

# POTASSIUM STATUS IN DIFFERENT PARTICLE SIZE FRACTIONS OF SOME FINNISH SOILS

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The potassium status of a soil mainly depends on the quantity and quality of the clay fraction. Yet, there is evidence that also the coarser material, particularly that of the size of silt, may markedly contribute both to the release of potassium for plants and to the fixation of applied potassium in nonexchangeable forms (e.g. OLSEN and SHAW 1943, BARSHAD 1951, PRATT 1952, SCHACHTSCHABEL and KÖSTER 1960, MACLEAN and BRYDON 1962).

According to the relatively scanty information available of the mineral composition of various particle size fractions in Finnish soils, there does not seem to be such an essential difference between the clay and silt materials, as it is typical of soils of a markedly longer pedological history. SOVERI (1956) states that in all particle size fractions of Finnish clay soils the same mineral association with the same structural types of minerals is present. Therefore, it is likely that in our young soils the behaviour of the silt material will not fundamentally differ from that of the clay to any higher degree than which would be caused by the difference in their specific surface area.

In previous papers (KAILA 1965a, 1965b), attention was paid to the relatively high fixation of added potassium by several silt, loam and even fine sand soils. It was supposed that, at least in some of these soils, the fixation may be largely attributed to the coarser fractions. In order to study the contribution of the material  $> 2 \mu$ , to the potassium status of the soil in general, the samples used in the latter paper were separated into the fractions of clay, silt and fine sand, and the separates were analyzed for their content of total potassium and exchangeable potassium, for their potassium reserves and their capacity to fix added potassium.



*Material and methods*

The thirty soil samples representing three layers of ten soils are described in the previous paper (KAILA 1965b). The samples were air-dried and passed through a 2 mm sieve.

The mechanical composition of the samples reported in Table 1 was determined by the usual hydrometer method after the destruction of organic matter with hydrogen peroxide treatment. The organic matter of the samples was not destroyed, when the soils were separated into the fractions  $< 2 \mu$ ,  $2-20 \mu$ , and  $20-200 \mu$ . The separation was performed by a procedure developed by Mr. Paavo Elonen, M.Sci. (Agric.) in this laboratory. The sample was dispersed in distilled water by ultrasonic vibration and washed through a 0.2 mm sieve to eliminate the sand fraction. The other fractions were separated by repeated sedimentation and decantation. The excess of water was evaporated from the clay suspension by heating on a water bath, and the moist material was dried at room temperature. The suspensions containing silt and fine sand were centrifuged for the removal of water and dried at room temperature.

The total potassium content of the original samples and the separates was determined by the  $\text{Na}_2\text{CO}_3$  fusion, and the readily exchangeable potassium by an extraction for one hour with 0.5 N neutral ammonium acetate in the ratio of 1 to 10. The potassium reserves, or nonexchangeable potassium released by acid, were estimated by treating the 2 g-samples extracted with ammonium acetate, with 20 ml 1 N HCl at  $50^\circ\text{C}$  for 18 hours. Allowance was made for the acetate solution left in the sample.

The fixation of potassium by the soil samples and the fractions was estimated both under «wet conditions» and under «dry conditions» according to the procedures used by SCHACHTSCHABEL and KÖSTER (1960), only the ratio of soil to the 0.5 N ammonium acetate solution was changed to 1 to 10. The amount of K added in both cases corresponded to 97.5 mg per 100 g of soil or fraction.

All the potassium determinations were performed with an EEL-flame photometer.

*Results*

**T o t a l K.** The total content of potassium in the original soil samples and the various particle size fractions is recorded in Table 1. The soils are relatively rich in potassium, as it is typical of Finnish mineral soils. The total content ranges from 1.99 per cent in a silt soil to 3.41 per cent in a subsoil sample of heavy clay. The average content is  $2.75 \pm 0.12$  per cent.

The potassium content calculated for the soil samples on the basis of their mechanical composition and the potassium content of the different fractions is well in accordance with that determined from the original samples. This may be taken to indicate that no significant loss of potassium did occur during the separation procedure, and that the fractionation without the destruction of organic matter was fairly efficient.

