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CATION EXCHANGE CAPACITY AND COMPOSITION OF ABSORBED CATIONS IN MEADOW-SWAMP SOILS

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Abstract
The article presents the absorption capacity and composition of absorbed cations of rice-growing meadow-swamp soils . It was noted that in the continuous planting system, a decrease in the amount of Ca2+ along the layer and the predominance of Mg2+ lead to a disruption of the element balance. This is accompanied by structural degradation, competition between cations, and negative impacts on plant physiology. It is explained that the amount of absorbed cations in these soils is one of the main factors determining their physicochemical properties, nutritional capacity, and melioration status.

Keywords: Meadow-swamp soil, rice, absorbed cations, soil colloids, crop rotation system.

Introduction

Rice-growing **meadow-swamp soils -** this is a type of soil formed under constant or seasonal hydromorphic conditions, characterized by high moisture content, with active oxidation-reduction processes. **Cation exchange properties** play an important role in ensuring the balance of water, air, and nutrients necessary for plant growth in these soils.

The ability of 100 g of soil **to absorb** and exchange **mmol charge cations is called the cation exchange capacity.** It represents **the agrochemical activity** and **fertilizer retention capacity** of the soil.

In well-meliorated and fertile meadow-swamp soils, cations prevail in the order **Ca^{2+} > Mg^{2+} > K^{+} > Na^{+}.** This regime is important for optimal **structural aggregation,** nutrient metabolism, and water retention. Meadow-swamp soils with rice cultivation have medium or high absorption capacity, and the humus and silt fraction positively influence this indicator. Calcium (Ca^{2+}) is the main exchangeable cation, ensuring structural stability. If the amount of sodium (Na^{+}) increases, the problem of salinization and dispersion arises. Under reduction conditions, oxidation causes the appearance of Fe^{2+} and Mn^{2+} ions, which changes the temporary exchange equilibrium. The stability of the cationic composition plays an important role in coordinating the water-air regime and ensuring nutrition in rice cultivation.

In the soil, cations are present in the form of adsorbed (absorbed) and free (dissolved) . Meadow-swamp soils suitable for rice cultivation are characterized by a high ion exchange capacity . The mechanism of this property is explained as follows, i.e., soil colloids (mainly humus and clay minerals) have a negative charge, humus molecules - phenolic -OH and carboxyl -COOH groups dissociate, forming a negative charge. Clay minerals (montmorillonite, illite, kaolinite) - due to isomorphic substitution forms a constant negative charge . Colloidal surfaces with a negative

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charge attract cations with electrostatic forces and form a "layer of adsorbed cations." This bond is exchangeable (reversible) and soluble cations can replace the adsorbed ones.

The absorption capacity of the soil and the compositional ratios of absorbed cations (Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}) are one of the main factors determining agroecological stability. Scientific research conducted in this area is aimed at a deep analysis of the influence of the crop rotation system on the chemical properties of soils.

As Brady and Weil (2008) note, the cation exchange capacity (CEC) of the soil is an important factor determining its fertility. In particular, a high proportion of Ca^{2+} ions strengthens soil aggregates, facilitating ion exchange in the root nutrition zone of plants. According to their scientific justification, the optimal ratio of Ca^{2+} to Mg^{2+} is around 3:1, which is often observed in crop rotation systems.

Karpinskiy (1981) elaborates on the order of substitution of the main absorbed cations in his work in Russian. In his opinion, under constant monoculture conditions, the accumulation of Mg^{2+} ions and a decrease in Ca^{2+} occurs, which leads to an imbalance in the physicochemical phase of the soil. The same situation was noted in the soils of the continuous sowing system we observed.

Local scientist Yuldashev notes that the main source of potassium for agricultural plants is exchangeable potassium. This form, to a certain extent, characterizes soil fertility. Soils with a heavy granulometric composition are more potassium-saturated than light soils. Potassium uptake depends on the saturation of soils with bases, including potassium.

In global studies conducted by Lal (2006), it was noted that the accumulation of organic matter and the restoration of cation balance through crop rotation have a direct positive effect on yields. These aspects are fully consistent with the high CAC and Ca^{2+} content observed as a result of crop rotation.

Zonn (1993) in his work on land reclamation emphasizes the relationship between cation distribution and water physics. Especially in hydromorphic soils, a high content of Na^{+} and Mg^{2+} ions can lead to soil compaction and salinization. These opinions are directly related to the predominance of Mg^{2+} and the decrease in KAS observed during continuous planting.

In general, the analyzed literature indicates that the crop rotation system is an important tool for optimizing the cationic composition of the soil, maintaining a normal ratio of Ca^{2+} and Mg^{2+}, and preserving soil fertility through high exchange capacity.

Object of research

The research was conducted on meadow-swamp soils of the Tashkent region.

