Studies on the Nutrient Status of some Coconut Soils in Ceylon

6. The Loamy soils from Vanathivillu (A) Preliminary Studies

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INTRODUCTION

VANATHIVILLU is situated thirteen miles north of Puttalam and two miles inland. Patches in the area have been cleared and planted with coconuts in the past. More recently the area has been extensively cleared for planting with coconuts under a Middle Class Colonization Scheme.

The climate of the area has been described in terms of C_1 A 'a' by Koelmeyer (1958) based on Thornthwaite (1948) classification. The topography is gently undulating, with dry zone type forest on the crests changing gradually to open thorny scrubs on the slopes and to villus in the depressions which are subject to inundation with the monsoonal rains.

The soil types are on a catenary sequence with deep reddish sandy clay loam on the crests changing to yellow on the slopes, and a whitish sandy loam at the level of the villus (Fig. 1). The last is less extensive and is not considered to be of economic importance. The area has been surveyed in detail by Perera (1963).

In these studies only the red loam and the yellow loam under forest, from recently cleared areas and under an old coconut plantation were considered.

The technique employed in collecting soil samples, setting up and maintenance of experiments and recording of data was essentially similar to that employed by Paltridge and Santhirasegaram (1957). The test plants were *Paspalum commersonii* (Lam), *Phaseolus lathyroides* (L), *Sesamum indicum* (L) and *Medicago sativa* (L).

EXPERIMENTAL

A. *Experiments to assess the status of major nutrients* (N, P, K, Ca and Mg)

These experiments were carried out on the two soil types under the three conditions and planted with three species. The forms and rates of the nutrients applied, both as treatments and as basal are given in Table 1.

TABLE 1.—Forms and rates of nutrients applied

(*Basal nutrients)

Nutrient	*Chemical*	*Rates of application cwt. or lb./ac.*
N	NH_4NO_3	3 cwt. = 118 lb. N
P	$NaH_2PO_4\ 2H_2O$	3 cwt. = 67 lb. P + 49 lb. Na
K	K_2SO_4	3 cwt. = 150 lb. K + 70 lb. S
Ca	$CaCO_3$	10 cwt. = 448 lb. Ca
Mg	$Mg\ SO_4 7H_2O$	1 cwt. = 12 lb. Mg + 14·6 lb. S
Fe*	$Fe\ SO_4 7H_2O$	7 lb. = 1·4 lb. Fe + 0·8 lb· S
Cu*	$Cu\ SO_4 5H_2O$	7 lb. = 1·8 lb. Cu + 0·9 lb. S
Zn*	$Zn\ SO_4 7H_2O$	7 lb. = 1·5 lb. Zn + 0·8 lb. S
Mn*	$Mn\ SO_4 2H_2O$	7 lb. = 1·8 lb. Mn + 1·0 lb. S
Mo*	$(NH_4)_6Mo_7O_{24}4H_2O$	1 lb. = 0·5 lb. Mo + 0·07 lb. N

All experiments were of a 2^5 factorial design of N, P, K Ca and Mg with two replicates planted with *P. commersonii* and harvested thrice (except in the case of the red loam, under new clearings, which was harvested only twice) ; one replicate planted with *P. lathyroides* and harvested twice, and one replicate planted with *S. indicum* where only seeds were harvested. The experiment with *P. commersonii* on the red loam under forest was maintained up to the fifth harvest to study the changes in response to the various nutrients with time.

B. Experiments to assess the status of Sulphur.

These experiments were carried out on the red leam and the yellow loam under forest only, and planted with *P. commersonii* and *P. lathyroides*. The design was a simple comparison of four treatments (Nil, NH_4NO_3, NH_4NO_3 + elemental S and $(NH_4)_2SO_4$) with four replicates. The amount of N (118 lb./ac.) and S (136 lb./ac.) wherever applied were in equivalent amounts. A basal application of P(3 cwt./ac. NaH_2PO_4. $2H_2O$) and K(3 cwt./ac. KCl) was made. The experiments were harvested on two occasions for both species.