In the 30 samples of clay and silt fractions and the 28 samples of fine sand the average potassium content (with the confidence limits at the 95 per cent level) and the corresponding minimum and maximum values are the following:

	Mean	Range
$< 2 \mu$	$3.02 \pm 0.11 \%$	$2.57-3.54 \%$
$2-20 \mu$	$2.75 \pm 0.10 \%$	$2.19-3.27 \%$
$20-200 \mu$	$2.16 \pm 0.13 \%$	$1.47-2.67 \%$

On the average, the clay fraction is not much richer in potassium than the silt material. There are samples, e.g. the silty soils HP 1, HP 2, and HP 3 from the inner part of Finland, in which the total potassium content is of the same order both in

Table 1. Mechanical composition of the samples and the total content of K in the soil and the different fractions.

	Depth cm	Particle size fraction %			Total K %				
		<2 $\mu$	2-20 $\mu$	20-200 $\mu$	soil	<2 $\mu$	2-20 $\mu$	20-200 $\mu$	
Vi 1	a	0-20	46	35	18	2.62	3.07	2.47	1.97
	b	20-40	42	35	21	2.54	3.02	2.37	2.02
	c	40-65	51	33	14	2.68	3.12	2.62	2.02
Vi 2	a	0-20	45	18	25	2.81	3.25	2.68	1.97
	b	20-40	74	12	11	3.27	3.47	2.96	1.99
	c	40-65	89	9	2	3.41	3.54	3.19	2.10
Vi 3	a	0-20	47	31	17	2.27	2.63	2.19	1.79
	b	20-40	54	24	21	2.68	3.07	2.74	2.03
	c	50-70	72	21	6	3.06	2.87	2.52	1.92
Le 1	a	0-20	32	29	34	2.12	2.67	2.32	1.77
	b	45-60	70	17	12	3.08	3.37	3.17	1.79
	c	95-105	40	54	5	3.13	3.27	3.27	2.17
HP 1	a	0-20	18	68	11	2.61	2.57	2.57	—
	b	30-40	18	80	1	2.78	2.77	2.87	2.67
	c	50-60	14	66	19	2.78	2.87	2.77	2.57
HP 2	a	0-20	16	68	15	2.56	2.62	2.72	2.52
	b	30-40	8	74	17	2.77	2.77	2.87	2.67
	c	50-60	17	78	5	2.80	2.87	2.87	2.67
HP 3	a	0-20	30	39	29	2.54	2.73	2.67	2.52
	b	30-40	28	48	22	2.68	2.83	2.79	2.01
	c	50-60	36	58	4	3.08	3.12	3.02	2.61
HP 4	a	0-20	30	56	13	2.68	2.92	2.67	2.32
	b	45-60	36	53	11	2.98	3.30	2.97	2.42
	c	95-105	38	56	6	3.14	3.41	3.08	2.52
To 1	a	5-15	11	61	27	1.99	2.67	2.42	1.47
	b	20-30	40	57	3	2.86	3.47	2.72	1.67
	c	40-50	18	72	10	2.60	3.22	2.67	—
Sa 1	a	10-20	24	36	35	2.51	2.87	2.62	2.15
	b	30-40	18	30	51	2.41	2.87	2.62	2.15
	c	90-100	83	11	6	3.17	3.25	3.19	2.10

the clay fraction and the silt fraction, and not markedly lower in the fine sand. On the other hand, in the clay soils Vi 1, Vi 2, and Vi 3 from the southern coast, the clay fraction has a significantly higher potassium content than the silt and particularly the fine sand fractions. Yet, this relationship is, obviously, not connected only with the texture of the soil, since there are clay soil samples (e.g. Le 1 c and Sa 1 c)

in which the potassium contents of the clay and silt fractions are equal, and silt soils (e.g. To 1 a and c) with a higher content of potassium in the clay fraction than in the other ones.

