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DYNAMICS OF HUMUS CONTENT IN THE MAIN SOIL TYPES IN THE RIVNE REGION

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Topicality *boils down to the need to prevent the reduction of the humus content in the soil and to fully restore its positive balance. The introduction of scientifically based crop rotations in production against the backdrop of reduced organic and mineral fertiliser application plays a significant role in the current environment.* ***Purpose****. To determine the dynamics of humus content in the main soil types of Rivne region and the reasons for its decline.* ***Materials and Methods****. The research was carried out on a network of monitoring plots laid out on different types of soil that characterise all soil and climatic conditions of Rivne region. Surveys of agricultural lands were carried out in accordance with agrochemical certification, which is intended to determine the quality of the soil. The study of the content of organic substances was carried out in accordance with DSTU 4289:2004.* ***Results.*** *We observe a steady trend of a significant decrease in the area sown under grain crops and grain legumes from 2000 to 2017, from 214,100 hectares to 77,500 hectares. According to the results of the research within the framework of agrochemical certification of agricultural lands, it was established that area of soils in the region with average and high humus content increased by 4.8 and 4.9 %, respectively and the area with low humus content decreased by 11.1 %. The positive balance of humus was formed due to the cultivation of maize for grain – 1.90 t/ha, grain legumes – 0.29 t/ha and winter wheat – 0.17 t/ha. In the areas under other agricultural crops, humus losses through mineralisation exceeded its formation Production of industrial crops and vegetables is the least balanced in terms of humus, with a deficit of 0.97 t/ha and 0.75 t/ha, respectively. The research conducted in the network of monitoring plots showed low humus content on sod-podzolic soils of both the Polissia zone and the Forest-Steppe of Ukraine. The average humus content was established for chernozem, light-grey and dark-grey soils.* ***Conclusions.*** *The application of organic fertilisers in the region decreased by 23.3 times compared to 1986–1990. The area under grain crops and grain legumes decreased from 214,100 to 77,500 ha in 2000–2017. In 2022, humus losses in the region totalled 386,400 tonnes, or 1.17 t/ha, while the region's humus supply was 478,100 tonnes, or 1.45 t/ha.*

Key words: *humus, soil, organic fertilizers, agrochemical certification, monitoring plot*

Introduction. Soil humus is the main reserve of nitrogen, phosphorus, sulphur, calcium, magnesium and other plant nutrients. The fertilisation system in the crop rotation should not only provide for a deficit-free balance of humus in the soil, but also its supplementing [1–3].

Changes in the humus content of soils depend on two mutually opposing processes such as humification and mineralisation of organic matter. The intensity of these processes results in the accumulation or loss of humus [4].

The application of mineral and organic fertilisers in crop rotation proves to be beneficial in terms of improving soil properties, increasing crop yields, saving fertilisers and reducing the risk of environmental destruction [5].

Nowadays, the constant decline in humus content, which plays a key role in soil formation, its valuable agronomic properties, and the supply of nutrients to plants, is a global problem. Humus is spent on mineralisation to release nutrients available to plants, but is also removed from the soil through erosion, with root and tuber crops, and is destroyed by various chemicals [6].

Losses of humus are accompanied by deterioration in the agrophysical properties of soils. V. V. Medvedev's research shows the following deterioration compared to virgin soil: cloddiness increased by 4–11 % of soil mass, dispersion by 3–6 %, content of agronomically valuable aggregates (size 10–0.25 mm) decreased by 10–18 %, water resistance of soil structure by 15–19 %, mechanical strength by 16–26 %, porosity of aggregates with size from 5 to 0.25 mm with average values of these indicators on virgin soil of 8, 15, 17, 55, 90, 42%, respectively [7, 8].

As a result, the humus content decreases. As microorganisms decompose less humus

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in the soil, their share increases, as well as the share of inert humus and its thermal stability (C:H). These processes lead to a decrease in the complexing ability of organic matter, its biological activity, structure-forming properties, and protective function [8]. Humus is the main determinant of all soil properties. It contains all the basic nutrients for plants and microorganisms (nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, and microelements). The gradual mineralisation of humus transforms these elements into mineral forms and is consumed by plants. The decomposition of humus and organic residues releases a large amount of carbon dioxide (CO_2), which is essential for the photosynthesis of green plants [9].

The need to develop soil monitoring, in particular, monitoring of humus content in the soil, is due to the importance of maintaining the natural environment in a state in which it retains the ability to regulate the cycles of biophilic elements as the basis of human life and the biosphere in general [10]. Conducting soil surveys as part of a comprehensive agrochemical survey allows us to identify adverse changes in soil properties, in particular, to identify areas with a deficient balance of nutrients and estimate the rate of humus loss.

