Jl. Rubb. Res. Inst. Sri Lanka (1986) **66**, 22–28

RESPONSES OF FIVE TROPICAL PASTURE SPECIES TO APPLICATION OF APATITE

by

L. S. S. PATHIRATNA, U. P. DE S. WAIDYANATHA AND O. S. PERIES

SUMMARY

Shoot growth and phosphorus content of Pueraria, Centrosema, Stylosanthus, Panicum *and* Paspalum *were best at 500 ppm and better at 100 ppm than at zero ppm apatite. Root growth on the other hand was stimulated at 100 ppm and marginally inhibited at 500 ppm. Both relative shoot and root growth responses were least for* Stylosanthus *which showed a notable ability to take up P from untreated soil compared to the other species. This may be related to its greater calcium uptake ability as evidenced in much higher calcium concentrations in its shoot than in the others. The grasses recovered far more P from both treated and untreated soil than the legumes.*

INTRODUCTION

Plant-borne factors play a vital role in the uptake and release of P from rock phosphates where root development, phosphate requirement and differential uptake pattern of ions by plants are more important (Black, 1968).

Differential root development characteristics of species, and their extensity have often been shown (Newman and Andrews, 1973) to improve the efficiency of P uptake. This is due to the increased root surface area and therefore improved contact between plant roots and P sources. Different growth rates of plant species form the basis of the phosphate requirement theory ; slow growing species with reduced plant P taking up less P than fast growing species for normal growth (Khasawneh and Doll, 1978).

Plant species also differ in their uptake pattern of cations and anions (Cunningham, 1964). The ratio of total cations and anions absorbed by plant can be related to efficiency of P uptake from rock phosphates (Van Ray & Van Diest, 1979). Plant species that take up high amount of Ca also tend to acidify the growth medium resulting in an increased availability of P from rock phosphates (Bekele et *al.*, 1983). Removal of Ca from the gorwth medium also brings in more P into solution by shifting the mass action equilibrium of P sources (Johnston and Olson, 1972).

Reported here is a study of some of the above factors on the uptake of P from Eppawala apatite by five common tropical pasture species.

MATERIALS AND METHODS

Apatite

The apatite used was mainly in the form of chloroapatite and francolite with 12% total P and 1.59 citric acid (2%) soluble P. The pH in water (1:2.5) was 7.59. The total Ca content in this material was 32.35% (Anon 1980).

Soil

The top (20.0 cm) soil from Dartonfield Estate, Agalawatta (red yellow podzolic-ultisoil) having a pH of 4.6 in water and an available P (NH_4F/HCL) content of 5.6 ppm was used.

Estimation of root length

Roots were washed out from soil and two random samples were measured using the grid line intersect method of Newman (1966) and Marsh (1971). Dry weight and total root lengths of these samples were estimated.

Analysis of P and Ca in plant material

Plant material was digested in Se/H_2SO_4 followed by automated colorimetric determination using the vanado molybdate. Determination of Ca was done by atomic absorption spectrophotometry (Singh and Ratnasingham, 1971).

Experimental

The five species, *Pueraria phaseoloides, Centrosema pubescens, Stylosanthus gayanensis, Paspalum plicatulum* and *Panicum maximum* var. Guninea B were planted in 25 cm diam pots holding 6.5 kg soil. Apatite was used at two levels *viz* 100 and 500 mg / pot (approx. 16 and 80 kgp/ha). Legumes were planted as acid —scarified seeds without rhizobial inoculation and grasses as tillers. Plants were harvested at the end of 120 days, and dry weight of shoots and roots, root length, P content in shoots and roots, Ca content in shoot were determined.

RESULTS

Because of inherent species differences, relative values of shoot dry matter, P content and root growth (length) as affected by apatite rates are more meaningful for comparison than absolute values.

Of the three legumes, *Pueraria* and *Centrosema* showed similar curvilinear response in both shoot growth and P content (Table I and 4) with increasing rates of apatite. On the other hand relative growth response of *Stylosanthus* to apatite was less than that of the other two legumes, and in fact less than that of all the other species. Also the relative P contents at the two rates of apatite were considerably lower for *Stylosanthus* than for all the other species. *Paspalum* and *Panicum* had the highest magnitude of growth response to apatite and of P uptake from it.

Table 1. *Effect of apatite on relative shoot growth (dry weight) of species*

	Apatite (ppm)			
	Nil	100	500	RRIS*
Pueraria	1.00	1.90	3.15	1.09
Centrosema	1.00	1.74	3.17	0.93
Stylosanthus	1.00	1.17	1.51	0.36
Paspalum	1.00	2.66	3.80	0.50
Panicum	1.00	2.70	3.90	0.45

*RRIS—Required relative increase for the values to be significant at 5% level.