Both in the original soils and their particle size fractions the potassium content usually increases with the depth, although not always to any marked degree. In the surface samples, the average potassium content of the clay fraction is 2.8 per cent, that of the silt fraction 2.5 per cent, and that of the fine sand 1.9 per cent. The respective figures for the samples from the deeper layers are 3.1, 2.9, and 2.1 per cent. This dependence on the sampling depth may be attributed to the higher content of organic matter in the surface soils and the lower degree of weathering in the deeper layers.

In connection with an unpublished work, the fractions of coarser clay, 0.2—2  $\mu$ , of some of these samples was analysed for the content of total potassium. Organic matter was destructed with hydrogen peroxide, when these separates were prepared. The soil samples had the following potassium content in the coarser clay:

Vi 1 a	3.56 %	HP 3 a	3.22 %
Vi 3 b	3.89 %	HP 4 a	3.32 %
Le 1 b	4.20 %	HP 4 b	3.51 %
HP 1 a	3.08 %	HP 4 c	3.62 %
HP 2 a	3.12 %	To 1 b	3.58 %

All these values are markedly higher than those for the fraction  $<2 \mu$  of the respective samples in Table 1. The difference is not likely to be due only to the removal of organic matter from the samples of 0.2 to 2  $\mu$ . Probably, it arises from the fact that the finer clay tends to be more weathered, and that it has lost potassium to a larger extent than the coarser material.

**E x c h a n g e a b l e K.** According to the data in Table 2, the content of readily exchangeable potassium in the clay fraction varies from 9 to 94 mg/100 g, in the silt fraction from 2 to 23 mg/100 g, and in the fine sand fraction from 1 to 9 mg/100 g. The average values are  $31 \pm 7$  mg/100 g in the 29 samples of clay,  $6 \pm 2$  mg/100 g in the 28 samples of silt, and  $2 \pm 1$  mg/100 g in the 20 samples of fine sand analysed.

The clay fraction contains 3.5 to 11 times as much exchangeable potassium as the silt fraction of the same 27 soil samples. In 19 samples the values for exchangeable potassium in the clay fraction are 7 to 33 times as high as those in the fine sand fraction of the same soils. On the average, the content of readily exchangeable potassium in the clay fraction is about 6 times as high as that in the silt fraction, and about 16 times as high as the amount in the fine sand fraction. These differences are lower than it could have been expected on the basis of the specific surface area of these three particle size fractions. Perhaps it could be attributed partly to a more complete exchange of potassium from the coarser material than from the clay fraction by the procedure used.

This may also be one of the reasons for the observation that the content of readily exchangeable potassium in most of the original samples tend to be somewhat lower than the corresponding value calculated on the basis of the mechanical composition of the sample and the content of exchangeable potassium in the different

fractions. Possible changes during the separation procedure must also be taken into account as an explanation. The difference between the calculated and the measured content is not marked except in the clay soil samples Vi 1 and HP 3a. On the basis of the available information it is not easy to understand why these soils should deviate from the other material in this respect.

The content of exchangeable potassium in the silt fraction is fairly closely correlated with that in the clay fraction: the total linear correlation coefficient  $r = 0.91^{***}$ . The correlation between the contents in the silt and fine sand fractions tends to be even closer:  $r = 0.97^{***}$ . A somewhat poorer correlation exists between the exchangeable potassium contents of the clay and fine sand fractions:  $r = 0.89^{***}$ .

**Nonexchangeable K released by acid.** The release of non-exchangeable potassium is estimated in this study by treating with hydrochloric acid the samples extracted with ammonium acetate for the removal of exchangeable potassium. The samples were not dried before the acid was added, and it was found by weighing that the amount of ammonium acetate solution left in the samples changed the ratio of extraction from 1:10 to about 1:11 in the suspensions of fine sand, silt and the original soil, and to about 1:12 in the suspensions of the clay fraction. Simultaneously, the concentration of the acid was diluted to 0.9 N in the former, and to about 0.8 N in the latter suspensions. Thus, these results are only roughly comparable since it is not likely that the higher increase in the amount of the extractant of the clay fraction would completely compensate the larger decrease in the concentration of the acid. The values calculated on the basis of the contents of nonexchangeable potassium in the various fractions are in some cases higher and in other cases lower than those determined from the original soil samples, but usually they are of the same order.

