SUMMARY

First experimental Results on the Fertilization of Hybrid Coconut in the Ivory Coast.

P. COOMANS, *Oléagineux*, 1977, **32**, N° 4, p. 155-166.

Mineral nutrition experiments done at Port-Bouet on sandy soils with low mineral element content have shown that it is absolutely necessary to apply an N, K, Mg balanced fertilizer to a hybrid coconut palm from the time of planting. Fertilizers can be classified in the following descending order : potassium chloride, kieserite and urea. They have a very clear-cut effect on the vegetative development, precocity of flowering and on the first yields, which reach 3,400 kg of copra per hectare in year n5 (from 4 1/2 to 5 1/2 years). The effect of the elements applied is directly related to their absorption. The results of the experiments have made it possible to establish a provisional manuring schedule for the Dwarf × Tall Port Bouet 121 hybrid coconut in the soil and climatic conditions of the South-East Ivory Coast.

RESUMEN

Primeros resultados experimentales sobre la fertilización de los cocoteros híbridos en Costa de Marfil.

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Las experiencias de nutrición mineral realizadas en Port-Bouet en suelos arenosos pobres de elementos minerales, mostraron que en los cocoteros híbridos es indispensable aplicar a partir de la plantación una fertilización N K Mg equilibrada. Se puede clasificar los fertilizantes por el siguiente orden de prioridad decreciente : cloruro de potasio, kieserite y urea. Tienen un efecto muy nítido en el desarrollo vegetativo, en la precocidad de la florescencia y en las primeras producciones que representan 3 400 kg de copra por hectárea al año n5 (de 4 años 1/2 a 5 años 1/2). La acción de los elementos aportados se relaciona directamente con la absorción. Los resultados de las experiencias permitieron elaborar una tabla de previsión de fertilizaciones para los cocoteros híbridos Enanos × Grandes (Port-Bouet 121) en las condiciones pedoclimáticas del Sudeste de Costa de Marfil.

First experimental Results on the Fertilization of hybrid Coconut in the Ivory Coast (1)

P. COOMANS (2)

I. — INTRODUCTION

Under its crop diversification policy, the Ivory Coast decided in 1966 to plant some 20,000 ha of coconut grove in the coastal zone to the East of Sassandra, made up of sandy soils.

The first plantings were done with improved local material, the yield of which, in the best conditions, reaches 3 tons of copra/ha/year. But it was only in 1970, with the perfecting of the hybrid between the Malayan Yellow Dwarf and West African Tall coconuts (hybrid Port-Bouet « 121 ») that coconut growing really developed in the Ivory Coast.

So that this new material can realize to the full its yield potential, twice as high as that of the local coconut palm, the fertilizer element needs had to be determined rapidly and accurately.

This note sums up the results obtained in the first two experiments planted, results which led to the establishment of a manuring schedule adapted to the soil and climatic conditions of the South-East Ivory Coast.

II. — EXPERIMENTAL CONDITIONS

Experiment PB-CC 16.

This experiment was planted in May 1970 on SODEPALM's Amavible plantation (3) established on tertiary sands a few kilometres North-East of the Port-Bouet Station. The results of the soil analyses, summarized in table I, show that the soils are chemically poor. A 3^3 factorial design studies the effects of P, Mg and K applied in the form of bicalcic phosphate, Kieserite and potassium chloride. Nitrogen in the form of urea, is studied at 2 levels, presence-absence, in split plots.

The main plots (24 useful trees) and the split-plots are planted half and half with hybrids of Ghana Yellow Dwarf (GYD) × West African Tall (WAT) and Equatorial Guinea Green Dwarf (EGGD) × WAT.

The spacing is in 8.5 m. equilateral triangles, i. e. a density of 160 trees/ha.

The manuring rates applied since planting are recorded in table II.

In year 0, 1/3 of the rate was applied two months after planting (July) and 2/3 at the end of the rainy season (November). From year 1, it was split into two applications : before and after the long rainy season (April-August). The fertilizer is spread broadcast in a circle described by the perpendicular of the leaves during the first years, and within one of 1 m. 50 radius from year 4 onwards. It is followed by light hoeing.

