Study of fertilization and regeneration of soils in the replanting of coconut palms

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I. — INTRODUCTION

This article gives details of two experiments of replanting old coconut palms carried out in the coastal area of the South-East of the Ivory Coast, a few kilometres from the Marc-Delorme station. In this area, there are some 6 000 ha of family plantations whose productivity is very low owing to the low genetic value of the trees (random WAT), their age (over 50 years) and the lack of upkeep which is the general rule.

These plantations may be replaced by hybrids of type PB 121, which are earlier bearers and more productive than the WAT coconut palm [Sangare *et al.,* 1980]. This hybrid stands up well to drought [Pomier *et al.,* 1982] and to attacks by *Aceria* (*Eriophyes guerreronis*), a nut mite which, since 1975, has been affecting the Ivory Coast's coconut groves planted in local material [Julia *et al.,* 1979].

The old coconut groves are planted in quaternary sandy soils which are naturally poor in minerals, and whose fertility has further decreased owing to a long simple cropping of coconut, the absence of fertilization and often very unfavourable cultivation practices, such as the interplanting of cassava or the systematic removal by the villagers of plant waste, leaves and husks.

It is essential, therefore, before implementing a general replanting programme for these groves, to study the specific problems of fertilization and soil regeneration.

II. — EXPERIMENTAL CONDITIONS

1. — Location.

The tests were carried out 5 km to the east of the Marc-Delorme station, alongside the Abidjan-Grand Bassam road, at a private planter's (Fig. 1) and on the site of replanting of a 40 year old coconut grove made up exclusively of random WAT coconut palms and not receiving any fertilizer. The productivity of these trees was low, around 300 kg of copra/ha/year.

2. — The soils.

These are marine quaternary sands (99.4 p. 100 of coarse sand between 0 and 50 cm), very poor in exchangeable cations and with a very low exchange capacity (CEC 1.8 meq/100 g between 0 and 20 cm).

The available water of these coarse sands is low (estimated at less than 100 mm rain equivalent between 0 and 2 m in depth).

3. — Climate.

The climatic data already presented by Sangare and Rognon [1] correspond to the conditions of the experiments (Table I). Average rainfall over the last ten years amounted to only 1 850 mm and some years recorded a high water deficit (1976-1977-1980) due to a bad distribution of rainfall.

The sweet water table stored between the lagoon network and the ocean is between 3 and 5 m down.

4. — Planting material.

The experiments were planted with hybrid PB-121 obtained by assisted pollination in the seed gardens of the Marc-Delorme station.

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5. — Experimental plans.

PB-CC 31

Fertilizer experiment planted in 1974 according to a factorial design of N^4 Mg^4 K^2 containing 4 blocks of 8 plots. The experimental plot is made up of 49 coconut palms (7 rows of 7 trees) of which 25 are useful.

The planting density is 160 trees per ha (8.5 m triangular). Before replanting, all the trunks of the old coconut palms were burnt in pits outside the experimental area [Coomans, 4].

The spreading of fertilizer was carried out manually in a ring around the coconut palms according to the rates set out in table II.

The usual types of fertilizer were used :

N : — sulphate of ammonia at 21 p. 100 of N until 1979,
— urea at 46 p. 100 of N from 1980 onwards ;

P : — tricalcic phosphate at 33 p. 100 of P_2O_5 until 1979,
— single superphosphate at 18 p. 100 of P_2O_5 from 1980 onwards.

For each type of fertilizer there is no control 0 (except for N during the first two years).

The plant cover is made up of herbaceous regrowth, basically grasses, slashed 3-4 times per year by rotary slasher.

PB-ES 94

This test was planted in 1973 in a Fisher block design with 3 treatments and 5 replications ; it studies the advantages of replanting a legume cover *(Pueraria javanica)* compared to planting on bare oil or a simple slashing of the natural regrowth.

The treatments are :

— bare soil (disking 3/4 times a year on average),
— natural regrowth slashed regularly by rotary slasher,
— legume cover *(Pueraria javanica)*.

The experimental plot consists of 4 rows of 30 coconut palms each, of which 56 are useful. The density of the plantation is 160 trees per ha.

Fertilizers common to all treatments were applied manually. Table III gives the quantities given for nitrogen manuring.

The same fertilizers as for PB-CC 31 were used ; however, the sulphate of ammonia was replaced by urea as early as 1976, and the tricalcic phosphate by superphosphate in 1977. All applications of fertilizer were stopped in 1978 at the request of the plantation owner. At this time, and for the same reason, the upkeep of the bare soil was also stopped. The recording of the harvest was interrupted during the 1978/79 and 1979/80 seasons.

III. — RESULTS

1-PB-CC 31

a) *Leaf analysis.*

For each of the fertilizers studied, there is a significant rate effect for the major element in its composition (Table IV).

The persistent effect of the sulphate of ammonia on levels of N are particularly remarkable. This is to be compared with the general weakness of N levels, since the N3 and N4 rates (1.5 kg and 2 kg of sulphate of ammonia) are the only ones which bring the leaf contents close to the Theoretical Critical Level. In experiments of the same type, but where planting had taken place after clearing and a cover established, the effect of the nitrogenous fertilizer disappeared after 3 years.

