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AGROECOLOGICAL ASSESSMENT OF THE CATION-EXCHANGE CAPACITY AND EXCHANGEABLE CATION COMPOSITION OF IRRIGATED MEADOW-SWAMP SOILS IN CENTRAL FERGANA

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Abstract
This paper presents an agroecological analysis of the relationship between cation-exchange capacity and the composition of exchangeable cations (Ca^{2+}, Mg^{2+}, K^{+}, and Na^{+}) and particle-size distribution in irrigated meadow-swamp soils of the F. Shamsiddinov massif in Central Fergana. Laboratory analytical investigations were conducted on soil profiles with heavy, medium, light loamy, sandy loam, and sandy textures. Based on the classification proposed by O.K. Komilov and A.U. Axmedov, the degree of soil sodicity was assessed. Weak sodification processes were identified in soils with medium and sandy loam textures due to an increase in the proportion of exchangeable sodium (Na^{+}). Scientific conclusions and recommendations for the amelioration of these soils are provided.

Keywords: Central Fergana, meadow-swamp soils, cation-exchange capacity, exchangeable cations, calcium, magnesium, sodium, particle-size distribution, sodification, agroecological assessment.

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Introduction

The productive capacity and fertility of soils largely depend on their cation-exchange capacity and the composition of exchangeable cations. In turn, cation-exchange capacity is closely associated with soil particle-size and mineralogical composition, humus content, the proportion of fine dispersed particles (clay), the chemical and mineralogical composition of colloidal particles, and soil reaction (pH). Compared with light-textured soils, heavy-textured soils generally have a higher adsorption capacity, which determines a range of their properties.

The soil exchange complex contains exchangeable cations such as Fe^{2+}, Al^{3+}, Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, and NH_4^{+}. In the studied meadow-swamp soils, Ca^{2+} and Mg^{2+} predominate. An increase in sodium content in the exchange complex of saline soils leads to the formation of soda and alkaline conditions. The presence of calcium cations promotes the coagulation of organic and mineral colloids; therefore, a high calcium content among exchangeable cations strengthens soil structure and improves its physical properties.

The aim of this study is to analyse the cation-exchange capacity and exchangeable-cation dynamics of irrigated meadow-swamp soils distributed in the F. Shamsiddinov massif in relation to their particle-size composition, and to assess the degree of soil sodicity.

Materials and Methods

The research was carried out on irrigated meadow-swamp soils of the F. Shamsiddinov massif in Central Fergana. Soil profiles representing different particle-size compositions were investigated under field and laboratory conditions: Profile 58—heavy-textured soil; Profile 117—medium-textured soil; Profile 77—light-textured soil; Profile 121—sandy loam soil; and Profile 143—sandy soil.

The degree of soil sodicity was determined by laboratory analysis according to the classification improved by O.K. Komilov and A.U. Axmedov, based on the percentage proportions of exchangeable Na^{+} and Mg^{2+} in the total exchangeable bases.

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Results and Discussion

The criteria for determining the degree of soil sodicity are based on the contents of exchangeable sodium (Na^+) and magnesium (Mg^{2+}) cations in the soil exchange complex. The sodicity degree of the soils in the study area was assessed according to the classification presented in Table 1.

Table 1. Classification for determining the degree of soil sodicity, refined by O.K. Komilov and A.U. Axmedov

No.	Degree of soil sodicity	Exchangeable Na (% of total)	Exchangeable Mg (% of total)	Degree of compaction
1	Non-sodic	≤ 5	≤ 50	None
2	Slightly sodic	5–10	50–60	Slight
3	Moderately sodic	10–20	60–75	Moderate
4	Strongly sodic	20–30	≥ 75	Strong
5	Sodic	≥ 30	—	—

According to the laboratory results for cation-exchange capacity and cation proportions by particle-size composition, the exchangeable-cation indicators of the soil types were established as follows (Table 2).

Heavy-textured soils (Profile 58). The total exchangeable bases amounted to 11.38 meq in the arable layer and 9.82 meq in the lower layers. Calcium accounted for 54.5–55.0%, magnesium for 38.7–39.5%, potassium for 1.4–2.1%, and sodium for 3.9–4.9%. As the sodium content was below 5%, these soils were classified as non-sodic.

Medium-textured soils (Profile 117). The total exchangeable bases amounted to 10.18 meq in the arable layer and 8.29 meq in the lower layers. Calcium accounted for 50.1–50.7%, magnesium for 42.2–43.4%, potassium for 0.4–2.0%, and sodium for 5.5–5.7%. Since the sodium content was within the 5–10% range, the soil was classified as slightly sodic.

Light-textured soils (Profile 77). The total exchangeable bases amounted to 9.83 meq in the arable layer and 8.59 meq in the lower layer. Calcium accounted for 50.9–54.7%, magnesium for 40.7–42.7%, potassium for 1.5–2.0%, and sodium for 3.0–4.4%. These soils were classified as non-sodic.

