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TREATMENT OF POST HARVEST RESIDUES WITH CELLULOSE DIGESTERS II. EFFECT ON SEED YIELD FROM BEAN, MAIZE AND SUNFLOWER

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Abstract

Milev, G., I. Iliev, Treatment of post-harvest residues with cellulose digesters II. Effect on seed yield from bean, maize and sunflower. FCS 9(1): 131-139

During 2011 – 2013, in the trial field of Dobrudzha Agricultural Institute a field experiment was carried out with the aim to find out what is the effect of stubble cellulose digester (microbial or others) on the seed yield from bean, maize and sunflower. The crops were grown under conditions of a stationary field trial after predecessor wheat. Three cellulose digesters, Bactofil C, Nutri-Life Accelerate (NLA) and Amalgerol premium were tested on plots without mineral fertilization. The post harvest residue was chopped by the combine to pieces of suitable size and spread evenly on the soil surface. The above cellulose digesters were applied by sprinkling the stubble area in autumn. The norm of the working solution was 400 l/ha, and the doses of the individual preparations were according to the recommendations of the producers. Immediately after sprinkling the post harvest residues from the previous crops, they were incorporated in soil by disking soil tillage machines. The effect from the use of the three cellulose digesters on the seed yield from the spring crops, although weak, was positive. A more significant increase of seed yield was found after using the preparations Bactofil C and NLA on bean and maize and the preparation Amalgerol premium on sunflower.

Key words: Post harvest residues – Stubble cellulose digesters – Seed yield

Резюме

Милев, Г., И. Илиев, Третиране на следжътвените растителни остатъци с целулозоразлагащи препарати II. Ефект върху добива на зърно от фасул, царевица и слънчоглед. FCS 9(1): 131-139

През периода 2011-2013 г. в опитното поле на Добруджански земеделски институт е изведен полски опит, целта на който бе да се установи ефекта на стърнищни целулозо-разлагащи препарати (на микробиална или на друга основа) върху добива на зърно от фасул, царевица и слънчоглед. Културите са отглеждани в условията на стационарен опит след предшественик пшеница. Три целулозоразлагащи препарата - Бактофил С, Nutri-Life Accelerate (NLA) и Амалгерол премиум са изпитани на фона на неторени с минерални торове парцели. Следжътвеният растителен остатък е раздробен от сламонарязващия апарат на комбайна до подходящи размери и равномерно разхвърлен върху повърхността на почвата. Посочените целулозоразграждащи препарати са приложени като площно опръскване на стърнището през есента. Нормата на разходния разтвор е 400 l/ha, а дозите на отделните препарати са според препоръките на фирмите производители. Непосредствено след опръскването на СО от предшествениците е извършено инкорпориране на същия в почвата с дискови почвообработващи машини. Въз основа на осреднените тригодишни резултати са направени следните изводи: Ефекта от приложението на трите целулозоразлагащи препарата върху добива на зърно от пролетните култури, макар и слаб е положителен.. По-съществено увеличение на добива на зърно е установено за препарата Бактофил С и NLA при фасул и царевица и.за Амалгерол премиум при слънчоглед.

Ключови думи: Следжътвени остатъци - Стърнищни целулозоразложители - Добив зърно

INTRODUCTION

The post harvest residues (PHR) from wheat, maize, sunflower and leguminous crops in a typical filed crop rotation in the region of Dobrudzha are an important source of organic reserves in the slightly leached chernozem soils (Buyanovsky and Wagner, 1986; Dimitrov, 1997; Goushevolov, 1998; Donkova and Tonev, 2005; Simeonov, 1973). It is known that immediately after plowing of PHR, temporary biological immobilization of nitrogen occurs in soil (Dinchev, 1983; Schomberg et al. 1994; Schoenau and Campbell, 1996). The rate of this immobilization depends on multiple factors, some of the most important being the C:N ratio in the respective PHR, the humidity and temperature under which decomposition occurs and the specific microbial activity of the respective soil type. The low content of nitrogen is typical of PHR from wheat, sunflower and maize – C:N ratio is about 80:1. Therefore the process of decomposition (nitrogen immobilization, respectively) is longer and as a result the crops in the rotation suffer more or less from nitrogen deficiency.

The problem with the PHR utilization has always been topical for both the agricultural professionals and researchers and for the ecology experts. It is known that at the beginning of the transition from centralized to market-oriented agriculture in Bulgaria, the percent of animal husbandry sharply decreased leading to huge excess of unconsumed straw. Subsequently mass burning of stubbles became the common practice with all accompanying harmful and disastrous effects on soil and the environment.