Table 2. *Effect of apatite on relative root length (m)*

	Apatite			
	Nil	100	500	RRIS*
Pueraria	1.00	2.11	1.95	0.62
Centrosema	1.00	1.76	1.61	0.30
Stylosanthus	1.00	1.28	1.18	0.30
Paspalum	1.00	2.47	2.12	1.48
Panicum	1.00	2.26	1.93	0.65

*RRIS—Required relative increase for the values to be significant at 5% level.

Table 3. *Effect of apatite on shoot root ratio (g/m)*

	Apatite		
	Nil	100	500
Pueraria	0.061	0.055	0.099
Centrosema	0.034	0.034	0.068
Stylosanthus	0.090	0.083	0.116
Paspalum	0.105	0.113	0.163
Panicum	0.068	0.081	0.137

Table 4. *Effect of apatite on relative shoot P content*

	Apatite (ppm)			
	Nil	100	500	RRIS*
Pueraria	1 00	2 07	3.96	0.91
Centrosema	1.00	1.89	3.60	0.89
Stylosanthus	1.00	1.23	2.02	0.30
Paspalum	1.00	2.37	3.70	0.33
Panicum	1.00	2.52	3.67	0.42

*RRIS—Required relative increase for the values to be significant at 5% level.

Apatite at the 100 ppm rate greatly stimulated root growth but at 500 ppm there was a relative inhibition though not singificant, compared to 100 ppm (Table 2). As with shoot growth, the relative response was least for *Stylosanthus* and highest for the grasses.

Except for the significantly higher concentrations of P (Table 5) at the 500 ppm apatite that at nil or 100 ppm in *Pueraria* and *Stylosanthus*, the concentrations were not affected in the other species by the rate of application. The results possibly suggest luxury consumption of P by *Pueraria* and *Stylosanthus* at high soil concentrations of P.

Table 5. *Effect of apatite on mean percentage shoot P*

	Apatite (ppm)		
	Nil	100	500
Pueraria	0.119	0.131	0.169
Centrosema	0.104	0.113	0.171
Stylosanthus	0.120	0.126	0.160
Paspalum	0.117	0.105	0.114
Panicum	0.109	0.101	0.102

LSD (P = .05) 0.014

Table 6 gives the percentage of P recovered from the amount applied apatite which indicates a higher relative recovery at 100 ppm than at 500 ppm. Grasses recovered far more P than legumes at both levels. It is noteworthy that the difference in P recovery amounts was smallest in *Stylosanthus* at the two rates of application.

Table 6. *Percentage recovery of apatite*

	Apatite (ppm)	
	100	500
Pueraria	14.4	7.8
Centrosema	11.9	7.1
Stylosanthus	9.6	6.8
Paspalum	36.1	13.7
Panicum	38.0	14.4

Significant increases in shoot calcium content (Table 7) over the zero apatite treatment were observed only at 500 ppm level with *Centrosema* and *Pueraria* but not with *Stylosanthus*. Of the two grasses *Paspalum* showed significant increases with both increments of apatite and *Panicum* only with the first increment.

Table 7. *Effect of apatite on relative shoot Ca content*

	Apatite (ppm)			
	Nil	100	500	RRIS *
Pueraria	1.00	2.07	2.50	2.39
Centrosema	1.00	2.23	4.11	2.25
Stylosanthus	1.00	1.10	1.30	0.49
Paspalum	1.00	3.23	5.01	1.69
Panicum	1.00	3.05	3.77	1.70

*RRIS = Required relative increase for the values to be significant at 5% level.

Calcium concentration in shoot was not affected by apatite treatments in *Pueraria* and *Stylosanthus* but increased significantly in *Centrosema* (Table 8). There was however no significant response beyond the first apatite level. A significant increase in calcium concentration was observed for one of the grass species (*Paspalum*) only at the higher level. Grasses had relatively lower calcium concentration than legumes, and *Stylosanthus* has a remarkably high shoot Ca concentration.

Table 8. *Effect of apatite on percentage Ca in shoot*

	Apatite (ppm)			
	Nil	100	500	Mean
Purerarla	0.950	1.032	1.014	0.999
Centrosema	0.898	1.078	1.135	1.037
Stylosanthus	1.553	1.414	1.344	1.437
Paspalum	0.626	0.765	0.823	0.738
Panicum	0.545	0.637	0.533	0.572

LSD (P = .05) for the crop means 0.117

The shoot-root ratio did not differ appreciably between nil and 100 ppm apatite but greatly increased at 500 ppm, because of the inhibitary effect of this concentation of apatite (Table 3) on root growth of all species as compared to 100 ppm.

DISCUSSION

All species showed substantial responses in terms of growth and P uptake to applied apatite suggesting that it can be used as a source of rock phosphate. It would seem that despite the low citric acid solubility the low soil pH enhanced availability of P from the phosphate to all species. This study does not permit ascertaining its effectiveness relative to other standard rock phosphates. However previous studies by Waidyanatha and Ariyaratne (1979) showed that saphos phosphate was superior to apatite for growth of *Pueraria* and *Panicum*, but that by Yogaratnam (1987) on rubber and Sivasubramaniam et *al.* (1981) on tea showed that Eppawala apatite could be substituted for imported RP.