Research results

In the studied meadow-swamp soils, it was established that the continuous and crop rotation forms of the rice cultivation system differ significantly in the content of absorbed basic cations (Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}) and their percentage. Under the conditions of continuous rice cultivation, the sum of cations absorbed in the 0-30 cm layer was 17.01 mg-eq/100 g of soil. This value decreases with depth, reaching 10.89 mg-eq/100 g in the 88-120 cm layer. In this case, the proportion of Ca^{2+} is 46-44%, Mg^{2+} - 47-60%, which indicates that under constant conditions the soil is bound to magnesium and the equilibrium is disrupted. This, in turn, reduces the structural stability of the soil, increases the risk of dispersion, salinization, and compaction. In the crop rotation system

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(alfalfa + rice) in the 0-30 cm layer, the total absorbed cations amounted to 20.36 mg-eq/100 g, which is 3.35 mg-eq/100 g (≈20%) more than in continuous cropping. The Ca^{2+} content is maintained in this layer within 62.28%, and in the lower layers within 57-53%. Mg^{2+} averages 32-42%, forming a balanced metabolic complex. This condition strengthens the aggregate structure of the soil and improves its water-physical properties due to the predominance and stability of calcium. Potassium (K^+) and sodium (Na^+), although in relatively small quantities in all variants (K^+ - 1.8-4.0%; Na^+ - 1.8-3.0%), an increase in the Na+ content was observed in the lower layers. This indicates that the leaching of sodium ions into pits and the risk of salinization is a potentially increased factor (Table 1).

Table 1 Refractive capacity and composition of absorbed cations

Layer depth, cm	per 100 g of soil, mg-eq				Gathering	% of the total			
	Ca	Mg	C	Neither		Ca	Mg	C	Neither
In continuous planting									
0-30	7.89	8.12	0.61	0.39	17.01	46.38	47.74	3.59	2.29
31-56.	7.64	8.41	0.67	0.46	17.18	44.47	48.95	3.90	2.68
56-88.	5.83	10.23	0.68	0.38	17.12	34.05	59.75	3.97	2.22
88-120.	4.76	5.12	0.68	0.33	10.89	43.71	47.02	6.24	3.03
In crop rotation									
0-30	12.68	6.64	0.67	0.37	20.36	62.28	32.61	3.29	1.82
31-52.	11.27	7.47	0.61	0.43	19.78	56.98	37.77	3.08	2.17
52-70	10.05	7.92	0.59	0.39	18.95	53.03	41.79	3.11	2.06
70-126	10.57	6.78	0.56	0.34	18.25	57.92	37.15	3.07	1.86

The research results show that **the crop rotation system** is preferable **for maintaining the balance of exchangeable cations and long-term stability** of soil fertility in meadow-swamp soils. This agrotechnology **stabilizes the calcium-magnesium balance,** contributes to the maintenance of low-mobility cations, and creates **the optimal chemical environment** for rice growth. With continuous planting, there are signs of a decrease in soil quality due to a decrease in Ca^{2+} and a predominance of Mg^{2+}.

As a result of the analysis of the absorption capacity of meadow-swamp soils and the composition of absorbed cations, it became known that the amount of absorbed cations in these soils is one of the main factors determining their physicochemical properties, feeding capacity, and melioration state. Due to the high content of humus and clay minerals in these soils, the cation exchange capacity is moderate, which enhances their fertilizer retention capacity and creates an advantage for irrigated agriculture.

Conclusions

The absorbed cation complex of the soil is rich in Ca^{2+} and Mg^{2+} cations, which play an important role in improving structural stability and agrophysical condition. **The crop rotation system** is more effective **in maintaining the exchange cation balancein** meadow-swamp soils, and is characterized by a high content **of calcium and magnesium.** This **increases the chemical fertility of the soil** and creates optimal nutritional conditions for plants.

A decrease in the Ca^{2+} content along the layer and the predominance of Mg^{2+} **in the continuous sowing system** leads to **a disruption of the elemental balance.** This is accompanied **by structural degradation,** competition between cations, and negative impacts on plant physiology.

The content of K^{+} and Na^{+} in both systems is relatively low, indicating that the elements have a **high leaching capacity**, but their percentage is more stable in crop rotation.

Overall, **in crop rotation conditions, the sum of exchangeable cations in the soil is higher** (up to 20.36 mg-eq) and their **percentage equilibrium** , provides **stable agroecological conditionsfor long-term rice cultivation** . As a result, the agrochemical and melioration properties of meadow-swamp soils are determined. Their in-depth study and control have important scientific and practical significance in increasing rice yields, efficient water use, and ensuring sustainable soil fertility.

References

1. Брейди Н., Вейл Р. Свойства и состав почв. – 14-е изд. – М.: Пирсон Эдюкейшн, 2008. – 965 с. (Brady N., Weil R. The Nature and Properties of Soils)
2. Зонн С.В. Мелиорация почв. – М.: Агропромиздат, 1993. – 271 с.
3. Карпинский Н.М. Агрохимический анализ почв. – М.: Колос, 1981. – 288 с.
4. Продовольственная и сельскохозяйственная организация ООН (ФАО). Руководство по описанию почв. – 4-е изд. – Рим: ФАО ООН, 2006. – 97 с.
5. Стивенсон Ф.Дж. Химия гумуса: происхождение, состав, реакции. – 2-е изд. – М.: Вили-Интерсайенс, 1994. – 496 с. (Stevenson F.J. Humus Chemistry)
6. Юлдашев Г., Исагалиев М. Т., Безуглова О. С., Изменение состава поглощенных оснований почв пустынь как индикатор их эволюции //«Живые и биокосные системы». – 2018. – № 26;
7. Якушев А.В., Соколов Д.А. Влияние систем земледелия на изменения свойств почв // Агрохимия. – 2010. – №1. – С. 47–53.
8. Lal R. Enhancing crop yields in developing countries through restoration of soil organic carbon // Food Policy. – 2006. – Т. 31. – №3. – С. 195–206.