STUDIES ON THE NUTRIENT STATUS OF SOME COCONUT SOILS IN CEYLON

3. The Forest Soil at Ambakelley

(c) The Sub-Soil

By K. SANTHIRASEGARAM and D.E.F. FERDINANDEZ,
Acting Agrostologist and Technical Assistant,
Coconut Research Institute of Ceylon.

Introduction

The nutrient status of the top layers of this soil was studied by Paltridge and Salmond (1) in 1957. The present studies deal with a layer some four to five feet below the surface.

According to the previous authors 'the soil at Ambakelley is a light sandy loam generally about five feet in depth over-lying a layer of rounded pebbles which is, itself, about two feet in thickness. Beneath these pebbles is a hard pan 6 to 12 inches thick and the sub-soil is a stiff brownish clay'. The present studies deal with this clayey sub-soil.

The top soil was found to be acutely deficient, in N, P and K for optimum growth of *Paspalum commersonii*. No deficiency of calcium was evident in the early stages of growth. But at a later stage however (after 137 days) slight increase in yields was obtained from an original dressing of 10 cwt. /acre $CaCO_3$. No evidence of any deficiency of other nutrients was observed. Based on this, only the effect of major nutrients was assessed here.

Further studies with the top soil by Santhirasegaram and Salmond (2) confirmed the deficiency of N, P and K requiring 2 cwt./acre of $NaH_2PO_4.2H_2O$ and K_2SO_4 for optimal growth of *Paspalum commersonii* (Lam) with periodic application of 1¼ cwt./acre $(NH_4)_2SO_4$.

In preparing samples of the soil an area of the virgin jungle was selected where this layer was known to be nearest to the surface and ten pits were dug at random. The pebbles and coarse vegetable matter (roots) were as far as possible avoided and the samples were then transported to the laboratory and thoroughly mixed to provide uniform material.

The pots used in the experiments were 6" polysterene flower pots with no drainage holes. Each pot contained approximately 2,000 gms. of the soil. The pots were watered daily, their water content being brought to constant level (85 per cent field capacity) by weight. The water used was rain-water filtered, passed through a commercial water softner, distilled and re-distilled. The final distillation was in pyrex glass. The test plant was *Paspalum commersonii* (Lam). All plants were raised from seeds. The response to the treatments were measured in terms of grams. dry weight of plant material harvested one inch above soil level. All nutrients were A.R. Chemicals. The dosage (amount/pot) was calculated as lb. or cwt./acre. All nutrients were applied as solution except calcium which was applied as powder (as calcium carbonate) and mixed with the top 1½" of soil in the pots. The experiments were conducted in the Institute's Phytosolarium.

2. Experimental

Experiment 1

(i) *Objective.*—To measure the effect of major nutrients (N, P, K, Ca and Mg) on the yield of *Paspalum commersonii* (Lam) growing on the sub-soil at Ambakelley.

(ii) *Design and Procedure.*—This was 2^5 factorial experiment with two replicates of each treatment.

All pots received a basal dressing of the minor nutrients except boron which however was present in sufficient quantities for satisfactory growth of the test plant. The forms and rates of application of the nutrients are enumerated in Table I. These are identical to those used for a similar experiment with the top soil.

TABLE I

Forms and Rates of Nutrient applied in Experiment 1

Designation	*Chemical*	*Rate of Application*
N_5	$(NH_4)_2SO_4$	5 cwt./acre = 118 lb. N + 135 lb. S.
P_3	$NaH_2PO_4\ 2H_2O$	3 cwt./acre = 67 lb. P + 49 lb. Na.
K_3	K_2SO_4	3 cwt./acre = 150 lb. K + 70 lb. S.
Ca_{10}	$CaCO_3$	10 cwt./acre = 440 lb. Ca
$Mg_{1\frac{1}{2}}$	$MgSO_4\ 7H_2O$	1½ cwt./acre = 18 lb. Mg + 21 lb. S.
Fe_{14}	$FeSO_4\ 7H_2O$	14 lb./acre = 2.8 lb. Fe + 1.6 lb. S.
Cu_{14}	$CuSO_4\ 5H_2O$	14 lb./acre = 3.6 lb. Cu + 1.8 lb. S.
Zn_{14}	$ZnSO_4\ 7H_2O$	14 lb./acre = 3.0 lb. Zn + 1.6 lb. S.
Mn_{14}	$MnSO_4\ 2H_2O$	14 lb./acre = 3.5 lb. Mn + 2.0 lb. S.
Mo_1	$(NH_4)_6Mo_7O_{24}\ 4H_2O$	1·4 lb./acre = 0.5 lb. Mo + 0.7 lb. N.

