Efficiencies of Eppawela, saphos and concentrated superphosphates in some coconut soils of Sri Lanka – a laboratory evaluation

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ABSTRACT

Five surface soils (0-30 cm.), belonging to the Great Soil Groups—Ultisols, Alfisols and Entisols, incubated in the laboratory with Eppawela, saphos and concentrated superphosphates, each at two rates, showed that the concentrated superphosphate treatment had the highest available P as determined by Olsen's, Bray's P and isotopic methods and Eppawela the least. In general there was no significant difference in available P between the controls and Eppawela treatments. With extended periods of incubation, Olsen's P in concentrated super and saphos phosphates increased up to 34 and 260 days respectively and then declined upto 390 days, the longest time of incubation tested, whereas Olsen's P in Eppawela increased up to 34 days and thereafter remained nearly the same. These changes in availability with time of incubation were related to the solubility of the fertilizers and fixation of the released P in the soils.

INTRODUCTION

The inorganic phosphorus fertilizer in use for manuring coconut in Sri Lanka is saphos phosphate. This is imported from the Middle East and involves the expenditure of valuable foreign exchange. In 1971 an apatite deposit was discovered at Eppawela, Sri Lanka, and experiments were commenced to evaluate the suitability of this apatite as P fertilizer for coconut. Though field experiments with coconut are expected to give the most reliable and direct information on the efficiency of the apatite source, they are time-consuming as it takes at least 5 years to obtain any conclusive results from these field experiments. Therefore a short term laboratory experiment was carried out with some selected coconut soils to compare the efficiency of Eppawela phosphate with a soluble form of phosphorus fertilizer such as concentrated superphosphate and the currently used saphos phosphate. This paper presents the results of this experiment.

MATERIALS AND METHODS

Soils were selected to cover the major Great Soil Groups-Ultisols, Alfisols and Entisols—of the coconut growing regions. The Dry Zone coconut soils were not included in the study as rock phosphate is not suitable for these soils (only a soluble form of P fertilizer such as concentrated superphosphate is suitable). Eppawela phosphate was obtained from samples selected in 1976 for an island-wide study under the International Atomic Energy Agency Co-ordinated research programme (Mistry, 1977). The properties of the soils and the fertilizers used are shown in Tables 1 and 2.

Five hundred g air-dried soil samples (< 2 mm) were mixed with Eppawela phosphate, saphos phosphate and concentrated superphosphate each at the rates of 0.5 and 1.0 mg/g and incubated at room temperature (26 to 31°C) and at 80% field capacity. Each treatment was replicated twice. Soil samples were drawn after 15, 34, 260 and 390 days of incubation and P was extracted by the methods of Bray P_1 (Bray and Kurtz, 1945), Olsen (Olsen *et al.*, 1954) and isotopic exchange (IAEA, 1976).

RESULTS AND DISCUSSIONS

Phosphorus availability vs *source of fertilizer*

Olsen's bicarbonate extractable P in samples drawn after different periods of incubation of the five soils are shown in Figures 1 to 5. Olsen's bicarbonate extractable P is considered to be a satisfactory index of available P for Coconut (Nethsinghe, 1965 ; Balakrishnamurtie, 1967) and therefore this form of P is chosen here to evaluate the efficiencies of the three sources of P fertilizers. Figures 1 to 5 clearly show that in all the five soils concentrated superphosphate was the most efficient and Eppawela phosphate the least and this pattern was maintained at all times of sampling. In most cases there was hardly any difference in the availability of P in controls and Eppawela phosphate treated soils. The results for all five soils show that even if Eppawela phosphate is applied at twice the rate of saphos phosphate, P availability cannot be raised to that of saphos phosphate. Available P in Eppawela phosphate treatments was always less than "9 μg/g" which is considered to be the P-level sufficient for coconut (Nethsinghe, 1965).

