

Formation of the Main Indicators of Grain Quality of Winter Barley Varieties Depending on Biopreparations for Growing under the Conditions of the Southern Steppe of Ukraine

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ABSTRACT

The article presents the data of the results of research conducted under the conditions of the educational and scientific practical center of the Mykolaiv NAU during 2016–2019 with four varieties of winter barley. The influence of foliar top dressing with modern biopreparations and growth-regulating preparations in the main periods of vegetation of plants on the grain quality indicators was determined. It was found that the protein content in grain depended and varied on the preparation taken for processing barley crops, the time of top dressing, varietal characteristics of winter barley, and significantly on the weather conditions of the growing year. Similarly, under the influence of these factors, other indicators of grain quality have changed.

Keywords: winter barley, varieties, grain quality, protein content, foliar top dressing, biopreparations.

INTRODUCTION

In recent years, microelements and growth regulators have been used to optimize plant nutrition and regulate growth processes. They have a positive effect on the metabolism of cultivated plants, enhance growth processes as well as resistance to adverse environmental conditions (droughts, temperature changes, diseases, damage by harmful organisms, etc.). Of course, these positives of growth-regulating preparations and trace elements contribute to increasing the level of yield and improving the quality of products [Gromov et al. 2005, Girka et al. 2013, Gamayunova et al. 2019, Huang et al. 2019, Shulaev et al. 2008].

It is known that the yield and the main components that determine the grain quality of all grain crops significantly depend and change under the influence of nutrition [Klimishina 2012, Panfilova et al. 2020]. The crop of barley (winter and spring) reacts the most to the application of fertilizers. Thus, the growth of winter barley grain from mineral nutrition, as determined by earlier studies with fertilizers in typical crop rotations

[Dmitrenko 1988], and in recent years [Gamayunova 2020], can reach up to 50% compared to the control. Fertilizers provide particularly high yield gains on depleted soils in favorable years for moisture, or on irrigation, where their efficiency can reach even 75%.

The yield and main quality indicators of winter barley grain significantly depend, in addition to the agroclimatic conditions, on the cultivation measures. In particular, the research of Cherenkov et al. [2011] found that the level of winter barley yield in the northern part of the steppe of Ukraine by 79% may depend on the conditions of overwintering. According to the results of the studies conducted in 2013–2015 on dark gray podzolic soils of the Western forest-steppe, it was also determined that the yield of winter barley grain depended and it was determined by the score of winter hardiness and resistance to lodging. Thus, according to the authors, the genetic yield potential (8.0 t/ha of grain is accepted) in the context of varieties was realized by 71–85% [Veremeenko et al. 2017]. Researchers found that the interaction of the genotype of a variety and

the environment determined the duration of the growing season. This trait affected not only the growth of yield, but also the quality of protein. For example, in dry years, when the growing season of winter crops is shorter, more protein accumulates in the grain [Zhemela and Musatov 1989]. Other scientists also reported an increase in the protein content in winter barley grain due to a shift in the sowing period from early to late [Cherenkov et al. 2012]. In their studies, grain accumulated 9.1% protein during sowing on September 15–17, it accumulated 9.4% protein on September 25–28, and it accumulated 11.4% protein on October 25–29. The authors attributed this result to the influence of higher temperatures and a decrease in soil moisture at different sowing times. The natural weight of grain in their studies, on the contrary, decreased from 623 to 618 G/L when the sowing dates were shifted to later ones.

Mineral fertilizers significantly affect all the processes of growth and development of winter barley plants. Thus, when conducting studies with winter barley two-handed varieties Dostoiny under the conditions of the northern part of the steppe of Ukraine, it was determined that the tillering coefficient increased by 9.9 up to 17.1%, $N_{60}P_{60}K_{60}$ increased by 10.4 up to 16.1% and it increased even further with the combined use of growth-regulating preparations for these fertilizer backgrounds [Tkalic et al. 2016]. The positive impact of this combination on increasing the yield of winter barley grain and the main indicators of its quality was noted.