Data in Table 2 show that both in the soil samples and their various particle size fractions the content of acid soluble nonexchangeable potassium usually increases with the depth more distinctly than is the case with the total potassium content. The clay soils Vi 1, Vi 2, Vi 3b and 3c, and To 1b have especially high amounts of this kind of potassium both in the clay fraction and the silt fraction. These samples are known to be rich in mica and micaceous minerals, and the same holds true also about the sample Le 1b.

The acid treatment released from the clay fraction 140 to 750 mg K per 100 g, or on the average  $400 \pm 70$  mg/100 g. The corresponding data for the silt fraction are 90 to 440 mg/100 g and  $230 \pm 50$  mg/100 g, and for the fine sand fraction only 20 to 170 mg/100 g, averagely  $70 \pm 20$  mg/100 g. These amounts correspond to an average of 13 per cent of the total content of potassium in the clay fraction, to 9 per cent of that in the silt fraction, and to about 3 per cent of total potassium in the fine sand material.

According to these results, the acid treatment has released from the clay fraction 0.9 to 3 times as much potassium as from the silt fraction, and from 3 to 13 times as much as from the fine sand fraction. Even if the figures for the potassium reserves in the clay fraction were too low, it is obvious that the difference between the silt and the clay fraction in the content of acid soluble nonexchangeable potassium is markedly lower than that in the contents of exchangeable potassium. On the other

Table 2. Easily exchangeable K and non-exchangeable K released by acid in the soil and the particle size fractions.

	Exchangeable K mg/100 g				Non-exchangeable K mg/100 g			
	soil	<2 $\mu$	2-20 $\mu$	20-200 $\mu$	soil	<2 $\mu$	2.-20 $\mu$	20-200 $\mu$
Vi 1 a	19	47	9	4	520	710	310	90
b	16	60	8	3	400	630	290	100
c	17	44	13	6	510	750	430	150
Vi 2 a	18	38	11	3	390	540	330	50
b	24	40	9	—	540	630	440	—
c	35	40	—	—	640	710	—	—
Vi 3 a	45	94	23	9	260	320	200	100
b	22	54	12	4	390	470	350	120
c	27	48	13	—	460	530	390	—
Le 1 a	15	38	8	2	220	320	180	50
b	18	24	7	—	320	370	300	—
c	8	17	3	—	350	330	350	—
HP 1 a	4	11	3	1	120	210	100	40
b	4	11	2	1	130	240	90	40
c	3	12	2	1	150	280	120	40
HP 2 a	8	30	5	2	110	200	100	40
b	2	9	2	1	140	220	120	50
c	4	12	2	—	160	270	120	—
HP 3 a	11	33	6	2	110	160	90	30
b	9	24	5	1	130	140	100	30
c	8	15	4	—	270	290	240	—
HP 4 a	7	14	3	1	170	260	120	30
b	7	18	3	1	260	340	200	40
c	8	18	4	—	370	470	260	—
To 1 a	5	—	3	1	260	—	320	80
b	12	30	3	—	520	750	360	—
c	5	17	3	1	430	550	370	170
Sa 1 a	9	28	3	1	150	260	130	20
b	7	33	3	1	130	280	100	30
c	27	38	—	—	—	420	—	—

hand, the contents of the former kind of potassium in the silt and clay fractions are relatively closely correlated with each other. The total linear correlation coefficient is  $r = 0.87^{***}$ . Between the silt and fine sand fractions the corresponding coefficient is  $r = 0.86^{***}$  and between the clay and fine sand fractions  $r = 0.77^{***}$ .

Table 3. Fixation of K by the soil and the different particle size fractions (as per cent of amount of K added, 97.5 mg K/100 g).