Phosphorus availability vs *time of incubation*

As the period of incubation increased, available P in concentrated super and saphos phosphate treatments increased upto 34 days and 260 days respectively and then decreased. The increase is due to the increased solubility of the fertilizer and the decline is probably due to the fixation of the released P. Concentrated superphosphate, being a soluble form of fertilizer, had become soluble in a matter of a few days and reached maximum availability in such a short period of incubation as 34 days and becoming fixed thereafter, whereas the saphos phosphate, being a rock phosphate took a longer time such as 260 days or more to reach maximum solubility. Even after this preiod, saphos phosphate may still be releasing P but because the rate of fixation is higher than the rate of release, the available P declined. Because saphos phosphate maintains a high level of available P for a period equal to or longer than concentrated superphosphate, the former may be equally effective or even better than the latter as P fertilizer for perennial crops such as coconut in these soils, if as in the laboratory experiments, they are wet during most part of the year. This condition is satisfied only in the Wet and Intermediate rainfall zones. Under these conditions saphos phosphate acts like a controlled release fertilizer.

The available P levels in Eppawela treated soils were very low and in some soils they were same as in control treatments and therefore no clear trend on the effects of time could be noted. But it appears that the available P increased upto 34 days and thereafter remained the same. This suggests that in a matter of a few days most of the available P is released and thereafter there exists an equilibrium between the rate of fixation and release. It was reported that Eppawela apatite has a layer of weathered material around the apatite crystal and P from this zone is relatively easily available than the P in the crystal (de Silva, 1976). The initial high rate of release may be from this layer and once this is exhausted the rest of the material may not release any significant amounts of P to overcome fixation. To test this hypothesis one has to sample Eppawela materials which have undergone different degrees of weathering and carry out similar incubation studies.

Phosphorus availability vs *soil types*

Contrary to the belief that rock phosphates such as saphos and Eppawela would have higher avilable P in more acidic soils (which are expected to solubilize the rock phosphates to a greater extent) than in the others, the results showed that available P is least in the most acidic soils such as Pothuhera and Heenatiya which belong to Ultisols. This is probably due to the high P fixing capacities of these soils (Table 1) where the Eppawela phosphate may have got solubilized but became unavailable by fixation of the released P.

Phosphorus availability mainly depends on the solubility of the fertilizer and fixation of the released P in the soils. As concentrated superphosphate is a soluble fertilizer, P availability is expected to depend only on the fixation. Table 3 shows the relation between Langmuir adsorption maxima (which is an index of the fixation capacity) and available P after 390 days of incubation. It could be seen that the higher the adsorption maxima, the lower the availability of P (with the exception of Halmillakotuwa).

Phosphorus availability by Bray's P_1 and isotopic methods

Available P determined by two other methods—Bray's P_1 and isotopic methods are shown in Table 4. Bray's method uses an acid extractant in contrast to the alkaline extractant of Olsen. Bray's P_1 method is considered to be a suitable one for determining availabe P in acid tropical soils (Rastogi *et al.*, 1976) and therefore included in this study. The isotopic method is an independent method where no chemical extractants are used and therefore do not attack or disturb the chemical status of the soil. It has the additional advantage that its applicability is independant of the soil type. As it was not possible to carry out the E_t determinations in the Red Yellow Podzolics and Reddish Brown Earths, only results of the other two soils are given in Table 4. In agreement with the Olsen's method, these two methods too showed that Eppawela phosphate is the least effective of the three fertilizers and available P in Eppawela treatment was no different from that of the control.

CONCLUSIONS

Available P determined by three independant methods on five contrasting types of soils showed that Eppawela phosphate was inferior to saphos phosphate even when applied at twice the rate of saphos. In most cases available P in Eppawela phosphate treatments were not significantly different from the controls.

