STUDIES ON THE NUTRIENT STATUS OF SOME COCONUT SOILS IN CEYLON

2. THE "CINNAMON" SAND ON HORAKELLY ESTATE
B. THE "HARD PAN"

By

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1. INTRODUCTION

In an earlier publication (*Paltridge and Santhirasegaram* 1957) data from experiments with the "top-soil" were recorded. The present paper records experiments with the "Hard Pan" or clay layer occurring at a depth of approximately five feet.

It was reported that plants growing in the "Cinnamon sand" would suffer from an acute deficiency of Potassium, of Calcium and of Nitrogen. They would also suffer from a deficiency of Sulphur, and from lesser deficiencies of Phosphorus and Magnesium. Leguminous plants would suffer from a deficiency of Boron and there was some evidence of an incipient deficiency of Copper.

The present studies were undertaken to assess the nutrient status of the "Hard Pan" and to compare the results with that of the "top soil".

In collecting samples of this soil an area where the "hard pan" was nearest the surface was selected and pits dug to expose the hard clay layer. Samples were taken from several such pits, and mixed thoroughly, after the coarser vegetable matter, such as roots were removed.

That soil was then air dried in the laboratory and used to fill a number of 6 inch polysterene pots, each containing approximately 2,000 grammes of soil, air dry weight. The response to any nutrient was measured in terms of the dry weight of the plant grown in each pot.

All pots were watered daily, their water content being brought to 85% "field capacity" by weight. In order to avoid any contamination, that water was filtered and passed through a commercial water softener and distilled and redistilled. The final distillation was done in "pyrex" glass. In experiments where Boron was a treatment the final distillation was omitted. The experiments were conducted in the Institute's "Phytosolarium".

The test plants were, a perennial grass, *Paspalum commersonii* (lam.), and a legume *Medicago sativa* (L).

2. EXPERIMENTAL

A. Experiment I

(*a*) *Objective:*—To measure the effect of the major nutrients N, P, K, Ca and Mg on the growth of *Paspalum commersonii* (lam.).

(*b*) *Design and Procedure:*—This was a 2^5 factorial experiment with two replicates of each treatment. The nutrients used and the rates of applications are enumerated in Table 1. Calcium was applied as $CaCO_3$ powder and mixed with the top one and a half inches of the soil in the pot. All other nutrients were applied as solutions.

TABLE 1

Showing chemicals used and rates applied

Designation	*Chemicals*	*Rate of Application/acre*
N_5	$(NH_4)_2SO_4$	5 cwts. = 118 lbs. N + 135 lbs. S
P_3	$NaH_2PO_4.2H_2O$	3 cwts. = 67 lbs. P + 49 lbs. Na
K_3	K_2SO_4	3 cwts. = 150 lbs. K + 70 lbs. S
Ca_{10}	$CaCO_3$	10 cwts. = 4 cwts. Ca
$Mg_{1\frac{1}{2}}$	$MgSO_4.7H_2O$	1½ cwts. = 18 lbs. Mg + 22 lbs. S
B_6	$Na_2B_4O_7.10H_2O$	6 lbs. = 1.0 lb. B + 1.0 lb. Na

The experiment was planted with seeds on 30th September, 1958. Seedlings in excess of two per pot were removed progressively as they appeared. On 3rd November the number of plants per pot was reduced to one and the plant removed designated "thinnings" were dried and weighed to obtain some additional data of the early stage of growth. The experiment was harvested thrice viz. 25th November, 1958, 2nd January and 11th February, 1959.

On 19th November, 2½ cwts. $(NH_4)_2SO_4$ per acre were applied to all nitrogen treatments as these plants showed symptoms of nitrogen deficiency. A few days before the second harvest i.e. on 29th December a further 2½ cwts. of $(NH_4)_2SO_4$, 1½ cwts. of $NaH_2PO_4.2H_2O$ and 1½ cwts. K_2SO_4 per acre were applied to the respective treatments.

To measure the effect of Calcium on soil acidity, the pH of the soil in all the pots were determined on 24th October and 4th December, 1958.

(*c*) *Results:*—All tested nutrients were found to increase yields significantly. The mean yields for the two replicates of all treatments at successive harvests are recorded in Table 2.