The response trends for 100 ppm (about 16 kg P/ha) and 500 ppm (80 kg P/ha) however suggest clearly that the optimum response is above 100 ppm for all species under the experimental conditions implying low solubility of the phosphate source. However, responses in pot experiments to nutrients are often greater in magnitude than in the field due to the limitation in soil volume for plant growth, and cannot therefore be interpolated directly to the field situation.

The magnitude of response to phosphate application was strikingly less for *Stylosanthus* than all the other species implying that it was relatively more efficient in taking up phosphorus from native soil sources that the others, or alternatively, they are less adapted to uptake of P from apatite. *Stylosanthus* in particular is known to be a good phosphate scavenger and thrives in soils deficient in phosphorus (Smith and Jackson, 1983).

One reason for this may be its ability to take up relatively large amount of calcium from soil (Table 7) which has been the case even in the absence of apatite. Decrease in calcium ion concentration in the root vicinity results in a concomitant shift in the mass-action equilibrium of calcium phosphate in the soil and more phosphate ions are solubilized (Johnston and Olsen, 1972). In the case of grasses and legumes other than *Stylosanthus* there is relatively greater uptake of calcium with apatite application which in a way is consistent with the relatively greater uptake of phosphate from apatite than *Stylosanthus*.

The unusually high concentration of P at 500 ppm apatite in *Pueraria* and *Stylosanthus* suggest luxury consumption of P by these two species at high soil concentration of the element.

The inhibitory of effect of 500 ppm apatite on root development is of concern and needs further investigation. It is important to ascertain whether it is due to any inhibitory ion such as the fluoride present in the apatite.

It is to be conclude that apatite when applied in sufficient quantities to compensate for the lower availability of phosphorus from it compared to other standard rock phosphates, is satisfactory for growth of pasture plants or other perennial crop systems.

ACKNOWLEDGEMENTS

The authors wish to thank Dr N. Yogaratnam, Head of Soils and Plant Nutrition Department for his valuable comments on the manuscript. Sincere thanks are due to Mr W. N. Wickremasinghe Biometrician for helping in statistical analysis. Thanks are also due to Dr Mrs A. C. I. Samaranayake for providing facilities in the Plant Science Department to carry out this work.

REFERENCES

ANON (1980). Final report, Technology of production and preliminary agronomic evaluation of speciality phosphates using Eppawala phosphate rock from Sri Lanka. *International Fertilizer Development Centre Muscle Shoals Alabama, U.S.A.*

BEKELE, T., CINO, B. J., EHLERT, P. A. I., VAN DER MASS, A. A. and VAN DIEST, A. (1983). An evaluation of plant-borne factors promoting the solubilising of alkaline rock phosphates. *Plant and Soil*, **75**, 361—378.

BLACK, C. A. (1968). *Soil Plant Relationships*. John Willey and Sons, New York, London Sydney, 792.

CUNNINGHAM, R. K. (1964). Cation-anion relationships in crop nutrition III. Relationships between the sum of the cations, sum of the anions and nitrogen concentration in several plant species. *J. Agric. Sci.*, **63**, 109—111.

JOHNSTON, W. B. and OLSON, R. A. (1972). Dissolution of fluorapatite by plant roots. *Soil Sci.*, **114**, 29—36.

KHASAWNECH, F. E. and DOLL, E. C. (1978). The use of phosphate rock for direct application to soils. *Adv. Agron.*, **30**, 159—206.

MARSH, B. A. B. (1971). Measurement of length in random arrangement of lines. *J. Appl. Ecol.* **8**, 265—270.

NEWMAN, E. I. (1966). A method of estimating tho total length of roots in a sample. *J. Appl. Ecol.* **3**, 139—145.

NEWMAN, E. I. and ANDREWS, R. E. (1973). Uptake of phosphorus and potassium in relation to root growth and root density. *Plant* and *Soil*. **38**, 49—69.

SMITH, F. W. and JACKSON, W. A. (1983). *Annual Report CISIRO Division of Tropical Crops and Pastures* 50—52.

SINGH, M. and RATNASINGHAM, K. (1971). Manual of Laboratory Methods of Chemical Soil Analysis. RRIM Kuala Lampur.

SIVASUBRAMANIAM, S., WICKREMASINGHE, K. N. and AYADURAI, S. (1981). The use of Eppawala Apatite for Tea in Sri Lanka. *Tea Q.* **50**,4—10.

VAN RAY, B. and VAN DIEST, A. (1979). Utilization of phosphate from different sources by six plant species. *Plant* and *Soil*. **51**, 577—589.

WAIDYANATHA, U. P. de S., and ARIYARATNE, W. A. (1979). *Ann. Rev. Rubb. Res. Inst. Sri Lanka*, 1979, 31—33.

YOGARATNAM, N. (1987) Unpublished.