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SOIL CHEMISTRY

Potassium in Plain Soils of the Southern Far East

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Abstract—Distribution patterns of potassium compounds along the profiles of different soils in the Russian Far East are described. The total potassium content is high in all the soils, while the contents of exchangeable and nonexchangeable potassium vary from medium to very high values. A positive correlation is found between the contents of labile potassium compounds and the clay fraction, whereas a negative correlation exists between the contents of total potassium and the clay fraction.

INTRODUCTION

Brown forest soils in the Russian Far East have been carefully examined by numerous investigators. However, data about potassium compounds in these soils are very limited and concern only the contents of total and exchangeable potassium [3–6]. This work presents the results of the study of potassium compounds in different soils of the southern part of the Far East region.

OBJECTS AND METHODS

The main types of soils developing in different geomorphic positions within the Middle Amur, Arkhara–Bureya, and Zeya–Bureya plains were investigated, including brown forest, bleached brown forest, bleached meadow brown, meadow brown, meadow brown chernozemic, meadow gley, and soddy soils of former flood plains. The main physico-chemical characteristics of these soils are given in Table 1.

The content of exchangeable potassium was determined according to Maslova. The content of nonexchangeable potassium was calculated as the difference between the content of potassium extracted by acid treatment (the 30-min boiling of soils in the 2.0 N HCl acid at the soil/solution ratio of 1 : 10; the method was elaborated at the Dokuchaev Soil Science Institute) and that of exchangeable potassium [1]. The total potassium content was determined via caking, according to Smith; the degree of potassium mobility was calculated as the ratio between the content of exchangeable potassium and that of its mobile compounds extracted by the 0.005 N solution of calcium chloride. The latter fraction was extracted at the soil/solution ratio 1 : 2, after the suspension had been shaken for 1 h (according to the procedure elaborated at the Pryanishnikov Research Institute of Fertilizers and Agropedology) [1]. The contents of nonexchangeable and total potassium were graded according to the Hsaung scale [19] developed for Chinese soils. The following gradations for the nonexchangeable potassium were used: low, 8–20 mg/100 g soil (at the total content of 0.7–1.7%); moderately low, 20–40 mg/100 g (1.3–2.3%); medium, 40–60 mg/100 g (1.3–2.5%); increased, 60–90 mg/100 g (1.5–2.6%); high, 90–140 mg/100 g (1.9–2.6%); and very high, more than 140 mg/100 g (1.9–2.9%). The soils of northeastern China are similar to the studied soils [8, 11]; therefore, the usage of this classification seems to be reasonable.

All the soils develop from loose sediments with different textures. The major rock-forming minerals are chlorite–hydromica and hydromica–smectite components [17]. Quartz and feldspars are present in loamy–sandy sediments in almost equal amounts. The contents of clay minerals and mica reach 35 and 8.2%, respectively. Among the heavy minerals of sandy sediments, the hornblende, biotite, and muscovite compose 44, 14, and 2% of the fraction of 0.05–0.01 mm, respectively. Among light minerals, quartz and potassium feldspars compose 52 and 25%, respectively [13]. The clay fraction of light brown clays and loams consists mainly of the minerals of hydromica and montmorillonite groups; kaolinite and quartz are also present [9].

By their texture, the upper horizons of brown forest soils are referred to as sandy loams and loams, while the lower ones, as loamy sands and sandy loams (Table 2). The fraction of coarse silt prevails; its content is maximum (36%) in the humus horizon and it decreases with depth (4–30%). A high content of coarse fractions points to low rates of chemical and biochemical transformation of soils, which is connected with the sandy composition of parent materials. The highest content of the clay fraction is observed in the middle part of the profile (10–24%). The content of fine silt is lower than that of clay. The vertical distribution of physical clay is typical for brown soils in general.

