Ukrainian Journal of Ecology

Ukrainian Journal of Ecology, 2021, 11(5), 15-20, doi: 10.15421/2021_205

ORIGINAL ARTICLE

Influence of foliar fertilization with micro-fertilizers on physiological grain quality of spring malting barley

O. Gorash[1], R. Klymyshena[1*], O. Zinchenko[2], O. Strilets[2]

[1]State Agrarian and Engineering University in Podilia, Kamianets-Podilskyi, Ukraine
[2]Institute of Bioenergy Crops and Sugar Beet NAAS, Kyiv, Ukraine
**Corresponding author E-mail: KlymyshenaRI@gmail.com*

Received: 12.06.2021. Accepted: 23.06.2021.

The research aims to establish the influence of foliar fertilization of spring barley plants with microfertilizers "Wuxal" during the growing season under different backgrounds of mineral fertilizers on the yield and physiological quality of grain. The following methods were used to generalize the results of the research and scientific substantiation of the purpose: general scientific (to determine the direction of research, planning, and bookmarking the experiment); special (laboratory-to determine physiological parameters); mathematical and statistical (for processing experimental data). The effectiveness of the effect of foliar fertilization of spring malting barley plants with microfertilizers "Wuxal" during the growing season the yield and the physiological quality of grain in terms of energy and ability to germination capacity has been established. When growing barley on the background of mineral nutrition $N_{30}P_{45}K_{45}$, the best variants were two-timed application of microfertilizers "Wuxal Grain" 1.5 L/ha during stem elongation and "Wuxal Grain" 1.5 L/ha at the beginning of the flowering phase and three-times foliar nutrition of plants with microfertilizers "Wuxal P Max" 1.5 L/ha during the tillering phase, "Wuxal Grain" 1.5 L/ha during stem elongation and "Wuxal Grain" 1.5 L/ha at the beginning of the flowering phase, where germination energy was 98.2% and 98.7%, and grain germination ability was 98.8% and 98.9%, respectively. Against the background of mineral nutrition $N_{60}P_{90}K_{90}$ variants for double application of microfertilizers were also the best "Wuxal Grain" 2.0 L/ha during stem elongation and "Wuxal Grain" 2.0 L/ha at the beginning of the flowering phase and three-times foliar nutrition of plants with microfertilizers "Wuxal P Max" 2.0 L/ha during the tillering phase, "Wuxal Grain" 2.0 L/ha during stem elongation and "Wuxal Grain" 2.0 L/ha at the beginning of the flowering phase, where the germination energy was 97.8% and 98.0%, and the ability to germinate grain -97.9% and 98.1%, respectively.
Keywords: Spring barley, grain yield, physiological quality of the grain, germination energy, germination ability, micro-fertilizers, foliar nutrition.

Introduction

Barley is the primary cereal used for the brewing industry (Gupta et al., 2010; DeSalle and Tattersall, 2020; Dráb et al., 2013; Zavřelová et al., 2021). It is known that the quality of malting barley depends on many factors - biological, environmental, and technological (Gorash et al., 2020; Przulj et al., 2014). In its assessment of brewing needs, in addition to the biochemical quality of the grain, considerable attention is paid to physiological properties (Klymyshena, 2011). That is why our research task was to study the effect of foliar nutrition of plants during growth and development under different backgrounds of mineral nutrition on physiological indicators of quality - energy, and ability to germinate grain.

Malt is the primary raw material used for beer production, which is why its quality is essential. Malt is obtained by controlled germination of barley grain (Hordeum vulgare L.), characterized by soaking it in water followed by germination (Woonton et al., 2005).

In order to obtain high-quality homogeneous malt, it is necessary to achieve important indicators, such as germination energy and grain germination ability (Frančáková et al., 2012). Essential characteristics of barley to ensure the technological process of malting include the ability to germinate grain (Briggs, 1998). Germination is a process in which there is an increase in bioactive compounds and modification of the endosperm of barley grains due to the enzymes of the cytase group (Madhujith and Shahidi, 2007).