		»Wets» fixation				»Dry» fixation			
		soil	< 2 $\mu$	2-20 $\mu$	20-200 $\mu$	soil	< 2 $\mu$	2-20 $\mu$	20-200 $\mu$
Vi 1	a	13	18	10	10	44	47	30	20
	b	11	16	13	10	36	43	27	17
	c	13	15	14	11	53	54	40	35
Vi 2	a	14	16	10	9	59	64	43	25
	b	27	34	37	—	84	89	87	—
	c	35	32	—	—	80	82	—	—
Vi 3	a	9	9	10	9	26	21	21	16
	b	11	10	12	9	23	25	20	16
	c	13	10	12	—	26	29	23	—
Le 1	a	20	37	12	9	52	45	30	21
	b	57	59	65	—	88	89	93	—
	c	87	77	86	—	95	93	97	—
HP 1	a	28	26	23	12	76	93	58	49
	b	34	34	27	11	76	87	64	24
	c	31	47	26	10	78	92	63	20
HP 2	a	11	11	9	8	45	41	35	17
	b	32	40	27	11	75	89	62	24
	c	49	54	37	—	87	93	77	—
HP 3	a	10	13	9	8	39	36	26	15
	b	7	19	5	2	19	26	16	7
	c	15	13	13	—	70	77	55	—
HP 4	a	12	12	12	8	70	67	49	16
	b	43	52	34	9	86	88	70	18
	c	22	28	24	—	74	89	62	—
To 1	a	10	—	7	6	47	—	43	26
	b	28	24	29	—	80	95	71	—
	c	44	36	40	25	88	85	80	53
Sa 1	a	39	46	43	10	75	85	78	18
	b	83	90	96	44	93	95	100	55
	c	68	64	—	—	85	89	—	—

A rather poor correlation appears to exist between the nonexchangeable acid soluble potassium and the exchangeable potassium of the different fractions: the correlation coefficient in the clay fraction is  $r = 0.42^*$ , in the silt fraction  $r = 0.41^*$ , and in the fine sand fraction it is  $r = 0.53^*$ . No relationship was found between the nonexchangeable potassium and the total potassium in the different fractions.

**Fixation of K.** Data in Table 3 prove that the clay fraction is by no means the only material in these soils capable of retention of added potassium in nonexchangeable forms. In some samples, e.g. Le 1b, Le 1c, and Sa 1b, the silt fractions has fixed even more potassium than the clay fraction, both under the «wet» and the «dry» conditions. Although the fixation by the fine sand material is usually low, it is not quite insignificant: in three samples, HP 1a, To 1c, and Sa 1b, about one half of the added potassium has been fixed under the «dry» conditions, and the third of these samples has been able to retain more than 40 per cent under the «wet» conditions.

In most soils the «dry» fixation by the original sample is markedly higher than the value calculated on the basis of the fixation by the various mechanical fractions. Under the «wet» conditions this is not always the case: sometimes the latter value may be equal to or even somewhat higher than the fixation by the original sample. It could be expected that the separation procedure would decrease the fixation capacity of the soil materials, probably most that of the clay fraction which was treated at a higher temperature before the final drying at room temperature. On the other hand, attention must be paid to the fact that when the fixation by the soil sample is very high, the same amount of potassium added to the separated clay or silt material may be too low to allow their total capacity to be effective. Obviously, this occurred at least in the sample Sa 1b.

In all the particle size fractions analysed the following percentage values represent the average fixation of the 97.5 mg K added per 100 g of the material:

	«Wet» fixation	«Dry» fixation
< 2 $\mu$ (29 samples)	32 $\pm$ 8 %	69 $\pm$ 10 %
2 $\mu$ - 20 $\mu$ (28 samples)	27 $\pm$ 9 %	54 $\pm$ 10 %
20 $\mu$ - 200 $\mu$ (20 samples)	12 $\pm$ 4 %	25 $\pm$ 6 %

The variation is large: under the «wet» conditions from 9 to 90 per cent in the clay samples, from 5 to 96 per cent in the silt samples, and from 2 to 44 per cent in the fine sand samples. The ranges for the «dry» fixation are not much narrower: from 21 to 95 per cent for the clay samples, from 16 to 100 per cent for the silt samples, and from 7 to 55 per cent for the fine sand samples.

