Coconut Experiment Work in New Ireland. III.—Progress of Fertilizer Trials 1958-1964.

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INTRODUCTION.

In an earlier paper (Charles 1959 a) a description was given of the condition of coconut palms on the east coast of New Ireland where extensive production decline had occurred over the previous ten to twenty years. A survey had indicated that the condition of the palms was related to variations in the type of soil developed from coral parent material.

Comprehensive fertilizer trials were laid down on the two most important soil types, yellow-brown clay-loams and red-brown clay-loams. Yield records up to May, 1958, showed a response to potassium on the yellow-brown clay-loam, and no significant response to any element tested on the red-brown clay-loam (Charles 1959 b).

Further progress in these trials, and in new trials initiated following the evidence of potassium response, will be reported in this paper.

COMPREHENSIVE FERTILIZER TRIALS. YELLOW-BROWN CLAY-LOAM.

Methods and Results.

This commenced as a comprehensive fertilizer trial in November, 1955, when the first fertilizer applications were made. Similar fertilizer dressings were repeated in November, 1957, with the exception of sulphate of ammonia, which was applied every six months between November, 1955, and May, 1959.

The only significant response recorded was to potassium. From May, 1957, to June, 1960, palms fertilized with potassium showed an increase of 12 to 14 nuts per year over control palms. This increase represented a return of 1.8 tons of copra for 1 ton of fertilizer applied.

By 1959 it appeared that the response to potassium had reached a steady level, and the possibility that any further deficiencies would become evident was remote. Hence from November, 1959, the applications of all fertilizers except potassium were discontinued. Also, this fertilizer was now applied to the group of palms which had previously received molybdenum (to which there had been no response). This new arrangement gave four groups of 32 palms each, with respect to the application of potassium chloride :—

(*a*) Palms fertilized continuously since 1955 ;

(*b*) Palms fertilized in 1955 and 1957, but not after 1957 ;

(*c*) Palms fertilized from November, 1959, but not previously ; and

(*d*) Palms not fertilized at all.

A further observation was that fertilized palms, though improved in appearance relative to the controls, were in 1959 still far from a condition of full vigour. It was therefore decided to increase the rate of potassium chloride application to 8 lb. per palm every two years.

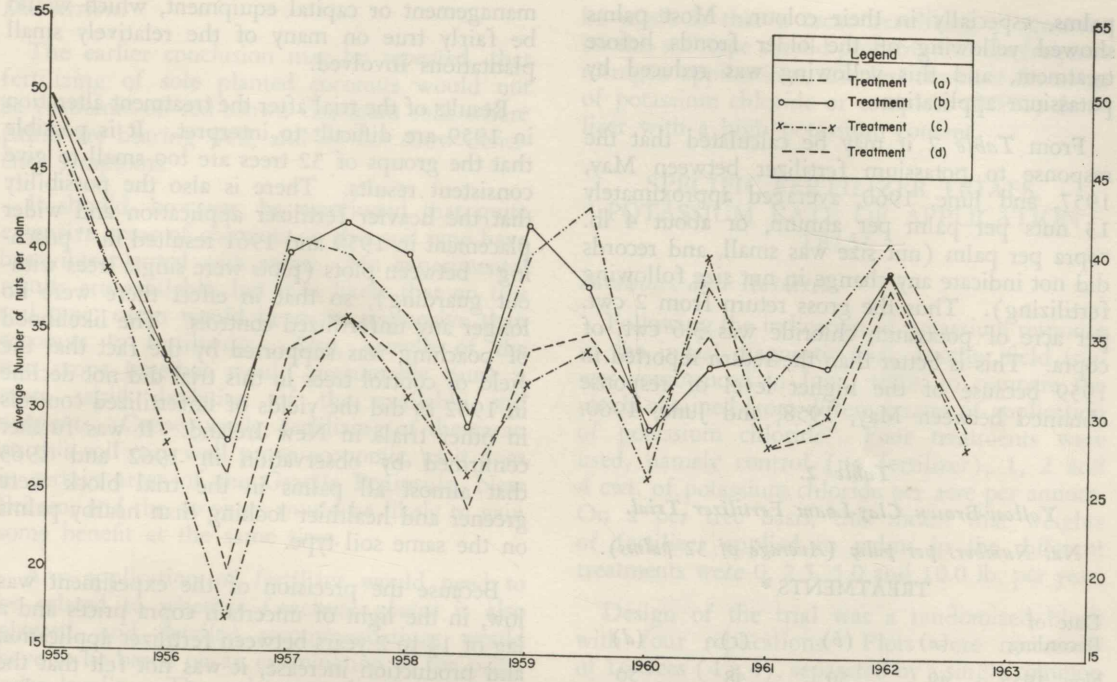

Figure 1.—Yellow-Brown Clay-Loam Fertilizer Trial. Estimates of nut numbers at six monthly intervals. For details of treatments, see Table 1.

