THE HUMUS REGIME OF TYPICAL CHORNOZEM IN SHORT CROP ROTATIONS WITH DIFFERENT LEGUMINOUS COMPONENTS

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Goal.* To study changes in the humus state of typical chornozem during 13 rotations of field short crop rotations with different leguminous components. *Methods.* General scientific and special for agricultural science: long-term field and analytical. To determine the content of total humus in a typical chornozem, they used I.V. Tiurin's method in Simakov's modification, the humus balance was calculated according to the methodology of the Institute of Soil Science and Agrochemistry named after O.N. Sokolovskyi. *Results.* The analysis showed changes in the content of total humus in the soil depending on the crops grown during 13 rotations of short crop rotations in the Left Bank Forest-Steppe of Ukraine at the experimental field of the Kharkiv National Agrarian University named after V.V. Dokuchaiev. A positive effect of peas and grass pea on the content of humus in the arable layer of typical chornozem in crop rotations was revealed, in which this indicator was 4.39 and 4.34 %, respectively, compared to paired crop rotation on average 0.34 % higher. In field crop rotations with a vetch-oats mixture and soybean, this indicator exceeded steam crop rotation by 0.11 %, but they were inferior to crop rotations with peas and grass peas in terms of humus content in the soil, the average difference was 0.13 %. The balance of humus in the soil of the investigated organic agroecosystems with different plant components was passive and varied from -109 to -635 kg/ha. The humus deficiency was smaller in field crop rotations with leguminous crops (vetch in a mixture with oats, soybeans, peas, lentils, beans, and grass peas) for growing buck-wheat in the 3rd year of the rotation. *Conclusions.* A higher content of humus in the soil was found in crop rotations with leguminous crops and corn for silage. A noticeable decrease in the content of organic matter in the soil due to the introduction of pure steam into organic agroecosystems was noted. The balance of humus in the soil of the investigated crop rotations with different plant components was passive. A smaller humus deficit was observed in crop rotations with leguminous crops for growing buckwheat in the 3rd year of the rotation.

***Key words**: agrotechnical experiments, cultivation, agricultural culture, predecessor, soil, organic matter.*

Today's urgent task is to reduce the cost of production and increase its competitiveness with the mandatory preservation and reproduction of soil fertility. Therefore, it is important to study the effect of crop rotations on the humus regime of t

Many scientific publications are devoted to the influence of agricultural plants, tillage and fertilizers on soil fertility. The authors [1-3] highlight only certain issues related to such action in different soil and climate zones. In modern farming conditions, intensive mineralization of humus in the soil is observed in connection with the intensity of tillage, the increase of the sown areas under row crops and the decrease in the use of organic fertilizers. At the same time, natural humus formation and humus accumulation are disturbed, the amount and quality of nutrients entering the soil, the intensity and direction of humification processes change [4-6].

Long-term agricultural use of the soil reduces the reserves of organic matter throughout the profile, but the rate of its loss slows down [7, 8].

According to the authors [9], the content of organic matter in the soil largely depends on the degree of influence of agricultural crops on it, their ratio in crop rotation, the type and amount of fertilizers. An increase in the share of row crops in crop rotation by 10 % leads to an increase in the loss of organic matter by 20-40 kg/ha.

Data on changes in the humus regime of soils under the influence of agricultural crops contain opposite opinions.

The purpose of the research is to determine the influence of agricultural crops on the humus regime of typical chernozem in short-rotation crop rotations.

Research materials and methods. Stationary long-term experiment on the study of short rotation crop rotation, established in 1962, was conducted on the experimental field of the Kharkiv Agricultural Institute named after V.V. Dokuchaev (now Kharkiv National Agrarian University named after V.V. Dokuchaev). According to research data of 1960, in the soil layer 0–20 cm, the content of humus was 6.1 %, easily hydrolyzable nitrogen – 72 mg/kg of soil, mobile phosphorus – 109, mobile potassium – 272 mg/kg of soil. The authors of [10], having carried out field and laboratory research, came to the conclusion that the soil cover of the experimental field is relatively homogeneous and is represented by typical deep low-humus heavy loam chernozem on loess-like loam.