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TABLE 1.—Properties of the soils

Soils	*Classifications*	*Sand* (%)	*Silt* (%)	*Clay* (%)	*Organic carbon* (%)	*C. E. C.* (*me/100g*)	*Olsen's P* (μg/g)	*pH water*	*Langmuir adsorption maxima* (μg/g)
Pothuhera	Ultisols (Red yellow podzolic)	69.6	4.9	21.7	1.24	6.1	2.5	4.8	414
Heenatiya	Ultisols (Red yellow podzloic)	70.3	2.9	25.1	1.66	13.4	3.9	4.9	349
Keenakelle	Entisols (Regosols)	86.4	0.8	12.7	0.80	12.3	4.0	4.9	246
Halmillakotuwa	Alfisols (Reddish Brown Earths)	74.6	5.1	17.8	0.97	6.3	3.0	5.5	159
Indihena	Alfisols (Non Calcic Browns)	88.2	1.8	8.2	0.64	12.5	3.9	5.3	136

TABLE 2—Properties of the Fertilizers

Source		Particle size (mesh)	Total P_2O_5 (%)	Citric acid soluble P_2O_5 %
Eppawela phosphate	..	–100	29.0	3.4
Saphos phosphate	..	–100	29.5	9.5
Concentrated superphosphate		–100	46.0	45.3

TABLE 3.—Langmuir adsorption maxima vs available P after 390 days of incubation

Soils	Langmuir maxima (μg/g)	Olsen's P (μg/g)	
		CSL	CSH
Pothuhera	414	17	37
Heenatiya	349	20	45
Keenakelle	246	53	102
Halmillakotuwa	159	26	63
Indihena	136	52	103

CS—concentrated superphosphate ; L—Low rate ; H—High rate.

TABLE 4.—Available phosphorus determined by Bray's and isotopic methods after two periods of incubation (mean of two replicates)

Treatment	Incubation period (days)	Keenakelle Bray P_1	Keenakelle E_t	Indihena Bray P_1	Indihena E_t	Halmilla-kotuwa	Pothuhera Bray–P_1	Heenatiya Bray–P_1
Bray–P1					µg/g			
Control	34	19	10	9	trace	trace	2	2
	260	10		4		1	trace	2
E L	34	28	5	18	1	3	3	2
	260	16		10		3	2	4
E H	34	53	4	34	15*	4	9	9
	260	41**		17		3	4	2
S L	34	30	26*	52*	23**	7	6	27*
	260	40**		39*		16*	4	16***
S H	34	80	23*	89**	36***	12	27	31**
	260	90***		78***		15*	22***	24***
C S L	34	224*	88***	196***	83***	62***	57**	59***
	260	171***		170***		35***	30***	29***
C S H	34	900***	192***	800***	161***	235***	269***	353***
	260	308***		314***		115***	68***	124***

*, **, *** significant at 5%, 1% and 0.1% respectively. E—Eppawela. S—Saphos. CS—Concentrated super. L—Low rate. H—High rate.