Fertilizer was applied at this rate in November, 1959, and November, 1961. The 1959 application, being larger than earlier applications, was spread in a circle extending further from the bases of the palms. By 1961 there was evidence from another trial that wide placement was better than close placement, and the fertilizer was broadcast over a larger area still, extending eight to ten feet from the palm bases.

A summary of the quantities of potassium chloride which have been applied to the four groups of palms, is given in *Table* 1.

Table 1.

Yellow-Brown Clay-Loam Fertilizer Trial.

Weights of Potasium Chloride applied in the four Treatments.

	Nov. 1955	Nov. 1957	Nov. 1959	Nov. 1961	Jan. 1963
Treatment (*a*)	4.5 lb.	4.5 lb.	8 lb.	8 lb.	8 lb.
Treatment (*b*)	4.5 lb.	4.5 lb.	—	—	—
Treatment (*c*)	—	—	8 lb.	8 lb.	8 lb.
Treatment (*d*)	—	—	—	—	—

Yield estimates for the four groups between November, 1955, and May, 1963, are shown in *Table* 2 and *Figure* 1.

As explained in the earlier paper (Charles 1959 b) yield estimates were based on six monthly counts of older immature nuts on the palms. In the earliest counts, a larger proportion of the immature nuts was counted than in later years. Hence the decline in yield over the period of recording is exaggerated. From 1958 onwards, the technique of counting was stabilized, and the count at each date would represent a fairly accurate estimate of the number of nuts to fall in the following six months.

Discussion.

Results in this trial prior to the change in treatments in 1959 were quite clear. *Figure* 1 shows the definite yield response which occurred after application of potassium chloride. Analysis showed this response to be statistically significant. This yield increase was accompanied by an improvement in the appearance of fertilized

palms, especially in their colour. Most palms showed yellowing of the older fronds before treatment, and this yellowing was reduced by potassium application.

From *Table* 2 it may be calculated that the response to potassium fertilizer between May, 1957, and June, 1960, averaged approximately 13 nuts per palm per annum, or about 4 lb. copra per palm (nut size was small, and records did not indicate any change in nut size following fertilizing). Thus the gross return from 2 cwt. per acre of potassium chloride was 3.6 cwt. of copra. This is better than the return reported in 1959 because of the higher level of response obtained between May, 1958, and June, 1960.

Table 2.

Yellow-Brown Clay-Loam Fertilizer Trial.

Nut Numbers per palm (Average of 32 palms).

Date of Recording	TREATMENTS * (*a*)	(*b*)	(*c*)	(*d*)
Nov. 1955	49	50	48	50
May 1956	39	41	39	43
Nov. 1956	33	33	28	33
May 1957	26	28	17	20
Nov. 1957	41	40	30	34
May 1958	40	42	36	36
Nov. 1958	36	40	31	33
May 1959	30	29	26	24
Nov. 1959	40	42	32	34
May 1960	43	38	34	35
Nov. 1960	28	29	26	30
May 1961	38	33	40	35
Nov. 1961	32	34	28	28
May 1962	36	33	30	29
Nov. 1962	41	39	39	38
May 1963	32	30	28	29

* For details see *Table* 1.

At a copra price of £60 per ton, the gross return from one ton of fertilizer would be approximately £108. At fertilizer cost of £45 per ton and an estimated cost of £12 per ton for harvesting, transporting, and drying the copra, the extra cost involved would be £75. Net return would be approximately £33 for each ton of fertilizer applied. This is the most favourable estimate of return, and assumes that fertilizer could be transported from wharf to plantation at no extra cost as back-loading on vehicles carrying copra. It also assumes that the increased production could be processed without increasing management or capital equipment, which would be fairly true on many of the relatively small plantations involved.

Results of the trial after the treatment alteration in 1959 are difficult to interpret. It is possible that the groups of 32 trees are too small to give consistent results. There is also the possibility that the heavier fertilizer application and wider placement in 1959 and 1961 resulted in " poaching " between plots (plots were single trees without guarding), so that in effect there were no longer any unfertilized controls. The likelihood of poaching was supported by the fact that the yield of control trees in this trial did not decline in 1962 as did the yields of unfertilized controls in other trials in New Ireland. It was further confirmed by observation in 1962 and 1963 that almost all palms in the trial block were greener and healthier looking than nearby palms on the same soil type.

