Improving the efficiency of using straw as a fertilizer

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Abstract. The article discusses the results of investigations carried out within the framework of the research project commissioned by the Ministry of Agriculture of the Russian Federation in 2020. In August 2019, a field experiment was laid for the disposal of straw of spring barley of Vladimir variety using a special machine for this, i.e. a unit for utilizing the non-grain part of the crop as a fertilizer. When disposing straw, it was processed with biopreparations-destructors: Agrinos-1 (2 l/ha), Sternifag SP (0.08 kg/ha), Biocomplex BTU (1 l/ha), humic product Ekorost (0.4 l/ha). The straw was crushed and embedded in the soil on the control plot without treatment with biological preparations. It was found that the process of straw decomposition is more intensive compared to that of 2018-2019 on average by 5 %. The variants with Agrinos 1 and Sternifag SP treatment showed better results and accelerated the degradation process by 20 % compared to the control. The biological productivity of spring oats of Skakun variety showed that all studied biological products had a positive effect on the increase in yield. The best indicators were achieved on the variants with Agrinos-1 and Sternifag SP equal to 48.9 dt/ha and 45.4 dt/ha, respectively (the control was 36.4 dt/ha).

1. Introduction

The annual growth of the world's population poses a global challenge to agrarians around the world and this is food provision. Provided that the reserves for expanding agricultural areas are limited, the load per hectare of arable land grows, since more and more crops need to be harvested from this area with each new season. It is known that when the crop is formed, nutrients are removed from the soil, which must be compensated [1]. So, for example, in the production of cereals, the resulting biological crop consists of both the main product or grain and the by-product or a non-cereal part (straw, chaff, husk), while, in terms of the organic matter content, one ton of straw is equivalent to 3.5-4 tons of manure [1–10].

The only limiting factor in the use of straw as a fertilizer is the long period of its decomposition in the soil, which occurs with the release of phototoxic compounds, which negatively affects the yield of subsequent crops [3–5]. Currently, scientific and practical interest is a way to increase the efficiency of using straw as a fertilizer by treating straw with biological biopreparations-destructors before embedding in the soil [1, 8].

Within the framework of this article, the results of studies on the utilization of spring barley straw as a fertilizer using various biological biopreparations-destructors are presented.

2. Materials and methods

The research was carried out on the experimental field of the URC "Agrotekhnopark" of Ryazan State Agrotechnological University in Ryazan district of Ryazan region. In August 2019, straw of spring
barley of Vladimir variety for forage purposes was utilized. Harvester-thresher Acros 595 Plus harvested the entire crop, while the non-grain part was placed behind in the swath (the straw chopper was off). Straw from the swath was picked up by a special machine or an aggregate for utilizing the non-grain part of the crop as a fertilizer (MTZ-82 + ADU NCHU based on Kverneland fx 230 (Figure 1)) [1]. Then the straw was crushed and treated with biopreparations-destructors: Agrinos-1 (2 l/ha, USA), Sternifag SP (0.08 kg/ha, Russia), Biocomplex BTU (1 l/ha, Ukraine), humic product Ekorost (0.4 l/ha, Russia). The treating was carried out differentially, depending on the volume of the incoming plant mass, which was determined automatically by the scanning device of the machine. The embedment of straw, chopped and treated with biopreparations-destructors, was to a depth of 0.1 m using a heavy disc harrow in two tracks. In the control plot, the straw was crushed and embedded in the soil without any treatment with biopreparations-destructors.

Figure 1. The unit for utilization of non-grain part of the crop (AdU NCHU) as a fertilizer MTZ-82 + AdU NCHU based on Kverneland fx 230 and its place in straw utilization technology

In April 2020, spring oats of Skakun variety Elita were sown on the experimental field.

The cellulose activity of the soil was determined by the application method. In March 2020, soil samples were taken from each experimental site and a comprehensive chemical analysis was carried out, which included determining acidity (pH value), potassium oxide, phosphorus (V) oxide, nitric acid salts containing a singly charged anion, organic matter.

For the entire period of the experiment (August 2019 - September 2020), the daily mean ambient temperature and precipitation depth were recorded. The data obtained were compared with the average for the entire observation period.

