

A coconut fertiliser trial on the podsollic soils of North Sumatra ⁽¹⁾

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Summary. — Coconut seednuts of the MAWA hybrid were imported to North Sumatra and planted on podsollic soils in October 1974. A factorial fertiliser trial was started in March 1977. By December 1978 no response had been obtained to phosphate and little response had been obtained to nitrogen, probably because the legume cover received rock phosphate applications and was effectively contributing nitrogen. Muriate of potash increased growth as measured by the petiole cross section and also various yield components. The positive response may be due to the potash or the chlorine. All fertilisers reduced frond boron levels and at high rates of fertiliser application boron deficiency may be a limiting factor.

THE SITE AND PLANTING MATERIAL

In October 1973 MAWA hybrid seed nuts were imported from the Ivory Coast and established in a polybag nursery prior to field planting in October 1974.

The planting is on Bah Lias Estate to the east of Pematang Siantar and about 30 km from the sea.

The soil is a reddish brown phase of the red-yellow podsollic soil group.

Soil analyses gave the following results (Table I).

TABLE I

Depth (Profondeur) cm	pH	p. 100 N	cations m. equiv/100 g			
			K	Mg	Ca	CEC
0-20	4.55	0.15	0.40	0.77	3.78	10.46
20-40	4.50	0.09	0.41	0.54	2.62	8.83
40-80	4.41	0.05	0.47	0.64	1.56	8.46

The soil permits deep rooting and the topography is very gently rolling.

Prior to planting with coconuts the area had been under lalang (*Imperata cylindrica*) for some years but prior to that had been planted with rubber.

The average rainfall is 2 627 mm per year and there is rarely a water deficit but 1976 was exceptionally dry (1 834 mm).

The coconuts were planted at 156 palms per hectare but about 12 p. 100 were lost for various reasons (blown over by wind and disease). The vacancies were planted with local Tall palms.

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(2) Harrisons Fleming Advisory Services, London (England).

Creeping legume covers were very successfully established. The covers received an application of rock phosphate at 200 kg/ha in 1974, 1975 and 1976 to give a total of 600 kg/ha. The roots of the legumes were well nodulated.

In the period from planting (October 1974) to the end of 1975 the coconuts received the following quantities of fertiliser :

Sulphate of ammonia	660 g/palm
Rock phosphate	380 g/palm
Muriate of potash	350 g/palm
Kieserite	580 g/palm
Compound 12.12.17.2 . . .	225 g/palm

No fertiliser was applied to the coconuts in 1976. There were visual signs of boron deficiency which were corrected by an application of borax at 50 g/palm in January 1977.

THE EXPERIMENT DESIGN

The experiment is a 3 × 3 × 3 factorial for NPK with each plot split for Mg laid out in blocks of nine whole plots. There are two replicates so that there are 54 whole plots and 108 sub-plots. Each sub-plot contains 25 palms arranged 5 × 5 but only the nine core palms (3 × 3) are recorded. Any palms supplied after the original planting are not recorded. The total palms in recording should be 972 but there are only 854. The worst « whole plot » contains 13 instead of 18 recorded palms and the non-recorded palms are scattered rather uniformly over the experiment. The site was accepted because no other area planted with hybrid coconuts was available.

The fertiliser treatments are given in table II.

TABLE II. — kg/palm (arbre)

Level (Niveau)		0	1			2		
			March (Mars)	Sept.	Total/an	March (Mars)	Sept.	Total/an
Sulphate of ammonia (Sulfate d'ammoniaque)	(N)	0	1	1.25	2.25	2.25	2.25	4.50
Rock phosphate (Phosphate de roche)	(P)	0	2	0	2	4	0	4
Muriate of potash (Chlorure de potassium)	(K)	0	1	1.25	2.25	2.25	2.25	4.50
Kieserite	(Mg) . . .	—	0.75	0.75	1.50	1.50	1.50	3.00

The first treatments were applied in March 1977.

The site was not large enough for two replicates of a 3⁴ design but in view of the irregularities of the material replication of the more important treatments was considered essential. It is known that oil palms on these soils often develop severe magnesium deficiency symptoms and it was decided to omit a zero level of magnesium and to use two levels as sub-plot treatments.

OBSERVATIONS

a) Growth.

Growth was recorded in various ways. The parameters presented in this paper are :

Relative frond area. — The procedure used to estimate frond area is based on the method used for oil palms [Hardon *et al.*, 1969]. Three leaflets are sampled about two thirds of the frond's length from its base and the length and width at the mid-point are recorded. The multiple of leaflet number \times mean length \times mean width was recorded as the « relative » frond area. The correction factor to convert this to actual frond area has not yet been calculated for coconuts so the data cannot be presented in square metres.

