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INFLUENCE OF BIODESTRUCTOR ON DECOMPOSITION OF CROP RESIDUES AND HUMUS CONDITION OF TYPICAL CHERNOZEM

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Abstract

The study examined the composting of agricultural plant residues during the summer period of 2021 in typical chernozem soil. The mass of plant residues decreased during composting, with the use of a destructor resulting in a greater loss of plant material. Different rates of decomposition were observed for residues of different crops, and surface residues generally decomposed more rapidly than root residues. Changes in total humus content were also observed, with an increase in the humus content during composting of wheat and barley residues without a destructor. However, most variants with a destructor showed negative changes in the content of total humus. The study found that humification processes took place only in the version with winter wheat and spring barley, and the use of a destructor led to a decrease in the intensity of humification processes or to the passage of dehumification processes. Overall, the study highlights the importance of considering the impact of crop residues and the use of a destructor on soil quality and nutrient cycling.

Key words*: typical chernozem, crop residues, stubble destructor, winter wheat, spring barley, maize, sunflower.*

INTRODUCTION

Organic matter and the processes of its transformation play a significant role in the formation of soil, its most important properties and features. Thus, organic matter participates in the nutrition of plants, creates favorable water and physical indicators of the soil, promotes the migration of elements in the soil and the biosphere.

Potential sources of organic matter in the soil are aerial and root remains of woody and herbaceous plants, biomass of invertebrates and microorganisms. The biomass of green plants (phytomass) and its annual increase (primary production) is several dozen, or even hundreds of times higher than the biomass of invertebrates and microorganisms (Tomashivskyi et al., 2020).

Above-ground and below-ground phytomass of groups depends on their composition, biological features of the dominant, meteorological conditions and rockiness of the substrate. On the example of the "Steppe Tract" plant group, the highest values of above-ground and underground mass are 330.0-735.0 and 1025.0-1310.0 g/m^2, respectively (Shevchuk, 2019). According to the data, the average accumulation of raw and dry above-ground mass of winter wheat varies from 3644 g/m^2 to 5900 g/m^2 for raw mass and from 1500 g/m^2 to 2200 g/m^2 for dry above-ground mass (Lytovchenko, 2015).

Preservation of plant remains helps to enrich the chemical composition of the soil with organic matter, in contrast to their traditional burning, and serves to feed and activate the activity of biota. The most active role in this is played by microorganisms capable of producing enzymes that destroy lignin, cellulose, fiber, and proteins of plant residues (Kovalenko, 2021). In addition, microorganisms actively convert soil minerals into soluble form: phosphorus, magnesium, calcium, sulfur, iron, boron, molybdenum, zinc, etc. Along with the processes of decomposition of organic residues in the soil, the process of synthesis of humic substances takes place.

The action of destructors is aimed at accelerated decomposition of plant residues and their transformation into humus substances, that is, at improving soil fertility and, as a result, increasing the yield of cultivated crops (Sidyakina, 2021; Korsun et al., 2017; Serhiieva, 2017; Kovalenko, 2022).

The analysis of publications allows us to state that in the experiments using stubble destructors, either microbiological processes during the introduction of destructor drugs, or its effect on the yield of the next crop are largely investigated, while not paying attention to the humus condition of the soil.

Given the critical scale of human impact on soils, today approximately 33% of global soil resources are degraded. Dehumification ranks first among soil degradation phenomena. Loss of humus by soils causes deterioration of their physical properties, reduction of nutrient content, intensification of erosion processes, etc. And therefore, soils lose their fertility. Therefore, the topic chosen by us to study the processes of humification of agricultural crop residues in the modern conditions of the introduction of agriculture using a stubble destructor is relevant in terms of developing directions for restoring the content of humus in arable soils.

MATERIALS AND METHODS

The research was conducted on the territory of the state enterprise of educational and research farm "Dokuchaevske" within the training, research and production center "Experimental Field" of State Biotechnological University. The soil was used for research: chernozem typical heavy loam on loess-like loam. Plant raw materials - surface post-harvest remains of winter wheat, corn, sunflower, barley.

