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Relationship Between Particle Size and Potassium Release in the Clarion and Marshall Soils[1]

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A study by Lawton and Pierre (1946) of different soil types in Iowa and their potassium availability showed that the Marshall series were consistently higher in exchangeable potassium than the Clarion series.

The Marshall series is developed in Wisconsin loess and is classified as a Medial Brunizem. The Clarion series is developed in Cary and Mankato till and is classified as a Minimal Brunizem. The Marshall series is dominantly a silty clay loam, whereas the Clarion series is dominantly a loam.

Pratt and Morse (1954) found, when they grouped several Ohio soils by areas, the potassium release was lowest from the sandy soils of the lake bed and highest from the associated fine textured soils. Volk (1942) found the percentage of Alabama soils responding to the second increment of applied potassium fertilizer increased as the texture became coarser. Lawton and Pierre (1946) reported that potassium release from Iowa soils was (1) highest in fine textured alluvial soils and (2) that loess derived soils showed higher release than soil derived from glacial till.

Merwin and Peech (1950) studied potassium release from different size fractions of four New York soils. They found the sand fractions contributed from 15 to 50 percent and the clay fractions 50 to 80 percent of the total potassium released. Rouse and Bertramson (1949) concluded that about half of the potassium-supplying power was in the 0.053 to 0.005 mm. fractions based on the release by 1.0 N HNO_3 and the percentage of the various fractions in the soils. Pratt (1950) working with 13 Iowa soils found the greatest release per unit weight of material was from 2.0 to 0.2 micron fraction in all soils but one. Coultas and McCracken (1952) studied potassium release in the O'Neill series and found that approximately 25 percent of the potassium released from the whole soil came from the sand fraction.

Two hypotheses are advanced to explain the differences in potassium release in the Clarion and Marshall series.

1. Textural differences, since data have been presented by other authors which show a decrease of potassium released with in-

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creased particle size.

2. Differences in mineralogical composition.

Method of Study

To test the above hypotheses twelve samples of each soil series were selected from slopes of 3-4 percent. Each sample was subdivided into two depths, 0-6 and 6-12 inches. The samples were analyzed for exchangeable potassium, the results plotted to note any central tendency and aberrant results discarded. The Clarion samples were selected from those having the average, lowest and highest exchangeable potassium, and the Marshall samples from samples closest to the average exchangeable potassium value. The soils selected were fractionated and potassium extracted with boiling 1.0 N HNO_3. Pratt (1950) found close correlation with this method of extraction and potassium released to alfalfa plants in greenhouse experiments.

Results and Discussion

The acid soluble potassium of the whole soil (Table 1) of the two Marshall samples are similar, with slightly less release from the 6-12 inch depth than from the 0-6 inch depth. The Clarion samples show more variation between samples, but the largest differences are found between the Marshall and Clarion samples.

Table 1

Acid soluble potassium of the whole soil in pounds per acre

Sample No.	Acid Soluble Potassium (Pounds Per Acre)
Marshall	
5a*	1334
5b	1094
8a	1354
8b	1156
Clarion	
3a	477
3b	396
6a	560
6b	553
9a	752
9b	562

*a—0-6-inch depth
b—6-12-inch depth.

Part of the differences between the Marshall and Clarion samples in acid soluble potassium is explained by the differences in release per unit weight of material of each fraction (table 2). The Marshall samples are consistently higher in release of potassium from each fraction, per unit weight of material, than the Clarion samples.

The differences in particle size distribution between the Marshall and Clarion samples (table 3) are large, especially in the greater than .050 mm. fractions. The Clarion samples range from

Table 2.

Acid soluble potassium released by size fractions in parts per million.

Sample No.	Size Fractions						
	2-.250 mm.	.250-.050 mm.	.050-.035 mm.	.035-.020 mm.	.050-.020 mm.	.020-.002 mm.	<.002 mm.
Marshall							
5a			159	184		400	1260
5b			109	150		331	1045
8a					169	440	1297
8b					154	395	1220
Clarion							
3a	15	25		[1]	106	281	815
3b	11	25			112	266	750
6a	11	26			86	260	867
6b	16	23			77	226	832
9a	25	53			146	380	922
9b	21	36			134	324	835

[1]The potassium release of the .050-.035 mm. and .035-.020 mm. size fractions of the Clarion samples was not studied because the size fractions percentage by weight was less than 10 percent of the total sample.