Because the precision of the experiment was low, in the light of uncertain copra prices and a lag of 1½ to 2 years between fertilizer application and production increase, it was not felt that the results of this experiment alone warranted a general recommendation for fertilizer use on this soil type. Nevertheless the trial was of value in diagnosing the primary soil deficiency and serving as a guide to further experiment. The design was a satisfactory compromise in that it permitted reasonable replication of a large number of treatments without having to use an unmanageable number of palms.

RED-BROWN CLAY-LOAM.

Method and Results.

As reported in the earlier paper (Charles, 1959 b) no response of significant magnitude was evident up to May, 1958. Fertilizer applications were repeated, and nut counts were continued until November, 1959 with nothing more substantial than a hint of response to nitrogen in May, 1959. A nut count which was carried out in November, 1959, indicated that this response, if real, was not sustained. Another nut count made in November, 1960, again failed to show that a response was occurring to any treatment and therefore the experiment was discontinued.

Discussion.

The earlier conclusion may be repeated, that fertilizing of sole planted coconuts would not be economic on red-brown clay-loam soils where palms are bearing well, and do not show deficiency symptoms.

It should, however, be mentioned that quite extensive areas of coconuts on this soil type have been interplanted with cacao. No experimental results are available, but it is likely that on this soil type, cacao would be more responsive than coconuts to fertilizing. Also, growth of the two crops together would presumably cause a more rapid depletion of the available soil nutrients. Consequently, fertilizing of the cacao on this soil may well prove economic, as it does in certain areas of the Gazelle Peninsula, New Britain, and the coconuts would be likely to gain some benefit at the same time.

Any application of fertilizer would need to be related to whether *Leucaena glauca* is also planted, and detailed recommendations would have to be based on an examination of the particular locality. The only generalization that can be made is that a cacao fertilizing programme on this soil type should probably include frequent nitrogen applications, and less frequent dressings of potassium chloride or complete (NPK) fertilizer with a high potassium content.

SPECIFIC FERTILIZER TRIALS. POTASSIUM RATE OF APPLICATION TRIAL.

Methods and Results.

Following the indication of potassium response in the initial diagnostic trial, another field trial was commenced in June, 1958, to compare the yields obtained from different rates of application of potassium chloride. Four treatments were used, namely control (no fertilizer), 1, 2 and 4 cwt. of potassium chloride per acre per annum. On a per tree basis, this meant that weights of fertilizer applied to palms in the different treatments were 0, 2.5, 5.0 and 10.0 lb. per year.

Design of the trial was a randomized block with four replications. Plots were nominally of 16 trees (4 x 4), separated by a single common untreated guard row. Fertilizer was broadcast

