Studies of the Nutrient Status of some Coconut Soils in Ceylon

5. The "Lateritic Gravel" on Mattegoda Estate

(A) Preliminary Studies

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INTRODUCTION

MATTEGODA Estate is situated in the district of Colombo, 8 miles south of the city and 7 miles inland. The annual rainfall is 135 in. and the climax vegetation still existing in patches is typical of the rain forest of the south-west of the Island, *Dipterocarpus zeylanica* being the dominant species.

The soil is typical of the lateritic formation of the wet and warm tropics. The topography is undulating with lateritic outcrops on the crests and gravel along the slopes. There is no differentiation into "loam" and "sand" as at Bandirippuwa (Paltridge and Santhirasegaram 1957).

The "sub-soil" is hard compact "cabook". It offers great resistance to root penetration.

For experiments described in this paper, soils were sampled from an area where coconut palms showed signs of malnutrition (yellowing, with poor yields).

The "top-soil" sampled included all material collected above a depth of 9 inches, while the "sub-soil" included material collected from a depth of 9-15 inches. Samples collected from a number of spots were brought to the laboratory, mixed thoroughly and all coarse vegetable matter removed. Thus a uniform sample for use in "pot-experiments" was obtained.

The general technique and procedure followed were similar to that described by Paltridge and Santhirasegaram (loc. cit). All experiments described here were conducted in the Institute's "Phytosolarium".

EXPERIMENTAL

A. *Preliminary Experiments with the "top-soil" from Mattegoda Estate* :

(a) *Experiment 1.*

(i) *Objective :* To study the effect of the major nutrients (N, P, K, Ca and Mg) on the yield of *Paspalum commersonii, Phaseolus lathyroides* and *Sesamum indicum* grown on this soil.

(ii) *Design and Procedure* : This was a 2^5 factorial experiment planted with the three species. All nutrients were applied in forms and rates enumerated in Table 1. $CaCO_3$ was applied in the form of powder and mixed with the top $1\frac{1}{2}$ inches of soil. All other nutrients were applied as solutions. All pots received a basal dressing of a mixture of Fe, Cu, Zn, Mn, Mo and B.

The experiment was planted on 1st November, 1958, and harvested as follows : *P. commersonii* was harvested thrice, viz., 14th December, 1958, 27th January and 12th March, 1959 ; the other two species were harvested only once, on 14th December, 1958. They were then discarded as the plants in the N_0 and P_0 treatments did not make any regrowth.

During the course of the experiment with *P. commersonii* all nutrients that had beneficial effect on growth were re-applied whenever necessary in order to ensure their supply in sufficient quantities. Such applications were as follows : after the 2nd harvest it was noticed that plants in the N treatment showed signs of nitrogen deficiency, hence half the original does of N

was added on 5th March, 1959. However, this did not completely eliminate the deficiency, as the response to N at the 3rd harvest was below expectation.

TABLE 1.—Forms and rates of fertilizer application in Experiment 1
(* *Basal nutrients*)

Designation	*Chemical*	*Rates of application/acre*
N	NH_4NO_3	3 cwts. ≡ 118 lb. N
P	$NaH_2PO_4\ 2H_2O$	3 cwts. = 66.8 lb. P + 49.5 lb. Na
K	K_2SO_4	3 cwts. ≡ 150.6 lb. K & 61.8 lb. S
Ca	$CaCO_3$	10 cwts. ≡ 448 lb. Ca
Mg	$MgSO_4\ 7H_2O$	1 cwt. ≡ 11.8 lb. Mg + 14.5 lb. S
Fe	$FeSO_4\ 7H_2O$*	7 lb. ≡ 1.4 lb. Fe + 0.8 lb. S
Cu	$CuSO_4\ 5H_2O$*	7 lbs. ≡ 1.8 lb. Cu. + 0.9 lb. S
Zn	$ZnSO_4\ 7H_2O$*	7 lbs. ≡ 1.5 lb. Zn + 0.8 lb. S
Mn	$MnSO_4\ 4H_2O$*	7 lb.s ≡ 1.75 lb. Mn + 1.0 lb. S
Mo	$(NH_4)_6Mo_7O_{24}.4H_2O$*	1 lb. ≡ 0.5 lb. Mo + 0.07 lb. N
B	$Na_2B_4O_7\ 10H_2O$*	1 lb. ≡ 0.13 lb. B + 0.13 lb. Na

(iii) *Results :* The data from each species are best dealt with separately :

P. commersonii.—At all harvests very high increases in yields were obtained with N, P and K, alone and in all combinations. Ca was responsible for increase in yields at the last two harvests. Mg consistently increased yields at all harvests, but the effect was not significant. The yields for the four effective nutrients are presented as means of two replicates (Mg_0 and Mg_1) in Table II. The data are consistent with increasing deficiency of all effective nutrients with time, except N, which was due to the insufficiency of added N at the 3rd harvest.

