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Criteria and of soils grouping on fitness of humus layer for recultivation and soiling

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The purpose. To determine criteria of fitness of humus layer of soils of natural-climatic zones of Ukraine in case of their breaking for recultivation and soiling, demands to its removal and subsequent utilization at soil cultivation, to determine types and subtypes of soils on which it is expedient or not inexpedient to remove humus layer, parameters of power of fertile layer which is subject to removal at cultivation on basic types and subtypes of soils. **Methods.** General scientific and special: generalization, abstract-logical, analysis, comparative-geographical. **Results.** Methodical approach is developed for assessment of expediency of utilization of humus layer of soils of natural-climatic zones of Ukraine, based on principles of individual bonitation of soils on the basis of creation of arable land on optimum and admissible conditions of growing of basic crops. Indexes and their parameters for assessment of fitness of humus layer of soils for recultivation and soiling are specified. Grouping of soils on the basis of nomenclature list of agro-industrial groups of soils is carried out and soils on which selective removal of humus layer is recommended are specified. They also specified soils on which selective removal of humus layer is recommended at absence of fertile soils, and also depending on economic and ecological feasibility report in each concrete event. They fixed soils on which selective removal of humus layer both on low agro-industrial indexes, and in conditions of mountain operations is not recommended. Norms of removal of humus layer of soils are differentiated depending on native zone, type, subtype of soil, level of its fertility. **Conclusions.** Grouping soils for selective removal of humus layer of soils can be applied at development of design documentation on engineering stage of recultivation of lands and will promote improvement of quality of reclamation operations.

Key words: *disturbed lands, recultivation of lands, soiling, selective removal, specifications of removal of humus layer of soil.*

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The land reform, which has been taking place in Ukraine for a long time, has neglected the important issue of land reclamation. Nowadays, the need to return to the economic circulation of affected lands is set in the law by the Land Code of Ukraine, the laws of Ukraine "On Environmental Protection", "On Land Protection" and "On State Control over the Use and Protection of Land". According to the Law of Ukraine "On Land Conservation", lands, which changed in the structure of the relief, the ecological state of soils and parent rock and in the hydrological regime as a result of mining, exploration, construction and other works are subject to remediation[1]. At the same time, the separated soil mass is subject to removal, storage and transfer to affected, unproductive land plots, in accordance with the work projects on rehabilitation of affected lands and increasing soil fertility [2]. During the removal of soil cover it is carried out removal of layers and separate storage of the upper, most fertile soil layer, and other layers soil in accordance with the structure of the soil profile, as well as the parent rock. Reclamation of land plots is carried out by layered covering on unproductive land plots or plots without the soil cover with removed soil mass, and, if necessary, the parent rock in the order that provides the greatest productivity of the reclaimed lands. The direction of further use of recultivated land should provide for the achievement of a cost-effective and environmentally safe level of returns per unit area of these lands [3, 4], in particular using the ecosystem approach [5].

Since 2019 with the force cancellation of the interstate regulations in Ukraine that are necessary for the implementation of land management works related to the removal of the fertile layer of soil [6-8], currently it is valid the normative document DSTU 7705: 2015 Environmental Protection. In clause 3.3.17 of DSTU 7705: 2015 it was indicated that the upper humus-accumulating soil horizons with more than 1% of humus content

subject to selective removingfrom lands that were affected for further use during land reclamation or the cultivation of non-productive lands [9]. Therefore, in order to improve the normative and methodological basis for carrying out research and land surveying activities related to removal of the fertile layer of soil, it is highly necessary to develop recommendations on the evaluation criteria of the fertile soil layer and the procedure for the execution of works in this direction.

It is proved that the main criterion in determining the capacity of the soil humus layer, recommended for removal (in the absence of restrictions on other physico-chemical and agrophysical properties for growing of the crops), is the content of humus (at least 1%) along the lower boundary of the humus layer [10].

The purpose of the research is to establish the criteria for the suitability of the humus layer of soils of the Ukrainian climatic zones, in case of their violation, for recultivation and tillage, requirements for its removal and subsequent use during land works, to determine the types and subtypes of soils on which it is expedient and inappropriate to remove humus layer, parameters of the capacity of the fertile layer, which is to be removed during land works on the main types and subtypes of soils.

Materials and methods of research. The basis of the research was the zoning of the former Ukrainian SSR according to the types of affected lands and directions of their recultivation [11]. Identification of types of violations enabled to identify violations of the technological processes of the formation of recultivated land, which determine the directions of reclamation.

Methods of research were general scientific and special: generalization, abstract-logical, analysis, comparative-geographical. The object of research was the soils of the natural-climatic zones of Ukraine, which are affected, or may be violated in case of any land works [12, 13].