The substances of the flour body of barley grains before the malting process are in a stable high-molecular state in which they can be stored for hundreds of years. To become available for the biological activity of yeast, they must be "broken down" into low molecular weight products. Cleavage also occurs under the influence of enzymes synthesized during germination. Enzymes are formed due to hormones, which with the penetration of water from the shield, spread along with the aleurone layer and promote the release of enzymes and their synthesis.

Hormones consist of gibberellic acid and similar substances. Amino acid is separated from them, and enzymes are formed, first β-glucanase, then α-amylase and protease. Alpha-amylases are formed and are not in the aleurone layer but in the endosperm and the first days of germination, this is directly related to grain respiration (Nartsiss, 2007). Accordingly, the main purpose of malting in the germination process is to obtain and activate enzymes. Of all the complex of malt enzymes of particular interest are those that break down carbohydrates (amylase), proteins (proteases), fats (lipases), phosphoric acid ester-cleaving enzymes (phosphatases), cytolytic enzymes (cytases).

It is the breakdown products needed for the yeast to ensure the fermentation process. Starch is broken down during mashing to dextrins, maltotriose, maltose, glucose - these components in the structure depend on enzymes that accumulate in the germinating grain. In non-germinating "inanimate grain" no biochemical transformations occur. Such grain is a ballast material that can significantly lead to negative consequences. Accordingly, enzymes activated and synthesized in the germinating grain, initial fermentation, main fermentation, and fermentation are provided further in the biotechnological process. The percentage of sugars that can be fermented is the final stage of fermentation.

The content of fermented sugars depends on the enzymatic activity. Ungerminated grains, along with insufficient germination energy, cause filtration difficulties, provide a high content of beta-glucan in the wort, which can be a significant factor in the formation of gel filtration problems. Ungerminated grains can be a source of starch, which can cause paste turbidity discoloration. In this regard, technologists focus on the possible so-called "blue cooking".

Barley grain with insufficient germination energy can affect incompletely dissolved parts of the endosperm, especially at the tips of the grain. This can be manifested in the following technological processes (Nartsiss, 2007).

Accordingly, the germination energy characterizes germination in 3 days. It should be as close as possible to the ability to germinate, which is set on the 5th day of analysis. This is noted by European experts (Nartsiss, 2007; Kuntse and Mit, 2001). According to regulatory requirements, barley of medium quality in terms of germination ability should provide at least 95%, ensure good quality - at least 97%, and selected barley can be only when the 5th day of germinated grain will be at least 98%.

Thus, barley grain should have the maximum energy and ability to germinate, i.e., germinate quickly and evenly (Šottníková et al., 2011). This is an important criterion for the quality of malting barley.

The research aims to establish the influence of foliar fertilization of spring barley plants with microfertilizers "Wuxal" during the growing season under different backgrounds of mineral fertilizers on the yield and physiological quality of grain.

Material and methods

The research was performed during 2015-2017 at State Agrarian and Engineering University in Podilia. The variety of spring barley Sebastian was used for research. Placement of experimental variants of foliar fertilization of plants with microfertilizers was randomized. The number of repetitions is four times.

Technological scheme variants of foliar nutrition of plants with microfertilizers: 1) A0-control, without nutrition; 2) A1-one-time foliar nutrition of plants with microfertilizer "Wuxal P Max" during tillering; 3) A2- one-time foliar nutrition of plants with microfertilizer "Wuxal Grain" during stem elongation; 4) A3-one-time foliar nutrition of plants with microfertilizer "Wuxal Grain" at the beginning of flowering; 5) A4-two-times foliar nutrition of plants with microfertilizers "Wuxal P Max" during tillering and "Wuxal Grain" during stem elongation; 6) A5-two-times foliar nutrition of plants with microfertilizers "Wuxal P Max" during tillering and "Wuxal Grain" at the beginning of flowering; 7) A6-two-times foliar nutrition of plants with microfertilizers "Wuxal Grain" during stem elongation and "Wuxal Grain" at the beginning of flowering; 8) A7-three-times foliar nutrition of plants with microfertilizers "Wuxal P Max" during tillering, "Wuxal Grain" during stem elongation and "Wuxal Grain" at the beginning of flowering.

