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The influence of the stubble biodestroyer and the main tillage method on the nutrient regime of the soil

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Abstract. Annually, soil fertility indicators decrease in Ukraine. Therefore, to ensure a deficit-free soil balance, it is necessary to attract additional reserves of organic raw materials, in particular, post-harvest residues of agricultural crops, and to use biological preparations for their destructuring. To date, the effect of stubble biodestructors on the processes of mineralization of post-harvest plant residues has not yet been fully studied, especially under different methods of main tillage, therefore the purpose of our study was to determine the influence of the destructor Ecostern Classic and the method of main tillage on its nutritional regime in the conditions of southern Ukraine. Research methods: field, laboratory. Research has established that the amount of nitrates, mobile phosphorus and exchangeable potassium that remained on average over the years of research in the soil of the experimental site after harvesting winter wheat was 6.3, respectively; 47.5 and 208.8 mg/kg of soil, and after harvesting winter barley – 5.9; 42.8 and 202.4 mg/kg of soil. After partial mineralization of plant residues of winter crops, in three months, the content of nutrients in the soil increased, especially when treated with the Ecostern Classic biodestroyer. It was determined that the use of plowing contributed to the acceleration of the mineralization of plant residues of winter wheat and the greater accumulation of nutrients in the soil. Thus, during the treatment of post-harvest remains of winter wheat with a biodestructor using plowing, 11.3 mg/kg of soil nitrates, 53.9 mg/kg of soil of mobile phosphorus and 261.8 mg/kg of soil of exchangeable potassium were determined. For the processing of post-harvest remains of winter barley, the indicators were slightly lower – 10.5, respectively; 51.5 and 251.0 mg/kg of soil. The practical value of the research lies in the improvement of the processes associated with increasing the fertility of the soils of southern Ukraine due to the much more rational use of post-harvest remains of winter wheat and barley

Keywords: post-harvest residues, destructuring, plowing, tillage, soil fertility, nutrients

INTRODUCTION

Ukraine is one of the richest countries in the world, because it has highly fertile soils, in particular, it owns the largest share of the world fund of chernozems [1]. Soil is the main means of agricultural production, and therefore the success of the agricultural industry depends precisely on soil fertility [1]. However, in the conditions of modern agricultural production in Ukraine, there is an increase in anthropogenic influence on soils, their biological and humus state is changing. In this regard, it is becoming increasingly important to study the patterns of microbial, biochemical and chemical processes in soils depending on the applied fertilizers. The urgent need to restore natural ecosystems to maintain their biodiversity at levels that guarantee ecological stability poses new tasks for science to ensure urgent measures aimed at protecting the environment from pollution and destruction [2].

An ecologically safe factor for increasing fertility, improving the agrophysical properties of soils, and a source of organic matter are crushed and plowed into the soil post-harvest residues of agricultural crops, in particular cereals [3]. Plant residues of agricultural crops are the most important resource for the reproduction of organic matter and maintenance of the functional properties of the soil, and are a key component of the sustainable development of agricultural production [12]. They provide the soil with organic substances, which are transformed by microorganisms living in the soil. Therefore, it is common to apply straw as a biological fertilizer and energy material for soil formation [13]. Crop straw used to play a vital role in people's daily lives as well as in industry, with energy use and pulp and paper making being the most common methods. Previously, plant biomass was the most important source of energy in rural areas, accounting for more than 70% of total energy consumption [6]. Today, cereal straw is increasingly attracting attention as a globally available raw material that can be used for the production of biologically-based chemicals and fuels using various technical processes and ways of valorization [7; 8].

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Biochemical and fuel industry sustainability goals may lead to increased demand for cereal straw, which may negatively impact soil organic matter. Cereal straw is a common by-product of agriculture in the world and in Europe in particular. Currently, general restrictions on straw removal are applied in the EU in order to preserve soil organic matter [9]. But according to the assumptions of some scientists, compliance with restrictions on the removal of straw from the fields does not affect the content of organic matter in the soil [10; 11].

