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THE EFFECT OF PRE-SOWING SEED TREATMENT WITH BIOPREPARATIONS ON PRODUCTIVITY OF CULTIVARS OF *Triticum spelta* L.

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Abstract

The article presents the results of scientific research devoted to the study of the productivity of spelt wheat depending on the varietal characteristics and pre-sowing treatment of seeds with biopreparations. Field tests were carried out during 2016-2018 on the experimental field of the Educational, Scientific and Practical Center of the Mykolaiv National Agrarian University in four repetitions by the method of the split sites. It was studied the influence of varietal characteristics and pre-sowing seed treatment with Organic-balance and Liposam biopreparations on the main elements of productivity of winter wheat spelt in conditions of southern Ukraine. We found that all the studied factors had an impact on grain yield and the main elements of spelt wheat productivity. The largest number of productive stems (780 PCs/m²) and the highest height (131.5 cm) were formed by plants of the variety Zorya Ukrainy in the variant with pre-sowing treatment of seeds Organic-balance (1 l/t) + Liposam (0.3 l/t). We also determined that factor B (pre-sowing treatment of seeds with biopreparations) did not significantly affect the formation of the main elements of the ear productivity, while factor A (varieties) had a significant impact. The most productive ear was at the Europa plant variety in the variant of pre-sowing seed treatment with Organic-balance + Liposam: ear grain content was 32.3 PCs the weight of the grain on 1 spike was 1.26 g. 1000 seeds weight was formed on the variety Zorya Ukrainy as 46.3 up to 47.0 g depending on pre-sowing seed treatment with biopreparations. It was found that the highest yield of spelt wheat (5.74 t ha^{-1}) was obtained by sowing the variety Europa in the variant with pre-sowing treatment of seeds with Organic-balance and Liposam, but the difference between the first variant of seed treatment (Organic-balance) was insignificant.

Key words*: Triticum spelta L. varieties, biopreparations, ear productivity, weight of 1000 seeds, grain yield.*

INTRODUCTION

Today in the world topical issues are the expansion of acreage and increasing grain yield of one of the oldest varieties of wheat - *Triticum spelta* L. (Babenko et al., 2008; Konvalina et al., 2013). European spelt is the result of hybridization of soft and tetraploid wheat (Poltoretskyi et al., 2018; Antofie and Sand, 2018; Dvorak et al., 2012).

This recently forgotten type of wheat was common in Germany and Switzerland during the late Neolithic period due to its high nutritional quality and exceptional frost resistance. For example, in the winter of 1900-1901yrs in Germany, 38% of winter wheat and only 1% of spelt were frozen.

Therefore, the areas under this culture were constantly growing and in 1900 they amounted to 314671 hectares in Germany, 39000 hectares in Switzerland, 5000 hectares in Austria (Hordienko, 1970).

Health benefits and unsurpassed taste of products made from spelt grains in the last decade caused a significant demand among consumers in Western Europe, America, Canada, Australia, who lead a healthy lifestyle, as well as people suffering from celiac disease (Dubois et al., 2018; Pazek and Rozman, 2011; Zorb et al., 2007).

Spelt grain has a higher energy value compared to soft wheat, it contains more fat, beta-carotene retinol; its gluten is more tensile, but less elastic. A floury endosperm, high protein and high drove viscosity by amillograph index are favorable properties of the grain when it used for the manufacture of cakes and confectionery (Liubych et al., 2017; Rajnincova et al., 2018; Wiwart et al., 2017).