The part of added potassium fixed by the silt fraction under the «wet» conditions ranges from 33 to 120 per cent of that fixed by the clay fraction of the same soil; the average is 87  $\pm$  10 %. Under the «dry» conditions the average fixation by the silt fraction is 79  $\pm$  6 per cent of the fixation by the clay fraction, ranging from 60 to 105 per cent. The fine sand fraction of 19 samples has fixed under the «dry» conditions from 21 to 80 per cent, or averagely 43  $\pm$  9 per cent of that fixed by the clay fraction, and under the «wet» conditions from 18 to 100 per cent of the amount fixed by the clay fraction of the same soil, on the average 51  $\pm$  12 per cent.

The correlation between the fixation by the different fractions of the same soils is relatively close, as may be seen from the following total linear correlation coefficients:



Between	»Wet» fixation	»Dry» fixation
clay and silt	0.93***	0.92***
silt and fine sand	0.90***	0.66**
clay and fine sand	0.73***	0.59**

Fixation under the »wet» conditions did not depend on the contents of exchangeable or nonexchangeable acid soluble potassium in any of the mechanical fractions. »Dry» fixation, on the other hand, seemed to be, to a certain degree, negatively correlated with the content of exchangeable potassium in the two finer fractions. The correlation coefficients are  $r = -0.67^{***}$  in the clay fraction and  $r = -0.55^{**}$  in the silt fraction.

The results of »wet» and »dry» fixation are relatively closely correlated in the silt fraction ( $r = 0.86^{***}$ ), somewhat less closely correlated in the fine sand fraction ( $r = 0.79^{***}$ ), and the poorest correlation is found in the clay fraction ( $r = 0.69^{***}$ ). On the average, the »dry» fixation is about 2 to 3 times as effective as the »wet» fixation by the different fractions. The average ratio tends to be somewhat lower in the fine sand fraction than in the clay fraction of the same soils, but the difference is not significant. At least in the samples Le 1c and Sa 1b, the fixation under the »wet» conditions is so high that, apparently, the amount of potassium added was far too low for saturating the fixing capacity of the clay and silt separates under the »dry» conditions.

No regular tendency towards higher fixation with the increase of the sampling depth can be found in the various particle size fractions.

### Discussion

The values calculated on the basis of the results obtained for the three particle size fractions and the mechanical composition of the soils agreed closely with those determined from the original soil samples only in regard to the total content of potassium. Even in the cases in which these values were satisfactorily in accord with each other in connection with the estimation of the contents of exchangeable or nonexchangeable potassium, or the fixation of potassium, this criterion is not sufficient to prove that no changes did occur during the separation procedure. It is also possible that the clay material was not completely removed from the fractions of silt and fine sand, since organic matter was not destroyed. Yet, the destruction of organic matter would have brought about marked changes of other kind in the material (c.f. WELTE 1961). Attention must also be paid to the fact that the determinations were performed using equal amounts of the extractants and potassium solution both when the original soil sample and the particle size separates were analysed. In the soil sample, the more active material, usually the clay fraction, is diluted by less active material, and as a part of the soil sample it will be treated relatively more effectively than when it is analysed as the separate, since in the latter case the ratio of extraction was not correspondingly decreased. Thus, there are several sources of error, and the present results may only give a rather rough estimation of the potassium status of the different particle size fractions in the soil.

According to the results obtained, the silt fraction, 2 to 20  $\mu$ , does not appear to be unimportant for the potassium economy of our mineral soils. On the average, the total content of potassium in it is slightly lower than that in the clay fraction, but in some soil samples silt may be somewhat richer in potassium than clay. As to the readily exchangeable potassium, clay is the markedly richer one, but the mean content of nonexchangeable acid soluble potassium is in the silt fraction more than one half of that in the clay. In this material, the average capability of fixing added potassium is not significantly higher in the clay fraction than in the silt fraction, neither under the «wet» nor under the «dry» conditions. Although it is likely that the fixation capacity of the clay material was somewhat impaired during the separation procedure, the results obtained for the silt fraction are of an order which make them noteworthy when the potassium fixation of these soils are in question.