A very high total content of potassium is observed in the brown forest soils. It is equal to 2.70% in the humus horizon, increases with depth, and can reach

Table 1. Physico-chemical characteristics of soils*

Horizon	Depth, cm	pH		Humus, %	Ca + Mg, meq/100 g	Base saturation, %
		water extract	KCl extract			
Brown forest soil						
A1	0–11	6.3	5.4	10.3	35.3	98.0
B1	11–28	5.8	4.6	2.9	15.8	83.0
B2	28–61	5.7	4.3	1.2	11.8	78.5
C	61–82	5.8	4.5	0.6	10.7	87.3
Meadow brown soil						
A1	0–18	6.1	5.7	6.4	29.6	Not det.
A1B	25–35	6.3	5.1	1.7	24.2	″
gB1	50–60	6.3	4.6	1.1	35.4	″
gB2	90–100	6.3	4.7	0.9	35.5	″
gC	140–150	6.4	4.8	0.8	32.2	″
Bleached brown soil						
Ap	0–12	5.8	4.7	3.5	12.2	99
A2g	12–22	5.6	3.8	0.9	6.1	80
A2B	22–30	5.6	3.3	1.0	14.0	71
B	35–45	5.4	3.4	1.2	26.3	74
C	90–100	5.3	3.4	0.7	31.4	85
Bleached meadow brown soil						
Ap	0–20	5.9	4.8	4.2	21.0	Not det.
A1A2	20–27	6.0	4.3	2.5	20.2	″
gB1	60–70	5.6	4.3	0.9	23.2	″
gB2	55–65	5.8	4.2	1.0	29.2	″
gBC	75–85	5.7	4.3	1.0	30.1	″
Meadow brown chernozemic soil						
A1	0–20	6.6	5.7	7.8	45.7	91
AB	20–30	6.0	4.6	2.2	38.0	91
B1	40–50	5.8	4.6	1.4	30.9	80
B2	70–80	5.8	4.7	0.9	27.5	82
B3	90–100	5.9	4.6	0.7	25.5	85
Meadow gley soil						
A1	0–10	5.3	4.7	5.4	17.0	80
G	30–40	5.5	4.0	0.9	14.8	74
Bg	65–75	5.2	.47	1.1	30.0	83
Cg	160–170	5.3	4.7	0.5	23.8	84
Soddy soil of former flood plain						
Ap	0–20	Not det.	5.7	3.7	17.1	Not det.
B1	25–35	″	6.3	0.4	6.2	″
B2	60–70	″	6.4	0.2	3.1	″
C	100–110	″	6.2	Not det.	3.1	″

* According to Zimovets [5], Ivanov [6], and Grishin [3].

Table 2. Potassium compounds and the physical clay content in brown forest and meadow brown soils

Horizon	Depth, cm	Total, %	Nonex-changeable	Exchange-able	Water-soluble	Degree of potassium mobility	Content of fractions, %; particle size, mm	
			K_2O, mg/100 g soil				<0.001	<0.01
Shallow brown forest soil on alluvial sediments, pit 136								
A1	0–10	2.70	80.2	11.9	1.9	5.0	10	23
AB	10–22	2.80	61.9	8.1	0.9	4.8	16	30
B1	22–38	2.90	77.9	7.5	0.8	4.6	22	38
B2	38–60	2.80	67.8	8.0	0.8	4.1	10	37
BC	60–87	3.12	76.0	6.5	0.6	3.7	5	24
Brown forest soil on coarse sand, pit 56								
Ap	0–20	2.73	121.4	22.8	2.6	6.3	7	24
B1	20–37	3.33	80.7	8.6	0.9	4.9	6	18
B2	37–64	3.55	69.0	7.9	1.0	4.2	9	18
BC	64–80	3.67	39.6	6.1	0.6	3.9	1	6
The same soil, pit 66								
Ap	0–20	2.73	94.5	17.5	3.8	5.7	6	27
B1	20–34	2.82	77.4	10.9	1.4	6.0	10	32
B2	34–60	3.50	41.9	7.5	0.8	4.8	4	12
BC	60–85	3.25	39.1	6.6	0.7	4.2	3	14
Brown forest soil on alluvial sediments, pit 19								
A1	0–9	2.77	86.3	12.8	1.0	4.6	19	32
AB	9–19	2.54	99.9	16.6	0.6	8.3	24	40
B1	19–33	2.61	93.7	12.9	1.0	5.6	22	39
B2	33–58	2.77	106.6	13.2	0.7	6.2	24	37
BC	58–76	3.00	62.9	10.2	0.7	4.0	19	29
The same soil, pit 9								
Ap	0–22	2.77	161.3	13.9	1.9	7.0	16	30
AB	22–40	2.77	133.9	11.3	1.3	7.3	22	38
B1	40–65	2.85	97.6	7.8	1.0	5.0	10	32
B2	65–93	3.00	73.1	8.6	0.8	5.6	6	22
BC	93–130	2.69	85.9	9.1	0.6	5.9	10	23
Meadow brown soil on sandy clay, pit 15								
Ad	0–15	1.61	105.9	19.9	1.6	11.1	20	32
A1	15–28	1.85	113.7	10.2	0.6	11.3	23	47
AB	28–48	2.60	120.2	10.0	0.9	11.1	25	47
B1	48–70	2.20	129.9	17.0	0.7	11.3	30	51
B2g	70–90	2.10	135.0	15.8	0.6	12.2	30	53
BCg	90–150	2.50	140.1	17.4	0.8	12.4	40	59
Meadow brown soil on lacustrine–alluvial clay, pit 17								
Ad	0–8	1.79	114.4	26.4	1.3	9.4	20	38
A1	8–17	1.93	119.4	16.0	1.0	12.3	31	49
AB	17–27	1.93	152.7	16.4	0.8	13.7	31	49
B1	27–48	2.10	144.4	15.3	0.7	12.8	40	55
B2g	48–65	2.30	173.8	17.4	0.9	13.4	40	59
BCg	65–133	2.30	174.0	23.0	0.7	14.4	48	63