The experiment was planted on 1st October, 1958 and harvested three times viz. 25th November, 2nd January 1959 and 11th February. In addition to these harvests, at an early stage, when there were two plants per pot and when reducing this to one per pot (30th October), the extra plant removed was dried and weighed (designated 'thinnings') to obtain additional data of the response at that stage of growth.

During the progress of the experiment any nutrient that appeared to have a beneficial effect and therefore required for growth was re-applied so as to be available in sufficient quantities.

Such applications were as follows:

On 19th November, 1958 — 2½ cwt./acre $(NH_4)_2SO_4$ was applied to all N_5 treatments.

On 29th December — Half the original dose of N, P and K were applied to the respective pots.

On 26th January, 1959 — 2½ cwt./acre $(NH_4)_2SO_4$ was applied to all N_5 treatments.

(iii) *Results.*—Magnesium had no significant effect on yields in any harvests, and the mean yields for four replicates (two of each Nil and Mg) are recorded for successive harvests in Table II.

TABLE II

Showing mean yields of all treatments affecting the growth of *Paspalum commersonii*.

HARVESTS			*Nil*	*N*	*P*	*NP*
Thinnings	Nil	Nil	0.015	0.015	0.060	0.230
		K	0.010	0.015	0.085	0.160
	Ca	Nil	0.010	0.020	0.060	0.230
		K	0.010	0.010	0.060	0.210
1st Harvest	Nil	Nil	0.170	0.100	0.420	3.170
		Ca	0.150	0.050	0.380	3.110
	Ca	Nil	0.130	0.030	0.410	3.840
		K	0.150	0.040	0.390	6.350
2nd Harvest	Nil	Nil	0.140	0.105	0.120	1.020
		K	0.180	0.080	0.160	0.870
	Ca	Nil	0.190	0.030	0.220	1.460
		K	0.220	0.130	0.290	2.520
3rd Harvest	Nil	Nil	0.110	0.080	0.170	0.000
		K	0.120	0.000	0.140	0.000
	Ca	Nil	0.100	0.130	0.280	0.850
		K	0.170	0.190	0.280	9.180

At the 'thinnings' stage only N and P had any significant effect of yields, both individually and in combination. But from the first harvest onwards the other two nutrients (K and Ca) also had highly significant effects. This pattern of responses was consistent. Mean yields for the various treatments are shown diagrammatically in Figs. I and II, and their effects may be summarised as follows:—

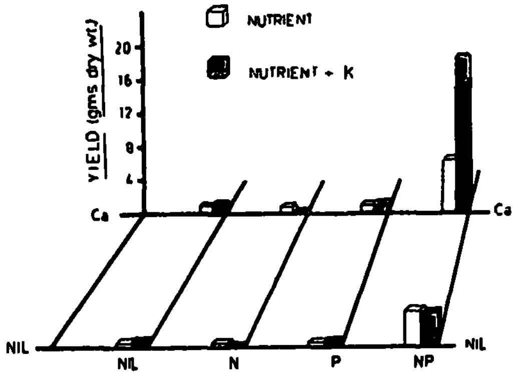

Fig. I

Experiment 1. Diagram showing cumulative yields from three successive harvests of *Paspalum commersonii.*

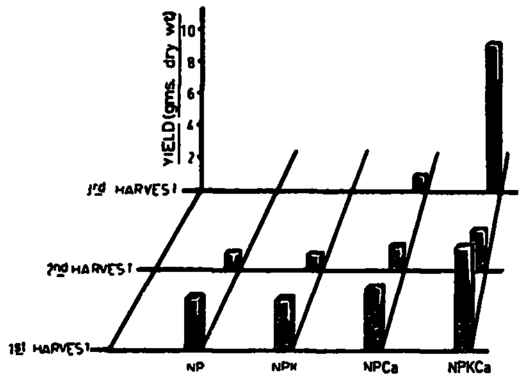

Fig. II

Experiment 2. Diagram showing mean yields of effective treatments in three successive harvests of *Paspalum commersonii.*

'Thinnings'

At this stage the plants were only thirty days old, yet, some definite information was obtained. The response to N, P and NP were significant at the 0.1 per cent level indicating the acuteness of the deficiencies of these nutrients. None of the other nutrients had any effect at this stage.

