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RELATIVE EFFICIENCY OF TWO SOURCES OF PHOSPHORUS IN THE ESTABLISHMENT OF TROPICAL PASTURE SPECIES

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SUMMARY

Results of pot and field experiments indicated that calcined Christmas Island phosphate is a suitable alternative to superphosphate as a source of phosphorus.

In pot experiments, its relative efficiency in terms of dry-matter was 66-71% for guinea grass and 42-55% for centro.

I. INTRODUCTION

Mineral rock phosphates, the main source of phosphorus for agricultural and industrial use, contain phosphorus in a water-insoluble stable form. They vary widely in purity, hardness and fertilizer value.

Hard, high-grade rock phosphates (usually fluorapatites or tricalcium phosphates) are used for the manufacture of superphosphate. Low-grade phosphate deposits are not regarded as suitable for superphosphate manufacture but their agricultural value can sometimes be increased by heat treatment. Calcined Christmas Island phosphate is manufactured by heating the low-grade phosphate ore from Christmas Island to about 450°C to degrade the mineral lattice and consequently increase the solubility of the phosphorus present in the ore. Doak *et al.* (1965) described the ore as consisting of crandallite and millisite as well as apatite.

Most soils on the wet tropical coast of North Queensland are of very low phosphorus status and a readily available source of phosphorus is a prerequisite for the rapid establishment of sown pasture species.

This investigation was aimed at evaluating calcined Christmas Island phosphate as a source of phosphorus for use in the establishment of tropical pasture species.

II. MATERIALS AND METHODS

Pot experiments were carried out in the glasshouse at the Tropical Agriculture Research Station, South Johnstone. Undrained 9 in. diam plastic pots were lined with polythene bags and filled with 10 lb of sieved soil. Soil moisture was maintained at 60% water-holding capacity. At each watering the pots were re-randomized on the benches. Basal fertilizers (all nutrients except N and P for centro or except P for guinea grass) were applied in solution, Finely ground superphosphate and calcined phosphate respectively was mixed with the surface inch of soil.

Each pot contained three plants of either centro or guinea grass in separate pots.

In the field experiment, fertilizers were broadcast by hand. A basal dressing of all nutrients except N and P was applied. Plant samples for chemical analyses were dry ashed and analysed by the phosphovanadomolybdate colorimetric method.

Soil samples were analysed for pH using a 1:2·5 suspension in water; for available phosphorus by the method of Kerr and von Stieglitz (1938); for total nitrogen by a Kjeldahl method with copper catalyst; for organic carbon by the method of Walkley (1947); for total exchange capacity and exchangeable potassium by the methods described by Beckwith (1964, p. 210); and for mechanical analysis by a Bouyoucos hydrometer method.

The soil used in pot experiment 1 was a very dark grey, coarse sandy clay loam derived from granite, that in pot experiment 2 was a yellow-red, coarse sandy loam of alluvial origin. Analyses are shown in Table 1.

Treatments consisted of guinea grass (*Panicum maximum* Jacq. var. *typica*) and centro (*Centrosema pubenscens* Benth.), superphosphate and calcined phosphate in a factorial arrangement in a 2 x 2 x 4 randomized block design with four replications.

In experiment 1, seeds were planted on January 29, 1965, and plants were harvested 12 weeks later; in experiment 2, planting was done on June 15, 1965, and harvesting 12 weeks later.

The fertilizers were applied at nil, 44, 88 and 132 lb of phosphorus per acre in experiment 1 and at nil, 22, 66 and 132 lb of phosphorus per acre in experiment 2. The calcined Christmas Island phosphate used (supplied by the British Phosphate Commission) had been milled nominally to 90% finer than 100 mesh and contained 15% total phosphate as P. Commercial superphosphate (10% P) was used as a comparison.

The field experiment was on the same soil type as that described for pot experiment 2. Treatments consisted of nil phosphate, and superphosphate and calcined phosphate each at 44, 88 and 132 lb P per acre in a randomized block with four replications. Stylo (*Stylosanthes guyanensis*) was planted on January 17, 1966, and harvested 8 weeks later.

