

INFLUENCE OF FERTILIZATION AND TILLAGE SYSTEMS ON THE HUMUS CONDITION OF DARK-GREY PODZOLIC SOIL

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Topicality. Modern agricultural systems have an ambiguous effect on the humus condition of soils. The urgent task is to restore and preserve the fertility of the dark grey podzolic soil, and increase the organic matter content in the agricultural system. **Purpose.** To determine changes in the humus condition of dark grey podzolic soil under sunflower under different tillage and fertilisation systems using by-products of crop rotation. **Materials and methods.** In the long-term stationary experiment, the following tillage systems were used: ploughing at a depth of 25–27 cm, disking at 15–17 cm and disking at 10–12 cm. Ploughing under sunflower was carried out with plough PLN-3-35, disking – disc harrow AH-2.4-20. The fertilisation systems were as follows: 1) no by-products; 2) by-products; 3) N_{10} (ammonium nitrate) per 1 tonne of by-products. The humus content in the soil was determined according to the I.V. Tyurin's method, the group composition of humus – according to method of M. M. Kononova and N. P. Bielchikova. **Results.** It was established that the highest humus content in the 0–20 cm layer of the soil under sunflower was 2.09 % for the variant with disking at a depth of 15–17 cm using by-products. On dark grey podzolic soil, humus accumulation is enhanced by disking at 15–17 cm and fertilisation with by-products and N_{10} , which is accompanied by characteristic changes such as an increase in the total content of humic acids and non-hydrolysed residue in the humus group composition. The highest content of humic acids was 0.29–0.34 % in the plots with moldboardless tillage under different fertilisation systems. The lowest content of this important humus fraction was 0.23–0.25 % in the variant with different depth ploughing. In the variants with disking to a depth of 15–17 cm and 10–12 cm when using by-products with N_{10} , the highest values of the ratio between carbon in humic acids and carbon in fulvic acids were 1.26 and 1.27, respectively. **Conclusions.** Application of moldboardless tillage, disking at a depth of 15–17 cm and fertilisation system with by-products + N_{10} contribute to the recovery of dark grey podzolic soil fertility and improvement of its humus condition. In the Western Polissia of Ukraine, it is recommended to carry out disking at a depth of 15–17 cm with the use N_{10} per 1 ton of by-products in the fertilisation system for sunflower cultivation.

Key words: humus, dark grey podzolic soil, fertilisation system, humic acids, fulvic acids

Introduction. Long-term anthropogenic load on the agricultural system changes both the humus content and its qualitative composition. The reason for this is the agrotechnical impact changing the natural development of humus formation, primarily of humus substances such as complex organic and mineral compounds that are not equally resistant to anthropogenic load. Soil in Ukraine is still poorly supplied with organic matter, with annual humus losses of 0.6–1.0 t/ha [1–3].

Soil fertility is related to soil formation and depends on the interaction between soil and plants. Plants absorb nutrients from the soil and produce organic compounds using photosynthesis. Soil microorganisms interact closely with higher plants, mineralise plant residues, and

support the formation of organic matter, humus, which concentrates the main part of soil nutrients. Under the impact of microorganisms, humus substances are also hydrolysed and mineralised, producing intermediate products [4].

Soil organic matter, its composition, reserves, and quality characteristics are the main indicators of soil fertility, whose changes largely depend on the intensity of agricultural practices, including fertilisation and tillage. Organic matter in the soil contains 85–90 % humus and forms in the small biological cycle of matter and energy [5, 6]. Humus intensifies biochemical and physiological processes, enhances metabolism and the general energy level of processes in the plant, increases the nutrient supply, which results in an increase in the productivity of agro-

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cenosis [7, 8].

The amount of humus and its qualitative composition are indicators of the ecological conditions of the soil. Agrochemical factors have a significant impact on the composition of humus compounds in the soil, changing the reserves of total carbon and the content of mobile fractions. D. S. Orlov and L. O. Gryshyna consider the group composition of humus as the most important indicator that characterises the soil conditions [9].

Literature sources give different interpretations of the effect of fertilisation on the fractional composition of soil humus. Some researchers point out that both physiologically alkaline and acidic mineral fertilisers have a negative impact on free and loosely bound humic and fulvic acids with R_2O due to an increase in mobile fractions of humus and simplification of the humic acid structure [10, 11].