Study was aimed at determining the dynamics of humus content of the main soil types in Rivne region and the reasons for its decrease.

Materials and Methods. The research was conducted on 27 monitoring plots located in all administrative districts on different soil types and covering all soil and climatic conditions of Rivne region [11]. For laying out the monitoring plots, we used an adjusted land management planning and cartographic base (1:100,000) with soil phases. For nested sampling, 20 point samples were taken from each elementary plot using the envelope method. The selected point samples (20 pcs × 4) were combined to form a nested (mixed) sample. Surveys of agricultural land were carried out as part of agrochemical certification by the Rivne Regional Centre of the State Institution Soils Protection Institute of Ukraine (SI Derzhgruntokhorona) [12].

The humus content of the soils was determined in accordance with DSTU 4289:2004 [13].

Results and Discussions. The soil cover of the region is heterogeneous and is characterised by great diversity in terms of genesis, grain size distribution, water and physical properties, and soil fertility. In the Polissia region, arable land is mainly represented by lightly textured sod-podzolic soils (59 %), sod (24.4 %) and boggy (13 %) soils and peat bogs (3 %). In the Forest-Steppe zone, arable land is mainly grey forest soils (40 %), of which dark grey podzolic soils (11 %); podzolic chernozems (24 %); typical chernozems (10 %); sod and crushed stone chernozems based on dense carbonate rocks (10 %); meadow and chernozem-meadow soils (6 %).

It is known that humus content is significantly affected by the amount of organic matter applied and the structure of crops.

Our research has shown that the volume of organic fertilisers applied in the region's agriculture has sharply decreased in recent years. In 2011–2015, only 0.8 tonnes of organic fertiliser per hectare of sown area was applied (Fig. 1).

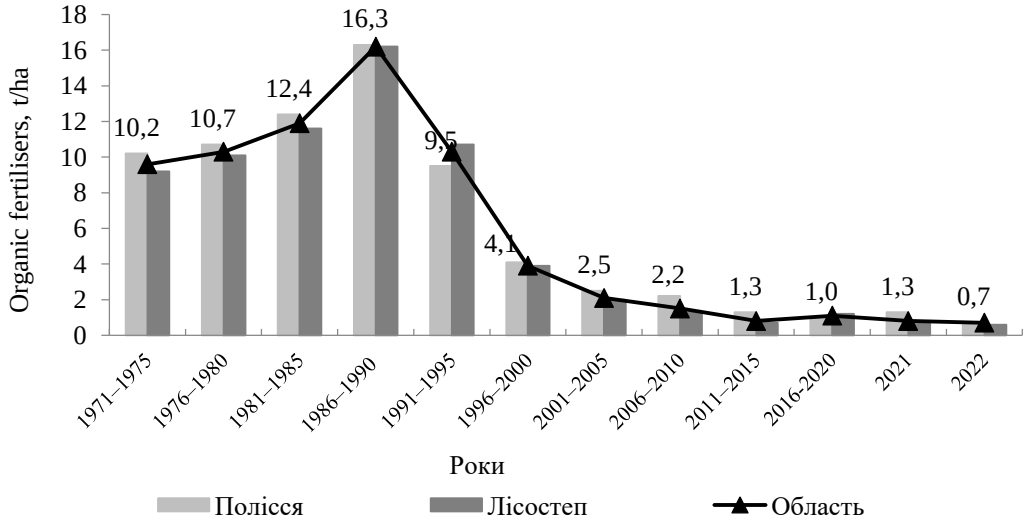


Fig. 1. Dynamics of organic fertiliser application.

A slight increase in manure production and application was observed in 2016–2020 (up to 1.1 t/ha). In 2022, organic fertiliser application was 0.7 t/ha. Organic fertilised area in 2020 was 36,100 ha, which is 12.3 % of the cultivated area. Meanwhile, the area under organic fertilisers in 2022 was 23,300 ha (7.1 % of the cultivated area). The percentage of organic fertilised areas ranged from 7–13.7 % in 2016–2019.

The application of organic fertilisers for crops varies as follows: sugar beet – 4.2 t/ha; maize for grain – 0.54 t/ha; wheat – 0.48 t/ha. From 2000 to 2017, there was a steady trend towards a significant decrease in the cultivated areas under grain crops and grain legumes (from 214,100 ha to 77,500 ha). Starting from 2018, the area under grain crops and grain legumes increased significantly to 123,900 ha in 2018, 150,600 ha in 2019 and 154,800 ha in 2022.