In Ukraine, wheat straw is one of the most common categories of agricultural waste, which is usually thrown away and burned every year, which creates environmental problems [12]. Research has established that plowing into the soil post-harvest residues of agricultural crops against the background of the use of modern biological preparations for their mineralization improves the nutrient regime of the soil, the work of beneficial soil microflora, which subsequently ensures an increase in the yield of agricultural crops [13]. To date, the effect of stubble biodestructors on the mineralization processes of post-harvest crop residues has not yet been fully studied, especially under different methods of main tillage, therefore the aim of the study was to determine the influence of the winter wheat stubble biodestructor and the method of tillage on the nutrient regime of the soil in the conditions of Southern Ukraine.

LITERATURE REVIEW

In modern agricultural production in the world, as noted by V. Sendetskyi, the priority for solving the problem of increasing soil fertility is the return of nutrients to the soil thanks to the plowing of plant residues and the use of biodestructors created on the basis of microorganisms that produce enzymes that decompose plant residues [14]. The author notes that their use contributes to the increase in the number and improvement of the life processes of beneficial microorganisms in the soil, as well as the suppression of pathogenic soil microflora. Simultaneously with the increase in fertility indicators, soil recovery is also observed [15]. E. Domaratskyi note that this is very relevant today, because it is soil fertility that determines the level of crop productivity and the ecological balance of the environment [16].

The nutrient regime of the soil is characterized by the content of macro- and microelements in it, it is one of the main factors affecting the yield of agricultural crops. According to V. Gamayunova's research, the higher the content of plant nutrients in the soil, the more fertile it is [1]. Soil fertility is determined by the amount of humus in it. Humus is an organic component of the soil, which is formed in the process of biological and chemical decomposition of the remains of animals and plants. The use of biodestructors accelerates these processes and accumulates nutrients in the soil. Scientists have proven that there is a dependence: the higher the percentage of humus in the soil, the more nutrients the plant receives and the higher the yield it forms [17].

According to researchers, modern farming conditions lead to a decrease in soil productivity due to the active use of nutrients from the soil and the lack of their replenishment, which leads to active soil degradation [18; 20]. It should be noted that a large proportion of nutrients is lost by the soil due to their accumulation and removal together with the marketable part of the harvest of agricultural crops, and without their compensation in the form of mineral fertilizers, modern bio- and restorative preparations, and crop residues, there is an increase in the deficiency of macro- and microelements in soil [19; 21]. That is why plowing into the soil post-harvest residues of agricultural crops, the use of modern biodestructors, as well as the study of the biological activity of soils is a crucial task at the current stage of the development of the agricultural sector. A deeper understanding of microbiological processes will reveal patterns of transformation of organic matter, consequences of anthropogenic impact on soils and ways to eliminate them. One of these measures is the use of biodestructors in modern agricultural technologies for effective decomposition of plant residues [22].

MATERIALS AND METHODS

Experimental research was conducted during 2019-2021 at the research field of the Educational-Scientific-Practical Center of Mykolaiv National Agrarian University. The farm is located in the third agro-climatic district, which is part of the Southern Steppe subzone of Ukraine. The climate of the area where the farm is located is temperate-continental, dry spells and droughts caused by low air humidity are often observed. The most characteristic feature of the area where the farm is located is a small amount of precipitation, which exceeds the moisture evaporation rate. Weather conditions during the years of research were typical for the area of the farm, but differed in terms of temperature and rainfall.

The soil of the experimental sites is represented by southern chernozem, residual-weakly saline heavy loam on loess. The reaction of the soil solution is neutral (pH – 6.8). The humus content in the 0-30 cm layer is 3.3%. Mobile forms of nutrients in the arable layer of the soil contain on average: nitrates (according to Grandval-Lyazh) – 18, mobile phosphorus (according to Machigin) – 49, exchangeable potassium (on a flame photometer) – 295 mg/kg of soil.