For 53 years (1962–2015), the research studied separate agricultural crops and 16 variants of field crop rotations with the following rotation of crops: 1 — predecessor of winter wheat, 2 — winter wheat, 3 — sugar beets and buckwheat, 4 — spring barley. The predecessors of winter wheat were: peas, rank, lentils and beans for grain, vetch-oat mixture and soybeans for green fodder, corn for silage and pure steam. The area of the sowing area is 142 m^2, the accounting area is 50–100 m^2. Experiments were carried out in 3 repetitions. The location of the plots in the experiments is consistent. When setting up and conducting the field stationary experiment, generally accepted methods were used [11].

The organic fertilization system was studied using only the non-marketable part of the crop for fertilizer - straw: legumes - an average of 2.7 t/ha; winter wheat — 5.1; buckwheat — 2.5, sugar beet haulm — 10 and barley straw — 2.5 t/ha. Soil samples for agrochemical analyzes were taken from the 0–30 cm layer. The content of organic matter was determined by the method of I.V. Tyurin in Simakov's modification. The balance of humus — the difference between the amount of its new formation in the soil and mineralization for a certain period, was calculated according to the methodology of the NSC «Institute of Soil Science and Agrochemistry named after O.N. Sokolovsky» [12].

Research results. The intensity and direction of energy and substance transformation processes in agroecosystems depend not only on its quantity and quality, but also on crop rotation, tillage, organic and mineral fertilizers, and meliorants. In regulating the balance of humus in the soil, a particularly important place belongs to the improvement of the structure of sown areas and the alternation of crops in crop rotations [13]. Intensive use of the soil under agricultural crops since the beginning of the experiment led to a decrease in the content of organic matter to 4.52-4.61 %, which was recorded by the author in 1976 [14]. According to this indicator, the soil of the experimental field belongs to the typical low-humus chernozem.

Determining the organic matter content in the soil in 2015 revealed that the long-term use of short-rotation crop rotations worsened its humus state. Calculations showed a decrease in the organic matter content in the experiment by 1.81 %. A deeper analysis of the data showed that over the past 39 years the decrease in the organic matter content (in %) in the soil has been much slower. Using the author's data [14] until 1976 (for 16 years), a decrease in the organic matter content compared to the original data of 1.54 % was recorded, i. e. the losses were 0.10 % each year, over the next 39 years — only 0.27 %, i. e. 0.007 % per year.

After 13 rotations, changes in the content of organic matter were observed depending on the crops grown. A positive effect of peas and ranks on the content of humus in the arable soil layer in crop rotations was found, where this indicator was on average 0.34 % higher than in the steam crop rotation (Table 1). The influence of legumes on soil fertility has been sufficiently studied. According to scientists, the increase in nitrogen content is due to the nitrogen-fixing ability of legumes, after harvesting which post-harvest residues enriched with nitrogen remain in the soil. Legumes also play an important role in providing the soil with organic matter [15, 16].

In crop rotations with soybeans and vetch-oats, this indicator exceeded the indicator of the steam crop rotation by 0.11 %. However, in terms of the content of organic matter in the soil, they were significantly inferior to crop rotations with peas and ranks, on average the difference was 0.13 %. This decrease in organic matter content is due to significantly smaller volumes of post-harvest residues that remained after harvesting soybeans and vetch-oat mixture for green fodder. The studies yielded unexpected results regarding the humus content in a crop rotation with silage corn, in which after many years of research this figure was 4.40 %. It is equivalent to the figure in crop rotations where legumes - peas and ranks - were grown. It can be assumed that this result depended on the large volume of root and post-harvest residues, which increased the organic matter content in the soil. In addition, in this case, the technology for growing corn for silage did not provide for many times inter-row tillage, which slowed down the processes of mineralization of organic matter.