In addition, spelt is a fairly common type of wheat in organic farming, because it has a number of advantages over soft wheat: it is not demanding on soil fertility, it has a high competitiveness to weeds, the power of the root

system, resistance to major diseases and pests, high winter and frost resistance, its grain contains a high mass fraction of protein (up to 28%) and gluten (up to 58%) (Konvalina et al., 2012; Hussain et al., 2009; Biel et al., 2016; Bavec et al., 2012). This crop is able to form a stable crop after the worst predecessors, with late sowing, lower doses of fertilizers and worse moisture supply. High germination, even under adverse conditions, combined with the high ability of plants to tillage and the formation of large grains allow to obtain stable grain yields of this crop (Lacko-Bartošová et al., 2010; Borysova and Ruzhitskaya, 2015). Since 2012, Ukraine has also been increasing the production of organic products and in recent years it is among the top ten world leaders in the area of organic crops, in particular 11.4% of the certified world area of spelt wheat (Willer and Lernoud, 2017).

The disadvantage in the cultivation of this crop is that its yield is less by 10-50% than soft wheat yield mainly through the fragility of the ear rod and the severity of threshing, as well as some agrotechnical difficulties in carrying out sowing through sowing seeds in scales (Srámek et al., 2009).

The value of spelt wheat grain and prospects of its cultivation in organic farming were substantiated in the world science and practice (Koutis, 2015; Ugrenović et al., 2018). However, the emergence of modern varieties and a large number of biopreparations (Kyrychenko, 2015) requires a revision of technologies for growing grain crops, including spelt wheat, which provides for the replacement of mineral fertilizers and chemical pesticides with biopreparations in order to increase the yield and quality of grain and create the most favorable conditions for the restoration of soil fertility in the organic farming system. And it is this question that most scientists today have not fully resolved.

MATERIALS AND METHODS

Field research was carried out during 2015-2018 years on the experimental field of the Educational, Scientific and Practical Center of the Mykolaiv National Agrarian University to study the effect of seed treatment with biopreparations on the growth and development and productivity of crops of spelt wheat varieties. The predecessor was peas. Sowing time was October 1. Seeding rate was 200 PCs/m². For sowing, non-threshed spikelets were used at the rate that each spikelet contains an average of 2.5 grains.

The scheme of experience included: factor A as domestic varieties of spelt wheat: Zorya Ukrainy (2012 registration year) and Europa (2015 registration year); factor B (seed treatment with biopreparations): control (seed treatment with water 10 l/t), Organic-balance (1.0 l/t), Organic-balance (1.0 l/t) + Liposam (0.3 l/t).

The variants were placed in the experiment by the method of split plots, the repetition of the experiment was fourfold. The area of the registration area was 25 m². Soil of research areas was southern black soil humus, light clay-loam soil on wide slightly drained loess on the watershed plateau, typical for the area of Southern Steppe. Their arable layer contains an average of 2.4% humus, light-hydrolyzed nitrogen as 16 mg/kg, mobile phosphorus as 160 mg/kg and exchanged potassium as 187 mg/kg of soil.

The studied biopreparations were Organic-balance and Biological sticking agent Liposam manufactured by Ukrainian producer of microbial and enzyme products for agriculture company "BTU-center". Organic-balance is listed in the list of auxiliary products for use in organic production, taking into account the requirements of the standard of international accredited certification bodies from organic production and processing.

Density and tillering of plants were determined on specially assigned test areas with a size of 1/6 m². The height of plants was determined in the phase of wax ripeness of grain.

RESULTS AND DISCUSSIONS

Productivity is the main feature that characterizes the economic value of the variety. It depends on the basic elements of the structure of winter wheat crops, in particular, the number of plants and productive stems per unit area, the number of spikelets and grains in the ear and their mass, the mass of grain of one ear, the ratio between grain and straw, which determine the potential productivity of wheat.

All these elements vary depending on the soil and climatic conditions of the area, agrotechnical factors and biological characteristics of the varieties, which leads to an increase or decrease in yield (Ugrenović et al., 2018).

The number of productive stems per unit area is an essential element of the yield structure, which is formed by the seeding rate, field germination, temperature, moisture supply, total and productive tillering and plant survival (Korkhova et al., 2018; Nozdrina, 2014).

Both insufficient and excessive tillering reduces yields due to the low number of productive stems, densing and lodging (Kiss et al., 2018; Zecevic et al., 2014). In conditions of the Steppe, the advantage is the sowing of varieties with an increased number of productive stems, especially in dry years. Therefore, the formation of the necessary structure of sowing should take into account the characteristics of the variety and all of its above mentioned ability to form stems.