Experiment PB-CC 18.

This experiment, a few hundred metres from the first, was planted in October 1970. In a factorial design of the $3 \times 2 \times 2 \times 2$ type (three modes of spreading and two levels of N, K and Mg), it studies the effect of N, K and Mg on the GYD × WAT hybrids planted at 160 trees/ha and compares split applications (April-July-November) with fertilization given in one lot, before (April) or after (July) the long rainy season.

Each elementary plot is composed of 6 rows of 8 trees or 24 useful trees (4 rows of 6 trees).

As in experiment PB-CC 16, the fertilizer is spread broadcast at the rates shown in table III.

Factors observed.

In order to appreciate the effect of the mineral elements on growth, the girth, the number of leaves emitted and the number of leaflets on the leaf of rank 3 were measured every year in June. From year 3, the observations concerned flowering. Since July 1974 for experiment PB-CC 16 and July 1975 for experiment PB-CC 18, dates of the first harvests, the nut yield per tree has been recorded. The copra per nut is determined from the second year of harvesting. The mineral nutrition is checked by leaf analysis, samplings being done each year in February (dry season).

III. — RESULTS

1. — Growth and development.

The statistical analyses of the girth measurements taken in experiment PB-CC 16 are given in table IV.

During the first months of growth, the nitrogen applications have a significantly positive effect, whereas from the third year, the responses diminish.

The effect of nitrogen already shows in the first year in the colouring of the foliage. The trees receiving no urea have pale green foliage giving a dull appearance to the leaflets. The symptoms die down two years after planting, by which time the leguminous cover is properly established and covers the soil well. At an early age, the phosphatic fertilizers have no action. The element whose application has the most effect is potassium, which results in an increase of 28 p. 100 in girth

(1) Communication presented at the International Symposium on Coconut Research and Development at Kasaragod (India), 28-31 December 1976.

(2) Agronomy Service, I. R. H. O. Station, Port-Bouet (Ivory Coast).

(3) Oil Palm Development Company (Ivoirian state corporation responsible for implementing oil palm anx coconut programmes).

by comparison with the control at 3 years. Rates 1 and 2 of KCl lead to the same results.

The effect of Mg only appears from year 1 on and is shown by a gain of 8 p. 100 in girth at 3 years. Rates 1 and 2 have practically equivalent effects. The K-Mg interaction is already very marked from early on : the action of Mg only appears in the presence of K and that of K is strengthened in the presence of Mg (Table V). Figure 1 gives the evolution of the vegetative characters in course of time with the principal treatments. The growth curves with an N, K, Mg manuring can be taken as references in the conditions of the South-East Ivory Coast.

The results of observations made on PB-CC 18 confirm those of PB-CC 16 and the need for an N, K, Mg manuring from the time of planting. There is no significant difference in growth between the various times of spreading although split applications generally give the best results.

Thus, the most marked effect of splitting results from the nitrogen applications with a gain of 25 p. 100 in girth in the first two years by comparison with the control N 0. The effect of the split N applications tails off sharply from the third year onwards.

It sould also be noted that the effect of Mg only appears in the presence of N and that the best combinaison is found when Mg is applied in split form in the presence of N (Table VI). The least satisfactory growth occurs when the two fertilizers are spread before the rainy season (April).

2. — Flowering.

On experiment PB-CC 16, the very first inflorescences appeared at the end of 1971, i. e. 2 1/2 years after planting. The effect of N, K and Mg on the precocity of flowering is fully confirmed (Table VII). The action of nitrogenous fertilizer on growth was only positive during the first two years, but in year 4, its effect on precocity of flowering appeared significant.

The phosphatic manuring, the number of flowering trees and the emission of inflorescences increases, but not yet significantly. The potassium chloride has a very significant effect on the characters observed : the number of trees in flower at 48 months is double by comparison with the control without K and the number of inflorescences emitted is three times higher.

The effects of Kieserite and the K-Mg interaction are also very marked (Fig. 2). The positive influence of these various fertilizers is confirmed on experiment PB-CC 18. The different modes of spreading lead to statistically equivalent results. However, the best response to nitrogen is obtained by split applications.

