RECENT STUDIES ON THE MANURING OF COCONUTS IN CEYLON—contd.

M. L. M. SALGADO, Ph.D. (Cantab.), B.Sc. (Lond.), Dip. Agric. (Cantab.),
SOIL CHEMIST, COCONUT RESEARCH SCHEME (CEYLON.)

(D).—EXPERIMENTAL DATA.

The results of the field experiments and laboratory investigations carried out by us during the last ten years will be now considered. Out of the seven manurial experiments conducted by us, that at Bandirippuwa Estate on a comparatively good soil that had been regularly manured and cultivated, and two experiments, though simpler in design on poor lateritic soils at Veyangoda and Ahangama, have produced results of both scientific and practical importance and will be discussed first.

THE MANURING OF GOOD COCONUT SOILS.

(1) N. P. K. Experiment at Bandirippuwa Estate : Good Soil.

This was the first of the series of experiments, laid down in 1934 November and after completing a year's premanurial records, manures were applied in November, 1935, and subsequently biennially without interruption. It is a 3 × 3 × 3 experiment, consisting of 6 blocks of 9 plots each, aimed at determining the response to manuring of N, P and K, applied at nil, single and double doses in all possible combinations. *In fact it may be mentioned that from a statistical point of view a 3 × 3 × 3 factorial design or similar factorial designs are by far the most satisfactory for experiments for coconuts* compared to Randomised Blocks and Latin Square designs.

The rates of application are as follows :—$N_1 = 0{\cdot}5$ lb. ; $N_2 = 1{\cdot}0$; $P_1 = 1$ lb., $P_2 = 2$ lb., $K_1 = 0{\cdot}75$ and $K_2 = 1{\cdot}50$ lb. per palm. Nitrogen quality is also compared in the form of cyanamide, groundnut cake and sulphate of ammonia.

In addition to records of nuts, and the weight of copra, of each individual palm and plot, detailed records have been kept of the number of bunches, female flowers formed, number of immature nuts fallen, and analyses have also been made of the up-take of potash by the husk and coconut water. For K_0 and K_2 plots the content of copra was also determined in 1939. (13). *This may therefore be legimately considered as the fundamental experiment on the manuring and nutrition of the coconut palm.*

From the examination of the data of the last 9 years the following conclusions can be drawn :—

(i.) *Phosphoric acid :* In no year has phosphoric acid given a response, either at the single or double levels.

Determinations by the Truog Method of the available phosphoric acid of soil samples taken from the manure circles and between the rows of palms before the first application of manure in 1935, has provided a very satisfactory

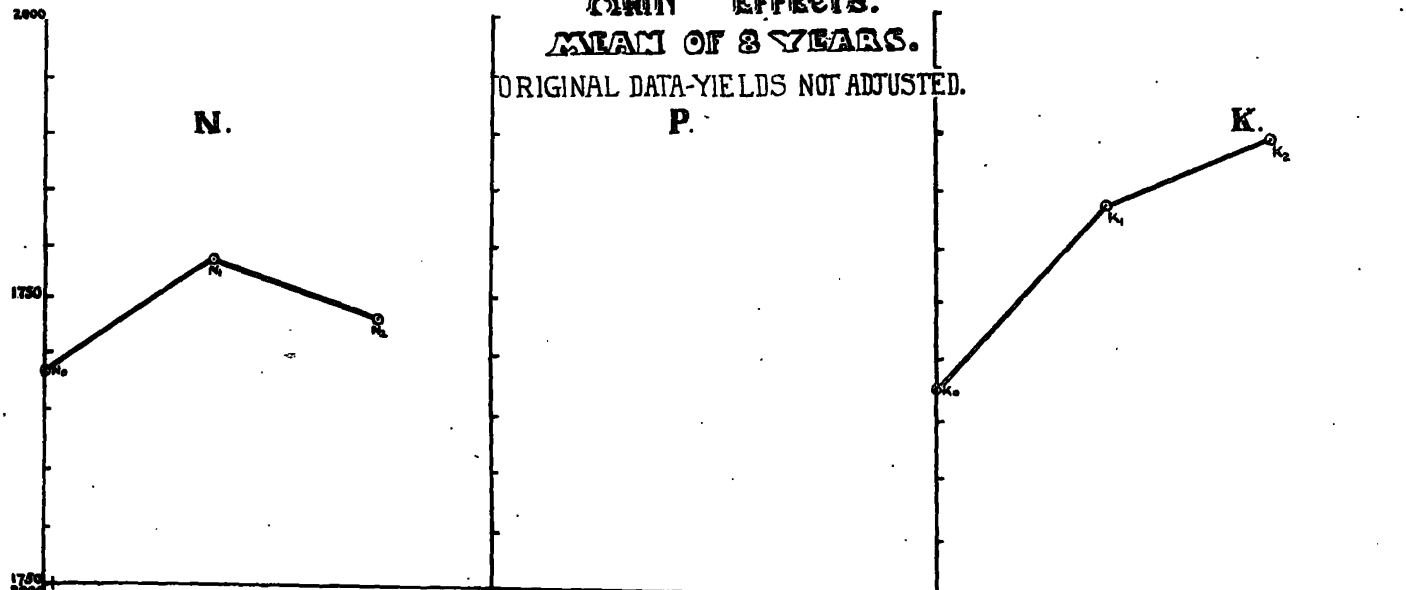
DIAGRAM- I.

N.P.K. EXPERIMENT, BANDIRIPPUWA ESTATE.

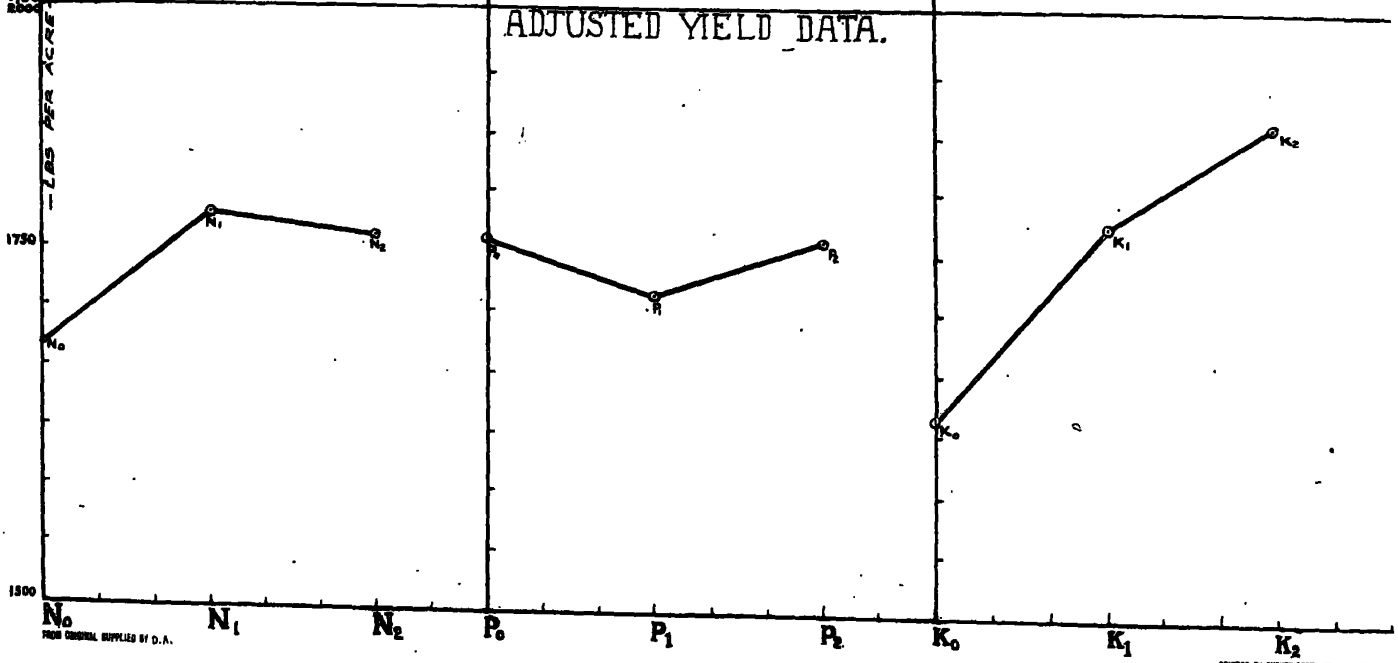
MAIN EFFECTS.