C. Experiments to assess the status of minor nutrients.

(*a*) Fe, Cu, Zn and Mn in the presence and absence of Ca : These experiments were carried out on the red loam and the yellow loam in new clearings only, and planted with *P. commersonii* and *M. sativa*. The design was 2^5 factorial with the minor nutrient treatments applied at 14 lb./ac. and Ca at 10 cwt./ac. of the chemicals given in Table I. All other nutrients were applied as basal, at the same rates as in Table I.

(*b*) *Experiments to assess the status of Mo and B.*

These were 2^5 factorials of two levels of Mo (O and 2 lb./ac. $(NH_4)_6 Mo_7 O_4 4H_2O$) and B (O and 6 lb./ac. $Na_2B_4O_7$. $10H_2O$) on the red loam and the yellow loam from new clearing planted with *M. sativa*. All other nutrients were applied as basal.

RESULTS

A. Major nutrients (N, P, K, Ca and Mg)

With the grass and the legume highly significant increases in yield due to nitrogen, phosphorus and potassium were recorded. Total yields from the various harvests for the three species are shown in Tables 2-4. In the case of *S. indicum*, while the response to nitrogen and phosphorus was as marked as in the other two species, the response to added potassium was either less marked or non-existent. This was probably due to the lower yield (see later).

TABLE 2.—Effect of N, P and K on the total yield (gm. dry matter) of *P. commersonii* grown on the two soil types under the three conditions

Soil	*Nutrients*			*Under Forest*	*New Clearing*	*Under Plantation*
Red	Nil	Nil	Nil	3·55	5·46	10·84
			K	4·75	10·47	11·72
		P	Nil	39·20	41·44	24·16
			K	33·70	44·37	22·80
	N	Nil	Nil	4·62	5·45	16·09
			K	4·83	3·10	11·91
		P	Nil	144·52	54·68	66·09
			K	203·33	54·67	84·95
Yellow	Nil	Nil	Nil	7·05	4·95	21·54
			K	9·15	5·43	20·99
		P	Nil	23·97	13·61	32·11
			K	22·95	27·57	25·79
	N	Nil	Nil	8·99	11·97	42·56
			K	18·00	13·58	43·30
		P	Nil	148·23	82·00	59·62
			K	239·99	140·52	79·49

TABLE 3.—Effect of N, P and K on the total yield (gm. dry matter) of *P. lathyroides* grown on the two soil types under the three conditions

Soil	*Nutrients*			*Under Forest*	*New Clearing*	*Under Plantation*
Red	Nil	Nil	Nil	0·20	1·35	0·16
			K	0·23	0·72	7·00
		P	Nil	25·39	33·65	24·42
			K	21·34	37·94	27·15
	N	Nil	Nil	0·41	0·42	2·41
			K	0·47	0·62	3·43
		P	Nil	31·97	35·95	30·71
			K	37·29	46·59	31·73
Yellow	Nil	Nil	Nil	0·49	0-97	13·53
			K	0·79	0-90	15·58
		P	Nil	28·57	39·85	25·65
			K	31·13	46·82	27·04
	N	Nil	Nil	1·00	0·69	14·25
			K	1·49	0·85	14·01
		P	Nil	36·65	46·39	26·55
			K	43·49	56·20	33·35

TABLE 4.—Effect of N, P and K on the seed yield (gm.) of *S. indicum* grown on the two soil types under the three conditions

Soil	*Nutrients*			*Under Forest*	*New Clearing*	*Under Plantation*
Red	Nil	Nil	Nil	0·00	0·00	0·52
			K	0·00	0·00	0·52
		P	Nil	1·63	1·36	1·44
			K	1·25	1·18	0·64
	N	Nil	Nil	0·00	0·00	0·44
			K	0·00	0·00	0·42
		P	Nil	9·00	4·61	7·85
			K	11·89	3·30	7·00
Yellow	Nil	Nil	Nil	0·00	0·00	0·76
			K	0·00	0·00	0·52
		P	Nil	0·27	0·61	0·93
			K	0·26	0·62	0·83
	N	Nil	Nil	0·00	0·00	6·55
			K	0·00	0·00	9·05
		P	Nil	6·54	2·07	6·44
			K	7·23	1·94	7·88

Calcium and magnesium were without effect on the total yield. At the early stages of growth, calcium entered into minor negative interactions mainly with phosphorus and nitrogen in some of the soils (Table 5).