The experimental plots for the background of mineral nutrition of barley plants $N_{30}P_{45}K_{45}$ -the single-use of microfertilizers "Wuxal" 1.5 L/ha, and for the background $N_{60}P_{90}K_{90}$ -the rate of single-use of microfertilizers "Wuxal" 2.0 L/ha. Physiological analyzes were performed based on the method of grain analysis according to State Standard of Ukraine 3769-98. The germination energy of the grain was set during germination after 3 days, germinating after 5 days. Student's criterion ($t_{0.05}$) was used to mathematical analyze the obtained research results (Dospehov, 1985).

Results and Discussion

In the technology of growing cereals, one of the important tasks is the need to ensure quality in crop formation (Poltoretskyi et al., 2000).

As a result of foliar nutrition of barley plants with microfertilizers "Wuxal," the best grain yield results were obtained.

Against the background of mineral nutrition $N_{30}P_{45}K_{45}$ under the conditions of variants A6 - double application of microfertilizers "Wuxal Grain" during stem elongation (1.5 L/ha)+"Wuxal Grain" at the beginning of flowering (1.5 L/ha) and A7 "Wuxal P Max" during tillering (1.5 L/ha)+"Wuxal Grain" during stem elongation (1.5 l/ ha)+"Wuxal Grain" at the beginning of flowering (1.5 L/ha) yield was 6.04 and 6.26 t/ha, respectively, and at the control (without microfertilizers) - 5.83 t/ha.

Against the background of mineral nutrition $N_{60}P_{90}K_{90}$ under the conditions of variants A6 - double application of microfertilizers "Wuxal Grain" during stem elongation (2.0 L/ha)+"Wuxal Grain" at the beginning of flowering (2.0 L/ha) and A7 "Wuxal P Max" during tillering (2.0 L/ha)+"Wuxal Grain" during stem elongation (2.0 L/ha)+"Wuxal Grain" at the beginning of flowering (2.0 L/ha) the yield was 7.22 and 7.44 t/ha, respectively, and at the control (without microfertilizers) -7.04 t/ha.

At the same time, the applied microfertilizers "Wuxal" helped improve the brewing quality of barley in physiological terms.

The obtained research results testify to the influence of "Wuxal" microfertilizers on the background of mineral nutrition $N_{30}P_{45}K_{45}$, both on the germination energy of barley grain and on its ability to germinate. Analysis of data by year confirms this pattern. In terms of germination energy in 2015, significant advantages were obtained compared to the control on variant A5, where two-times foliar fertilization of plants with microfertilizers was used: the first time-during the tillering phase "Wuxal P Max" (1.5 L/ha) and the second time at the beginning of the flowering phase "Wuxal Grain" (1.5 L/ha).

The difference is 1% (t_{fact}-3.10 > $t_{0.05}$-2.45) (Table 1). In 2016, a significant difference was not proved: d -0.6% with the established errors S_x is insignificant. In 2017, it was similarly regular, the difference of 0.4% at t_{fact}-1.76 < $t_{0.05}$-2.45.

Table 1. Energy germination of barley grain depending on microfertilizers "Wuxal" at 1.5 L/ha on the background of $N_{30}P_{45}K_{45}$, %.

Variant of the research		Year			
		2015	2016	2017	Average
A0	Control	96.0 ± 0.26	97.9 ± 0.22	97.1 ± 0.125	97.0
A1	"Wuxal P Max" during tillering	95.8 ± 0.22	97.9 ± 0.29	97.0 ± 0.189	96.9
A2	"Wuxal Grain" during stem elongation	96.1 ± 0.29	97.8 ± 0.25	97.1 ± 0.125	97.0
A3	"Wuxal Grain" at the beginning of flowering	96.6 ± 0.37	98.0 ± 0.37	97.2 ± 0.250	97.3
A4	"Wuxal P Max" during tillering+ "Wuxal Grain" during stem elongation	96.0 ± 0.33	98.0 ± 0.27	97.0 ± 0.350	97.0
A5	"Wuxal P Max" during tillering+ "Wuxal Grain" at the beginning of flowering	97.0 ± 0.19	98.5 ± 0.27	97.5 ± 0.189	97.7
A6	"Wuxal Grain" during stem elongation+"Wuxal Grain" at the beginning of flowering	97.5 ± 0.34	99.1 ± 0.23	98.0 ± 0.320	98.2
A7	"Wuxal P Max" during tillering+ "Wuxal Grain" during stem elongation+"Wuxal Grain" at the beginning of flowering	99.0 ± 0.19	99.2 ± 0.16	98.0 ± 0.189	98.7