MEAN OF 8 YEARS.

ORIGINAL DATA-YIELDS NOT ADJUSTED.



ADJUSTED YIELD DATA.



FROM ORIGINAL SUPPLIED BY D.A.

PRINTED BY SURVEY DEPT., CEYLON, APRIL, 1947.

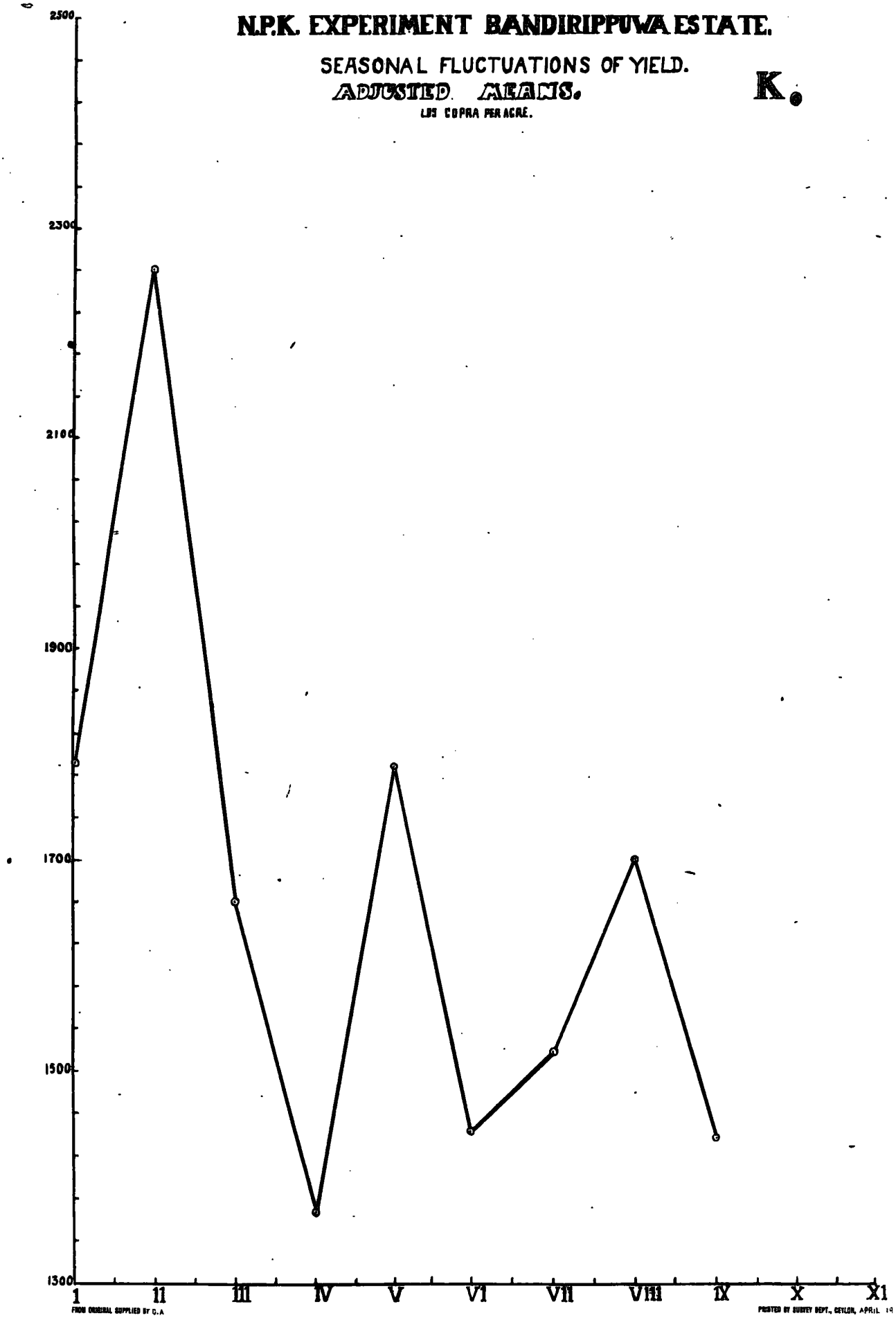
DIAGRAM-2

N.P.K. EXPERIMENT BANDIRIPPUWA ESTATE.

SEASONAL FLUCTUATIONS OF YIELD.

ADJUSTED MEANS. K.

LBS COPRA PER ACRE.



