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PECULIARITIES OF BISHOFITE EFFECT ON YIELD AND SEED QUALITY OF SPRING BARLEY VARIETIES

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Today, one of the promising practices in agricultural production is to increase the yield of spring barley. To obtain the desired results we studied the effect of natural bishofite (magnesium chloride salt) application on the phenological phases of spring barley varieties Helios, Vakula and Parnas. Field experiments were conducted during the period of 2017-2019 in the fields of Reshetylivka district, Poltava region.

The area of experimental crops was 1 hectare. The soil of the experimental plot was gray forest and heavy loamy by the granulometric composition. Agrochemical evaluation of the soil was carried out before laying the field experiment. The basic soil elements, grain quality of the studied barley varieties and its chemical composition were determined according to the valid standards and generally accepted methods.

The research showed that using bishofite solutions in order to stimulate growth of spring barley plants in the concentrations of 1.5% and 2.0% had a negative effect on plant growth. Under the influence of bishofite solution in such concentrations compared to the control, the plant growth decreased by 7% and by 23%, respectively. It was found that the most effective concentration of bishofite treatment was 1.0% concentration.

Treatment of barley plants of the studied varieties revealed the stimulation of growth processes of spring barley at the early stages of ontogenesis with the spread of this effect on the further growth and development of the crop, increasing the yield and grain quality. And it is the 1.0% aqueous solution of bishofite that makes for the best growth rate. The stimulating factor of such a bishofite solution on the growth indicators of barley plants (leaf surface area, weight of wet and dry substance of the above-ground part and roots) was determined.

A decrease in plant development was observed in the most used barley samples at higher concentrations. The effect of growth stimulators was also significant on dry matter accumulation in spring barley plants in the different periods of organogenesis, on elements of the structure and yield quality of such an important crop. Consequently, the application of plant growth stimulators is justified not only by their environmental friendliness, high efficiency, but also by their cost-effectiveness.

Key words: *spring barley, yield, seed treatment, grain weight, growth stimulators, seed protectants.*

Горобець М.В. Вплив бішофіту на врожайність та якість насіння сортів ярого ячменю

У статті представлено результати дослідження впливу сучасних факторів росту на продуктивність ярого ячменю у сучасних умовах. Установлено вплив факторів росту на накопичення твердих речовин у рослинах ярого ячменю на різних етапах органогенезу, визначено вплив факторів росту на елементи структури і продуктивності досліджуваної культури. Проаналізовано найефективніші фактори росту.

Нині одним із перспективних заходів підвищення врожайності ярого ячменю є використання насіння зі стимуляторами росту, що спричинюють проростання рослин, покращують їх толерантність до несприятливих біотичних та абіотичних факторів та якість зерна. Їхнє застосування дозволяє прискорити настання фенологічних фаз, тим самим сприяючи скороченню вегетаційного періоду загалом, а це, у свою чергу, дає змогу більш раціонально використовувати сільськогосподарську техніку під час збирання врожаю. Фактори росту рослин є нетоксичними і безпечними для людини та навколишнього середовища, з огляду на їхнє походження. Насіннєвий матеріал або рослини, оброблені факторами росту, краще реагують на несприятливі умови навколишнього середовища.

Розглянуто можливості використання розчину бішофіту для стимуляції росту рослин ячменю і встановлено, що у концентрації 1,5% та 2,0% розчин бішофіту негативно впливає на ріст рослин. Під впливом розчину бішофіту у концентрації 1,5% порівняно із контролем зростання рослин зменшилося на 7%, а за використання 2,0% – на 23%.

Установлено, що найефективнішою концентрацією за оброблення розчином бішофіту є концентрація 1,0%. Оброблення рослин ячменю досліджуваних сортів виявило стимуляцію ростових процесів ярого ячменю на ранніх етапах онтогенезу, а також його подальшого росту і розвитку, підвищення врожайності, кормових і поживних якостей зерна. Саме за концентрації 1,0%-ного водного розчину бішофіту швидкість росту є найбільшою. За концентрації 1,5% спостерігається уповільнення розвитку рослин більшості використаних зразків ячменю. Показано стимулюючу дію 1,0%-ного розчину бішофіту на швидкість росту рослин ячменю (площу листкової поверхні, масу сирої і сухої речовини надземної частини та коренів).