The biological yield was determined by the method of taking four samples (sheaves) using a frame with an area of 0.5 m² along the diagonal of each experimental plot, through equal segments. In each
selected sheaf, the number of all and productive stems was counted. 25 productive stems were selected from each sheaf and the number and weight of grains in each panicle were counted. Crop quality was assessed by dry matter content and crude protein content.

3. Results
Table 1 shows the results of a comprehensive chemical analysis of soil according to the variants of the experiment. Figure 2 shows a graph of the cellulosic activity of the soil as a change in the weight of linen sheets as a percentage of the initial one. Table 2 shows the parameters of yield and quality of the resulting grain of spring oats (Skakun variety).

Table 1. Results of chemical analysis of soil by variants (samples were taken on March 18, 2020)

| Parameter                          | Variant       | Control | Agrinos-1 | Sternifag SP | Ekorost | Biocomplex BTU |
|------------------------------------|---------------|---------|-----------|--------------|---------|----------------|
| acidity (pH)                       |               | 5.2     | 5.2       | 5.0          | 4.8     | 4.9            |
| potassium oxide, mg/kg of soil     |               | 127     | 163       | 141          | 128     | 132            |
| phosphorus (V) oxide, mg/kg of soil|               | 154     | 188       | 157          | 153     | 138            |
| nitric acid salts containing a singly charged anion, mg/kg of soil | | 8.81 | 11.91 | 9.36 | 16.62 | 11.58 |
| organic matter, %                  |               | 2.53    | 2.75      | 2.66         | 2.85    | 2.92           |

Figure 2. Graph of cellulosic activity of the soil in the form of changes in the mass of linen sheets as a percentage of the initial one

Table 2. Parameters of yield and quality of the obtained grain (oats Skakun variety), 2020

| Preparation       | Parameter     | Yield, dt/ha | Dry matter, % | Crude protein, % |
|-------------------|---------------|--------------|---------------|------------------|
| Control           |               | 36.4         | 11.89         | 9.88             |
| Agrinos-1         |               | 48.9         | 11.98         | 12.19            |
| Sternifag SP      |               | 45.4         | 11.87         | 10.88            |
| Ekorost           |               | 39.9         | 11.82         | 10.52            |
| Biocomplex BTU    |               | 40.2         | 11.86         | 11.25            |
The unit for utilizing the non-grain part of the crop when harvesting in September 2020 showed an operating speed of 7-8 km/h with an hourly efficiency of 5-5.5 ha/h. The stock of the working stroke in terms of the technological volume was 3,000 meters, so with an average run length of 400 meters, it allowed up to 6-7 working strokes. The working pressure varied in the range of 0.18-0.34 MPa.

4. Discussion
The use of biopreparations-destructors made it possible to increase the efficiency of using straw as a fertilizer, as it accelerated the process of its decomposition. In variants where plant residues decomposed more intensively, subsequent plants developed better, which was reflected in high yield as compared to the control.

The experiment proved the results of the experiment of 2018-2019 [1] with the efficiency of biopreparations-destructors Agrinos-1 and Sternifag SP at negative temperatures, while the variants with the treatment with Biocomplex BTU and Ekorost decreased their intensity.

Straw decomposition was more intensive as compared to that of 2018-2019 [1] that might indicate a positive cumulative effect when using plant residues for several years.

5. Conclusion
As a result of the studies, the high efficiency of biopreparations-destructors Agrinos-1 and Sternifag SP was established, and their effective work in winter was confirmed. So, the decomposition rate of straw increased by an average of 17-20%; that was 3-5% more intensive than that of the previous year.

The combination of spring barley straw with biopreparations-destructors contributed to an increase in the yield of spring oats by an average of 8.43 dt/ha (18.8%).

The unit for utilizing the non-grain part of the crop as a fertilizer demonstrated its reliable operation and ensured the assimilation of the working solution by the crushed plant mass for more than 90%.

Thus, one can conclude that the use of biopreparations-destructors can increase the efficiency of using straw as a fertilizer. Of the considered biopreparations-destructors, it is recommended to use Agrinos-1 (2 l/ha) and Sternifag SP (0.08 kg/ha).

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