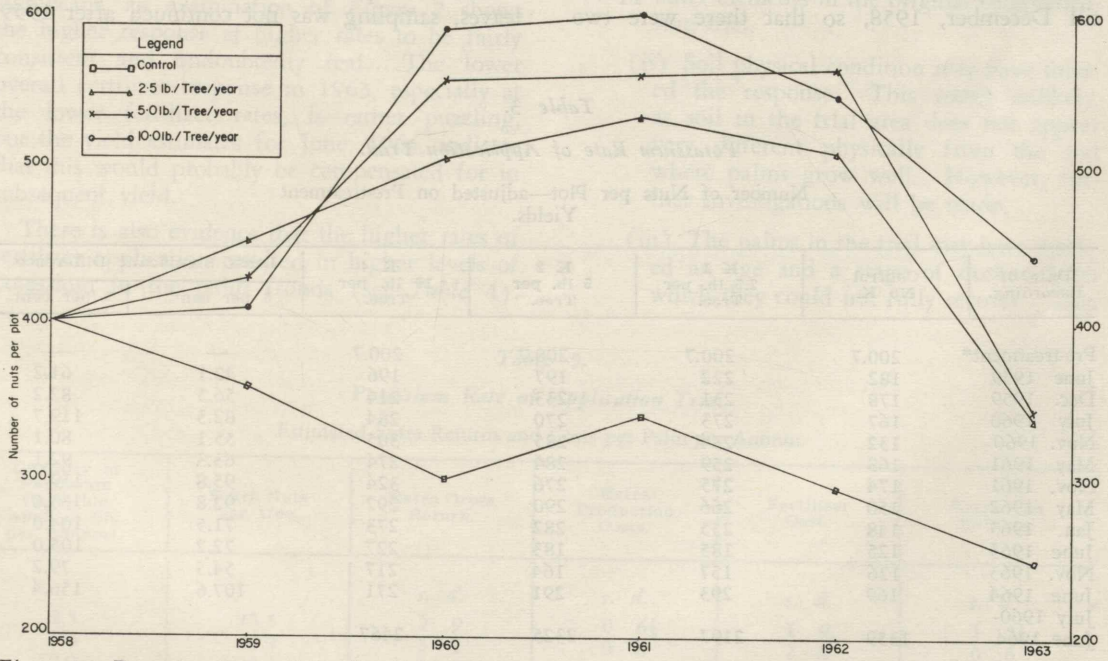

Figure 2.—Potassium Rate of Application Trial. Estimated nut numbers, adjusted for pre-treatment yields (May and November counts combined).

over a circle 20 to 24 feet in diameter around the base of each palm. Grass and cover crop were cut back prior to fertilizing.

The site selected was a typical yellow-brown clay-loam soil, where the growth of palms had been very variable. Palms were over 40 years old at the date of commencement of the trial, and in general were of poor appearance.

Many palms were missing in the stand, and because of this the actual number of palms in the plots averaged only 12. By 1963 this average had decreased to 11, through the death of a further 12 palms. The number of missing palms in the stand was even greater than the 25 per cent. indicated by the plot average, as gaps had to be left between some plots and some replicates where large groups of palms were missing.

Before the trial commenced, *Leucaena glauca* was planted in the coconut lines. Cacao was planted under this shade in 1958. The growth of the cacao trees has been very variable.

The trial was marked out and nut counts commenced in June, 1958. Fertilizer was not applied till December, 1958, so that there were two pre-treatment yield estimates. Fertilizing has been repeated in November or December each year.

There was very great variability between plot yields, as is indicated by pre-treatment totals, where the total nut number for the poorest plot was 71, while for the best plot the total was 440. Variation was great within, as well as between, replicates, and the four treatments started off at different levels. Average numbers of nuts per palm in the pre-treatment counts were : Control—17.3 ; K1—15.0 ; K2—15.1 ; K4—22.6. Results have therefore been adjusted by covariance analysis, and adjusted yield estimates are shown in *Table* 3. To reduce random fluctuations, a further analysis was made on annual yield figures (combined May and November counts), and the adjusted yields so obtained are shown in *Figure* 2.

In addition to estimates of yield, in the first two years of the experiment leaf samples were taken from one tree in each plot for analysis of the potassium content. A summary of the results of these analyses is shown in *Table* 4. Because of practical difficulties in collecting leaves, sampling was not continued after 1959.

Table 3.

Potassium Rate of Application Trial.

Number of Nuts per Plot—adjusted on Pre-treatment Yields.

Date of Recording.	Control No K.	K 1 2.5 lb. per Tree.	K 2 5 lb. per Tree.	K 4 10 lb. per Tree.	Least Significant Difference	
					5 per cent.	1 per cent.
Pre-treatment*	200.7	200.7	200.7	200.7	—	—
June 1959	182	222	197	196	42.1	61.2
Dec. 1959	178	231	233	214	56.5	82.2
July 1960	167	273	270	284	82.3	119.7
Nov. 1960	132	234	285	305	55.1	80.1
May 1961	168	259	284	274	63.3	92.1
Nov. 1961	174	275	276	324	95.8	139.3
May 1962	150	266	290	292	92.8	135.0
Jan. 1963	148	255	282	273	71.5	104.0
June 1963	125	185	183	227	72.2	105.0
Nov. 1963	126	157	164	217	54.5	79.2
June 1964	169	293	291	271	107.6	156.4
July 1960-June 1964	1359	2197	2325	2467	—	—

* Average of June and December, 1958, counts.

Table 4.

Potassium Rate of Application Trial.

Quantity of Potassium Chloride applied (lb. per annum).	Percent Potassium in Palm Fronds.		
	December, 1958.	June, 1959.	December, 1959.
0	0.62	0.68	0.70
2.5	0.67	1.02	1.09
5.0	0.66	1.01	1.32
10.0	0.64	0.96	1.69

To assess the return from each treatment the average annual yield response has been calculated for the period June, 1960, to December, 1963 (see *Table* 5). Estimates of gross return and costs shown in *Table* 5 are based on nut size of 6,800 nuts per ton of copra, and as before, on a price of £60 per ton for copra, a cost of £45 per ton for fertilizer and production cost of £12 per ton.

Discussion.