The leaf content at level 1 of KCl and kieserite indicate severe deficiencies of K and Mg. These deficiencies are corrected at level 2.

b) *Precocity of flowering.*

The percentage of flowering at 49 and at 61 months shows a positive and highly significant response to sulphate of ammonia (Table V). There is no response, however, to potassium chloride and kieserite.

c) *Production.*

First yields are confirmation of previous observations of precocity of flowering.

Nitrogen would seem to be the essential production factor, increasing considerably the number of nuts/tree and therefore the amount of copra/tree (despite a slight depressive effect of the higher rates on copra/nuts). Maximum yield is obtained with rate 3 (Table VI). There is reason to believe that the absence of nitrogen would lead to a low yield.

There is no significant difference between the four Mg or K treatments. However, the K-Mg contingency table reveals that maximum yield is obtained at the K^2 Mg^2 rate (3 kg of KCl and 1 kg of kieserite) (Table VII). This result agrees with those of other experiments.

d) *Interpretation.*

The precocity of hybrids is good, comparable to that observed in a plantation after clearing. However, the production level seems to be lower, although the poor yields of 1980/81 may be attributed in part to the high water deficit of 1980.

The outstanding result is the need for nitrogenous fertilization after the third year, as the natural low level of nitrogen nutrition may be attributed to the absence of a legume cover (see paragraph II-5). Test ES-94 allows us to study this hypothesis.

2-PB-ES 94.

a) *Leaf analysis.*

Following the uniform application of nitrogen fertilizer (Table III) until 1977, the N levels are good in 1977 (Table VIII) for « bare soil » and « legume cover » treatments, whilst the « natural regrowth » treatment is down because of the presence of grasses.

After the cessation of fertilizer spreading in 1978, the situation changed considerably. At the end of 1980, the former bare soil and regrowth treatments present visual symptoms of serious nitrogen deficiency. Legume treatments, on the other hand, have a satisfactory vegetative appearance pointing to sufficient nitrogen nutrition, as confirmed in the 1981 foliar results.

The N content (NO_3^-) of soils of the legume treatment, much higher than that of regrowth and bare soil in 1981, confirm the positive effect of legume cover on the nitrogen status of the soils.

N content (NO_3^-) (ppm)

	0-20 cm	20-40 cm
Legume	0.820	0.260
Regrowth	0.250**	0.120*
Bare soil	0.300**	0.130*

b) *Precocity of flowering.*

Here, the bare soil treatment has the advantage, followed by slashed natural regrowth, with the legume treatment a year behind, in 1977 (Table IX).

c) *Production.*

1977/78, the first production year, revealed the superiority of the bare soil treatment, whilst that with a legume cover was barely beginning to produce. The 1981 harvest indicated an opposite trend, however, with highest bearing in the legume treatment. In 1981, there was rather a close link between the number of nuts and leaf nitrogen content (r = 0.76***) whilst there was no connection with potassium content.

d) *Interpretation.*

These results show that once the problem of nitrogen deficiency has been resolved by adding sufficient fertilizer, water supply is the main limiting factor (1974/76 period). Consequently, the subjects natural regrowth (slashed regularly) and especially bare soil treatments are superior in precocity over the legume cover treatment, which has a higher water demand. This unfavourable aspect of legume cover in Ivory Coast conditions has already been mentioned by Fremond and Brunin [5].

The cessation of nitrogen applications in 1978 changed the factors of the problem, with this element becoming the main limiting factor. The maintenance of the legume cover for five years restored the biological activity of the soil, enabling it to supply part of the nitrogen needed by the plantation, as shown by the leaf contents. This suggests that the better production obtained in 1981 with the legume cover will be maintained in the years to come.

These results are in agreement with the conclusions of experiment CC-31.

IV. — CONCLUSION

The results of these experiments confirm the drop in fertility of the coastal quaternary sands of the Ivory Coast, already very poor at the outset after a long single cropping of coconut. The resultant nitrogen deficiency leaves the planter two alternatives :

— either a permanent application of nitrogen fertilizers :

This is a solution which is easy at the outset, since it avoids the replanting of a legume cover, difficult to carry out on these poor soils.

However, at the adult stage, an annual manuring of **1.5 kg of sulphate of ammonia** per tree (besides the usual application of 2 to 3 kg of KCl and 1 kg of kieserite) is essential. This represents an additional cost of some **14 000 F CFA** ha/year. Nevertheless, this nitrogen manuring results in a gross increase in annual income, between the ages of 5 and 7 years, of 50 000 F CFA/ha compared with the lower rate of 500 g/tree/year of experiment PB-CC 31.

Unfortunately, as it is widely known, the farmers are very reluctant to use fertilizers ;

— or the replanting of a legume cover :

A cover crop regenerates the nitrogen in the soil, thereby making it possible to reduce or to stop the use of nitrogen fertilizers after a few years.

On coastal sands with a low water retention level, however, this method results in a slower development of the tree owing to competition from the legume cover for water during periods of drought. Furthermore, the difficulties encountered in planting *Pueraria javanica* (or *Centrosema*) on these impoverished quaternary soils should not be underestimated. Ideally, other leguminous plants which are better suited to sandy soils and resistant to prolonged drought should be used. First tests have been undertaken in this field.

The nitrogen problem having been resolved one way or another, it remains to be seen what the exact potential of the replanted trees will be. Production at the adult stage of replanted trees on these poor soils might well be lower than for a plantation established after clearing. The real potential will only be known after several more years of observation of these two tests.