3.67% in the BC horizon. The same trend was observed in the soils of the Caucasus, Carpathians, Sayan, and Baltic regions [2, 3]. The potassium content was higher in the sandy–loamy soils formed on coarse sand than in the loamy soils developed on alluvial loams (Table 2).

On the contrary, the maximum content of nonexchangeable potassium was found in the upper part of the profile and varied from moderately high in sandy–loamy soils to very high in loamy soils. If the parent material is represented by alluvial sands, the content of nonexchangeable potassium is also increased in the BC horizon. If it is a coarse sand, there is no increase in the content of nonexchangeable potassium in the BC horizon. The same tendency is observed for similar soils in northeastern provinces of China [19]. In the humus horizons of virgin lands, the potassium content is lower than in their cultivated analogues.

The same texture-dependent distribution is intrinsic to exchangeable potassium. Its content varies from medium to high in the upper layers, but remains low in the lower horizons. The content of water-soluble potassium in the root-inhabited layer is high in sandy–loamy soils and somewhat lower in loamy soils.

The whole profile of brown forest soils is characterized by the percolative water regime and oxidizing medium (Eh varies between 510 and 740 mV) [10]. Under these conditions, weathered alkaline cations (including potassium) are leached out from the soil profile. A relative accumulation of available forms is possible only via biological retention in the upper organic horizons and passive accumulation in primary and secondary silicates resistant to weathering [16]. This is supported by data on the vertical distribution of different potassium compounds in the soil profile.

The high content of potassium feldspars, mica, and hydromica and the predominance of coarse, particle-size fractions in brown forest soils lead to a high mobility of exchangeable potassium in all horizons, especially the lower ones.

The upper horizons of meadow brown soils are loamy, while the lower ones are loamy–clayey (Table 2). The content of fine fractions increases gradually with depth. The fraction of fine silt is distributed evenly and its content is 15–19%. The fraction of the coarse silt prevails, its content in the upper horizons reaching 34%. The content of fine sand is significant in the BCg horizon (28%).

The content and distribution of total potassium in the meadow brown soils point to its deficiency in the upper horizons (Table 2). The content of nonexchangeable potassium increases with depth from high to very high values, together with an increase in the content of physical clay. A high content of exchangeable potassium in the organic horizons seems to be related to its retention in the hydrolyzable fraction of soil organic matter [12].

The content of exchangeable potassium in the sod horizons is increased and high due to biological accumulation. It becomes lower in the middle of the profile and increases again in the parent material. The maximum content of water-soluble potassium is found in the humus horizon. The degree of potassium mobility decreases downwards with an increase in the content of fine particles. Compared to the soils developed on sandy clays, the soils on lacustrine–alluvial clays contain more nonexchangeable and exchangeable potassium (although it is less mobile) and less total potassium.