TABLE 5.—The interactions of Ca with P and N in combination on the yield (gm. dry matter) of *P. commersonii* and *P. lathyroides* grown on the red loam and the yellow loam under the three conditions. (*Sig. at 5% level)

				Under Forest		*New Clearing*		*Under Plantation*	
				P.c.	P.l.	P.c.	P.l.	P.c.	P.l.
R	H_1	P.		79·12	26·16	71·63	34·14	73L·2	37·65
		P. Ca		67·95	13·39*	86·90*	22·80*	59·27*	35·65
	H_2	P.		86·59	42·68	19·23	49·90	19·11	19·60
		P. Ca		86·79	33·76*	17·40	47·29	15·47	21·55
Y	H_1	P.		89·32	40·71	54·64	40.74	59·43	37·89
		P. Ca		80·07	34·89	55·28	31·78*	63·07	34·84
	H_2	P.		64·10	33·09	56·33	59·70	24·59	18·14
		P. Ca		64·15	31·15	38·10*	57·04	24·93	21·69
R	H_1	N.		70·33	19·23	38·23	20·75	62·94	22·34
		N. Ca		52·99*	7·54*	47·64	12·15	49·57	19·9
	H_2	N.		75·96	22·66	18·07	27·13	20·05	12·69
		N. Ca		75·35	20.71	13·96	23·55	14·48*	13·28
Y	H_1	N.		84·08	26·05	47·89	25·77	61·11	25·84
		N. Ca		74·89	22·67	46·42	18·53	55·85	22·03
	H_2	N.		62·58	18·23	55·41	30·37	34·26	17·92
		N. Ca		61·31	15·68*	36·22*	29·46	37·23	22·33

Magnesium entered into a positive interaction with nitrogen in the yellow loam under forest at the second harvest (Table 6).

TABLE 6.—The effect of P and Mg, and N and Mg on the yield (gm. dry matter) of *P. commersonii and P.lathyroides* grown on the yellow loam under forest

(*Sig. at 5% level)

	P	*P. Mg*	*N.*	*N. Mg.*
P.c.	56·92*	71·33	53·71*	70·18*
P.l.	28·53*	35·71	14·84	19·07

The change in the magnitude of the response to the three effective nutrients with time was followed with the red loam under forest. The yield in the absence of a particular nutrient was calculated as a percentage of that in the presence of all positively effective nutrients. These are presented in Fig. 2.

In the absence of nitrogen a relative yield of 61.3 % was recorded at " thinnings " when the plants were 25 days old. At first harvest when the plants were 42 days old a value of 17.5 % was recorded. Thereafter, there was little change, and at the final harvest, 157 days from planting, a value of 13.1 % was recorded.

In the absence of phosphorous there was very little growth. The relative yield at " thinnings " was 6.2 % which dropped to almost nil from the first harvest onwards.

In the absence of potassium relative yields from " thinnings " to the 3rd harvest fluctuated around 70 %. At the 4th harvest it dropped to 51.7 % and at the final harvest a very low value of 8.3 % was recorded. This rather sudden drop at the latter stages of growth and death of plants in the absence of added potassium has been recorded in other soils too.

The response from the two soil types to the various major nutrients was essentially similar. There were however minor variations under the various vegetational conditions. The dry matter yield of plants grown on soils under the coconut plantation in the absence of added nitrogen, phosphorous and potassium was much higher than under forest and clearings. In the case of *S. indicum* there were no seeds produced from soils under forest and clearings while under the coconut plantation the red and the yellow loams produced 0.52 and 0.76 gm. respectively. In the presence of nitrogen, phosphorous and potassium the yields from soils under the coconut plantation were generally lower than that from the other two conditions.