1. Soil humus state after 13 rotations of different crop rotations (2015 p.), %

Predecessor of winter wheat	Soil layer, cm				Humus reserves, t/ha
	0–10	10–20	20–30	0–30	
Pure steam	4.17	4.14	4.07	4.13	146
Peas for grain	4.43	4.36	4.39	4.39	154
Ranks for grain	4.38	4.31	4.32	4.34	155
Vetch-oat mixture for green fodder	4.25	4.24	4.22	4.24	151
Soybeans for green fodder	4.27	4.22	4.23	4.24	153
Corn for silage	4.59	4.49	4.11	4.40	160
$HIP_{0,95}$	0.41	$F_f<F_{0,95}$	$F_f<F_{0,95}$	—	—

In crop rotation with pure steam, a noticeable decrease in humus content was found. In the soil, processes of mineralization of organic matter of plant root residues, humus, organic fertilizers and microbial waste products are constantly occurring. It is in the field of pure steam that the organic mass gradually accumulated in previous years is completely decomposed. The presence of pure steam in the crop rotation mobilizes the nitrogen background and helps to clean the soil from weeds, but, as studies have shown, can lead to a deterioration in the humus state of the soil [17].

The intensity of mineralization of organic substances affects the humus content in the soil [18-20]. Long-term cultivation of crops in crop rotations and differences in their biological characteristics and cultivation technologies contribute to the concentration of organic residues in certain layers. A significant part of the root system of plants is concentrated in the upper soil layer, and a larger amount of their organic mass also remains in this layer.

The studies noted a steady increase in the content of organic matter in the upper soil layer in all developed crop rotations. This layer had the most favorable thermal regime, which, in combination with cyclical changes in weather conditions, ensured the gradual decomposition of organic residues and created conditions for intensive humification and accumulation of humic substances in the soil. With increasing depth along the profile, the amount of humus decreased on average by 0.07 %. It should be noted that there was a tendency to increase its amount in crop rotations with peas, ranks and corn for silage. Growing legumes in crop rotations contributed to the entry of protein-rich biomass into the soil, which in the conditions of biological farming ensured its stability and reduced humus losses, as a result of which the reserves in the soil amounted to 151–155 t/ha, which is on average more than in steam crop rotation by 7 t/ha.

Calculations of the humus balance in the soil under the predecessors of winter wheat showed that it was negative. Its minimum deficit was obtained in the fields under the cultivation of green fodder crops. Under the vetch-oat mixture it was 242 kg/ha, under soybeans – 283 kg/ha. It was in these crop rotations that the least amount of humus was mineralized and the maximum amount of stubble residues remained. The greatest humus deficit was determined in the pure steam field – 2000 kg/ha. It was this amount of humus in the steam field that was mineralized without any input.

In 4-field crop rotations, only in the 2nd year of rotation, i. e. under winter wheat, did receive a positive humus balance. It was maximal when winter crops were placed in a pure pair, minimal when wheat was grown after corn for silage. Variants with leguminous predecessors occupied an intermediate position. Obviously, this indicator depended on the yield of winter wheat grain and the supply of organic matter with post-harvest residues.

Conversely, one of the most deficient humus balances was in the 3rd field of crop rotation with sugar beets. The reason for this is the small amount of non-marketable products, surface residues and roots, and the high mineralization of organic matter. The humus balance in the soil under sugar beet did not depend on the predecessor, it was somewhat higher in crop rotations with corn, beans, soybeans and ranks. A significantly lower humus deficit was found in the soil under buckwheat 277–369 kg/ha depending on the crop rotation. Such a deficit can be explained by the high coefficient of humification of buckwheat plant residues, straw with its subsequent incorporation into the soil and less intensive humus mineralization under buckwheat.

An even smaller humus deficit was observed under spring barley. Since 16 variants of short-rotation field crop rotations were studied, the humus content depended on the first crop of the crop rotation and directly on the barley predecessors. It was lower in crop rotations with sugar beets, higher in variants with buckwheat. Regarding the dependence of the humus balance on the first crop, it should be noted that it was lower in crop rotations with peas, vetch-oat mixture, pure steam and lentils, and somewhat higher in variants with soybeans and corn for silage.

