2SO_4$, with both leaf N and S significantly increased (Ollagnier and Ochs 1972).

In diagnosing S deficiency in coconuts based on foliar diagnosis, a reference optimum and critical level (concentration) of leaf-S is required. Manciot, Ollagnier and Ochs (1979) mentioned that S deficiency exists at 0.13% leaf-Cl (leaf 14), with 0.15%-0.20% as the critical level, while Southern (1969) recommended the level of 0.15%. However, lately in the Philippines, the availability of a sulfur study particularly involving increasing rates allowed an analysis of the critical and optimum levels o leaf-S in relation to those levels currently in use hence, this paper.

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## MATERIALS AND METHODS

This study utilized the data on yield and lea nutrient analyses (leaf 14) of an experiment in a ran domized complete block design. The experimen consisted of five $CaSO_4$ fertilizer treatment levels : (Control), 0.75, 1.50 2.25, and 3.30 kg/tree/yr, or 30 to 40-yr-old local tall palms in a S-deficient area of Sta. Cruz, Davao del Sur (Mindanao).

The analysis of variance was used to determine the trend response of coconut yield and leaf nutrient status to $S(CaSO_4)$ fertilization.

A quadratic equation was derived to fit leaf-S level to nut yield per tree thru a general linear model approach.

$$Y = a + bX + cX^2 \quad (Eq.\ 1)$$

where $Y$ is the nut per tree
$X$ is the leaf-S level
$a$ is the intercept
$b$ is the coefficient of $X$
$c$ is the coefficient of $X^2$

The optimum level of X is computed as follows:

$$X\ opt = \frac{-b}{2c} \quad (Eq.\ 2)$$

The critical level for leaf nutrient concentration refers to that level (% of ppm) of a leaf nutrient at a reference leaf, of which the application of the proper amount of the limiting nutrient is likely to improve growth or yield significantly.

Since the optimum level of X gives the maximum nut yield as follows:

$$\hat{Y}\ max = a + b\ (Xopt) + c\ (Xopt)^2 \quad (Eq.\ 3)$$

Under the conditions of the experiment, the value that gave a significant difference between treatment observation was 9.6 nuts/tree ($\hat{Y}_1$) thru an Honest Significant Different test (HSD) at 1% level. Thus, we can consider:

$$\hat{Y}\ max - \hat{Y}_1 = a + bX_{cr} + c(X_{cr})^2 \quad (Eq.\ 4)$$

where $X_{cr}$ is the critical level of leaf-S

## RESULTS AND DISCUSSION

The sulfur ($CaSO_4$) fertilization of the 'skirting' and S-deficient significantly increased yield (Table 1). The response on nut per tree was quadratic while that on copra yield was linear. On the influence on the leaf nutrient levels, only leaf-S produced a quadratic response (Table 2).

A quadratic response curve was derived between nut per tree as the dependent variable (Y) and leaf-S level as the independent variable (X), as shown below:

$$\hat{Y} = -18.9 + 675.5\,X - 1794.0\,X^2$$

About 75% of the variation, which is highly significant, in $\hat{Y}$ was attributed to X (leaf-S).

The optimum level of leaf-S (Fig. 1) is given as:

$$Xopt = \frac{-675.5}{2(1794)} = 0.19\%$$

and the maximum nut per tree is

$$Xmax = -18.9 + 675.5\,(0.19) - 1794.0\,(0.19)$$
$$= 44.7 \text{ nuts/tree/yr}$$

thus, $\hat{Y}$ max $- \hat{Y}_1 = 44.7 - 9.6 = 35.1$ nuts; the $X_{cr}$ therefore is 0.115% or approximately 12%, as shown in Table 3.

Thus, the leaf-S deficiency level of 0.13% pointed out by Manciot et al. (1979) is actually the critical level based from this study. Also, it shows that the value of 0.15% S suggested by Southern (1969) and currently used in foliar diagnosis is higher by 0.02%, while the range mentioned by Manciot et al. (1979) as critical level (0.15%-0.20% S) covers the optimum level of leaf-S (0.19%) obtained in the present study.

This determination or distinction of the critical and optimum leaf-S is a very valuable information in foliar diagnosis since it would enable a more precise diagnosis of nutrient status of coconuts/coconut areas, thereby making more efficient and effective fertilizer recommendation. With increased production and lower fertilizer cost, a higher margin of profit from fertilizer application can be realized.

**TABLE 1. Effect of $CaSO_4$ fertilization on yield of skirting coconut palms**

| FERTILIZER (kg $CaSO_4$/tree/yr) | NUT PER TREE (no.) | COPRA PER NUT (g) | COPRA PER TREE (kg) |
|---|---|---|---|
| 0(Control) | 28.7 | 250.8 | 6.8 |
| 0.75 | 42.6 | 265.9 | 10.0 |
| 1.50 | 42.5 | 280.1 | 10.4 |
| 2.25 | 43.1 | 283.2 | 10.7 |
| 3.30 | 47.1 | 291.4 | 12.2 |
| MEAN | 40.8 | 274.3 | 10.0 |
| Statistical Significance | ** | * | ** |
| Std. Error | 1.829 | 13.801 | 0.662 |
| HSD .05 | 6.4 | 48.6 | 2.3 |
| .01 | 9.6 | NS | 3.5 |
| Trend Response | | | |
| Linear | ** | * | ** |
| Quadratic | * | NS | NS |
| Residual | NS | NS | NS |
| C.V. (%) | 7.8 | 8.7 | 11.4 |

NS Not significant
* Significant at 5% level.
** Highly siginificant at 1% level.