It was also found that cultivated areas under commercial crops in 2024 increased by 1.9 times compared to 2014, while cultivated areas under fodder and grain crops decreased by 1.2 times.

According to results of the XI round (2016–2020) of the soil survey, the humus content of the region's soils was distributed as follows: very low content (less than 1.1 %) – 800 ha (0.3 %); low (1.1–2.0 %) – 86,300 ha (31.1 %); medium (2.1–3.0 %) – 139,400 ha (50.2 %); elevated (3.1–4.0 %) – 41,000 ha (14.8 %); high (4.1–5.0 %) – 8,700 ha (3.1%); very high content (more than 5.1 %) – 1,700 ha (0.5%).

Compared to the previous round of soil surveys, there is a redistribution of areas by groups, in particular, the area of Polissia soils with high humus content increased by 6.3 %, while soils with very low and medium humus content decreased by 2.2 % and 4.3%, respectively (Table 1).

Table 1. Distribution of surveyed lands by humus content

Zone	Number of the survey round	Distribution of areas, %					
		very low	low	medium	elevated	high	very high
		(<1.1 %)	(1.1–2.0 %)	(2.1–3.0 %)	(3.1–4.0 %)	(4.1–5.0 %)	>5.0 %
Polissia	X	2.3	41.3	45.3	9.3	1.6	0.2
	XI	0.1	40.4	41.6	15.6	2.0	0.3
	deviation	***-2.2***	***-0.9***	***-4.3***	***6.3***	***0.4***	***0.1***
Forest-Steppe	X	0.4	42.4	45.4	10.1	1.5	0.2
	XI	0.4	26.0	54.8	14.3	3.7	0.8
	deviation	***0***	***-16.4***	***9.4***	***4.2***	***2.2***	***0.6***
Region	X	0.8	42.2	45.4	9.9	1.5	0.2
	XI	0.3	31.1	50.2	14.8	3.1	0.5
	deviation	***-0.5***	***-11.1***	***4.8***	***4.9***	***1.6***	***0.3***

In the Forest-Steppe zone, the area of soils with medium and high humus content increased by 9.4 % and 4.2 %, respectively, and that with low humus content decreased by 16.4 %. In general, the area of soils with medium and high humus content increased by 4.8 and 4.9 %, respectively, and the area of soils with low humus content decreased by 11.1 %. The analysis of the data revealed that the supply of humus from plant residues is 470,100 tonnes, or 1.43 tonnes per hectare. The humus yield per tonne of organic fertiliser is 42 kg in the Polissia zone and 54 kg in the Forest-Steppe zone. The formation of humus from organic fertilisers amounts to 8,100 tonnes, or 0.02 t/ha. In total, the region obtained 478,100 tonnes of humus from organic fertilisers and non-commodity products (1.45 t/ha). The cost item includes humus losses from mineralisation and water erosion. The calculations showed that losses of humus in the region as a whole in 2022 were 386,400 tonnes, or 1.17 t/ha, and the humus supply was 478,100 tonnes, or 1.45 t/ha. The new humus formation totalled 91,700 tonnes, with a balance of 0.28 t/ha (Fig. 2).