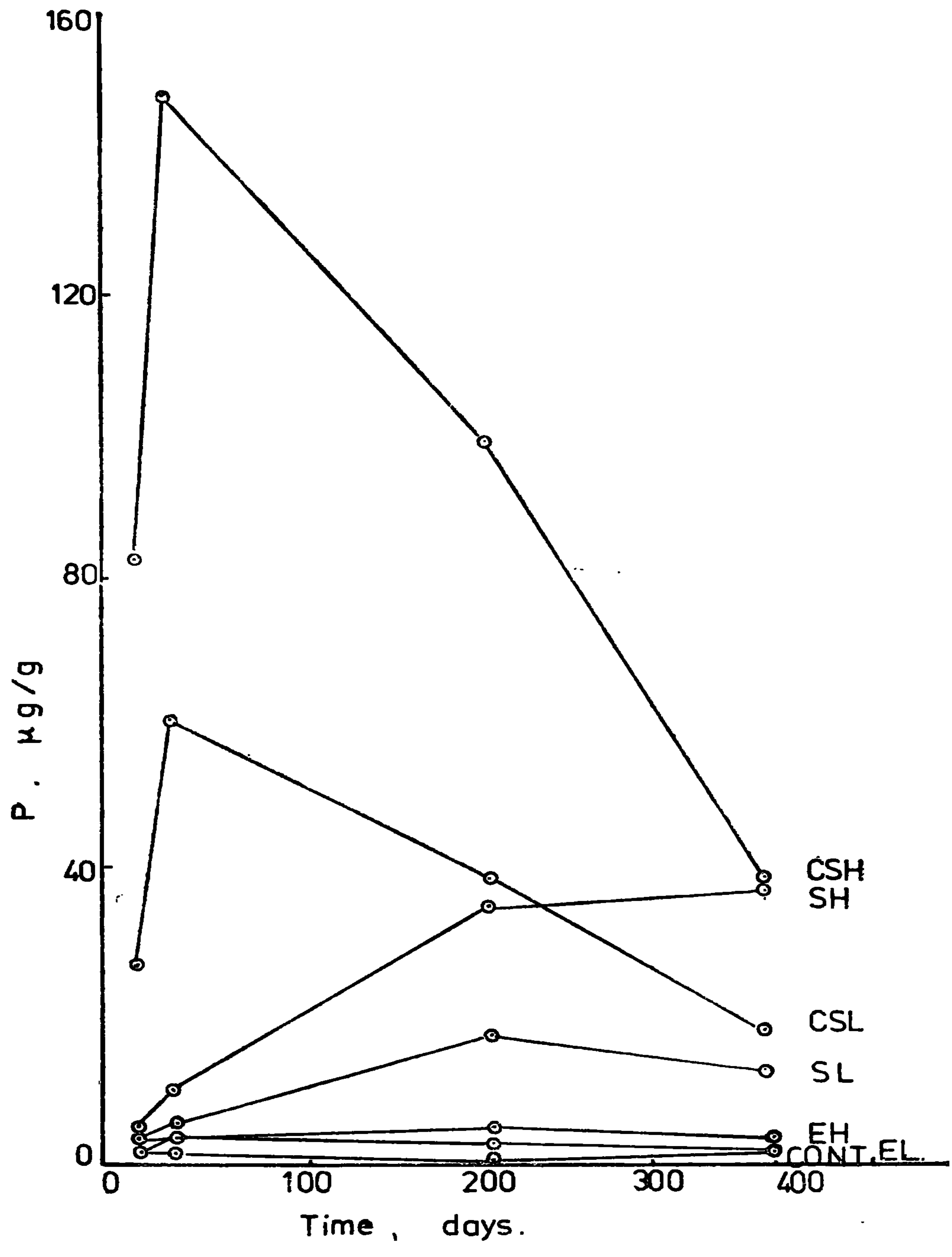

Fig. 1—Olsen's bicarbonate extractable P in Pothuhera after several periods of incubation (CONT—Control, E—Eppawela, S—saphos, CS—concentrated super, L—low rate, H—high rate).