The separate of fine sand, 20 to 200  $\mu$ , contains markedly less total, exchangeable and nonexchangeable potassium than the other fractions studied. Its capacity to fix potassium is also significantly lower than that of the silt and clay fractions, but it was not always as inactive as it has been supposed to be. Fixation of about one half of the added potassium by some samples of fine sand is not negligible. Perhaps this capacity will not in the soil get chance to be fully effective because of the competition of the finer material with a probably higher bonding energy for potassium. This possibility hampers the evaluation of the contribution of the different particle size fractions to the release and fixation of potassium in the soil until more information of it is obtained.

The close correlation between the fixation of potassium by the silt and the clay fractions does not disagree with the supposition that the differences in the mineral composition of these materials are more of a quantitative than a qualitative kind. In connection with this work no mineralogical analyses were made, but according to the information available about some of these samples, quartz, feldspars, and micaeous minerals dominates the clay and silt fractions, and usually also some vermiculite, and chlorite are present. More detailed quantitative analyses could be useful, though on the other hand, MacLEAN and BRYDON (1961) found that differences in the release and fixation of potassium were not related to the contents of various minerals in the soil fractions.

### *S u m m a r y*

Samples of fine sand, silt and clay soils from the surface and the deeper layers were separated without destruction of organic matter into the following fractions: clay  $< 2 \mu$ , silt 2—20  $\mu$ , and fine sand 20—200  $\mu$ . The separates were analysed for their content of various forms of potassium and the fixation of added potassium against an extraction with ammonium acetate.

The mean content of total potassium was in the clay fraction  $3.02 \pm 0.11 \%$ , in the silt fraction  $2.75 \pm 0.10 \%$ , and in the fine sand fraction  $2.16 \pm 0.13 \%$ . Clay was richest in readily exchangeable potassium, with an average content of  $31 \pm 7$  mg/100 g in the 29 samples analysed, while the corresponding values were in the 28 samples of silt  $6 \pm 2$  mg/100 g, and in the 20 samples of fine sand  $2 \pm 1$  mg/100 g.

The content of nonexchangeable potassium released by HCl at 50°C was, on the average, in the clay samples  $400 \pm 70$  mg/100 g, in the silt samples  $230 \pm 50$  mg/100 g, and in the fine sand samples  $70 \pm 20$  mg/100 g.

Without drying, the 29 clay samples fixed  $32 \pm 8$  per cent (9 to 90 per cent) of the 97.5 mg K added per 100 g of the material. This «wet» fixation was by the 28 silt samples  $27 \pm 9$  % (5 to 96 %), and by the 20 fine sand samples  $12 \pm 4$  % (2 to 44 %). Drying of the KCl-suspension at 80°C resulted in fixation of  $69 \pm 10$  % (21 to 95 %) by clay material,  $54 \pm 10$  % (16 to 100 %) by silt, and  $25 \pm 6$  % (7 to 55 %) by fine sand.

In all fractions a low correlation was found between the contents of readily exchangeable and nonexchangeable acid soluble potassium. The «wet» fixation did not depend on these forms of potassium, but in the clay fraction and the silt fraction the «dry» fixation was negatively, even if slightly, correlated with the exchangeable potassium,  $r = -0.67^{***}$ , and  $r = -0.55^{**}$ , respectively. The relationship between the «wet» and the «dry» fixation was closest in the silt fraction ( $r = 0.86^{***}$ ) and poorest in the clay fraction ( $r = 0.69^{***}$ ).

The relatively close relationship between the clay and the silt separates in regard to their contents of exchangeable ( $r = 0.91^{***}$ ) and nonexchangeable potassium ( $r = 0.87^{***}$ ), and the fixation of potassium under «wet» conditions ( $r = 0.93^{***}$ ) and «dry» conditions ( $r = 0.92^{***}$ ) may be taken to support the supposition that these fractions differ from each other more in their quantitative than in their qualitative mineral composition. Between the silt and fine sand fractions fairly high correlation was found for their contents of exchangeable potassium ( $r = 0.97^{***}$ ), their contents of nonexchangeable potassium ( $r = 0.86^{***}$ ), and for their values of «wet» fixation ( $r = 0.90^{***}$ ), while a lower correlation existed between the results of «dry» fixation ( $r = 0.66^{**}$ ).