TABLE 2

Experiment I—Showing mean yields for the two replicates of all treatments at successive harvests

Harvest	*Treatment*			*Nil*	*N*	*P*	*NP*	*Effective Treatment*	*Level of Significance*
Thinnings Age 34 days	Nil	Nil	Nil	0.01	0.02	0.03	0.07	N; P.	0.1%
			K	0.02	0.01	0.06	0.18	K; Ca.	1.0%
		Ca	Nil	0.01	0.01	0.08	0.12	Mg; N × P;	0.1%
			K	0.02	0.02	0.10	0.17	P × K; P × Mg.	1.0%
	Mg	Nil	Nil	0.01	0.04	0.07	0.16	P, × Ca.	
			K	0.02	0.02	0.06	0.28		
		Ca	Nil	0.01	0.01	0.08	0.22		
			K	0.01	0.02	0.19	0.49		
First Age 56 days	Nil	Nil	Nil	0.11	0.06	0.17	0.17	N; P; K.	0.1%
			K	0.15	0.03	0.38	1.68	Ca; Mg.	1.0%
		Ca	Nil	0.14	0.08	0.41	1.22		
			K	0.12	0.10	0.32	2.03	N × P; N × K.	0.1%
	Mg	Nil	Nil	0.25	0.04	0.30	1.18	P × K;	
			K	0.14	0.06	0.39	2.06	N × Ca; P × Mg.	1.0%
		Ca	Nil	0.10	0.07	0.34	1.48		
			K	0.04	0.12	0.48	4.23		
Second Age 94 days	Nil	Nil	Nil	0.18	0.00	0.12	0.00		
			K	0.24	0.00	0.19	0.97		
		Ca	Nil	0.16	0.15	0.19	0.00	N; P; K; Ca.	0.1%
			K	0.12	0.19	0.17	0.77	N × P; N × K; N × Ca.	0.1%
	Mg	Nil	Nil	0.18	0.00	0.06	0.00	P × K; N × P × K.	
			K	0.19	0.12	0.17	0.62	P × Ca; K × Ca.	
		Ca	Nil	0.27	0.24	0.18	0.00	N × P × Ca.	1.0%
			K	0.12	0.29	0.24	3.91	P × K × Ca.	
Third Age 134 days	Nil	Nil	Nil	0.14	0.00	0.11	0.00		
			K	0.27	0.00	0.13	0.00	K; Mg; Ca.	
		Ca	Nil	0.25	0.00	0.15	0.00	N × K; N × Ca.	1.0%
			K	0.11	0.45	0.16	0.81	P × K; N × K × Ca.	
	Mg	Nil	Nil	0.16	0.00	0.15	0.00		
			K	0.29	0.46	0.15	0.67		
		Ca	Nil	0.27	0.47	0.25	0.00		
			K	0.16	0.49	0.25	5.81		

Analysis of data showed that there was a marked and progressive increase in response to all tested nutrients. The pattern of response at successive harvests is shown diagrammatically in Figure I and may be summarised as follows:

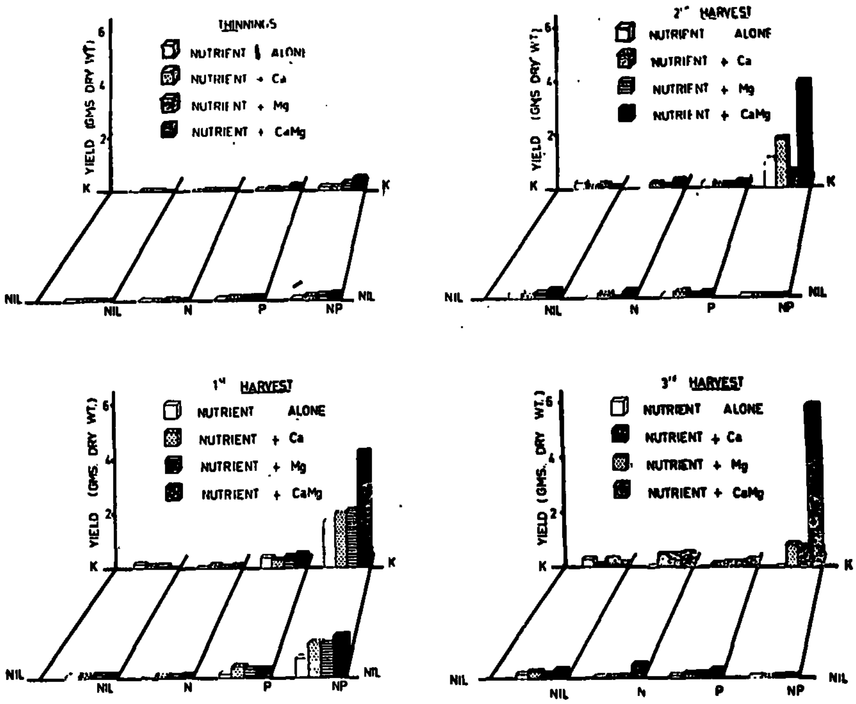

Figure I — Diagram showing the mean yield for the two replicates of all treatments at thinnings and the three successive harvests.