Analysis of the data of variant A6 under the condition of double application of microfertilizers "Wuxal Grain" during stem elongation (1.5 L/ha) and "Wuxal Grain" at the beginning of the flowering phase (1.5 L/ha) shows that the results of better energy germination of barley grain compared to the control variant were stable over the years. In 2015, the difference was 1.5%, in 2016 - 1.2%, in 2017-0.9%: t_{fact} -3.50; 3.77; 2.62 at $t_{0.05}$-2.45.

A similar pattern of differences compared to the control was in the data of variant A7 with three-times uses of microfertilizers "Wuxal P Max" during the tillering phase (1.5 L/ha), "Wuxal Grain" during stem elongation (1.5 L/ha), and "Wuxal Grain" at the beginning of the flowering phase (1.5 L/ha). The difference in 2015 was 3%, in 2016-1.3%, and in 2017-0.9% according to the established Student's criterion, respectively t_{fact} -9.32; 4.78 and 3.96 at $t_{0.05}$-2.45.

Thus, the regularity of the effect of microfertilizers application "Wuxal" on vegetative plants of barley under growing conditions against the background of $N_{30}P_{45}K_{45}$ on the energy of grain germination was a variant of two-times (A6) and three-times foliar fertilization (A7). On average, over the three years under the influence of the technological agricultural measure, the germination ability increased by 1.2% and 1.7%, respectively.

Regarding the ability to germinate grain, the results are shown in Table 2. The first four variants (A0, A1, A2, A3) compared to the control do not require statistical calculations to prove the relevant statement.

Table 2. The ability to germinate barley grain depending on microfertilizers "Wuxal" at 1.5 L/ha on the background of $N_{30}P_{45}K_{45}$, %.

Variant		Year			
		2015	2016	2017	Average
A0	control	98.0 ± 0.19	98.1 ± 0.125	97.1 ± 0.125	97.7
A1	"Wuxal P Max" during tillering	98.0 ± 0.27	98.0 ± 0.270	97.0 ± 0.189	97.7
A2	"Wuxal Grain" during stem elongation	98.1 ± 0.39	98.1 ± 0.220	97.1 ± 0.125	97.8
A3	"Wuxal Grain" at the beginning of flowering	98.0 ± 0.19	99.1 ± 0.125	97.5 ± 0.267	98.2
A4	"Wuxal P Max" during tillering+ "Wuxal Grain" during stem elongation	98.0 ± 0.27	98.0 ± 0.270	97.1 ± 0.353	97.7
A5	"Wuxal P Max" during tillering+ "Wuxal Grain" at the beginning of flowering	98.9 ± 0.12	99.0 ± 0.330	97.8 ± 0.226	98.6
A6	"Wuxal Grain" during stem elongation+"Wuxal Grain" at the beginning of flowering	99.1 ± 0.12	99.2 ± 0.160	98.0 ± 0.320	98.8
A7	"Wuxal P Max" during tillering+ "Wuxal Grain" during stem elongation+"Wuxal Grain" at the beginning of flowering	99.2 ± 0.16	99.5 ± 0.190	98.1 ± 0.226	98.9

Positive effects of microfertilizers on the ability to germinate barley grain were obtained by technological schemes of its application: in variant A5 - at the onset of the tillering phase "Wuxal P Max" (1.5 L/ha) and at the beginning of the flowering phase "Wuxal Grain" (1.5 L/ha); on variant A6 - during stem elongation "Wuxal Grain" (1.5 L/ha) and at the beginning of the flowering phase "Wuxal Grain" (1.5 L/ha); and also on variant A7 - during the tillering phase "Wuxal P Max" (1.5 L/ha), during stem elongation "Wuxal Grain" (1.5 L/ha) and at the beginning of the flowering phase "Wuxal Grain" (1.5 L/ha). Statistically, the regularity of the best results is proved based on a comparison with the data of the control variant.