The textural composition of bleached brown soils is heterogeneous. The upper horizons are loamy–clayey and clayey, while the deeper ones are clayey (Table 3). Vertical distribution patterns of the fractions of coarse silt and clay are the other way around, the first one prevails in the upper horizons (31–44%). The content of fine silt is comparable to that of clay, sometimes exceeds it, and increases with depth. A specific feature of these soils is the high content of sand. The total content of sand fractions can reach 23%, their distribution is uneven, and a certain maximum is observed in the BCg horizon.

The group of mica and hydromica forms a significant percentage of the clay fraction [10, 11]. It determines the high total potassium content and its even vertical distribution in the profile of bleached brown soils (Table 3). The content of nonexchangeable potassium is high and increases up to very high with depth, together with the content of clay fractions. The content of nonexchangeable potassium in the upper horizons of virgin soils is less than in their plowed analogues. The same phenomenon is observed in the brown forest soils. The most probable reason for that is the nonexchangeable fixation of potassium added with fertilizers.

The vertical distribution of potassium follows the eluvial–illuvial pattern; its content in the humus horizons varies from medium to high; maximum values are observed in the BCg horizons, while minimum values are seen in the upper layers of virgin soils. The content of water-soluble potassium is insignificant. The highest mobility of potassium is observed in the bleached horizons that contain almost no labile silicates.

The profiles of bleached meadow brown soils have a contrasting texture. The upper horizons are loamy and clayey–loamy, while the lower ones are loamy–clayey (Table 3). The prevailing fractions are those of coarse silt and clay, constituting 22–50 and 14–35%, respectively. Note that the clay content in the humus horizon is twice as low as in the rest of the profile due to the intensive leaching of mineral colloids from the upper layers [5, 6].

The total potassium content in the bleached meadow brown soils is relatively high (Table 3), especially in the middle part of the profile, except for virgin lands. However, due to the biological accumulation, the latter contain more exchangeable potassium. The difference in exchangeable potassium contents between virgin and plowed soils points to the fact that the latter become somewhat exhausted. The content of nonexchangeable potassium varies from high to very high (except for the

Table 3. Potassium compounds and the physical clay content in bleached brown forest and meadow brown soils

Horizon	Depth, cm	Total, %	Nonexchange-able	Exchange-able	Water-soluble	Degree of potassium mobility	Content of fractions, %; particle size, mm	
			K_2O, mg/100 g soil				<0.001	<0.01
Bleached brown soil on colluvial clay, pit 8								
A1	0–20	2.09	92.8	12.6	0.4	7.8	25	45
A2	20–43	2.27	99.3	11.8	0.6	7.4	35	48
B1	43–65	2.33	113.4	17.7	0.7	9.7	35	61
B2g	65–95	2.33	163.1	23.8	0.7	12.9	39	66
BCg	95–130	2.33	193.3	24.9	0.8	13.5	30	58
The same soil, pit 13								
Ap	0–22	2.33	128.0	15.3	0.9	9.0	22	46
A2	22–38	2.09	136.7	13.1	0.7	8.1	30	51
B1	38–68	2.33	174.2	20.3	0.8	11.0	27	58
B2g	68–96	2.42	226.2	26.1	0.7	13.1	26	64
BCg	96–120	2.33	230.7	26.1	0.8	14.7	23	68
Bleached brown soil on sandy clay, pit 6								
Ap	0–22	2.18	140.1	24.1	1.1	14.0	20	51
A2	22–42	2.36	131.9	14.1	0.7	7.5	27	54
B1	42–65	2.18	159.0	26.8	0.8	13.5	35	58
B2g	65–90	2.09	161.2	26.7	0.8	13.6	35	66
BCg	90–150	2.18	174.9	24.3	0.6	12.5	25	57
The same soil, pit 28								
Ap	0–20	2.32	169.0	23.2	0.9	14.8	19	56
A2	20–35	2.08	152.8	18.0	0.5	10.6	16	58
B1	35–55	2.17	172.6	19.8	0.6	11.0	23	60
B2g	55–72	2.17	172.4	21.9	0.6	11.9	31	61
BCg	72–95	2.25	176.7	25.4	0.6	12.9	32	57
Bleached meadow brown soil on loamy clay, pit 4								
Ad	0–10	1.83	105.6	26.0	2.0	9.0	14	40
A2g	10–18	2.10	98.5	15.8	1.2	8.3	33	44
B1g	18–55	2.30	86.6	16.4	0.8	8.2	28	57
B2g	55–90	2.30	114.7	20.7	0.8	10.4	30	59
BCg	90–150	2.22	129.7	22.1	1.2	11.6	29	59
The same soil, pit 20								
Ap	0–25	2.30	111.5	16.3	0.9	9.6	15	38
A2g	25–33	2.50	111.9	13.9	0.8	7.7	33	46
B1g	33–66	2.50	146.0	16.3	1.1	8.2	27	68
B2g	66–93	2.30	168.2	22.0	0.8	11.0	29	56
BCg	93–130	2.10	170.9	20.9	1.0	12.3	26	56
The same soil, pit 1								
Ap	0–23	2.30	133.8	21.8	1.3	9.5	17	43
A2g	23–42	2.40	128.7	18.2	0.8	8.7	35	47
B1g	42–84	2.50	141.7	21.6	0.9	10.8	29	62
B2g	84–110	2.40	169.0	26.2	0.9	11.9	28	59
BCg	110–160	2.30	143.3	26.7	1.2	12.7	32	63

