Mineral nutrition and fertilization of the Malayan Dwarf × West African Tall (PB 121-MAWA) hybrid coconut

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The distribution of the Malayan Dwarf × West African Tall hybrid (named Port-Bouët 121 hybrid by the Institut de Recherches pour les Huiles et Oléagineux, and commonly known as the MAWA in Malaysia) has been undertaken on a vast scale, especially in Indonesia, the Philippines, Malaysia, the Ivory Coast, Brazil and Mexico.

In an earlier report on coconut fertilization throughout the world, presented in 1979 at the Manila congress organized by the FAO, we emphasized the fact that, despite very important and convincing results revealed by research workers, much work remained to be done, since probably less than 1 p. 100 of the world's coconuts receive fertilizer. From this point of view, it is desirable that the hybrid should be better treated than the Tall coconut, since otherwise it would be unable to exteriorize its full potential.

The Kuala Lumpur coconut conference (3) is an opportunity for reviewing our knowledge of current fertilization experiments on this type of coconut, and we will review here the results obtained in a certain number of experiments using the PB-121 — MAWA hybrid, restricting ourselves to this type of planting material.

I. — NUTRITIONAL ELEMENTS EXPORTED BY THE MAWA

In the Ivory Coast, Ouvrier and Ochs have studied the development of the nutrient contents [1982] of the different parts of the MAWA coconut according to age — leaflets, petiole, rachis, stem, bud, roots and bunches — in a plantation where fertilization, governed by leaf analysis, ensured a high yield.

The results obtained are summarized in Tables I and II, and it is interesting to study them from different points of view.

In an exploitation system where an effort is made to minimize exports by extracting albumen at the foot of the tree and letting the husks, piled up, for example, in alternate interrows, slowly release their mineral elements, exports are confined to two main sources — the albumen and the yearly growth of the stem.

Taking a hypothetical maximum yield of 6.7 tons of copra, these exports would be as follows (in kg/ha/year) :

	N	K	Mg	Cl
Albumen	80	47	8	12
Stem	61	19	8	42
Total :	141	66	16	54

When the planter uses the shells, husks, petioles and rachis, annual exports become much greater :

	N	K	Mg	Cl
Nuts	104	172	12	108
Stem	61	19	8	42
Leaves	67	60	31	65
Total :	232	251	51	215

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(3) International Conference on Cocoa and Coconut — Progress and Outlook, 15-17 October 1984, in which the I.R.H.O. took part.

Ng Siew Kee [1967-1968] estimates the annual consumption of nutrition elements by the oil palm in Malaysia (based on a plantation producing 25 tons of bunches/ha/year) at :

192 kg N ; 251 kg K ; 61 kg Mg.

It can therefore be seen that a good coconut plantation exports quantities of nutritional elements comparable to those exported by oil palms. However, fertilizing element requirements will perhaps vary in a ratio of 1 : 3 or 4, according to the amounts of by-products returned to the soil.

In the experiments that will be described below, the nut production is exported, but the leaves are placed in windrows and decomposed naturally.

II. — MATERIALS AND METHODS

The experiments analysed in this paper are situated in West Africa, especially in the Ivory Coast, where the PB-121 hybrid has been extended since 1970, and also in Indonesia, where the Government decided shortly afterwards to use this hybrid for regenerating the coconut population.

Climates and soils are obviously very different. The Lower Ivory Coast (PB-CC 16-24-28-31 and GD-CC 01) is characterized by a short and a long dry season, with water deficits varying greatly around a mean of 600 mm between 350 and 800 mm during the period studied for yield.

The experiment located in Benin (CC 1) is situated in a perimeter irrigated by drip irrigation, where watering only compensates for about half of the deficit, which is naturally very high (760 mm).

In the Ivory Coast, the soils are always very sandy and highly desaturated, whether they are tertiary colluvial deposits of coastal quaternary sands. Organic matter contents are very low (N = 0.5 p. 1000, C = 0.5 p. 100 from 0-15 cm depth), especially in the case of experiment CC 31, set up on the site of an old, over-exploited coconut plantation.

The absorbent complex of these very sandy soils is of course very limited, with a sum of exchangeable bases of about 0.5 meq/100 g in the surface layer :

0.35 meq/100 g calcium,
0.10 meq/100 g magnesium,
0.05 meq/100 g potassium.

Phosphorus contents are always very high — about 500 ppm.