TABLE 1

ANALYSES OF SOILS USED IN THE EXPERIMENTS

Experiment	pH	Available Phosphorus (p.p.m. P)	Total Nitrogen (%)	Carbon (%) (W and B)	Total Exch. Cations (m. equiv. %)	Exch. Potassium (K+m.-equiv. %)	Clay (%)	Silt (%)	Fine Sand (%)	Coarse Sand (%)
Pot Expt. No. 1	5·7	30	0·14	2·10	8·8	0·30	21	14	13	53
Pot Expt. No. 2 and Field Expt.	5·8	3	0·12	1·76	5·4	0·15	20	12	15	54

III. RESULTS

In pot experiment 1, the soil had received an accidental dressing of superphosphate from an aircraft. As a result there were no yield responses in centro, and the phosphorus percentages in the plants receiving no phosphate were quite high. Grass yields increased significantly in all phosphate treatments, with the superphosphate treatments consistently outyielding the calcined phosphate treatments. For the 44, 88, and 132 lb P rates the dry-matter yields for calcined phosphate were respectively 66, 69 and 71% of the corresponding yields for superphosphate. Results are summarized in Table 2.

TABLE 2

DRY-MATTER YIELDS AND PHOSPHORUS CONTENT AND YIELD OF PLANT TOPS FROM POT EXPERIMENT 1

Treatment		Dry Matter (g/pot)		Percentage Phosphorus		Phosphorus Yield (mg/pot)	
		Guinea Grass	Centro	Guinea Grass	Centro	Guinea Grass	Centro
Nil phosphorus		2·51	1·43	0·178	0·268	4·47	3·83
Superphosphate (44 lb P)		7·41	2·42	0·145	0·283	10·75	6·84
Superphosphate (88 lb P)		9·96	2·90	0·211	0·290	21·02	8·41
Superphosphate (132 lb P)		9·47	2·85	0·240	0·273	22·72	7·78
Christmas Is. phosphate (44 lb P) ..		4·89	2·12	0·161	0·293	7·87	6·21
Christmas Is. phosphate (88 lb P) ..		6·88	2·10	0·153	0·285	10·53	5·98
Christmas Is. phosphate (132 lb P) ..		6·68	1·98	0·173	0·310	11·56	6·14
Necessary differences for significance	5%	1·97	1·97	—	0·021	—	—
	1%	2·63	2·63	—	0·029	—	—

The soil used in pot experiment 2 was extremely phosphorus deficient and very large responses in dry matter and phosphorus yield were obtained for both guinea grass and centro as shown in Table 3.

TABLE 3

DRY-MATTER YIELDS AND PHOSPHORUS CONTENT AND YIELD OF PLANT TOPS FROM POT EXPERIMENT 2

Treatment		Dry Matter (g/pot)		Percentage Phosphorus		Phosphorus Yield (mg/pot)	
		Guinea Grass	Centro	Guinea Grass	Centro	Guinea Grass	Centro
Nil phosphorus		0·242	0·132	0·099	0·076	0·227	0·1028
Superphosphate (22 lb P)		9·687	1·003	0·085	0·225	8·088	2·2370
Superphosphate (66 lb P)		18·072	1·855	0·090	0·203	16·357	3·7390
Superphosphate (132 lb P)		21·622	2·765	0·135	0·194	29·066	5·3780
Christmas Is. phosphate (22 lb P) ..		6·385	0·550	0·109	0·156	6·929	0·8710
Christmas Is. phosphate (66 lb P) ..		11·597	0·778	0·097	0·195	11·123	1·5082
Christmas Is. phosphate (132 lb P) ..		14·927	1·458	0·088	0·207	13·026	2·9657
Necessary differences for significance	5%	2·563	0·651	0·013	0·013	2·760	1·2392
	1%	3·544	0·899	0·019	0·043	3·816	1·7133

TABLE 4

DRY-MATTER YIELDS AND PHOSPHORUS CONTENT AND YIELD OF PLANT TOPS FROM THE FIELD EXPERIMENT

Treatment	Dry Matter (lb/ac)			Percentage Stylo	Percentage Phosphorus* (moisture free)			Yield of Phosphorus (lb/ac)		
	Stylo	Weed	Total		Stylo	Weed	Mixture	Stylo	Weed	Total
Nil phosphorus	723	111	1,834	43	0·1308	0·14	0·14	0·94	1·54	2·48
Superphosphate (44 lb P) ..	1,177	3,441	4,618	25	0·2038	0·17	0·18	2·35	5·75	8·10
Superphosphate (88 lb P) ..	470	4,277	4,747	12	0·2250	0·19	0·19	1·07	8·04	9·11
Superphosphate (132 lb P) ..	586	4,804	5,390	15	0·2393	0·22	0·22	1·36	10·38	11·74
Christmas Is. phosphate (44 lb P)	1,332	2,041	3,373	41	0·1433	0·14	0·14	1·92	2·77	4·69
Christmas Is. phosphate (88 lb P)	1,199	2,413	3,612	34	0·1775	0·18	0·18	2·15	4·42	6·57
Christmas Is.phosphate (132 lb P)	900	2,557	3,457	25	0·1938	0·19	0·19	1·65	4·81	6·46
Necessary differences for significance 5%	551	1,505	1,508	14	0·0288	—	—	1·13	3·04	—
Necessary differences for significance 1%	755	2,062	2,067	19	0·0395	—	—	1·54	4·17	—

* Results are quoted to four decimal places for statistical analyses purposes only.