In 2015, on variant A5, the germination ability was 98.9±0.12, which is 0.9% more than the control data (t_{fact}-4.0 > $t_{0.05}$-2.45). In 2016, the data difference was also 0.9% at t_{fact}-2.55. In 2017, grains germinated better on variant A5 compared to the control, the difference was 0.7% (t_{fact}-2.71 > $t_{0.05}$-2.45). On average, over three years, the germination ability was 98.6%. However, it should be emphasized that in 2017 germination did not reach 98.0%, but was an average of 97.8%. It should also be noted, especially in 2015 and 2016, that the differences between germination energy and germination ability were slightly larger than in the A7 variant.

The characteristic of the data of variant A6 gives all grounds to carry barley on the received parameters of physiological indicators to a category of selected barley. In 2015, germination was 99.1%, in 2016 - 99.2%, in 2017 - 98.0%. The differences compared to the control variant, respectively, were 1.1; 1.1 and 0.9% with the established criterion t_{fact}-4.89; 5.42; 2.62; $t_{0.05}$-2.45. On average, over three years, the germination ability of barley grain was 98.8%.

Regarding the data of variant A7, were three times spraying of barley crops with a solution of microfertilizers "Wuxal" was used, it should be emphasized that no differences were found compared to the data of variant A6. However, in 2015, in variant A6, the germination energy was lower than the germination ability by 1.6%. Statistical differences in the comparison of the data of variant A7 before control were significant. By years, they were 1.2; 1.4; 1.0%. Accordingly, the criteria t_{fact} were more extensive than the table with a significant error of 5% (t_{fact}-4.84% - in 2015; 6.17 - in 2016 and 3.88 - in 2017 at $t_{0.05}$-2.45) .

Therefore, the best variants for the technological scheme of application of foliar fertilization of barley in the cultivation of mineral nutrition $N_{30}P_{45}K_{45}$, which provides stable grain germination rates of 98.0-99.5% are variants: A6 - two-times spraying of plants with a solution of microfertilizer "Wuxal Grain" at the rate of 1.5 L/ha during stem elongation and 1.5 L/ha at the beginning of the flowering phase and A7 - three-times sprays of microfertilizers at 1.5 L/ha each time during the tillering phase "Wuxal P Max" during stem elongation "Wuxal Grain" and at the beginning of the flowering phase "Wuxal Grain".

Analysis of experimental data obtained by applying mineral fertilizers in the norm $N_{60}P_{90}K_{90}$ shows similar results to those obtained by growing barley on the background of $N_{30}P_{45}K_{45}$. Regarding the germination energy, the comparison of the data proves that the positive changes during a single application of microfertilizer "Wuxal P Max" during the tillering phase (variant A1), "Wuxal Grain" during stem elongation (variant A2), and "Wuxal Grain" at the beginning of the flowering phase (variant A3) is not obtained. Differences in data compared to the control are unreliable and are in the range of 0.1-0.3% (Table 3). On average, over three years, the germination energy in these variants ranged from 96.6% to 96.8%; for the control variant, this parameter is 96.7%.

Table 3. Energy germination of barley grain depending on microfertilizers "Wuxal" at 2.0 L/ha on the background of $N_{60}P_{90}K_{90}$, %.

