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EFFECT OF LIME, BIOMASS ASH, COMPOST AND THE EFFECTIVE MICROORGANISMS SUBSTANCE ON THE GRAIN YIELD AND YIELD COMPONENTS OF SPRING BARLEY

ABSTRACT

The field experiment was conducted in 2013 in Duninowo [51°21′ N, 21°40′ E]. The factors under analysis were: I. 6 fertilization variants; II. 2 levels of microbiological preparation use. The aim of the research was the assessment of the effect of the use of ash from biomass, calcium fertilizers and bio-compost (BIOTOP) together with Effective Microorganisms microbiological substance on yield, its structure and physiological parameters of spring barley cultivar Sebastian. The research does not show any significant effect of the used fertilizer variants on the increase of yield of spring barley cultivar Sebastian. As a result of the use of bio-compost BIOTOP, the level of chlorophyll in the leaves of spring barley cultivar Sebastian (SPAD) was decreased. The use of microbiological preparation did not have any effect on the analysed physiological parameters of spring barley cultivar Sebastian, i.e. yield, the number of grains per spike and SPAD values. The results indicate the positive effect of microbiological preparation on the size of assimilation area of crop per area unit (LAI).

Keywords: biomass ash, biocompost, spring barley, fertilization

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INTRODUCTION

The use of waste products is an effective way of limiting the need of storing these products. The content of waste products is varied and largely determined by numerous factors, such as assimilability of nutrients.

Ash from biomass is to be treated as mineral material with significant content of biogenic elements. Regulation of the Minister of Environment of 5 April 2011 on R10 recovery process (Journal of Laws of 2011 No. 86, item 476), specifies the conditions of recovery by means of distribution on the surface of ground for soil fertilisation or enhancement. Biomass ash comprises fly ash from peat and untreated wood not subjected to chemical treatment, code 10 01 03. The use of ash is subject to conditions specified in the Regulation. Ash should be introduced to soil in which admissible values of substance concentration are not exceeded, as specified in the Regulation of the Minister of Environment of 9 September 2001 on soil and land quality standards (Journal of Laws of 2002 No. 165, item 1359).

Bio-compost produced from organic waste is a source of organic material and, when combined with biomass ash, can be a valuable raw material for fertilisation purposes.

According to Higa [2002], who was the first person to lay down the combination of microorganisms in preparation, broad spectrum of microorganisms in such preparations accelerate the mineralisation of organic mass, have antioxidant properties for the soil directly, and indirectly for the plant.

The aim of the research was the assessment of the effect of biomass ash, calcium fertilizer and BIOTOP bio-compost together with microbiological preparation EM on yield, its structure and physiological parameters of spring barley – Sebastian cultivar.

MATERIALS AND METHODS

The experiment was carried out in 2013 in Duninowo [51°21′ N, 21°40′ E]. The factors under analysis included: I. factor of 6 fertilisation variants; II. 2 levels of EM preparation use (Table 1).

Fertilisation with ash and bio-compost was done during spring cultivation. Spring barley – Sebastian cultivar was sown in the amount of 170 $kg \cdot ha^{-1}$ on 26 April 2013. Spraying with Pragma (25$g \cdot ha^{-1}$) herbicide and Soprano (0.4 $dm^3 \cdot ha^{-1}$) fungicide, as well as magnesium sulphate (VI) and manganese sulphate (VI) was done during vegetation period in the amount of 1$kg \cdot ha^{-1}$. Fertilization with nitrogen and sulphur amounted to 170 kg N and 25kg S per hectare.

Spraying with microbiological preparation EM was done once, on 11 June 2013, in the amount of 40 $dm^3 \cdot ha^{-1}$. In the variant where the preparation was not used, the area was sprayed with water in the same amount. The pH of soil on which barley was grown was 7.1.

During vegetation, the content of chlorophyll was determined with the use of photo-optical method using Minolta Spad 502 chlorophylo-meter in 10 measurements for each variant. Leaf area index (LAI) was determined using Ceptometer Accu Par in 5 measurements for each variant.

Tab. 1. Variants of fertilizer

Variant	Fertilization
1	Control
2	Lime 3,0 $t \cdot ha^{-1}$
3	ash from biomass 1,5 $t \cdot ha^{-1}$
4	Lime 3,0 $t \cdot ha^{-1}$ + ash from biomass 1,5 $t \cdot ha^{-1}$
5	ash from biomass 1,5 $t \cdot ha^{-1}$ + Biotop compost 20 $t \cdot ha^{-1}$
6	Lime 3,0 $t \cdot ha^{-1}$ + ash from biomass 1,5 $t \cdot ha^{-1}$ + Biotop compost 20 $t \cdot ha^{-1}$

The content of macrocomponents in soil in assimilable forms is to a large extent determined by the amount of precipitation which provides adequate moisture content especially during the vegetation period. The vegetation period of 2013 was assessed as moist due to precipitation in May and June which markedly exceeded the long-term average (www.ogimet.com).