In the new clearing, there was no response to nitrogen and potassium at the first harvest. From the second harvest onwards, however, the response was similar to the other vegetational conditions.

B. *Sulphur*

Both species responded to S in the two soils (Table 7). In the red loam $NH_4 NO_3$ + S was superior to $(NH_4)_2 SO_4$ while this was not significant in the yellow loam.

TABLE 7.—The effect of forms of N and S on the yield (gm. dry matter) of *P. commersonii* and *P. lathyroides* grown on the red loam and the yellow loam under forest

	Red		*Yellow*	
	P.c.	P.l.	P.c.	P.l.
Nil ..	9·82..	10·27..	8·99..	10·38
NH_4NO_3 ..	18·25..	10·04..	14·88..	8·75
NH_4NO_3+S ..	51·31..	12·97..	63·00..	12·32
$(NH_4)_2SO_4$ ..	46·45..	9·89..	60·95..	13·39
L. s. d. (5%) ..	3·92	1·80	7·63	5·14

C. *Minor nutrients*

None of the minor nutrients had any effect on the yields of the two species tested.

DISCUSSION

The red and the yellow sandy clay loams from Vanathivillu appear to be essentially similar in their nutrient status. Clearing of the natural vegetation is usually by felling the plants, and when dry, burning them *in situ*. By this way, considerable amounts of mineral nutrients would be returned to the soil. This coupled with release of the nutrient due to burning may account for the lack of response to potassium at the first harvest in the soils from new clearings. Similar augmentation of nitrogen is most unlikely. The lack of response to this nutrient at the first harvest probably was due to other factors such as abundant growth of leguminous herbs as pioneer colonizers of new clearings. Whatever the source of supply of potassium and nitrogen, they were not of much consequence as significant positive responses were recorded at the next harvest.

Under forest and plantation conditions, soil nitrogen was not sufficient for satisfactory growth even up to the first harvest and an acute deficiency was experienced at all stages. Phosphorous was available even to a lesser extent, and there was virtually no growth in its absence.

The pattern of response recorded for potassium, where in its absence yields dropped sharply at the latter stages leading to death of plants, has been recorded in other soils too. With the lateritic soils at Bandirippuwa, it was suggested by Paltridge and Santhirasegaram (1957)

that it was most probably due to fixation of potassium on wetting. Karim and Malik (1957) showed that in a clay loam, potassium fixation was marked at high pH, high calcium content and high moisture content. Fixation was also found to increase with time. These conditions were ideally met with in the present experiments.

The clay minerals in the Vanathivillu soils were mainly kaolinite with traces of montmorillonite (Perera, personal communication). Dowdy and Hutchinson (1963) and Richards and Mclean (1963) have shown that kaolinite would fix only very small quantities of potassium compared to minerals such as montmorillonite and illite.

The lack of positive response and the few depressive effects recorded with calcium may be explained as due to the presence of an abundance of that nutrient in the soils. The negative interaction of calcium and phosphorus may be due to immobilization of the latter by the former in already highly phosphorous deficient soils. Usually a legume would be expected to require more calcium than a grass, but depressive effect of calcium wherever recorded was of the same magnitude or more so with the legume than the grass. This again may be due to the effect of calcium on phosphorus.

The magnesium status may be described as incipient deficiency, needing further confirmatory studies. The soils are deficient in sulphur. The low response in the red loam from $(NH_4)_2\ SO_4$ compared to (NH_4NO_3 + S) may be associated with greater loss of nitrogen from the former. These soils are adequately supplied with minor nutrients.

SUMMARY

The status of the plant nutrients, in the red sandy clay loam and the yellow sandy clay loam on the Vanathivillu catena, sampled from under forest, from new clearings and under coconut plantations was studied in pots.