Research was conducted with wheat and barley of winter forms. The technology of growing crops in the experiment was generally accepted according to the existing zonal recommendations for the Southern Steppe of Ukraine. After harvesting winter wheat and winter barley, their post-harvest residues were processed with the Ecostern Classic stubble destructor in a dose of 2.0 liters of biological preparation with a consumption of 200 liters of working solution per 1 ha.

The following factors and options were studied in the experiment: Factor A is the method of basic soil cultivation: 1. Shelfless (chisel processing); 2. Plowing. Factor B – processing of post-harvest residues: 1. Water; 2. Ecostern Classic.

In the experiment, the biodestructor of stubble Ecostern Classic was used – it is a concentrated agent, which includes fungi and bacteria that accelerate the decomposition of plant residues, in addition, the biological preparation contains antagonists of pathogenic microorganisms, living cells *of Bacillus subtilis, Paenibacillus, Azotobacter, Enterobacter, Enterococcus, Agrobacterium* and *fungi genus Trichoderma, in particular Trichoderma lignorum and Trichoderma viride*. The number of colony-forming units (CFU) is 3.5x109 per cm^3. The biopreparation is intended for the effective decomposition of plant residues, increasing the biological activity of the soil, improving it due to the introduction of useful microorganisms and, as a result, increasing the productivity of crops in crop rotation [22].

Research was conducted according to generally accepted methods. Thus, the content of nitrates in the soil was determined according to DSTU 4729:2007 with disulfophenolic acid according to the Grandval-Liajou method [23]. Nitrates with disulfophenolic acid form trinitrophenol, which in an alkaline environment forms ammonium trinitrophenolate of yellow color, the intensity of which color is proportional to the nitrogen content. By photometering the solution, the nitrate content in the soil was determined. Nitrates were extracted from the soil with water at a ratio of soil to water of 1:5. The content of mobile phosphorus and exchangeable potassium was determined by the modified Chirikov method according to DSTU 4115-2002 [24]. The method is based on the extraction of phosphorus and potassium from the soil with a 0.5 N solution of acetic acid at a ratio of soil: acid of 1:25 at a temperature of 18-20°C with subsequent determination of phosphorus on a photoelectrocolorimeter, and mobile potassium on a flame photometer. The soil was sampled after harvesting winter wheat and winter barley (before treatment with biopreparation) and three months after that.

RESULTS AND DISCUSSION

In recent years, the cultivation of agricultural crops in Ukraine has undergone excessive intensification, a lack of organic fertilizers, and the absence of leguminous crops in crop rotations, which contributes to an increase in the man-made load on the soil and its degradation. The most significant damage is caused by soil erosion, which covers up to 57.5% of the territory, soil pollution – up to 20%, and flooding – up to 12%. The consequence of excessive intensification of agricultural production is also a decrease in the content of nutrients in the soil and an annual loss of humus at the level of 0.065 t/ha. Preservation of soils and their properties can be facilitated by the use of plant residues of agricultural crops in agricultural technologies, because they replenish the soil with organic matter, macro- and microelements [4]. Thus, the straw of grain crops consists of organic substances (80%) and water (15%). Cellulose, hemicellulose and lignin are the energy material for the vital activity of soil microorganisms, and the products of their destruction serve as the material for the formation of humus.

On average, straw of grain crops contains 0.5% nitrogen, 0.25% phosphoric anhydride, 0.8% potassium oxide and 35-40% organic carbon. All these compounds can replenish the reserves of nutrients in the soil due to the destruction of plant residues of grain crops. The results of research by V.M. Sendetskyi [14] established that with one ton of straw, 4.8-5.6 t/ha remained on the field during the years of research, 15-20 kg of nitrogen, 8-10 kg of phosphorus, and 30-40 kg of potassium were returned to the soil . The content of nutrients in post-harvest crop residues depends on the elements of cultivation technology, as well as on climatic conditions during the growing season of plants. In turn, the amount of nutrients that return to the soil with plant remains depends on the degree of their decomposition. Under natural conditions, the decomposition of post-harvest plant residues and the release of nutrients from them in available forms takes place over several years. Biopreparations based on cellulose-destroying microorganisms are used precisely to accelerate the destructuring processes.

