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The reasons for the low effectiveness of agro-ameliorative measures on heavy soils of Kolkhida

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A B S T R A C T

The article analyzes the reasons for the low efficiency of ameliorative measures on heavy clay soils of Kolkhida. It is shown that: the low efficiency of the investigated ameliorative measures can be explained by the unfavorable conditions of the formation of the structure in clay soils of wetlands Colchis:

- Mechanical and mineralogical composition of soils contains 50% or more silt, which includes minerals characterized by intracrystalline absorption and a large force that prevents the formation of structures.
- Drainage and high standing of soil-groundwater cause a waterlogging of the biologically active layer.
- Reversibility of colloids prevents their coagulability, and thus the structuring of the soil during draining.

In conclusion, all of the above factors prevent the formation of a solid agronomically valuable structure of the clay swelling soils of Colchis and determine the low effectiveness of ameliorative measures.

Keywords: Heavy clays, Swelling, Shrinkage, Porosity, Humidity, Aeration.

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Introduction

The main purpose of reclamation of heavy waterlogged soils of Kolkhida is to bring them to a state that allows them to be used for high-performance agricultural development. However, in spite of huge capital investments, no agro-ameliorative measure produced any significant effect.

The effectiveness of land-reclamation measures and with it the degree of return on investment depends on how scientifically proved are the recommended measures. This, in turn, is determined how correctly we understand the reasons, causing unfavorable soil properties of the ameliorative object.

The design of rational land reclamation measures requires a clear picture of the water-air regime of the soil of the territory both before and after their implementation, which requires preliminary study of a number of issues:

- What is the impact of swelling shrinkage process on water-air regime?
- What amount of water should be removed from the root zone to ensure optimal water-air regime;
- What is the ratio of water and air at different volume masses of arable and sub-plow layers?
- How can agromeliorative measures affect on unfavorable properties of heavy structure less soil?

The main part

In the clay soils of Kolkhida, the most active silt fraction of the soil is contained in a large amount - up to 50% or more to the weight of the soil. It contains clay minerals of montmorillonite type capable of intracrystalline soaking, which causes a strong swelling of these soils. In the swollen state, the clay soils of Kolkhida are found most of the year. Only in spring and early summer they usually dry out and shrink.

Data obtained during the study of the process of swelling – shrinkage of the initial field humidity (during the period of water-logging) to the humidity of the air-dry state, allowed us to identify two very important features of heavy clay soils of Kolkhida. The first is the specific character of the shrinkage of these soils during drying, the second - in a very large amount of water swelling [1-3]. A clear idea of the nature of the shrinkage of podzolic gley soil is shown in Fig.

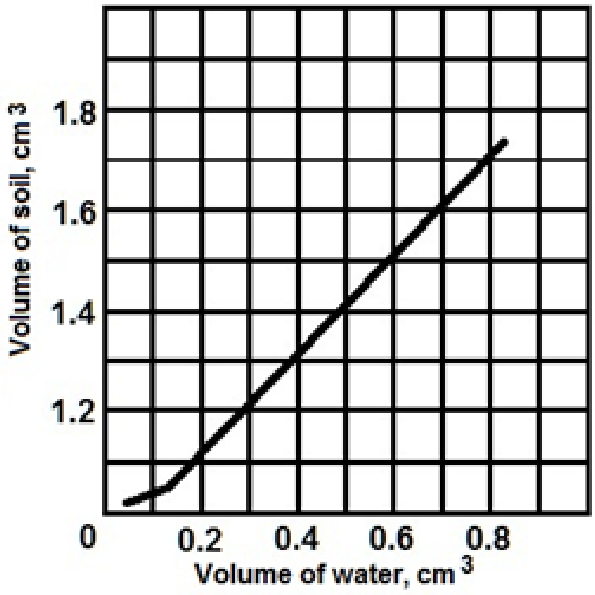

Fig.1. Typical shrinkage schedule

The coordinates for plotting the curves are the ratios $-\frac{V}{V_0}$ on the ordinate axis, $\frac{W}{V_0}$ on the abscissa axis, where - V the soil volume in cm3, V_0 - the soil volume after shrinkage, W - the volume of water (equal to the weight) in the sample.

The graph shows that, for heavy genetic horizons in the mechanical composition, shrinkage occurs almost in the entire range of humidity change. The linear nature of the dependence means normal shrinkage. This is the kind of shrinkage when the decrease of the volume of the soil is equal to the volume of evaporated water, and remains in a wide range.

In connection with this type of shrinkage, drying does not cause the expected improvement in the air regime, which is a very important feature in practice of heavy clay soils of Kolkhida (4-6).

While determining the shrinkage, data was obtained, allowing the studied soils to calculate the water content of swelling for the first time, by considering the water that caused an increase in the volume of soil equal to the volume of this water (7,8).

Table 1 provides data from which shows the swelling water is 31 to 47% of the weight of the soil, or 55-76% of the initial humidity. If hygroscopic water is added to this amount (also in % of the weight), then we get the amount of water that cannot be removed by any hydro technical measure.

