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# DISTRIBUTION OF FERTILIZER RESIDUES IN A FOREST NURSERY MANURING EXPERIMENT ON A SANDY PODSOL AT WAREHAM, DORSET

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Experiments made on sandy podsols used as forest nurseries (Benzian 1965) showed that potassium chloride applied to the seedbed was not fully effective because potassium was rapidly leached from the rooting zone. Mattingly (1966) showed that soluble phosphates also are easily leached from the surface horizon ( $A_1$ ) of these soils but that insoluble phosphates, namely rock phosphate and basic slag, accumulated mainly in the sand and silt. We have determined the distribution of fertilizer residues in the four major soil horizons in the top 20-inch layer of soil of plots given different forms of nitrogen and phosphate, as well as potassium and magnesium fertilizers, annually since 1949. (W 41, the same experiment as used by Mattingly.)

Soil samples from each horizon of all plots were taken in early Spring 1964. The soil is an acid podsol which has developed under *Calluna* heath on a sandy phase of the Bagshot beds. Descriptions, mechanical analyses and average depths of the horizons are in Table 18, together with measurements of the organic carbon from one plot. Exchangeable cations (Ca, Mg, K, Na), total phosphate and pH in water were measured on all samples.

Table 18  
MECHANICAL ANALYSES, DEPTH AND ORGANIC CARBON CONTENT OF THE 4  
MAJOR SOIL HORIZONS

Horizons	Description	Average depth ins.	Coarse sand %	Fine sand %	Silt %	Clay %	Organic carbon %
$A_1$	Dark grey sand	7.6	56	36	5	3	1.0
$A_2$	Bleached white sand	2.8	56	35	6	3	0.4
$B_1$	Dark brown loamy sand	2.5	52	29	9	8	2.5
$B_2$	Red-brown sandy loam	4.3	49	28	10	12	1.5

## Results

Both the nitrogen and phosphate fertilizers affected pH, especially in the surface  $A_1$  and the bleached  $A_2$  horizons. The pH in the  $B_1$  and  $B_2$  horizons was similar except that ammonium sulphate had acidified all horizons of plots given 'no P'; on plots given basic slag or rock phosphate, the pH was lessened by ammonium sulphate in the  $A_1$  and  $A_2$  horizons only.

In the  $A_1$  and  $A_2$  horizons the pH correlated with total exchangeable cations, but the regressions showed that the  $A_1$  horizon had greater cation exchange

capacity than A<sub>2</sub>, because it contained more organic matter. Exchangeable cation content was greatest in the B<sub>1</sub> horizon of plots that were not given phosphates. The results emphasised how organic matter determines cation exchange capacity of this soil, which contains very little clay.

In the plots where K was not given, all the nitrogen fertilizers lessened exchangeable K in the A<sub>1</sub> and A<sub>2</sub> horizons, but increased it in the B<sub>1</sub> and B<sub>2</sub> horizons; the total amount of K in the profile was the same with all treatments. Where potassium chloride was applied, ammonium sulphate lessened exchangeable K in each horizon, whereas 'Nitro-Chalk' and crushed hoof lessened exchangeable K in the A<sub>1</sub> and A<sub>2</sub> horizons only; all the N fertilizers lessened the total amount of exchangeable K in the profile. A potassium balance sheet, calculated from crop analyses over several years, shows that the crops have taken up 23 per cent of the K applied; 7 per cent is retained in the exchangeable form in the horizons analysed, and 70 per cent has been leached from the top 17 in. of soil.

The exchangeable sodium exceeded the exchangeable potassium in each horizon of all the plots, even those given an average of 66 lb. per acre of K annually for 15 years. In a soil with such a small buffering capacity for K, the relative amounts of K and Na in the soil after leaching during the winter is probably much influenced by the composition of the rain. Salt carried from the sea by rain probably explains the large Na/K ratio at this site, which is only a few miles from the Dorset coast.

Calcium was the main exchangeable cation in all plots, and was much increased by the applied phosphate fertilizers. Both ammonium sulphate and crushed hoof lessened exchangeable calcium significantly in the A, but not in the B, horizons. 'Nitro-Chalk' maintained exchangeable calcium of the A horizon at the same amounts as in the plots not given N fertilizers. Calcium is probably the most important exchangeable cation because of the exchange characteristics of the organic matter, which has a much greater affinity for calcium than for the other major cations (Russell 1961).

Table 19 summarizes the mean pH, exchangeable cations and total phosphate in the four horizons of all plots.

Table 19

MEAN ANALYSES OF EACH HORIZON FOR ALL 32 PLOTS OF THE EXPERIMENT

Horizon	pH (water)	Exchangeable (m-equiv./100 g)				Total P ppm
		Ca	Mg	K	Na	
A <sub>1</sub>	5.3	2.41	0.16	0.02	0.09	170
A <sub>2</sub>	5.0	1.21	0.12	0.02	0.07	126
B <sub>1</sub>	4.6	1.83	0.19	0.06	0.10	348
B <sub>2</sub>	4.7	0.57	0.10	0.04	0.10	203

The total-phosphate analyses (by fusion) showed that much of the applied P, which Mattingly showed was leached from the A<sub>1</sub> horizon, accumulated in the B horizons, especially on those plots that were given superphosphate. Total

phosphate in the B<sub>1</sub> and B<sub>2</sub> horizons was much larger in the plots given superphosphate than in those given rock phosphate or basic slag (Table 20). Although only 14 per cent of the applied superphosphate P (in relation to the 'no P' plots) was recovered from the surface horizon; recovery from the whole profile was nearly 90 per cent.\* Uptake by the transplants accounts for a further 8 per cent of the applied P, showing that only a small amount of P is leached below 17 inches into the C horizon.

Table 20

TOTAL PHOSPHATE CONTENT (PPM) OF THE HORIZONS (EACH FIGURE IS THE MEAN OF ALL THE NITROGEN, POTASSIUM AND MAGNESIUM TREATMENTS)

Horizon	'No phosphate'	Basic slag	Rock phosphate	Superphosphate
A <sub>1</sub>	74	240	239	127
A <sub>2</sub>	74	129	118	186
B <sub>1</sub>	156	332	366	536
B <sub>2</sub>	137	212	174	351

### Conclusions

The distribution of cations remaining in the soil from fertilizer applied annually to a sandy podsol for 15 years was influenced primarily by the cation exchange characteristics of the organic matter contained in the four major horizons, namely A<sub>1</sub>, A<sub>2</sub>, B<sub>1</sub>, B<sub>2</sub>. Approximately 70 per cent of the applied potassium had leached from the profile. Calcium was the dominant exchangeable cation.

Much of the P applied as superphosphate had leached out of the A<sub>1</sub> horizon, but it was adsorbed by the B horizons, so that there was little leaching from the whole profile. Basic slag and rock phosphate were retained mainly in the A<sub>1</sub> horizon.

### REFERENCES

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\* The slight differences in estimates of total recovery and analyses, between our results and those given by Mattingly, are due to differences in the plots sampled (we included both the 'no-N' and the 'ammonium sulphate' plots), depths of sampling the A<sub>1</sub> horizons, year of sampling and method of calculation of recovery.