1st Harvest

At this stage the plants were eight weeks old. Except magnesium, all other nutrients tested had increased yields significantly. There was virtually no growth in absence of nitrogen and phosphorus. This is clearly shown in the following relative yields where yield for NP is taken as 100.

Nil	*N*	*P*	*NP*
3.65	1.35	9.46	100.0

K alone and Ca alone increased yields by 21.7 per cent and 33.0 per cent relatively. All combinations of these four nutrients up to the second order were significant at the 0.1 per cent level.

2nd Harvest

The data from this harvest is somewhat different from the previous harvest. The effect or N, P and Ca both individually and in various combinations were responsible for significant increase in yields; the magnitude of response however was much less marked than in the first harvest. But on the other hand potassium was without any effect on the yield and did not enter into any interaction with other nutrients.

3rd Harvest

After the second harvest a good number of plants failed to make regrowth and were dead. This was particularly so in the nitrogen treatments that did not receive any calcium (N_5CaO treatments). Thus the plants at this stage were suffering from acute deficiency of N, P and Ca. Further potassium which did not have any effect at the second harvest was responsible for very high increase in yields and entered into positive interactions with the other three nutrients. At this harvest as the data would indicate, all plants except those that received N, P, K and Ca were dead or very poor.

The highest yield obtained from treatments not containing all four of these nutrients was 1.40 gms. compared to an average of 9.18 gms, from the N, P, K, Ca treatments. After this harvest all plants except those of the N, P, K, Ca treatments died and the experiment was discontinued.

(iv) *Discussion.*—If the data from the second harvest were not taken into consideration, it would appear that the pattern of response to the various nutrients indicate an increasing deficiency with age. The abnormality at the second harvest however was, most probably, due to lack of sufficient quantity of some nutrient. As all plants showed acute nitrogen deficiency during the growth prior to this harvest, and because the effect of phosphorus was very dominant at the first harvest, half the original dose of N, P and K were re-applied four days (29th December) prior to the harvest. This extra dose gave rise to good growth of the plants, particularly in the complete fertilizer and the magnitude of responses followed the same pattern as that of the first harvest. This justifies our explanation that the lack of response to K at 2nd harvest was due to lack of sufficient quantity of the nutrient.

In order to obtain some measure of the degree of these deficiencies and to compare the nutrient status of this layer with that of the top-soil, the data were reanalysed, wherein, mean yields of treatments in absence of particular nutrients were expressed as a percentage of that obtained with full fertilizer treatments (N, P, K, Ca). The response in absence of individual nutrients with age is shown diagrammatically in Fig. III.