Studies shown that the tillering coefficient of spelt wheat is 2-3 times higher than that coefficient of soft wheat (Morgun et al., 2016; Pospišil et al., 2011).

Studies with winter wheat varieties were conducted in different weather conditions years, which made it possible to better determine their productivity potential. The results of the research determined that the factor A (varieties) significantly influenced on the coefficient of productive tillage over the years, depending on the pre-treatment of seeds with biopreparations. Thus, the highest productive tillering in the years of research was characterized by the variety of wheat spelt Zorya (st.), the coefficient of productive tillering of plants which was the highest (from 10.6 up to 10.9) in 2016 year, and the lowest (4.7-5.1) in 2017, while for variety Europa it was from 6.1 up to 7.7 and from 4.5 up to 4.7, respectively (Table 1).

Table 1. Influence of varietal characteristics and pre-sowing treatment of wheat spelt seeds with biopreparations on the coefficient of productive tillering of plants, 2016-2018

Variety (factor A)	Pre-sowing seed treatment with biopreparations (factor B)	2016	2017	2018	Average for 3 years
Zorya Ukrainy (st.)	Control	10.6	4.7	5.5	6.9
	Organic-balance	10.8	4.9	5.7	7.1
	Organic-balance + Liposam	10.9	5.1	5.9	7.3
	Average in variety	10.8	4.9	5.7	7.1
Europa	Control	6.1	4.5	3.0	4.5
	Organic-balance	6.5	4.7	3.2	4.8
	Organic-balance + Liposam	7.7	4.7	3.2	5.2
	Average in variety	6.8	4.6	3,.1	4.8
The least significant difference (LSD) at p<0.05: factor A		0.54	0.22	0.20	0.17
The least significant difference (LSD) at p<0.05: factor B		0.24	0.09	0.15	0.11

During years LSD on the B factor was from 0.20 up to 0.54. The coefficient of productive tillering of plants in the variety Zorya Ukrainy was 7.1, the average for the three years of research was by 67.6% higher than the variety Europa.

Pre-sowing seed treatment with biopreparations had significantly lower impact on this indicator. Productive tillering of wheat plants spelt was the biggest (from 5.2 up to 7.3) in both of the studied varieties as it was the second variant with seed treatment (Organic-balance + Liposam), which was by 5.5% more than the control variety Zorya (st.) and it was by 13.5% more than the variety Europa.

It is known that plant height is important in the formation of winter wheat productivity (Liu et al., 2010) and, therefore, it is a genetic trait of the variety (Zečević et al., 2005).

As a result of our research, it was found that the highest plants of the variety Zorya Ukrainy were formed, the height of which on average for 2016-2018yrs ranged from 130.7 up to 134.5 cm depending on the pre-sowing treatment of seeds with biopreparations, which was by 8.2-9.0 cm more than in plants of the Europa variety (Figure 1).