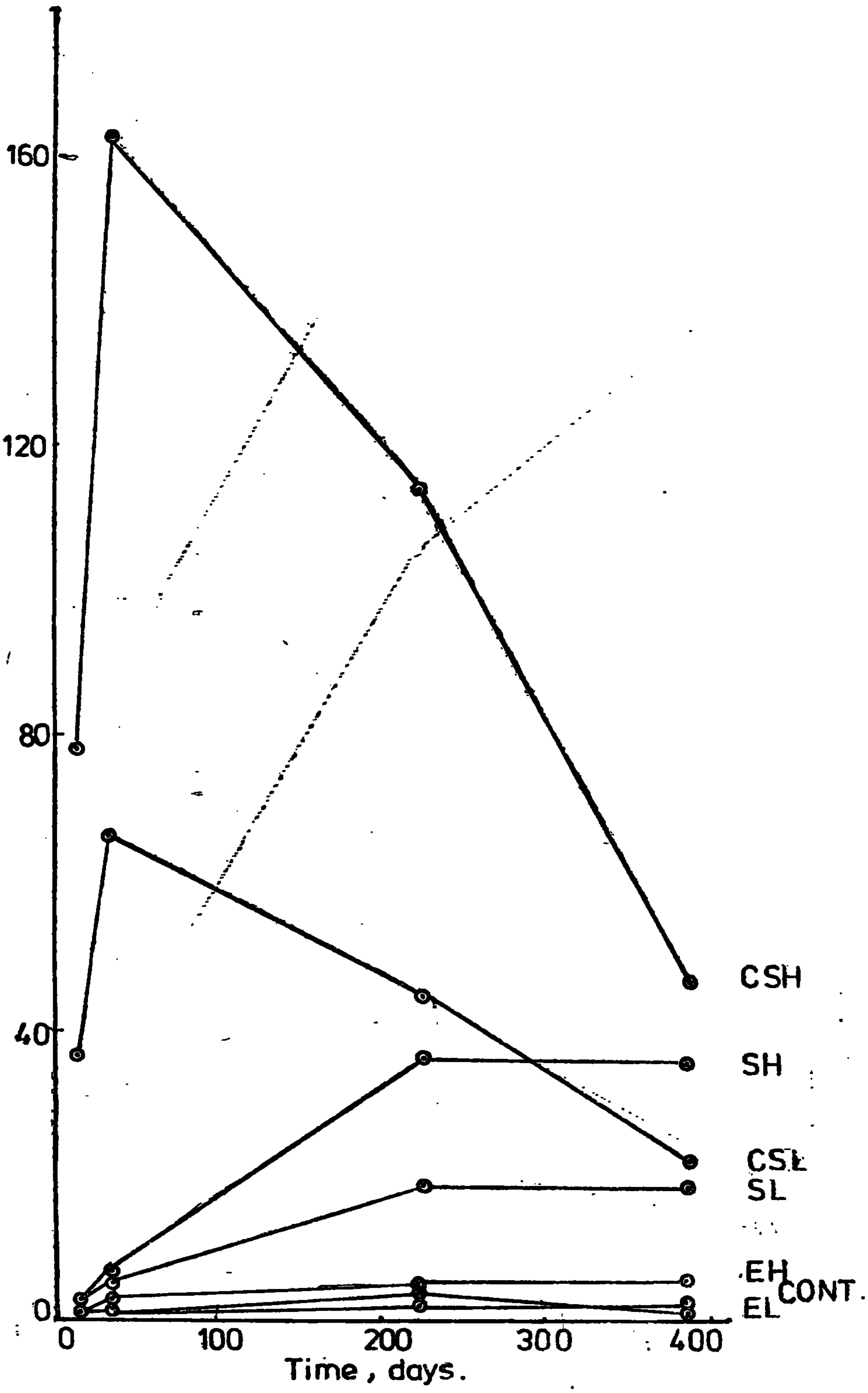

Fig. 2—Olsen's bicarbonate extractable P in Heenetiya after several periods of incubation. (CONT—control, E. —Eppawela, S—saphos, CS—concentrated super, L—low rate, H—high rate).