From the results shown in *Table* 3 it can be seen that yields from the three positive levels of fertilizer were all significantly higher than control yields. Although differences between these three levels were not generally statistically significant, an examination of *Figure* 2 shows the higher response at higher rates to be fairly consistent and undoubtedly real. The lower overall fertilizer response in 1963, especially at the lower fertilizer rates, is rather puzzling, but the yield estimates for June, 1964, indicate that this would probably be compensated for in subsequent yield.

There is also evidence that the higher rates of fertilizer application resulted in higher levels of potassium in the palm fronds (see *Table* 4). By twelve months after the initial application, foliar potassium levels were more or less proportional to the amount of fertilizer added.

The most important conclusion to be drawn from the trial is that the lowest rate of fertilizer (2.5 lb. per palm of potassium chloride) gave the most economic response, and at higher rates the net return diminished rapidly. On the basis of these results, application rates greater than 1 cwt. per acre per annum could not be recommended.

A curious feature of the trial was that even when palms received a large and uneconomic application of fertilizer each year they were not brought to anything like a condition of full health, as indicated by the general appearance of the palms and the yields obtained from them.

Possible explanations of this are :—

(i) The soil may be low in nutrients other than potassium, and these become limiting once potassium has been supplied. This seems unlikely in view of the absence of any interaction between potassium and other elements in the original comprehensive trial.

(ii) Soil physical condition may have limited the response. This seems unlikely, as soil in the trial area does not appear very different physically from the soil where palms grow well. However, further investigations will be made.

(iii) The palms in the trial may have reached an age and a stage of decline from which they could not fully recover. This

Table 5.

Potassium Rate of Application Trial.

Estimated Extra Returns and Costs per Palm per Annum.

Quantity of Potassium Choloride applied (lb. per annum).	Extra Nuts per tree.	Extra Gross Return.	Extra Production Costs.	Fertilizer Cost.	Extra Net Returns.
		s. d.	*s. d.*	*s. d.*	*s. d.*
2.5	15.5	2 9	0 6½	1 0	1 2½
5.0	17.9	3 2	0 8	2 0	0 6
10.0	20.5	3 7	0 9	4 0	—1 2

was probably an important factor, as the palms were in many cases very debilitated and all were quite old.

(iv) The method of application may not have been satisfactory. While it is standard practice in some countries for fertilizer to be turned into the soil in some way, there seems no obvious reason why this should prove more efficient than surface broadcasting, under local conditions where, even in the absence of rain, dew is heavy enough to dissolve the fertilizer within a few days and carry it into the soil.

To investigate the two last, a new trial has been commenced on younger palms, including a cultivation treatment at the time of fertilizer application.

Results of a long term fertilizer experiment in Ceylon (Eden, Gower and Salgado, 1963) are of considerable interest in respect of the influence of age and condition on palm responsiveness to fertilizer. In this trial, in the first 15 years there was a marked decline in yield of unfertilized control palms, while fertilized palms maintained their yield. After 15 years the control palms were fertilized, but although this arrested the decline in yield it did not restore them to normal health. This may indicate that the effects of potassium deficiency in coconuts are to some extent irreversible, and the subject is worthy of further investigation.

POTASSIUM METHOD OF APPLICATION TRIAL.

Methods and Results.

In the original diagnostic trials, the fertilizer was placed in a narrow band extending only three to five feet from the base of the palms, as a precaution against inter-plot "poaching". It was observed that this concentrated fertilizing caused severe burning of grass and cover crop species, and it was surmised that some burning of palm roots might occur, possibly inhibiting fertilizer uptake.

It was therefore desired to compare the narrow placement with broadcasting over a larger area. Also, it was thought desirable to study frequency of application, since leaching rate is high, and two-yearly applications may not be frequent enough.

A trial was therefore laid down with four treatments, as outlined below :—

1. Control—no fertilizer.
2. Biennial application of 2 cwt. of potassium chloride per acre, broadcast over a narrow band (a circle 6 to 10 ft. in diameter around the base of each palm, as in the original diagnostic trial).
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.

Design was a randomized block with six replications. Plots were nominally 10 trees (5 x 2) separated by a common untreated guard row. The trial was superimposed on the original cultivation trial, in which there had been no treatment responses (Charles, 1959 b). Fertilizer treatments were rearranged, where necessary after randomization, so that all were represented equally on the old cultivation treatments. Palms were over 40 years of age and in poor condition, with many missing. Actual numbers of trees per plot averaged only eight, and out of an original 196 there were six deaths between 1958 and 1963.

Nut counts on these palms had been maintained since November, 1955. The first fertilizer applications were made in November, 1958, and these were repeated annually or biennially as required.