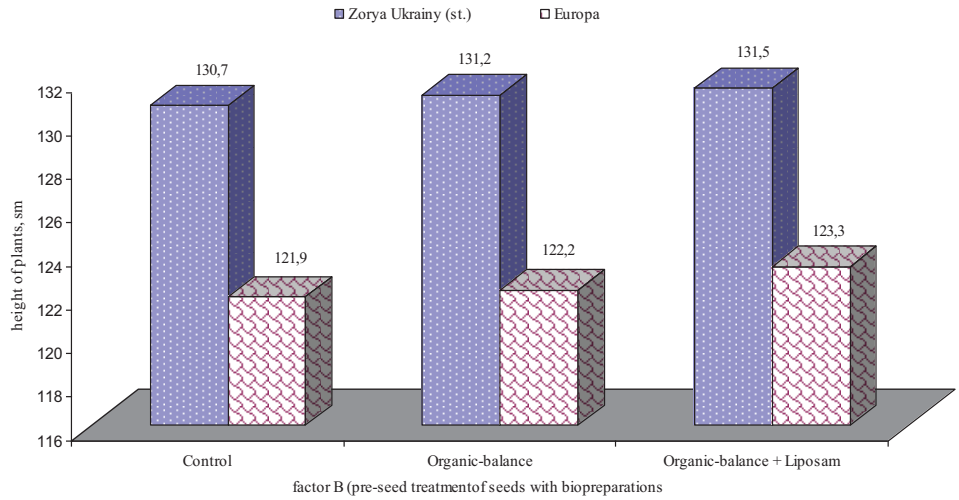

Figure 1. Height of spelt wheat plants (cm) depending on varietal characteristics and pre-sowing seed treatment with biopreparations, 2016-2018

Factor B had little effect on the formation of spelt wheat plant height. So, on average, over the years of research, the height of both varieties was the highest (131.5 cm and 123.3 cm) as it was formed in spelt wheat plants with pre-sowing treatment with Organic-balance + Liposam, which was by 0.8-1.4 cm higher than the control.

It was found that the highest density of the productive stem of spelt wheat (780 PCs/m²) was formed in plants of the variety Zorya Ukrainy by pre-sowing seed treatment with Organic-balance (1 l/t) + Liposam (0.3 l/t), which was by 1.0% higher than the second variant of seed treatment (Organic-balance) and it was by 1.8% higher than the control.

Significantly lower number of productive stems per 1 m^2 was formed by variety Europa. Thus, on average, for 2016-2018 year, the density of the productive plant stem by pre-sowing seed treatment with Organic-balance was 595 PCs/m², by treatment with Organic-balance + Liposam it was 598 PCs/m², which exceeded the control by 1.2% and 1.7%, respectively. Thus, the variety of winter wheat spelt Zorya Ukrainy over the years of research formed the most productive stem as 766-780 PCs/m² depending on factor B, which was by 23.1-23.3% less than the variety Europa (Figure 2).

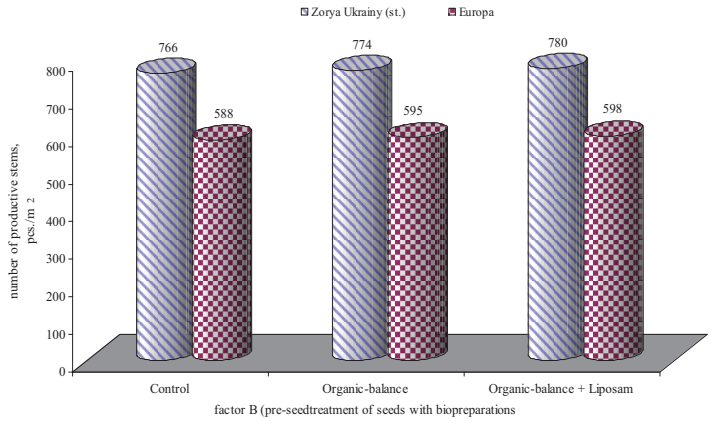

Figure 2. Number of productive stems (PCs/m²) of spelt wheat depending on varietal characteristics and pre-sowing seed treatment with biopreparations, 2016-2018

However, adjusting only the density of the stem, it is not always possible to provide a high yield. For increasing the level of productivity of winter wheat it should be also increased the productivity of the ear, which depends on many factors, the main of them are the genetic characteristics of the variety and cultivation technology.

Our studies found that the variety of wheat spelt Zorya Ukrainy for three years of research formed a long ear (13.5 cm) with the largest number of spikelets in the ear (17.1 PCs/ear), which was by 6.7% and 5.3%, more than such indicators of the variety Europa, respectively (Table 2).

