# NUTRIENT COMPOSITION OF COCONUT LEAVES AND ITS RELATIONSHIP TO NUT YIELDS IN TANZANIA

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The use of foliar analysis as a tool for the diagnosis of nutritional deficiencies in crops is now well recognized. In oil palms it was first introduced by Chapman and Gray (1949) and further worked out by Broeshart (1956), Prevot and Ollagnier (1956) and later by several other workers. In the case of coconut, considerable work has been done in many parts of the world, particularly in India, (Devi and Pandalai, 1968), Ceylon (Salgado, 1955) and I.R.H.O. Paris (Prevot and Bachy, 1962, Ziller and Prevot 1962). Reviewing the results of 20 years research carried out by I.R.H.O. in different coconut growing centres, Fremond *et al* (1966) fixed the critical levels of foliar N, P, K, Ca and Mg as 1.8 to 2, 0.12, 0.8 to 1.0, 0.5 and 0.3 per cent of dry matter respectively. Smith (1969) studying the results of a fertilizer experiment done on two Jamaican soils reported that the yield of coconut was related to the ratios between N and K in the leaves. He, however, disagreed with the concept of fixing independent critical levels of major nutrients.

In Tanzania, no detailed fertilizer experiments have been completed and hence no specific fertilizer recommendations are available for coconut, but the preliminary results of fertilizer experiment carried out at Tanga (Anderson 1967) indicated the necessity of fertilization for increasing the yields. A team of experts from I.R.H.O. (Anon. 1969) after a brief reconnaissance mission to study the situation of coconut in Tanzania and to suggest improvement measures, recommendea investigatory leaf analysis for determining the mineral deficiencies limiting coconut production. The present investigation was designed to evaluate the nutrient composition in leaves of high and low-yielding coconut palms in Tanzania to see whether this information would provide a basis for fertilizer recommendations.

## Materials and Methods

Fifty middle-aged trees each of the tall (typica) variety were selected for this study from the high and low yielding groups of palms from two centres namely, the Livestock Breeding Station, Tanga, and the Coast Agricultural Station, Bagamoyo. Both centres are located in the coastal sandy belt of the country. The average yield of coconut palms in Tanzania is roughly estimated as 25 nuts per tree per year (Anderson, 1967) and hence those trees which yielded more than 60 nuts per year were categorized as high-yielding and those which produced less than 15 nuts were grouped as low-yielding for the purpose of the study. The trees were selected from blocks which had received no fertilizer treatments.

### *Foliar Analysis*

Leaves for the collection of samples were selected using the formula $\frac{n}{2} + 1$, where "n" is the total number of leaves present in the crown of the tree (Menon and Pandalai, 1958).

Leaflets from the leaves were collected in February, 1971 following the procedure suggested by Fremond *et al* (1966). The samples were first wiped with a piece of cloth to remove any soil or other contaminants adhering to them. The material was then oven dried to a constant weight at 105°C. The dried samples were ground (Christy and Norris Mill) and thereafter stored in glass bottles. Samples were drawn from these bottles for analysis by employing the method of quartering.

Nitrogen was determined by a semi microkjeldahl method, using selenium as a catalyst. For phosphorus the sample was wet digested using sulphuric and nitric acid mixtures (1: 1) and P determined as the molybdophosphoric blue colour (Dickman and Bray, 1940). Calcium, magnesium and potassium were determined by the Lundegardh flame method (Mitchell, 1964), using a Hilger medium spectrograph, after dry ashing the sample in a muffle furnace and removing phosphate by passing the solution through the chloride form of permutit resin De-acidite E.

*Soil analysis*

Nethsinghe (1966) studying the root activity of coconuts using radioactive phosphorus, observed that the density of active roots was higher in the area immediately surrounding the palm up to a distance of about 5½ feet from the bole. So soil samples were collected from a radius of five feet from the base of both high and low-yielding trees for analysis. The samples were collected from the top 12 inches of the soil and they were mixed to make four composite samples from each yield group at the two centres.