Depth, cm	Humidity in % at		Volume of 100 g of soil in cm^3 for		Difference		Shrinkage factor for Franceson	Water swelling in % from the start
	field humidity	air-dry condition	field humidity	air-dry condition	water content in cm^3	volume in cm^3 (water swelling)		
3-13	59, 96	5, 79	104, 5	68, 0	54, 2	36, 5	0, 67	60, 8
15-25	55, 57	6, 10	95, 7	58, 5	49, 5	37, 2	0, 75	66, 9
37- 47	55, 88	8, 79	94, 2	55, 7	47, 1	38, 5	0, 82	68, 9
68-78	51, 40	7, 07	88, 9	53, 1	44, 3	35, 8	0, 81	69, 6
5-15	66, 87	6, 88	108, 3	68, 7	60, 0	39, 6	0, 66	59, 2
33-43	53, 24	6, 82	94, 3	59, 9	46 4	84, 4	0, 74	64, 7
63-73	51,15	10, 34	90, 6	55, 7	40,9	34, 9	0, 85	68, 2

Table 1. *Water content of swelling in clay soils of Kolkhida (Settlement, podzolic-gley)*

Studies carried out to determine the effect of drying the soil on swelling, showed that even a three-time drying of the soil at 1050 could not eliminate it. The final swelling value after all the drying was 38% versus 47% in the original soil. In some cases, 46% versus 49% in the original (Table 2), which indicates the reversibility of the colloids of these soils.

Thus, swelling cannot be eliminated by drying, and, consequently, the idea that under the influence of drying, the colloids of the soil coagulate and as a result of which the soil is structured, applies only to soils in which the colloids are irreversible (7).

Depth, cm	Measurement I		Measurement II		Measurement III		Measurement IV	
	Swelling, %	Water swelling, %	Swelling, %	Water swelling, %	Swelling, %	Water swelling, %	Swelling, %	Water swelling, %
3-13	47,0	82,6	40,6	67,0	38,9	62,2	37,9	64,3
“	44,3	83,8	37,1	67,4	35,9	65,6	34,3	64,9
25-35	48,3	86,0	44,3	69,1	41,9	67,9	39,2	68,2
“	47,5	81,6	42,8	69,3	41,2	65,5	39,2	66,1
60-70	49,2	85,4	49,0	75,6	46,7	67,8	46,2	67,5
“	48,4	81,4	47,8	73,4	47,2	67,2	42,5	64,3
90-100	43,8	75,9	40,7	67,0	36,3	61,4	36,4	62,8
“	43,1	78,5	37,8	:65,2	36,6	61,9	35,8	61,2

***Table 2**. Effect of drying on soil swelling*

According to the table 2, due to swelling, that heavy clay soils of Kolkhida have the ability to keep from 31 to 47% of water swelling, which cannot be removed by any hydro technical measures.

Determination of the optimum moisture content in percentage from MFD (Maximum field discharge) and evaluation of the water-air regime by humidity regime is based on the opinion that the difference between the MFD and the lower limit of available moisture for normal soils gives a range of field moisture (6,7). If this position is acceptable for irrigated and non-irrigated soils, it cannot be accepted for excessively moistened, swampy, swelling soils of Kolkhida, where MFD often coincides or is very close to full saturation, since the air capacity is zero. This means that air is a limiting factor for the use of water by the plant. Without the necessary minimum (determined for each plant), the plant cannot develop.

Consequently, the entire range from MFD to wilting moisture cannot be considered as useful water, and its upper limit is the moisture content at which the soil contains the minimum air required for a given plant.

What is the minimum volume of aeration pores that should be in the soil? Generally, it is considered that if pore volume occupied by air, when MFD is less than 10-15% of the soil volume, agro technical techniques will be required to improve aeration (2).

It can be explained by the fact that the flow of water into the soil causes a disproportionately large disconnection of pores compared with the volume of water that has arrived, through which soil aeration could be carried out. Studies have shown that the deactivation of pores and the associated decrease in the diffusion coefficient is particularly revealed in structure less soils and in soils of strongly swelling (8).

As it is shown above, in the clay soils of the central part of the Kolkhida lowland contains minerals of the montmorillonite group. In montmorillonite clays, swelling is associated with an increase in both inter-packet distances and distances between primary particles.

While drying these soils begins the process of volumetric shrinkage, which occurs mainly in 2 phases: first - when the decrease in the volume of the soil is equal to the volume of evaporated water - normal shrinkage, and the second - when the volume reduction is less than the volume of evaporated water - residual shrinkage. In this regard, the decrease in the moisture content of individual genetic horizons differently changes their aeration. The humidity range in which the soil aeration improvement depends on its structural state. In more structured soils it is wider than in less structured soils. In the upper humus horizon, some improvements in aeration occur at high humidity, evidently in connection with the release of a small pore volume from the gravitational water. Later, some stability is observed and, from about 40-42% humidity, the aeration curve begins to rise (1, 3).

The influence of agro-ameliorative measures on the water-air regime affects mainly on the upper 0-10 cm layer of the arable layer, where the air content is higher than on the control. In the lower layers, the difference was not found (Table 3).