The splitting of rate 1 of KCl and of Kieserite also has a better effect, but at rate 2, which gives results significantly higher than those for rate 1, it is the July and April spreadings which prove to be the most profitable.

3. — First yields.

The first bunches on experiment PB-CC 16 were harvested at the end of 1974, i. e. 4 1/2 years after planting. Table VIII summarizes the yield data for the first harvesting campaign.

The response to fertilization in the form of the number of nuts per tree is clear and very considerable.

The application of N, K, Mg manuring to the GYD × WAT hybrid has made it possible to multiply the copra/ha yield by 16 by comparison with the unfertilized control in year 5. The effect on EGGD × WAT is somewhat less (Fig. 3).

The effect of phosphatic manuring is not always significant even though at rate 1 it increases the number of nuts per tree on the GYD × WAT hybrid by 26 p. 100.

The total quantity of N, K, Mg fertilizer applied during the four years preceding bearing is 1 480 kg/ha. The corresponding cost, spreading included, is 59,200 CFA Francs (40 CFA Francs/kg spread). If the copra is sold at 60 Francs/kg (price fixed by the Agricultural Products Stabilization Fund in the Ivory Coast), the profit after deduction of all processing costs, is about 25 CFA Francs/kg of copra. In these conditions, therefore, an increase in yield of 2,370 kg/ha will cover the outlay involved. It will be noticed that the differences in yield are such that the profit realized in the very first harvesting campaign with a N, K, Mg manuring amply makes up for the cost of fertilizers applied from the beginning (Fig. 3).

On experiment PB-CC 18, the first nuts were harvested in July 1975, i. e. 57 months after planting. This experiment, set up in the short rainy season, shows a time lag of one year by comparison with the preceding one which profited from a long rainy season assuring a good start, although only six months elapsed between the dates of planting.

4. — Mineral nutrition.

The results of leaf analyses obtained on experiment PB-CC 16 are recorded in table IX. If the K and Mg contents of the controls are compared, the potassic and magnesian fertilizers increase the K and Mg contents respectively in a highly significant manner. The nitrogen is only absorbed significantly during the first two years, during which urea has an effect on the colouring of the foliage.

The urea applications no longer increase the leaf nitrogen when the leguminous cover has overlaid the soil adequately and when the trees without N have begun to turn green again, even though this fertilizer afterwards had a clearly positive influence on the precocity of flowering and the first yields.

Phosphorus assimilation only starts in the fourth year. On the whole, except for nitrogen from year 4 on, the positive effect of manurings is linked to their absorption. On experiment PB-CC 18, the leaf analysis confirms the very good absorption of the elements applied. The date of spreading has no effect on the N and K contents in the leaves, although the levels are generally lowest when application is made in April. On the other hand, it has a very marked action on the Mg contents, at least during the first three years. The single rate of Kieserite split up has practically the same effect on the Mg contents in the leaves as the double rate applied in April or in July (Mg = 0.27 p. 100 D. W. against Mg = 0,28 p. 100 D. W. on the February 1972 leaf samplings).

IV. — INTERPRETATION AND DISCUSSION

1. — K-Mg relationship.

On experiment PB-CC 16, potassic applications, even at the lowest rates, induce a magnesian deficiency in the absence of Kieserite shown by the appearance of a chlorosis in the first year of planting : yellow discoloration of the oldest leaf tissues, running from the tips towards the rachis of the leaf. The discoloration is especially marked on the parts exposed to the sun. In the next stage marginal necrosis sets in, followed by premature drying of the leaf, which then presents no photosynthetic activity. These visual symptoms are accompanied by a decrease in the magnesium contents proportional to the KCl applications (Table X) and which is very large in the absence of magnesium fertilizer, the Mg levels being 0.176 and 0.101 respectively for treatments K1 Mg 0 and K 2 Mg 0. This sensitivity to induced magnesian deficiency is much greater in the hybrid coconut palm than in the West African Tall [1]. This character comes from the Dwarf, especially the Red Dwarf and the Yellow Dwarf, which are very sensitive to a K-Mg imbalance.