TABLE II.—Means yields (gm/pot) and levels of significance of all treatments affecting growth of (*P. commersonii*) at successive harvests in Experiment I.

Harvests		*Treatments*	*Nil*	*N*	*P*	*NP*	*Effective Treatments*	*Levels of Significance*
1st	Nil	Nil	0·02	0·02	0·43	2·37	N, P, K, NP	
		K	0·02	0·02	0·77	8·52	NK, PK	0.1%
	Ca	Nil	0·02	0·02	0·74	2·20	NPK	
		K	0·03	0·03	1·36	4·90		
2nd	Nil	Nil	0·05	0·05	0·36	0·00	N, P, K, Ca NP, NK, PCa	0·1%
		K	0·07	0·06	0·67	5·49	KCa, NPK	
	Ca	Nil	0·07	0·10	1·13	1·50		
		K	0·13	0·17	1·80	8·79	NCa, NPCa	5·0%
3rd	Nil	Nil	0·05	0·07	0·75	0·00	P, K, Ca, NP PK, NPK	0.1%
		K	0·07	0·09	0·59	1·46		
	Ca	Nil	0·25	0·25	0·77	0·04	KCa	1·0%
		K	0·67	0·82	1·15	2·77	N	5·0%

In the total yield from the three harvests the positive effect of Mg was significant and it entered into positive interaction with N, P and NP (Table III).

TABLE III.—Total yield from the three harvests (gm/pot) of all combinations of N, P and Mg. affecting the yield of *P. commersonii* in Experiment I

	Nil	N	P	NP	Total
Nil	0·85	1·07	6·53	29·12	37·57
Mg	1·10	1·28	6·12	34·70	43·20

P. lathyroides.—This species was harvested only once. There was a very high response to N and P, alone and in combination. K was without any significant effect. This is in contrast to the response observed with *P. commersonii*. This lack of early response to K with *P. lathyroides* had been observed by Paltridge and Santhirasegaram (1957) on Bandirippuwa soils, and Santhirasegaram (1965) on Ratmalagara soils. The yields are recorded as means of two replicates (Mg_0 and Mg_1) in Table IV.

TABLE IV.—Mean yields (gm/pot) and levels of significance of treatment affecting growth of *P. lathyroides* in Experiment I

Treatments		*Nil*	*N*	*P*	*NP*	*Effective Treatments*	*Levels of Significance*
Nil	Nil	0·03	0·03	0·30	0·92	P	0·1%
	K	0·05	0·04	0·46	1·62	N, NP	5·0%
Ca	Nil	0·07	0·01	0·95	1·40		
	K	0·03	0·06	1·00	2·27		

S. indicum—The results were essentially similar to that recorded with *P. commersonii* and are presented in Table V

TABLE V.—Mean yield (gm/pot) and levels of significance of treatments affecting growth of *S. indicum* in Experiment I

Treatments		*Nil*	*N*	*P*	*NP*	*Effective Treatments*	*Levels of Significance*
Nil	Nil	0·02	0·04	0·15	1·05	N, P, NP	1·0%
	K	0·02	0·02	0·19	3·02		
Ca	Nil	0·03	0·03	0·63	1·28	K, NK	5·0%
	K	0·02	0·02	0·49	2·72	NPK	

(iv) *Discussion :* All three species clearly demonstrated acute deficiencies of N and P in the " top-soil " from Mattegoda Estate. Except in the legume, growth would have been severely restricted in the absence of N. K was essential at all stages of growth of *P. commersonii* and *S. indicum.* The legume would have met with severe limitations of growth in the absence of K had it been possible to continue the experiment for a longer period. A late response was evident in the case of Ca.

(b) *Experiment II.*

(i) *Objective :* To study the effect of the minor nutrients (Fe, Cu, Zn, and Mn) on the yield of *P. commersonii, P. lathyroides* and *S. indicum* grown on the " top-soil " from Mattegoda Estate.

(ii) *Design and Procedure :* This was a 2^4 factorial experiment. All pots received a basal dressing of the major nutrients (N, P, K, Ca and Mg) at rates shown in Table I, the dosage of the minor nutrients were also as in Table I.

