PROGRESS OF NEW IRELAND FERTILIZER TRIALS 1964 TO 1970

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ABSTRACT

Trials on the yellow-brown clay-loam soils of the east coast of New Ireland continued to show responses to potassium fertilizer. The previous recommendation of a biennial application of 5 lb of potassium chloride broadcast evenly over a circle about 20 ft in diameter around the base of the palm as giving the greatest economic response was confirmed.

In a new trial with palms about 30 years old, an estimated average annual increment of at least 3.6 cwt was shown in the 6 years after initial fertilizer application. Additional net profit was estimated at about $A12 per acre per year. Evidence indicated that the actual yield increment would be considerably greater once fertilizer usage was an established practice. A significant yield response to sulphur occurred once the potassium deficiency was corrected and a biennial application would appear appropriate where there is good reason for suspecting low plant sulphur levels.

A single cultivation affected yields adversely for at least 3 years. There were no yield differences detected between palms where fertilizer was broadcast over a circle about 20 ft in diameter around the palm base or where fertilizer was broadcast evenly over the whole area.

Interplanted cacao benefited, in terms of girth increment, from fertilizer applied primarily for coconut palms.

INTRODUCTION

EVIDENCE of potassium deficiency in coconuts and other crops on the east coast of New Ireland was published by Baseden and Southern (1959). Diagnostic trials showed a response to potassium on the deeper yellow-brown clay-loams and clays but a worthwhile response failed to eventuate on the shallower, less acid, red-brown loams and clay-loams (Charles 1959*a*, *b*).

The results of subsequent specific fertilizer trials were reported by Charles and Douglas (1965). A more economic response was obtained from an annual application of 2.5 lb potassium chloride to each palm than from 5 or 10 lb, while a better response appeared to result from broadcasting fertilizer over a circle 20 to 24 ft in diameter around the palm base than from placement over a smaller circle.

There were indications that a biennial application of 5 lb was preferable to annual treatments. A good response to potash fertilizer in coconut seedlings was also demonstrated.

Although potassium applications had increased yields of mature palms it was considered that they had not been brought back to full health. Charles and Douglas examined possible reasons for the absence of a full recovery and mentioned that a new trial had begun on younger palms.

The present paper covers continuation of coconut experimentation in New Ireland from 1964 to early 1970. During this period the Potassium Method of Application Trial and the Potassium Rate of Application Trial were concluded. The trial on younger palms was continued to study the effect of incorporation of fertilizer into the soil by cultivation, the use of NPK fertilizer instead of potassium chloride and two methods of fertilizer placement.

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POTASSIUM RATE OF APPLICATION TRIAL

Methods and Results

The progress of this trial from its beginning in 1958 to June, 1964 was described by Charles and Douglas (1965).

Four rates of application of potassium chloride were compared—nil, 1, 2 and 4 cwt per acre per annum, which on a per palm basis was equivalent to 0, 2.5, 5.0 and 10.0 lb per year. The design was a randomized block with four replications and with plots nominally of 16 palms (4 x 4) separated by a single general row. The trial was treated on a typical yellow-brown clay-loam soil in a very variable stand of palms over 40 years old. There was great variability between plot yields and results were adjusted by covariance analysis to reduce random variation by allowing for pretreatment differences.

After fertilizer application in accordance with the original treatments in December, 1964, the following changes were made:—

K0 = Control (unchanged);
K1 = 2.5 lb potassium chloride annually (unchanged);
K2 = 5 lb potassium chloride biennially (previously 5 lb annually); and
K3 = Applications discontinued (previously 10 lb potassium chloride annually).

The K1 treatment was re-applied in May, 1966 (6 months overdue) while K2 was applied in December, 1966.

The treatment changes were designed to examine the indication from the Potassium Method of Application Trial that biennial applications were preferable to annual and to note the residual effect of heavy applications.

Unfortunately, increasing within-treatment variation made result interpretation difficult. The plantation manager suspected that labourers had applied fertilizer in the trial area in his absence and this could have contributed to the increased variability. The trial was concluded in May, 1967.

Table 1 shows average nut counts. Figures from July 1960 to June 1964 are averaged as they had previously been published (Charles and Douglas 1965).