Frond length. — This is the distance from the lowest leaflet to the end of the rachis.

Petiole cross-section. — At the point of lowest leaflet insertion the width and depth of the petiole are recorded. This can be done easily on the palm using a specially designed recording caliper (for petiole depth) and sliding guage (for width). The petiole cross-section is presented at $\frac{1}{2}$ depth \times width (cm²). In the oil palm this is a very sensitive indicator of growth [Corley *et al.*, 1971].

b) Yield.

The number of nuts harvested in 1978 was recorded

but the variability from palm to palm and plot to plot was very great. Also it is most unlikely that the first application of treatments in March 1977 could affect the number of nuts harvested in 1978. The results were not statistically significant and are not presented. In the period October 1978 to January 1979 the weight of fresh copra per nut was determined based on two random nuts per palm per harvest. Observing only those palms which were already flowering in January 1978 the total number of flowers per palm was recorded as well as the number of nuts remaining on the palms in December 1978. The count included button nuts. Data on these various yield components are presented but meaningful estimates of the yield of copra per palm will not be available until the end of 1979.

c) Nutrition.

Leaf samples were collected from frond 14 in the usual way and analysed by the Marihat research station laboratory near P. Siantar. The data presented refer to samples collected in December 1978.

RESULTS

The results to the end of 1978 which were available in early 1979 are presented in table III (growth and yield) and table IV (nutrition). As the experiment has not yet been in progress for two years the results must be regarded as provisional. A justification for presenting these results is that they demonstrate that useful preliminary conclusions can be reached rather quickly even from long term experiments.

Statistical analyses have been confined to main effects only. All interaction effects have been pooled with « error ». It is thought unlikely that a more detailed analysis will substantially modify the conclusions drawn. For comparative purposes the residual coefficient of variation (RCV) has been presented. This is the square root of the « error mean square » expressed as a percentage of the general mean. It is a useful measure

TABLE III. — **Coconut fertiliser experiment** (*Expérience engrais sur cocotiers*)
(Mawa hybrids, planted October 1974, 1st, treatment March 1977, Data recorded in December 1978
— Hybride P-B 121, plantation oct. 1974, 1^{er} traitement mars 1977, données obtenues en déc. 1978)

	Treatment (Traitement) kg/palm/ (arbre)/an	Relative frond area (Surface foliaire)	Frond length (Longueur de feuille) cm	Petiole cross-section (Section du pétiole) cm ²	Fresh copra/nut (Albumen/ noix) -g- 10/78-1/79	Female flowers /palm (°) (Fleurs femelles/ arbre) total 1978	Nuts counted on palm (°) (Noix sur arbre) Dec. 1978	
N 0	S/A	0	11.78	405	27.14	289	645	93.1
N 1		2.25	11.56	402	27.93	287	690	98.4
N 2		4.50	11.55	407	27.81	288	767 **	92.7
P 0	RP (PR)	0	11.83	407	27.77	286	696	97.4
P 1		2	11.59	405	27.83	292	684	92.8
P 2		4	11.48	401	27.29	288	723	94.0
M 0	M/P (KCl)	0	11.59	405	26.50	243	649	87.8
M 1		2.25	11.65	405	27.87 *	302 **	697	99.1 *
M 2		4.50	11.65	403	28.51 **	320 **	756 **	97.3 *
ean (Moyenne)	—	—	11.63	404	27.63	288	701	94.7
SD (ppds) 5 p. 100.	—	—	NS	NS	1.04	30	53	9.0
1 p. 100.	—	—	NS	NS	1.40	40	71	12.0
CV (C. V.) p. 100	—	—	7.1	6.2	7.9	21.8	16.0	19.9
K 1	Kies.	1.5	11.64	404	27.47	288	718	92.5
K 2		3.0	11.63	405	27.78	289	684	97.0
SD (ppds) 5 p. 100.	—	—	NS	NS	NS	NS	NS	NS
1 p. 100.	—	—	NS	NS	NS	NS	NS	NS

(°) The data refer only to those palms that were flowering in January 1978 and includes button nuts (*Les chiffres se rapportent seulement aux arbres qui étaient en fleurs en janv. 1978*).

(*) Statistical significance is (significatif à) = * : 5 p. 100 ; ** : 1 p. 100.