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Sandy loam soils (Profile 121). The total exchangeable bases amounted to 9.61 meq in the arable layer and 8.16 meq in the lower layers. Calcium accounted for 50.2–51.0%, magnesium for 42.7–44.1%, potassium for 0.3–1.0%, and sodium for 4.8–5.3%. These soils were classified as slightly sodic ($Na^+ > 5\%$).

Sandy soils (Profile 143). The total exchangeable bases ranged from 8.19 to 9.45 meq. Calcium accounted for 49.5–51.9%, magnesium for 41.2–44.4%, potassium for 2.2–4.0%, and sodium for 3.2–3.9%. These soils were assessed as non-sodic.

Table 2. Cation-Exchange Capacity and Composition of Exchangeable Cations in Irrigated Meadow-Swamp Soils

Profile	Soil layer depth, cm	Ca	Mg	K	Na	Total exchangeable bases, meq	Ca (%)	Mg (%)	K (%)	Na (%)	Degree of sodicity
Heavy-textured soils											
58	0-25	6.2	4.5	0.24	0.44	11.38	54.5	39.5	2.1	3.9	Non-sodic
	25-48	6.1	4.2	0.21	0.46	10.97	55.6	38.3	1.9	4.2	Non-sodic
	48-76	6.0	4.0	0.18	0.47	10.65	56.3	37.6	1.7	4.4	Non-sodic
	76-110	5.8	3.9	0.16	0.48	10.34	56.1	37.7	1.5	4.6	Non-sodic
	110-140	5.7	3.7	0.14	0.49	10.03	56.8	36.9	1.4	4.9	Non-sodic
	140-176	5.4	3.8	0.14	0.48	9.82	55.0	38.7	1.4	4.9	Non-sodic
Medium-textured soils											
117	0-30	5.1	4.3	0.20	0.58	10.18	50.1	42.2	2.0	5.7	Slightly sodic
	30-48	5.0	4.1	0.18	0.54	9.82	50.9	41.8	1.8	5.5	Slightly sodic
	48-84	4.8	4.0	0.13	0.51	9.44	50.8	42.4	1.4	5.4	Slightly sodic
	84-127	4.6	3.9	0.06	0.52	9.08	50.7	43.0	0.7	5.7	Slightly sodic
	127-151	4.4	3.7	0.06	0.48	8.64	50.9	42.8	0.7	5.6	Slightly sodic
	151-190	4.2	3.6	0.03	0.46	8.29	50.7	43.4	0.4	5.5	Slightly sodic
Light-textured soils											
77	0-29	5.0	4.2	0.20	0.43	9.83	50.9	42.7	2.0	4.4	Non-sodic
	29-44	4.9	4.0	0.16	0.41	9.47	51.7	42.2	1.7	4.3	Non-sodic
	44-79	4.8	3.8	0.11	0.44	9.15	52.5	41.5	1.2	4.8	Non-sodic
	79-112	4.9	3.6	0.14	0.44	9.08	54.0	39.6	1.5	4.8	Non-sodic
	112-140	4.6	3.5	0.12	0.28	8.50	54.1	41.2	1.4	3.3	Non-sodic
	140-176	4.7	3.5	0.13	0.26	8.59	54.7	40.7	1.5	3.0	Non-sodic

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Sandy loam soils											
121	0-32	4.9	4.1	0.10	0.51	9.61	51.0	42.7	1.0	5.3	Slightly sodic
	32-47	4.7	4.0	0.06	0.48	9.24	50.9	43.3	0.6	5.2	Slightly sodic
	47-78	4.5	3.9	0.03	0.44	8.87	50.7	44.0	0.3	5.0	Slightly sodic
	78-114	4.3	3.7	0.06	0.38	8.44	50.9	43.8	0.7	4.5	Non-sodic
	114-147	4.1	3.6	0.07	0.39	8.16	50.2	44.1	0.9	4.8	Non-sodic
Sandy soils											
143	0-31	4.7	4.2	0.21	0.34	9.45	49.7	44.4	2.2	3.6	Non-sodic
	31-45	4.6	4.1	0.24	0.36	9.30	49.5	44.1	2.6	3.9	Non-sodic
	45-56	4.5	3.8	0.26	0.41	8.97	50.2	42.4	2.9	4.6	Non-sodic
	56-71	4.6	3.7	0.28	0.28	8.86	51.9	41.8	3.2	3.2	Non-sodic
	71-110	4.4	3.5	0.27	0.32	8.49	51.8	41.2	3.2	3.8	Non-sodic
	110-137	4.2	3.4	0.33	0.26	8.19	51.3	41.5	4.0	3.2	Non-sodic

Conclusion

The cation-exchange capacity of the studied irrigated meadow-swamp soils was found to be moderate to below moderate, ranging from 8.19 to 11.38 meq.

Cation-exchange capacity decreased with declining humus content and a reduced proportion of dispersed particles.

An increase in exchangeable sodium was observed in profiles with higher gypsum and salt contents, resulting in slight sodicity in the medium-textured and sandy loam soils.

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