The soil texture was detrmined by Bouyoucos hydrometer method; pH was measured in 1:2.5 soil water and $CaCl_2$ suspensions, organic carbon was determined by Walkley—Black method, total N by semimicro method; P was extracted by Bray and Kurt's method No. 4; available K, Ca, and Mg were extracted with $^1$N. neutral ammonium acetate and determined spectrographically.

## RESULTS

The leaf analyses were statistically analysed and a summary of the results is given in Table I. The soil analysis data are presented in Table II.

The salient features are:—

*Nitrogen*.—High-yielding trees recorded a higher foliar content of N in both the localities even though the difference attained statistical significance in Tanga centre only. The levels of N found in both groups of palms from the two centres are lower than the critical level of 1.8 to 2 per cent fixed by I.R.H.O.

In the soil, N level was a little higher for the high-yielding trees in both centres.

*Phosphorus*.—The P results varied between the two centres. In Tanga both groups had almost the same level of foliar P, but in Bagamoyo the low-yielding trees registered a significantly higher content than the high-yielding ones. In the high as well as low-yielding trees in both the localities, the level of P was more than the critical level of 0.12 per cent suggested by I.R.H.O.

Low-yielding trees grew in soil with a greater available P at both centres compared to the soil round high-yielding trees.

*Potassium*.—Foliar K was higher in the low-yielding palms than in the high-yielding ones and significantly so in both localities. Both groups of palms had a higher foliar K content than the critical level of 0.8 to 1 per cent proposed by I.R.H.O.

As with the leaves, the K level in the soil was also higher for the low-yielding trees in both localities.

*Calcium and Magnesium*.—High-yielding palms in both localities had a statistically higher foliar calcium content than the low yielding ones. But in both the centres the level of Ca found in the two yield groups was lower than the critical level of 0.5 per cent fixed by I.R.H.O.

In the soil, no wide difference was observed in calcium between the two yield groups in both localities.

With regard to foliar Mg the low-yielding trees in both localities had a significantly higher content than the high-yielding ones. The results also showed that palms from Tanga centre alone had a level higher than the critical level of 0.3 per cent proposed by I.R.H.O.

The soil analysis results also conformed with the foliar analysis i.e. in both centres for low-yielding trees, the soil Mg content was higher than for the high-yielding ones.

## DISCUSSION

The foliar level of nitrogen was found to be slightly higher in the high-yielding trees in both localities than in the low-yielding ones even though the difference was statistically significant in Tanga only. Smith (1969) observed a close positive relationship between the foliar N and production of female flowers. In the same study, he also found that the rate of production of flower bunches was increased with increase in foliar N. So it is possible that low N depressed the production of bunches and female flowers with the resultant low yields in the poor yielding trees in Tanzania.

In the present investigation, the level of N in both the yield groups in the two localities was lower than the critical level of 1.8 to 2 per cent fixed by I.R.H.O. But in a study carried out in India on different yield groups of coconut palms, a mean percentage of $1.587 \pm 0.050$ per cent N was observed in palms that yielded an average of $85 \pm 9.94$ nuts per year, (Devi and Pandalai, 1968). So compared to Indian standards the level of N was generally higher in the palms of Tanzania. Therefore the standards fixed by I.R.H.O. for N may not hold good for Tanzania. Further, Smith (1969) pointed out that the yield of coconut

TABLE I—FOLIAR NUTRIENT CONTENTS OF HIGH AND LOW-YIELDING COCONUT PALMS (PER CENT ON OVEN DRY BASIS)