After harvesting, the yield and selected components of the yield were determined.

The statistical analysis was done using the two-factor analysis of variance, and confidence half-intervals (LSD) were calculated using Tukey's test. Statistica ver.10 software was used for the calculations.

The lime fertiliser used in the experiment was a postcellulose lime fertiliser, variety 07, brand name PROFITKALK. The calcium content expressed as CaO was 39.2%.

Characteristics of biomass ash

The biomass ash used in this experiment was obtained from the combustion of wood material. The granulometric composition of ash was determined using the aerometric analysis by Prószyński and was the following: the content of sand fraction 32% d.m., silt fraction 41% d.m. and clay fraction 27% d.m.

The findings allowed for determining the soil classification of ash – heavy loam. Ash pH (in water) was 13.2. The content of available phosphorus expressed as $P_2O_5 \cdot 100g^{-1}$ d.m was < 0.01, available potassium – 10768 mg K_2O per 100 g. The content of available magnesium in the analysed ash from biomass was 118 mg $Mg \cdot 100g^{-1}$. The content of the remaining metals in dry mass of ash was the following: zinc 563 mg $Zn \cdot kg^{-1}$, copper 78.9 mg $Cu \cdot kg^{-1}$, nickel 23.7 mg $Ni \cdot kg^{-1}$, chromium 15.4 mg $Cr \cdot kg^{-1}$, lead 12.1 mg $Pb \cdot kg^{-1}$, cadmium 2.7 mg $Cd \cdot kg^{-1}$, arsenic 2.0 mg $As \cdot kg^{-1}$, mercury < 0.4 mg $Hg \cdot kg^{-1}$.

The characteristics of BIOTOP compost

The BIOTOP compost was produced by Water Pipelines Ltd. in Słupsk. The composted ingredients were the following: straw 32%, stabilised sediment 32%, green waste 25%, bark waste 11%. The content of the product is the following: nitrogen, phosphorus and potassium–2.5, 1.0, 0.2% respectively. The content of metals does not exceed the following values: zinc 600 mg $Zn \cdot kg^{-1}$, copper 40 mg $Cu \cdot kg^{-1}$, nickel 9.5 mg $Ni \cdot kg^{-1}$, chromium 5.0 mg $Cr \cdot kg^{-1}$, lead 20.0 mg $Pb \cdot kg^{-1}$, cadmium 0.8 mg $Cd \cdot kg^{-1}$, mercury < 0.01 mg $Hg \cdot kg^{-1}$. The compost's pH (in water) was 7.4

RESULTS AND DISCUSSION

Yield and its structure

Mean yield of spring barley cultivar Sebastian obtained in the experiment (Table 2) ranged from 6.86 to 7.29 $Mg \cdot ha^{-1}$, and was comparable regardless of fertilization variant – 7.13 $Mg \cdot ha^{-1}$ on average. Spring barley cultivar Sebastian is a type of malting barley characterized by high technological properties. In the course of three-year-long research in Lubelszczyzna, the obtained yield amounted to 7.07 $Mg \cdot ha^{-1}$ as for the average level of agro-technology, and 8.21 $Mg \cdot ha^{-1}$ as for high level of agro-technology [www.wodr.konskowola.pl]. The field experiment conducted by Liszewski et al. [2011] in the period of 2008-2009 using the split-block method on good wheat soil complex, produced the mean yield of spring barley cultivar Sebastian in the amount of only 4.93 $Mg \cdot ha^{-1}$. Relatively high amount of yield obtained from the control variant of fertilization, to a certain extent explains the lack of significant effect of fertilization variant used in the experiment (Table 2). Decreasing effect due to the increase of nitrogen doses is widely discussed in the literature on the subject: Wróbel [1993], Fotyma [1997], Noworolnik and Leszczyńska [2001].

The use of microbiological preparation contributed to the slight increase in barley yield, however it was not statistically significant (Table 2).

In comparison with the control variant, there was a tendency for an increase in the number of plants due to the use of all fertilization variants. However, the increase was statistically insignificant (Table 2).