As in the Rate of Application Trial, there was high variability between the plots, although there was not as great a difference between the initial yields of the four treatments. In the pre-treatment period, 1956-1958, plot yields ranged from 56 to 277 nuts ; average numbers of nuts per tree were approximately 20, 23, 16 and 22 for treatments 1, 2, 3 and 4, respectively.

Results have been adjusted by covariance analyses, and these adjusted yield estimates are shown in *Table* 6. Similar covariance analyses have been carried out on annual yields, and the adjusted figures are shown geographically in *Figure* 3.

Table 6.

Potassium Method of Application Trial.

Number of Nuts per Plot—adjusted on Pre-treatment Yields.

Time of Recording.	Treat. 1.	Treat. 2.	Treat. 3.	Treat. 4.	Least Significant Difference	
					5 per cent.	1 per cent.
Pre-treatment *	163	163	163	163	—	—
May 1959	151	155	166	168	33.4	46.3
Dec. 1959	136	154	179	183	45.8	63.5
July 1960	127	174	201	176	36.4	50.5
Nov. 1960	135	219	223	219	46.6	64.5
May 1961	129	181	219	216	49.8	69.1
Nov. 1961	140	155	192	195	41.5	57.6
May 1962	118	139	188	175	28.0	38.9
Jan. 1963	118	177	210	158	38.7	53.3
June 1963	90	154	203	179	38.3	53.2
Nov. 1963	97	161	201	190	44.5	61.8
June 1964	106	192	216	224	61.9	85.9

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

Discussion.

While all fertilizer treatments showed a significant yield response, results shown in *Table* 6 and *Figure* 3 strongly suggest that the biennial narrow band placement (Treatment 2) was less effective than the biennial broad band placement (Treatment 3). There was no indication that annual application was superior to biennial application when both were spread over a wide band, and in fact the biennial treatment may have been more effective than annual treatment.

The apparent difference in response, when the same weights of fertilizer were applied, may perhaps be explained in terms of a concentration effect concerned with fertilizer application. Where the concentration is too great, roots may be damaged, and uptake slowed down. Thus greater losses through leaching might occur. Where the concentration is too low, as perhaps was the case with the annual application, there may be significant losses to competing grass and cover crop.

The yield response obtained to the annual application of 1 cwt. per acre of potassium chloride in this experiment fully supports the results obtained for the similar treatment in the Rate of Application Trial. In this trial, the average annual yield increase was 17.4 nuts per palm, while in the rates trial it was 15.5 nuts per palm, a small difference in relation to the precision of the two trials.

The results of this trial indicate that biennial fertilizer application is as effective as annual, while all the trials described combine to indicate that a worthwhile profit may be expected from the application of potassium chloride at the rate of 4 to 5 lb. per palm every second year, on yellow-brown clay-loam soils.

FERTILIZER TRIAL WITH SEEDLINGS.

Method and Results.

This trial was superimposed on a Replanting Trial (to be discussed fully in a later publication) in New Ireland. The soil type was a yellow-brown clay-loam, but the mature palms were better than average for this soil.

For a measure of potassium response, each of the twelve plots of the replanting trial was split, and fertilizer was applied to seedlings in one half while the other half was left as a control. Measurements were made on 18 seedlings in each sub-plot.

The seedlings were transplanted in January, 1959, after about six months in the nursery. Potassium chloride was applied to the treated plots at the rates given in *Table* 7. The fertilizer was broadcast over a circle around the base of each seedling, the diameter of the circle being increased from about three feet in the first year to about 10 feet in the fourth year.