Towards the end of the trial, nut water samples were collected when the trial was visited, provided sufficient suitable nuts were available. Results of analyses are shown in *Table* 2.

Nut characteristics were noted on three occasions and these are shown in *Table* 3.

Discussion

The conclusions drawn by Charles and Douglas (1965) appear confirmed even though increased plot variations prevented the attainment of statistically significant differences between fertilized and unfertilized treatments over the last three years of the trial.

Table 1.—Potassium Rate of Application Trial—average number of nuts per plot, adjusted on pretreatment yields

Date	Control	K1 (2.5 lb per palm)	K2 (5 lb per palm)	K3 (10 lb per palm)	Least Significant Difference	
					5 %	1 %
Pretreatment*	200.7	200.7	200.7	200.7		
July, 1960 to June, 1964	151	244	258	274		
December, 1964	249	430†	399†	412†	149	217
July, 1965	270	425	422	372	159	232
May, 1966	163	234†	247	252	156	221
November, 1966	185	232	207†	213	98	143
May, 1967	218	305	317	332	143	208
Average December, 1964, to May, 1967	217	325	318	316		

*Average of June and December, 1958, counts.

†Indicates fertilizer application.

Table 2.—Potassium content of nut waters (milli-equivalents per litre)

Treatment	July, 1965	May, 1966	November, 1966
K0	20.5	14.7	23.4
K1	45.9	38.6	45.2
K2	52.9	44.7	42.7
K3	61.0	48.5	56.2

Table 3.—Average husked nut circumference and wet meat plus shell weights

Treatment	Circumference (inches)	Weights (lb)
May, 1966		
K0	13.90	1.11
K1	13.90	1.13
K2	13.97	1.24
K3	14.65	1.34
November, 1966		
K0	13.11	0.94
K1	12.92	0.89
K2	12.85	0.98
K3	13.41	1.01
May, 1967		
K0	12.84	
K1	12.63	
K2	13.19	
K3	13.19	

From June, 1964 onwards the relatively consistent differences in nut production between the three levels of fertilizer were not maintained. However, nut weights in May, 1966, and November, 1966, indicated differences between rates. Despite these differences results indicated that the lowest rate of fertilizer gave the most economic response while at the higher rates the net financial return diminished quickly.

Nut water potassium levels increased with increasing applications of fertilizer. At intervals of about 7, 17 and 23 months after the December, 1964 fertilizer, potassium levels varied according to the amount of fertilizer added. By November, 1966, the 2.5 lb application in May, 1966, had raised the potassium level of the K1 treatment above that of the 5 lb potassium chloride treatment (which had not been fertilized since December, 1964).

Measurements of nut characteristics hinted at fertilizer increasing size but samples were insufficiently large to warrant certainty. Copra cutters could not be kept out of the trial area prior to sampling so it is likely that truly representative samples were not obtained—cutters show a definite tendency to ignore small nuts and concentrate on the larger ones.

POTASSIUM METHOD OF APPLICATION TRIAL

Methods and Results

Charles and Douglas (1965) described this trial from its commencement in 1958 to June, 1964. This trial compared the effect of placement of fertilizer in a narrow band around the base of the palm with broadcasting over a wider area. Application frequencies were also studied.

Treatments were as follows:—

1. Control—no fertilizer.
2. Biennial application of 2 cwt of potassium chloride per acre, broadcast over a narrow band (a circle 6 ft to 10 ft in diameter around the base of each palm).
3. Biennial application of 2 cwt of potassium chloride per acre, broadcast over a broad band (a circle 20 to 24 ft in diameter around the base of each palm).
4. Annual application of 1 cwt of potassium chloride per acre, broadcast over a broad band).

Palms were over 40 years of age and in poor condition with many missing. A randomized block design with six replications was used, with plots nominally of 10 palms (5 x 2) separated by a common guard row. The trial was superimposed on the original cultivation trial in which there had been no treatment response (Charles 1959*b*). It was concluded in May, 1967.

Results after adjustment by covariance analysis are shown in *Table* 4. Figures from July, 1960 to June, 1964 are averaged as they had been previously published (Charles and Douglas 1965).