On the other hand, the contemporary agricultural production has at is disposal advanced biotechnology practices such as composting of various organic materials with the aim to obtain humus-like substances (Das Keshav and Keener, 1997; Michel et. al, 2002; Milev, 2011).

Recently some companies specialized in the production of microbiological products (AGRO.bio Hungary Ltd., 2001; Nutri Tech Solution Ltd., Australia, 1994) offer specially formulated preparations for accelerated decomposition of stubble residues (the so called “stubble digesters“). The application of these preparation leads according to some authors to accelerated decomposition of PHR and to shorter duration and intensity of the biological immobilization of nitrogen. (Kutok and Shigekata, 1994; Tiquia et al, 2002). The harvesting machines widely used are already capable of chopping and evenly spreading the PHR on the cultivated area thus facilitating plowing and the subsequent soil tillage (Dormaar JF and Carefoot JM, 1996; Opoku G, and Vyn TJ, 1997).

With a view of testing the activity of the above preparations under conditions of a crop rotation typical for the region of Dobrudzha, a filed experiment was carried out to determine the effect of stubble cellulose-decomposing preparations (microbial or other) on the seed yield and absolute weight of bean, maize and sunflower.

MATERIAL AND METHODS

Under conditions of a stationary field trial, bean (*Phaseolus vulgaris* L.), maize (*Zea mais* L.) and sunflower (*Heliantus annuus* L.) have been grown in crop rotation with wheat. Three cellulose digesting products - Bactofil C, Nutri Life Accelerate (NLA) and Amalgerol premium (Table 1), were tested in plots not treated with mineral fertilizers. These plots have not been fertilized because some of the aims of the experiment were growing of the mentioned crops under conditions as close as possible to organic production. The entire amount of post harvest residue from wheat was incorporated. It was chopped by the straw processing mechanism of the harvester to pieces of suitable size and then evenly spread on the soil surface. The treatment of the chopped post harvest residues (PHR) was done during the second decade of September by sprinkling the area with *Hardi* sprayer designed for experimental purposes. The norm of the working solution was 400 l/ha, and the doses of the respective preparations were as recommended by the producers. Immediately after sprinkling of the PHR from the previous crops, it was incorporated in soil using disking tillage machines.

The soil in the trial field was slightly leached chernozem with the following content of the plow layer: humus 3.30 % (according to Tyurin), pH_{KCl} - 5.55, mineral nitrogen 12.1 mg/1000 g, mobile forms of phosphorus and potassium 5.35 and 22 mg/100 g, respectively (according to Ivanov, 1984).

Table 1. Composition of the used products
Таблица 1. Състав на използваните продукти

Product	Composition
BactoFil Cell Бактофил С	***Bacteria/Бактерии***:*Cellvibrio sp., Pseudomonas fluorescens micro-organism variants; macro–and microelements, enzymes bio-synthesised by the micro-organisms and other soil-conditioning ingredients.*
Nutri-Life Accelerate	**Fungi/Гъби:** *Trihoderma lignorum & resei, Aspergillus spp., Penicillium spp., Chaetomium globosum, Paecillumyces spp., Phanerochaete chrysosporum* ***Bacteria/Бактерии***: *Bacillus polimyixa, Streptomyces spp.*
Amalgerol premium Амалгерол премиум	Extraction from sea weeds, mineral oils, etc. Екстракт от морски водорасли, минерални масла и др.

According to the producers, the purpose of the respective product is as follows:

Bactofil C is a cellulose-digesting micro biological product containing no less than 3 x 10^9 cells / ml. Special selection of cellulose decomposing micro organisms, which can remain active under low temperatures as well, decomposing maize and sunflower stems. Recommended dose: 1 l/ha.

Nutri Life Accelerate (NLA) is a powdered micro biological product which causes accelerated decomposition of stubble plant residues and composted plant mixtures. Recommended dose: 30 l/ha of brewed concentrate.

Amalgerol premium: This product is not specially (obligatory) designed as stubble digester. It stimulates plant growth, increases the micro biological activity in soil and thus indirectly accelerates PHR decomposition. Recommended dose for stubble treatment: 3-5 l/ha.