The experiment was planted on 8th November, 1958. *P. commersonii* was harvested thrice, while *P. lathyroides* and *S. indicum* were harvested twice.

(iii) *Results :* The data for the three species were analysed for individual and for total yields from the various harvests. There was no significant effect recorded for any of the nutrients tested and the data are not presented here.

(c) *Experiment III.*

(i) *Objective :* To study the effect of two major nutrients N and Ca and two minor nutrients Mo and B on the growth of *Medicago sativa* grown on the " top-soil " from Mattegoda Estate.

(ii) *Design and Procedure :* This was a 2^4 factorial experiment planted with *Medicago sativa* on 21st November, 1958. All pots received a basal dressing of P, K, Mg, Fe, Cu, Zn and Mn at forms and rates as in Table I. The rates and forms of the tested nutrients were also

as in Table I. Except that B was applied at the rate of 6 16./ac. $Na_2 B_4 O_7 10H_2 O$. The experiment was harvested five times.

(iii) *Results :* At the 1st harvest, when the plants were 76 days old, responses to Ca, N and B (significant at the 5.0% level) were recorded. After the 1st harvest all Ca_0 plants failed to regrow. At the 3rd harvest B gave high increments in yields (340%) significant at 0.1% level. The results at the next two harvests were essentially similar to those at the 3rd. Mean yields for the two effective treatments are recorded in Table VI.

TABLE VI.—Mean yields (gm./pot) and levels of significance of treatments affecting the growth of M. *sativa* at successive harvests in Experiment III

Harvests	*Treatments*	*Nil*	*B*	*Effective Treatments*	*Levels of Significance*
1st	Nil	0·03	0·06	Ca B	
	Ca	0·25	0·67		5·0%
2nd	Nil	0·00	0·00	Ca, B	
	Ca	0·59	1·06		0·1%
3rd	Nil	0·00	0·00	Ca	0·1%
	Ca	0·47	2·05	B, CaB	1·0%
4th	Nil	0·00	0·00	Ca	0·1%
	Ca	1·08	2·94	B, CaB	1·0%
5th	Nil	0·00	0·00	Ca, B	0·1%
	Ca	1·22	3·59	CaB	1·0%

(iv) *Discussion*: In the experiment described earlier the response to Ca and N were tested and it was evident with *P. commersonii* that there was a late response to Ca. While the response to N was high at all stages of growth of the grass, it was less so with the legume, P. *lathyroides*. The results from this experiment are in conformity with those results. The data from this experiment show that for satisfactory growth of *M. sativa* on this soil application of B is necessary. The requirements of B increased with time.

(*d*) *Experiment IV.*

(i) *Objective :* To study the effect of forms of S as $Na_2 SO_4$, $Al_2 (SO_4)_3$ and $H_2 SO_4$ and the element, on the growth of *P. commersonii, P. lathyroides* and *S. indicum* grown on the " top-soil " from Mattegoda Estate.

(ii) *Design and Procedure* : Simple comparison of treatments in the presence and absence of S in four different forms. All pots received a basal dressing of N, P, K, Ca and Mg as in Table I, except that K and Mg were applied as chlorides.

The experiment was planted on 22nd February, 1959 and harvested as follows :—twice for *P. commersonii* and *P. lathyroides* and once for *S. indicum.*

(iii) *Results* : Analysis of the data showed that S had no effect on the growth of plants in this soil. The data are therefore not presented here.

B. *Preliminary Experiments with the " sub-soil " at Mattegoda Estate :*

(*a*) *Experiment V*

(i) *Objective* : Same as Experiment I.

(ii) *Design and Procedure* : Same as Experiment I. The experiment was planted on 23rd October, 1959. *P. commersonii* was harvested twice ; viz. 26th November and 30th December, 1959. The other two species were harvested only once (20th November 1959). Nutrients that were suspected to be in short supply during the course of the experiment were re-applied as follows :—full dose N on 23rd November ; and half dose of P, K and Mg on 24th December, 1959.

(iii) *Results* : As in the corresponding experiment with the " top-soil " the results are dealt with separately for the three species : *P. commersonii*—In both harvests all tested nutrients, with the exception of Ca, were responsible for significant increases in yields, alone and in combinations. Ca however entered into positive interactions with N and P in the 1st harvest and with N and Mg in the 2nd. The yields are recorded as the means of two replicates (R_1 and R_2) in Table VII.

TABLE VII.—Mean yields for the two replicates of all treatments with levels of signification at the two harvests for *P. commersonni* in Experiment V.