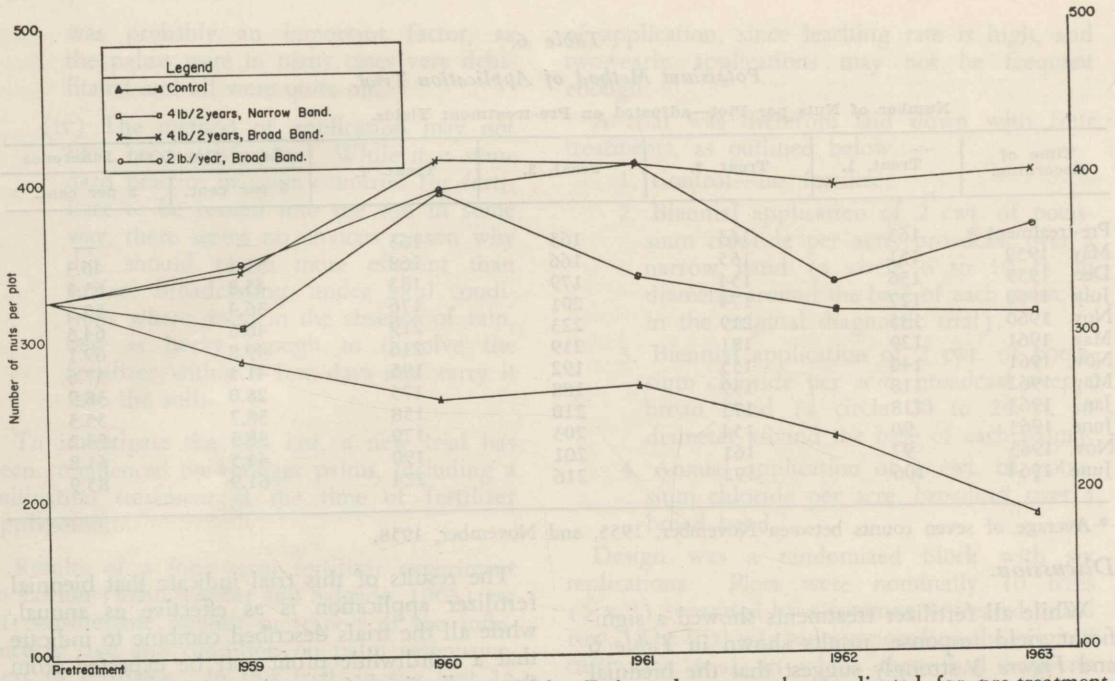

Figure 3.—Potassium Method of Application Trial. Estimated nut numbers, adjusted for pre-treatment yields (May and November counts combined).

Table 7.

Fertilizer Trial with Seedlings.

Potassium chloride applications.

Date of Application.	Quantity Applied per Seedling.
June, 1959	4 oz.
December, 1959	6 oz.
December, 1960	8 oz.
December, 1961	8 to 16 oz. according to seedling size.

Unfortunately it became evident as the trial progressed that it was sited in a bad locality. It was on the boundary of the plantation, close to a swamp, and as the seedlings reached a susceptible size (beginning in 1961) they were severely damaged by dynastid beetles (*Scapanes* sp.) followed later by palm weevils (*Rhynchophorus* sp.). Because of such damage, and in the interests of the Replanting Trial as a whole, it was decided in June, 1962, to discontinue the fertilizer trial as such and to apply potassium to all surviving seedlings and replants.

Leaf samples for chemical analysis were collected at regular intervals. The sample taken consisted of two central leaflets from the youngest fully opened frond of six seedlings in each sub-plot. Results of such analyses are given in *Table* 8.

Growth measurements were made on the seedlings at six-monthly intervals. Leaf production, leaflet weight and seedling height were taken as criteria on which to base growth comparisons. In this paper, results for these measurements

are given only for the period from transplanting to May, 1961, when damage to the seedlings was not excessive. After this date, records are considered to be unreliable, especially as dynastids showed a preference for the more vigorous fertilized seedlings (as discussed below).

Table 8.

Fertilizer Trial with Seedlings.

Potassium Content of Leaves (averages from 12 sub-plots).

Sampling Date.	Treatment.	
	No K.	K.
	per cent.	per cent.
December, 1959	0.98	1.79
December, 1960	0.99	1.65
December, 1961	1.18	1.68

The mean number of leaves produced by relatively undamaged seedlings, from transplanting to May, 1961, is given in *Table* 9. The mean weights of leaflets sampled in May, 1961, are also given in this table.

Table 9.

Fertilizer Trial with Seedlings.

Mean Number of Leaves Produced and Mean Weights of Leaflets (averages from 12 sub-plots).

Treatment.	Mean No. Leaves June, 1959-May, 1961.	Mean Weight of Leaflets May, 1961.
No K	13.4	7.2 gm.
K	14.3	11.8 gm.

The "seedling height" originally recorded was the distance from the ground to the tip of the tallest leaf, when this leaf was straightened out. However, in May, 1961, many seedlings were too tall for this technique to be carried out satisfactorily, and so the height was recorded by standing a scale beside the leaf without straightening it. The average heights are shown in *Figure* 4. In interpreting this histogram it is necessary to remember the change in method of measurement in May, 1961. Whereas one would expect the palms to increase rapidly in height after eighteen months in the field, this is not indicated in *Figure* 4, due to the alteration in technique.

Discussion.

Results given for potassium content and mean weight of leaflets (see *Tables* 8 and 9) and seedling height (see *Figure* 4) indicate that seedlings growing on yellow-brown clay-loam benefit substantially from applications of potassium fertilizer. Figures given in *Table* 9 suggest that the application of fertilizer did not significantly affect the rate of leaf production by seedlings during the period June, 1959, to May, 1961. Therefore, it seems that the increased rate of tissue production which resulted from the improvement in potassium status of fertilized seedlings was reflected mainly in the production of larger leaves.