FROM ORIGINAL SUPPLIED BY C.A

PRINTED BY SURVEY DEPT., CEYLON, APRIL 19

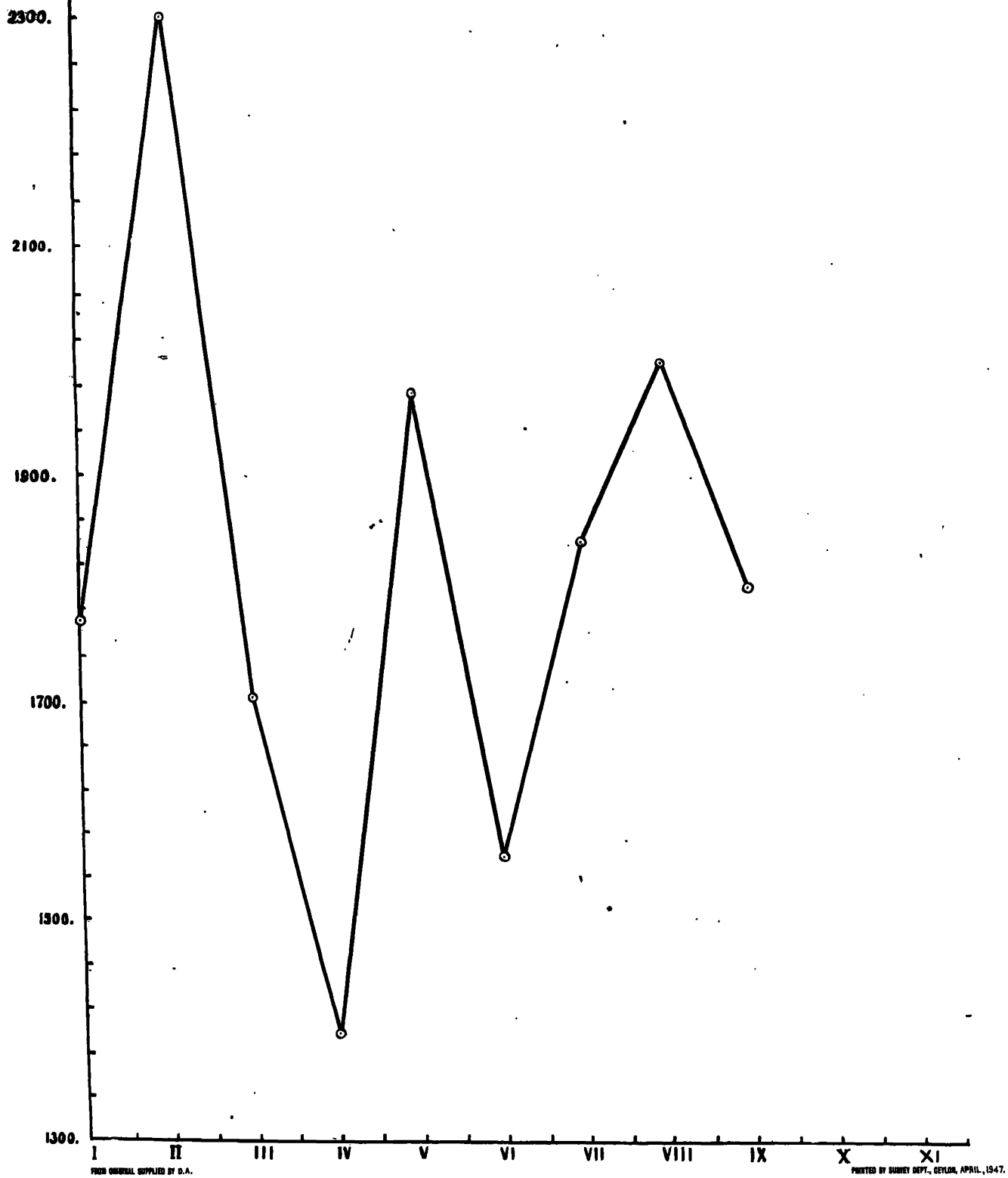
DIAGRAM 3.

N.P.K. EXPERIMENT. BANDIRIPPUWA ESTATE.

SEASONAL FLUCTUATIONS OF YIELDS : LBS COPRA/ACRE.

ADJUSTED YIELDS OF K_1 TREATMENTS.

K_1.



FROM ORIGINAL SUPPLIED BY D.A.

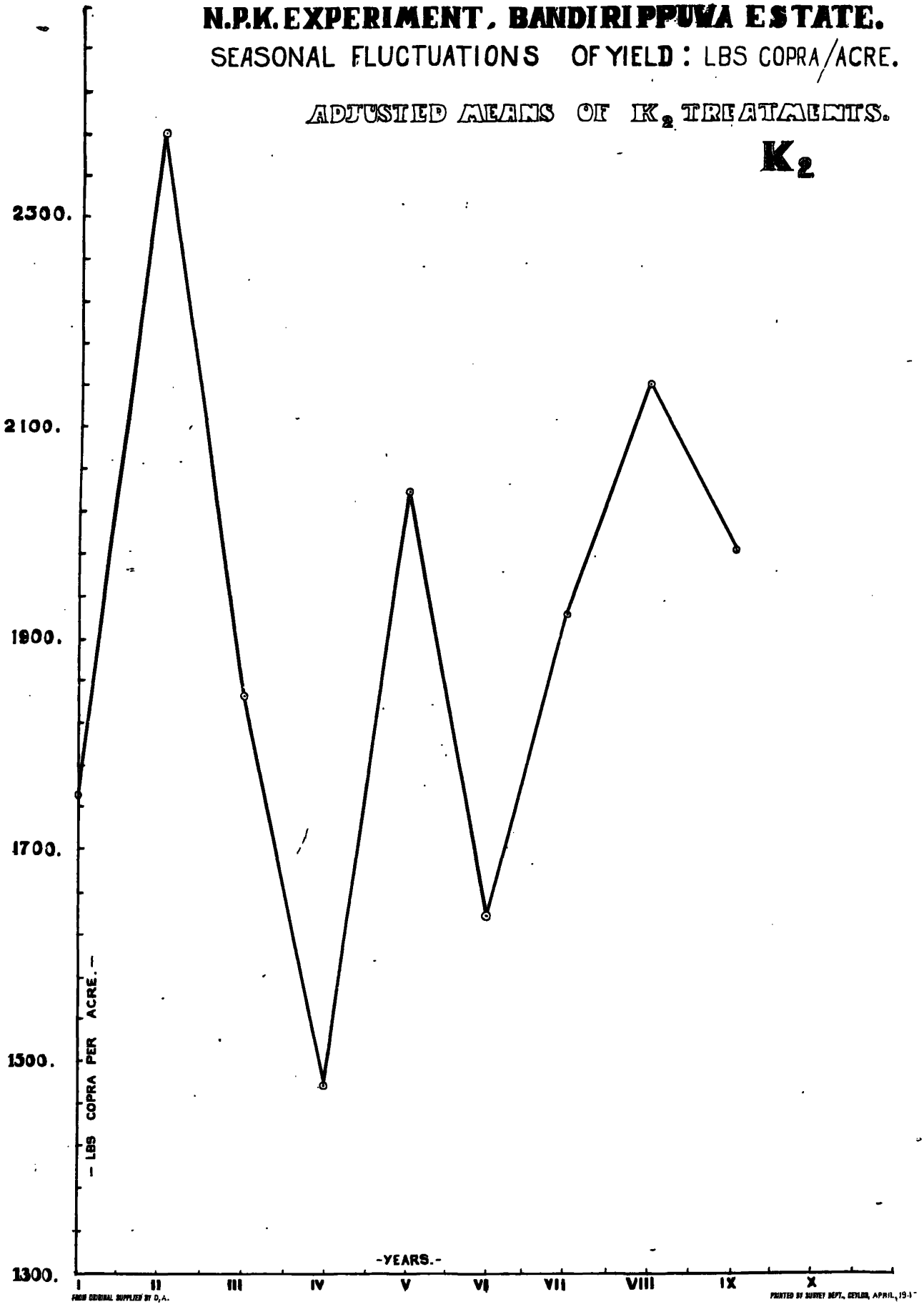
PRINTED BY SURVEY DEPT., CEYLON, APRIL, 1947.

DIAGRAM 4.

N.P.K. EXPERIMENT, BANDIRIPPUWA ESTATE.

SEASONAL FLUCTUATIONS OF YIELD : LBS COPRA/ACRE.

ADJUSTED MEANS OF K_2 TREATMENTS.



FROM ORIGINAL SUPPLIED BY D.A.