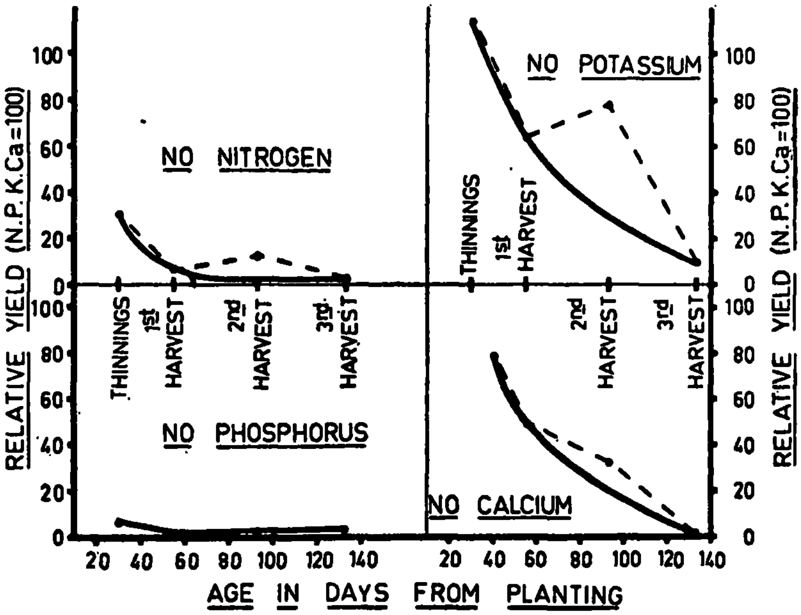

Fig. III

Experiment 1. Diagram showing trend of mean relative yields on successive harvests of *Paspalum commersonii.*

Nitrogen

Even at the early stages, absence of nitrogen reduced the yield to 30 per cent at 'thinnings' and to about 5 per cent at first harvest. Thereafter there had been a steady decrease. This pattern of response is similar to that reported for the top soil by Paltridge and Salmond. For the top soil however the yield at first harvest was higher than for the sub-soil. Within the limit of comparison of the two data it would appear that the top soil is slightly richer in nitrogen than the sub-soil.

Phosphorus

The yield in absence of phosphorus was even less than that obtained in absence of nitrogen. At no stage was it more than 5 per cent. This yield is again much less than that obtained for the top soil (40 per cent) indicating an even more acute deficiency at the sub-soil. The diagram showing the trend of mean relative yields in successive harvests with the top soil is reproduced in Fig. IV for comparison.

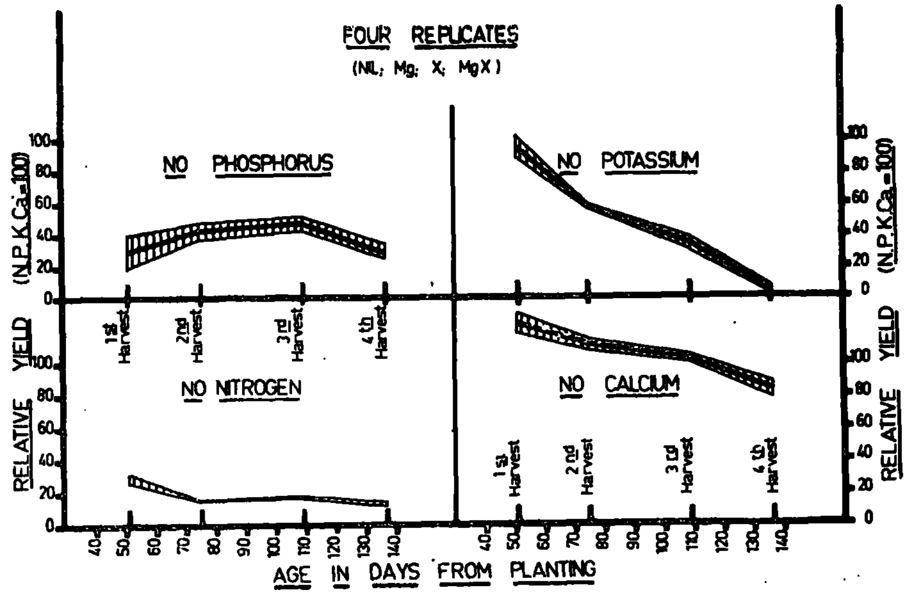

Fig. IV

Diagram showing trend of mean relative yields (± S.D.) in successive harvests of *Paspalum commersonii* growing in top soil of Ambakelley. (Reproduced from Paltridge and Salmond. C.R.I. Bulletin No. 14).

Potassium

In absence of potassium mean relative yields decreased steadily from an initial value of 113 per cent at 'thinnings' to 9 per cent at the third harvest. This pattern is essentially similar to that obtained with the top soil even in magnitude.

Calcium

At 'thinnings' the yield in absence of calcium was 80 per cent and at first harvest 50 per cent. In the top soil the values for the first two harvests were above 100 indicating depression due to calcium and a slight indication of deficiency was recorded only at the fourth harvest when yields dropped to 83 per cent. Here however, all plants in absence of calcium were dead indicating acute deficiency.