middle part of the profile of virgin soils where it is increased). Compared to clayey–loamy soils, the bleached meadow brown loamy soils contain less nonexchangeable potassium.

Note that, in bleached brown and meadow brown soils, a stepwise increase in the content of nonexchangeable potassium occurs at the transition from the bleached to the B1 horizon. This is probably connected to the higher degree of dispersion of minerals in the illuvial horizon due to the hydration of clay minerals, which leads to the disturbance of their crystalline lattice and thus increases their potassium-fixing capacity. In addition, the bleached horizon of these soils has the lowest capacity for ion exchange [7]. Ivanov [6] relates the highest sorption capacity of B horizons to an active soil weathering enhanced by the combination of abundant moisture supply and high temperatures in the summer period.

Both exchangeable potassium and nonexchangeable potassium have the eluvial–illuvial vertical distribution. This is probably due to the predomination of kaolinitic hydromica and low-charge ferrous beidellite with few exchange sites in the bleached horizon. The content of montmorillonite, which is richer in exchange sites with high binding energies, increases with depth [9].

Potassium mobility in the bleached meadow brown soils is high in the upper layers and decreases in the lower layers. The content of water-soluble potassium is low, its maximum being observed in the sod horizon.

By their texture, meadow brown chernozemic soils are silty–loamy clays (Table 4). The clay fraction is distributed rather evenly, but its highest content is observed in the middle part of the profile. The content of fine silt varies from 10 to 21%. The maximum content of coarse silt (39–47%) is attributed to the upper horizons. A slight accumulation of the clay fraction in B horizons occurs as a result of argillization and clay illuviation from the humus horizons on the background of an intensive illuviation. This points to the specific genesis of these soils [14].

A high total content of potassium in the meadow brown chernozemic soils (up to 2.92%) is due to the abundance of trioctahedral hydromica, which is the main source of potassium. Its relatively even vertical distribution is related to the absence of clear differentiation in the distribution of mineral groups (Table 4). The only difference is an elevated content of total potassium in the soils formed on alluvial materials, as compared to those on clayey colluvium.

These soils possess a significant potassium potential, because the content of nonexchangeable potassium is very high in all horizons. This is due to both the fine texture and the presence of potassium-bearing minerals.

The content of exchangeable potassium in the plow layer varies from high to very high and decreases downwards. The content of water-soluble potassium is low and decreases with depth. As a result of a high potassium retention, the degree of potassium mobility is low.

Meadow gley soils have a fine texture in all horizons; the content of physical clay in the lower horizons can reach 75% (Table 4). The clay fraction prevails, although, as in the other soils, its content in the upper layers is reduced. The fraction of fine silt is unevenly distributed; its content varies from 5 to 26%. All horizons contain significant amounts of fine sand (up to 26%).

The total potassium content in the humus horizon of meadow gley soils is relatively low and constitutes 1.85%, which is less than in the other soils (Table 4). It increases with depth and reaches maximum in the BCg horizon of the soils developed on sandy lacustrine–alluvial clays.