Table 3.

Particle size analysis.

Sample No.	Size Fraction					
	>.050 mm.	.050-.035 mm.	.035-.020 mm.	.020-.011 mm.	.011-.002 mm.	<.002 mm.
Marshall						
5a	2.0	18.7	21.2	13.6	11.4	33.1
5b	0.6	18.5	20.0	17.0	9.9	34.0
8a	1.0	17.4	22.4	14.3	14.2	30.7
8b	0.9	18.0	22.0	13.8	14.1	31.2
Clarion						
3a	53.8	8.5	5.7	4.1	7.8	20.1
3b	57.0	7.6	5.2	4.4	7.0	18.8
6a	46.2	8.5	7.2	6.0	8.9	23.2
6b	46.7	8.9	6.8	6.0	11.9	19.7
9a	42.4	8.5	6.5	5.0	10.2	27.4
9b	40.8	9.1	6.3	6.0	9.8	28.0

	Particle Size Distribution, Sand Fraction				
	2-1 mm.	1-.500 mm.	.500-.250 mm.	.250-.105 mm.	.105-.050 mm.
Clarion					
3a	5.8	13.5	28.5	32.0	20.2
3b	5.4	12.9	27.7	32.2	21.8
6a	3.8	12.7	28.5	33.8	21.2
6b	3.6	11.2	28.0	34.7	22.5
9a	5.3	12.2	25.6	33.3	23.6
9b	4.9	11.4	24.4	33.3	26.0

40.8 to 57.0 percent sand while the Marshall samples have a maximum of 2.0 percent sand. Differences are also apparent in the less than .020 mm. fractions.

It is shown in table 4 that the greater than .020 mm. fractions in all samples supply only a small amount of potassium when compared with the less than .020 mm. fractions. This may be partially explained by difference in surface area and/or mineralogical composition of the different size fractions.

Table 4.

Acid soluble potassium contributed by fractions in pounds per acre.

Sample No.	2-.250 mm.	.250-.050 mm.	.050-.035 mm.	.035-.020 mm.	.050-.020 mm.	.020-.002 mm.	<.002 mm.
Marshall							
5a			60	78		200	834
5b			40	60		178	711
8a					135	251	797
8b					124	220	761
Clarion							
3a	8	14			30–	67	228
3b	8	16			29	51	282
6a	4	13			27	78	403
6b	6	13			24	81	328
9a	11	22			44	116	506
9b	7	17			41	102	468

In table 5 the percentage of the total potassium released by each size fraction shows that the less than .002 mm. fraction is the largest contributor. The percentage contributed by this fraction ranges from 67.4 percent to 76.8 percent. When the less than .020 mm. fractions are combined the total contributed by these fractions on a percentage basis ranges from 86.3 to 91.7 percent. This range is small considering the range in release per unit weight of material for the less than .020 mm. fractions shown in table 2.

The predominance of the less than .020 mm. fractions in the Marshall samples and the greater than .020 mm. fractions in the Clarion samples, plus the greater release per unit weight of material in the Marshall samples accounts for a large part of the differences found in table 1. The greater than .020 mm. fractions in all samples, especially the sand fractions, apparently act more as a dilutent than an active participant in potassium release.

To test the hypothesis that differences in mineralogical composition may be partially responsible for the differences in potassium release, the .050-.020 mm. fractions were studied by grain counts under a petrographic microscope. Grain counts ranged from 350 to 395 per slide.

Table 5.

Percentage potassium released by each size fraction.

Sample No.	2-.250 mm.	.250-.050 mm.	.050-.020 mm.	.020-.002 mm.	<.002 mm.	<.020 mm.
Marshall						
5a			11.8	17.1	71.1	88.2
5b			10.1	18.0	71.9	89.9
8a			11.4	21.2	67.4	88.6
8b			11.2	19.9	68.9	88.8
Clarion						
3a	1.8	3.1	6.7	15.0	73.4	88.4
3b	2.1	4.1	7.5	13.2	73.1	86.3
6a	0.7	2.5	5.1	14.9	76.8	91.7
6b	1.3	2.9	5.3	17.9	72.6	90.5
9a	1.6	3.1	6.3	16.6	72.4	89.0
9b	1.1	2.7	6.4	16.1	73.7	89.8

Table 6.