Soil samples of typical chernozem were taken from the arable layer with a depth of 0-30 cm.

Dry matter and moisture by weight were determined. Gravimetric method. Soil samples are dried to constant weight at (105 ± 5) °C.

Determination of total humus by the Turin method. The method is based on the oxidation of soil organic matter by a solution of potassium dichromate in sulfuric acid, followed by determination of organic carbon content through the determination of potassium dichromate after oxidation by titrometry.

Calculation and preparation of plant material and soil for composting was performed according to the method of Chesnyak. Plant residues are selected a week before harvest. The rests are selected manually, the crop rests are crushed to the size of 0.5 cm and in a shade bring to an air-dry condition. The weight of the soil in terms of a completely dry sample for each repetition is equal to 100 g. The selected general soil sample to grind it better with plant residues is ground, sifted through a sieve and visible plant remains are selected. Two days before the start of the experiment in the general soil sample determine the moisture content and the content of total humus.

After the preparation of plant material and soil, each sample was placed in a kapron bag, the volume of which corresponds to the volume of the soil (6*10 cm). The samples are at a depth of 14-16 cm in the arable layer of the soil. To determine the influence of the stubble destructor on the humification of agricultural crop residues, the prepared soil and plant material were treated with the "Ekostern" stubble destructor, produced by "BTU-Center", according to the recommendations: corn, sunflower - 1.2-2.0 l/ha, cereals - 1.0-1.5 l/ha.

In field conditions "composting" of plant samples with soil was carried out in the summer of 2021 for 3 months - June, July, August at a depth of 15 cm.

RESULTS AND DISCUSSIONS

In the territory where the research was conducted, the weather conditions according to the average multi-year data collected at the weather station of the KhNAU (Obraztsova, 2001) are characterized as follows (Table 1): the average multi-year precipitation is 529 mm, according to the average multi-year data of the same weather station, the wettest month is July with 71 mm of precipitation. The amount of precipitation in June and August, according to consolidated long-term data, is slightly lower and amounts to 59 mm and 56 mm, respectively. The average annual temperature is +7.2°C. July is the warmest with a temperature of +20.5°C, the air temperature in June reaches a mark of +19.2°C, and in August the temperature drops to +19.6°C.

Table 1. The long-term average data for monthly air temperature and precipitation levels according to the KhNAU weather station data

Month	VI	VII	VIII	Annual
Average air temperature, °C	19.2	20.5	19.6	7.2
Amount of precipitation, mm	59	71	56	529

In the year of the study (Table 2), in comparison with long-term data, an increase in the average monthly temperature is observed in each of the months. Thus, in June, the average air temperature was higher than the long-term data by 1.6°C and amounted to +20.8°C. July was 4.6°C warmer compared to long-term data, the average monthly temperature in 2021 reached +25.1°C. The largest temperature difference compared to long-term data was observed in August, so in 2021 the air temperature reached +24.7°C, which is 5.1°C more than the average long-term observations. The distribution of precipitation in the summer months of 2021 was as follows: in June, the amount of precipitation was 82 mm, which is 23 mm more than the average of long-term observations. In July, in comparison with long-term data, a slight decrease in the amount of precipitation to 65 mm was found. A significant difference between the average multi-year data and the data of 2021 was found in the month of August, the amount of precipitation decreased by 44 mm to 12 mm (Table 2).

Table 2. The average monthly air temperature and precipitation levels in 2021 according to the KhNAU weather station data

Month	VI	VII	VIII	Annual
Average air temperature, °C	20.8	25.1	24.7	9.6
Amount of precipitation, mm	82	65	12	520

All in all in 2021, the monthly temperature increased compared to long-term data, particularly in August, and there was less precipitation in August than the long-term average.