Studies [12] have shown that under conditions of long-term application of organic and mineral fertilisers in crop rotation on light loamy soils, the initial level of humus decreased in the control (without fertilisers) and mineral fertilisation system by 30–40 %. The decreased content of humus was accompanied by changes in the main parameters of its qualitative composition such as a decrease in the content of humic acids, increased fulvation, and depletion of soil organic matter with active compounds that are easily mineralised. The low level of chemically and physiologically active organic matter in soil humus leads to the vulnerability of the stable central part of humic acid (HA) macromolecules, resulting in its transformation and also biological and chemical destruction, which decreases the total soil carbon content and leads to loss of fertility.

In experiments on light loamy soils, organic fertilisers kept the humus content and improved the qualitative indicators of organic matter compared to the control, while the application of a mineral fertilisation system increased dehumification, deteriorating the composition of soil organic matter [13–15].

According to a number of studies, the organic-mineral fertilisation system compared to the separate use of mineral and organic fertilisers showed an increase in C_{org} . (organic carbon content) in the soil [16].

The transformation of humus substances

and the degree of its severity under various manifestations of agrogenic impact reflect the nature and degree of change in humification conditions. The leading role in the manifestation of degradation and regradation transformation is played by humic acids; they are responsible for agronomic value of humus and its environmental sustainability [17]. Different agricultural conditions weaken or intensify the formation of humus structures and their polymerisation, which changes the content, composition, structure and properties of humic acids.

The regulatory mechanism for stabilising reserves and improving the qualitative humus composition can be tillage and fertilisation systems that use by-products [18].

The study of the impact of various agricultural practices on the content and transformation of organic matter is necessary to ensure the balanced utilisation of its resources and to develop effective monitoring measures for the agrosystem sustainability in general. Activities aimed to restore and preserve humus and soil fertility, will also help to control the carbon cycle in agro-systems and reduce CO_2 emissions.

Purpose of the research is to determine the changes in the humus condition of dark grey podzolic soil under different tillage and fertilisation systems using by-products in crop rotation with sunflower.

Materials and Methods. In 2021–2022, the research on qualitative changes in humus was conducted in a long-term stationary experiment of the Institute of Agriculture of Western Polissia of NAAS of Ukraine. The stationary experiment was conducted on three fields with one field included in the crop rotation, with the following crops alternating: winter wheat – soybeans – maize – sunflower.

In the experiment, three tillage systems were studied (ploughing to a depth of 25–27 cm, disking to a depth of 15–17 cm, and disking to a depth of 10–12 cm). Ploughing for sunflower was carried out with a PLN-3-35 plough, and disking was carried out with an AG-2.4-20 disc harrow. The experimental design included three fertilisation systems: 1) no by-products; 2) with by-products; 3) by-products + N_{10} (ammonium nitrate) per 1 tonne of by-products. For sunflower, by-products of winter wheat were used in the experiment.

Experimental plot soil is dark grey pod-

zolic with humus content in the 0–20 cm layer of 1.9 %, with mobile phosphorus and potassium content of 254 and 110 mg/kg (by Kirsanov), respectively, and easily hydrolysed nitrogen content of 87 mg/kg (by Kornfield).

The registration plot area is 100 m², repeated three times. Crop production practices were generally accepted.

The mineral fertiliser rate for sunflower was N₇₀P₃₅K₆₀. Fertilisers were applied in the form of ammonium nitrate, potassium chloride and ammophos.

Soil samples were taken from the 0–20 cm layer during the harvesting period. Total humus content in the soil was determined by the method of I. V. Tiurin (DSTU 4289:2004); humus group composition – by the method of I. V. Tiurin in the modification of M. M. Kononova and N. P. Bielchikova (MVV 31-497058-

006-2002).

Results and Discussion. The analysis of the humus state of dark grey podzolic soil indicates that the humus content and its qualitative composition depend on fertilisation and tillage systems.

Under different soil management conditions, the intensity of mineralisation and humification processes varies. The organic matter content in the arable layer of 0–20 cm of soil varied in response to both fertilisation and tillage systems. Higher soil humification in the topsoil was achieved due to moldboardless tillage and accumulation of post-harvest residues, which are the main source of organic matter, in this layer. Studies have shown that humification processes intensified under moldboardless tillage, and humus accumulated more efficiently than under different depths of ploughing (Table 1).