Previous studies have determined that hydrothermal conditions, the presence of moisture in the soil, and the culture, the remains of which were treated with a biodestroyer, have a great influence on the cellulolytic activity of the southern chernozem. The most intensive decomposition of plant residues 90 days after treatment with the biopreparation was noted in the pea treatment variant – 82.6%, which is 54.6% more compared to the control for treatment of residues with water only. A very effective effect of the stubble biodestroyer was found on barley, where 65.3% of the post-harvest residues were decomposed, while treatment with water alone provided decomposition of only 33.9% of the stubble [11]. The same dependence was observed in our research during 2019-2021. It was established that the vital activity of cellulose-degrading microorganisms is not constant over time and changes depending on the method of soil cultivation and the option of applying the treatment of post-harvest residues of the studied crops.

The activity of cellulose-destroying microorganisms is inhibited at high soil moisture and low temperatures. In the process of warming the soil, the intensity of cellulose decomposition increases, in addition, this indicator in our studies was influenced by the method of soil cultivation and the crop whose remains were processed. This indicator reached its maximum values when processing post-harvest remains of winter wheat with a biodestructor – 91.7-93.2%, depending on the studied method of main soil cultivation (Table 1).

Table 1. *The degree of destruction of post-harvest residues of winter wheat and barley after treatment with Ecostern Classic, % (average for 2019-2021)*

Culture is a precursor	The method of basic soil cultivation	Processing of post-harvest residues	
		water	Ecostern Classic
Winter wheat	Policeless (chisel processing)	76.5	91.7
	Plowing	79.1	93.2

Table 1, Continued

Culture is a precursor	The method of basic soil cultivation	Processing of post-harvest residues	
		water	Ecostern Classic
Winter barley	Shelfless (chisel processing)	75.2	90.4
	Plowing	77.4	92.7

Source: *developed by the authors*

At the same time, the highest degree of destruction of post-harvest residues was determined for the use of plowing and the use of Ecostern Classic – 93.2%, which exceeded the indicators of the option of combining tillage without plowing and water treatment of plant residues by 17.9 percentage points.

The same dependence of the decomposition of cellulose in the soil depending on the studied factors was observed during the processing of post-harvest remains of winter barley, but the indicators were lower. So, on average, according to the experimental variants, decomposition of 83.9% of the post-harvest winter barley residues was observed, which is less than the processing of winter wheat residues by 1.4 percentage points. It should be noted that the use of Ecostern Classic ensured a slightly greater destruction of the remains of winter barley plants compared to the option of treatment with water only. So, on average, 91.6% of the residues were decomposed by the tillage factor, which exceeded the indicators of the water-only treatment option by 16.7 percentage points.

The effect of tillage was also noted in our research. An increase in cellulolytic activity with the use of plowing was determined on all studied precursor cultures. So, on average, according to options for processing post-harvest residues, in this option, the degree of destruction of post-harvest residues of winter wheat was 86.2%, and winter barley – 85.1%, which, respectively, exceeded the indicators for no-till tillage respectively by 2.4 and 2.7 percentage points.

The researches of V. Sendetskyi [15] established that the use of the drug Vermystim-D contributed to the acceleration of the destruction of straw and the destruction of pathogenic soil microflora. Due to the accumulation of nitrogen-fixing, phosphate-mobilizing, bactericidal and fungicidal microorganisms in the soil, as well as the products of their vital activity, soil fertility is improved. Due to the treatment of plant residues with Vermistym-D, the processes of growth and development of soil microorganisms, which fed on them, that is, destroyed them, were activated. During such destruction, macro- and microelements were released into the soil in a form available to plants. This is confirmed by our research. The use of Ecostern Classic ensured the destruction of post-harvest residues of winter wheat at the level of 91.7-93.2%, and winter barley – 90.4-92.7%, while nutrients were released from plant residues in a form available to plants.