Thinnings:—At this stage although the plants were only 34 days old, all the tested nutrients were responsible for high increments of yields. The effect of N, P, Mg and NP were significant at the 0.1% level while those due to K, Ca, PK, PCa and PMg were significant at the 1.0% level.

1st Harvest:—The plants were 56 days old at this stage. All tested nutrients were responsible for high increments of yields. N, P and K were responsible for increments of 319, 1,105 and 90% respectively, while Ca and Mg increased yields by 69%. All first and the second order interactions of N, P and K were significant at the 0.1% level.

2nd Harvest:—The pattern of response at this stage was essentially similar to that at the 1st harvest, except for that due to Ca which (alone) was responsible for increments of 259%. All plants that received nitrogen without calcium, and the K nil treatments that did not receive N and P, did not register any growth. Yields were very low in the absence of potassium, the addition of which increased yields by 290%. Mg increased yields only by 22%. All 1st and 2nd order interactions of N, P and Ca were significant at the 0.1% level. There was appreciable growth only in the full fertiliser treatments.

3rd Harvest:—At this stage yields were very low except in the full fertilizer treatments. Mg which had little effect at the 2nd harvest was responsible for high increments of yields (280%).

(*d*) *Discussion:*—The data from this experiment shows that the sub-soil at Horekelley Estate is deficient in N, P, K, Ca and Mg. In order to get a measure of their deficiencies and also to compare the nutrient status of this soil with that of the "top-soil" the data were reanalysed and individual yields in the absence of any particular nutrient was expressed as a percentage of that obtained for the full fertilizer treatments (N, P, K, Ca and Mg). The effect due to the absence of individual nutrients is shown diagrammatically in Figs. II to VI.

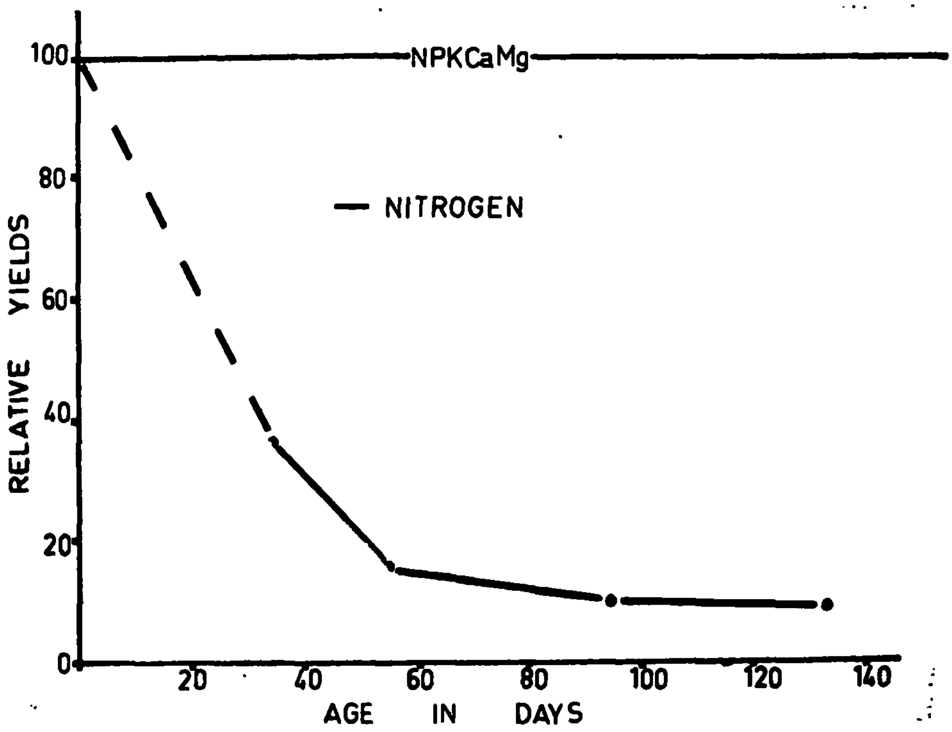

Figure II — Diagram showing the relative yields in the absence of nitrogen at successive stages of growth.