Similar results of the influence of the combined use of fertilizers with growth-regulating preparations on increasing the grain yield and improving its quality were obtained in the cultivation of spring barley [Chernobay 2014, Panfilova et al. 2020, Gamayunova and Kasatkina 2019], winter wheat [Panchenko et al. 2019, Panfilova 2019], and other grain crops in years with different weather conditions. The research in this direction is extremely relevant in modern agriculture, as the introduction of effective resource-saving technologies allows increasing the level of crop yields, improve their quality, and also it has a positive effect on the preservation and reproduction of soil fertility [Ostapchuk et al. 2015]. After all, there is a direct relationship between the provision of soil with available nutrients, the level of yield and the quality of grown products. The products made from barley and oats, which are defined by

the International Organization FDA (Food and Preparation Administration), the systematic use of which reduces the risk of coronary heart disease are especially important in nutrition. Researchers have proven that the products made from barley grains contribute to the prevention of diabetes [William and Wheat 2012] and even cancer [Aggarwal et al. 2010].

This work aimed to study the winter barley varieties subjected to resource-saving nutrition, which consists in the use of biopreparations and growth-regulating preparations on the main indicators of grain quality.

RESEARCH METHODOLOGY

In order to determine the effectiveness of modern biopreparations and their impact on the main indicators of grain quality, studies were conducted during 2016–2019 with four varieties of winter barley. The varieties taken for study were sown at the optimal time for this climatic zone. The research was conducted in the educational and scientific practical center of the Mykolaiv NAU. The soil of the experimental sites is Southern chernozem, which has an average supply of mobile nutrients, the humus content in the soil layer of 0–30 cm is 2.9 up to 3.2%, pH is 6.8 up to 7.2. The experiment scheme included the following options: Factor A – Grade: 1. Dostoiny; 2. Valkyrie; 3. Oscar; 4. Jason; Factor B – foliar top dressing: 1. control (water treatment); 2. Azotophyte; 3. Mycofrend; 4. Melanoriz; 5. Organic Balance. The studies with the latter were conducted during the periods of 2017–2018 and 2018–2019. The rate of use of preparations was 200 g/ha, and the working solution was 200 l/ha. Foliar top dressing of winter barley was carried out once during the spring tillering phase and twice during the growing season, in addition to tillering, also at the beginning of the stooling phase.

The area of the sown area was 72 m², accounting area was 30 m², the experiment was repeated four times. The predecessor of winter barley was peas. Taking into account the importance of the predecessor and the availability of nutrients in the soil, mineral fertilizers were not applied for winter barley. The agricultural techniques for growing winter barley were generally accepted for the steppe zone of Ukraine, except for the factors taken for study.

RESULTS AND DISCUSSION

The studies conducted with varieties of winter barley established that the use of nutrition optimization in the cultivation of this crop, to a certain extent, affected the quality of grain. First of all, the protein content in grain changed (Table 1). This indicator depended on the preparation taken for top dressing, the number of crop treatments carried out, the conditions of the growing year, and slightly on the characteristics of the variety. In particular, it was determined that the protein content in winter barley grain, regardless of the variety, slightly increased under the influence of foliar top dressing with growth-regulating preparations compared to the control, where plant crops were treated with water. The protein content in the grain increased and varied depending on the amount of top dressing, twice during the growing season on average over the years of research and increased compared to a single treatment during the spring tillering of plants (Fig. 1).