PRINTED BY SURVEY DEPT., CEYLON, APRIL, 1941

DIAGRAM 5.

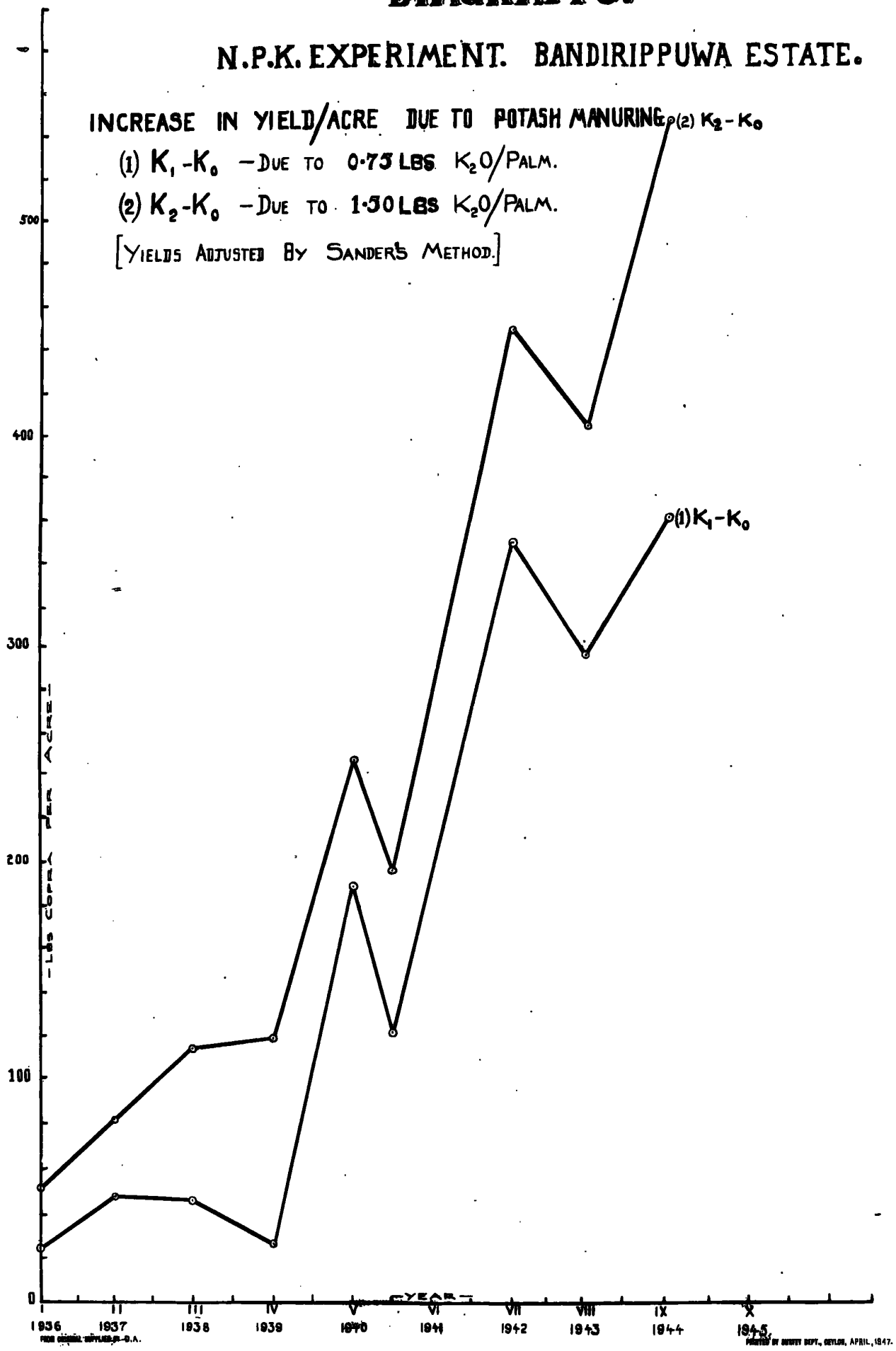
N.P.K. EXPERIMENT. BANDIRIPPUWA ESTATE.

INCREASE IN YIELD/ACRE DUE TO POTASH MANURING

(1) $K_1 - K_0$ – DUE TO 0·75 LBS K_2O/PALM.

(2) $K_2 - K_0$ – DUE TO 1·50 LBS K_2O/PALM.

[YIELDS ADJUSTED BY SANDER'S METHOD.]



PRINTED BY SURVEY DEPT., CEYLON, APRIL, 1947.

explanation of this lack of response. It may be mentioned that this lack of response is contrary to empirical tradition according to which the use of heavy applications of bone meal was the general rule in coconut manure mixtures. Available phosphoric acid in the manure circles was found to be at the average of 130 parts per million compared to barely 12 p.p.m. in the unmanured area between the rows, thus indicating a considerable accumulation and persistence of available phosphoric acid as a result of previous applications.

In similar samples taken 5 years later the available phosphoric acid had dropped from 130 to 44 p.p.m. in the P_0 plots, *i.e.*, where no phosphoric acid had been applied. Even at the latter level palms showed no response to further applications of phosphoric acid and even after 9 years the original reserves of this constituent have not been exhausted as shown by the lack of response. A third set of samples have been taken last year for the P_0 Plots and will be examined.

On the P_1 plots (where 1 lb. phosphoric acid per palm) have been applied, the available phosphate in similar samples taken in 1941, that is after 3 biennial applications in 1935, 1937 and 1939, has risen from an average of 131 p.p.m. to 462 p.p.m. On the corresponding P_2 plots (2 lb. Phosphoric acid per palm) this had risen from an average of 80 p.p.m. to 832 p.p.m.

A calculation based on the weight of soil in the manure circle determined to be 4,900 lb. would show what a remarkable accumulation of phosphoric acid does exist where unusually high doses have been applied.

A calculation based on the original P_0 sample of soil shows that 0·64 lb. phosphoric acid or the equivalent of 2 lb. saphos phosphate was originally present when this experiment was commenced and during 5 years there was yet present 0·22 lb. of this constituent, equivalent to 0·72 lb. saphos phosphate.

The average phosphate accumulation in 1935 at the commencement of the experiment in the manure circle alone amounted to 135 lb. saphos phosphate per acre. In 1940, this figure came down to 45 lb. and therefore the reduction for a period of 5 years without phosphate manuring was 90 lb. saphos phosphate per acre. Similar studies have been made in the case of other experiments mentioned later and soil samples taken from estates whose previous manuring programmes were available, but time does not permit a further elaboration of the subject.

Determination of total phosphoric acid of a few of the soil samples from this experiment as also samples from the sub-soil showed useful indications, a discussion of which has to be postponed for a later occasion.

NITROGEN.

The response to single and double doses of Nitrogen is rather intriguing. In the second year after manuring (1937) nitrogen alone, and that the double dose only, gave highly significant response (P.01). In 1938 and 1939, the 3rd and 4th year after the first manuring (the first and second years after the second application) nitrogen produced a response which was significant at P.05.