For the grass pots the calcined phosphate dry-matter yields were 66, 64 and 69% of the superphosphate yields at the 22, 66 and 132 lb P rates respectively. The differences in the centro yields for the two sources were even more pronounced, being 55, 42 and 53% for the same three rates.

The field experiment was situated on approximately 30-year-old pasture land. Although land preparation consisted of two cultivations and a preplanting application of paraquat, there was a profuse germination of weeds such as snakeweed (*Stachytarpheta urticifolia*), flannel weed (*Sida cordifolia*), pink burr (*Urena lobata*) and blue top (species of *Ageratum.*) Stylo has poor seedling vigour and competition from these weeds adversely affected its yield. They are weeds of old cultivation and respond markedly to fertilizers.

The competitive effects of these weeds are evidenced in the dry-matter yields of stylo (Table 4).

These appear to be negatively related to rate of phosphate. This negative relationship is greatest when superphosphate is used. However, the total dry-matter yield of all species (weeds and stylo) appears to be positively correlated with rate of phosphate.

TABLE 5

OVERALL RELATIVE EFFICIENCIES OF THE TWO SOURCES IN THE FIELD EXPERIMENT

Source	Mean Total Dry-matter Yield (lb/ac)	Mean Percentage P in Stylo
Superphosphate	4,918	0·2227
Christmas Island phosphate	3,481	0·1715
Necessary differences for significance (1%) ..	1,193	0·0228

IV. DISCUSSION

Doak *et al.* (1965) found that calcined Christmas Island phosphate produced responses in the dry-matter yield of subterranean clover, radish, and a pasture mixture of ryegrass, paspalum and white clover on the Papatoetoe silt loam in New Zealand (pH 5·2–5·6). Its efficiency relative to superphosphate was high, ranging from 91 to 103%.

In the present study, results show that although the calcined phosphate is a suitable alternative source of phosphorus, it is not as effective as superphosphate in terms of dry-matter and phosphorus yield of guinea grass, centro and stylo in their first 8-12 weeks of growth.

The two pot experiments show that for guinea grass the calcined phosphate is about two-thirds, while for centro it is only half as effective as superphosphate in terms of dry-matter yield.

The apparent negative correlation between stylo yield and phosphate application in the field experiment was due to a reduction in plant numbers rather than in plant size. Although there were fewer plants, individual plants were larger. As stylo is noted for being intolerant of shade, while the weeds of cultivation are responsive to fertilizer, it is considered that the "total yield" constitutes a more reliable parameter than the yield of stylo. Chemical analysis of plant tops supports this reasoning.

The total yields in the field experiment (Table 5) confirm that superphosphate is a more readily available source of phosphorus. The overall status of phosphorus in stylo, weeds, and the mixture supports this conclusion.

Residual effects of calcined phosphate have not been explored. It is likely that the release of plant-available phosphorus from the calcined phosphate in the soil could continue for some time. There is a need for a full evaluation of this fertilizer as a source of phosphorus.

The calcined phosphate used was from an experimental batch and was finely ground. Application was difficult and a granulated form would be preferable for commercial use.

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REFERENCES

BECKWITH, R. S. (1964).—Methods of chemical analysis. *Bull. Commonw. Bur. Past. Fld Crops* No. 47.

DOAK, B. W., GALLAGHER, P. J., EVANS, L., and MULLER, F. (1965).—Low temperature calcination of "C" grade phosphate from Christmas Is. *N.Z. Jl Agric. Res.* 8:15.

KERR, H. W., and VON STIEGLITZ, C. R. (1938).—The laboratory determination of soil fertility. *Tech. Commun. Bur. Sug. Exp. Stns Qd* No. 9, 1938.

WALKLEY, A. (1947).—A critical examination of a rapid method for determining organic carbon in soils—effect of variations in digestion conditions and of inorganic soil constituents. *Soil Sci.* 63:251.

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