Depth in cm	Option	Humidity of soil in% to weight	Volumetric weight in g / cm^3	in% to the volume of soil	
				Water	Air
0-10 10-20	already plowed	48,5 65,7	0,99 0,93	48,04 61,1	14,3 3,4
0-10 10-20	Row on the drainage	53,2 58,5	0,84 1,01	44,7 59,1	23,2 2,6
0-10 10-20	The deposit	43,7 56,4	1,20 1,03	52,4 58,1	2,4 2,2

Table 3. *The ratio of water and air in different versions*

To determine the effect of agro-ameliorative measures on the water-air regime of heavy soils in Kolkhida, studies were carried out at the Khorga experimental base of the Kolkhida experimental and ameliorative station, where these options were chosen: old-fall (10 years), skills with drainage (3 years) and a reservoir for comparison.

Table 4 provides data on the water and air content and their ratio in the soil on options with agro-reclamation measures and on controls. Thus, neighboring areas without activities (virgin land or fallow land).

Analysis of the data in the table shows that in the Khorga, in the experience with tea, in the soil (podzolic-gley) in the row with drainage, the ratio of water and air in the upper layer 0-10 cm varies in both terms from 2: 1 to 2.4: 1. Deeper, this ratio increases, reaching 15.7: 1.

Based on the data given, it appears that the apparent effectiveness of agro-ameliorative measures has not been determined by the air content in the soil and by the ratio of water and air in row with drainage.

The data show that even in the dry period, when there should be a maximum air in the soil, its content is sufficient only in the 0-10 cm layer and often less in the lower layers.

The above mentioned is confirmed by the results of studies obtained at the Khorga experimental base for soils with different degrees of compaction (Table 5) (1, 6, 7).

Depth in cm	I term - May				
	Moisture of soil in% to weight	in% to volume		Ratio of water and air	Unavailable water in% to volume
		water	Air		
		Tea on row with a drain			
0-10	34,9	38,7	19,3	2,0 : 1	18,9
10-20	33,9	43,7	7,8	5,6 : 1	21,9
20-30	37,5	48,0	4,0	12,0 : 1	21,5
40-50	32,3	45,2	3,3	13,7 : 1	21.4
0-10	25,7	31,5	22,1	1,4 : 1	22,2
10-20	29,8	39,3	11,1	3,5 : 1	23,5
20-30	31,9	40,8	11,3	3,6 : 1	21,9
40-50	32.1	42,7	7,7	5,5 : 1	21,5
	II term - October				
		Tea on row with a drain			
0-10	34,7	40,2	16,5	2,4 : 1	19,7
10-20	40,2	47,0	9,3	5,1 : 1	19,9
20-30	45,8	53,1	3,4	15,6 : 1	19,4
40-50	49,2	55,1	3,5	15,7 : 1	17,1
0-10	34,6	41,5	13,4	3,1 : 1	21,6
10-20	40,0	48.4	6,1	7,9 : 1	21,6
20-30	39,9	47,9	7,0	6,8 : 1	20,5
40-50	38,7	49,5	2,9	17,1 : 1	20,7

Table 4. *The content of water and air in the soil at low degrees of moisture*

Bulky weight, g / cm^3	Porosity, %	maximum moisture capacity, %	minimum moisture capacity, %	Optimal air content, %	Aeration,%	Non-productive humidity, %	productive humidity, %
1,3	51,3	39,6	40,0	15,4	0,0	33,0	7,0
1,2	55,0	45,8	42,0	16,6	3,5	33,0	9,0
1,15	56,9	49,5	43,0	17,4	6,5	33,0	10,0
1,1	58,8	53,5	46,0	18,2	7,5	33,0	13,0
1,0	62,5	62,5	48,0	20,0	14,5	33,0	15,0
0,9	66,3	73,6	48,0	22,0	25,6	33,0	15,0

Table 5. *The ratio of water and air at different bulky masses*

The data given clearly indicate that, even against of systematic drainage with a backfill, acceptable water-air ratios are possible only with a bulky weight of less than 1.0 g / cm3.

Naturally, grinding the soil to such a state (especially in the Kolkhida conditions) requires the use of special equipment and huge energy inputs, which is unprofitable. However, even in this case, the effect obtained is very short-lived, as the aggregates obtained in this way, when in contact with water, are dispersed and compacted to the original state. The radical improvement of the aggregate composition of the Kolkhidian soils by cultivation with agro technical and other methods is practically unreal (8).

Conclusion

The mechanical and mineralogical composition of soils in the central part of Kolkhida contains more than 50% of silt, consisting of minerals of montmorillonite, which are characterized by intracrystalline absorption, and irreversible soil colloids, which prevent the formation of structures under periodic swelling and shrinkage.

Very large (up to 2000 mm) and long (dry period not more than 1.5 months) precipitation, as well as big amount of groundwater standing against the lack of structure determines the maximum water saturation of soil and the lack of air content practically throughout the year. In the dry period, there is no productive moisture.

Agromeliorative measures affect only superficial 0-10 cm of soil.

The above prevents the formation of a solid, agronomical valuable structure and the provision of an optimal water and air regime, which makes it impossible to conduct productive agricultural development of this part of Kolkhida.

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