Research results. The expediency of separate removal of the soil humus layer, or even of the potentially fertile layer, is determined with the technology of extraction of minerals, the technogenic relief that is being formed, by the directions of reclamation in the area. Properties of this layer for different directions of use should be different depending on the requirements of agricultural and forestry crops, the creation of recreational zones, construction, etc. This is based on a new methodological approach for determining the criteria for the suitability of the fertile soil layer, depending on the directions of reclamation.

Since during the reclamation works the humus layer is used mainly for the creation of arable land (other directions do not require the mandatory use of it), we have developed a new methodological approach to assess the feasibility of using the humus layer of soils in the natural climatic zones of Ukraine, based on the principles of partial soil appraisal [14], according to agroecological requirements of growing of basic crops: wheat and winter rye, spring barley, oats, corn for grain, sugar beet, sunflower, potatoes, flax [15].

To determine the criteria, we took into account soil properties, which are expressed in quantitative indicators, are stable over time, considerably affect the yield of agricultural crops and fully reflect the essence of soil fertility.

The main criteria are the thickness of the humus layer of soil and the content of humus and physical clay in the arable layer. The modification criteria that determine the specific properties of the soil include the degree of salinity and erosion; pH gradation; depth and degree of soil gleying and salinity. For each diagnostic indicator, which is a typical criterion, the estimated point was calculated as the ratio of the actual value to the reference multiplied by 100. References are the optimal and permissible values of diagnostic indicators for the main agricultural cultures in accordance with the standardization of parameters of agroecological conditions of their cultivation, taking into account the structure of crop areas [15]. That is, for each natural and climatic zone, optimal and acceptable parameters of diagnostic indexes were calculated taking into account requirements of crops grown in this zone (Table). Optimal conditions are the ones under which the maximum implementation of the adaptive potential of culture is possible, the permissible conditions for reducing the yield by 20-30% [15]. The average point is calculated as weighted average score. Modification criteria are taken into account as correction coefficients in accordance with the method of soil appraisal [14]. The expediency of removing the humus layer of soil is established under conditions where the weighted average score is 100.

Table 1 –Parameters of the humus layer of the soils that provide its optimal and satisfactory productivity

Natural-climatic zone	Capacity of the humus layer, cm		Content in arable layer,%			
			humus		physical clay	
	optimal	permissible	optimal	permissible	optimal	permissible
1	2	3	4	5	6	7
Polissya	59	44	3,2	2,3	21-50	40-56 10-20
Forest-Steppe	63	47	3,3	2,5	21-55	55-65 15-25
Steppe	63	47	3,3	2,5	21-55	52-65 15-25
Dry Steppe	63	47	3,3	2,5	21-55	55-65 10-20
Carpathian mountain zone	56	41	3,0	2,0	18-45	43-65 10-20

Hypothetically reclaimed soils with a capacity of a humus soil layer of 40-60 cm can provide optimal and satisfactory conditions for growing of basic crops under the optimum values of agrochemical, physico-chemical and agro-physical parameters.

Research [16] for the conditions of the Northern Steppe showed that the yield of grain crops (winter wheat, rye, barley, buckwheat) on reclaimed soils with the application of 40-60 cm of the humus layer reached the level of yield on zonal soils. However, increasing the capacity of this layer to 80-100 cm slightly affected the increase in yields due to the rise in price of the technical phase of land reclamation.

For the conditions of the Southern Forest-Steppe, based on the predictive modeling of humus formation processes, an intense manifestation of this process in the surface layers and deceleration from a depth of 50-70 cm was established[17].

Determination of the parameters for the capacity of the soil humus layer to be taken for removal under land works should be based on the principles: assessing the expediency or impossibility of removing it depending on the level of fertility and the structure of the soil, the level of fertility of the genetic horizons of the soil profile of the main types and subtypes of the soils, depending on the content in their humus, physico-chemical, agrochemical and water-physical properties.

The main criteria for determining the capacity of a soil humus layer, recommended for removal is the level of fertility of the mixture formed during removal and mixing of the genetic horizons, which should not be lower than the fertility of potentially fertile breeds and meet the requirements of agricultural and forestry crops grown in a concrete natural-climatic zone. In the case of using a mixture for irrigation, the fertility level should be higher than on land subject to covering with soil.