2. Humus balance in short rotation crop rotations (average for 1996-2015)

Predecessor of winter wheat	Crop rotation productivity, t f. units/ha	Amount of post-harvest residues, t/ha			Humus formed	Humus mineralization	Humus balance
		non-marketable products	terrestrial	root	kg/ha		
Pure steam	2.31 2.17	3.05 2.77	1.20 1.28	2.16 2.00	908 927	1543 1420	-635 -493
Peas	3.75 2.71	3.66 3.35	1.33 1.40	2.56 2.39	1097 1105	1417 1295	-320 -190
Ranks	3.53 2.55	3.45 3.16	1.28 1.36	2.48 2.32	1051 1061	1417 1295	-366 -234
Lentils	3.72 2.66	3.57 3.21	1.31 1.38	2.52 2.36	1074 1077	1417 1295	-343 -218
Vetch-oats	3.71 2.68	2.91 2.60	1.15 1.22	2.37 2.20	1076 1086	1317 1195	-241 -109
Soybeans	3.78 2.77	2.83 2.49	1.12 1.19	2.29 2.13	1044 1047	1317 1195	-273 -148
Corn	3.36 2.39	3.50 3.20	1.28 1.36	2.47 2.33	1054 1068	1417 1295	-363 -227
Pure steam	3.39 2.44	2.63 2.33	1.06 1.13	2.74 2.56	979 981	1410 1288	-431 -307

Note: The numerator shows the figures for crop rotations with sugar beets, the denominator shows the figures for crop rotations with buckwheat.

Calculations of the humus balance in the soil for crop rotation showed that it was passive (Table 2). Depending on the crop rotation, the humus balance varied within the range of -109–-635 kg/ha. The first and third crops of the crop rotation had a greater impact on the humus balance.

The greatest deficit of humus was found in crop rotations with pure steam and sugar beet, much lower – in crop rotations with vetch-oat mixture and soybean for green fodder and peas for grain. This is explained by the high productivity of the crop rotation, the amount of post-harvest residues and the decrease in humus mineralization compared to other crop rotations. It is worth noting that the balance of humus in crop rotations with sugar beet and buckwheat was different (-241. -635 and -109. -93, respectively)

Висновки

The content of organic matter in the arable soil layer after 13 rotations of crop rotations was 4.13–4.40 %. A higher content of humus in the soil was found in crop rotations with legumes (peas and ranks) and corn for silage. A noticeable decrease in the content of organic matter in the soil was noted when pure steam was introduced into organic agroecosystems, the difference was 0.19 % compared to other crop rotations. The humus balance in the soil of the studied crop rotations with different plant components was passive. The humus deficit was lower in crop rotations with vetch-oat mixture, soybeans, peas, lentils, beans and ranks when growing buckwheat in the 3rd year of rotation.

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The humus regime of typical chornozem in short crop rotations with different leguminous components

Goal. To study changes in the humus state of typical chornozem during 13 rotations of field short crop rotations with different leguminous components. **Methods.** General scientific and special for agricultural science: long-term field and analytical. To determine the content of total humus in a typical chornozem, they used I.V. Tiurin's method in Simakov's modification, the humus balance was calculated according to the methodology of the Institute of Soil Science and Agrochemistry named after O.N. Sokolovskyi. **Results.** The analysis showed changes in the content of total humus in the soil depending on the crops grown during 13 rotations of short crop rotations in the Left Bank Forest-Steppe of Ukraine at the experimental field of the Kharkiv National Agrarian University named after V.V. Dokuchaiev. A positive effect of peas and grass pea on the content of humus in the arable layer of typical chornozem in crop rotations was revealed, in which this indicator was 4.39 and 4.34 %, respectively, compared to paired crop rotation on average 0.34 % higher. In field crop rotations with a vetch-oats mixture and soybean, this indicator exceeded steam crop rotation by 0.11 %, but they were inferior to crop rotations with peas and grass peas in terms of humus content in the soil, the average difference was 0.13 %. The balance of humus in the soil of the investigated organic agroecosystems with different plant components was passive and varied from -109 to -635 kg/ha. The humus deficiency was smaller in field crop rotations with leguminous crops (vetch in a mixture with oats, soybeans, peas, lentils, beans, and grass peas) for growing buckwheat in the 3rd year of the rotation. **Conclusions.** A higher content of humus in the soil was found in crop rotations with leguminous crops and corn for silage. A noticeable decrease in the content of organic matter in the soil due to the introduction of pure steam into organic agroecosystems was noted. The balance of humus in the soil of the investigated crop rotations with different plant components was passive. A smaller humus deficit was observed in crop rotations with leguminous crops for growing buckwheat in the 3 rd year of the rotation.

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