The trial was designed by the method of the long plots, the check and the treated variants being placed on the main plots, and the plots of lower order being sown with the crops respectively involved in the trial. The size of the harvest plots was 15 m^2, in four replications of the variants. Phenological observations and biometrical measurements were done during the experiment. The indices seed yield and 1000 seed weigh were read.

The conditions for application of the cellulose digesters during the first and second year of the investigation were not favorable: low air humidity and dry soil surface and plant residues. In 2012 the conditions were comparatively favorable: the air humidity was 78 %, there was dew on the soil surface and the plant residues, the air temperatures were 17 - 19^o C, and wind speed was 1.0 m/s with south-east orientation. It was typical for this year that the air temperature maximum later during the day reached rather high values: 29° C, while air humidity dropped to 41 %.

Table 2. Conditions of sprinkling and working parameters of the sprayer equipment
Таблица 2. Условия на опръскване и работни параметри на пръскачката

Parameters/Параметри	Year/Година		
	2010	2011	2012
Air temperature/Температура на въздуха	20-22^{0}C	16-18^{0}C	17-19^{0}C
Relative air humidity (morning and afternoon)/ Относителна влажност (преди и след обед)	55-50%	60-55%	75-41%
Wind speed/Скорост на вятъра	1.0 m/s	1.5 m/s	1.0 m/s
Sprayer working width/Работна ширина на пръскачката	5 m	5 m	5 m
Boom nozzle spacing/Разстояние между дюзите	0.5 m	0.5 m	0.5 m
Working pressure/Работно налягане	2.5 bar	2.5 bar	2.5 bar
Sprayer working speed/Работна скорост	4.5 км/h	4.5 км/h	4.5 км/h
Nozzle rate/Дебит на 1 дюза	2.25 l/min	2.25 l/min	2.25 l/min
Boom height/височина на щангата	0.60 m	0.6m	0.60 m

The data from Table 2 gives an idea about the distribution of the vegetation and autumn-and winter rainfalls during the individual years. Highest vegetation rainfalls were registered in 2011 – 232.8 mm, and lowest – in 2013: 176 mm. The amounts of these rainfalls during the first (232.8 mm) and second (227.8 mm) year of the investigation were closest to the precipitation value of the mean long-term period (254.0 mm). The rainfalls in September, which are of immediate significance for the successful inoculation of PHR with the microbial agents of the respective products, were rather scarce, being highest in 2010 - 21.0 mm. These rainfalls were considerably below the mean long-term norm of 45.7 mm. The amounts of rainfalls in October and November, which are important for the progressive colonization of PHR, were most favorable in 2011 - 118.4 mm. During the first and the second year these rainfalls were close to the mean long-term amount typical for these months. During the third year (2012), the precipitation in October and November was much lower than the mean long-term norm.

Table 3. Vegetation and autumn-and-winter rainfalls during the investigated period, mm
Таблица 3. Вегетационни и есенно-зимни валежи за периода на проучването, mm

Montfs/Месеци	Years/Години				Averaged for 3 years/ Средно за 3 год.	Averaged for 60 years/ Средно за 60 год.
	2010	2011	2012	2013		
April/IV		49.2	40.1	35.7	41.6	48.3
May/V		80.4	118.9	23.0	74.1	49.6
June/VI		35.1	27.6	11.3	24.6	64.0
July/VII		51.8	36.5	66.2	51.5	51.8
August/VIII		16.3	4.7	40.3	20.4	40.3
Amount/ Сума IV-VIII		232.8	227.8	176.5	212.3	254.0
September/IX	21.0	5.0	7.8	-	11.2	45.7
October/November X-XI	84.6	114.8	56.2	-	85.2	97.8
Autumn-and-winter rainfalls, X-III/Есенно-зимни валежи	-	206.4	283.0	250.8	246.7	294.0

The autumn and winter rainfalls, which are also decisive for the intensive micro biological activity in the soil substrate, were highest in 2012 - 283.0 mm. The first and the third year of the investigation were characterized with amounts of these rainfalls considerably below the mean long-term value.

RESULTS AND DISCUSSION

The grain yield from the three spring crops over years is given in Table 4. In 2011 a more ostensible positive effect on this index was found in bean after treatment with Bactofil C and NLA. All three tested products had positive effect on maize, although lower than on bean. The effect of the investigated preparations was slightly negative on sunflower yield.