The plants in the 'no calcium' treatments immediately after the second harvest showed symptoms on the young leaves that were emerging, which were associated with young plants following application of ammonium sulphate. (It should be noted that four days prior to the second harvest, half dose of N, P and K were re-applied to appropriate pots). This was due to the ammonium sulphate increasing the acidity particularly in the no calcium treatments and the consequent death of plants. Mean pH's in the N Ca combination were as follows:—

Nil	*N*	*Ca*	*NCa*
6.31	4.65	8.63	6.87

Experiment 2

(i) *Objective.*—To study the effect of two forms of nitrogen in presence and absence of calcium in different forms on the growth of *Paspalum commersonii* (Lam) and the pH of the sub-soil at Ambakelley.

(ii) *Design and Procedure.*—This was a 2 × 3 factorial experiment with three replicates of all treatments. Nitrogen was applied as NH_4NO_3 and $(NH_4)_2SO_4$ in equivalent amounts of N (118 lb. N/acre); and calcium as nil, carbonate and sulphate in equivalent amounts of Ca (440 lb. Ca/acre). All pots received a basal dressing of P (NaH_2PO_4 $2H_2O$ 3 cwt./acre) and K (K_2SO_4 3 cwt./acre). The experiment was planted on 14th February 1959 and harvested twice viz. 23rd March and 2nd May. On 18th March the nitrogen treatments were reapplied at half rate. pH measurements were made at the time of each harvest.

(iii) *Results.*—At first harvest there was a significant difference (0.1 per cent) between the two forms of nitrogen but there was no difference between the forms of calcium and the N Ca interaction was not significant. It was observed that NH_4NO_3 treatments yielded 52.65 gms. as compared to 27.72 gms. from $(NH_4)_2SO_4$ treatments.

At the second harvest however, while the difference between the forms of nitrogen was maintained as in the previous harvest, the N Ca interaction was significant as the following total yields would show:

	Nil	*$CaSO_4$*	*$CaCO_3$*
NH_4NO_3 ..	3.33	3.67	3.83
$(NH_4)_2SO_4$ ..	0.00	0.15	1.40

(iv) *Discussion.*—It will be noted that at the second harvest in the case of $(NH_4)_2SO_4$ there was hardly any growth in the Nil and $CaSO_4$ treatments, while there was considerable growth in the $CaCO_3$ treatment. On the other hand there was no difference over the various treatments of calcium with NH_4NO_3.

That these responses are correlated to the pH of the soils will be shown by the mean pH measured following first harvest.

	Nil	*$CaSO_4$*	*$CaCO_3$*
NH_4NO_3 ..	4.3	4.8	7.0
$(NH_4)_2SO_4$ ..	3.5	3.6	6.3

Over all treatments of calcium the pH is low with $(NH_4)_2SO_4$ than with NH_4NO_3 and in the case of $CaCO_3$ the values are higher than with the no calcium and $CaSO_4$ treatments.

At this stage it has to be pointed out that this acidity due to ammonium sulphate has been encountered with other soils too.

The change in pH would have direct as well as indirect effect on the growth of plants. Direct increase in acidity would interfere with certain metabolic activities and thus bring about a reduction in growth, indirectly some of the mineral nutrients may be made unavailable particularly trace elements (3).

In this soil it was observed that application of $(NH_4)_2SO_4$ did not interfere with the growth of plants in the top soil and consequently there was no response to $CaCO_3$; while in the sub-soil the acidity caused by the application of $(NH_4)_2SO_4$ had to be corrected with application of $CaCO_3$.

3. Summary and Conclusions

Two experiments were carried out with the sub-soil at Ambakelley.

The sub-soil was found to be deficient in N, P and K for the growth of *Paspalum commersonii*, as was the top soil. Comparison of the relative yields indicate that the sub-soil is more deficient in nitrogen and phosphorus than the top soil. The pattern of response however, appear to be similar in both cases.

Unlike the top soil, the sub-soil gave marked response to calcium.

4. Acknowledgement

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5. Bibliography

(1) Paltridge, T.B. and Salmond, Beryl (1957) C.R.I. Bulletin No. 14.

(2) Santhirasegaram, K. and Salmond, Beryl (1959) Ibid. (in print).

(3) Small, J. (1946) pH and Plants. Baillièré Tindell and Cox, London.