Harvests	*Treatments*			*Nil*	*N*	*P*	*NP*	*Effective Treatments*	*Levels of Significance*
1st	Nil	Nil	Nil	0·49	0·55	1·21	1·80	N, P, NP	0·1%
			K	0·93	0·90	0·72	3·28	K	1·0%
		Mg	Nil	0·61	1·63	1·37	2·58		
			K	0·86	0·98	1·31	2·85	Mg, NCa, PK	5·0%
	Ca	Nil	Nil	0·44	1·06	1·05	1·99	PCa, NPK	5·0%
			K	0·57	0·92	1·12	6·12		
		Mg	Nil	0·39	0·74	0·55	3·02		
			K	0·50	0·49	1·85	7·72		
2nd	Nil	Nil	Nil	0·04	0·00	0·15	0·01	P, NK	1·0%
			K	0·03	0·06	0·08	0·53		
		Mg	Nil	0·04	0·00	0·19	0·01	N, K, NP	5·0%
			K	0·01	0·00	0·16	2·08	PK, NPK	5·0%
	Ca	Nil	Nil	0·09	0·00	0·18	0·00		
			K	0·04	0·07	0·19	1·22		
		Mg	Nil	0·08	0·07	0·12	0·06		
			K6	0·07	0·06	0·18	2·78		

These results were similar to those recorded for *P. commersonii* with the "top-soil" except that Mg had a bigger effect. *P. lathyroides*—There was no response to N, being a legume with effective nodulation. All other tested nutrients increased yields significantly. The yields for all tested nutrients are presented in Table VIII.

TABLE VIII.—Yields (gm/pot) and levels of significance of all treatments affecting the growth of *P. lathyroides* in Experiment V

Treatments			*Nil*	*N*	*P*	*NP*	*Effective Treatments*	*Levels of Significance*
Nil	Nil	Nil	0·03	0·02	0·01	0·03	P, K, Ca	0·1%
		Mg	0·06	0·05	0·13	0·08	PK, PCa	1·0%
	K	Nil	0·01	0·02	0·01	0·09	PMg	
		Mg	0·08	0·06	0·23	0·57	Mg, NCa	
Ca	Nil	Nil	0·08	0·04	0·07	0·05	KMg, NPCa	5·0%
		Mg	0·07	0·07	0·18	0·21	PKMg	
	K	Nil	0·07	0·07	0·06	0·11		
		Mg	0·08	0·10	0·29	0·70		

S. indicum—The responses were similar to those of *P. commersonii* except for the lack of response to K alone. It however entered into positive interaction with Mg and the effect would have been more marked had the experiment been continued for a longer period. Mg and P were responsible for very high increments of yields. The individual yields for all treatments are presented in Table IX.

TABLE IX.—Yields (gm/pot) and levels of significance of all treatments affecting growth of S. indicum in Experiment V

Treatments			*Nil*	*N*	*P*	*NP*	*Effective Treatments*	*Levels of Significance*
Nil	Nil	Nil	0·10	0·08	0·05	0·08	Mg	0·1%
		K	0·04	0·07	0·11	0·00	Ca, P, PMg	10%
	Mg	Nil	0·09	0·10	0·09	0·14	KMg	
		K	0·08	0·08	0·12	0·25	N, NP, NMg	
Ca	Nil	Nil	0·12	0·07	0·09	0·12	NPMg	5·0%
		K	0·07	0·05	0·09	0·10		
	Mg	Nil	0·10	0·07	0·11	0·23		
		K	0·09	0·05	0·10	0·34		

(b) *Experiment VI.*

(i) *Objective* : Same as Experiment II.

(ii) *Design and Procedure* : Same as Experiment II.

(iii) *Results* : None of the tested nutrients had any significant effect on the growth of the two species and the data are not presented here.

(iv) *Discussion* : The data from the two experiments carried out on the "sub-soil" showed that it was acutely deficient in N, P, K, Ca and Mg. None of the minor nutrients tested were found to affect plant growth.

SUMMARY

(1) Six experiments were carried out with the lateritic gravel from Mattegoda Estate, four with the "top-soil" and two with the "sub-soil".

(2) The data from these experiments show that plants growing in the "top-soil" would suffer from acute deficiencies of N. P, K, Ca and B.

(3) They would also suffer from a deficiency of Mg.

(4) The "sub-soil" was found to be acutely deficient in N, P, K, Ca and Mg.

(5) S and the minor nutrients (Fe, Cu, Zn, Mn and Mo) were without effect on plant growth on this soil.

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