During the second year of the investigation the effect from the application of the three cellulose digesters was positive on all crops. The increase of yield in bean was within +180 and +140 kg/ha, respectively for the preparations Bactofil C and NLA. In maize, the increase was within +610, +440 and +300 kg/ha for Bactofil C, NLA and Amalgerol premium, respectively. In sunflower yield increase was also within a narrow range - from 220 kg for Bactofil C to 310 and 320 kg/ha for NLA and Amalgerol premium, respectively.

Table 4. Seed yield from spring crops depending on the way of PHR treatment over years

Таблица 4. Добив на зърно от пролетни култури в зависимост от начина на третиране на следжътвения остатък по години

Crop / Култура; Variants of treatment / Варианти на третиране	PHR from wheat/СЖО от пшеница					
	Bean Фасул		Maize Царевица		Sunflower Слънчоглед	
	kg/ha	D±	kg/ha	D±	kg/ha	D±
2011						
Check/Контрола	2290	-	12200	-	3310	-
Bactofil C/Бактофил C	2640	+350	12610	+410	3170	-140
NLA*	2730	+440	12370	+170	3160	-150
Amalgerol premium/ Амалгерол премиум	2340	+50	12580	+380	3200	-10
2012						
Check/Контрола	1410	-	6920	-	2470	-
Bactofil C/Бактофил C	1590	+180	7530	+610	2690	+220
NLA*	1530	+140	7360	+440	2780	+310
Amalgerol premium/ Амалгерол премиум	1490	+80	7220	+300	2790	+320
2013						
Check/Контрола	1540	-	5450	-	1790	-
Bactofil C/Бактофил C	1460	-80	5930	+480	1860	+70
NLA*	1490	-50	6720	+1270	2010	+220
Amalgerol premium/ Амалгерол премиум	1430	-110	5820	+370	2070	+280

NLA*: *Nutri-Life Accelerate*

In 2013, the cellulose digesters had slight negative effect on seed yield from bean. In maize this effect was unidirectional and positive, yield increase being significant for the preparation NLA: +1270 kg/ha. The effect from the treatment with the three products on sunflower was slightly positive. After using Amalgerol premium, yield increase was with 280 kg/ha, after NLA - with 220 kg/ha and there was only very slight effect of Bactofil C – yield increase of 70 kg/ha.

Table 5. Seed yield from spring crops depending on the way of treatment of PHR averaged for 3 years, kg/ha
Таблица 5. Добив на зърно от пролетни култури в зависимост от начина на третиране на следжътвения остатък средно за 3 години, kg/ha

Variant of treatment Варианти на третиране	PHR from wheat/ СЖО от пшеница					
	Bean Фасул		Maize Царевица		Sunflower Слънчоглед	
		D±		D±		D±
Check/Контрола	1750	-	8190	-	2520	-
Bactofil C/Бактофил С	1900	+8.5%	8690	+7.2%	2570	+1.9%
NLA*	1920	+9.7%	8820	+7.7%	2650	+5.1%
Amalgerol premium/ Амалгерол премиум	1750	0.0%	8540	+4.2%	2690	+6.7%

NLA*: *Nutri-Life Accelerate*

Table 6. Dispersion analysis of yield
Таблица 6. Дисперсионен анализ на добива

Factors of the experiment Фактори на опита	PHR from wheat СЖО от пшеница		
	Bean Фасул	Maize Царевица	Sunflower Слънчоглед
Factor A – PHR treatment **Фактор А** третиране на СЖО	D± kg/ha	D± kg/ha	D± kg/ha
Check/Контрола	-	-	-
Bactofil C/Бактофил С	+150*	+500*	+50
NLA*	+170*	+630*	+130
Amalgerol premium/ Амалгерол премиум	0.00	+350	+170*
Factor B – year **Фактор В** година	Check Контрола	Preparations (Total) Препарати (общо)	
2011	-	+280	-
2012 Bean/Фасул	-	+130*	-
2013	-	-80**	-
2011 Maize	-	+320	-
2012 Царевица	-	+450*	-
2013	-	+700**	-
2011 Sunflower	-	-100	-
2012 Слънчоглед	-	+280**	-
2013	-	+190*	-

NLA*: *Nutri-Life Accelerate*
,,*** significance of differences at P=5%, 1% and 0.1%; NS – not significant*

Table 5 shows the seed yields from the three crops averaged for the three-year investigation. The tested cellulose digesters had, with some minor exceptions, positive effect on the yield from all crops. In bean and maize highest effect was found for Bactofil C and NLA, and in sunflower – for NLA and Amalgerol premium. On the average, Bactofil

C and NLA increased the yield from bean with 9.1 %, and from maize – with 7.4 %. There was no effect on yield from bean after treatment with Amalgerol premium and on yield from sunflower after treatment with Bactofil C.

