Nutrient removal in the harvest of the hybrid coconut, PB-121

depending on potassium and magnesium manuring

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INTRODUCTION

Several of our earlier articles have dealt with the fertilization of the PB-121 or Mawa hybrid [1, 2].

This question deserves much attention, since hybrids, whose yield potential is high, are often grown on chemically very poor soils. The sands of the Lower Ivory Coast are among the most representative cases.

Mineral fertilization therefore becomes essential if high yields are to be obtained. The problem is to make this fertilizer applications profitable under greatly fluctuating economic conditions (regular increase in the price of fertilizers, considerable variations in the price of copra and copra oil).

Economic proportions of fertilizer are calculated according to the results of mineral nutrition experiments performed in the field.

In addition, the immobilization and removal studies performed up to now have given us a good idea of the plant's requirements, and of the evolution of these requirements over a period of time [3, 4].

The possible variations in the quantities of mineral elements removed during harvest, according to the potassium and magnesium fertilizer received by the trees, had not yet been studied, and this study is the subject of the present article, whose aim is to give us more detailed knowledge of the use of fertilizers by the PB-121 hybrid coconut.

OPERATIONAL METHOD

The study was performed on experiment PB-CC 16, planted in 1970 on sandy soil (tertiary and quaternary colluvial soils).

The experimental design was factorial 3 × 3 subdivided. The elements studied were phosphorus, potassium, magnesium and nitrogen.

To evaluate removal, we used the samples of nuts taken for the determination of copra/nut (one nut per bunch harvested) over a period of two years. Fifty-four individual samples were taken, and these were later grouped together, leaving only the nine treatments consisting of the pairs of K/Mg treatments. Each treatment represented nut samples taken from 36 trees.

The nut components analyzed were shell, husk and albumen ; water was not analyzed in this study, on account of the low percentage of mineral matter that it represents, and the problems involved in analysis.

The samples were dried in an oven at 105 °C, and the shell and husk were crushed before being sent to the laboratory for analysis.

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RESULTS

First of all, we calculated the weight of dry matter removed per tree for the three components. These figures were used to calculated the amount of mineral matter removed per tree.

1. — Dry matter production.

Table I explains the influence of K/Mg fertilizer on dry matter produced.

The total amount of dry matter produced is directly linked to the dose of potassium applied, when a sufficient amount of kieserite is applied to correct the magnesium deficiency induced.

An examination of the proportions of the different components shows that :

— the percentage of shell hardly varies at all,

— **potassium chloride significantly increases the proportion of albumen,** although it is not possible to differentiate between doses KCl 1 and KCl 2.

2. — Variation in contents.

a) Evolution of contents according to fertilizers applied and to samples.

Mean contents were calculated for K, Mg and Cl, according to the dose of potassium on the one hand, and to the dose of kieserite on the other (Table II).

In general, we did not observe any effect of **magnesium** manuring on contents of elements other than magnesium. Kieserite application increased magnesium contents in the husk and albumen, but differences were less marked than for potassium. There is no magnesium in the shell.

The effect of **potassium chloride** applications on elements other than potassium and chlorine was slight. Potassium and chlorine contents were greatly increased by KCl application. **It was noticed that the amounts of KCl applied had no effect on albumen contents, but only on contents in the husk and shell.**

The effect was considerably greater for the husk, but variations were also more marked.

b) Relationship between amounts of dry matter produced and contents.

There were very few significant correlations (Table III). Because of the low level of mineralization in the shell, we did not calculate correlations for this component.

Also, on account of the considerable differences in yield observed between the different doses of potassium, we separated the doses (36 pieces of data for each correlation).

For the husk, the link with phosphorus was only significant with dose KCl 2.

For magnesium, the relationship was negative for KCl 0 and KCl 1, but positive for KCl 2.

For sulphur only, correlations were all positive and significant, or almost (dose KCl 1).

For the albumen, correlations had very little significance, only for KCl 1 and nitrogen.

It may be considered that contents are practically unaffected by the weight of dry matter produced, and there is thus no **dilution effect.**

3. — Removal.

a) Percentage of elements exported according to doses applied.

Results are shown in Table IV.

The absence of phosphorus, calcium and magnesium in the shell should be noted.

For potassium and chlorine, variations were similar. The proportion of these elements in the husk and the shell increased when potassium chloride was applied. The husk is a considerable exporter of potassium and chlorine.

For magnesium, a slight increase in the husk was observed, linked to the dose of kieserite.

For sulphur, an increase in the husk was observed, according to the dose of kieserite, and a decrease with potassium applications. The opposite effect was noted in the albumen. Variations were negligible in the shell.

b) Elements exported per ha **(mean of 2 years).**

In our calculations of removals, we considered that the nuts were taken away from the plots.

Results are provided in Table V.

For all elements, we observed an increase in exports per ha according to the dose of potassium. This is directly linked to the influence of the fertilizer, both on dry matter production and on contents.

The figures are comparable to those obtained in an earlier study [3], taking into account the yield potential.

The husk is a considerable exporter of potassium and chlorine, especially with the higher doses of KCl. If husking is performed in the field, the amounts of chlorine and potassium removed by the husked nuts are greatly reduced compared to those removed by whole nuts.

Amounts of elements exported (kg/ha) :

	KCl 0	KCl 1	KCl 2
K	11.5	29.3	32.8
Cl	2.6	7.5	8.9

c) Elements exported per ton of copra produced. (Table VI).

We calculated the quantity of elements exported in kg/ton of copra produced, in order to examine the effectiveness of fertilizers.

A decrease in the amount of nitrogen exported was observed when potassium was applied, although it was not possible to differentiate between KCl 1 and KCl 2. The same influence was observed on phosphorus and sulphur.