The eluvial–illuvial distribution with the minimum in the G horizon is typical for the nonexchangeable potassium. Its content is significant. However, despite a finer texture of meadow gley soils, it is 1.5–2 times less in them than in the meadow brown chernozemic soils. The most probable reason for that is the accumulation of kaolinite in the middle part of the profile of meadow gley soils (especially, in the gley horizon). The highest content of nonexchangeable potassium is observed in the BCg horizon, where montmorillonite predominates among clay minerals. At the same time, the content of nonexchangeable potassium in the clayey horizons is somewhat higher than in the sandy loamy–clayey horizons.

The content of exchangeable potassium is high in all horizons, with a slight decrease in the gley horizon. The content of water-soluble potassium is high and reaches 3.5 and 2.3 mg/100 g in the upper loamy and loamy–clayey horizons, respectively. Its maximum in the virgin sod horizon is related to the active biogenic uptake on the background of minimal leaching in conditions of a very contrastive redox regime (200–700 mV in the upper and 400–600 mV in the lower layers) [10]. According to Sokolova [15], the availability of potassium of trioctahedral mica is higher under reducing conditions, as compared to the oxidizing conditions. This explains the higher mobility of exchangeable potassium in the surface layers. In addition, meadow gley soils are formed in conditions of a high groundwater level. Ascending capillary fluxes of water with different degrees of mineralization saturate the soil with the most available forms of various elements, including potassium [5].

Soddy soils of former flood plains are fine sandy coarse silty loams developed on Tertiary alluvial sands (Table 4). Coarse fractions predominate in these soils. The content of coarse sand increases sharply (from 2 to 42%) in the B2 horizon and becomes maximal in the C horizon (77%), while the content of fine sand decreases gradually with depth (from 29% in the A1 to 9% in the C horizon).

A very high total potassium content in the whole profile is typical for these soils (Table 4). Having a coarse texture and consisting mainly of slightly weathered mica, they are characterized by the medium and

Table 4. Potassium compounds and the physical clay content in meadow brown chernozemic, meadow gley, and soddy soil of the former flood plain

Horizon	Depth, cm	Total, %	Nonexchangeable	Exchangeable	Water-soluble	Degree of potassium mobility	Content of fractions, %; particle size, mm	
			K_2O, mg/100 g soil				<0.001	<0.01
Meadow brown chernozemic soil on sandy clay, pit 21								
Ap	0–22	2.50	305.9	26.1	0.9	10.4	25	52
AB	22–34	2.42	272.1	20.1	0.9	10.6	29	58
B1	34–57	2.50	302.2	23.1	0.7	12.2	36	59
B2	57–74	2.58	278.6	23.1	0.9	11.6	30	59
B3	74–88	2.46	281.0	23.6	0.7	11.8	30	57
BCg	88–109	2.61	203.7	23.2	0.6	12.2	25	48
Meadow brown chernozemic soil on clay colluvium, pit 23								
Ap	0–24	2.36	352.2	34.8	1.0	12.9	27	53
AB	24–47	2.45	305.8	26.2	0.8	15.4	29	54
B1	47–67	2.36	277.6	25.0	0.7	13.9	34	56
B2	67–100	2.36	277.0	24.6	0.6	13.7	30	47
B3	100–124	2.36	290.4	25.5	0.6	13.4	26	53
BCg	124–170	2.45	291.0	23.0	0.7	12.8	28	55
Meadow gley soil on lacustrine–alluvial sandy clay, pit 3								
Ad	0–10	1.85	111.1	30.1	3.5	9.4	20	34
A1	10–21	2.20	103.7	31.7	2.6	10.9	27	50
G	21–42	2.54	86.4	24.2	1.7	10.3	35	55
B1g	42–60	2.60	92.0	31.9	1.4	12.8	38	58
B2g	62–87	2.50	121.2	32.1	1.8	13.0	46	68
BCg	87–160	2.50	129.8	32.7	1.6	11.7	46	66
Meadow gley soil on lacustrine–alluvial clay, pit 5								
Ap	0–22	2.27	118.5	30.8	2.3	10.1	27	53
G	22–46	2.27	106.4	17.5	1.0	10.0	37	60
B1g	46–75	2.18	119.2	20.1	0.8	11.8	35	62
B2g	75–105	2.30	121.5	26.7	0.7	12.4	37	64
BCg	105–150	2.30	175.5	28.2	1.0	13.4	50	74
Soddy soil of former flood plain on coherent sand, pit 30								
A1	0–27	2.87	76.0	10.4	2.7	8.0	7	28
B1	27–47	2.95	65.2	8.6	1.8	7.5	5	18
B2	47–58	2.95	55.1	8.0	1.4	4.6	3	18
BC	58–80	3.02	37.0	5.8	0.8	3.8	2	8
C	80–120	3.21	35.1	5.3	0.8	3.6	1	6
Soddy soil of former flood plain on loose sand, pit 26								
Ap	0–28	2.74	89.7	14.3	2.6	7.5	15	37
B1	28–37	2.82	85.3	12.6	1.9	7.4	12	34
B2	37–50	2.95	64.1	8.8	1.4	6.2	6	26
BC	50–78	3.08	45.8	8.0	0.9	4.6	4	18
C	78–125	3.54	47.5	5.2	0.9	4.3	2	8