To the greatest extent, under the influence of two top-dressing, on average for 2016–2019, the protein content increased in the winter barley variety Jason. Similar indicators of the protein content were determined in the grain varieties Valkyrie and Oscar. The lowest amount of protein in the grain was distinguished by the Dostoyny winter barley variety. From double top dressing, the protein content in the grain of this variety increased by 0.35% compared to the control, the protein content of Valkyrie increased by 0.30%, and the protein content Oscar and Jason varieties increased by 0.39 and 0.45%,

respectively. Thus, it can be argued that the winter barley variety Jason reacted the most to foliar top dressing, increasing the protein content in the grain compared to the control by 0.45%, and to a lower extent compared to Valkyrie, although the absolute values of the amount of protein on average for three years of cultivation for all preparations were the lowest in the grain of the Dostoyny variety. Similar results were obtained in the studies conducted in the southern steppe zone of Ukraine on the influence of nutrition on the yield and main indicators of grain quality with spring barley varieties, including: and for the use of growth-regulating preparations for top dressing [Gamayunova and Panfilova 2020].

Regarding the effectiveness of the growth-regulating preparations and biopreparations taken for the study regarding their effect on the protein content in the grain of winter barley varieties, preference should be given to Azotophyte and Organic Balance, which contributed to a more significant increase in its content in the grain, compared with the use of Mycofrend and Melanoriz for top dressing (Fig. 2).

Again, a significantly more pronounced effect on the increase in this indicator of double treatment of crops compared to carrying out one top dressing during the spring tillering phase of plants can be seen, and even more so with the control option, in which the sowing of winter barley plants was treated with water.

The results obtained are consistent with the data of the studies conducted during 2011–2013 at the Institute of Irrigated Agriculture (in the Southern steppe zone of Ukraine) [Zayats 2015]. The author reported that foliar top dressing with Crystallon

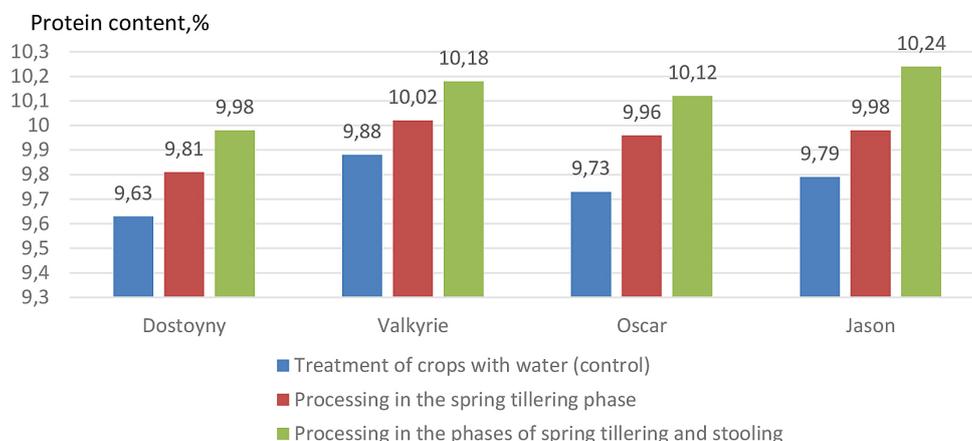


Fig. 1. Influence of foliar top dressing with biopreparations on the protein content in the grain of the studied varieties of winter barley (average for 2017–2019 for all preparations), %

