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STUDY EFFECT OF MICROBIAL INOCULANTS ON DECOMPOSITION OF BARLEY STRAW

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Abstract

The purpose of the study was to analyze the effect of microbial inoculants on the decomposition of barley straw. The field experiment, located at the soddy-podzolic sandy loam soil in order to study the effect of microbiological preparations on biotransformation of barley straw, biological properties of soddy-podzolic soil. The conclusion was that the use of microbiological agents-destructors is justified firstly when incorporation of high doses of straw in the cereal crop rotations, use of straw under cereal culture, in technology no-till, i.e. in the situations when it is necessary to provide conditions for the speedy decomposition of post-harvest crop residues, used as a fertilizer, in order to prevent its negative impact and to promote positive action.

Key words: straw decomposition, microbiological preparations, CO_2 emission, microbial biomass, number of soil microorganisms

INTRODUCTION

Russian and foreign researchers have currently evaluated crop residues as the most important resource of the reproduction of organic matter and preserve the functional properties of the soil in agrocenoses [6,9,11]. One of main requirements for an innovative system of agriculture is production of greatest possible amount of crop residues to return them to the soil in order to maintain soil health and quality. Return and incorporation of post-harvest residues into soil allows to close the cycle of nutrients and productivity and sustainability of agro-ecosystems increase.

In Russia, the excess of straw cereals and leguminous plants, which have not been used in animal husbandry and other branches, account for not less than 40-64 million tons annually. Straw incorporation into soil is being promoted as an alternative of management crop residues. However soil straw decomposes rather slowly because of the high content of cellulose and lignin and low nitrogen content, which may lead to reduction in yields. One way to enhance the decomposition of post-harvest crop residues can be obtained by processing of microbiological inoculants containing high efficiency of microorganisms-decomposers.

In some domestic and foreign studies it has been found that the use of microbiological modifiers can accelerate the processes of mineralization and humification of straw in the soil, which then reduces the phytotoxicity of the products and increases crop yields [1,2,4, 5,10]. The data of field experiments to assess the effectiveness of inoculation of crop residues microbiological preparations received to date from Russian scientists are few and insufficient and require clarification and confirmation of the results of additional researches.

The present study aimed to examine the effects of three microbial inoculants of barley straw destruction returned into soil.

MATERIALS AND METHODS

Studies were performed in a field experiment, located at the soddy-podzolic sandy loam soil experimental field of All Russian Research Institute of Organic Fertilizers and Peat. This experimental field is located in Russia, lowland Meschersky (in the center of the East

European Plain) (56 ° 03 'N, 40 ° 29' E) at 150 m above sea level. The site is situated in the zone temperate continental climate, average rainfall for the year - 599 mm, the average temperature for the year - 3.9° C. Soddy-podzolic sandy loam soil, are low in organic matter (C_{org} - 0.55-0.62 %) and nutrients, unstable water regime, acidity (pH_{kcl} - 4.5-4.9).

Experimental design: 1. No Fertilizer (NF); 2. Barley Straw (BS); 3. BS + N50; 4. BS + N50 + Barcon (B); 5.BS + N50 + Ekstrasol (E); 6. BS + N50 + Ekstrasol CS (Ecs).

In August (2012-2013), after harvesting the grain barley straw, it was comminuted to 15-20 mm and evenly distributed over the surface of the plots at a dose of 5 t / ha, a compensating dose of nitrogen (ammonium nitrate) at a rate of 10 kg per 1 ton of straw was applied, the barley straw then treated with biologics in accordance with the experimental design after that it was plowed in the arable soil layer (0-20 cm). The following spring, spring triticale (*Triticosecale Wittmack*) was sown.

In the experiment, microbiological preparations was used (were developed in All-Russia Research Institute of Agricultural Microbiology: Barcon - based on microbial cultures-destructors of cellulose and lignin plant waste; Ekstrasol - based culture effective strains of Bac. subtilis; Ekstrasol CS - with enhanced cellulolytic activity.