Table 2. Influence of varietal characteristics and pre-sowing seed treatment with biopreparations on the main elements of spelt wheat ear productivity, 2016-2018

Variety (factor A)	Pre-sowing seed treatment with biopreparations (factor B)	The length of the ear, sm	Number of spikelets pcs/ear	Number of grains, pcs/ear	Grain weight of 1 ear (g)
Zorya Ukrainy (st.)	Control	13.3	17.0	25.6	1.02
	Organic-balance	13.5	17.2	26.1	1.06
	Organic-balance + Liposam	13.6	17.2	26.5	1.07
	Average in variety	13.5	17.1	26.1	1.05
Europa	Control	12.5	15.7	30.7	1.19
	Organic-balance	12.6	16.3	32.0	1.22
	Organic-balance + Liposam	12.8	16.5	32.3	1.26
	Average in variety	12.6	16.2	31.7	1.22
The least significant difference (LSD) at p<0.05: factor A		0.18	0.4	0.4	0.02
The least significant difference (LSD) at p<0.05: factor B		0.11	0.6	0.5	0.01

But the number of spikelets in the ear little determines the productivity of winter wheat. The second most important element of the crop structure is the number of grains in the ear, which is determined by the meteorological conditions of the year, varietal characteristics and technology model. The highest grain number in ear was obtained by the variety Europa, which on average over three years formed as 31.7 pieces/ear, as it was by 17.7% more than such number the variety Zorya Ukrainy.

To a large extent, the productivity of the ear depends on the mass of grain from 1 ear. In our studies, this indicator was higher in plants of the variety Europa and on the average on B factor it was 1.22 g, which was by 13.9% higher than such indicator of the variety Zorya Ukrainy.

At the final stages of development of winter wheat plants, the highest level of productivity is achieved due to the better fullness of the grain, which is characterized by such indicator as the mass of 1000 grains, which is a clearly expressed varietal characteristic (Lacko-Bartošová et al., 2010). Our studies shown that the variety Zorya Ukrainy formed on average for the years of research (2016-2018) the heaviest grain, the 1000 seeds weight of which variety on average varied depending on pre-treatment of seeds with biopreparations from 46.3 up to 47.0 g (Figure 3).

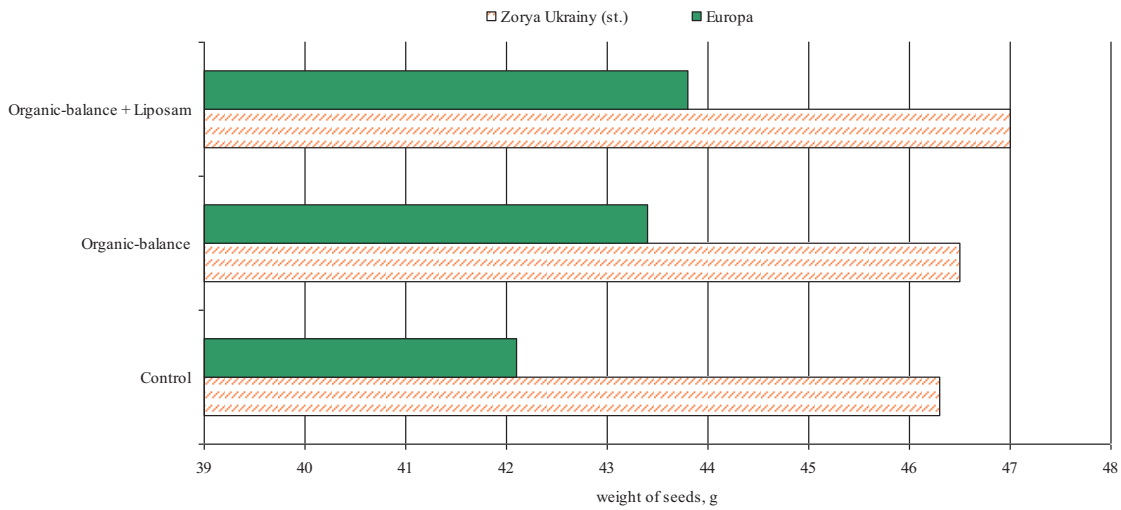

Figure 3. 1000 seeds weight of spelt wheat depending on varietal characteristics and pre-sowing treatment of seeds with biopreparations (2016-2018) (g)

Slightly lower, that indicator formed on the variety Europa from 42.1 up to 43.8 g, it was by 6.8-9.1% less than such indicator of the variety Zorya Ukrainy. According to the results of the dispersion analysis it was found that the factor B had a negligible effect on the formation of the 1000 seeds weight of the studied spelt wheat varieties, the share of which factor was only 7%.