TABLE IV. — **Coconut fertiliser experiment** (*Expérience engrais sur cocoliers*)
 (Mawa hybrids, planted October 1974, 1st. treatment March 1977, nutrient levels frond 14, December 1978
 — *Hybride P-B 121, plantation oct. 1974, 1^{er} traitement mars 1977, teneurs feuille 14, déc. 1978*)

	Treatment (<i>Traitement</i>) kg/palm (<i>arbre</i>) /an	p. 100 on DM (<i>p. 100 matière sèche</i>)						ppm				
		N	P	K	Mg	Ca	Cl	Na	B	Mn	Fe	
N 0	S/A	0	1.88	0.142	1.62	0.199	0.208	0.270	371	11.8	336	70
N 1		2.25	1.91 *	0.141	1.57 *	0.202	0.291	0.261	382	10.6 **	430 **	72
N 2		4.50	1.93 **	0.141	1.57 *	0.193	0.284	0.266	386	9.9 **	531 **	73
P 0	R/P (<i>PR</i>)	0	1.92	0.135	1.62	0.190	0.288	0.255	374	11.1	410	73
P 1		2	1.90	0.143 **	1.56 *	0.206 **	0.287	0.269	396	10.7	452 *	72
P 2		4	1.91	0.145 **	1.57 *	0.198 *	0.281	0.271	369	10.5 *	435	70
K 0	M/P (<i>KCl</i>)	0	1.89	0.140	1.55	0.186	0.286	0.074	339	12.1	402	70
K 1		2.25	1.92	0.142	1.59 *	0.201 **	0.288	0.290 **	388	10.5 **	417	73
K 2		4,50	1.91	0.140	1.61 **	0.206 **	0.281	0.432 **	412	9.7 **	477 **	72
Mean (<i>Moyenne</i>)			1.91	0.141	1.58	0.198	0.285	0.265	380	10.5	432	72
MSD (<i>ppds</i>) 5 p. 100.			0.03	0.006	0.03	0.008	NS	0.110	21	0.5	35	NS
1 p. 100.			0.04	0.008	0.05	0.011	—	0.148	29	0.7	47	—
R. C. V. (<i>C. V.</i>) p. 100			3.1	3.5	4.4	9.0	9.1	17.6	11.8	10.7	17.2	15.7
Mg 1	Kies.	1.5	1.90	0.141	1.60	0.193	0.286	0.262	377	10.8	429	72
Mg 2		3.0	1.91	0.141	1.57	0.203 *	0.284	0.269	382	10.7	435	71
MSD (<i>ppds</i>) 5 p. 100.			NS	NS	NS	0.008	NS	NS	NS	NS	NS	—
1 p. 100.			—	—	—	NS	—	—	—	—	—	—

— S/A and M/P applications split between March and September (*S/A et KCl fractionnés en mars et septembre*).
 — R. C. V. = Residual coef. variation (*Coefficient de variation — C. V.*).

of the residual variability after removing the effects of blocks and the main treatments.

a) Growth.

Neither the frond area data nor the frond length data have given any significant result. The petiole cross-section measurements, however, show a very significant response to muriate of potash but no significant response to N, P or Mg (Table III). It should be noted that the coefficients of variation of all three parameters are rather similar but it is only the petiole cross-section data that has given a significant result.

b) Yield components.

The results show that muriate of potash has very significantly increased the fresh copra per nut. This result has been obtained despite a high residual coefficient of variation. The effect is very great :

	g/nut	p. 100 KCl 0
KCl 0	243	100
KCl 1	302	124
KCl 2	320	132

This effect was obtained about 20 months after starting the experiment.

To reduce the error due to the varying precocity of the palms only palms already flowering in January 1978 are included in the following figures. Female flower production per palm was increased by both sulphate of ammonia (+ 19 p. 100) and by muriate of potash (+ 16 p. 100). The number of nuts on the palm in December 1978 was not increased by sulphate of ammonia, and the response to muriate of potash was only 11 p. 100.

c) Nutrition (Table IV).

The applied nutrients increased the corresponding

levels in the fronds. Thus, sulphate of ammonia increased frond N, rock phosphate increased frond P muriate of potash increased frond K and Cl, kieserite increased frond Mg. All these effects achieved statistical significance.

All the applied fertilisers reduced frond boron levels but increased frond manganese levels. These effects achieved significance except in the case of kieserite.

The mean nutrient levels over the whole experiment in succeeding years is given below and compared with « normal » values. The « normal » levels are based partly on other authors opinions and partly on the results from a large number of analyses in various parts of the world (Table V).