Research has determined that after harvesting winter wheat and winter barley, before applying the biodestructor, the soil contained, respectively, 6.3 and 5.9 mg/kg of soil nitrates, 47.5 and 42.8 mg/kg of soil mobile phosphorus and 208.8 and 202.4 mg/kg of exchangeable potassium soil (Fig. 1).

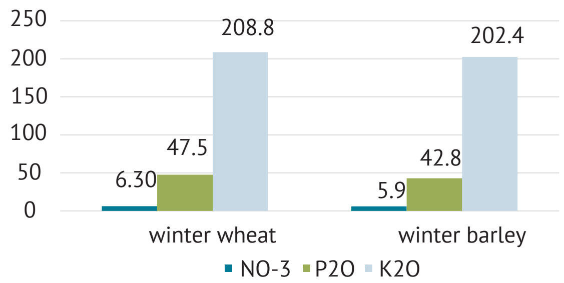

Figure 1. *The content of nitrates, mobile phosphorus and exchangeable potassium in the 0-30 cm layer of the soil before processing the post-harvest remains of winter wheat and barley with a destructor, mg/kg of soil (average for 2019-2021)*

Source: *developed by the authors*

With the intensification of agricultural production, it is possible to restore the consumption of nutrients for the formation of crop yields through the use of mineral fertilizers, but the importance of biopreparations, in particular biodestructors of stubble, is no less important, because they contribute to the mineralization of post-harvest remains of agricultural crops and the release of nutrients that accumulate in the plant body Microorganisms, in particular actinomycetes and fungi, affect the rate of decomposition of organic substances and the cycling of nutrients. Their influence on the transformation and circulation of carbon, nitrogen, phosphorus, potassium, sulfur and iron consists in the mineralization of organic compounds or the transformation of forms inaccessible to plants into accessible compounds. Treatment of winter wheat stubble with the biopreparation Ecostern Classic helped to increase the nitrate content in the soil, compared to their content before treatment, by 4.3-5.0 mg/kg of soil or 40.6-44.2% (Table 2).

Table 2. *NPK content in the 0-30 cm soil layer depending on the methods of soil cultivation and the use of Ecostern Classic, mg/kg of soil (average for 2019-2021)*

The method of basic soil cultivation	Processing of post-harvest residues	Contents		
		NO_{3-}	P_2O	K_2O
	Winter wheat			
Shelfless (chisel processing)	water	8.5	48.3	220.2
	Ecostern Classic	10.6	51.4	242.7
Plowing	water	9.6	50.2	235.1
	Ecostern Classic	11.3	53.9	261.8

Table 2, Continued

The method of basic soil cultivation	Processing of post-harvest residues	Contents NO_{3-}	P_2O	K_2O
Winter barley				
Shelfless (chisel processing)	water	7.8	47.5	217.9
	Ecostern Classic	9.1	48.7	225.3
Plowing	water	8.4	49.4	224.9
	Ecostern Classic	10.5	51.5	251.0

Source: *developed by the authors*

It should be noted that the amount of nitrates in the soil also increased, but was somewhat smaller, in the options for processing winter wheat plant residues with only water. Depending on the soil treatment option, the indicators were 8.5-9.6 mg/kg of soil, or were lower compared to their initial value by 25.9-34.4%.

The positive effect of stubble biodestructors on the nitrate content in the soil was also noted in the studies of Yu.O. Sergeeva [25]. Thus, at the beginning of the sorghum growing season, the content of nitrates in the arable layer of the soil was higher after processing post-harvest residues with the cellulose destructor biopreparation – by 20.4 mg/kg more than the control version of the experiment. In the flowering phase of sorghum, the nitrate content in the soil increased by 74.4 mg/kg due to the use of the Stubble biodestroyer. Before the end of the growth and development of sorghum plants, a significant advantage was observed in the variant using the cellulose destructor biological preparation – 32.1 mg/kg of soil.

