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RESIDUAL VALUE OF CUMULATIVE DRESSINGS OF SUPERPHOSPHATE, ROCK PHOSPHATE AND BASIC SLAG ON A SANDY SOIL AT WAREHAM, DORSET

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There is little information on the relative value of residues in soil from repeated dressings of different phosphate fertilizers. A long-term factorial experiment (W 41) with spruce transplants, which started in 1949 at Wareham Nursery in Dorset (Benzian, 1965), provided soils suitable for studying this problem. Soil samples (0–6 in.) were taken in the early springs of 1955, 1959 and 1963 from plots given either 'no phosphate', or else equivalent annual dressings of superphosphate, Gafsa rock phosphate or basic slag. All plots sampled has nitrogen either as 'Nitro-Chalk' or as hoof; plots without nitrogen or with ammonium sulphate were avoided. The soils were air-dried and sieved to a size of <2 mm. The residues of phosphate fertilizers applied in the field were evaluated in glasshouse experiments, and the distributions of phosphate in different particle-size fractions of the soil were measured in the laboratory.

Changes in Total P Content and Isotopically-exchangeable Phosphorus

Table 21 gives the cumulative amounts of phosphorus applied up to each sampling date, the total P in the soils (by fusion analysis), the labile or isotopically-exchangeable P from glasshouse experiments (Mattingly, 1957) and yields of ryegrass in the glasshouse.

Total and labile P decreased slightly with time, where phosphate was not given, increased slightly where superphosphate was given, and increased much more where rock phosphate or basic slag were given. Assuming an acre of soil 6 in. deep weighs 2,000,000 lb., then 1 gram P per square yard should increase total P in soil by approximately 5 parts per million. On this assumption, the total recoveries of phosphate in 8 years, from superphosphate, rock phosphate and basic slag are, 21, 220 and 136 parts per million, or 7 per cent, 67 per cent and 41 per cent respectively of the amounts applied. Bolton and Coulter (1966) sampled the whole experiment in 1964, including 'no N' and ammonium sulphate plots. They reported somewhat larger recoveries of P, especially from superphosphate, when calculated from the differences between the P contents of treated and 'no phosphate' plots.

Evaluation of Fertilizer Residues in the Glasshouse

In each sampling year, the soils were cropped in the glasshouse with ryegrass (*Lolium perenne*). Potassium dihydrogen phosphate (5·0 parts per million P, labelled with 10 μC ^{32}P per pot) was mixed uniformly with all the soils, which also received adequate, uniform, dressings of N, K, Mg and micro-nutrients. The total isotopically-exchangeable P in the soils (Table 21) was calculated from the $^{32}P/^{31}P$ ratio in the ryegrass.

Table 21

CUMULATIVE AMOUNTS OF P ADDED TO WAREHAM SOILS, TOTAL P CONTENTS OF SOILS, LABILE (ISOTOPICALLY-EXCHANGEABLE) P IN SOILS AND YIELDS OF RYEGRASS IN 1955, 1959 AND 1963

Treatment	Cumulative amounts of P added (g. per sq. yd.)			Total P in Soil (ppm)			Labile P in Soil (ppm)			Yield: grams dry matter per pot		
	1955	1959	1963	1955	1959	1963	1955	1959	1963	1955	1959	1963
None	—	—	—	97	90	81	10	9	8	2·14	3·77	3·29
Superphosphate	18	42	78	120	126	141	32	43	52	7·58	10·56	8·42
Rock phosphate	18	48	84	130	220	350	33	71	91	8·66	14·59	13·50
Basic slag	18	48	84	123	196	259	28	70	130	7·37	13·78	13·09

Standard error—± 0·395 ± 0·133

Although the total amount of superphosphate gained by the soil between 1955 and 1963 was small (21 parts per million), the plots receiving this fertilizer contained 60 parts per million more total phosphate in 1963 than the 'no phosphate' plots; and 44 parts per million of this was isotopically-labile P (Table 21). These residues increased yields three-fold, and uptakes of P six-fold, compared with the control (Table 21). This large residual effect from so little superphosphate arises from the very small amount of labile P (8 parts per million in 1963) in the 'no phosphate' plots at Wareham. Residues from superphosphate increased the labile P in the soil to 52 parts per million in 1963 (Table 21). Yields increased exponentially, and uptakes linearly, with the labile P content of soil.

Yields and P uptakes from residues of rock phosphate were slightly greater than from residues of superphosphate in 1955, and much greater in 1959 and 1963. Yields and P uptakes from residues of basic slag were also greater than from superphosphate residues in 1959 and 1963, but were slightly smaller than from rock phosphate residues. Labile P values (Table 21) were larger in 1959 and 1963 with rock phosphate or basic slag, than they were with superphosphate.

Distribution of Phosphate in Different Particle-size Fractions of Soil

The total, and the labile, P contents of the soils, and their behaviour in the glasshouse experiments, shows that much of the phosphate applied as rock phosphate or basic slag has accumulated. Both are in fine particles about the size of coarse and fine sand (2000–20μ). To measure the distribution of phosphate in different particle-size fractions, the soils were dispersed by shaking with water, and then separated by sieving and decantation. The total P in each fraction was measured after igniting a sample at 550°C for 2 hours and extracting the residue with 0.2N H_2SO_4 for 2 hours.

Changes in the distribution of acid-soluble P in different particle-size fractions of the soils, between 1955–1963, showed that the small amount of phosphate retained from superphosphate accumulated mostly in the $<20\mu$ size fraction, and in solution. The P content of all fractions increased where rock phosphate or basic slag were given. The phosphate in fractions of soil of a size $>75\mu$ was much greater with rock phosphate than with basic slag. This was probably because ground rock phosphate contains a larger proportion of coarse material (50–70 per cent $>75\mu$) than basic slag (28–30 per cent $>75\mu$) and because slag is more soluble in acid soils.

Conclusions

Chemical analysis of the top six inches of soil from an experiment at Wareham Nursery shows that about 7, 67 and 41 per cent of the phosphate applied between 1955 and 1963 as superphosphate, Gafsa rock phosphate and basic slag respectively has been retained by the soil. These results on a very light sand (1–2 per cent clay $<2\mu$) differ greatly from those for heavier soils which retain all the phosphorus applied as superphosphate in the ploughed layer. The average annual rainfall at Wareham (about 35 in.) seems enough to leach more than 90 per cent of the applied water-soluble phosphate from the top 6 in. of soil.

Plots given superphosphate contained 60 parts per million more total P in 1963 than 'no phosphate' plots, 44 parts per million of which remained isotopically-exchangeable. These residues gave yields and uptakes by ryegrass, in the glasshouse, three- and six-fold respectively greater than those from controls.

Much of the rock phosphate remains in the soil in the coarse and fine sand ($>75\mu$). Residues of basic slag accumulate in the fine sand and silt ($>75\mu$) and in solution. The small amounts of phosphate from superphosphate were retained in finer fractions ($<20\mu$) and in solution.

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