From *Figure* 4, it can be seen that in May, 1961, at 2.5 years of age, fertilized seedlings were 30 per cent. taller than were controls. But for dynastid beetle damage, this response would undoubtedly have been greater, as fertilized palms were more severely affected than were controls. In November, 1961, numbers of beetle damaged seedlings amounted to 5 per cent. of the total in the control sub-plots and 8 per cent. in fertilized. The difference between treatments was even more marked in June, 1962, when the percentages were 6 and 15, respectively. This is not thought to be a direct effect of the fertilizer, but simply a preference on the part of the beetles for large seedlings. This suggestion is supported by the fact that the only plot where damage was substantially greater on control than on fertilized seedlings was an exceptional plot where control seedlings were larger than fertilized.

Considering results of this trial in conjunction with the trials on mature palms, a general recommendation can confidently be made for potassic fertilizing of coconut seedlings planted on yellow-brown clay-loam soils. In fact, it would be unwise to plant on this soil type without fertilizing.

The rate of application should be related to the size of the seedlings, progressing from 8 oz. per seedling in the first year after transplanting up to 4 lb. every two years at maturity. In the

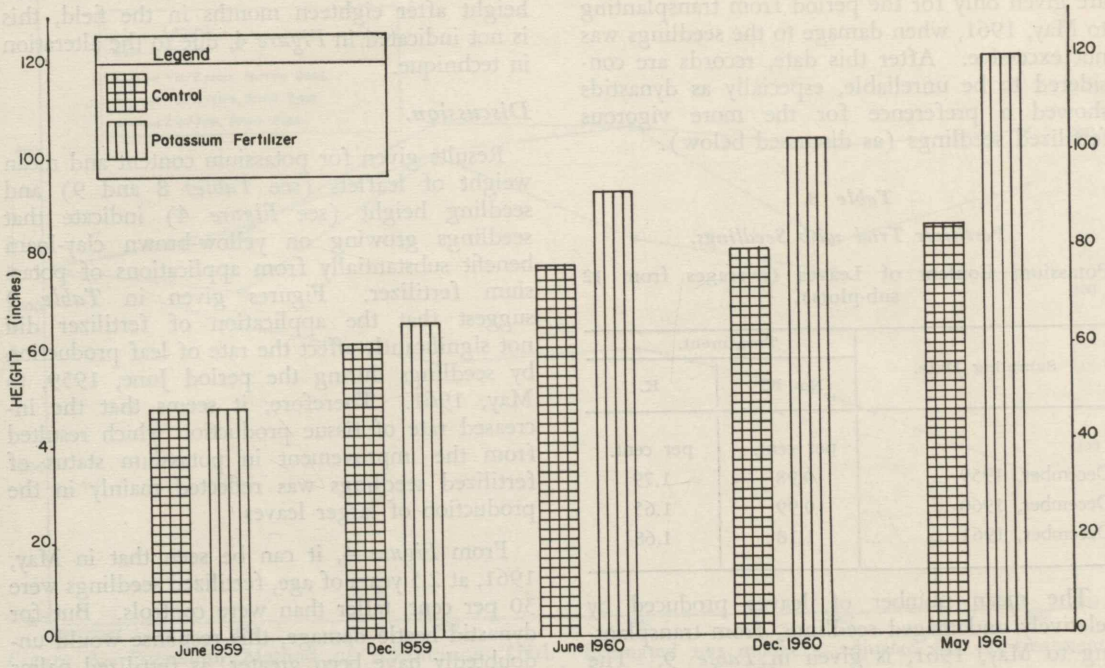

Figure 4.—Potassium Fertilizer Trial on Seedlings. Heights of seedlings.

first two or three years it would be desirable to split the annual application and apply every six months.

SUMMARY.

Comprehensive fertilizer trials on mature coconuts in New Ireland indicated response to potassium on yellow-brown clay-loam soils. Further trials showed a more economic response from 2½ lb. potassium chloride per palm per annum than from higher rates ; as good a response from biennial application as from annual ; and better response from broadcasting over a circle 20 to 24 feet in diameter around the base of the palm than from placement in a smaller circle. Good growth response was obtained from potassic fertilizing of seedlings.

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REFERENCES.

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

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

EDEN, T., GOWER, J. C. and SALGADO, M. L. M. (1963) . A factorial fertilizer experiment on coconuts. *Empire J. exper. Agric.* 31 : 283-295.