Use of stubble's biodestructor for soil fertility improvement and environment protection

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Abstract – The article presents the results of researches on the effect of treatment of crop residues of spring barley and peas by stubble Biodestructor (PE "BTU-center", Ukraine) on the content of nutrients in the soil and microbiological soil activity. The conducted work allowed to assess the impact of the biopreparation on soil fertility and environmental protection.

Keywords – stubble biodestructor, crop residues of peas and spring barley, the content of nutrients in the soil, microbiological soil activity.

Introduction

Modern agricultural production has a significant anthropogenic influence on ecosystems, which substantially shifts the natural equilibrium and changes the ratio between the biota in them, and sometimes radically transforms existing natural ecosystems into new, artificial ones. It is known that in order to support agrophytocenoses in economically valuable condition, to improve its productivity, a person applies a number of agrotechnical measures which are aimed at its preservation. Intensification of agricultural production leads to the fact that the pressure on the natural components of artificial agroecosystems (soils, water resources, etc.) increases annually. In many cases, the ignorance of elementary norms and rules of economic activity by man results in natural disasters and environmental disasters [1]. The soil, as a component of biogeocoenosis, is influenced by different time, intensity, scale of anthropogenic loading, which, in turn, violates the normal course of soil processes, all that leads to significant changes in the functioning of the microbial group [2, 3].

Reproduction of soil fertility while improving the safety of the environment and crop production is an urgent task of agricultural production. For reducing the use of resources of industrial origin, while maintaining soil fertility, it would be advisable to use plant residues in agricultural technologies, which, in conditions of a limited amount of organic fertilizers, are one of the main sources of replenishment of soils with organic matter [4, 5].

For improving the processes of decomposition of post-harvest crop residues, the nutrient regime of the soil and its microbiological activity, it would be advisable to use stubble biodestructors. Taking into account the variety of data available in the professional scientific literature on the biological activity of the soil depending on agrotechnical factors affecting it, we decided to investigate its microbiological activity depending on the processing of crop residues of peas and barley spring by the stubble biodestructor.

Materials & Methods

Experimental studies were conducted during 2011-2015yrs on the experimental field of the Mykolaiv NAU. After harvesting spring barley and peas, crop residues were treated with thebiodestructor (PE "BTU-center", Ukraine) at a dose of 2 liters of biopreparation with the addition of 3.0 kg of ammonium nitrate and the flow rate of the working solution of 300 liters per 1 ha, after which the crop residues were disked by the heavy disk harrow BDT-7 to a depth of 10-12 cm.

For determining the content of mobile forms of nitrogen, phosphorus and potassium in the soil layer of 0-30 cm the soil samples were taken before the treatment of crop residues by the biodestructor and three months after that, when their partial mineralization had already occurred. Soil samples for determining the total bacterization, the number of micromycetes and nitrogen-fixing bacteria in the soil layer of 0-20 cm. Research and accounting was carried out according to generally accepted methods and state standards.

Results

Studies found that, on average, over the years of research, before the processing of crop residues of spring barley and peas, the nitrate content in the soil layer 0 - 30 cm ranged from 7.9 up to 9.8 mg/kg of soil, mobile phosphorus ranged from 49.5 up to 50.3 mg/kg of soil, and exchangeable potassium ranged from 214 up to 254, mg/kg of soil (table 1).

Table 1

Influence of stubble biodestructor on NPK content in 0 – 30 cm soil layer, mg/kg soil (average for 2011 – 2015yrs)

Preceding crop	Treatment of crop residues by biodestructor	Content, мg/kg soil		
		NO_3^-	P_2O	K_2O
Spring barley	before the treatment of crop residues	7.9	49.5	214.0
	treatment by water	9.7	50.6	224.0
	treatment by biopreparation	12.6	53.8	253.0
Peas	before the treatment of crop residues	9.8	50.3	254.0
	treatment by water	12.2	57.0	269.0
	treatment by biopreparation	13.8	61.3	287.0

On average, over the years of research, after harvesting peas, compared with spring barley, the nitratesin the soil remained larger by 1.9 mg/kg of soil or 19.4%, the mobile phosphorusthe 0.8 mg/kg of soil or 1.6%,the exchangeable potassiumin the soil remained larger by 40 mg/kg of soil or 15.7%.