The content of mobile phosphorus and exchangeable potassium in the soil after processing the post-harvest remains of winter wheat with a biodestructor also increased compared to the initial value. On average, according to the variants of the main tillage, the amount of mobile phosphorus in the arable layer of the soil under the action of Ecostern Classic slightly increased – by 9.9%. At the same time, due to the natural mineralization of winter wheat stubble, the amount of the studied nutrient increased by 3.6%.

The same trend was noted with regard to the content of exchangeable potassium in the 0-30 cm soil layer. After the use of the biopreparation Ecostern Classic on plant residues of winter wheat, on average over the years of research, 242.7-261.8 mg/kg of exchangeable potassium was determined, while 220.2-235.1 mg/kg of soil was determined for the water-only treatment option. At the same time, the amount of exchangeable potassium increased compared to its value before the application of the option of processing plant residues, respectively, by 14.0-20.2 and 5.1-11.2%, depending on the option of processing post-harvest residues.

Studies have established that, on average, according to soil treatment options, the content of nutrients in the option of using Ecostern Classic exceeded the option of treating winter wheat residues with water only by 1.9-24.6 mg/kg of soil or 6.5-17.3%, depending on element.

The same trend was observed during the processing of plant residues of winter barley. Thus, on average over the years and variants of the experiment, the content of nitrates in the soil increased by 3.1 mg/kg of soil or 34.1%, mobile phosphorus by 6.5 mg/kg of soil or 13.2%, and exchangeable potassium by 27.4 mg/kg soil or 11.9% compared to their initial values.

Research has determined that the use of the modern Ecostern Classic stubble biodestroyer contributed to better mineralization of plant residues of winter barley, release from them and return of nutrients to the soil. Thus, depending on the variant of the method of the main tillage, after processing the post-harvest remains of winter barley with a biopreparation in the soil layer of 0-30 cm, 9.1-10.5 mg/kg of soil nitrates, 48.7-51.5 mg/kg of mobile soil were determined of phosphorus and 225.3-251.0 mg/kg of exchangeable potassium soil, which exceeded the indicators of processing crop residues with water alone by 14.3-20.0; 2.5-4.1 and 3.3-10.4%, respectively.

At the same time, it should be noted that there was an increase in the content of nutrients in the soil compared to their initial values, regardless of the option of using the biodestructor. Thus, with the use of plowing and the use of winter water for processing post-harvest remains of barley, the content of nitrate nitrogen, mobile phosphorus and exchangeable potassium increased by 2.5; 6.6 and 22.5 mg/kg of soil or 29.8; 13.4 and 10.0%, and from the use of Ecosterne Classic by 4.6, respectively; 8.7 and 48.6 mg/kg of soil or 43.8; 16.9 and 19.4%. The same tendency was observed for the use of tillage without a shelf (chisel), but the indicators were somewhat lower.

In the studies of O.V. Humenyuk [26], using a biodestroyer at a dose of 10 l/ha in combination with the application of mineral fertilizers at a dose of N120P100K160, the maximum content of mineral nitrogen, mobile phosphorus and exchangeable potassium in the studied soil was noted. Research by A. Panfilova [27] showed that the amount of mobile macroelements in the soil significantly increased when the Biodestructor treatment of stubble combined with nitrogen fertilizer (N30) of the post-harvest remains of spring barley and peas increased. Thus, on average, the use of the biopreparation contributed to an increase in nitrates in the soil by 32.6%, mobile phosphorus by 13.4%, and exchangeable potassium by 13.3%, compared to their initial content (after harvesting the crops). The species composition of predecessor cultures also affected the content of nutrients. Thus, on average over the years of research, three months after the treatment of post-harvest remains of spring barley with the Stubble Biodestructor, 12.6 mg/kg soil nitrates, 53.8 mg/kg soil mobile phosphorus and 253.0 mg/kg soil exchangeable potassium accumulated in the soil, which is less compared to the indicators for peas, respectively, by 8.7; 12.2 and 11.8%.