All soils were acutely deficient in nitrogen, phosphorus and sulphur. They were also deficient in potassium whose effect was less marked at the early stages but increased with time. There was no deficiency of calcium. Magnesium had very little effect and is considered to exhibit incipient deficiency.

The minor nutrient status was studied on the two soil types sampled from new clearings. Both soil types were found to be adequately supplied with all the minor nutrients.

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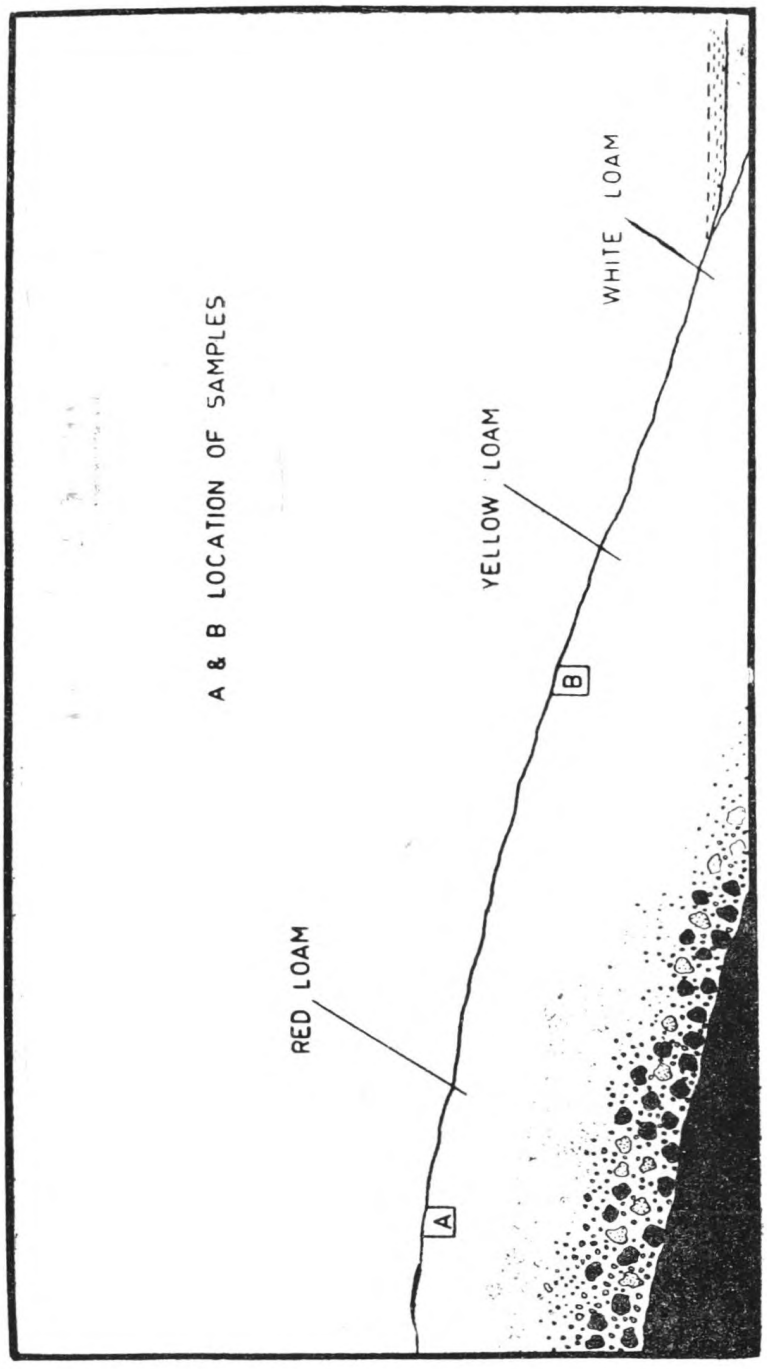