Discussion

The conclusions drawn by Charles and Douglas (1965) were confirmed. A significant yield response was shown to all fertilizer treatments and the results suggest that the biennial narrow band placement was less effective than the biennial broad band placement. Annual applications were certainly not superior to biennial ones—there is an indication that the reverse may be true. Biennial applications would be recommended provided they are not inferior to annual, because of the saving in application costs.

POTASSIUM-NPK-CULTIVATION TRIAL

Introduction

The possibility of responses to other nutrients on New Ireland soils shown to be deficient in potassium was examined. The use of a compound fertilizer (NPK), which incorporated potassium at the same rate as used in the sole potassium treatments, was included as a treatment.

It is the accepted practice in some coconut-growing countries to incorporate fertilizer into the soil, so cultivation after fertilizer application was included in the trial. There had been reports of palms in New Ireland responding favourably to cultivation so the possibility of this practice improving soil nutrient availability as well as the physical condition of the soil was noted. On the other hand there is a distinct possibility, especially in relatively shallow soils, that cultivation will prove harmful by damaging palm roots.

Fertilizer application over a circle 20 to 24 ft in diameter around the base of the palm had proved superior to applications over a smaller circle in the Potassium Method of Application Trial. It was decided to test whether broadcasting evenly throughout an area of palms might prove equally effective, as it was thought that planters might wish to apply fertilizer by a mechanical fertilizer spreader.

The following treatments were chosen:—

T1 = Control (untreated);

T2 = Cultivation;

T3 = 5 lb potassium chloride biennially;

T4 = 5 lb potassium chloride biennially with cultivation following application; and

T5 = 15 lb NPK biennially with cultivation following application.

The compound fertilizer had a $N : P_2O_5 : K_2O$ ratio of 13 : 13 : 21.

Cultivation consisted of a run up and a run back between each line of palms and the centre line of Leucaena shade with a Ferguson twin

Table 4.—**Potassium Method of Application Trial—average number of nuts per plot, adjusted on pretreatment yields**

Date	Control	Biennial Narrow Band	Biennial Broad Band	Annual Broad Band	Least Significant Difference 5 %	Least Significant Difference 1 %
Pretreatment*	163	163	163	163	....	....
July, 1960 to June, 1964	118	172	206	192	....	....
December, 1964	137	219†	270†	232†	37	51
July, 1965	128	186	267	196	50	69
May, 1966	74	151†	179†	190†	37	51
November, 1966	72	159	181	180	39	54
May, 1967	83	193	195	177	46	64
Average December, 1964 to May, 1967	99	182	218	195	....	....

*Average of seven counts between November, 1955, and November, 1958.

†Indicates fertilizer application.

disc plough set at 4 in. Difficulty was experienced because fairly heavy ground cover and occasional coral outcrops prevented the plough from penetrating evenly. However, the main aim of burying the fertilizer was achieved.

A randomized block design with four replications was used. Plots were nominally of 49 palms (7 x 7) with a common untreated guard row between plots. Only the inner 25 palms were used in assessments so there was at least 90 ft between a recorded palm and the limit of its neighbouring treatment.

Plots of treatments 3, 4 and 5 were split for application method. Palms in three adjacent lines of each plot were fertilized by broadcasting uniformly over that area while three lines on the other side of the plot were fertilized evenly over a circle about 20 ft in diameter around the base of the palms. The centre row of each fertilized plot had fertilizer distributed so as to correspond to the adjacent broadcasting treatment.

The soil of the trial area was a yellow-brown clay-loam soil somewhat variable in depth. The stand was producing poorly and showed symptoms typical of potassium deficiency. Responses would not have been restricted by senility as the stand was only about 30 years old. There were few misses. Palms were planted on a 30ft triangular spacing and were under-planted with cacao which was about two years old when the trial started. Leucaena shade was thinned during the course of the trial.

Pretreatment nut counts were made in May and November, 1963, and treatments were allocated at random but with a few plots interchanged so that the pretreatment mean yields were approximately equal for all treatments.

Cultivation and fertilizer applications were first carried out in November, 1963, and assessments were conducted thenceforth at about six-monthly intervals except between July, 1965, and May, 1966, when a visit was omitted.