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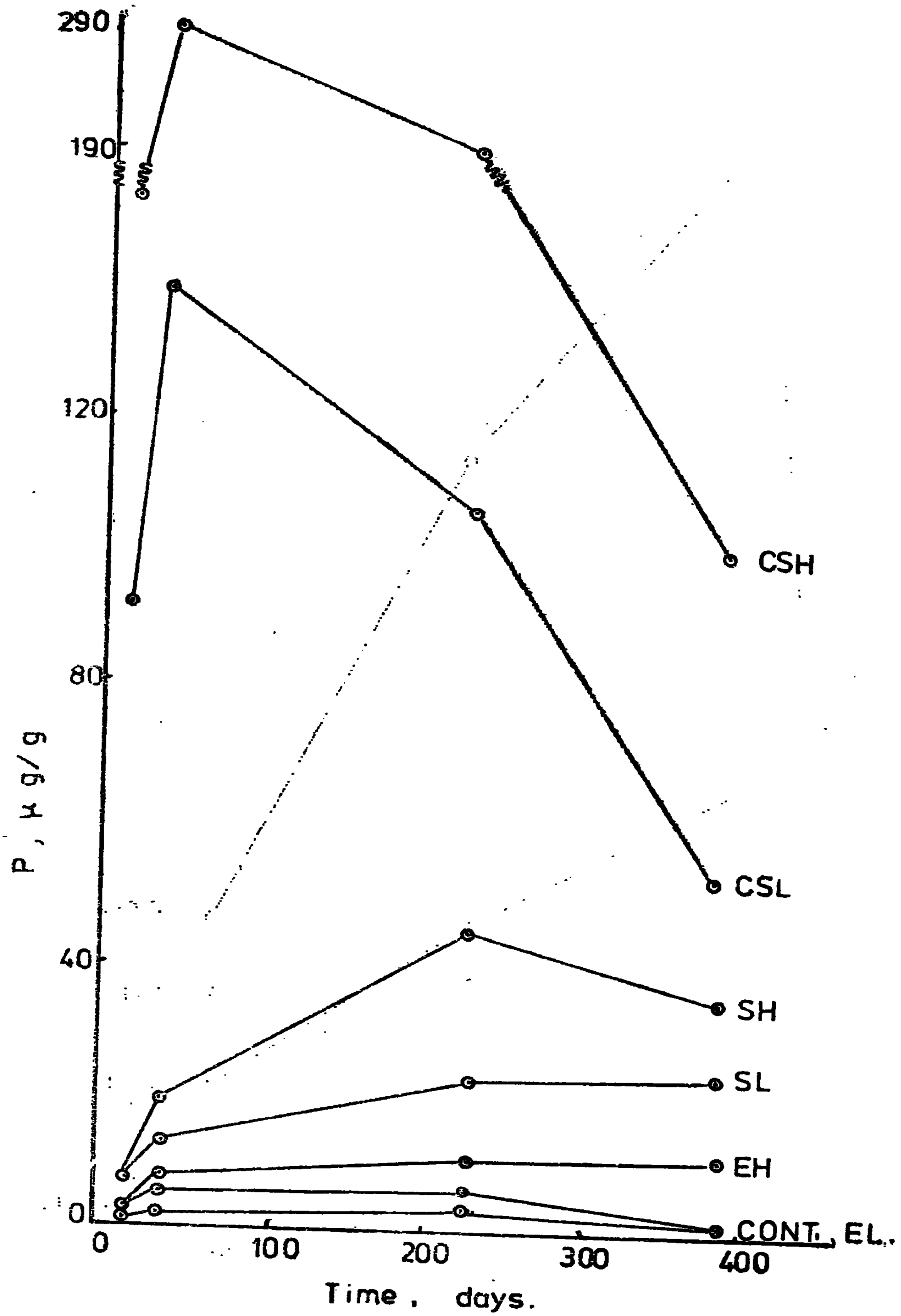

Fig. 3—Olsen's bicarbonate extractable P in Keenakella after several preiods of incubation. (CONT—control, E—Eppawela, S—sapho , CS—concentrated super, L—low rate, H—hightate).