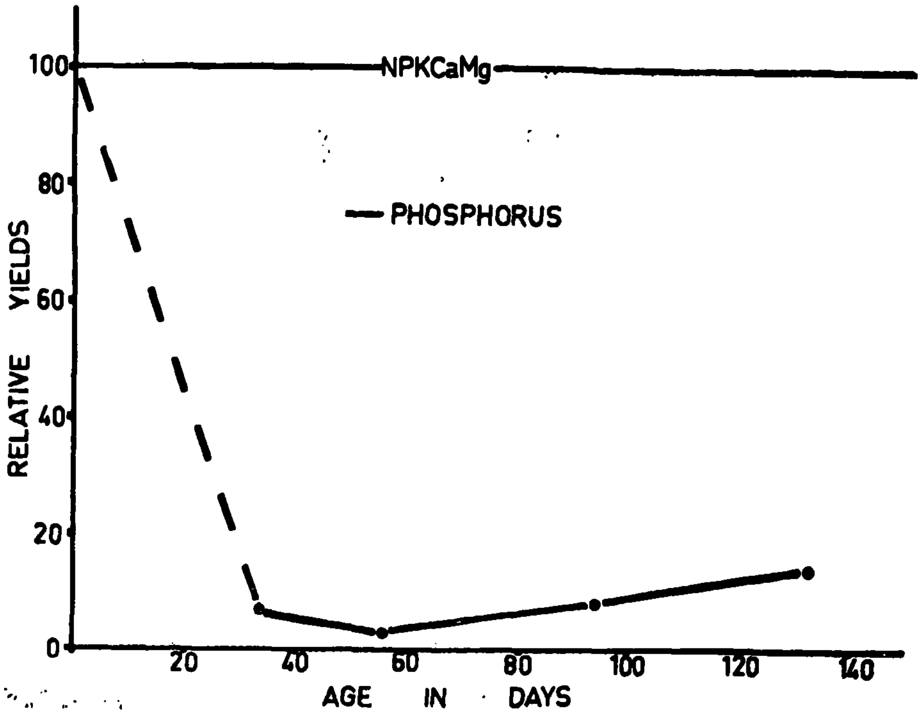

Figure III — Diagram showing the relative yields in the absence of phosphorus at successive stages of growth.

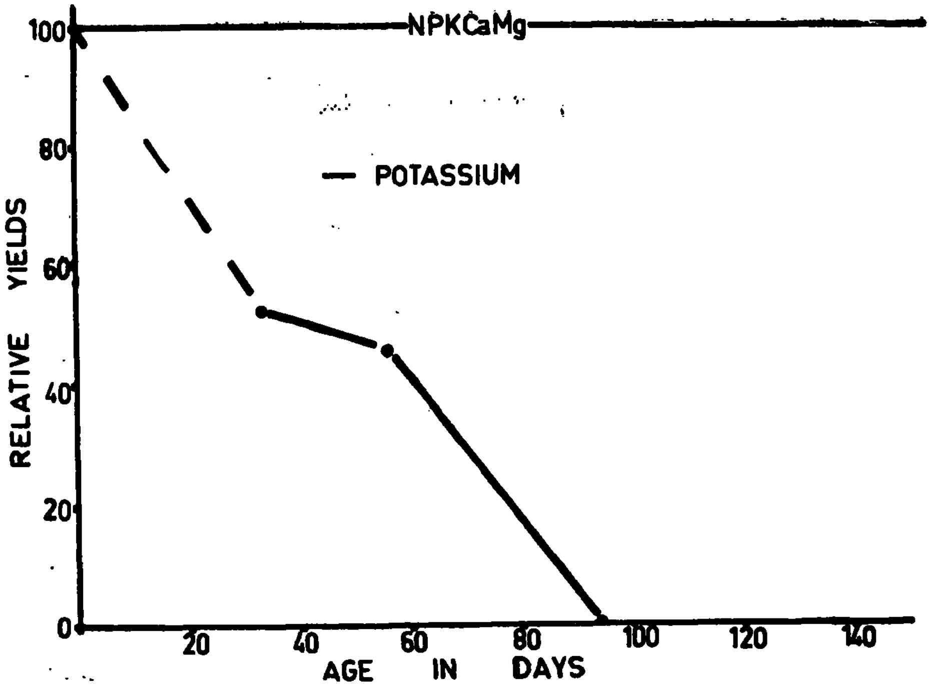

Figure IV — Diagram showing the relative yields in the absence of potassium at successive stages of growth.