In subsequent years the nitrogen response has been rather erratic, not significant in 1940, barely significant in 1941 and not significant in the subsequent three years to date.

TABLE I.

N. P. K. Experiment, Bandirippuwa—The effect of Nitrogen, Phosphoric Acid and Potash on the Yield
(COPRA) OF COCONUTS.

ADJUSTED MEAN YIELDS FOR MAIN EFFECTS (PER ACRE)

(*a*) *Nitrogen* (*N*)

Year after 1st Manuring		Lbs. Copra per Acre (66 Palms)			General Mean	Significant Difference lbs. per Acre	Calculated as % of N_0		
		N_0	N_1	N_2			N_0	N_1	N_2
1st year (M. I)	1936	1702	1807	1805	1772	115	100	106·17	106·05
2nd year (M. II)	1937	2203	2289	2415*	2303	119	100	103·90	109·62
3rd year (M. III)	1938	1640	1761†	1740	1715	93	100	107·38	106·10
4th year (M. IV)	1939	1388	1468†	1392	1416	81	100	105·76	100·29
5th year (M. V)	1940	1852	1966	1984	1735	139	100	106·16	107·13
6th year (M. VI)	1941	1480	1606†	1560	1551	104	100	108·51	105·41
‡7th year (M. VII)	1942	1721	1880	1805	1800	143	100	109·24	104·88
‡8th year (M. VIII)	1943	1890	2003	1909	1932	141	100	105·98	101·01
‡9th year (M. IX)	1944	1718	1794	1723	1745	140	100	104·42	100·29
Total 9 years		15594	16574	16333					
Mean of 9 years		1733	1842	1815			100	106·29	104·73

(*b*) *Phosphoric Acid* (*P*)

Year after 1st Manuring		Lbs. Copra per Acre. (66 Palms)			General Mean	Significant Difference lbs. per Acre	Calculated as % of P_0		
		P_0	P_1	P_2			P_0	P_1	P_2
1st year (M. I)	1936	1804	1687	1823	1772	115	100	93·51	101·05
2nd year (M. II)	1937	2323	2273	2311	2303	119	100	97·85	99·48
3rd year (M. III)	1938	1690	1698	1756	1715	93	100	100·47	103·91
4th year (M. IV)	1939	1429	1424	1396	1416	81	100	99·65	97·69
5th year (M. V)	1940	1968	1868	1965	1735	139	100	94·92	99·85
6th year (M VI)	1941	1542	1548	1557	1551	104	100	100·59	101·00
‡7th year (M. VII)	1942	1831	1740	1834	1800	143	100	95·03	100·17
‡8th year (M. VIII)	1943	1975	1901	1927	1932	141	100	96·30	97·60
‡9th year (M. IX)	1944	1786	1694	1734	1745	140	100	94·85	97·09
Total 9 years		16348	15833	16303			100	96·86	99·72
Mean for 9 years		1816	1759	1811					

(*c*) *Potash* (*K*)

Year after 1st Manuring		Lbs. Copra per Acre (66 Palms).			General Mean	Significant Difference lbs. per Acre	Calculated as % of K^0		
		K_0	K_1	K_2			K_0	K_1	K_2
1st year (M. I)	1936	1797	1771	1747	1772	115	100	98·55	97·22
2nd year (M. II)	1937	2260	2307	2340	2303	119	100	102·08	103·54
3rd year (M. III)	1938	1661	1708	1775†	1715	93	100	102·83	106·86
4th year (M. IV.)	1939	1367	1395	1487†	1416	81	100	102·05	108·78
5th year (M. V)	1940	1788	1978*	2037*	1735	139	100	110·63	113·93
6th year (M. VI)	1941	1443	1565*	1639*	1551	104	100	108·45	113·58
7th year (M. VII)	1942	1528	1879*	1998*	1800	143	100	122·30	130·70
8th year (M. VIII)	1943	1697	2000*	2105*	1932	141	100	117·86	124·04
9th year (M. IX)	1944	1442	1804*	1989	1745	140	100	125·10	139·93
Total		14983	16407	17117					
Mean of 9 years		1665	1823	1902			100	109·49	114·23

* Significant at P. 01.
† Significant at P. 05.
‡ Original yield data not adjusted by Sander's Method.

The double dose of nitrogen (except during the 2nd year of manuring, 1937) depresses the response of the application at the first level. While this depressing effect has been consistent, it is not statistically significant.

It is quite possible that the indifferent nitrogen response may be due to the fact that since the commencement of the experiment, no cattle were allowed to graze between the palms as commonly done on coconut estates, whereas the growth of pasture was periodically disc-harrowed at least twice a year and biennially incorporated in the soil by ploughing simultaneously with the application of manure. A calculation based on the analysis of pasture samples taken from the experimental plots and analysed showed that almost 46 lb. per acre of nitrogen and 43 lb. potash were turned in to the soil bienially. If the poor nitrogen response is typical of all coconut estates in Ceylon, the coconut palms may perhaps be the only case of a tropical crop in Ceylon which has sown such minor and indefinite response to nitrogen.

There is also no difference between ground-nut cake, sulphate of ammonia and cyanamide as was mentioned.

It is proposed to modify the experiment by allowing cattle to graze uniformly under controlled conditions and it remains to be seen if a higher nitrogen response would result.

POTASH

A significant response to the first level of potash (·75 lb. per palm) occurred only in the fifth year after the first biennial manuring, but in the third year where the double dose of potash (1.5 lb.) was applied.

TABLE II.

N. P. K. Experiment, Bandirippuwa Estate : Main Effects, (Nitrogen) (N).

Treatment.	Female Flowers per Acre.	Nuts per Acre.	Per cent. Female Flowers formed into Nuts.	Copra lb. per Acre.	Per cent.	Copra out-turn Nuts per Candy.
			1936 : I.			
N_0	11,127	3,517	31·16	1,713	100	1,150
N_1	11,496	3,785	32·93	1,821	105	1,164
N_2	10,985	3,706	33·73	1,781	104	1,165
			1938 : III.			
N_0	12,169	3,385	27·82	1,646	100	1,152
N_1	14,327	3,694	29·78	1,769	107	1,169
N_2	14,707	3,711	25·06	1,729	105	1,202
			1939 : IV.			
N_0	10,363	3,394	32·75	1,391	100	1,366
N_1	11,688	3,626	31·02	1,472	106	1,379
N_2	11,502	3,562	30·97	1,385	99	1,440
			1940 : V.			
N_0	11,914	3,978	33·39	1,859	100	1,199
N_1	13,943	4,307	30·89	1,975	106	1,222
N_2	14,111	4,420	31·32	1,969	106	1,257

TABLE II.—*contd.*

1941 : VI.

Treatment.	Female Flowers per Acre.	Nuts per Acre.	Per Cent. Female Flowers formed into Nuts	Copra lb. per Acre.	Per Cent.	Copra out-turn Nuts per Candy.
N_0	10,257	3,325	32·42	1,486	100	1,254
N_1	11,470	3,684	32·12	1,612	108	1,280
N_2	11,363	3,649	32·11	1,549	104	1,319

1942 : VII.