According to various authors [Słaboński 1985, Liszewski i Błażewicz 2001, Pecio 2002, Thompson 2004, Żarski 2009], the malting barley, such as Sebastian cultivar, is particularly sensitive to weather conditions during stem elongation phase and earning stage – favourable conditions at that time are high temperature and moderate precipitation. Mean number of productive ears collected from 1m² amounted to 613, while the experiment conducted by Liszewski et al. [2011] in better meteorological conditions produced 965 ears from 1m². Due to precipitation in May and June, the vegetation period of 2013 was moist and as a result of used fertilization, there was a decrease in the number of ears per 1m². The number of ears were reported to increase only following the use of the three fertilizers: calcium, compost and ash.

The seeds weight ranged from 52.8 to 62.3 g (Table 2) and exceeded the mean weight of spring barley cultivar Sebastian as given by Liszewski et al. [2011], i.e. 40.8 g. The weight of 1000 seeds varied only slightly and did not present any patterns according to the effect on the substances under analysis.

The conducted experiment did not show any effect of the used microbiological preparation on the components of spring barley yield cultivar Sebastian (Table 2). The obtained results are confirmed by Martyniuk and Księżak [2011] who, on the grounds of their research as well as other international experiments, claim that preparations labelled as Microbiologically Effective (EM) do not have a significant effect on yield or soil properties.

To a certain extent, the results obtained in the research can be explained by the fact that the experiment was conducted on soil with relatively high pH, which results in the decrease of alkalizing effect of introduced fertilizers.

Tab. 2. Effect of fertilization (N) and the use of preparation of microbiological on yield and yield components of spring barley cv. Sebastian

Trait	Variant	Preparation of microbiological		Average
		without preparation	with preparation	
Yield [Mg ·ha^{-1}]	1	7,44	7,07	**7,25**
	2	6,98	7,48	**7,23**
	3	7,28	7,29	**7,29**
	4	6,34	7,39	**6,86**
	5	6,87	7,07	**6,97**
	6	6,99	7,40	**7,20**
Average		**6,98**	**7,28**	**7,13**
$LSD_{0.05}$ for		**F - n.s.; P – n.s.; F x P – n.s**		
Number of plants per m^2	1	242	240	**241**
	2	292	270	**281**
	3	290	252	**271**
	4	264	292	**278**
	5	300	284	**292**
	6	246	304	**275**
Average		**272**	**274**	**273**

$LSD_{0.05}$ for		**F - n.s.; P – n.s.; F x P – n.s.**		
Number of ears per m^2	1	602	636	**619**
	2	590	622	**606**
	3	572	608	**590**
	4	602	608	**605**
	5	590	642	**616**
	6	598	686	**642**
Average		**592**	**634**	**613**
$LSD_{0.05}$ for		**F -28,4; P – 26,2; F x P – n.s.**		
Number of grains per ears	1	22,0	20,1	**21,0**
	2	19,2	21,0	**20,1**
	3	21,9	20,9	**21,4**
	4	20,0	21,0	**20,5**
	5	20,2	19,8	**20,0**
	6	19,7	19,6	**19,7**
Average		20,5	20,4	**20,4**
NIR $_{0,05}$ dla:		**F - n.s.; P – n.s.; F x P – n.s.**		
Weight of 1000 seeds [g]	1	56,3	55,1	**55,7**
	2	62,3	57,4	**59,8**
	3	58,2	57,4	**57,8**
	4	52,8	57,7	**55,3**
	5	57,3	55,8	**56,6**
	6	59,4	55,0	**57,2**
Average		**57,7**	**56,4**	**57,1**
$LSD_{0.05}$ for		**F - n.s.; P – n.s.; F x P – n.s.**		

Physiological parameters of plants

Chlorophyll content in leaves (SPAD)

Tab. 3 Changes of chlorophyll content in of spring barley cv. Sebastian leaves (SPAD)

Variant	Preparation of microbiological		Average
	without preparation	with preparation	
1	48,9	51,1	**50,0**
2	54,8	57,2	**56,0**
3	56,1	56,6	**56,4**
4	52,6	53,4	**53,0**
5	45,9	56,1	**51,0**
6	52,4	56,4	**54,4**

Average	**51,8**	**55,1**	**53,4**
$LSD_{0.05}$ for	**F- 4,05; P – n.s. ; F x P – 5,72**		

In the conducted experiment, the mean value of SPAD was 53.4 and was comparable to that obtained by Liszewski et al. [2012], i.e. 51.4 for this cultivar. The use of calcium (2) as well as ash (3) resulted in an increase of chlorophyll in leaves of spring barley, as compared with the data obtained for control variant.