According to the treatment of crop residues of spring barley and peas by stubble Biodestructor together with 3.0 kg of ammonium nitrate, the content of mobile macronutrients in the soil increased significantly. Thus, on average for precursor crops, the studied factor provided an increase in the content of nitrates in the soil by 4.3 mg/kg of soil or 32.6%, the content ofmobile phosphorus in the soilby 7.7 mg/kg of soil or 13.4%, and the content ofexchangeable potassium in the soil by 36.0 mg/kg of soil or 13.3% compared with the initial values (before the treatment of crop residues).

The number of soil microflora is subject to significant fluctuations depending on the type of soil, moisture supply of the vegetation period, the method of basic tillage, the selection of crops and the order of their alternation in crop rotation. In our studies, a comparative analysis of the quantitative characteristics of the microbial grouping of soil samples before processing of crop residues by the stubble biodestructor determined that the number of bacteria and microscopic fungi in soil samples varied depending on the precursor culture (table 2).

Table 2

Influence of stubble biodestructor on microbiological soil activity, PCs/1 g of soil (average for 2011 – 2015 yrs)

Preceding crop	Treatment of crop residues by biodestructor	Total number of bacteria		Total number of micromycetes		Nitrogen fixators	
		soil layer, cm					
		0-10	10-20	0-10	10-20	0-10	10-20
Spring barley	before the treatment of crop residues	$3,5 \cdot 10^7$	$2,6 \cdot 10^7$	$3,3 \cdot 10^5$	$2,7 \cdot 10^5$	$8,9 \cdot 10^6$	$8,3 \cdot 10^6$
	treatment by water	$9,1 \cdot 10^7$	$8,0 \cdot 10^7$	$4,6 \cdot 10^5$	$4,0 \cdot 10^5$	$24,9 \cdot 10^6$	$21,8 \cdot 10^6$
	treatment by biopreparation	$10,7 \cdot 10^7$	$9,9 \cdot 10^7$	$5,4 \cdot 10^5$	$4,8 \cdot 10^5$	$38,3 \cdot 10^6$	$35,8 \cdot 10^6$
Peas	before the treatment of crop residues	$5,3 \cdot 10^7$	$4,8 \cdot 10^7$	$1,7 \cdot 10^5$	$1,4 \cdot 10^5$	$14,2 \cdot 10^6$	$13,8 \cdot 10^6$
	treatment by water	$11,2 \cdot 10^7$	$10,4 \cdot 10^7$	$3,0 \cdot 10^5$	$2,5 \cdot 10^5$	$32,5 \cdot 10^6$	$30,7 \cdot 10^6$
	treatment by biopreparation	$13,0 \cdot 10^7$	$12,0 \cdot 10^7$	$3,5 \cdot 10^5$	$2,9 \cdot 10^5$	$46,6 \cdot 10^6$	$44,9 \cdot 10^6$

The results of microbiological analysis of the soil before treatment of crop residues by the stubble biodestructor indicate that the total number of bacteria in the studied soil layers is determined slightly less after growing spring barley and in the soil layer 0 - 10 cm it was $3.5 \cdot 10^7$ PCs/1 g of soil, and in the layer 10 - 20 cm it was $2.6 \cdot 10^7$ PCs/1 g of soil.

After harvesting peas in the soil layer 0 – 10 cm, there were $5.3 \cdot 10^7$ PCs./1 g of soil bacteria, and in the layer 10 – 20 cm there were $4.8 \cdot 10^7$ PCs./ 1 g soil, respectively, it was more by $1.8 \cdot 10^7$ and $2.2 \cdot 10^7$ PCs./1 g soil than the content of samples after growing spring barley.

The total number of micromycetes, on the contrary, is more determined in the soil after growing spring barley as $2.7 \cdot 10^5$ up to $3.3 \cdot 10^5$ PCs/1 g of soil depending on the investigated layer. At the same time, the share of pathogens accounted for 62.9 up to 63.3%.

The treatment of crop residues by the stubble biodestructor, on average for precursor cultures led to an increase in the total number of bacteria in the soil by $7.3 \cdot 10^7$ up to $7.5 \cdot 10^7$ PCs/1 g of soil or 63.0 up to 66.4% depending on the studied layer. At the same time, it should be noted that in areas without the use of a biopreparation, and for the treatment of post-harvest residues with water, the total number of bacterial microflora also increased slightly compared to their initial number, but this occurred to a lesser extent as $9.2 \cdot 10^7$ up to $10.2 \cdot 10^7$ PCs/1 g of soil, which was more by $5.5 \cdot 10^7$ up to $5.8 \cdot 10^7$ PCs/1 g of soil or 56.9 up to 59.8% depending on the soil layer.