N_0	11,873	3,665	30·87	1,721	100	1,193
N_1	14,114	4,118	29·17	1,880	109	1,226
N_2	14,204	4,097	28·84	1,805	105	1,271

1943 : VIII.

N_0	11,629	4,070	35·00	1,890	100	1,193
N_1	13,168	4,427	33·61	2,003	106	1,226
N_2	12,785	4,334	33·90	1,909	101	1,271

(Original data *not* adjusted by Sander's Method.)

N. P. K. Experiments : Bandirippuwa Estate : Main Effects (Phosphoric Acid) (P)

1936 : I.

	Female Flowers per Acre.	Nuts per Acre.	Per cent. Female Flowers formed into Nuts.	Copra lbs. per Acre	Copra out-turn Nuts per Candy.
P_0	11,766	3,746	31·84	1,814	1,157
P_1	10,842	3,588	33·09	1,719	1,169
P_2	11,000	3,674	33·40	1,782	1,155

1938 : III.

P_0	14,408	3,538	24·56	1,695	1,169
P_1	13,597	3,624	26·66	1,716	1,183
P_2	13,300	3,627	27·27	1,788	1,172

1939 : IV.

P_0	11,964	3,565	29·80	1,431	1,395
P_1	10,687	3,543	33·16	1,433	1,385
P_2	10,903	3,473	31·85	1,385	1,405

1940 : V.

P_0	14,293	4,294	30·04	1,974	1,218
P_1	12,539	4,141	33·02	1,889	1,228
P_2	13,136	4,271	32·51	1,940	1,233

1941 : VI.

P_0	11,561	3,534	30·57	1,546	1,280
P_1	10,544	3,583	33·98	1,562	1,284
P_2	10,986	3,542	32·24	1,539	1,289

TABLE II.—*contd.*

1942 : VII.

	Female Flowers per Acre.	Nuts Acre.	Per cent. Female Flowers formed into Nuts.	Copra lbs. per Acre	Copra out-turn Nuts Candy.
P_0	14,164	3,964	27·99	1,831	1,212
P_1	12,737	3,855	30·27	1,740	1,241
P_2	13,290	4,060	30·55	1,834	1,239

1943 : VIII.

P_0	13,080	4,318	33·01	1,975	1,225
P_1	11,723	4,205	35·87	1,901	1,239
P_2	12,785	4,308	33·71	1,927	1,252

(Unadjusted Data.)

N. P. K. Experiments : Bandirippuwa Estate : Main Effects (Potash) (K)

1936 : I.

	Female Flowers per Acre.	Nuts Acre.	Per cent. Female Flowers formed into Nuts.	Copra lbs. per Acre	Copra out-turn Nuts per Candy.
K_0	11,253	3,422	32·28	1,740	1,167
K_1	11,402	3,728	32·70	1,815	1,150
K_2	10,973	3,654	33·30	1,759	1,163

1938 : III.

K_0	13,846	3,472	25·08	1,629	1,194
K_1	13,675	3,612	31·03	1,733	1,167
K_2	13,784	3,706	26·89	1,782	1,165

1939 : IV.

K_0	11,828	3,431	29·01	1,351	1,422
K_1	10,983	3,489	31·77	1,408	1,388
K_2	10,742	3,661	34·08	1,490	1,376

1940 : V.

K_0	13,047	3,894	29·85	1,752	1,243
K_1	13,592	4,383	32·25	2,005	1,224
K_2	13,328	4,428	33·22	2,045	1,213

1941 : VI.

K_0	11,731	3,359	28·63	1,418	1,326
K_1	10,884	3,613	33·19	1,584	1,277
K_2	10,476	3,687	35·19	1,645	1,256

1942 : VII.

K_0	13,331	3,516	26·37	1,528	1,286
K_1	13,476	4,079	30·27	1,879	1,215
K_2	13,383	4,285	32·01	1,998	1,201

1943 : VIII.

K_0	13,159	3,940	29·93	1,697	1,288
K_1	12,407	4,365	35·18	2,000	1,215
K_2	12,016	4,526	37·67	2,105	1,201

Note :—Above yield data have not been corrected by Sander's Method.

Table III. expressed in lb. per acre illustrates the progressive increases in response to potash manuring as the experiment is continued for nine years to date. As the accompanying figures illustrate, the potash response is almost linear.

Potash is, no doubt, therefore, the dominant manurial requirement of coconut palms. Compared to nitrogen, which showed a maximum increase of 8 *per cent.*, potash has given increases of as much as 25 *per cent.* for similar applications and 30 *per cent.* for the higher. After nine years, the increase per acre due to potash manuring amounts to almost a candy of copra *per annum*, on a comparatively good soil as at Bandirippuwa Estate.

Palms in plots receiving no potash during this period show visible signs of potash deficiency in the foliage and the crown. A study of metabolic changes brought about by the disturbance of the N.P.K. balance as shown by the distinct foliage changes in the crown, the characteristics and peculiar chlorosis and leaf-scorch which develop with grey-blight later, and the various physiological disturbances brought about in the leaves, kernel, coconut water and the husks will repay study.

Unfortunately the coconut palm is not easily amenable to pot experiments as carried out by Wallace (44) on orchard crops. Our financial resources are limited but it should not be beyond the limitations of ingenuity to devise a suitable pot-culture technique for even bearing palms.

The soil cannot be studied without considering the soil plant-atmosphere polyphase system, but under the restricted facilities, we have been studying at least one aspect, the potash up-take by the palms as shown by its content in coconut water and husk, which components of the palm have a tendency to concentrate storage of potash. It is hoped to extend this year its study to a complete study of the potash up take in husk, water and fronds in order to determine how far applied potash and soil reserves of potash are u+ilised by the palm. Certain preliminary data based on several hundred analyses have provided useful indications that may prove in a way similar to the Neubaur method of assessing soil fertility or the modern method of leaf analysis.

TABLE III.

N. P. K. Experiment : Bandirippuwa.
Increase of Yield due to Potash Manuring
Expressed as Lbs/Acre

(Adjusted by Sander's Method)

Year.	$(K_1-K_0.)$	$(K_2-K_0.)$	Year.
M I. ..	26 ..	50 ..	1936
M II. ..	47 ..	80 ..	1937
M III. ..	47 ..	114* ..	1938 (severe drought in 1938)
M IV. ..	28 ..	120* ..	1939
M V. ..	190* ..	249† ..	1940
M VI. ..	122† ..	196† ..	1941
M VII. ..	352† ..	470† ..	1942 (Uncorrected)
M VIII. ..	300† ..	407† ..	1943 (Uncorrected)
M IX. ..	362† ..	346† ..	1944 (Uncorrected)
Total (9 years)	1,474	2,232	
Mean/annum	163	248	

There are indications that there is a negative interaction between high application of phosphoric acid and potash, *i.e.*, excess phosphoric acid seems to depress the up take of potash by the palm. This observation is quite consistent with the behaviour of potash-loving plants as shown by the work of Cowie (14, 15) and by Knowles & Watkin (24) for the potato crop, and the work of Croucher & Mitchell on banana manuring (16).

A point of interest is that the response to potash shows a rise and fall during alternate years. This is shown clearly in Diagram 5, a rise in the year when manure is applied followed by a fall in the second year.