The data from the dispersion analysis of yield (Table 6) point to a significant positive effect of Bactofil C and NLA on bean and maize, and of Amalgerol premium on sunflower. The year conditions were important for the performance of the cellulose digesters. In some years (2011 for bean and 2013 for sunflower), there were unfavorable conditions and negative effect on yield was observed. The preparation Amalgerol premium had lowest influence when applied on bean and maize. This result is probably due to the fact that the product is not specifically formulated as an obligatory cellulose digester. Its effect on post harvest residue decomposition comes from the stimulation of a number of enzyme processes in soil and the general enhancement of its micro biological activity.

Table 7. 1000 seed weight of spring crops depending on the way of treatment of PHR from wheat, g

Таблица 7. Маса на 1000 семена от пролетни култури в зависимост от начина на третиране на следжътвения остатък на пшеницата, g

Variants of treatment Варианти на третиране	Crops/Култури		
	Bean Фасул	Maize Царевица	Sunflower Слънчоглед
2011			
Check/Контрола	385.1	383.8	64.4
Bactofil C/Бактофил С	392.5	393.2	63.8
NLA*	380.3	385.0	66.3
Amalgerol premium/ Амалгерол премиум	391.7	389.5	62.2
2012			
Check/Контрола	337.4	333.1	57.7
Bactofil C/Бактофил С	340.5	337.6	62.3
NLA*	344.0	336.2	58.9
Amalgerol premium/ Амалгерол премиум	338.4	338.8	62.8
2013			
Check/Контрола	345.2	395.2	62.5
Bactofil C/Бактофил С	342.4	383.7	58.4
NLA*	339.7	383.6	63.7
Amalgerol premium/ Амалгерол премиум	340.5	389.2	61.1
Averaged for/Средно 2011-2013			
Check/Контрола	355.9	370.5	61.5
Bactofil C/Бактофил С	358.4	371.5	61.5
NLA*	355.6	371.2	62.9
Amalgerol premium/ Амалгерол премиум	356.8	372.5	62.0

The effect of the variants of treatment with regard to the index 1000 seed weight was vacillating in the respective crops (Table 7). In general, the application of these products increased the value of the index with 1 to 2 g, averaged for the period of investigation. The analysis of the obtained positive results allows considering that the cellulose digesters applied in this investigation contributed to the faster decomposition of the post harvest plant mass from the previous crop. The effect on the value of the yield was indirect and was due to the shorter duration of nitrogen immobilization as a result from the large amount of plant residues from the predecessor.

The relatively weak effect of these products on yield can be due to other reasons, as well. These could be insufficient moisturizing of the residues at the moment of application which predetermined slow propagation of the active agents and respective difficult colonization of the substrate.

This assumption has also been confirmed in our previous investigation with pot experiments where under controlled conditions the colonization of the substrate from wheat and its further decomposition occurred much faster and steady (Milev, 2011).

The results obtained in the spring crops were similar to those from wheat, where the respective plant residue from the spring crops was treated (Milev et al., 2014, *in print*). In this case with the different predecessors of wheat, an adaptation to the specific plant residue was probably necessary. In the current investigation, for example, Bactofil C and NLA had good effect on bean and maize, while Amalgerol premium had good influence on sunflower against the background of the same post harvest residue from wheat.

In this respect, as with any innovative solution, the treatment of the post harvest residues with such type of products may need more precise and long-term investigations with the aim to work out practices for their application, dosage, dates of applying, etc. Therefore they should be used at farms where agricultural production is maintained at a sufficiently high level and where there is the appropriate technological equipment.

The micro biological treatment of PHR, although being with weaker effect on seed yield in comparison to mineral fertilizers, has a number of advantages, namely: it contributes to lower chemical pressure on soil, reduces the fertilizer norms, and increases the general biological soil activity.

CONCLUSION:

The cellulose digesters Bactofil C, NLA and Amalgerol premium had in this investigation positive effect on the seed yield from bean, maize and sunflower. The first two products were most efficient on bean and maize, while the third was most successful on sunflower.

The effect from the cellulose digesters depended primarily on the conditions at the moment of their application, respectively on the condition of the substrate.

It is advisable to use these products in farms with sufficiently high level of agriculture and technological equipment.

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