Cultivation, with or without fertilizer, proved detrimental and was discontinued after only the one initial ploughing.

Fertilizer was re-applied in May, 1966 (about six months after it was due). Treatments were revised in February, 1968, and again in February, 1970.

By 1968, nut water analyses had indicated low sulphur levels, and as the appearance of the palms suggested the possibility of a sulphur deficiency, treatments were altered to include a potassium sulphate application. A comparison between annual and biennial potash application was also started. Treatments as revised in February, 1968, were:—

T1 = Control (untreated);
T2 = 2.5 lb potassium chloride applied annually;
T3 = 5 lb potassium chloride applied biennially;
T4 = 6 lb potassium sulphate applied biennially; and
T5 = 15 lb NPK applied biennially.

Fertilizer was broadcast over circles about 20 ft in diameter around the bases of palms as overall broadcasting had not proved superior and in the experiment situation involved more effort.

In February, 1970, plots were split, one side of each fertilized plot receiving a double application and the other the normal application. The middle row received an intermediate amount.

Nut counts were recorded at roughly six-monthly intervals (except for the interval between July, 1965, and May, 1966) and nut characteristics were recorded on occasions. Cacao girth was measured to see if interplanted cacao benefited.

Nut water samples were taken at regular intervals. Freshly fallen nuts were collected in as large numbers as possible and plots were sampled before any necessary fertilizer application.

Results

Nut counts, after very minor adjustments for pretreatment differences are shown in *Table* 5.

Estimates of annual production based on nut counts are shown in *Table* 6 and illustrated in the *Figure*. Estimates were made by combining two consecutive counts, except for 1965 when only one count was made—in this case the

Table 5.—Number of nuts per plot, adjusted on pretreatment yields

Date	T1	T2	T3	T4	T5	Least Significant Difference	
						5 %	1 %
Pretreatment*	341	341	341	341	341	....	....
June, 1964	436	453	530	552	494	124	175
December, 1964	463	412	585	560	548	165	232
July, 1965	384	241	588	477	471	95	134
May, 1966	341	255	370†	326†	430†	89	126
November, 1966	220	195	359	365	406	97	137
May, 1967	218	216	599	544	516	171	241
February, 1968	356	324†	889†	785†	763†	136	193
August, 1968	416	327	770	758	766	185	261
February, 1969	371	406†	594	703	669	146	206
August, 1969	223	398	510	586	476	87	123
February, 1970	184	399†	548†	607†	523†	55	77
TOTAL	3,612	3,626	6,342	6,263	6,062	....	....
Average June, 1964 to February, 1970	328.4	329.6	576.5	569.4	551.1	....	....

*Average of counts in June, 1963, and November, 1963.
†Indicates fertilizer application.

Table 6.—Estimated annual copra production (cwt) 1964 to 1969 bases on 6,000 nuts per ton of copra

Year	T1	T2	T3	T4	T5
1964	6.71	6.46	8.32	8.30	7.78
1965	5.73	3.60	8.78	7.12	7.03
1966	4.24	3.36	5.44	5.16	6.24
1967	4.29	4.03	11.11	9.92	9.55
1968	5.88	5.47	10.18	10.91	10.71
1969	3.04	5.95	7.90	8.91	7.46
Average	4.98	4.81	8.62	8.39	8.13

July, 1965, recording was doubled. It is estimated that about 6,000 nuts are required to produce one ton of copra. Actually the estimated production for a particular year was really production for the latter half of the year combined with that of the first part of the following year as counts estimate production for approximately the next six months.

Average nut circumferences and weights are shown in *Table* 7.

Table 8 compares methods of fertilizer placement.

Nut water potassium contents are shown in *Table* 9. Sulphur contents of nut waters were determined from May, 1967, onwards and are shown in *Table* 10.

Records of average cacao girth under the various treatments are shown in *Table* 11.