On the other hand, the magnesian manuring has no effect on the K contents in the leaves (Table X). However, certain trees in the plots receiving the highest rate of Kieserite in absence of KCl have K deficiency symptoms shown by foliar discoloration in the form of rust-coloured patches (K = 0.762 p. 100 for the K 0 Mg 2 plots).

2. — Correlations between characters observed and leaf contents.

On experiment PB-CC 16, the correlation, characters observed-K contents, is already positive in the first year ($r = + 0.514^{**}$ for girth at 14 months) ; it proves clearly that the principal deficiency is potassic. During the early years however, it is impossible to determine the action on growth proper to the K and Cl ions, as there are very close liaisons between the vegetative characters and K and Cl contents on the one hand, and positive correlations between these two elements (LA 1971 : $r = 0.973^{***}$, LA 1972 : $r = 0.930^{***}$; LA 1973 : $r = 0.963^{***}$) on the other.

In year 4, on the other hand, the partial coefficients of correlation indicate that the positive effect of potassium chloride is certainly due to the K ion :

P. 100 flowering trees-K contents (Cl constant) $r = 0.736^{***}$,

P. 100 of flowering trees-Cl contents (K constant) $r = -0.421^{**}$.

At an early age, there is no direct correlation between the vegetative observations and the N contents. In year 2, the liaison becomes positive and significant ($r = + 0.546^{*}$ for girth at 26 months), taking only the plots receiving K and Mg into consideration, thus indicating that these two elements take priority.

In year 3, the relationship becomes negative ($r = -0.498^{**}$) but it is probalby linked to an effect of dilution occuring during the phase of acceleration of foliar emission just before flowering. On the other hand, in year 4, the correlations between the N contents — flowering precocity and first yields, becomes positive and highly significant ($+ 0.562^{***}$ and $+ 0.468^{***}$ respectively). They seem to indicate that nitrogen has a direct action on these characters which is not simply the outcome of a back effect of N on development.

Although Kieserite acts very favourably on all the factors observed, there is no liaison between the vegetative growth and the Mg contents.

On experiment PB-CC 18, where the effect of nitrogen is

more marked than on PB-CC 16, there is a close liaison from an early age between growth and the N contents in the leaves ($r = 0.495^{***}$ on girth at 20 months). As the urea rates applied on PB-CC 18 were higher than those applied on PB-CC 16, it can be thought that the latter were insufficient in the first years.

On the whole, there is a very good concordance between the effects of the fertilizers, the assimilation of the elements applied and the relationships between the leaf contents-growth, precocity of flowering and first yields.

3. — Manuring schedule.

Nitrogen. — In both experiments, urea has a favourable effect on the vegetative development of the trees, which is reflected in the precocity of flowering and the first yields. As the effect during the first three years was slightly more marked in the experiment PB-CC 18, it is the rates applied on this experiment which will be retained as a matter of prudence. Trials in the nursery [2] showed that for N, urea is preferable to ammonium sulphate. However, this fertilizer can be used, in which case the rates should be doubled.

Phosphorus. — In experiment PB-CC 16 on tertiary sands, the P applications have no effect on either growth or the start of bearing, therefore for the first years at least the use of phosphate is unnecessary. However, the direct responses recorded in the leaf analyses suggest that this fertilizer will probably have a role to play later on.

On the other hand, in the case of plantations established on sands of the offshore bar, where the phosphorus contents are distinctly lower (total P = 24 ppm), it seems prudent to start applying phosphate in the first year. For the moment, the rates of PB-CC 16 can be recommended on these soils.

Potassium and Magnesium. — These two elements cannot be separated, for on the hybrid coconut and on chemically poor sandy soils, K applications alone induce a magnesium deficiency, manifested by yellowing of the leaves. Thus all K applications require an Mg application. In PB-CC 16, the two elements act favourably on all the growth factors (Table V) and on the start of bearing (Table VIII), the effects of rates 1 and 2 of both types of fertilizer, however, not being significantly different.