Table 1. Impact of fertilisation and tillage systems on the humus condition of dark grey podzolic soil, 2022

Tillage (factor A)	Fertilisation (factor B)	Humus, %	C total, %	C, % to soil weight			C _{humic res.}	C _{HA} : C _{FA}
				obtained by mixing Na ₄ P ₂ O ₇ + NaOH				
				total	C _{HA}	C _{FA}		
Different depth ploughing at 25–27 cm	no by-products	1.62	0.94	0.48	0.25	0.23	0.46	1.09
	by-products	1.62	0.94	0.48	0.23	0.25	0.46	0.92
	by-products + N	1.71	0.99	0.47	0.25	0.22	0.52	1.14
Disking at 15–17 cm	no by-products	1.81	1.16	0.59	0.32	0.27	0.57	1.19
	by-products	2.00	1.05	0.54	0.30	0.24	0.51	1.25
	by-products + N	2.09	1.21	0.61	0.34	0.27	0.60	1.26
Disking at 10–12 cm	no by-products	1.84	1.07	0.59	0.31	0.27	0.48	1.15
	by-products	1.90	1.10	0.54	0.29	0.25	0.56	1.16
	by-products + N	1.91	1.11	0.59	0.33	0.26	0.52	1.27
LSD ₀₅	factor A	0.08	0.05	-	0.03	0.01	-	-
	factor B	0.06	0.03	-	0.02	0.02	-	-
	interaction AB	0.05	0.04	-	0.02	0.01	-	-

Note: C total, % – total carbon content; C_{HA} – carbon content of humic acids; C_{FA} – carbon content of fulvic acids; C_{humic res.} – content of non-hydrolysed residues; C_{HA} : C_{FA} – ratio of the carbon content of humic acids to the carbon content of fulvic acids; C_{org., %} – organic carbon content

In all variants of tillage, especially disking, with the use of by-products in the fertilisation system, the humus content in the soil increased.

The lowest humus content in the arable soil layer was 1.62–1.71 % in variants with ploughing under sunflower in fertilisation systems with by-products. In the 0–20 cm arable soil layer, the highest humus content was in the variants with disking to a depth of 15–17 cm using by-products and by-products + N₁₀ at a

rate of 2.00 and 2.09 %, respectively. Disking to a depth of 10–12 cm using the fertilisation system with by-products resulted in a slightly lower humus accumulation of 1.90–1.91 % compared to disking to a depth of 15–17 cm. In the variants under moldboardless tillage without the by-products, the humus content was reduced by 0.25 % compared to the variants with the by-products in the fertilisation system.

The highest total carbon content was 1.21 % for disking to a depth of 15–17 cm with

the use of by-products + N₁₀ in the fertilisation system, 1.91 % for disking at a depth of 10–12 cm with the same fertilisation system, 0.94 % for different depth ploughing without by-products, 1.16 % for disking at 15–17 cm and 1.07 % for disking at 10–12 cm.

In the dark grey podzolic soil, the share of fulvic acids in the humus was 0.22–0.27 % of the total carbon content and humic acids – 0.23–0.34 %. At the same time, the content of fulvic acids and humic acids varied depending on the tillage and fertilisation systems.

The highest content of humic acids was 0.29–0.34 % in plots with moldboardless tillage under different fertilisation systems. The control variant with different depths of ploughing was characterised by the lowest content of humic acids (0.23–0.25 %). In variants with moldboardless tillage using by-products, humic acids are dominated by fulvic acids in the humification.

The highest total amount of insoluble residue was in the variant of disking to a depth of 15–17 cm using by-products + N₁₀ and reached 0.60 %, while in the variant of different depth ploughing without by-products, it was 0.46 %.

The fertilisation system with the use of by-products increased the share of humic acids and ratio C_{HA}: C_{FA}, indicating improved humus quality. The highest values of the ratio C_{HA}: C_{FA} were in the variants of disking to a depth of 15–17 cm and 10–12 cm with the use of by-products + N₁₀ and amounted to 1.26 and 1.27, respectively. In the dark grey podzolic soil, when using the tillage and fertilisation systems with by-products, the ratio C_{HA}: C_{FA} is higher

than 1, which indicates the dominance of humic acids in the humus composition.