Discussion

Although differences were not statistically significant 7 and 13 months after initial fertilizer application, fertilized palms appeared to be carrying more nuts than control palms. As each nut count represents an estimation of production for the subsequent 6 months some response to fertilizer, in terms of actual copra production, could be expected as early as 12 months and certainly within 18 months of application. It is likely that early responses are due to a reduction in premature nutfall and increased fruit set. Additional responses later will come from increased frond and hence inflorescence production as well as increased fruit set.

Significant responses to potassium were revealed by a nut count 20 months after initial fertilizer application. A substantial increase in copra production could therefore be expected within two years of fertilizer use.

Cultivation depressed yields, no doubt through damage to the root systems of the palms. Unfertilized plots which had been ploughed at the end of 1963 produced consistently fewer nuts than control plots until 1969, a year after they had been fertilized with potassium chloride. There was an indication that cultivation adversely affected yields of fertilized plots as well (*Table* 6).

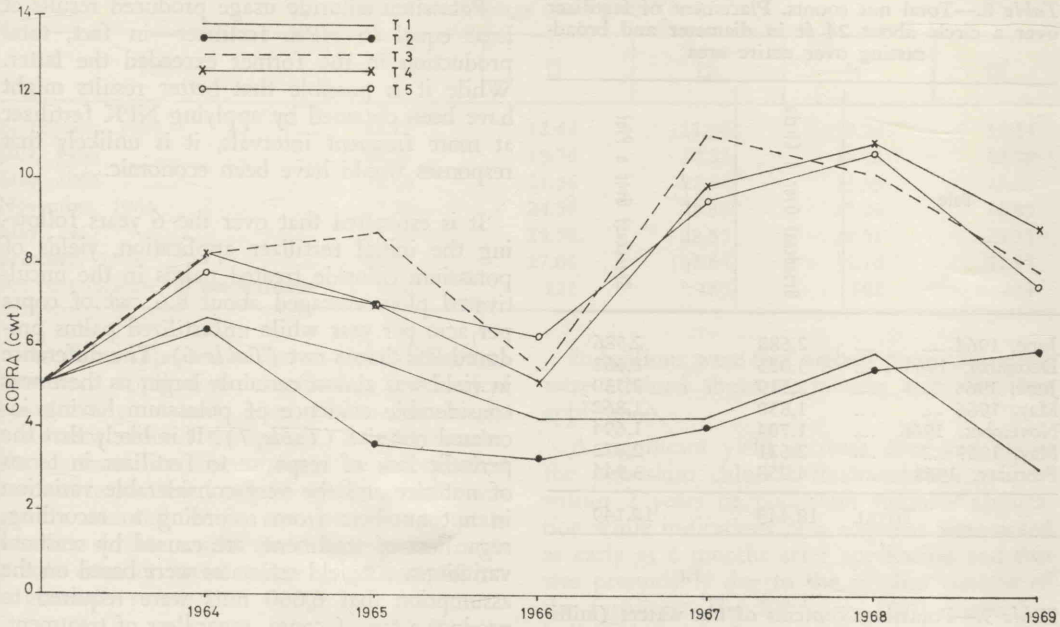

Figure.—Estimated annual copra production

Table 7.—Husked nut circumferences and weights of wet meat plus shell

Date	Weights (lb)					Circumferences (in)				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
May, 1963	1.05	1.06	0.96	0.04	0.95	....	....	....	....	....
November, 1963	1.00	0.96	0.98	0.99	0.98	....	....	....	....	....
June, 1964	0.93	0.93	0.71	1.04	0.93	....	....	....	....	....
July, 1965	....	....	....	....	....	13.11	13.09	14.11	13.90	14.15
May, 1966	0.87	0.87	0.89	0.87	0.82	12.61	12.55	11.47	11.81	11.99
November, 1966†	1.27	1.39	1.54	1.38	1.60	13.50	13.97	14.47	14.14	14.98
May, 1967	....	....	....	....	....	14.47	14.40	15.19	14.92	14.88
February, 1968	1.91*	1.98*	2.57*	2.30*	2.75*	14.07	13.78	14.61	15.42	14.59
August, 1968	1.16	1.16	1.27	1.22	1.24	13.92	14.21	14.85	14.46	14.73
February, 1969	1.05	1.16	1.14	1.08	1.07	14.04	14.48	14.37	13.64	13.97
August, 1969	1.05	1.08	1.33	1.25	1.31	13.78	14.13	15.17	14.49	15.01
February, 1970	1.13	1.14	1.31	1.24	1.37	13.83	14.35	14.87	14.61	14.63

†High figures due probably to faulty weighing equipment.