To substantiate the parameters of the capacity of the humus layer to be removed, the following indicators should be used: the humus content at the lower bound of the humus layer should be at least 1%; For areas of distribution of soils with low humus content – sod-podzolic, sod and other lower limits of humus content is established on a case-by-case basis; pH of water extraction for chernozems and chestnut soils should be 5.5-8.2; pH of the salt extract, for sod-podzolic, light gray forest, gray forest, dark gray podzolized soils and chernozems podzolized - not less than 4,5; contents of exchangeable (available) aluminum (mg/100 g), at pH of salt. <5 - not more than 3; the mass fraction of exchangeable sodium (%) from the capacity of the cation exchange should be in the mixture of the fertile layer of chernozem, dark chestnut, chestnut soils in complexes with solonets - no more than 5; the mass fraction of water-soluble toxic salts in the humus layer of the soil should not exceed 0.05% (chloride salinity), 0.1 (sulfate-chloride), 0.2 (chloride-sulfate), 0.3 (sulfate), 0.1 (soda-

chloride, chloride-soda, soda), 0.15 (soda-sulfate, sulfate-soda), 0.2 (sulfate or chloride-hydrocarbonate) not from the soil mass; the content of granulometric fractions less than 0.01 mm, should be within 10 (15) - 65%; content of $CaCO_3$ not more than 30%; the content of $CaSO_4 \times 2H_2O$ should be no more than 10%.

The soil humus layer, to be removed, should not contain radioactive elements, heavy metals, residual quantities of pesticides, and other toxic substances higher than the normative levels for these substances. During soil surveys and the use of large-scale soil maps, the standards for removing the humus layer are established in accordance with the requirements listed above.

In determining the capacity of the soil humus layer to be removed, it should be taken into account that it is not removed on short-profile and lashed soils with a profile power less than 25 cm. This applies to soils formed on elution products of solid carbonate, igneous rocks, sandstones, clayey shales, conglomerates, volcanic rocks and soils that are submerged. The rules of removing are determined in each case separately. This also applies to saline soils in a complex with solonets and soils of the Carpathian forest zone: acid burozems, podsolized-burozems-acid, podzolic-burozemic acid and superficial gley. On crushed soils, the contents of the skeleton from the volume of soil must not exceed 20.

It is necessary to remove the humus layer of soil in accordance with the specified requirements not only from full-variety species, but also eroded ones. On complex soils, the removal capacity should be established on the worst soil fertility indexes of this complex; on saline soils and complexes of saline soils with zonal soils the removal capacity of a humus layer should be determined by the limit of the appearance of water-soluble toxic salts, the depth of occurrence of strongly gypsum and strongly carbonated carbonate-gypsum horizons.

According to the specified criteria and requirements, it is proposed to divide the soils into 3 groups:

- soils, which recommended the selective removal of the humus layer - a full-profile soils with the best agro-industrial properties for growing crops;

- soils, on which it is recommended the selective removal of the humus soil layer in the absence of fertile soils, as well as depending on the economic and environmental justification in each particular case.

These are soils with lower capacity of the humus layer, high alkalinity, acidity, worse physico-chemical and agrophysical properties than the soils of the 1st group. They can be defined as conventionally suitable for removing a humus layer of soil;

- soils, on which it is not recommend the selective removal of the humus layer of soil as a result of low agro-industrial properties, and under the conditions of mining operations.

These are soils of different types, subtypes of humus, erosion, hydromorphism and lithological composition. The removal of a humus layer of soil from steep slopes in mountainous terrain is determined by the possibility of technology, and at a high level of groundwater - after its reduction.

The scientific and methodological recommendations generalize and give the recommended norms for removing the humus layer of full-profile soils within the regions of Ukraine for the 1st and 2nd groups and the list of soils where it is inappropriate to remove the humus layer of soil in accordance with the nomenclature list of agro-industrial groups of soils [18].

The main reasons of the poor quality of land reclamation are the lack of necessary data on the composition and properties of the fertile layer, potentially fertile rocks and the landscape approach to land reclamation [19, 20]. The developed grouping of soils on the selective removal of the humus layer of soil will help to improve the project documentation for the technical stage of land reclamation and improve the quality of remediation works.

Conclusions

1. A methodical approach was developed for assessing the feasibility of using a humus soil layer, based on the principles of partial soil cultivation on the basis of its use for the creation of arable land under the optimal and acceptable conditions for the cultivation of main crops.

2. The indicators and their parameters for assessing the suitability of the soil humus layer for reclamation and tillage are specified.

3. Soil grouping was carried out according to the nomenclature list of agro-industrial groups of soils, and the types and subtypes of soils in which it is expedient to remove the humus layer, the parameters of the power of

the fertile layer, which is subject to demolition during land works on the bases of its use for the creation of arable land, is determined.

4. The rules for removing the humus layer of soil are differentiated depending on the natural zone, type, subtype of the soil, and the level of its fertility.

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