In PB-CC 18, the effect of rate 2 of KCl which is intermediary to rates 1 and 2 of PB-CC 16, is significantly greater than rate 1. For Kieserite there is no significant difference between the two rates applied. Thus rate 2 of KCl of experiment PB-CC 18 and rate 1 of Kieserite of experiment PB-CC 16 should be retained for the manuring schedule.

The fitting of the experimental data of PB-CC 16 to a response surface to K and Mg will also make it possible to estimate the best treatments which in the present case, are being achieved in the regions explored experimentally. The abscissa corresponding to maximum development during the first three years, to the maximum percentage of trees flowering at 48 months and to the best yield in year 5 (Fig. 4), are calculated in deriving the polynomial equations characteristic of the surfaces partially from X_1 and X_2. Naturally, the surfaces do not represent the response to the fertilizer applied in the preceding year, but indeed the cumulative effect of the fertilizers applied since planting. By successive differences, the optimum annual rates are determined. These together with the rates determined by the analysis of the principal effects have been carried in original units in table XI.

It is noted that for potassium chloride, the optimum rates established from response surfaces are very close to those determined by the analysis of the principal effects. On the other hand, for Kieserite the values found are quite different. These differences are due to the fact that there is a positive K-Mg interaction on growth and the start of bearing. Thus it is the Kieserite rates determined from the response surfaces which will be retained.

4. — Time of application of fertilizer.

In experiment PB-CC 18, the different times of application studied as well as the splitting of manurings, give practically equal results. Nevertheless certain values (better growth with the splitting of N and Mg, greener foliage when the applications are split) indicate that split dressings are preferable to a single application on sandy soils, at least during the first two years. At an early age, splitting makes it possible to limit losses through leaching by rain on soils with a low power of fixation and in the presence of a root system yet undeveloped. This method of spreading will be maintained beyond the second year in the case of plots very deficient in Mg, this element being assimilated better when the applications are split. Generally, fertilizer spreading will be done in one application from the third year on. In the conditions of the Lower Ivory Coast, the period from July to September is the most appropriate as it makes it possible to avoid the excessive leaching of the long rainy season (May-June), at the same time profiting from the short rainy season for solubilization [3].

5. — Reference level.

On the whole, the relationships between the leaf contents and growth, flowering or first yields are of a linear type and do not allow the levels to which the optima correspond to be determined. Thus, for the moment, the averages of the element contents of the best plots of PB-CC 16 (12 plots receiving N, K, Mg) will be considered as reference levels to follow or to estimate the nutritional state of the young coconut groves ; they and their coefficients of variation (figures between brackets) are shown in Table XII. These reference levels should not be considered as critical levels, but as levels which will almost infallibly enable maximum yield to be obtained. In effect it is possible that the same result could be obtained with lower levels, at least for some elements.

CONCLUSION

From these experiments conducted on tertiary sands, it emerges that a balanced N, K, Mg manuring is indispensable from the time of planting on hybrid material and on soil poor in mineral elements.

The fertilizers have a very clear effect on the vegetative development which is found in the precocity of flowering and the first yields. The positive effect of the elements applied is in direct liaison with their absorption.

Taking account of the effects observed, the fertilizers can be classified in order of decreasing priority as follows : potassium chloride, Kieserite and urea.

The K-Mg interaction is very marked : the effect of Mg only appears in the presence of K and the effect of K is stronger in the presence of Mg. In the absence of Mg, the high K rate becomes depressive and induces a magnesium deficiency.

Phosphatic fertilizer, in the conditions of the two experiments, is not indispensable at an early age, but the absorption of this element from the fourth year on foreshadows a positive effect in the near future.

On the basis of the experimental results obtained, a provisional manuring schedule (Table XIII) can be recommended for the young plantations of hybrids planted at a density of 160 trees/ha on ferrallitic tertiary sands in the conditions of the South-East Ivory Coast.

Starting in the third year, the rates can be adjusted in function of the leaf analysis results.

There is no significant difference between the various times of application studied, although split dressings especially of nitrogenous and magnesian fertilizers, give the best results.

As the effect is only clear on the vegetative characters, splitting is only advised during the first three years.