Percentage quartz, feldspars, and heavy minerals .050-.020 mm.

Sample No.	% Quartz	% K Feldspar	% Plagioclase	% Heavy Minerals
Marshall				
8a	65	23	8.1	3.9
8b	67	22	8.3	2.7
Clarion				
3a	73	15	6.3	2.7
6a	73	16	5.6	5.4
9a	66	23	5.8	5.2

The percentage K feldspar includes both orthoclase and microcline; however, microcline was less than one percent of the total sample in all soils studied. Of the heavy minerals hornblende was the most abundant. Biotite and muscovite combined were less than one percent of the total sample.

The combined percentage of the orthoclase and microcline of each sample correlates closely with the release of potassium from that sample (Fig. 1).[1] This does not agree with the data of Rouse and Bertramson (1949) or Phillippe and White (1952) who reported no relationship between the mineralogical composition of the coarser fractions and the potassium extracted by boiling 1.0 N HNO_3.

[1]Fig. 1 includes the results of four other samples which were not reported in this paper; two each of Weller, a gray-brown podzolic, and Seymour, a maximal Brunizem.

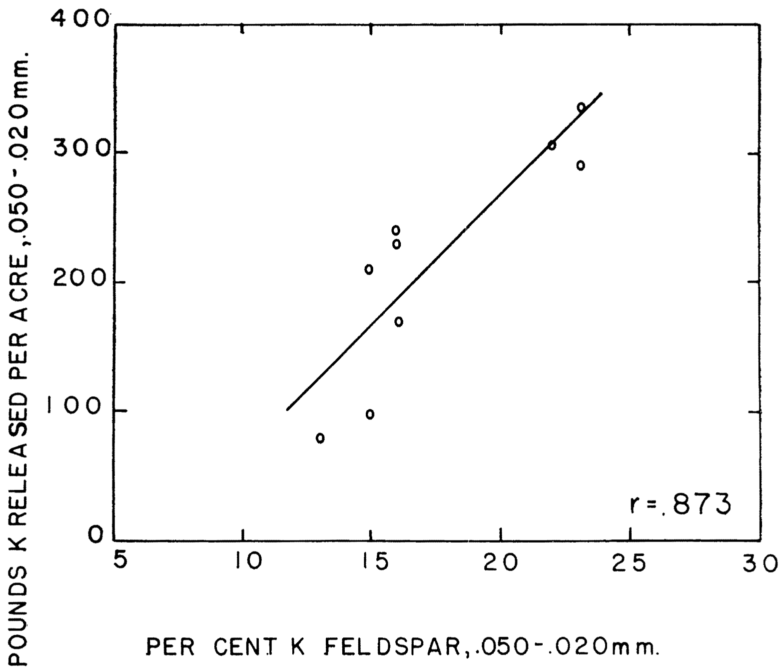

Figure 1. Relationship between potassium released in boiling 1.0 *N* HNO_3 and the percentage potassium bearing feldspar.

Summary and Conclusions

The effect of particle size distribution on potassium release is clearly shown. The sand and coarse silt fractions serve more as a diluting agent than as an active participant in potassium release. The release of the less than .020 mm. fractions, especially the less than .002 mm. fraction, determines in a large part the potassium release of the whole soil in boiling 1.0 *N* HNO_3. These fractions contributed more than 85 percent of the total potassium released, regardless of their percentage by weight of the whole soil. The differences in exchangeable potassium between the Clarion and Marshall soils is due primarily to the predominance of the less than .020 mm. fractions in the Marshall soils and the predominance of the greater than .020 mm. fractions in the Clarion soils.

A correlation was found between the percentage of potassium bearing feldspar in the .050-.020 mm. fractions and the amount of potassium released in boiling 1.0 *N* HNO_3 by that fraction. Although a correlation exists, the amount released by these fractions under field conditions is probably minor. Consequently, differences in mineralogy in the coarser fractions are not as important in the samples studied as the particle size distribution in determining potassium release of the whole soil.

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