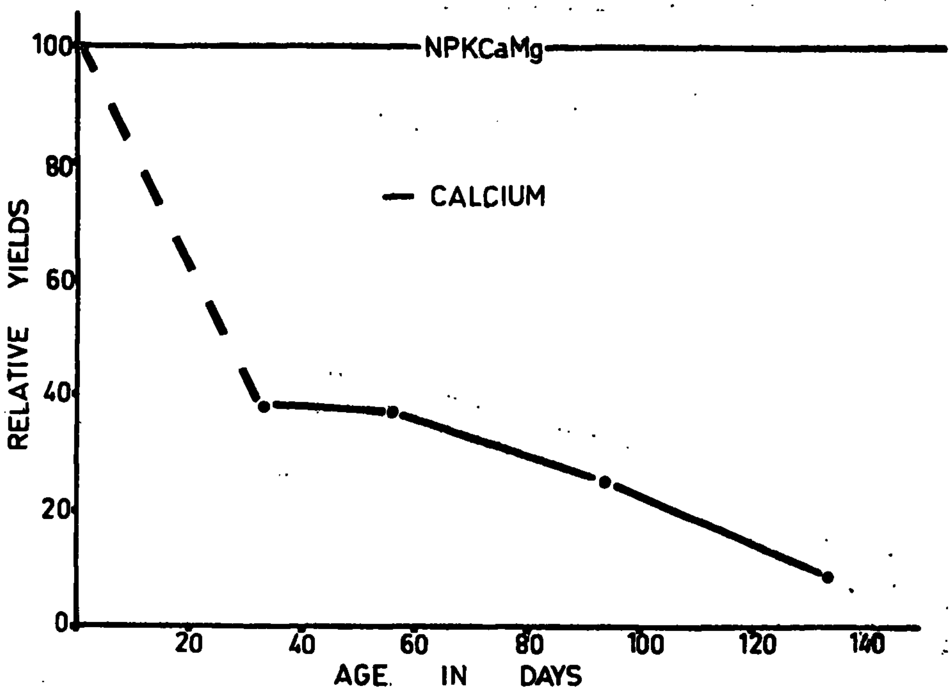

Figure V — Diagram showing the relative yields in the absence of calcium at successive stages of growth.