*Weight of husked nut (wet meat and shell plus nut water).

Table 8.—Total nut counts. Placement of fertilizer over a circle about 24 ft in diameter and broadcasting over entire area

Date	Broadcast Over a Circle	Broadcast Over a Plot
June, 1964	2,688	2,586
December, 1964	3,023	2,661
June, 1965	2,519	2,530
May, 1966	1,830	1,862
November, 1966	1,704	1,694
May, 1967	2,621	2,872
February, 1968	4,058	3,944
TOTAL	18,443	18,149

Table 9.—Potassium contents of nut waters (milli-equivalents per litre)

Date	T1	T2	T3	T4	T5
May, 1963	13	17	15	14	14
November, 1963	11	14	12*	12*	13*
June, 1964	12	12	20	14	22
July, 1965	11	13	25	21	26
May, 1966	13	13	21*	20*	20*
November, 1966	14	10	27	21	29
May, 1967	12	14	40	32	41
February, 1968	12	13*	33*	32*	32*
August, 1968	12	14	36	37	34
February, 1969	12	19*	35	34	38
August, 1969	11	19	28	28	33

*Indicates fertilizer application.

Table 10.—Sulphur contents of nut waters (parts per million)

Date	T1	T2	T3	T4	T5
May, 1967	12.0	11.5	8.8	13.5	4.3
February, 1968	5.0	9.4	4.3	4.4	5.3
August, 1968*	2.0	3.9	1.6	3.2	2.8
February, 1969	3.3	3.8	3.1	6.6	2.8
August, 1969	2.4	3.0	2.2	4.2	1.6

*Nut water samples had deteriorated before analysis and this may have affected results.

Potassium chloride usage produced results at least equal to NPK fertilizer—in fact, total production in the former exceeded the latter. While it is possible that better results might have been obtained by applying NPK fertilizer at more frequent intervals, it is unlikely that responses would have been economic.

It is estimated that over the 6 years following the initial fertilizer application, yields of potassium chloride treated palms in the uncultivated plots averaged about 8.6 cwt of copra per acre per year while unfertilized palms produced less than 5 cwt (*Table* 6). The difference in yield was almost certainly larger as there was considerable evidence of potassium having increased nut size (*Table* 7). It is likely that the periodic lack of response to fertilizer in terms of nut size and the very considerable variation in nut numbers from recording to recording, regardless of treatment, are caused by seasonal variations. As yield estimates were based on the assumption that 6,000 nuts were required to produce a ton of copra, regardless of treatment, over-estimates of unfertilized palm yields are likely. Subjective assessments also suggested that unfertilized palms were likely to shed more unripe nuts than fertilized ones.

Even on an average additional return of about 3.6 cwt of copra per acre per year, fertilizing with potassium chloride was worthwhile as it produced an estimated net profit of about $A12 per acre. This estimate is based on a copra price of $A150 per ton, fertilizer together with application cost priced at $A100 per ton and a production cost of $A50 per ton of copra (excluding fertilizer). It is apparent, as well, that once fertilizer has been used for some time responses would be considerably higher than those from the first few years after initial fertilizer application. Responses to potassium chloride from 1964 to 1969 were 1.61, 3.05, 1.20, 6.82, 4.30, 4.86 cwt per acre respectively. The average response for the first three years was 1.95 cwt as compared with 5.33 cwt for the subsequent three years. Taking this and the probable over-estimation of production from unfertilized palms into account a response well in excess of 3.6 cwt of copra per acre per year could be expected once fertilizer had been used for some time.