**TABLE 2. Influence of $CaSO_4$ fertilization on leaf nutrient levels of skirting coconut palms**

| FERTILIZER (kg $CaSO_4$/tree/yr) | LEAF NUTRIENT (Leaf 14) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | N | P | K | Ca | Mg | Na | Cl | S | Bppm |
| 0 (Control) | 2.115 | 0.127 | 1.169 | 0.320 | 0.177 | 0.085 | 0.940 | 0.095 | 10.3 |
| 0.75 | 2.069 | 0.148 | 0.882 | 0.404 | 0.200 | 0.094 | 0.684 | 0.160 | 10.8 |
| 1.50 | 2.055 | 0.138 | 0.771 | 0.447 | 0.211 | 0.110 | 0.628 | 0.165 | 9.8 |
| 2.25 | 2.126 | 0.140 | 0.786 | 0.446 | 0.210 | 0.093 | 0.639 | 0.171 | 9.9 |
| 3.30 | 2.069 | 0.141 | 0.680 | 0.524 | 0.240 | 0.086 | 0.635 | 0.195 | 10.2 |
| MEAN | 2.087 | 0.139 | 0.858 | 0.428 | 0.208 | 0.094 | 0.705 | 0.157 | 10.2 |
| Statistical Significance | NS | * | * | * | ** | NS | ** | ** | NS |
| Std. Error | 0.073 | 0.004 | 0.073 | 0.035 | 0.008 | 0.011 | 0.035 | 0.008 | 0.350 |
| HSD .05 | NS | 0.014 | 0.257 | 0.123 | 0.028 | NS | 0.124 | 0.026 | NS |
| .01 | NS | NS | NS | NS | 0.042 | NS | 0.184 | 0.039 | NS |
| Trend Response | | | | | | | | | |
| Linear | NS | NS | ** | ** | ** | NS | ** | ** | NS |
| Quadratic | NS | NS | NS | NS | NS | NS | NS | * | NS |
| Residual | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| C.V. (%) | 6.1 | 4.7 | 14.7 | 13.9 | 6.6 | 20.0 | 8.6 | 8.2 | 6.0 |

NS Not significant
* Significant at 5% level.
** Highly significant at 1% level.

**TABLE 3. Predicted values of nut per tree based on the quadratic equation derived**

| LEAF-S LEVEL (X) | PREDICTED YIELD (NUT/TREE) $\hat{Y}$ |
|---|---|
| % | no. |
| 0.08 | 23.7 |
| 0.09 | 27.4 |
| 0.10 | 30.7 |
| 0.11 | 33.7 |
| 0.115 = $X_{cr}$ — Critical level | 35.1 = $\hat{Y}_{max} - \hat{Y}_1$) |
| 0.12 | 36.3 |
| 0.13 | 38.6 |
| 0.14 | 40.5 |
| 0.15 | 42.1 |
| 0.16 | 43.2 |
| 0.18 | 44.6 |
| 0.19 = $X_{opt}$ — Optimum level | 44.7 = $\hat{Y}_{max}$ |
| 0.20 | 44.4 |
| 0.21 | 43.8 |
| 0.22 | 42.9 |

$\hat{Y} = 675.5 - 1794\ X^2 - 18.9$
$\hat{Y}_{max}$ = maximum nut/tree at optimum leaf-S level
$\hat{Y}_1$ = HSD value at 1% significant difference

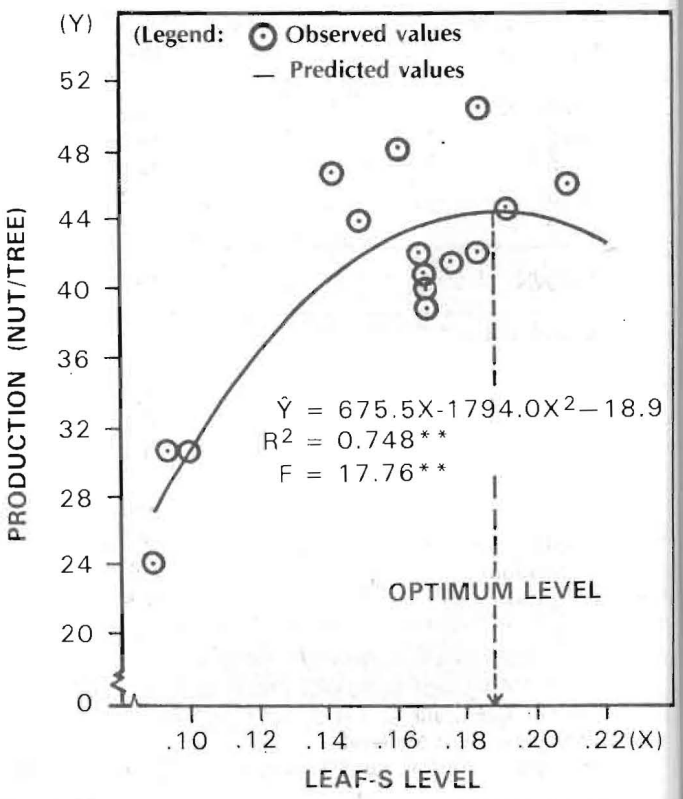


Figure 1. Relationship between nut production and leaf-S level of bearing coconut palms.

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