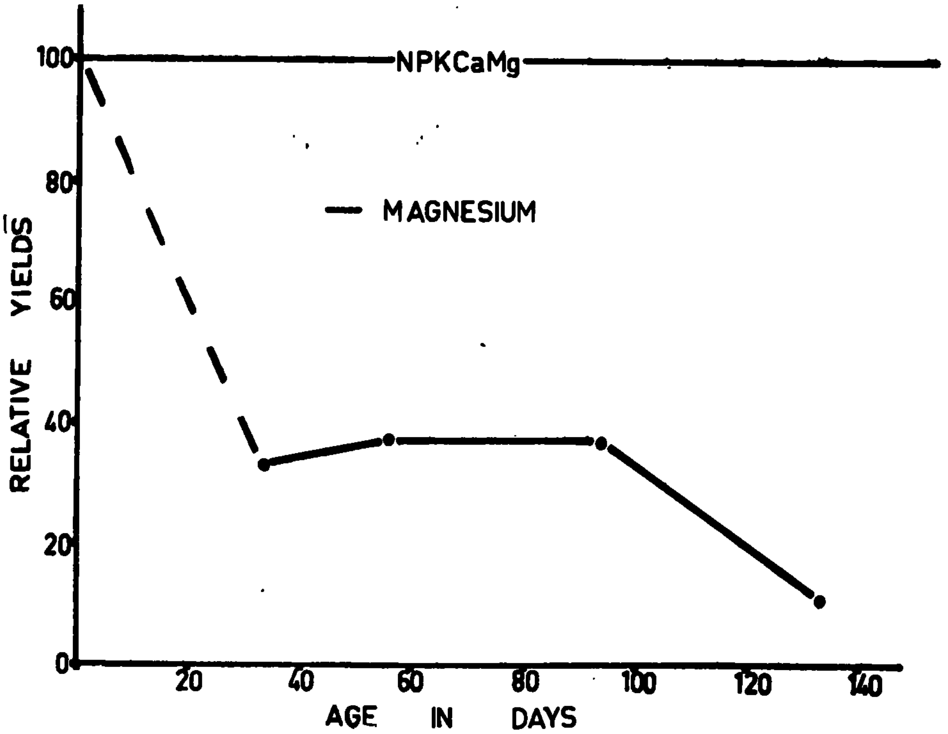

Figure VI — Diagram showing the relative yields in the absence of magnesium at successive stages of growth.

The effect due to the absence of individual nutrients may be summarised as follows:—

Nitrogen:—In the absence of nitrogen, yields decreased by 63% at the thinnings stage. Thereafter the relative yields declined steadily for the three harvests from a value of 15 at the 1st harvest to 9% in the 3rd harvest.

Phosphorus:—Phosphorus was found to be acutely deficient in the sub-soil. Even at the thinnings stage the relative yields were as low as 6 and dropped further to 3% at the 1st harvest. However, from then onwards the relative yields increased steadily through 8 at the 2nd to 19% at the 3rd harvest. This indicates an increase in the available P with age. Such a decreasing response to P at successive harvests has been recorded for the surface soil showing that there is essentially no difference in the response to P in both layers.

Potassium:—In the absence of K relative yields decreased steadily at successive harvests from an initial value of 52 at the thinnings stage through 46 in the 1st to zero in the 2nd and 3rd harvests. All plants in the N treatment that did not recieve P, K and Ca and also those plants in the N treatments that received P but not K died after the 1st harvest. Although there was a steady decline in the relative yields in the absence of K in the surface soil at successive harvests, they did not reach zero even after 140 days.

Calcium:—In the absence of Ca relative yields declined steadily at successive harvests from an initial value of 38 at the thinnings stage through 37 at the 1st and 25 at the 2nd to 9% at the 3rd harvest. This low relative yields in the 3rd harvest is mainly due to the death of plants in the Ca_0 pots that received nitrogen (Ca_0N_5). The death of plants in such treatments may be due to two reasons; either, lack of Ca in sufficient quantities for proper growth, or, due to the lowering of soil pH due to the application of $(NH_4)_2SO_4$. The pHs determined during the course of the experiment are recorded in Table 3.

TABLE 3

Experiment I—Showing mean pH values of nitrogen and calcium treatments

Date	*Treatment*	*Nil*	*$CaCO_3$*
24.10.58	Nil	5.58	6.67
	$(NH_4)_2SO_4$	5.19	6.32
4.12.58	Nil	5.69	6.66
	$(NH_4)_2SO_4$	4.84	5.83

Magnesium:—In the absence of Mg relative yields remained steady at 33% up to the 2nd harvest. However, at the 3rd harvest it dropped to 11%. This was essentially similar in pattern and magnitude to that obtained with the surface soil.

B. Experiment II

(*a*) *Objective:*—To measure the effect of N, Ca, B and Mo on the growth of *Medicago sativa* (L).

(*b*) *Design and procedure:*—This was a 2^4 factorial with two replicates of each treatment. The forms and rate of application of these nutrients used are enumerated in Table 4.

All pots received a basal dressing of P_3, K_3, Mg_1, Fe_7, Cu_7, Mn_7 and Zn_7.

TABLE 4

Experiment II—Showing chemicals used and their rates of application

Designation	*Chemical*	*Rate of application/acre*
N_3	NH_4NO_3	3 cwts. = 118 lbs. N
Ca_{10}	$CaCO_3$	10 cwts. = 4 cwts. Ca
B_6	$Na_2B_4O_7 . 10H_2O$	6 lbs. = 1 lb. B + 1 lb. Na
Mo_2	$(NH_4)_6Mo_7O_{24} . 4H_2O$	2 lbs. = 1 lb. Mo + 0.14 lb. Na
Fe_7	$FeSO_4 . 7H_2O$	7 lbs. = 2.4 lbs. Fe + 0.8 lb. S
Cu_7	$CuSO_4 . 5H_2O$	7 lbs. = 1.8 lbs. Cu + 0.9 lb. S
Mn_7	$MnSO_4 . 4H_2O$	7 lbs. = 1.8 lbs. Mn + 1.0 lb. S
Zn_7	$ZnSO_4 . 7H_2O$	7 lbs. = 1.5 lbs. Zn + 0.8 lb. S