The strategic task of modern intensive and energy-saving technologies for growing agricultural crops is to increase the breathability of plants, as well as to preserve soil fertility and improve its agrophysical and agrochemical indicators. An important role in this belongs to the rational cultivation of the soil, with the help of which it is possible to purposefully influence the preservation and increase of soil fertility, as well as the realization of the potential yield of agricultural plants [28]. Studies have determined that the method of main tillage also influenced the decomposition of winter wheat straw. On average, over three years and options for processing post-harvest residues, when plowing was used, the soil contained more nitrates by 0.9 mg/kg of soil or 8.6%, mobile phosphorus by 2.2 mg/kg of soil or 4.2%, and by 17.0 mg/kg of soil or 6.8% exchangeable potassium compared to the option of no-shelf (chisel) tillage.

The same dependence was observed in the experiment with the post-harvest remains of winter barley. So, on average, over the years of research and by the factor of crop stubble treatment, under plowless (chisel) tillage, 8.5 mg/kg of soil nitrates, 48.1 mg/kg of soil of mobile phosphorus and 221.6 mg/kg of soil were determined in it of exchangeable potassium soil, which was less than the indicators of plowing for the main tillage, respectively, by 1.0; 2.4 and 16.4 mg/kg of soil or 10.5; 4.8 and 6.9%.

The researches of I. Garo & V. Gamayunova [29] established that tillage methods had little effect on the content of nitrates in the soil, the difference between disking and plowing was only 0.2-0.3 mg/kg of soil (it was within the error of the experiment) with a slight tendency of the preference of plowing. To an even lesser extent, the content of mobile phosphorus in the soil layers changed depending on the method of main tillage. Thus, during the period of milk maturity of winter rape seeds, the 0-50 cm layer of this element contained 29.0 mg/kg for disking and 31.5 mg/kg for plowing.

V. Gangur [28] established that the content of mobile phosphorus was higher in traditional tillage, which creates more favorable conditions for the transformation of this element of mineral nutrition. The use of the No-till system for the cultivation of grain crops helps to increase the content of easily hydrolyzed nitrogen and exchangeable potassium in the soil layer (0-20 cm) compared to other methods of soil cultivation.

According to Nze Memiaghe [30], in order to reduce soil erosion, improve water conservation and prevent soil degradation, zero tillage is increasingly used, compared to the classical system of tillage. At the same time, it was established that zero tillage increases the use of phosphorus from the soil. Research by P. Jha *et al.* [31] established a significant effect of the combined application of zero tillage and stubble preservation in the field on the rate of mineralization of plant residues, as well as increasing the accumulation of nitrogen in the soil due to the improvement of the biological functioning of the soil.

Agricultural practices, including tillage systems and post-harvest residue management, strongly influence a wide range of soil properties. Depending on the application of these factors, both negative and favorable changes in its structure, chemical composition, and biological activity may occur. Research by K. Kotwica *et al.* [32] established that the use of methods of basic tillage for the cultivation of winter wheat contributed to changes in the basic biological and chemical properties of the soil. But the differences observed between different tillage methods indicate that the addition of organic matter is a more important factor influencing the values of biological and chemical parameters of the soil. This is also confirmed by our research – the use of post-harvest remains of winter wheat and barley, especially against the background of the use of Ecostern Classic stubble biodestroyer, ensured an increase in the content of plant nutrients in the soil, especially when plowing was used as the main tillage.

CONCLUSIONS

On the basis of three-year data, it can be concluded that the treatment of post-harvest residues of winter wheat and winter barley with a biodestructor ensured an increase in the content of nutrients in the soil. So, on average, over the years of research, during the processing of post-harvest remains of winter wheat, the content of nitrates in the 0-30 cm soil layer increased by 40.6-44.2%, mobile phosphorus – by 7.6-11.9%, and exchangeable potassium – by 14.2-20.2% compared to their initial value. Treatment of winter wheat stubble with only water provided lower indicators. Thus, depending on the method of the main tillage, the content of nitrates in the 0-30 cm bent layer compared to the option of using a biodestructor was lower by 15.0-19.8%, mobile phosphorus by 6.0-6.9%, exchangeable potassium by by 9.3-10.2%.