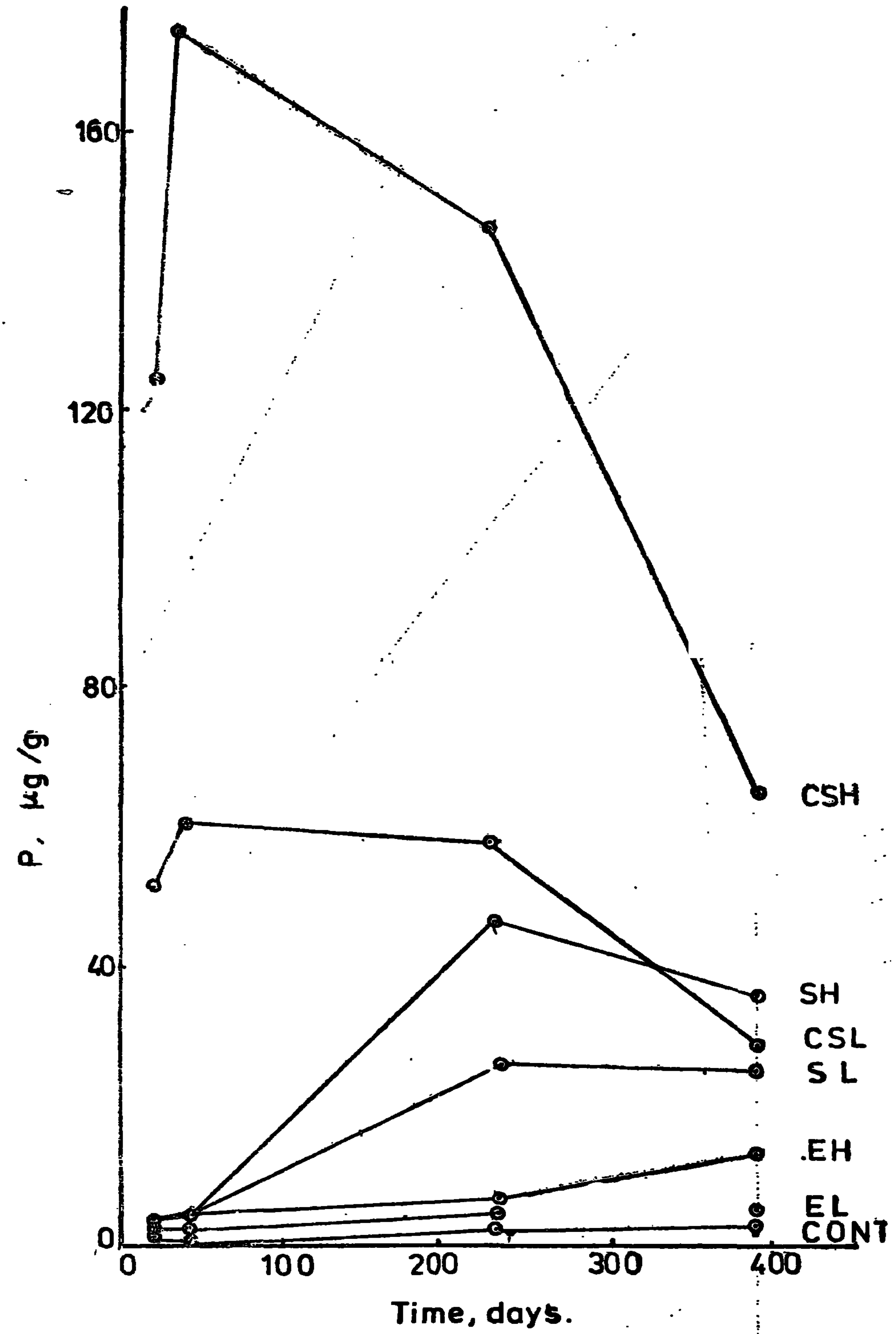

Fig. 4—Olsen's bicarbonate extractable P in Indihena after several periods of incubation. (CONT—control, E—Eppawela, S—saphos, CS—concentrated super, L—low rate, high rate).