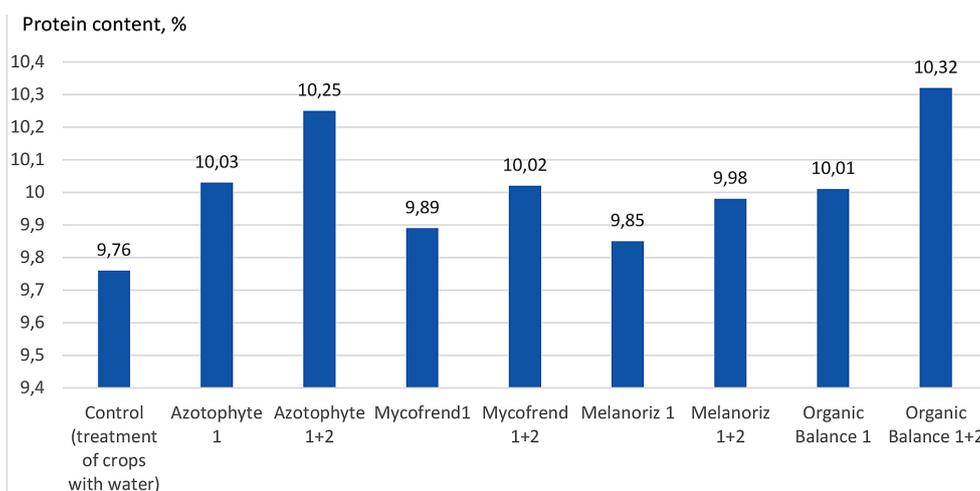


Fig. 2. Protein content in winter barley grain depending on the biopreparation and the amount of top dressing (average for 2017–2019 for the studied varieties)

during the earing of winter barley against the background of the calculated dose of fertilizers and the use of herbicide and fungicide, increased the protein content in the grain up to 9.61% compared to its amount without the use of Crystallon up to 9.21% and 7.95% in the control version.

According to the results of conducted research, the protein content in winter barley grain differed both in the effect of optimizing nutrition by using biopreparations and the variety taken for study, and in the weather and climatic conditions of the growing years (Fig. 3).

Thus, the highest protein content of grain was determined in 2017 studies. Regarding the varietal composition, the Valkyrie variety accumulated the most protein in the grain, both when processing plant crops with water (in control)

and on average for the studied preparations. At the same time, the increase in its content from foliar top dressing in grain of this variety was insignificant and it amounted to only 0.11% compared to the control (11.11 and 11.0%, respectively). In more moisture-friendly growing years, the protein gains in winter barley grains of this variety from nutrition optimization were significantly higher: in 2018, the following factors were observed: 9.70%, and they were in the control 9.31% (+0.39%), in 2019 they were 9.73 and 9.34% (+0.39%), respectively. When growing winter barley of the Oscar variety in the driest year, i.e. 2017, the increase in protein content in grain from top dressing amounted to 0.36% to control, and the increase in protein content of Dostoyny variety amounted to 0.34% (Table. 1).

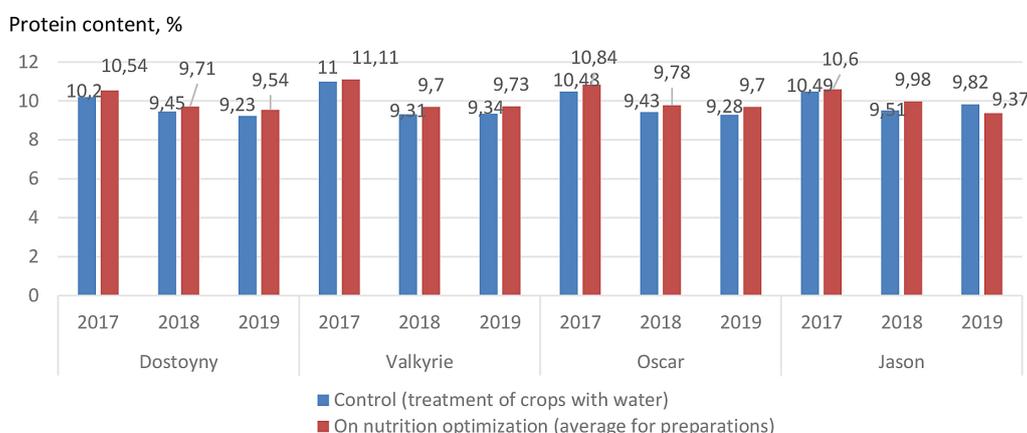


Fig. 3. Protein content in the grain of winter barley varieties depending on the optimization of nutrition in the years of research, %

Earlier studies [Cherenkov et al. 2012] also determined the difference in the amount of protein accumulated in winter barley grain depending on the weather conditions of the growing year. The

authors report that in 2008, the grain accumulated the least amount of protein in terms of moisture, and in 2007 it accumulated the most in terms of elevated temperatures and soil drought.

