THE EVALUATION OF THE RESIDUAL EFFECT OF FERTILIZER IN LONG-TERM FERTILITY PLOTS

I. POTASSIUM¹

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[Received for publication December 7, 1962]

ABSTRACT

Residual effects of long-term annual applications of fertilizer potassium on the potassium status of an acid sandy loam Podzol were investigated in a greenhouse experiment. Potassium accumulated in the surface soil in a form readily available to plants.

On plots with higher cation exchange capacities, resulting from manurial treatments, there was no evidence to indicate leaching below 15 inches. On plots where cation exchange capacity was not increased by treatment, a higher percentage potassium saturation at greater depths indicates that leaching of potassium had occurred to a depth of 21 inches. An increased concentration of nitric acid-soluble potassium at greater depths suggests that some of the leached potassium has been converted to the non-exchangeable form.

Accumulation in the surface soil was sufficient to supply most of the potassium requirement of ladino clover under conditions of intensive cropping. The results suggest that exchangeable and nitric acid-soluble potassium are reliable criteria of available potassium.

INTRODUCTION

In a review of literature dealing with the residual effects of fertilizers, Nelson and Stanford (9) present evidence that potassium applied regularly accumulates in the soil in a form which is available to plants. They state that this accumulation is reflected by higher crop yields and greater uptake of potassium but may not necessarily be reflected by the usual rapid extraction procedures. The latter is contingent upon the degree of reversion of applied potassium to slowly available non-exchangeable forms. Further evidence of the accumulation of applied potassium is presented by Cook and Davis (1), Peterburgskii and Yanishevskii (11), and Struchtemeyer *et al.* (14).

Conversely, Kime (8), who conducted studies on a fine sandy loam, concluded that fertilizer potassium which was not utilized by the immediate crop was lost by leaching. Further evidence of loss of potassium by leaching or fixation on coarse-textured soils is presented by Hanway *et al.* (5), Robertson *et al.* (13), and Iversen (7). It is concluded by Nelson and Stanford (9), however, that potassium losses by leaching have been over-emphasized except on very sandy soils. This conclusion is supported by Hoover (6), who found that relatively little of the applied potassium moved from the A to the B horizon even under conditions conducive to extreme leaching.

In New Brunswick, where high rates of fertilizer are applied for potato production, there is considerable interest in the fate of that portion of the fertilizer potassium which is not utilized by the crop. Recent greenhouse and laboratory investigations have been concerned with its movement in the soil and the extent to which it can supply the potassium requirements of succeeding crops. Soil samples from long-term fertility plots which had received differential fertilizer treatments were utilized in this study.

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MATERIALS AND METHODS

Soil samples were collected from a long-term fertility experiment in which potatoes had been grown annually for 24 years on an acid sandy loam Podzol. Plots representing five rates of potassium, applied annually, were sampled to a depth of 27 inches. Cation exchange capacity (10), exchangeable potassium (10), and potassium soluble in boiling 0.1N nitric acid (12), were determined on all samples.

The availability of potassium in the surface soil was assessed under conditions of intensive cropping in the greenhouse. Samples were prepared for cropping by liming to a uniform pH of 6.5 (4) with calcium hydroxide, and by treating with a soil conditioner to assure a uniform degree of aggregate stability (3). A fertilizer treatment equivalent to 40 pounds N, 200 pounds P₂O₅, 30 pounds Mg, and 5 pounds B per acre was applied to all samples. Potassium chloride was applied at rates equivalent to 0 and 200

TABLE 1.—POTASSIUM DISTRIBUTION IN AN ACID SANDY LOAM AFTER 24 YEARS OF FERTILIZATION

Depth (in.)	Annual treatment per acre				
	1600 lb. 5-10-13	800 lb. 5-10-13	No treatment	16 tons manure	800 lb. 5-10-13+8 tons manure
	Estimated K applied (lb./acre)				
	4160	2080	0	3200	3680
Depth (in.)	A. Exchangeable K (p.p.m.)				
0-6	198*	150*	46	247*	341*
6-9	77	85	43	138*	236*
9-12	78	55	28	44	111*
12-15	63	50	32	35	104*
15-21	62	34	33	30	68
21-27	23	21	25	27	28
Mean	84	66	34	87	148
Depth (in.)	B. K soluble in boiling 0.1 N nitric acid (p.p.m.)				
0-6	753*	613*	298	637*	807*
6-9	581*	504*	295	422*	667*
9-12	632*	428*	307	328	444*
12-15	607*	367	342	300	324
15-21	465*	320	296	335	367
21-27	369*	357	261	313	294
Mean	568	432	300	389	484

*Significantly greater than corresponding value in untreated; L.S.D. (P.05) values for exchangeable and nitric acid-soluble K are 56 and 98 respectively.

pounds K_2O per acre. Ladino clover was used as the indicator crop. Treatments were replicated six times. After six crops had been grown, the soil was removed from the pots, sieved free of roots, refertilized and reseeded. Six additional crops were grown. Plant material from the twelve crops was dried, ground and analysed for potassium content (2).