The use of Ecostern Classic stubble biodestructor contributed to better mineralization of plant residues of winter barley. So, depending on the variant of the method of basic soil cultivation, 9.1-10.5 mg/kg of soil nitrates, 48.7-51.5 mg/kg of mobile phosphorus and 225.3-251.0 mg/kg of exchangeable potassium soil, which exceeded the indicators of processing crop residues with water alone by 14.3-20.0; 2.5-4.1 and 3.3-10.4%, respectively.

Studies have established a positive influence of the method of main tillage on the nutritional regime already from the initial stage of decomposition of post-harvest residues. The soil with the use of plowing was characterized by the best indicators. Thus, in an experiment with the treatment of post-harvest residues of winter wheat with a biopreparation, the content of nitrates increased by 8.6%, mobile phosphorus by 4.2%, and exchangeable potassium by 6.8% compared to the option of no-till tillage, and winter barley, respectively by 10.5; 4.8 and 6.9%.

Practical aspects and conclusions of our research can be used by agricultural producers to improve soil fertility indicators, in particular, to increase the content of plant nutrients in it. It should be noted that the topic of the scientific article requires further research, taking into account modern stubble biodestructors and their processing of post-harvest residues not only of winter wheat, but also of other agricultural crops.

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Вплив біодеструктора стерні та способу основного обробітку на поживний режим ґрунту

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Анотація. Щорічно в Україні відбувається зниження показників родючості ґрунтів. Тому, для забезпечення бездефіцитного балансу ґрунту необхідно залучати додаткові резерви органічної сировини, зокрема післяжнивні рештки сільськогосподарських культур, а для їх деструктиризації використовувати біопрепарати. На сьогодні ще не зовсім повно вивчено дію біодеструторів стерні на процеси мінералізації післяжнивних решток рослин, особливо за різних способів основного обробітку ґрунту, тому метою нашого дослідження було визначити вплив деструктора Екостерн Класичний та способу основного обробітку ґрунту на його поживний режим в умовах півдня України. Методи досліджень: польовий, лабораторний. Дослідженнями встановлено кількість нітратів, рухомого фосфору та обмінного калію, що залишилася в середньому за роки досліджень у ґрунті дослідної ділянки після збирання пшениці озимої склала відповідно 6,3; 47,5 та 208,8 мг/кг ґрунту, а після збирання ячменю озимого – 5,9; 42,8 та 202,4 мг/кг ґрунту. Після часткової мінералізації рослинних решток озимих культур, за три місяці, вміст елементів живлення у ґрунті зростав, особливо за обробки біодеструктором Екостерн Класичний. Визначено, що застосування оранки сприяло пришвидшенню мінералізації рослинних решток пшениці озимої та більшому нагромадженню у ґрунті елементів живлення. Так, за обробки післяжнивних решток пшениці озимої біодеструктором за використання оранки у ґрунті було визначено 11,3 мг/кг ґрунту нітратів, 53,9 мг/кг ґрунту рухомого фосфору та 261,8 мг/кг ґрунту – обмінного калію. За обробки післяжнивних решток ячменю озимого показники були дещо меншими – відповідно 10,5; 51,5 та 251,0 мг/кг ґрунту. Практична цінність досліджень полягає у вдосконаленні процесів, пов'язаних із підвищенням родючості ґрунтів півдня України за рахунок значно раціональнішого використання післяжнивних решток пшениці та ячменю озимих форм

Ключові слова: післяжнивні рештки, деструктиризація, оранка, безполицевий обробіток ґрунту, родючість ґрунту, елементи живлення