The number of micromycetes under the action of the stubble biodestructor also increased slightly compared with the definition of them before the treatment of crop residues – on average over the years of research and for precursor cultures it increased by 44.4% in the soil layer 0 – 10 cm, and it increased by 46.2% in the soil layer 10 – 20 cm. At the same time, for the treatment of residues only with water (in terms of natural decomposition), the number of microscopic fungi in the soil layer 0 – 10 cm increased by 34.2%, and 10 – 20 cm it increased by 36.4%. Studies also determined that the use of the stubble biodestructor led to a certain reduction in the proportion of pathogenic fungi in the soil, regardless of the precursor culture.

It should be noted that the studied factors had an impact on the quantitative characteristics of microscopic pathogenic fungi. So, on average, over the years of research, regardless of the treatment of crop residues, several more pathogenic fungi were determined after incorporation into the soil of the residues of spring barley as $2.8 \cdot 10^5$ up to $3.2 \cdot 10^5$ and it were determined $2.3 \cdot 10^5$ up to $2.6 \cdot 10^5$ PCs/1 g of soil depending on the soil layer. At the same time, the use of the stubble biodestructor reduced this indicator by 11.5 up to 12.5% compared to the treatment of post-harvest residues with water. The increase in the amount of micromycetes in the soil may be evidence of its increase in total toxicity, which in turn may be a consequence of violations of the alternation of crops in crop rotation, unjustified amount of mineral fertilizers, etc.

The cultivation of leguminous crops, in particular peas, contributed to a decrease in the number of pathogenic fungal microflora compared with the variants for growing of spring barley, which can be explained by the biological characteristics of peas, based on the ability of plants to symbiotic activity with soil microorganisms, natural fixation of molecular nitrogen, and as a consequence, natural enrichment of soil with nutrients for plants and improvement of its fertility in general.

The issue of optimal agrocenosis supply with nitrogen is closely related to the microbiological fixation of this element from the air. Intensification of the process of nitrogen fixation in agrocenoses becomes possible under the condition of legumes growing and application of nitrogen-fixing microorganisms the functioning of which is an important factor in increasing soil fertility. In addition, nitrogen fixation is the only way to provide plants with biological nitrogen, which does not violate the eco-logical balance in the environment.

In our studies, the use of treatment of crop residues of spring barley and peas by the stubble biodestructor contributed to the increase in the amount of nitrogen fixators in the soil. Thus, in the soil variants without the use of a biopreparation in the 0-10 cm layer, there were nitrogen fixators as $24.9 \cdot 10^6$ up to $32.5 \cdot 10^6$ PCs / 1 g of soil, and in the soil layer 10-20 cm there were nitrogen fixators as $21.8 \cdot 10^6$ up to $30.7 \cdot 10^6$ PCs / 1 g soil, which respectively was less by $13.4 \cdot 10^6$ up to $14.1 \cdot 10^6$ and $14.0 \cdot 10^6$ up to $14.2 \cdot 10^6$ PCs / 1 soil g or it was less by 30.3 up to 35.0 % and 31.6 up to 39.1% compared to variants for the use of the stubble biodestructor.

It should be noted that the use of peas as a precursor culture provides a slightly greater number of nitrogen fixators compared to spring barley in the soil layer 0 – 10 cm by 7.6 up to $8.3 \cdot 10^6$ PCs/1g of soil or 17.8 up to 23.4%, and in the layer 10 – 20 cm – it increases by 8.9 up to $9.1 \cdot 10^6$ PCs/1 g of soil or 20.3 – 29.0% depending on the treatment of post-harvest residues.

Conclusion

For the treatment of crop residues of spring barley and peas with the stubble biodestructor together with ammonium nitrate at a dose of 3.0 kg/ha, the microbiological activity is somewhat activated and the content of mobile macronutrients increases in the soil. So, on average, over the years of research in the soil layer 0 – 10 cm the total number of bacteria increased by 59.2 up to 67.3%, the total number of micromycetes increased by 38.9 up to 51.4%, the total number of nitrogen fixators increased by 69.5 up to 76.8% depending on the precursor culture. On average, over the years of research, in the soil layer 0 – 30 cm the content of nitrates increased by 29.0 – 37.3%, the content of mobile phosphorus increased by 8.0 – 17.9%, the content of exchangeable potassium increased by 11.5 – 15.4% depending on the preceding culture. At the same time, several more nutrients and somewhat large total number of bacteria in the soil are formed during the processing of post-harvest residues of peas, which is due to the biological characteristics of the culture.

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