The amount of plant material laid down for composting and the content of total humus in typical chernozem before the start of the experiment are given in the Table 3.

Table 3. The content of general humus in chernozem typical and the mass of plant material when setting up the experiment

Agricultural crop	The content of total humus in the soil, %	Mass of plant material, g	
		surface plant residues	root residues
Winter Wheat	5.8	8.52	8.52
Spring Barley	5.8	7.94	7.94
Sunflower	5.9	9.19	9.19
Maize	5.7	8.28	8.28

The highest content of total humus before laying the experiment was recorded in the sunflower variant at 5.9%. The content of total humus in the soil of other variants did not exceed 6%. The lowest humus content was found in the corn variant at 5.7%.

During three summer months of composting with winter wheat, the following changes occurred: the content of total humus in the variant ranged from 6.4% to 6.6%. The highest amount of humus was found in the variant with the addition of surface plant residues without the use of a stubble destructor, at 6.6%. The lowest amount of humus, 6.4%, was observed when using the stubble destructor with both surface and root crop residues. The largest increase in newly formed humus in this variant was 0.8% (Figure 1).

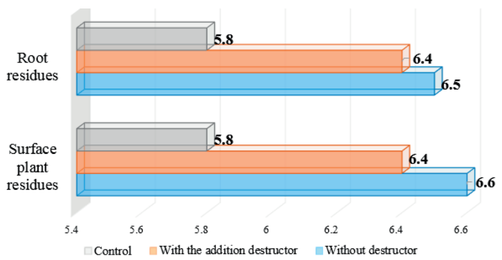

Figure 1. Content of total humus in the version with winter wheat

The variation in mass fluctuation of plant residues with winter wheat was distributed as follows over the same period of time: a uniform decrease in mass was observed in the variant without adding the destructor, while the average decrease for both types of plant residue input was 3.0 g. When adding the destructor, there was an uneven manifestation of plant material reduction, with the mass of root plant residues decreasing by half to 4.26 g, which was slightly more than 1 g less than the previous variant. In the variant with the adding of the stubble destructor, there is an uncharacteristic effect of weakening the transformation of the stubble in comparison with a similar option, but without the adding of the stubble destructor. The mass of this variant was smaller than the control by 1.69 g and larger than the variant without adding the destructor by 1.33 g (Figure 2).

In the variant with spring barley, the following situation was observed. When root residues were added without adding the destructor, the increase in newly formed humus was 0.6%, whereas in the variant where the destructor was implemented, the amount of total humus decreased by 0.7% to a value of 5.1%, indicating the prevalence of the mineralization process over humification (Figure 3).

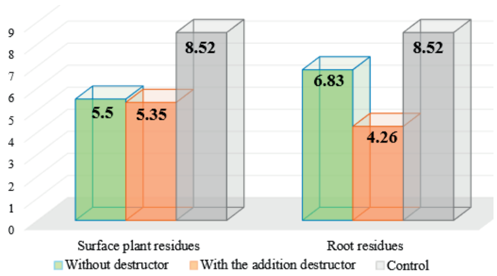

Figure 2. Change in the weight of surface and root residues in the version with winter wheat

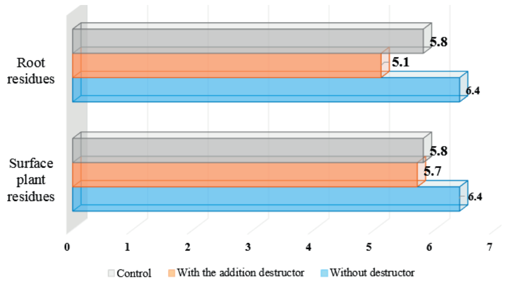

Figure 3. Total humus content in the variant with spring barley

From the presented diagram, we can see that in the variant with spring barley and addition of straw destructor, the weight loss was 2.55 g for surface harvest residues and 2.53 g for root residues (Figure 4). In contrast, in the variant without straw destructor, the weight loss was 0.85 g for surface harvest residues, which is 1.70 g less than in the corresponding variant with straw destructor. The weight loss for root residues without the addition of straw destructor was 0.87 g.