By many scientists it was studied the positive effect of biopreparations on grain yield in the cultivation on the organic technology (Zrckova et al., 2017; Jablonskyte-Rasce et al., 2013).

Our studies found that, on average, over the years of research, the highest grain yield (as 4.32 t/ha^{-1} and 5.74 t/ha^{-1}, respectively) was obtained from both studied varieties in the variant with pre-sowing treatment of seeds with Organic-balance + Liposam, as it exceeded control by 0.21 and 0.44 t/ha^{-1} (Table 3).

Table 3. Influence of varietal characteristics and pre-sowing seed treatment with biopreparations on grain yield of spelt wheat (t/ha^{-1})

Pre-sowing seed treatment with biopreparations (factor B)	2016	2017	2018	Average for 3 years
Variety Zorya Ukrainy (st.) (factor A)				
Control	4.03	4.21	3.41	3.88
Organic-balance	4.55	4.42	3.65	4.21
Organic-balance + Liposam	4.78	4.53	3.66	4.32
Average factor B	4.45	4.39	3.57	4.14
Variety Europa (Factor A)				
Control	6.24	6.10	4.25	5.53
Organic-balance	6.55	6.21	4.40	5.72
Organic-balance + Liposam	6.51	6.26	4.46	5.74
Average factor B	6.43	6.19	4.37	5.66
The least significant difference (LSD) at p<0.05: factor A	0.26	0.10	0.17	0.09
The least significant difference (LSD) at p<0.05: factor B	0.11	0.18	0.09	0.07

Table 3 shows that the yield of the studied spelt wheat varieties varied during the years of research. So, the highest grain yield was obtained in 2016 as 4.03 up to 4.78 t/ha^{-1} for the variety Zorya Ukrainy and it was 6.24 up to 6.51 t/ha^{-1} for the variety Europa. In 2018 the lowest grain yield was from 3.41 up to 3.66 t/ha^{-1} and from 4.25 up to 4.46 t/ha^{-1}, respectively.

According to the results of the analysis of variance found that the greatest impact on the formation of grain yield of spelt wheat was by factor A (variety), the share of that factor of in the grain yield varied over the years: such as 94% - in 2016; 98% - in 2017; 92% - in 2018.

CONCLUSIONS

The highest coefficient of productive tillering (7.1) and the most productive stem stand (766-780 PCs/m²) was formed in plants of the variety Zorya Ukrainy, as in average for three years of research which studied indicators by 67.6% and 23.1-23.3%, respectively for the exceed indicators of the variety Europa. The longest ear (13.5 cm), with the highest number of spikelets (17.1 PCs/spike) was formed from plants of the variety Zorya Ukrainy, and the largest ear grain content (31.7 pieces/ear) was had by the variety Europa. The largest mass of 1000 seeds of wheat was formed by the variety Zorya Ukrainy as 46.3 up to 47.0 g depending on pre-sowing seed treatment with biopreparations. The highest grain yield (4.32 and 5.74 t/ha^{-1}) was obtained from both studied varieties in the variant with pre-sowing treatment with Organic-balance + Liposam seeds, as it exceeded the control by 0.21 and 0.44 t/ha^{-1}. Thus, given the market conditions and favorable soil and climatic conditions, the selection of spelt varieties and the search for opportunities to optimize growth processes, for the implementation of the potential crop yield will contribute to the growth of organic production in the country, as it is a natural phenomenon against the background of a significant demand for "healthy" products worldwide.

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