In Benin, the soils have developed on the terminal continental plateaux (Barre lands). They are less sandy (30 p. 100 clay at 100 cm depth), and less desaturated, with :

1.85 meq/100 g calcium,
0.85 meq/100 g magnesium,
0.12 meq/100 g potassium

on the surface. Phosphorus content is low, about 110 ppm.

In Indonesia, the two experiments located in the Province of North Sumatra benefit from abundant, well-distributed rainfall, with a nil water deficit, unless it is an exceptional year. The third experiment is situated in Lampung Province (South Sumatra) where rainfall is also favourable, except for one or two years in five, when there is a severe drought (500 mm water deficit).

The soils are derived from sediments of more or less ancient volcanic origin ; they are therefore more or less lateritized and desaturated :

— 30-50 p. 100 clay from the surface downwards ;
— more plentiful organic matter than in African soils (C 1.5 p. 100 and N 1.5 p. 1000 on the surface) ;
— cation exchange capacity 10-20 meq (Ammonium acetate) ;
— 2-5 meq/100 g of exchangeable bases ;
— 0.4 meq of exchangeable K at Bangun Purba and Bah Lias (North Sumatra), 0.3 meq at Bergen (Lampung).

Total phosphorus is low at Bergen (150 ppm compared with 350 ppm in the North Sumatran experiments).

III. — RESULTS AND DISCUSSION

Tables I and II show the main effects of different fertilizers on :

— yield in copra/tree,

— copra/nut,

— leaf element contents.

Table I concerns the experiments performed in the Ivory Coast, and Table II those performed in Indonesia.

1. — Nitrogen nutrition and fertilization.

In both the Ivory Coast and Indonesia, the application of nitrogen in the form of urea has no sighificant effect on yield in terms of number of nuts as long as the fertility level of the soils enables legume cover plants to establish themselves properly.

This explains why the only effect observed corresponds to the conditions encountered in trial CC 31 (extremely exhausted soils with no cover plant).

Nitrogen application nearly always has a depressive effect on copra/nut.

As a whole, these new experimental results confirm the wisdom of choosing an optimal nitrogen level of about 2.2 p. 100 for West Africa. In Indonesia, the low contents at Bangun Purba have not yet been corrected, for a reason unknown to us.

In any case, nitrogen does not appear to be a very important factor of the mineral nutrition of the hybrid, although exports are very high. However, it should be noted that, in several of these experiments, beneficial effects have been observed on growth and the precocity of bearing.

2. — Phosphorus nutrition and fertilization.

The two experiments showing a response to phosphate fertilizers are characterized by low total soil phosphorus contents (100-150 ppm), and by the lowest leaf contents, about 0.110 p. 100.

Correction of this deficiency increases yield by about 10-15 p. 100.

— In Benin, 3.9 kg copra/tree for 3 kg rock phosphate,

— At Bergen, Indonesia, 2.3 kg copra for 1 kg rock phosphate with a financial efficiency ratio (1) varying from r = 2.6 to r = 4.6.

A more detailed examination of the side-effects of phosphorus application on leaf nitrogen contents (and vice versa) shows no close link like that which has become classic for the oil palm. It is therefore possible to define a specific optimal level of phosphorus in the leaf, which may be situated around 0.120 p. 100.

3. — Potassium and chlorine nutrition and fertilization.

There can be no question of interpreting responses to KCl application without referring to chlorine nutrition, which is of vital importance to the coconut [Ollagnier, Ochs, Pomier and de Taffin, 1983].

From the results of these nine experiments, it is not yet possible to define optimal potassium and chlorine levels. The fertilizer used provides both elements, and it is difficult to separate them.

The experiments in the Ivory Coast point to an optimal leaf potassium level of 1.4 p. 100. The effect of KCl at Bah Lias and Bangun Purba can be attributed to the action of chlorine alone, since natural leaf potassium contents are already quite high (1.5 p. 100). The effect of KCl in the Bergen experiment could be the result of a joint action of K and Cl, but an analysis of correlations is more in favour of a dominant effect of chlorine ;

— Copra/tree according to K (Cl = constant) r = 0.001,

— Copra/tree according to Cl (K = constant) r = 0.69***.

In this experiment, as in the Benin experiment, it appears difficult to bring potassium contents up to the level considered to be optimal in the Ivory Coast. This phenomenon may be the result of cation antagonism at the level of absorption with calcium at Bergen and with magnesium in Benin.