Regardless of the experimental variant, a decrease in the total humus content was observed by 0.4% compared to the control after 90 days of composting.

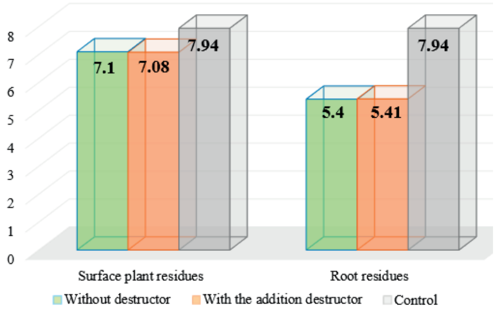

Figure 4. Change in the weight of harvest residues in the variant with spring barley

The total humus content decreased to 5.3%. Therefore, we can assume that despite the introduction of plant residues, mineralization processes prevailed over humification processes, leading to a decrease in humus content in the typical chernozem arable layer (Figure 5).

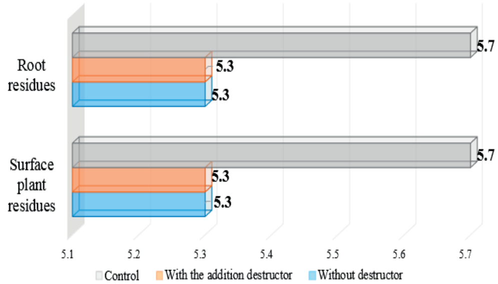

Figure 5. Content of total humus in the version with maize

In the version with maize, a trend similar to the version with barley can be traced after 90 days of composting. Thus, with the addition of a stubble destructor, the weight decreases by 2.68 g and amounts to 5.60 g with the addition of surface root residues, and with the addition of roots, the weight decreases to 5.01 g, i.e., it decreases by 3.27 g. Without the addition of the stubble destructor with the introduction of surface harvest residues of corn, the weight decreases to 7.33 g, which is 0.95 g less than the control, and with the introduction of root harvest residues of corn, the weight decreases by 1.41 g to 6.87 g (Figure 6).

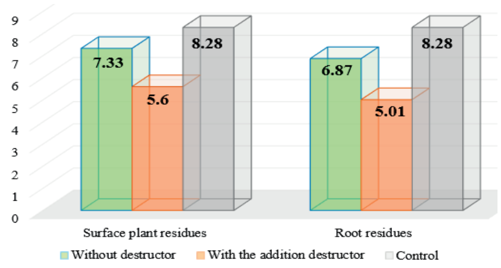

Figure 6. Change in the weight of plant material in the version with maize

The overall humus content in the variant with sunflower underwent the following changes after 90 days of summer composting. Only in the variant with the addition of surface plant residues without the addition of straw destructor, there was an increase in newly formed humus, but not significantly - by 0.1%. The opposite situation occurred when adding straw destructor and when adding root harvest residues, in this variant, there was a decrease in overall humus by 0.1%. Therefore, we can say that the processes of mineralization-synthesis in this variant were in balance (Figure 7).

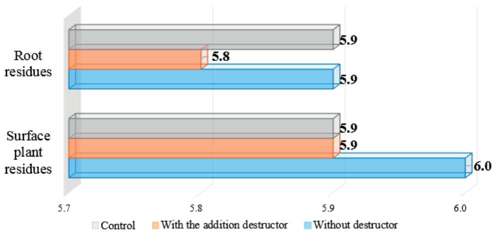

Figure 7. The content of total humus in the version with sunflower

Moreover, the change in the weight of the residues during this period of time according to the options is not of a similar nature. For example, in the variant with the application of surface residues, the weight differs as follows: with the addition of the destructor, it decreased by 4.24 g compared to the control, and without its action, by 2.73 g. Therefore, we can conclude that the action of the destructor accelerated the processes of conversion of plant mass. When comparing the experiment variants with the addition of root residues, we see the following: the decrease in weight due to the action of the destructor exceeds the same variant without its application by 0.54 g and amounts to 6.85 g (Figure 8).