In this connection recent work of Volk and others in America (1, 10, 18, 23, 40, 42, 43.) have to be kept in mind in studying the behaviour of applied potash during droughts and their conversion to non-available forms and back again releasing available potash under wet conditions. If such fixation does take place it would be advisable to apply in annual small doses than in biennial full doses. In the manuring of orchard crops, which like the coconut palm respond to potash, the modern idea is that potash should be added frequently in small amounts than infrequently in big doses.

(2) **The Manuring of poor Coconut soils : Manurial Experiments at Ahangama and Veyangoda.**

While the best coconut soils, on which *yields of even 3,000* nuts or 2·5 candies per acre *can be obtained by judicious cultivation alone without manuring*, are restricted to the alluvia of the North-Western Province, there is, as mentioned before, an extensive area of lateritic soils of very poor fertility, which form the dominant soil type on which coconuts have been planted in the Western and Southern Provinces. Before the fall in prices in 1930 and particularly when boom conditions prevailed yields were maintained on those estates by the systematic and intensive use of artificial manures. Since then yields have gone down to rock-bottom as a result of estates sometimes being neglected and almost left to nature.

The problems of economic manuring of these areas should have a prior claim in our studies. In 1939 two *co-operative* manurial experiments were, therefore, laid down at Eddunkelle Estate, Ahangama, an estate in a typical coconut area representative of both the Galle and Matara districts, and at Kumbaloluwa Estate in the Pasyala-Veyangoda area of Siyane Korale.

In contrast to the comparatively fertile soils of Bandirippuwa Estate, the soils of these two experiments consist of extremely poor lateritic gravel, with little reserves of plant food, subject always to much heavier rainfall. When these experiments commenced both estates had not been manured for a very long time : for almost a decade.

The treatments were a comparison of O, NK, and NPK, with and without husks buried in pits, arranged in 6 Randomised Blocks of 6 plots each. Rates of application biennially were N : 0·5 lb. ; K : 1 lb ; and P : 0·6 lb. per palm.

The yield increases obtained in this experiment are particularly striking as shown by the data summarized in Table IV: and the following points became apparent :—(*a*) The response is very quick unlike on the Bandirippuwa soil. (*b*) The percentage yield increases are very large rising from 110 per cent. increase in the second year to almost 145 per cent. in the third year at Ahangama, and in the case of Kumbaloluwa soil the differences are even of a much higher order. (*c*) Phosphoric acid, and that as small a dose of 0.6 lb. P_2O_5 per palm

TABLE IV.

Manuring of Poor Soils : Ahangama and Veyangoda.

Ahangama.—Southern Province : Manure First Applied, April, 1939 and Subsequently once in two years.

Treatments.	1st Year, 1939–1940. Nuts per Acre.	Lbs. Copra Acre.	per cent.	Copra out-turn	2nd Year, 1940–1941. Nuts per Acre.	Lbs. Copra Acre.	per cent.	Copra out-turn.	3rd Year. 1941–1942. Nuts per Acre.	Lbs. Copra Acre.	per cent.	Copra out-turn.	4th Year, 1942–1943. Nuts per Acre.	Lbs. Copra Acre.	per cent.	Copra out-turn.	5th Year, 1943–1944. Nuts per Acre.	Lbs. Copra Acre.	per cent.	Copra out-turn
O	1,148	478	100	1,344	714	299	100	1,338	920	408	100	1,264	1,197	508	100	1,320	1,100	476	100	1,295
NK	1,142	490	103	1,306	1,203	562	188	1,197	1,771	809	199	1,225	1,558	744	146	1,173	1,646	774	162	1,190
NPK	1,281	553	116	1,299	1,239	627	210	1,187	2,108	998	245	1,183	2,297	1,073	211	1,199	2,280	1,096	230	1,165
	133	75	16		615	328	110		1,188	590	145		1,100	565	111		1,180	620		

Veyangoda.—Manures First Applied December, 1939.

	1940.				1940.				1942.				1943.				1944.			
O	688	246	100	1,569	433	166	100	1,465	932	343	100	1,524	656	100	100	1,579	394	161	100	1,367
NK	604	221	90	1,530	544	237	143	1,300	1,232	491	143	1,404	840	318	136	1,480	391	179	111	1,225
NPK	611	228	83	1,503	584	258	155	1,270	1,669	699	204	1,336	1,721	672	288	1,435	1,393	642	397	1,216
	—77	—18	—17		151	92	55		737	356	104		1,065	439	188		999	481	297	

has a marked, almost spectacular response on these soils particularly at Kumbaloluwa, where in the fourth year phosphoric acid forms a definite limiting factor to the response of nitrogen and potash in combination, in contrast to Bandirippuwa where Phosphoric acid gave no response during 9 years to date.

It should also be noted that the response to manuring at Ahangama was early (in the second year) and at Veyangoda the corresponding level of response was obtained only in the third year. This is also of interest, and is due to the fact that at the commencement of the experiment, Kumbaloluwa palms, as a result of lack of manuring for years had gone back to a degree not shown by those at Eddunkelle, as demonstrated by the initial yields. The first effect of the manuring was obviously to improve the foliage and crown before before nuts were developed in subsequent years at Kumbaloluwa. It should also be noted that the difference in intrinsic fertility of the two soils have been maintained inspite of the manuring as shown by the fact that while in the fifth year 1,096 lb. copra per acre is produced at Ahangama, only 642 lb. is produced in the fully manured NPK plots.

The spectacular response to phosphoric acid in these poor lateritic soils has been explained by the determination of the available phosphoric acid of the soils as in the experiment at Bandirippuwa estate. In contrast to the accumulated reserves of phosphoric acid as a result of previous manuring, the soils of both Eddunkelle and Kumbaloluwa show mere traces which can hardly be determined accurately by the Truog or Citric Acid Methods, colorimetrically, varying between 12 to 20 p.p.m.

In the NPK plots from which samples were taken in November, 1942, before the 3rd biennial manuring, it was observed that considerable accumulation of phosphoric acid had occurred during this period, in some cases up to almost 200 p.p.m., in spite of very modest application of 2 lbs. saphos phosphate equivalent to 0·6 lbs. phosphoric acid biennally compared to perhaps biennia application of 6 lbs. bone meal (1·3 lb. phosphoric as was the practice in old days).

An intriguing problem arises here: If the available P figures by the Truog method can be used as a reliable method of assessing the phosphate requirements of coconut palms, it may perhaps be useful to eliminate phosphoric acid application further until the reserves come down to a level at which phosphate manuring would be necessary. It would perhaps be unsafe to adopt the same chemical standards based on a single value to totally different types of soils. The question of phosphate nutrition of the palms has certainly been only partially tackled but the practical implications are, nevertheless, of considerable economic value, particularly, today, when the prices of all manures are exorbitant.

(3) Influence of Manuring on Copra out-turns.