| | N | | P | | K | | Ca | | Mg | | N/P | | N/K | | K/Ca | | K/Mg | | Ca/Mg | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 11 | 1 | 11 | 1 | 11 | 1 | 11 | 1 | 11 | 1 | 11 | 1 | 11 | 1 | 11 | 1 | 11 | 1 | 11 |
| High-yielding trees, Mean .. .. | 1·599 | 1·704 | 0·130 | 0·131 | 1·119 | 1·506 | 0·330 | 0·293 | 0·305 | 0·214 | 12·55 | 14·42 | 1·51 | 1·17 | 4·75 | 5·86 | 4·29 | 7·53 | 1·24 | 1·50 |
| Low-Yielding trees, Mean .. .. | 1·458 | 1·680 | 0·128 | 0·153 | 1·329 | 1·703 | 0·261 | 0·187 | 0·424 | 0·245 | 11·70 | 11·1 | 1·14 | 1·02 | 6·43 | 10·85 | 3·99 | 7·60 | 0·77 | 0·79 |
| Difference of Means | 0·141 | 0·024 | 0·002 | *0·022* | *0·210* | *0·197* | 0·069 | 0·106 | *0·119* | *0·031* | 0·85 | 3·31 | 0·37 | 0·15 | *1·68* | *4·99* | 0·30 | *0·07* | 0·47 | 0·77 |
| S.E. Difference .. | 0·060 | 0·042 | 0·005 | 0·007 | 0·104 | 0·056 | 0·030 | 0·019 | 0·33 | 0·016 | 0·165 | 0·732 | 0·032 | 0·048 | 0·199 | 0·692 | 0·128 | 0·573 | 0·045 | 0·127 |
| Calculated .. | 2·342 * | 0·566 | 0·381 | 3·188 ** | 2·010 * | 3·511 ** | 2·274 ** | 5·521 ** | 3·584 ** | 1·987 ** | 5·164 ** | 4·520 ** | 1·746 ** | 3·277 ** | 8·421 ** | 7·222 ** | 2·344 * | 0·127 | 10·514 ** | 6·071 ** |
| P.05 for significance | 1·98 | 1·98 | 1·98 | 1·98 | 1·75 | 1·98 | 1·98 | 1·98 | 1·98 | 1·98 | 1·98 | 2·01 | 1·98 | 1·98 | 1·98 | 1·98 | 1·98 | 1·98 | 1·98 | 2·01 |

NOTE:— 1 = Tanga
11 = Bagamoyo
* = Significant at P .05
** = Significant at P .01

TABLE II—SOME PHYSICAL AND CHEMICAL CHARACTERISTICS OF SOILS COLLECTED FROM BELOW HIGH AND LOW-YIELDING COCONUT PALMS

| | Sand | Silt | Clay | pH | | Organic Carbon % | Total N % | Available P ppm | Exchangeable m% | | | N/P | N/K | K/Ca | K/Mg | Ca/Mg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Water | $CaCl_2$ | | | | K | Ca | Mg | | | | | |
| **Tanga** | | | | | | | | | | | | | | | | |
| High-yielding .. .. | 84·7 | 5·0 | 10·3 | 7·3 | 6·5 | 0·73 | 0·076 | 47 | 0·46 | 3·50 | 0·62 | 16·2 | 4·2 | 0·13 | 0·74 | 5·6 |
| Low-yielding .. .. | 82·0 | 4·5 | 13·5 | 7·0 | 6·7 | 0·62 | 0·074 | 89 | 0·53 | 2·80 | 0·89 | 8·3 | 2·8 | 0·19 | 0·60 | 3·1 |
| **Bagamoyo** | | | | | | | | | | | | | | | | |
| High-yielding .. .. | 81·6 | 5·6 | 12·8 | 6·5 | 5·2 | 0·38 | 0·052 | 25 | 0·15 | 2·80 | 0·50 | 20·8 | 5·3 | 0·05 | 0·30 | 5·6 |
| Low-yielding .. .. | 85·6 | 3·6 | 10·8 | 6·6 | 5·4 | 0·56 | 0·050 | 37 | 0·27 | 2·60 | 0·60 | 13·5 | 4·8 | 0·10 | 0·45 | 4·3 |

palms was related to the ratio between foliar N and K and not to their individual contents. Calculated on the basis of the critical levels proposed by I.R.H.O., the N/K ratio would be 2.25. Likewise in the studies done in India the N/K ratio was 2.1. In the present investigation, even though the N/K ratio did not reach the above standards, the high-yielding palms registered a significantly higher ratio than the low-yielding ones. This is reflected in the soil analysis results also (Table II). This result therefore indicated that, in addition to the level of N, it was possibly the low ratio between N and K that limited the yield in the low-yielding groups of trees.