The effect of the dose of potassium chloride applied was very noticeable for both potassium and chlorine. The amount of potassium exported by KCl 0 was relatively great, but an increase was then observed that was directly proportional to the doses applied : + 30 p. 100 for KCl 1 and + 50 p. 100 for KCl 2.

This was clear for the KCl 2 Mg 0 treatment, which produced considerably less than KCl 2 Mg 1 and KCl 2 Mg 2, but exported the same amount of potassium per ton of copra produced.

However, if the husks are returned to the field, the amount of potassium exported per ton of copra varies little (in kg/t) :

KCl 0	KCl 1	KCl 2
8.46	8.91	9.79

There is a linear relationship between the potassium applied and the potassium removed, and consequently little unnecessary consumption.

For magnesium, we observed the effect of the K/Mg interaction : a decrease in exports according to doses of potassium, but an increase with the same dose under the influence of kieserite application (the effect was more noticeable for KCl 0).

With calcium, a depressive effect of potassium and magnesium fertilizer was observed.

4. — Relationships between contents in leaf 14 and in components.

The mean contents per season were calculated for each treatment. In this way, we obtained 18 pairs with the contents obtained in the February 1978 and February 1979 L.A.

The following correlations were found :

Nitrogen	
Leaf— shell	r = + 0.4613 ns
Leaf — husk	r = + 0.6195**
Leaf — albumen	r = + 0.3295 ns
Phosphorus	
Leaf — husk	r = + 0.5624*
Leaf — albumen	r = + 0.6700**
Potassium	
Leaf— shell	r = + 0.9790***
Leaf — husk	r = + 0.9711***
Leaf — albumen	r = + 0.1517 ns
Calcium	
Leaf — husk	r = + 0.5772*
Leaf — albumen	r = + 0.6873**
Magnesium	
Leaf — husk	r = + 0.7390***
Leaf — albumen	r = + 0.7636***
Chlorine	
Leaf — shell	r = + 0.9611***
Leaf — husk	r = + 0.9211***
Leaf — albumen	r = + 0.9326***
Sulphur	
Leaf— shell	r = + 0.1134 ns
Leaf — husk	r = + 0.9181***
Leaf — albumen	r = + 0.6585**

The best correlations were those obtained for potassium (Fig. 1), chlorine and magnesium.

It should be noted that for the husk the slope of the correlation line is 1.02, i.e., **any increase in leaf K contents corresponds to an identical increase in the husk.**

5. — Relationships between dry weights of husk and albumen and the amount of elements exported.

Correlations were calculated separating the three doses of potassium (36 pieces of data).

For all elements, simple correlations (element exported and husk or albumen) were very highly significant.

We therefore studied partial correlations to determine the most important component :

— For nitrogen, the link is always strongest with the albumen except for KCl 0 ;

— The amount of phosphorus removed is most strongly linked with the weight of albumen ;

— For potassium, the partial correlations between K exported and weight of albumen, with weight of husk as a constant, are never significant. Conversely, as the dose of potassium increases, the amount of K exported is more strongly linked to the weight of husk, taking albumen as a constant. This relationship, which is non-significant for KCl 0, becomes significant for KCl 1, and very highly significant for KCl 2.

— The same effects are observed for magnesium and chlorine.

— For magnesium, the link is less strong, especially with albumen.

— For sulphur, there is a link with husk in the absence of K, and with albumen at dose KCl 2.

DISCUSSION

Potassium and chlorine are the elements most exported in the harvest.

It has been shown that :

— Potassium exports are strongly linked to the dose of KCl ;

— The higher the dose of potassium, the greater the proportion of potassium in the husk ;

— Potassium used per ton of copra produced varies in the same way.

Potassium removed therefore increases more quickly than production from dose KCl 1 onward. In this case, it may be considered that there is a risk of inducing luxury consumption with high doses **if husks are not returned to the field.** We shall see how the method used for determining fertilizers eliminates this risk.

Using experimental results, with the help of the calculation of the response surface, we drew the curves for copra production and potassium removal according to doses of KCl (Fig. 2). It was noted that, for the PB-121, the separation between production and potassium removal corresponds more or less to the optimal economic dose (2 kg KCl/tree/year). In this case, by applying the experimental results, we do not run the risk of inducing excessive consumption. A manure that has been determined in this way should enable yield potential to be exteriorized under normal conditions.

Assuming that yield is depressed following climatic variations, we lower the threshold of effectiveness of the fertilizer, resulting in an accumulation of potassium in the husks. Since the link between leaf and husk K contents is very strong, the following year's leaf analysis will allow this state of affairs to be detected, and consequently enable potassium manuring to be corrected.

Also, **dehusking under the trees,** and leaving the husks on the spot, **allows potassium to be restored.** In this case, copra production and K removal are proportional, and there is no luxury consumption since excess K is restored to the soil.

Thus, using agronomic experiments and leaf analysis, it is possible to determine the most effective potassium fertilizer.

CONCLUSION

In this study, performed on the PB-121 hybrid, we have been able to confirm that under the conditions found in the lower Ivory Coast (sandy soils poor in nutrients) **chlorine and potassium manuring increase the proportion of albumen in the nut.** Nitrogen, phosphorus, magnesium and sulphur are found mainly in the albumen, and the amount exported per ton of copra remains constant regardless of the manuring rate.

With regard to potassium and chlorine, found mainly in the husk, the amount removed per ton of copra increases with the manuring rate, whereas it remains fairly constant for the shell and albumen.

This study has also revealed a perfect correlation between leaf and husk K levels.

Leaving the husks under the trees gives additional security by restoring to the soil excess K and Cl exports.

There is therefore no risk of luxury consumption of K and Cl if, as recommended by the I.R.H.O., fertilization is based on the results of manuring experiments and routine leaf analyses.