The data of the Bandirippuwa Experiment summarised in Table III. and those in Table II. would repay study in relation to the question of coprā out-turns. On the comparatively fertile soil where the potash response occurs quite late and the gross response as lbs. copra per acre is much smaller than on the poor soil, copra out-turns are effected only after the 4th year and that to a proportionately smaller extent compared with the poor soil. In this connection it is of interest that Nitrogen consistently from the

4th year affects the out-turn adversely, *i.e.*, more nuts are required per candy, and for the heavier application of nitrogen averages about 75 nuts a candy. On the other hand, potash improves out-turn consistently to a corresponding degree, while phosphoric acid seems to have no effect at all. In the case of the poor soils, the complete mixture of NPK improves out-turn by over hundred nuts a candy. Here unfortunately, the design of the experiment is such, being non-factorial that we are not able to disentangle the differential main effects due to N. P. and K individually.

(4) Influence of Manuring on Female Flowers and setting of nuts.

Table II. also illustrates quite distinctly the influence of manuring on the development of female flowers and the setting of nuts. While Nitrogen increases the total female flowers formed by nearly 15 *per cent.*, potash seems to have very little influence and if at all seems to reduce the total development of female flowers, while phosphoric acid too seems to depress the development of females flowers to a greater extent than potash. On the average nearly 30 *per cent.* of the female flowers formed are developed into mature nuts after fertilization. There are also quite significant variations in the percentage setting between picks ranging from 23 to 40 *per cent.*, but time does not permit further examination of this aspect.

In the case of poor soils, while the total number of female flowers developed per palm is very much less, the effect of manuring on the development of female flowers is much pronounced, a complete mixture increasing almost three-fold the female flowers at Ahangama. The percentage setting on poor soils also seems to be higher, almost reaching 50 *per cent.*

TABLE V.

N. P. K. Experiment—Bandirippuwa : Per cent. Female Flowers set for Each Pick of 6 Years III.—IX—1938-1943.

Pick.	Nuts.	Female Flowers.	Per cent. Set.
	M. II.—1938.		
1st : December ..	7,598 ..	38,636 ..	19·67
2nd : February ..	7,659 ..	35,616 ..	21·50
3rd : April ..	8,756 ..	34,443 ..	25·42
4th : June ..	11,634 ..	33,718 ..	34·50
5th : August ..	11,119 ..	35,930 ..	30·95
6th : October ..	6,206 ..	24,431 ..	25·40
Total ..	52,971	202,774	26·12
	M. IV.—1939.		
1st : December ..	9,259 ..	24,966 ..	37·10
2nd : February ..	9,756 ..	23,227 ..	42·00
3rd : April ..	10,685 ..	22,854 ..	46·75
4th : June ..	10,092 ..	23,677 ..	42·62
5th : August ..	7,130 ..	31,971 ..	22·30
6th : October ..	5,026 ..	38,023 ..	13·22
Total ..	51,948	164,718	31·54

M. V.—1940.

Pick.	Nuts.	Female Flowers.	Per cent. Set.
1st: December ..	5,171 ..	39,353 ..	13·14
2nd: February ..	10,121 ..	37,767 ..	26·80
3rd: April ..	16,987 ..	44,176 ..	38·45
4th: June ..	13,135 ..	27,592 ..	47·60
5th: August ..	9,926 ..	23,176 ..	42·82
6th: October ..	7,034 ..	24,147 ..	29·13
Total ..	62,374	196,211	30·79

M. VI.—1941.

1st: December ..	4,837 ..	22,350 ..	21·64
2nd: February ..	4,107 ..	28,603 ..	14·36
3rd: April ..	8,349 ..	28,769 ..	29·02
4th: June ..	13,377 ..	29,595 ..	45·07
5th: August ..	13,268 ..	29,373 ..	45·17
6th: October ..	8,387 ..	23,761 ..	35·30
Total ..	52,325	162,451	32·21

M. VII.—1942.

1st: December ..	6,250 ..	27,877 ..	22·42
2nd: February ..	3,920 ..	27,003 ..	14·51
3rd: April ..	9,995 ..	38,439 ..	26· 0
4th: June ..	16,151 ..	42,704 ..	37·82
5th: August ..	13,795 ..	38,450 ..	35·88
6th: October ..	8,206 ..	22,831 ..	35·94
Total ..	58,317	197,304	29·56

M. VIII.—1943.

1st: December ..	7,079 ..	19,308 ..	36·67
2nd: February ..	7,481 ..	25,884 ..	28·90
3rd: April ..	9,190 ..	24,601 ..	59·63
4th: June ..	16,624 ..	43,645 ..	38·08
5th: August ..	12,734 ..	33,403 ..	38·12
6th: October ..	9,881 ..	37,656 ..	26·24
Total ..	62,989	184,497	34·14

TABLE VI.

N. P. K. Experiment—Bandirippuwa : Influence of Manuring on the Development of Female Flowers and Setting of Nuts.

(Mean of 6 Years (III. to VIII. Years)—1939-1944)

Treatment.	Nuts/Acre.	Female Flowers per Acre.	Per cent. Female Flowers formed into Nuts.
Nitrogen—			
N ..	3,636 ..	11,367 ..	31·99
N_1 ..	3,976 ..	13,118 ..	30·31
N_2 ..	3,962 ..	13,112 ..	30·22
$N - N_0$	326	1,745	—1·77

Treatment.	Nuts/Acre.	Female Flowers per Acre.	Per cent. Female Flowers formed into Nuts.
Phosphoric Acid—			
P_0	3,869	13,231	29·24
P_1	3,826	11,971	31·95
P_2	3,880	12,399	31·29
P_2–P_0			
Potash—			
K	3,602	12,824	28·09
K_1	3,923	12,503	31·38
K_2	4,049	12,288	32·95
K_2–K_0			

TABLE VII.

Influence of Manuring on the Development of Female Flowers and Setting of Nuts on Poor Soils

(*a*) Kumbaloluwa Estate, Veyangoda.

Pick. No.	Pick. Date.	Treatment.	Nuts.	Female Flowers.	Per cent. Set.
M. V. 5	September 1944	O	438 100%	986 100%	44·4
		NK	410 94%	743 75%	55·1
		NPK	1,247 285%	2,489 252%	50·1
M. V. 6	November 1944	O	216 100%	516 100%	41·86
		NK	205 95%	421 82%	48·70
		NPK	716 331%	1,406 272%	50·92

(*b*) Eddunkelle Estate, Ahangama.

M. VI. 2	June 30, 1944	O	774 100%	1,970 100%	39·7
		NK	1,137	2,129 108%	53·4
		NPK	1,831	3,380 171%	54·7
M. VI. 3	August 20, 1944	O	683 100%	1,813 100%	37·67
		NK	931	1,739 96	53·53
		NPK	1,338	2,708 149%	49·41

TABLE VIII.

Variation of Development and Setting of Female Flowers between Picks.

N. P. K. Experiment : Bandirippuwa.

Female Flowers mean of 6 Pisks of 6 Years (M III.—M VIII.)

Pick.	Month.	Nuts.	Female Flowers.	Per cent. Set.
1st	December	40,194	172,490	23·30
2nd	February	43,043	178,100	24·16
3rd	April	63,962	193,282	32·95
4th	June	80,973	2,000,931	40·29
5th	August	67,972	192,303	35·35
6th	October	44,740	170,849	26·18
	Total	340,884	2,907,955	30·77