Fig. I.—Diagramatic representation of the Vanathivillu Catena

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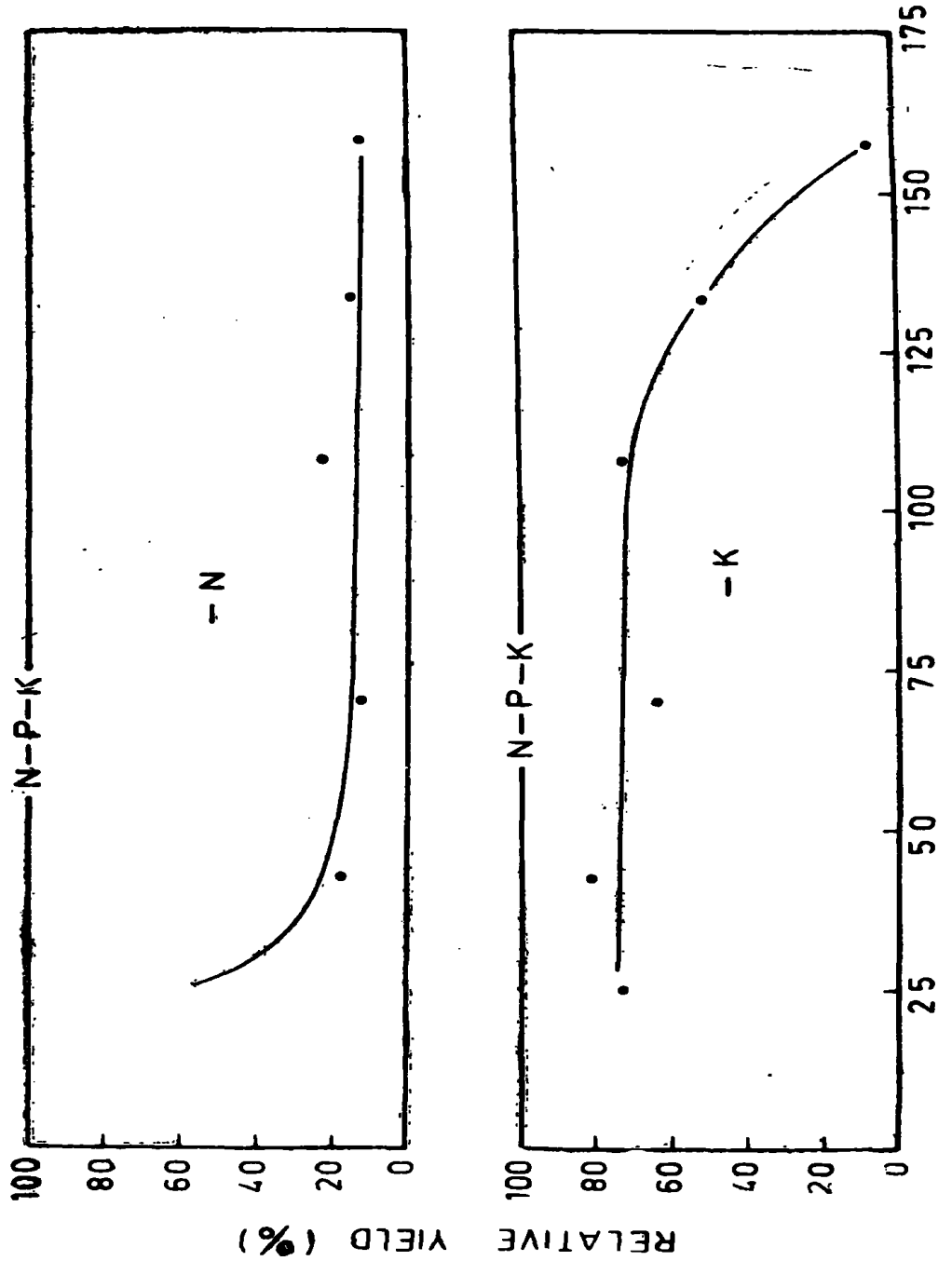

Fig. 2.—Yield of *P. commersonii* in absence of added N and K relative to the complete fertilizer (NPK) with time on Vanathivillu red loam.