RESULTS AND DISCUSSION

Potassium Distribution in the Solum

Levels of exchangeable potassium and potassium soluble in nitric acid (Table 1) show that considerable accumulation of fertilizer potassium has occurred. Manurial treatments favored accumulation of exchangeable potassium in the surface soil and to a depth of 15 inches. The cation exchange capacity (Table 2) is higher on plots which received manure. This may account for the fact that potassium was not leached beyond the 12-15 inch depth on these plots. A marked increase in levels of nitric acid-soluble potassium occurred on plots which had received commercial fertilizer alone. Further, this increase occurred at all depths. Increases in potassium saturation (Table 2) and nitric acid-soluble potassium suggest that potassium has been leached to the 21-27 inch depth on plots receiving the higher rate of commercial fertilizer and that a portion of the leached potassium has been converted to the non-exchangeable form.

TABLE 2. — CATION EXCHANGE CAPACITY AND POTASSIUM SATURATION AFTER 24 YEARS OF FERTILIZATION

Depth (in.)	Annual treatment per acre				
	1600 lb. 5-10-13	800 lb. 5-10-13	No treatment	16 tons manure	800 lb. 5-10-13+8 tons manure
A. Cation exchange capacity (m.e./100 gm.)					
0-6	6.6	7.3	6.5	9.3*	10.4*
6-9	3.6	4.8	6.0	6.9	10.2*
9-12	3.2	3.5	3.5	3.8	5.6*
12-15	2.6	3.3	3.4	3.3	4.7
15-21	2.8	2.8	3.1	3.6	4.3
21-27	1.9	1.9	2.3	2.2	2.5
Mean	3.4	3.9	4.1	4.8	6.3
B. Potassium saturation (%)					
0-6	7.7*	5.3*	1.8	6.8*	8.4*
6-9	5.5*	4.5*	1.8	5.1*	5.9*
9-12	6.3*	4.0	2.0	3.0	5.1*
12-15	6.2*	3.9	2.4	2.7	5.7*
15-21	5.6*	3.1	2.7	2.1	4.0
21-27	3.1	2.8	2.8	3.1	2.9
Mean	5.7	3.9	2.2	3.8	5.3

*Significantly greater than corresponding value in untreated; L.S.D. (P. 05) values for cation exchange capacity and for potassium saturation are 2.0.

FIGURE 1. Duration of residual effect of potassium applied to an acid sandy loam podzol. Field treatments (per acre): 1.) 600 lb. 5-10-13; 2.) 800 lb. 5-10-13; 3.) Check — no treatment; 4.) 16 tons manure; 5.) 800 lb. 5-10-13 + 8 tons manure.

Availability of Residual Potassium

Greenhouse yields without potassium fertilization, per cent potassium sufficiency, and potassium uptake by twelve crops of clover (Table 3) show the accumulated potassium to be highly effective in supplying crop requirements. Soil receiving no potassium in the field showed a marked response to fertilizer potassium on all crops in the greenhouse. No response was obtained where 4160 pounds had been applied in the field experiment from 1931 to 1955. With intermediate rates of application in the field, a response

TABLE 3. — YIELD RESPONSE AND POTASSIUM UPTAKE BY LADINO CLOVER IN THE GREENHOUSE

Estimated K applied in field experiment	Clover yield in greenhouse (12 crops)		Potassium sufficiency (No K/K × 100)	K uptake on no K plots
	No K	K		
lb./acre	gm./pot	gm./pot	%	mgm./pot
4160	135	148	91	1721
2080	101	147	69	1166
0	69	124	56	538
3200	124	151	82	1804
3680	125	164	76	1918

to fertilizer potassium was obtained during the latter stages of the greenhouse experiment.

The duration of the effect of residual K is demonstrated by curves based on percentage potassium sufficiency for each crop (Figure 1). This is directly related to the amounts of potassium applied during the 24 years of the field experiment. The fact that the 4160 pounds per acre potassium treatment was able to supply 76 per cent of the potassium requirements after twelve crops had been produced (equivalent to 30 tons of dry matter per acre) is ample evidence of the availability of residual potassium.

In assessing availability of soil potassium, the amount taken up by the crop provides the most reliable estimate. Since this approach is usually impractical, chemical analyses involving various chemical extractants are employed. In this experiment, correlation coefficients expressing relationship between potassium uptake and levels of exchangeable and of nitric acid-soluble potassium were 0.93 and 0.94 respectively. It is concluded that either method provides a reliable estimate of the potassium status of the soil.

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