Table 1. Protein content in the grain of winter barley varieties in the years of cultivation, depending on the use of growth-regulating preparations, %

Variety (Factor A)	Variant of nutrition (Factor B)	Yrs of research			Average for 2017-2019 yrs	
		2017	2018	2019	%	increase in control, %
Dostoiny	Control (water treatment)	10.20	9.45	9.23	9.63	0.00
	Azotophyte 1	10.34	9.57	9.37	9.76	0.13
	Azotophyte 1+2	10.43	9.72	9.63	9.93	0.30
	Mycofrend 1	10.78	9.50	9.26	9.85	0.22
	Mycofrend 1+2	11.00	9.59	9.31	9.97	0.36
	Melanoriz 1	10.20	9.48	9.24	9.64	0.01
	Melanoriz 1+2	10.48	9.62	9.25	9.78	0.15
	Organic-Balance 1	-	9.96	10.02	9.99	0.36
	Organic-Balance 1+2	-	10.21	10.23	10.22	0.59
Valkyrie	Control (water treatment)	11.00	9.31	9.34	9.88	0.00
	Azotophyte 1	11.12	9.67	9.56	10.12	0.24
	Azotophyte 1+2	11.33	9.84	9.72	10.30	0.42
	Mycofrend 1	11.03	9.49	9.41	9.98	0.10
	Mycofrend 1+2	11.09	9.63	9.47	10.06	0.18
	Melanoriz1	11.02	9.51	9.45	9.99	0.11
	Melanoriz 1+2	11.06	9.68	9.52	10.09	0.21
	Organic-Balance 1	-	9.71	10.25	9.98	0.10
	Organic-Balance 1+2	-	10.09	10.43	10.26	0.38
Oscar	Control (water treatment)	10.48	9.43	9.28	9.73	0.00
	Azotophyte 1	10.94	9.69	9.59	10.07	0.34
	Azotophyte 1+2	11.08	9.98	9.82	10.29	0.56
	Mycofrend 1	10.87	9.47	9.34	9.89	0.16
	Mycofrend 1+2	11.02	9.68	9.42	10.04	0.31
	Melanoriz1	10.95	9.45	9.43	9.94	0.21
	Melanoriz 1+2	11.06	9.69	9.52	10.09	0.36
	Organic-Balance 1	-	9.97	9.91	9.94	0.21
	Organic-Balance 1+2	-	10.29	10.22	10.26	0.53
Jason	Control (water treatment)	10.49	9.50	9.37	9.79	0.00
	Azotophyte 1	10.58	9.98	9.88	10.15	0.37
	Azotophyte 1+2	10.80	10.52	10.12	10.48	0.69
	Mycofrend 1	10.49	9.55	9.49	9.84	0.05
	Mycofrend 1+2	10.63	9.77	9.61	10.00	0.21
	Melanoriz1	10.47	9.57	9.45	9.83	0.04
	Melanoriz 1+2	10.60	9.75	9.54	9.96	0.17
	Organic-Balance 1	-	10.16	10.05	10.11	0.32
	Organic-Balance 1+2	-	10.58	10.41	10.50	0.71
HIP 05. on Factor A		0.08	0.05	0.03		
on Factor B		0.11	0.08	0.09		
on Factors A & B		0.15	0.11	0.13		

* Value on Organic-Balance for 2018–2019.