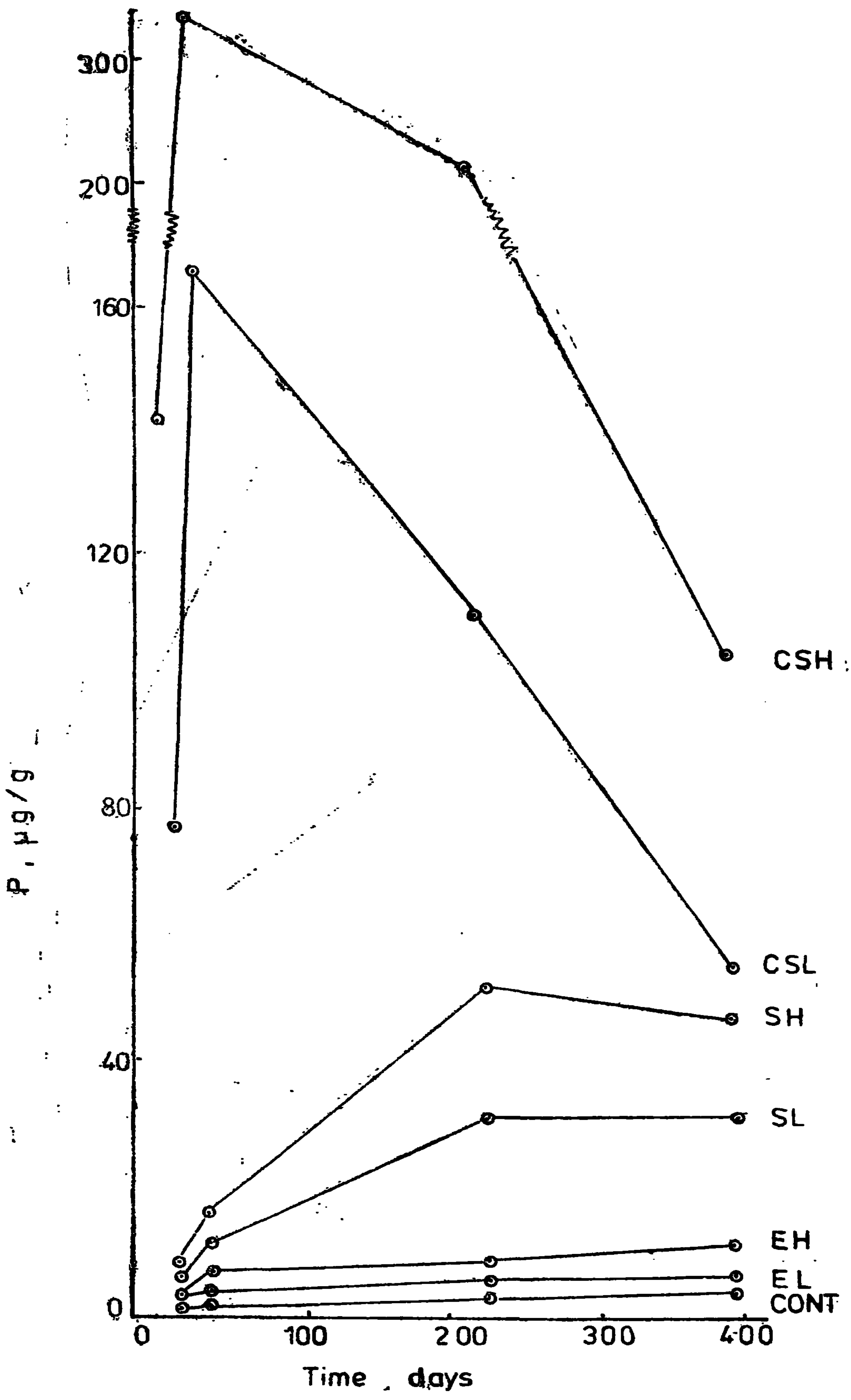

Fig. 5—Olsen's bicarbonate extractable P in Halmillakotuwa after several periods of incubation. (CONT—control, E—Eppawela, S—saphos, CS—concentrated super L—low rate, H—high rate).