The results obtained by various authors [Fatyga 1995; Pecio and Bichońska 2003; Liszewski 2008] indicate that SPAD measurements, which reflect the nutritional state of plants (nitrogen uptake), are higher due to increase of the fertilizer dose. However, in the conducted experiment, the increase in nitrogen dose by means of use of BIOTOP compost, did not result in the increase of chlorophyll content in the leaves of barley grown as a part of the experiment. The result of total use of ash, calcium and compost was comparable to the results obtained with the use of calcium and ash (Table 3). It can be attributed to the high yield obtained in the control mode. The direct relationship between the increase of the SPAD values and the yield proves that the lack of increase in yield due to used fertilizer is reflected in the lack of changes in SPAD readings (Table 2 and 3).

The use of Effective Microorganisms microbiological preparation contributed to the certain increase in chlorophyll levels in barley leaves, however it was statistically insignificant – variations in the reactions of plants from individual fertilizer modes were random (Table 3).

Leaf area index (LAI)

The values of the leaf area index for the spring barley cultivar Sebastian (Table 4) varied due to the use of different fertilizer components and ranged from 3.81 to 6.24 m^2/m^2. The highest values of LAI index were obtained for the control variant. The use of ash, calcium or both fertilizers simultaneously had a negative effect on the properties under analysis. Value comparable to that obtained for control variant was determined for variant 6 (calcium + ash + compost).

The use of Effective Microorganisms microbiological preparation had a positive effect on the amount of assimilation area of crop per unit of the area LAI, as compared to results obtained for fertilizer variants without preparation.

Tab. 4. Effect of fertilization (N) and the use of preparation of microbiological on leaf area index of spring barley cv. Sebastian (LAI)

Variant	Preparation of microbiological		Average
	without preparation	with preparation	
1	5,60	5,67	**5,63**
2	4,43	5,30	**4,86**
3	3,95	6,24	**5,09**
4	3,81	4,67	**4,24**
5	5,11	5,11	**5,11**
6	5,37	5,08	**5,22**
Average	**4,71**	**5,34**	**5,03**
$LSD_{0.05}$ for	**F- 0,257; P – 0,154; F x P – 0,363**		

CONCLUSIONS

There was no significant effect of the use of fertilizer variants on the increase of spring barley yield, cultivar Sebastian.
Only the increase in the number of grains per spike of spring barley cultivar Sebastian was found following fertilization with three components: calcium, ash and compost.
Due to the use of Biotop compost fertilizer, the content of chlorophyll in the leaves of spring barley cultivar Sebastian (SPAD) decreased.
Fertilizer in the form of Biotop compost caused the increase of assimilation surface of crop per area unit (LAI).
The use of EM microbiological preparation did not have any effect on the analysed parameters characteristic for spring barley cultivar Sebastian: yield, the number of grains per spike, and SPAD values.
The positive effect of EM microbiological preparation on the size of the assimilation area of crop per area unit (LAI) was found.

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WPŁYW STOSOWANIA WAPNA, POPIOŁU Z BIOMASY I KOMPOSTU ORAZ PREPARATU „EFEKTYWNE MIKROORGANIZMY" NA PLONOWANIE I KOMPONENTY PLONU JĘCZMIENIA JAREGO

STRESZCZENIE

Doświadczenie polowe przeprowadzono w roku 2013 w Duninowie [51°21′N, 21°40′E]. Badanymi czynnikami były: I. 6 wariantów nawożenia, II. 2 poziomy stosowania preparatu mikrobiologicznego. Celem przeprowadzonych badań była ocena wpływu popiołów z biomasy, nawozu wapniowego oraz biokompostu (BIOTOP) w połączeniu z preparatem mikrobiologicznym "Efektywne Mikroorganizmy". Przedmiot badań stanowiła analiza wpływu tych nawozów wprowadzonych do gleby na plon i strukturę plonu oraz parametry fizjologiczne jęczmienia jarego odm. Sebastian. Nie stwierdzono statystycznie istotnego wpływu zastosowanych wariantów nawozowych na wzrost plonu jęczmienia jarego odm. Sebastian. W wyniku wprowadzenia nawozu w postaci kompostu Biotop uzyskano obniżenie zawartości chlorofilu w liściach jęczmienia jarego odm. Sebastian (SPAD). Zastosowanie preparatu mikrobiologicznego nie miało wpływu na analizowane w doświadczeniu parametry fizjologiczne (plon, obsada kłosów i wartość SPAD) charakteryzujące jęczmień jary odm. Sebastian. Odnotowano dodatni wpływ preparatu mikrobiologicznego na wielkość powierzchni asymilacyjnej łanu przypadającą na jednostkę powierzchni (LAI)

Słowa kluczowe: popioły z biomasy, biokompost, jęczmień jary, nawożenie