Conclusions. The obtained research results evidence the positive impact of moldboardless tillage systems and the use of by-products in the fertilisation system on the humus condition of dark grey podzolic soil.

In the Western Polissia of Ukraine, the highest humus content in the 0–20 cm soil layer was 2.09 % in the variant with disking at 15–17 cm with the use of by-products during sunflower cultivation.

On dark grey podzolic soil, disking to a depth of 15–17 cm with the use of by-products + N₁₀ in the fertilisation system promotes humus accumulation with characteristic changes: the total content of humic acids and the content of non-hydrolysed residue increases in the humus group composition.

The highest content of humic acids (0.29–0.34 %) was observed in plots with moldboardless tillage under different fertilisation systems. The variant with different depth ploughing was characterised by the lowest content of this important fraction of humus at 0.23–0.25 %. The highest values of the ratio C_{HA}: C_{FA} were in the variants with disking at a depth of 15–17 cm and 10–12 cm with the use of by-products + N₁₀ and were respectively 1.26 and 1.27.

Moldboardless tillage, disking to a depth of 15–17 cm and a fertilisation system with by-products + N₁₀ contribute to the restoration of fertility of dark grey podzolic soil and improvement of its humus condition.

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Фурманець М. Г.¹, Фурманець Ю. С.¹, Фурманець І. Ю.² Вплив систем удобрення та обробітку на гумусний стан темно-сірого опідзоленого ґрунту. Зернові культури. 2023. 7 (1). 163–167.

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Актуальність. Сучасні системи землеробства неоднозначно впливають на показники гумусного стану ґрунтів. Відновлення й збереження родючості темно-сірого опідзоленого ґрунту та підвищення вмісту органічної речовини в агросистемі є актуальним. **Мета.** Встановити зміни гумусного стану темно-сірого опідзоленого ґрунту за різних систем його обробітку та удобрення з використанням побічної продукції культур сівозміни під соняшником. **Матеріали і методи.** Довгостроковий стаціонарний дослід. Системи обробітку ґрунту (оранка на глибину 25–27 см, дискування на – 15–17 см, дискування на – 10–12 см). Оранку під соняшник проводили плугом ПЛН-3-35, дискування – АГ-2,4–20. Системи удобрення: 1) без побічної продукції; 2) побічна продукція; 3) побічна продукція + N₁₀ (аміачна селітра) на 1 т побічної продукції. Вміст гумусу в ґрунті визначали за методом І. В. Тюріна, груповий склад гумусу — за М. М. Коновою і Н. П. Бельчіковою. **Результати.** Встановлено, що за вирощування соняшнику найвищі показники вмісту гумусу в 0–20 см шарі ґрунту були у варіанті з дискуванням на 15–17 см за використання побічної продукції – 2,09 %. Застосування на темно-сірому опідзоленому ґрунті дискування на 15–17 см та в системі удобрення побічної продукції + N₁₀ сприяє гумусонагромадженню і супроводжується характерними змінами: в груповому складі гумусу зростає загальний вміст гумінових кислот і підвищується вміст негідролізованого залишку. Найбільшими показниками вмісту гумінових кислот відзначалися ділянки на яких використовували безполицеві обробітки ґрунту за різних систем удобрення – 0,29–0,34 %. Варіант з різноглибинною оранкою відзначався найнижчим вмістом цієї важливої фракції гумусу 0,23–0,25 %. Найвищі показники співвідношення C_{ГК} : C_{ФК} були у варіантах дискування на глибину 15–17 см та на 10–12 см за використання побічної продукції + N₁₀ становили, відповідно 1,26 та 1,27. **Висновки.** Застосування безполицевого обробітку ґрунту, дискування глибиною 15–17 см та системи удобрення з побічною продукцією + N₁₀ сприяють відтворенню родючості темно-сірого опідзоленого ґрунту та поліпшенню його гумусного стану. В умовах Західного Полісся України за вирощування соняшнику доцільно проводити дискування на глибину 15–17 см із використанням в системі удобрення побічної продукції + N₁₀ на 1 т побічної продукції.

Ключові слова: гумус, темно-сірий опідзолений ґрунт, система удобрення, гумінові кислоти, фульвокислоти