At the same time, the positive humus ba-

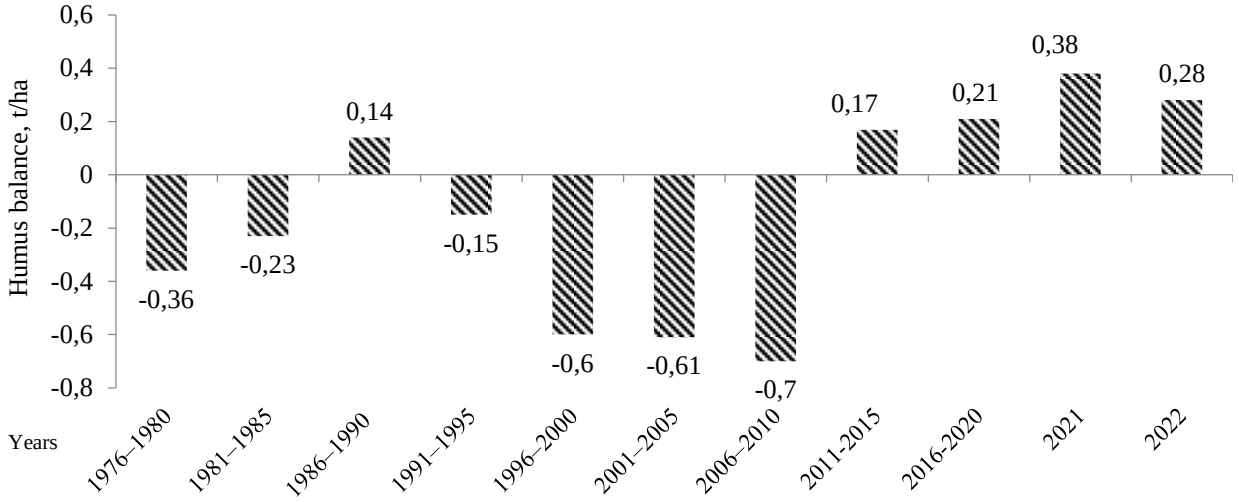
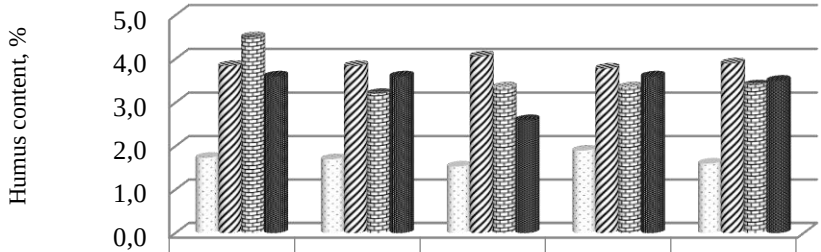


Fig. 2. Dynamics of humus balance in agriculture of Rivne region.

lance was formed due to the cultivation of maize for grain in the amount of 1.90 t/ha, legumes – 0.29 t/ha, and wheat – 0.17 t/ha. On all other areas of crop cultivation, humus losses exceeded its formation. The least balanced in terms of humus is the cultivation of commercial crops and vegetables, where humus deficit was 0.97 t/ha and 0.75 t/ha, respectively.

Studies on the monitoring plots for the main soil types of the Polissia zone of Rivne region have revealed the lowest humus content in sod-podzolic soils (1.5–1.9 %) compared to the average of 1.7 % (Fig. 3).

The humus content in chernozem soils was



	2018	2019	2020	2021	2022
дерново-підзолистий	1,7	1,7	1,5	1,9	1,6
дерновий	3,8	3,8	4,1	3,8	3,9
лучний	4,5	3,2	3,4	3,4	3,4
чорнозем	3,6	3,6	2,6	3,6	3,5

Fig. 3. Dynamics of changes in humus content of the main soil types in the Polissia zone.

2.6–3.6 %, while the average was 3.4 %. Over the five years of research, the humus content of sod soils ranged from 3.8–4.1 %, with an average of 3.9 %. In meadow soils, the humus content was 3.2–4.5 %, respectively, with an average of 3.6 %.

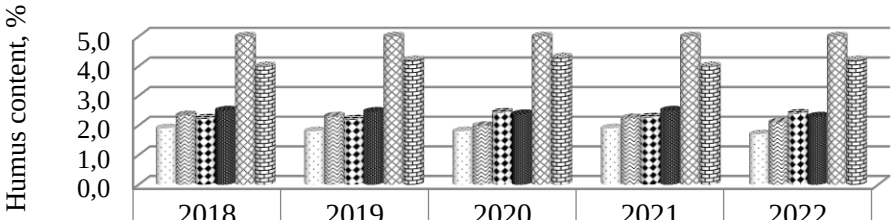
Thus, the main types of soils in the Polissia zone can be placed in a descending order by humus content: sod soils, chernozem, meadow soils, and sod-podzolic soils.

During the five years of research, there was a tendency to reduce the humus content in sod soils by 1.2 times. The decrease in the humus content of sod soils is explained by the impact of a biological factor, namely, the predominance of soil mineralisation processes over its new humus formation.

According to the results of the data on the monitoring plots of the main soil types in the Forest-Steppe zone over five years, it was found that the humus content ranged from 2.0–2.3 % in light grey soils, (average of 2.2 %); 2.2–2.4 % in dark grey soils (average of 2.3 %); 2.3–2.5 % in chernozem soils (average of 2.4 %). The humus content in sod-podzolic soils ranged from1.8–

1.9 % (average of 1.8 %). Over the last five years, the humus content in meadow and peat-bog soils ranged from 4.0–4.3 % and 6.0–6.4 %, respectively (Fig. 4). The average value was 4.1 and 6.2 %, respectively.