Variant		Year			
		2015	**2016**	**2017**	**Average**
A0	Control	96.2 ± 0.163	96.9 ± 0.295	97.1 ± 0.125	96.7
A1	"Wuxal P Max" during tillering	96.1 ± 0.125	97.2 ± 0.450	97.0 ± 0.267	96.8
A2	"Wuxal Grain" during stem elongation	95.9 ± 0.125	97.0 ± 0.190	96.9 ± 0.125	96.6
A3	"Wuxal Grain" at the beginning of flowering	96.2 ± 0.163	97.2 ± 0.163	97.1 ± 0.125	96.8
A4	"Wuxal P Max" during tillering+ "Wuxal Grain" during stem elongation	96.0 ± 0.267	97.0 ± 0.267	96.9 ± 0.125	96.6
A5	"Wuxal P Max" during tillering+ "Wuxal Grain" at the beginning of flowering	97.0 ± 0.327	97.9 ± 0.295	97.4 ± 0.183	97.4
A6	"Wuxal Grain" during stem elongation+"Wuxal Grain" at the beginning of flowering	97.4 ± 0.183	98.1 ± 0.125	97.8 ± 0.250	97.8
A7	"Wuxal P Max" during tillering+ "Wuxal Grain" during stem elongation+"Wuxal Grain" at the beginning of flowering	98.1 ± 0.125	98.1 ± 0.226	97.9 ± 0.125	98.0

Double application of foliar fertilization of barley plants with microfertilizers "Wuxal P Max" during the tillering phase and "Wuxal Grain" during stem elongation (variant A4) did not provide the desired results. Each year, the germination energy was at the level of the control variant.

Double application of microfertilizers (variant A5): the first time during the tillering phase "Wuxal P Max" and the second time at the beginning of the flowering phase "Wuxal Grain" in 2015 provided an improvement in germination energy, but no significant differences compared to the control t_{fact}-2.19 < $t_{0.05}$-2.45. Similarly, in 2016, despite the difference of 1%, comparing the data of the variants set t_{fact}-2.40 < $t_{0.05}$-2.45. The 2017 data do not require statistical comparison to prove equivalence.

Analysis of the data of variant A6, where the application scheme involved spraying barley plants with a solution of microfertilizers "Wuxal Grain" during stem elongation (2.0 L/ha) and "Wuxal Grain" at the beginning of the flowering phase (2.0 L/ha) shows about significant advantages over the data of the control variant. In 2015, the difference was 1.2% (t_{fact}-4.90 > $t_{0.05}$-2.45). In 2016, similarly, the germination energy of barley grain was higher compared to the control variant by 1.2% (t_{fact}-3.75 > $t_{0.05}$-2.45). Also, the results obtained in 2017 prove the significant effectiveness of variant A6 compared to variant A0 (t_{fact}-2.50 > $t_{0.05}$-2.45).

Evaluation of the results of the effect of three-time fertilization of plants with microfertilizers "Wuxal P Max" during the tillering phase (2.0 L/ha), "Wuxal Grain" during stem elongation (2.0 L/ha), and "Wuxal Grain" at the beginning flowering phase (2.0 L/ha) also proves the effectiveness of this scheme. Compared to control, there are significant advantages in all three years of research. In 2015-2017, the difference was 1.9; 1.2; 0.8% with actual Student criteria of 9.27; 3.23 and 4.52, respectively. However, it should be emphasized that when comparing the germination energy data of variant A7 to the data of variant A6, no significant changes and differences were found.

The performed analyzes also prove that foliar nutrition of plants with microfertilizers against the background of mineral nutrition $N_{60}P_{90}K_{90}$ effectively affects the physiological quality of grain - the ability to germinate (Table 4).

In the control variant, the average germination ability of grain was 96.9% over three years. No significant changes in the germination ability of grain on variants A1, A2, A3, A4, A5 were detected. Comparison of data to control the results of statistical calculations prove the uniqueness of the data.

The analysis of two variants A6 and A7 according to experimental data are characterized by positive consequences of the impact of this technological measure. In all years of research, the data of variant A6-two-times foliar fertilization of plants with microfertilizers "Wuxal Grain" during stem elongation (2.0 L/ha) and "Wuxal Grain" at the beginning of the flowering phase (2.0 L/ha) were significant larger than the control data. Thus, in 2015 the difference was 1.3% at t_{fact}-5.20 > $t_{0.05}$-2.45, in 2016-0.9% at t_{fact}-4.39 > $t_{0.05}$-2.45 and in 2017 - 0.8% at t_{fact}-2.56 > $t_{0.05}$-2.45.