This experiment was planted on 15th November, 1958. There was no germination in the Ca-Nil treatments and was very poor in the N-Nil treatments. The experiment was therefore reconstituted to test B and Mo; N and Ca being made basal treatments. Due to the insufficiency of the calcium added, the seedlings turned pale, and finally died. Therefore, on 22nd June, 1959, a further 10 cwts. of $CaCO_3$ was added and fresh seeds planted. Germination was very poor in the B-Nil treatments. In September, the plants showed signs of withering indicating inadequacy of the added Ca, and a further 10 cwts. of $CaCO_3$ were added on 10th October. At this stage all pots had received a basal dressing of 30 cwts. of $CaCO_3$/acre.

The experiment was harvested thrice, viz. on 2nd October, 19th November, 1959 and 12th January, 1960. During the course of the experiment any other nutrients found deficient were added. The nutrients added were as follows:—

27.10.59. — 3 cwts. NH_4NO_3 per acre.
— 3 cwts. K_2SO_4 per acre.
14.11.59 — 3 cwts. NH_4NO_3 per acre.

(*c*) *Results:*—In all harvests there was a very big response to B. Mo had no effect on yields at any stage. The deficiency of B was so great that there was practically no growth in the B-Nil treatments. The mean cumulative yields for all harvests of all treatments are recorded in Table 5.

TABLE 5

Experiment II—Showing mean cumulative yields of all treatments for all harvests

Nil	*Mo*	*B*	*MoB*
0.29	0.39	2.85	1.95

(*d*) *Discussion:*—The data from the experiment indicate that this soil is acutely deficient in Ca and B. It has been reported that the surface soil was also acutely deficient in these two nutrients.

C. Experiment III

(*a*) *Objective:*—To measure the effect of Fe, Cu, Zn and Mn on the growth of *Paspalum commersonii* (lam.).

(*b*) *Design and procedure:*—This was a 2^4 factorial experiment with two replicates of each treatment. The forms and rates of application are the same as in Experiments I and II (Tables 1 and 4).

This experiment was planted on 26th November 1958 and harvested thrice, viz. on 2nd January, 11th February and 16th March, 1959.

(*c*) *Results:*—None of the tested nutrients except Zn and Cu had any effect on yields. Zn which was responsible for a slight increase in yields in the 1st harvest, depressed yields in the 2nd and 3rd harvests. This negative response was significant at the 1.0% level at the 3rd harvest. Cu was responsible for slight increments of yields at the 3rd harvest which however was not significant. The mean yields for the two replicates of all treatments are recorded in Table 6.

TABLE 6

Experiment III—Showing mean yields for the two replicates of all treatments at successive harvests

Harvest	*Treatment*		*Nil*	*Zn*	*Mn*	*Zn Mn*
1st	Nil	Nil	2.52	3.97	3.90	4.77
		Cu	2.45	2.74	2.07	3.49
	Fe	Nil	3.25	3.14	2.67	2.94
		Cu	2.71	2.81	2.94	3.11
2nd	Nil	Nil	3.65	2.00	3.07	2.89
		Cu	3.13	2.71	2.32	2.01
	Fe	Nil	2.81	2.26	3.33	1.76
		Cu	3.50	2.92	2.64	2.47
3rd	Nil	Nil	3.51	2.64	2.73	1.62
		Cu	3.99	3.28	3.24	2.31
	Fe	Nil	4.01	2.76	3.75	1.09
		Cu	3.33	3.22	3.22	2.52

(*d*) *Discussion:*—The data from this experiment shows that there is no effect due to any of the tested nutrients at the early stage of growth. However, the slight response due to Cu at the later stages indicates an incipient deficiency of this nutrient. Similar results have been obtained with the surface soil.

3. SUMMARY AND CONCLUSIONS

The three experiments carried out with the sub-soil indicate an acute deficiency of N, P, K, Ca, Mg and B. The surface soil was also found to be deficient in all these nutrients.

4. ACKNOWLEDGEMENTS

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5. REFERENCES

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2. Paltridge, T.B. and Santhirasegaram, K.—1957 C.R.I. Bulletin No. 13.