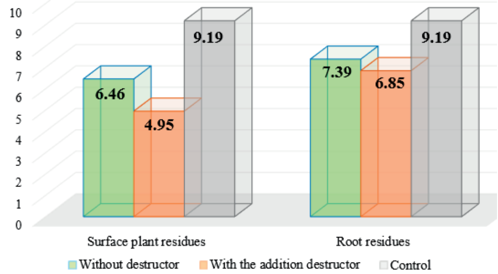

Figure 8. Weight change in the version with sunflower

So, the majority of plant material, whether above-ground or root mass, decomposes on average one and a half times faster under the action of the destructor. However, this does not necessarily mean that when plant residues decompose in this way, they will necessarily be fixed as newly formed humus.

CONCLUSIONS

During the composting of plant residues in chernozem typical agrocenosis, which lasted during the summer period of 2021, there was a change in the mass of both root and surface residues of grain and industrial crops.

In the control variant without a destructor, the smallest decomposition of plant material on average is observed in variants with corn residues, at around 17%. Taking into account the decomposition of surface and root residues, it is found that in variants with wheat and sunflower, the decomposition of surface residues occurs more intensively than the decomposition of root residues. The weight loss of surface residues is 30-35% compared to 20% for root residues. Depending on their morphological affiliation, the residues of barley and corn also had different rates of decomposition. In this case, the intensity of decomposition of root residues (loss of 21-47%) prevails over the intensity of decomposition of surface residues (loss of 12-13%). The most intensive weight loss among surface residues was observed for winter wheat residues, and among root residues - for barley.

When using a destructor, a greater loss of plant material is observed during the summer composting period, and only in the variant with barley does the loss of plant material mass equal or is less than that of the control. The residues of winter wheat decomposed most intensively, with an average weight loss of plant material of around 43%. In most variants, under the action of the destructor, root residues underwent greater decomposition. In the variant with sunflower, the intensity of decomposition of surface residues was almost twice as high as that of root residues. The loss of plant material for corn root residues was 39% and for surface residues was 32%. Surface residues of sunflower and root residues of winter wheat were most intensively transformed.

During the composting of agricultural plant residues in typical chernozem soil during June-August 2021, changes in the total humus content were observed.

In the variants without the addition of a destructor, an increase in the total humus content was found during the composting of wheat and barley residues. In the variant with winter wheat, the composting of surface residues resulted in a 14% increase in humus content, while for root residues, it was a 12% increase. Composting barley residues led to a 17% increase in humus content, regardless of the morphological features of the residues. Composting of technical crops residues did not result in an increase in the humus content of typical chernozem soil. In the variant with sunflower, no changes in the total humus content were detected, while in the variant with maize, a process of humus loss was observed - by 7%.

When using the destructor of crop residues, most of the variants showed negative changes in the content of total humus. In the variant with spring barley, no change in humus content was detected when composting surface residues, but with root residues, the humus content decreased by 12%. In the variant with sunflower, the humus content remained unchanged. The incorporation of corn residues into the soil with the use of the destructor, as well as in the control variant, led to a decrease in the content of total humus by 7%. Only in the variant with winter wheat did the humus increase, with an increase of 10% for both surface and root residues.

So, in the conditions of the summer period of 2021, the composting of the remains of agricultural plants (winter wheat, spring barley, sunflower, corn) in the arable layer of 0-30 cm of typical chernozem led to a decrease in their mass, and the mass of the remains was lost more intensively under the conditions of using a stubble destructor. It was found that humification processes took place only in the version with winter wheat and spring barley. Moreover, the use of a stubble destructor led either to a decrease in the intensity of humification processes, or to the passage of dehumification processes.

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