Table 4. The ability to germinate barley grain depending on microfertilizers "Wuxal" at 2.0 L/ha on the background of $N_{60}P_{90}K_{90}$, %.

Variant of the research		Year			
		2015	2016	2017	Average
A0	control	96.2 ± 0.163	97.2 ± 0.163	97.2 ± 0.164	96.9
A1	"Wuxal P Max" during tillering	96.1 ± 0.125	97.4 ± 0.420	97.0 ± 0.267	96.8
A2	"Wuxal Grain" during stem elongation	96.0 ± 0.189	97.1 ± 0.226	97.0 ± 0.189	96.7
A3	"Wuxal Grain" at the beginning of flowering	96.5 ± 0.189	97.2 ± 0.163	97.1 ± 0.125	96.9
A4	"Wuxal P Max" during tillering+ "Wuxal Grain" during stem elongation	96.2 ± 0.250	97.1 ± 0.226	97.0 ± 0.189	96.8
A5	"Wuxal P Max" during tillering+ "Wuxal Grain" at the beginning of flowering	97.0 ± 0.327	97.9 ± 0.295	97.5 ± 0.189	97.5
A6	"Wuxal Grain" during stem elongation+"Wuxal Grain" at the beginning of flowering	97.5 ± 0.189	98.1 ± 0.125	98.0 ± 0.267	97.9
A7	"Wuxal P Max" during tillering+ "Wuxal Grain" during stem elongation+"Wuxal Grain" at the beginning of flowering	98.1 ± 0.125	98.4 ± 0.226	97.9 ± 0.125	98.1

Analysis of variant A7, where the crops were sprayed three times with microfertilizers "Wuxal P Max" during the tillering phase (2.0 L/ha), "Wuxal Grain" during stem elongation (2.0 L/ha), and "Wuxal Grain" at the beginning of the flowering phase (2.0 L/ha) for three years when comparing the data to the control was also characterized by significant differences in the parameters of grain germination. The following differences were found when comparing variants A7 and A0: in 2015 - 1.9% (t_{fact}-9.27 > $t_{0.05}$-2.45), in 2016 - 1.2% (t_{fact}-4.30 > $t_{0.05}$-2.45) and in 2017 - 0.7% (t_{fact}-3.40 > $t_{0.05}$-2.45). However, it should be emphasized that no significant differences in the effect on germination ability between variants A6 and A7 were found. In fact, the results are unambiguous, both with double and triple spraying of plants with a solution of microfertilizers "Wuxal" in terms of the impact on grain germination.

Thus, the effect of microfertilizers "Wuxal" at 2.0 L/ha each time spraying barley crops according to the scheme of variants A6 and A7 on the background of growing $N_{60}P_{90}K_{90}$, both on the energy of grain germination and its ability to germinate.

Conclusion

The efficiency of foliar nutrition of spring barley plants with microfertilizers "Wuxal" depended on the technological scheme of application, i.e., on the number of methods of agricultural measures for the phases of development-tillering, stem elongation, flowering. When growing barley with $N_{30}P_{45}K_{45}$, the best variants were two-times application of microfertilizers "Wuxal Grain" 1.5 L/ha during stem elongation and "Wuxal Grain" 1.5 L/ha at the beginning of the flowering phase and three-times foliar nutrition of plants with microfertilizers "Wuxal P Max" 1.5 L/ha during the tillering phase, "Wuxal Grain" 1.5 L/ha during stem elongation and "Wuxal Grain" 1.5 L/ha at the beginning of the flowering phase, where germination energy was 98.2% and 98.7%, and grain germination ability was 98.8% and 98.9%, respectively. Against the background of mineral nutrition $N_{60}P_{90}K_{90}$ variants for double application of microfertilizers were also the best "Wuxal Grain" 2.0 L/ha during stem elongation and "Wuxal Grain" 2.0 L/ha at the beginning of the flowering phase and three-times foliar nutrition of plants with microfertilizers "Wuxal P Max" 2.0 L/ha during the tillering phase, "Wuxal Grain" 2.0 L/ha during stem elongation and "Wuxal Grain" 2.0 L/ha at the beginning of the flowering phase, where the germination energy was 97.8% and 98.0%, and the ability to germinate grain - 97.9% and 98.1%, respectively.