increased content of exchangeable and nonexchangeable potassium in the upper horizons and very low and low content in the parent material. This is explained by a partial loss of hardly available natural potassium from minerals under the impact of water erosion [18]. The difference in the potassium content between virgin and cultivated soils indicates that soil treatments result in a certain accumulation of available potassium. The degree of mobility of exchangeable potassium in these soils is the highest, and the content of water-soluble potassium is significant. Together with a low content of nonexchangeable potassium, this is due to the high rate of potassium mobilization in coarse soils, which can lead to a quick potassium depletion.

The correlation between the characteristics of soil potassium status and textural properties was found in the upper horizons. The correlation at $P > 90\%$ was regarded as significant.

The increase in the physical clay content coincides with the increase in the contents of exchangeable and nonexchangeable potassium (r is 0.32 and 0.47, respectively) and with a decrease in the total potassium content (r is –0.51). The content of nonexchangeable potassium correlates closely with the content of the fractions of <0.01 and <0.001 mm (r is 0.47 and 0.32, respectively), these particles providing the major part of exchange sites. The negative correlation between the contents of total potassium and clay fraction (–0.47) indicates that the latter contains relatively little potassium. In addition, the correlation is more significant in fine soils (–0.53) where the weathering is more intensive and results in the destruction of primary minerals. A significant correlation (0.34–0.83) among the contents of exchangeable, nonexchangeable, and water-soluble potassium is an indirect indication of a dynamic equilibrium existing among these forms. Moreover, a closer correlation between exchangeable and nonexchangeable potassium in fine soils (0.54–0.43), as compared to coarse soils, testifies that the separation of these forms is rather conventional. The absence of easily soluble primary minerals in fine particles is indicated by negative coefficients of the correlation between the water-soluble potassium and the content of the fractions of <0.01 and <0.001 mm (r is –0.43 and –0.41, respectively).

CONCLUSIONS

(1) The mineralogical and particle-size composition of parent materials determine the content and vertical distribution of potassium compounds in the soils of different genesis. The total potassium content decreases along the range: loose sands > alluvial substrates > sandy clays > colluvial clays. An opposite trend is observed for nonexchangeable potassium.

(2) Multiple correlations of a different tightness between the parameters of soil potassium regime point to the dynamic status of this element in soils.

(3) The horizons formed under contrasting redox conditions contain less total potassium, while their exchangeable potassium is more mobile.

(4) The highest contents of exchangeable and nonexchangeable potassium in meadow brown chernozemic and meadow gley soils point to favorable conditions of potassium nutrition; however, the aeration of these soils must be improved.

(5) Medium and increased contents of exchangeable potassium and high potassium mobility are observed in soddy soils of former flood plains and brown forest soils on the background of low content of nonexchangeable potassium. This points to favorable conditions of plant nutrition and the risk of the depletion of these soils in the case of an intensive cultivation.

(6) An increased and high content of mobile potassium in the bleached brown and meadow brown soils cannot provide for a good plant nutrition because of the low mobility of exchangeable potassium. The cultivation leads to the degradation of potassium status of bleached meadow brown soils. These soils need both the addition of potassium fertilizers and the regulation of water regime and aeration.

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