To assess the impact of the applied biopreparations on the decomposition of straw, the following methods were applied: emission C-CO_2 was determined by absorption method (amount of CO_2 absorbed was determined by titration of 1 M NaOH against 0.2 M HCl) [12]; soil microbial carbon (C_{mic}) was determined by rehydration-extraction method [3]; number of the soil microorganisms participating in circulation of carbon and nitrogen was determined accounting method on solid and liquid nutrient mediums [13].

RESULTS AND DISCUSSIONS

An emission of carbon dioxide from the soil is an integral indicator of actual soil biological activity and reflects the intensity of mineralization of organic matter. Monitoring of CO_2 emission from the soil of the experiment was carried out in dynamics, starting from day 1 after ploughing of straw, with an interval of 7 days before the appearance of negative soil temperatures and frosts. According to the obtained data for the entire observation period which lasted for 63 days after ploughing of straw into the soil, the minimum amount of C-CO_2 produced is from the soil registered of treatments "NF" – 72.5 g/m^2. In the variant with introduction of a 5 t/ha of straw, this value was higher by 1.5 times i.e. 109.4 g/m^2.

Additive compensating dose of N50 to straw contributed to the increase in carbon emissions by 27% i.e. 139.3 g/m^2. Everything used in the experiment biologics showed high effectiveness in the intensification of decomposition of plant biomass straw was been fixed by increasing the size of CO_2 emission, which during the period of observations were in the amount of 32-58 % higher than in the embodiment where the straw is applied without the use of biologics and N50 (BS), and 4-24 % higher compared to treatments "BS+N50" (Fig. 1).

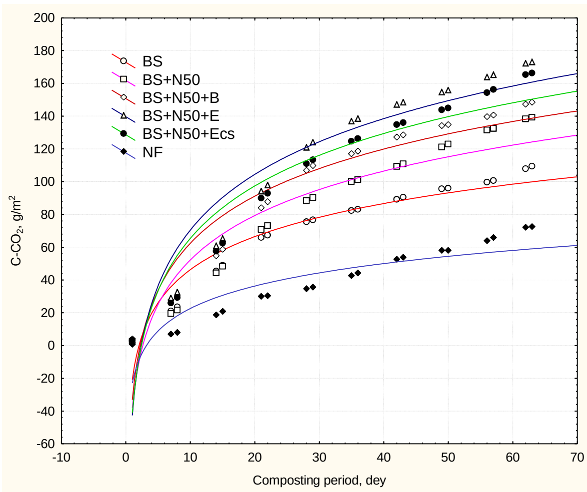

Fig. 1. Cumulative emission curves of C – CO_2

In accordance with the intensity of impact on C-CO_2 production in this experiment studied microbial inoculants can be arranged in the following sequence: Ekstrasol> Ekstrasol CS> Barcon.

The obtained experimental data are consistent with the research results [1] in the incubation experiment (73 day), whereby of straw incorporation into the soil increased the CO_2 emission by 39 % compared with the control, while treatment with biologic showed another 10 % increase. According to research [8], in conditions of sufficient moisture soil respiration (CO_2 evolution) was increased when introduction straw inoculated with biological product based micromycetes *Limonomyces roseipellis*.

The decomposition of plant residues in the soil is carried out not only with the mineralization of labile fractions of organic matter to CO_2, but the assimilation of carbon in the microbial biomass. The increase in the organic carbon content in the microbial biomass can be an indicator of accumulation trend of biochemical processes of post-harvest residues transformation. In what follows, the microbial biomass carbon is transformed into carbon humus and thus replenishes its reserves in the soil.

As a result of analysis of the content of microbial biomass (C_{mic}), in field experiment it can be noted that the most noticeable effect of inoculation of straw biological products appeared after 1.5 months of ploughing straw into soil when the value of C_{mic} in these treatments 1,22 -1,35 times higher compared to treatments "BS+N50" (Fig. 2).