References

Briggs, D.E. (1998). Malts and malting (Blackie Academic & Professional). Birmingham, United Kingdom, p:786.

DeSalle, R., Tattersall, I. (2020). Why Brewers Choose Barley. American Scientist, 108:50.

Dospehov, B.A. (1985). Metodika polevogo opyta [Methods of field experience]. Moskva: Agropromizdat, p:351.

Dráb, Š., Psota, V., Frančáková, H., Sachambula, L., Hartmann, J., Tokár, M. (2013). The dependence of malt quality on the variety and year. Kvasny Prum., 59:182-189.

Frančáková, H., Líšková, M., Bojňanská, T., Mareček, J. (2012). Germination index as an indicator of malting potential. Czech Journal of Food Sciences, 30:377-384.

Gorash, O., Klymyshena, R., Khomina, V., Vilchynska, L. (2020). Ecological and biological conformity of conditions of the brewing barley cultivation zone. Ukrainian Journal of Ecology, 10:246-253.

Gupta, M., Abu-Ghannam, N., Gallaghar, E. (2010). Barley for Brewing: Characteristic Changes during Malting, Brewing and Applications of its By-Products. Comprehensive Reviews in Food Science and Food Safety, 9:318-328.

Klymyshena, R. (2011). Fiziolohichna yakist zerna ozymoho pyvovarnoho yachmeniu [Physiological quality of grain of winter brewing barley]. Bulletin of Agricultural Science, 11:79-80.

Kuntse, V., Mit, G. (2001). Tekhnolohyia soloda i pyva [Technology of malt and beer]; per. s nem. SPb.: izd-vo Professyia, p:912.

Madhujith, T., Shahidi, F. (2007). Antioxidative and antiproliferative properties of selected barley (*Hordeum vulgarae* L.) cultivars and their potential for inhibition of low-density lipoprotein (LDL) cholesterol oxidation. Journal of Agricultural and Food Chemistry, 55:5018-5024.

Nartsiss, L. (2007). Pyvovarenye. T. 1. Tekhnolohyia solodorashchenyia [Brewing. T. 1. Technology of malting]; perevod s nem. pod obshch. red. H.A. Yermolaeva, E.F. Shanenko. SPb.: Professyia, p:584.

Poltoretskyi, S., Tretiakova, S., Mostoviak, I., Yatsenko, A., Tereshchenko, Y., Poltoretska, N., Berezovskyi, A. (2020). Growth and productivity of winter wheat (Triticum aestivum L.) depending on the sowing parameters. Ukrainian Journal of Ecology, 10:81-87.

Przulj, N., Momcilovic, V., Simic, J., Mirosa Vljevic, M. (2014). Effect of growing season and variety on quality of spring two-rowed barley. Genetika, 46:59-73.

Šottníková, V., Psota, V., Gregor, T., Sachambula, L. (2011). Germination dynamics during post harvest maturation of malting barley. Kvasny Prum., 57:242-245.

Woonton, B. W., Jacobsen, J. V., Sherkat, F., Stuart, I. M. (2005). Changes in germination and malting quality during storage of barley. Journal of the Institute of Brewing, 111:33-41.

Zavřelová, M., Psota, V., Matušinsky, P., Musilová, M., Némethová, M. (2021). Evaluation of malting quality of spring barley genetic resources from different regions of origin. Kvasny Prumysl, 67:392-402.

Citation:

Gorash, O., Klymyshena, R., Zinchenko, O., Strilets, O. (2021). Influence of foliar fertilization with micro-fertilizers on physiological grain quality of spring malting barley. Ukrainian Journal of Ecology, 11 (5), 15-20.