TABLE V

	P. 100 on dry matter (<i>matière sèche</i>)	Frond (<i>Feuille</i>) 4 *		Frond (<i>Feuille</i>) 14	
		1976 « normal »	1977	1978	« normal »
N	2.05	1.80	1.94	1.91	2.00
P	0.152	0.16	0.134	0.141	0.14
K	2.16	1.70	1.75	1.58	1.00
Mg	0.23	0.23	0.199	0.197	0.26
Ca	0.25	0.34	0.33	0.29	0.55

(*) = pretreatment (*avant traitement*).

DISCUSSION

As a method of measuring growth the petiole cross-section appears more satisfactory than frond area or frond length. The petiole cross-section shows a significant response to muriate of potash and a positive response to sulphate of ammonia which approaches significance. Ultimately frond area and frond length are likely to give a response but it appears that the petiole cross-section responds more quickly.

Muriate of potash has given a positive and significant effect on each of three yield components (copra per nut, flowers per palm and nuts per palm). Muriate of potash has increased frond K from 1.55 p. 100 to 1.61 p. 100

but even the 1.55 p. 100 is substantially above « normal ». Muriate has also increased frond Cl level dramatically from 0.074 p. 100 to 0.432 p. 100. Various authors consider that the coconut can respond to applications of chlorine [Ollagnier and Ochs, 1971 ; Uexkull, 1972] and a normal level may be about 0.5 p. 100. These figures suggest that the effects of the muriate of potash on the growth and yield components may be due to the chloride rather than the potash. The data clearly demonstrate the need for further experimentation to study the coconuts requirement for chlorine on the podsolic soils of North Sumatra.

The effect of sulphate of ammonia has almost certainly been masked by the presence of the nitrogen-fixing bacteria in the well nodulated roots of the legume cover crop. Sulphate of ammonia has increased the number of female flowers per palm but by December 1978 had failed to increase the number of nuts per palm.

Both sulphate of ammonia and muriate of potash have reduced the levels of boron in the frond. The interaction between the two fertilisers was studied (cf. Table VI).

TABLE VI

	N 0	N 1	N 2
Nuts/palm (<i>Noix/arbre</i>)			
— KCl 0	81	91	92
— KCl 1	89	106	102
— KCl 2	109	98	84
B ppm in frond 14 (<i>dans la feuille 14</i>)			
— KCl 0	13.2	11.9	11.0
— KCl 1	11.8	10.4	9.4
— KCl 2	10.3	9.5	9.3

The N × K interaction for nuts per palm is statistically significant (P. 0.01). The combination of sulphate of ammonia and muriate of potash is no better than control. Either fertiliser alone is effective but more especially the muriate of potash. Brunin and Coomans [1973] obtained an increase in yield when frond 14 boron levels were raised from an average of 6.7 ppm to 10.2 ppm. They suggested that there was a clearly defined critical level below which the palms were abnormal and above which there was little benefit from a further increase. In the present experiment the two interaction tables suggest that the critical level may be about 9.5 ppm. It is well known that boron plays an important role in the process of pollen tube growth and pollination. An effect of boron deficiency on the success of pollination could explain the failure of sulphate of ammonia to increase nut number, although flower number was increased.

Oil palms on the podsolic soils sometimes suffer severe boron deficiency especially if they have been generously fertilised. The coconuts in the experimental area showed deficiency symptoms prior to the start of the experiment. Further research to study the boron requirement of coconuts on these podsolic soils is needed.

CONCLUSIONS

Growth records included the number of fronds produced, frond length, frond area and petiole cross-section. The most sensitive measurement is the petiole cross-section which is also very easily measured.

During the first year of maturity nut production did not respond to the treatments but significant effects on copra per nut were found. Both sulphate of ammonia and muriate of potash increased the number of flowers per palm but only muriate of potash increased the number of nuts on the palm.

During immaturity the vigorous legume cover crop received 600 kg/ha of rock phosphate. This good management practice has resulted in adequate N and P levels in the fronds and masked responses to applied nitrogen and extra phosphate.

Muriate of potash has increased growth and yield components whilst increasing frond K from 1.55 to 1.61 p. 100 and frond Cl from 0.074 to 0.432 p. 100. It is not possible to state if the effects are due to the potash or to the chloride but frond chlorine levels were below normal levels whereas frond potash was not.

Sulphate of ammonia and muriate of potash have both depressed the levels of frond B. When both fertilisers are applied frond B drops to below the tentative critical level. Boron deficiency may be limiting yield at high rates of sulphate of ammonia and muriate of potash application possibly by reducing the effectiveness of pollination.

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