The effects of both potassium and chlorine can be felt on the number of nuts and the copra/nut. The increase in copra/nut may be considerable. In Indonesia, the effect of chlorine alone enables copra/nut to be increased by 40 p. 100.

The PB-121 hybrid, the result of a cross between Dwarf mother trees with a low copra/nut and a West African Tall, has inherited a copra content lower than that of the South-East Asian Talls. This disadvantage, already greatly compensated by the production of a large number of nuts, is strongly attenuated by the combined effects of potassium and chlorine, which bring the copra/nut up to about 240 g.

The increases obtained are very large in all cases, and amply valorize the expenses involved, with a financial efficiency ratio generally greater than 5.

The extent of the response depends, of course, on the water supply. In experiment CC 28 at Grand Lahou in the Ivory Coast, the slope of the land leads to a systematic difference between the three blocks : Block III, situated on low ground, benefits from a water table close to the soil surface. It yields more than Block I (19.2 kg copra/tree, compared with 13.5), and derives greater benefit from potassium fertilization (+ 4.3 kg, compared with 2.3 kg).

4. — Magnesium nutrition and fertilization.

In contrast to potassium, magnesium never influences the copra/nut. The experiments in the Ivory Coast show that the effect of Kieserite may be very great : e.g., in experiment CC 16, in which the response reaches 40 p. 100 in main effect. The association of KCl and Kieserite leads to an improvement of more than 300 p. 100, by addition of the two effects plus interaction (Table III).

The response surfaces of this experiment enable the optimal level to be fixed at 0.200 p. 100, and the experiments in Indonesia do not cast any doubts on this figure.

CONCLUSIONS

The experiments in the Ivory Coast shown in Table I are situated less than 5 km from the ocean, and consequently benefit from dry and damp deposits, estimated by Delmas at about 100 kg of chlorine/ha/year, which explains why the chlorine contents of controls without KCl are already very high (0.43-0.55 p. 100). Other experiments, studying more specifically the chlorine problem, have been set up further inland, up to several hundred km from the ocean.

— Dabou, 25 km from the sea, with a chlorine content of 0.098 p. 100,

— Gagnoa, 125 km, chlorine content 0.039 p. 100,

— Abengourou, 190 km, chlorine content 0.080 p. 100,

— Daloa, 230 km, chlorine content 0.207 p. 100.

These experiments are all characterized by very low chlorine contents, due to the sudden decrease in chlorine deposits after the first 10 km.

They all point to an effect of chlorine on early growth and precocity of flowering.

Only the Dabou experiment is yielding : it shows without doubt that chlorine increases yield by 50 p. 100. In this experiment, the response to KCl, which triples yields, is about 1/3 due to Cl, and 2/3 to K (Table IV).

The three Indonesian experiments, which are located at about the same distance from the sea as Dabou, are also characterized by very low leaf chlorine contents. It is therefore not surprising to obtain considerable responses to KCl application, due to the effect on yield of chlorine alone.

A chlorine deficiency should be expected each time that natural deposits are less than exports ; i.e., most frequently as soon as the plantation is even a short distance from the coast, although this does not exclude the possibility of finding deficiencies near the sea, as observed in the Philippines and at Port-Bouët. In this case, fertilization should often be centred on the correction of this deficiency, using the chloride that is the cheapest for the smallholder or the national economy, and taking into account the possible effect of the accompanying cation.

Sodium chloride could be used for the volcanic soils of Indonesia or the Philippines, which generally have a good potassium supply. Ammonium chloride would be suitable for overcultivated soils of the same type, and potassium chloride for the lateritic soils common in West Africa, where there is a potassium, as well as a chlorine deficiency.

It would very likely be possible to formulate extremely simple and effective fertilizers to develop fertilizer use on coconut in smallholdings, without neglecting to encourage the return of leaves, and especially husks, which, as we have seen, allow potassium and chlorine exports to be reduced by three-quarters.

An effective manuring policy of this kind, coupled with the development of the hybrid coconut on smallholdings, is almost always very profitable. Given identical soil conditions, the Ivory Coast experiments show that 200 kg of fertilizer are sufficient to produce an extra ton of copra, whereas 250 kg are needed to obtain a similar result with the WAT. ■

(1) Value of copra before processing 300 $/t — Cost of RP = 150 $/t.

$$r = \frac{\text{Increase in yield}}{\text{Cost of fertilizer}}$$