The foliar level of P in both the high and low-yielding palms in the two localities was higher than the critical level of 0.12 per cent proposed by I.R.H.O. This showed that coconut palms in Tanzania are well supplied with P. In the present study, foliar P was found to be almost equal between the two yield groups in Tanga, but at Bagamoyo the low-yielding trees recorded a significantly higher P than the high-yielding ones. This discrepancy may be due to the low level of available soil P observed in Bagamoyo compared to Tanga (Table II). When the availability was low, there could be a preferential movement of P to the fruits particularly in the high-yielding trees, thus reducing their leaf P. This difference might also be a result of the N P interaction caused by different levels of these nutrients in the two localities. Similar antagonisms had been observed by Burr (1961) and Emmert (1961). Results from the present investigation show that for both the centres high-yielding trees had a significantly higher N/P ratio than the low-yielding ones. This trend was observed in the soil analysis results also (Table II).

In the case of potassium, the interesting point noted in the present investigation was that in both sites low-yielding palms registered a significantly higher content of foliar K than the high-yielding ones. This result was not in agreement with the observations of Devi and Pandalai (1968) as they observed a positive relationship between K level and yield of palms. But in similar studies, Prevot and Fremond (1960) found a positive relationship between K and number of nuts only when the level of K was less than 0.4 per cent and above that level the correlation became negative.

Among the element N, P, and K, the demand for potassium is the highest for the coconut plant (Fremond *et al,* 1966). It has also been proved that K is metabolically very important for palms (Salgado. 1955). Of the total potassium absorbed by the coconut, 62 per cent goes into the production of nuts (Pillai and Davis, 1963). So in high-yielding trees, there is a greater utilization of the absorbed potassium than in the low-yielding ones. Reviewing the research carried out by various workers on the effect of fruit production on mineral composition in plant tissues, Emmert (1959) and Smith (1962) concluded that as a rule, an increase in the crop load of fruit trees was accompanied by a decrease in leaf K concentration. So it is reasonable to deduce that the low level of K met with in the high-yielding trees was a result of the dilution effect caused by a higher crop production in these trees.

The foliar K content, in both the groups of palms in the present study, was higher than the critical level proposed for this element by I.R.H.O. (0.8 to 1 per cent). This might be due to the low levels of calcium in the soil (Table II) resulting in a higher absorption of K in both the yield groups. This deduction is in agreement with the observations of Salgado (1955) and Bachy (1963) who found the existance of similar antagonism between K and Ca.

The critical level of calcium proposed by I.R.H.O. is 0.5 per cent. But coconut is reckoned as a lime-loving tree and levels of 0.6 to 0.7 per cent Ca are often met with in good and very productive trees (Fremond *et al,* 1966). In the present investigation the levels of foliar Ca found, in both the high and low-yielding trees, were far lower than the critical level suggested. However, high-yielding trees had a significantly higher level of foliar Ca than the low-yielding ones.

In the case of magnesium, the low-yielding trees registered a significantly higher foliar level than the high-yielding ones. This is in agreement with the level of Mg observed in the soils of the two yield groups (Table II). But when the calcium/magnesium ratio was looked into, it could be seen that the high-yielding trees in both the localities recorded a considerably higher ratio than the low-yielding ones in the leaves as well as in the soil. This result suggests that a low Ca/Mg ratio might possibly be another reason for the poor yield in the low-yielding groups of palms in Tanzania.

### SUMMARY

A study was carried out to assess the foliar nutrient composition of high and low-yielding coconut palms of the Typica variety from two localities in Tanzania to examine its possible relationship to yield and to see whether it would help for any fertilizer recommendations. The results, within the limits of the study indicated that the yield was related to N/P, N/K and Ca/Mg ratios, but the level of K had to be interpreted in terms of a balance between K and Ca. When the individual nutrients were considered the levels of N and Ca alone had a positive relation with the yield. The study further revealed that the nutrient composition of the leaves reflected to some extent the nutrient status of the soil. So application of fertilizers having N and Ca might possibly correct the nutrient ratios and thereby improve the productivity of low-yielding coconut palms in Tanzania.



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