Thus, the main types of soils in the Forest-



	2018	2019	2020	2021	2022
дерново-підзолисті	1,9	1,8	1,8	1,9	1,7
ясно-сірі	2,3	2,3	2,0	2,2	2,1
темно-сірі	2,2	2,2	2,4	2,3	2,4
чорнозем	2,5	2,5	2,4	2,5	2,3
торфово-болотні	6,4	6,4	6,3	6,0	6,1
лучні	4,0	4,2	4,3	4,0	4,2

Fig. 4. Dynamics of changes in humus content of the main types of soils in the Forest-Steppe zone.

Steppe zone can be placed in a descending order by humus content: peat-bog soils > meadow soils > dark grey soils > chernozem soils > light grey soils > sod-podzolic soils.

Thus, sod, meadow and chernozem soils of the Polissia zone are characterised by high humus content, while sod-podzolic soils have low humus content. The chernozems, light grey and dark grey soils of the Forest-Steppe zone have average humus content, while the sod-podzolic soils of the zone have low humus content. The meadow and peat-bog soils of the Forest-Steppe zone have a high and very high humus content, which is explained by their genetic characteristics.

Conclusions

1. The decline in humus content was caused by intensified mineralisation processes, changes in the structure of cultivated areas, low application of organic fertilisers and grass cultivation.

2. In 2022, humus losses in the region amounted to 386,400 tonnes (1.17 t/ha), while the humus supply was 478,100 tonnes (1.45 t/ha). The positive balance of humus was ensured by growing maize for grain, grain legumes and wheat. On all other crop areas, humus losses exceeded its new formation.

3. The sod-podzolic soils of the monitoring plots in the Polissia and Forest-Steppe zones were characterised by low humus content. Chernozems, light grey and dark grey soils of the Forest-Steppe zone had average humus content.

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Інститут сільського господарства Західного Полісся НААН, вул. Рівненська, 5, с. Шубків, Рівненський р-н, Рівненська обл., 35325, Україна

Актуальність зводиться до необхідності запобігання зменшенню вмісту гумусу в ґрунті та переходу повністю на його позитивний баланс. У сучасних умовах впровадження у виробництво науково обґрунтованих сівозмін, роль яких ще більше зростає, коли зменшується внесення органічних і мінеральних добрив. **Мета** досліджень встановити динаміку вмісту гумусу основних типів ґрунтів Рівненської області та його зміни. **Матеріали та методи.** Дослідження проводилися у мережі моніторингових ділянок, закладених на різних типах ґрунтів і характеризують всі ґрунтово-кліматичні умови Рівненської області. Обстеження земель сільськогосподарського призначення проводилися відповідно до агрохімічної паспортизації, що призначена для визначення якісного стану ґрунту. Дослідження вмісту органічної речовин проводили згідно з ДСТУ 4289:2004. **Результати.** За результатами досліджень у рамках агрохімічної паспортизації земель сільськогосподарського використання встановлено, що площі ґрунтів області з середнім та підвищеним вмістом гумусу збільшилися, відповідно, на 4,8 та 4,9 %, з низьким – зменшилися на 11,1 %. Позитивний баланс гумусу формується за рахунок вирощування кукурудзи на зерно – 1,90 т/га, зернобобових – 0,29 т/га та пшениці озимої – 0,17 т/га. На площах з вирощуванням інших сільськогосподарських культур втрати гумусу на мінералізацію перевищували його утворення. Найменш збалансоване за гумусом виробництво технічних культур, де дефіцит становить 0,97 т/га та овочів – 0,75 т/га. Проведеними дослідженнями у мережі моніторингових ділянок відмічено низький вміст гумусу на дерново-підзолистих ґрунтах як зони Полісся так і зони Лісостепу. Середній вміст гумусу встановився для чорноземних, ясно-сірих та темно-сірих ґрунтів. **Висновки.** Встановлено зниження обсягів використання органічних добрив у області у 23,3 рази порівняно з 1986–1990 рр. Посівні площі під зерновими та зернобобовими зменшувалися у 2000–2017 рр. (з 214,1 до 77,5 тис. га). Втрати гумусу взагалі по області в 2022 р. склали 386,4 тис. тонн, (або 1,17 т/га), надходження – 478,1 тис. т/га – 1,45 т/га.

Ключові слова: *гумус, ґрунт, органічні добрива, агрохімічна паспортизація, моніторингова ділянка*