In spite of the sources of errors, examined in the discussion, it was found justifiable to conclude that the silt fraction is likely to play an important role in the release and fixation of potassium in Finnish mineral soils, and that the fine sand fraction, although significantly less inactive, may in some soils be noteworthy in these respects.

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## SELOSTUS:

## MAALAJITTEIDEN KALIUMIN PITOISUUDESTA JA KALIUMIN PIDÄTYKSESTÄ

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Aikaisemmin tutkituista hieta-, hiesu- ja savimaanäytteistä eristettiin fraktiot  $< 2 \mu$ ,  $2-20 \mu$  ja  $20-200 \mu$  hapettamatta orgaanista ainesta. Lajitteista määritettiin kokonaiskaliumin, helposti vaihtuvan ja vaihtumattoman, happoon liukenevan kaliumin pitoisuudet sekä kaliumin pidättäminen.

Kokonaiskaliumin pitoisuus oli saveksessa keskimäärin  $3.02 \pm 0.11 \%$ , hiesussa  $2.75 \pm 0.10 \%$  ja hiedassa  $2.16 \pm 0.13 \%$ . Saveksessa oli paljon runsaammin vaihtuvaa kaliumia kuin muissa:  $31 \pm 7 \text{ mg/100 g}$ . Hiesussa ja hiedassa keskiarvot olivat  $6 \pm 2 \text{ mg/100 g}$  ja  $2 \pm 1 \text{ mg/100 g}$ . Happokäsittely liuotti vaihtumatonta kaliumia saveksesta  $400 \pm 70 \text{ mg/100 g}$ , hiesusta  $230 \pm 50 \text{ mg/100 g}$  ja hiedasta  $70 \pm 20 \text{ mg/100 g}$ .

Kuivattamatta saves pidatti keskimäärin  $32 \pm 8 \%$  ( $9-90 \%$ ) lisätystä kaliumin määrästä, joka oli  $97.5 \text{ mg/100 g}$ , hiesu pidatti vastaavasti  $27 \pm 9 \%$  ( $5-96 \%$ ) ja hieta  $12 \pm 4 \%$  ( $2-44 \%$ ). Kun kaliumkloridisuspensio kuivatettiin määritettäessä, oli saveksen pidätyskyky  $69 \pm 10 \%$  ( $21-95 \%$ ), hiesun  $54 \pm 10 \%$  ( $16-100 \%$ ) ja hiedan  $25 \pm 6 \%$  ( $7-55 \%$ ).

Kaikissa lajiteissa oli vain heikko riippuvuus vaihtuvan ja vaihtumattoman kaliumin pitoisuuksien välillä. Kun pidätys määritettiin kuivattamalla suspensio, havaittiin heikohko negatiivinen korrelaatio saatujen tulosten ja vaihtuvan kaliumin arvojen välillä saves- ja hiesufraktioissa. Paras vuorosuhde eri tavoin määritettyjen pidätyksen arvojen välillä oli hiesulajitteessa, heikoin saveslajitteessa.

Varsin kiinteä vuorosuhde näytti vallitsevan saveksen ja hiesun välillä vaihtuvan kaliumin ja vaihtumattoman kaliumin pitoisuuksissa sekä kaliumin pidätyksessä. Tämä tukee osaltaan oletusta, ettei maittemme saves- ja hiesufraktioiden mineralogisen koostumuksen välillä ole niin merkittäviä eroja kuin maissa, jotka ovat meikäläisiä maita vanhempia.

Monet tekijät vaikuttavat siihen, etteivät eristetyt fraktiot reagoi täysin samoin kuin ollessaan käsittelemättömän maanäytteen osina. Silti voidaan saatujen tulosten katsoa osoittavan, että tutkittujen näytteiden hiesufraktiolla voi olla suuri merkitys maitten kaliumtaloudessa, ja että myös hieta-lajite on ainakin eräissä maissa huomionarvoinen tässä suhteessa.