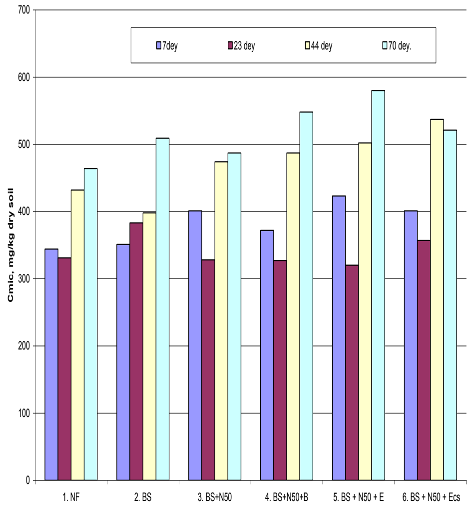

Fig. 2.The content of microbial biomass in arable layer of soddy-podzolic soil in different periods after of straw incorporation

The increase in the organic carbon content of microbial biomass, and humus has been found in studies [8], if introduced into the soil straw inoculated with biological product based on the culture of the fungus *T. reesei.*

As a result of measurement of number of the soil microorganisms participating in transformation C - and N-containing connections, it has been found that an increase in the group of proteolytic bacteria by 1.39 and 1.70 times and amylolytic bacteria by 1.62 and 1.64 times in the treatments with application of Extrasol and Extrasol CS, respectively. The positive impact of biologics on the number of microorganisms involved in the mineralization of cellulose, marked a 1 year after plowing in straw (october 3,2012), when the number of aerobic cellulolytic microorganisms in treatments with inoculation straw Barcons, Ekstrasol and Ekstrasol CS was higher by 38 -43% compared to treatments “BS + N50” (Table 1).

Table 1. Number of agronomically beneficial microorganisms in soddy-podzolic soil after straw introduction with microbial preparations (0-20 cm)

Treatments	Proteolytic	Amylolytic	Cellulolytic	Micromycetes	Nitrifiers	Cl. pasteurianum
	$x10^6$ CFU/g dry soil		$x10^3$CFU/g dry soil			
NF	4.1 4.5	8.3 8.9	20.6 29.6	34.7 55.1	8.0 6.7	272 25
BS	5.6 7.7	10.8 19.8	28.0 33.1	57.0 91.2	9.5 5.5	491 150
BS+ N50	6.2 6.8	11.4 19.1	31.3 36.5	56.7 76.7	20.0 12.0	495 450
BS+ N50+B	6.7 6.1	12.3 15.0	39.0 50.5	58.0 81.7	14.3 12.6	495 25
BS+ N50+E	10.6 6.6	18.5 9.8	39.7 51.0	52.3 53.6	14.7 9.7	822 250
BS+ N50+Ecs	8.6 6.7	18.7 9.7	31.0 52.1	59.7 67.6	15.3 10.0	822 95

Note: Above the line – May 4, 2013; below the line – October 3, 2013.

Previous studies in laboratory experiment showed that inoculation of barley as well as winter wheat straw Barcon was the following effects: increase in the number and biomass of soil microorganisms, increased coefficient of straw humification on 52-66% and content of easily mineralized organic carbon (labile and extracted with hot water), reduced phytotoxicity straw transformation products [6]. Our findings are also consistent with the results of field tests on chernozem in which it is shown that introduction into soil of wheat straw treated with microbial preparation

Extrasol produced on the basis of *Bacillus subtilis* strain Ch-13 results in increase of activity of all main groups of microorganisms responsible for destruction and involvement of lignocellulotic compounds into the process of humus formation [7].

CONCLUSIONS

Based on the results of research in the field experiment established the effectiveness of microbiological preparations-destructors against decomposition of crop residues of cereals in the soddy-podzolic soil. The results provide a basis for further research on the development of ways to intensification of crop residues decomposition under the influence of microbial inokulants.

1. The use of microbiological agents-destructors is justified firstly when incorporation of high doses of straw in the cereal crop rotations, use of straw under cereal culture, in technology no-till, i.e. in the situations when it is necessary to provide conditions for the speedy decomposition of post-harvest crop residues, used as a fertilizer, in order to prevent its negative impact and to promote positive action.

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