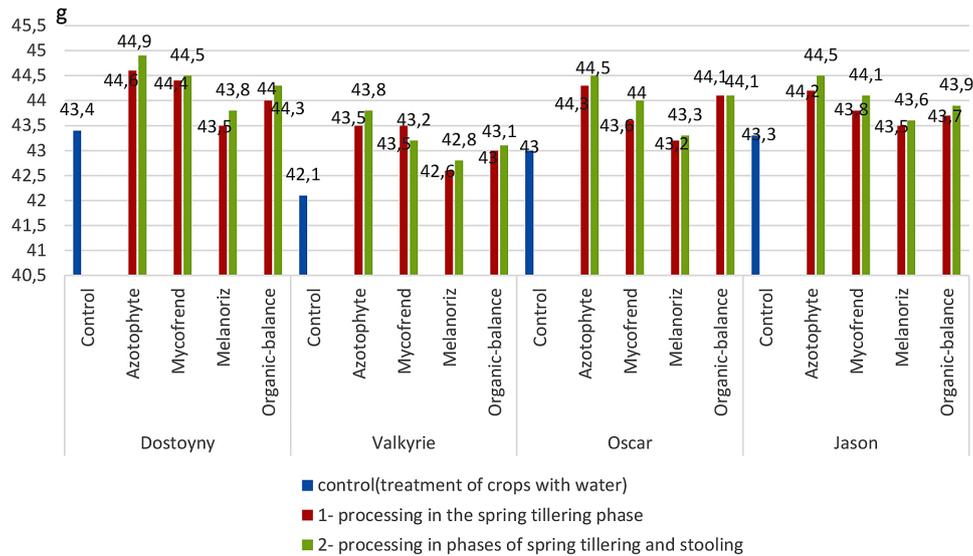


Fig. 4. Influence of foliar top dressing on the mass of 1000 grains of winter barley varieties (average for 2017–2019), g

Comparing the protein content formed in the variety grain of winter barley in the conducted experiments, its maximum increase on average from top dressing for all preparations was in 2019 for Variety Jason and Oscar as 0.45 and 0.42 absolute percent, respectively, according to the control. In the Valkyrie variety its content increased by 0.39 and in the Dostoyny variety it increased by 0.31%. At the same time, it should be noted that during the ripening period of winter barley grain in 2019, a significant amount of precipitation fell, the plants died, which provided both a decrease in the protein content in the grain compared to the previous years of cultivation, and the level of yield due to the difficulties with harvesting. However, it was in this year of research that the protein content for nutrition optimization increased the most compared to the treatment of crops with water.

Optimization of the nutrition of plants of the studied varieties of winter barley to a certain extent affected the mass of 1000 grains. This indicator increased slightly from foliar top dressing with growth-regulating preparations, and to a greater extent with double treatment of plant crops. Variety features affected the mass of 1000 grains less significantly, and it varied more significantly depending on the conditions of the growing year. As for the studied biopreparations, the mass of 1000 grains increased most from the use of Azotophyte, and it was determined to be the smallest by nutrition of plants of all the studied varieties with Melanoriz. This can be clearly indicated on average for three years of cultivation (Fig. 4).

CONCLUSIONS

All biopreparations that were used for foliar top dressing had a positive effect on increasing the protein content in the variety grain of winter barley. However, it grew the most from the use of Organic-Balance and Azotophyte, and to a lesser extent – Mycofrend and Melanoriz. Of the varieties taken for the study, variety Jason accumulated the most protein in the grain, then Valkyrie, Oscar and the least Dostoyny with double top dressing on average over the years of cultivation: 10.24; 10.18; 10.12 and 9.98%, respectively, and for the protein content in the grain of control variants: as 9.79; 9.88; 9.73 and 9.63%, respectively. The amount of protein formed in the winter barley grain, in addition to the studied factors, was significantly affected by the weather conditions of the growing years. In particular, significantly greater amount accumulated in the driest 2017, and the least amount of protein accumulated in a favorable year for humidity in 2019. Foliar nutrition with biopreparations and weather conditions during the years of growing varieties of winter barley affected such a quality indicator as the mass of 1000 grains; in turn, the biological features of varieties affected it to a much lesser extent.

The conducted studies confirmed the expediency of carrying out foliar top dressing in the main periods of vegetation with biopreparations to optimize the nutrition of winter barley plants in order to form a stable grain yield with high quality indicators.

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