Table 11.—Average cacao girth (cm)

Date	T1	T2	T3	T4	T5
November, 1963	12.15	12.44	11.94	12.28	13.34
July, 1965	15.71	15.76	17.55	18.38	18.99
May, 1966	19.36	21.56	22.44	23.39	23.80
November, 1966	22.26	24.59	25.36	27.26	26.85
May, 1967	25.12	25.50	28.55	29.51	29.13
February, 1968	26.77	27.61	31.64	32.16	31.35
Per cent increase on pretreatment	120	122	165	162	139

As there appeared to be no yield differences between application methods, mechanical broadcasting should give similar results to placement around the palms. As this conclusion is based on results from an interplanted coconut-cacao stand where grass growth was greatly reduced it is not possible to state whether similar results could be expected from a sole coconut stand where grass competition is generally severe.

Potassium fertilizer increased potassium nut water levels considerably. Levels generally remained suboptimal (40 to 45 p.p.m. is considered optimal) and had not reached those encountered in the Potassium Rate of Application Trial. It is noted, however, that analyses in the rate of application trial were first conducted more than 6 years after initial fertilizing while the current trial has only just reached this stage. Higher fertilizer rates have been superimposed, but it is doubtful, on the basis of indications from the Rate of Potassium Application Trial, whether they will prove economical.

A fairly consistent pattern of potassium uptake was noted. Seven months after the initial application potassium levels in nut waters had risen in fertilized palms indicating that potassium had been taken up and translocated to well-developed nuts. Levels 18 months after application were higher but still suboptimal—it is possible that levels may have reached their maximum at some intermediate time. Levels 30 months after application and before re-application were lower than at 18 months. Subsequent fertilizer applications resulted in levels considerably higher than after the first application.

It is probable that much of the potassium was initially used in foliar development.

Indications were that highest potassium levels were attained about 12 months after fertilizer application.

A significant yield increase over and above the potassium chloride treatment was evident within 2 years of potassium sulphate application while indications of a response were noted as early as 6 months after application and this was presumably due to the sulphur content of the fertilizer. The February, 1970, inspection indicated that palms supplied with potassium sulphate were yielding the equivalent of 9 cwt of copra per acre per year while those receiving potassium chloride were producing about 8 cwt. The difference was statistically significant at the 5 per cent level. The potassium sulphate treated palms had noticeably greener foliage.

This result is quite important as low sulphur levels in nut waters are common on the east coast of New Ireland. Sulphur may well be a fairly widespread factor limiting production especially where the previously overriding potassium deficiency has been corrected with potassium chloride. A biennial application of 6 lb of potassium sulphate per palm is suggested in areas where fairly obvious deficiency symptoms remain once potassium has been added or where chemical analyses indicate low plant sulphur levels.

Yield responses to sulphur applications in Papua New Guinea have usually been accompanied by rapid rises both in foliar and nut water sulphur contents. In the New Ireland trial, however, nut water contents have to date only risen very slightly despite yield responses. This is the more puzzling because a small pilot trial established on the same plantation showed rapid rises in nut water sulphur levels after

potassium and sulphur applications. Pretreatment levels in this case were low to marginal and sulphur was supplied as elemental sulphur.

Girth measurements of interplanted cacao (*Table* 11) indicated a definite response to fertilizer. These measurements failed to reveal any additional response which could be attributed to the nitrogen or phosphorus (or both) supplied in the NPK treatment although the possibility of a production response cannot be excluded. The relatively heavy shade provided by coconuts and Leucaena may have limited responses to nitrogen. An interval of two years between applications was probably too great for nitrogen status to be appreciably improved.

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REFERENCES

BASEDEN, S. C. AND SOUTHERN, P. J. (1959). Evidence of potassium deficiency in coconut palms on coral-derived soils in New Ireland from analyses of nut waters, husks, fronds and soils. *Papua New Guin. agric. J.*, 11 : 101-115.

CHARLES, A. E. (1959*a*). Coconut experiment work in New Ireland. I. Field survey and introduction. *Papua New Guin. agric. J.*, 11 : 89-94.

CHARLES, A. E. (1959*b*). Coconut experiment work in New Ireland II. Progress report on field trials. *Papua New Guin. agric. J.*, 11 : 116-120.

CHARLES, A. E. AND DOUGLAS, L. A. (1965). Coconut experiment work in New Ireland. III.—Progress of fertilizer trials 1958-1964. *Papua New Guin. agric. J.*, 17 : 76-86.

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