Установлено вплив факторів росту на накопичення твердої речовини у рослинах Hordeum vulgare на різних етапах органогенезу. Визначено вплив факторів росту на елементи структури і продуктивності Hordeum vulgare.

Застосування факторів росту рослин виправдано не тільки із погляду на екологічність і високу продуктивність, але і з огляду на те, що для перероблення рослинами вони потрібні у незначній кількості. Тому нині актуальним є розроблення і застосування у сільському господарстві факторів росту рослин.

Ключові слова: *ярий ячмінь, урожайність, протруювання насіння, маса зерна, стимулятори росту, захисні засоби.*

Great interest in barley as an important cereal crop of modern agriculture is associated with its versatility, because this crop provides the population with food, animal farming with fodder, industry with a valuable protein raw material. Growth of grain production is the key problem of agrarian sector in Ukraine. The yield potential of spring barley varieties is quite high – more than 8.0 t/ha, but its realization is limited by the unfavourable climatic conditions, lodging of crops and their damage by diseases and pests.

Spring barley is of great importance in ensuring food security of our country, as it is a crop of universal use. Today, one of the promising measures to increase the spring barley yield is the use of various growth stimulators, which is ensured by a wide range of their effects on plants, the possibility to regulate certain stages of development in order to mobilize the potential of the plant organism, and therefore to increase the yield and quality of grown products.

The great potential for increasing yields and quality indicators is essential for obtaining high and stable yields of high-quality grain crops. But, as practice shows, mineral nutrition only by macronutrients of the first order is not enough to solve the problems. Plants need micronutrients throughout the growing period, but most of all in the initial phases of development, in the period from 3 to 7 leaves and grain formation. Such periods are critical in the development of barley plants, because the level of consumption of mineral nutrients increases when not only the quantity but also the stability is important. However, the plants are susceptible to various stress factors that disturb normal root nutrition. Therefore, even on soils with high nutrient content spring barley plants for various reasons may experience hunger because of the lack of some or other elements of mineral nutrition [10].

The natural bishofite, a magnesium chloride salt extracted in the form of brine by underground dissolution of the formation with water, was used in the research. Bishofite is an oily liquid with a yellowish tint, odorless, with magnesium chloride content of 420-430 g/l, other impurities are 10-15 g/l. Its density is 1.301.34 g/cm^3, pH is 4.5-4.7, freezing point is (minus 20-30°C), the total mineralization is 450-460 g/l. The composition of natural bishofite includes:

- main content (magnesium chloride) – 90-96%;
- impurities – calcium sulfate, sodium and potassium chloride, calcium sulfate, magnesium bromide;
- microelements: boron, cadmium, bismuth, molybdenum, iron, aluminum, titanium, copper, silicon, barium, strontium, rubidium, cesium, lithium.

In the last decade, positive experience of bishofite application in crop production was collected. The application of bishofite for treatment of plants during vegetation allows to provide them with balanced nutrition in microelements, to increase the efficiency of macronutrient use (absorption by plants of macronutrients in the presence of microelements, better development of plant root system), to increase the efficiency of protective and stimulating mixtures used to increase plant resistance. and crop yields, increase plant tolerance to pests and diseases.

In other words, bishofite has a complex effect on plants of twenty macro- and microelements contained in bishofite, but all working concentrations and doses of working solution of the preparation are characterized by a clear and individual approach to its application, type of crop and period of treatment, as well as soil and climatic differences.

Analysis of recent studies and publications. As an example, let us consider the experience of bishofite application on winter crops in 1997 on the area of 1000 ha in 3 districts of Volhohrad region [5]. Bishofite was compared with such well-known preparations as Agate-25 K, Fenoram, Crezacin as well as the control was laid without treatment. Despite the extreme situation (drought), the yield was high. Economic yield in variants with Agate-25 K was 21.3 centners/ha, Crezacin – 20.0 centners/ha, Fenoram –25.3 centners/ha, Bishofite – 30.6 centners/ha; in control (no treatment) – 17.2 centners/ha. The positive effect of bishofite solution was shown in pest control and disease control, which decrease up to 30%, as well as improvement of grain quality: gluten increases by 4%, reaching 32-34%, i.e. all the obtained grain is food-grade.

Vasin V. H. provides data on the effective use of a mixture of growth stimulators and fungicides for the cultivation of cereals. In particular, the treatment of spring barley seed by Fenoram (1/2 rate of consumption) in mixture with biological preparations Rizoplan, Emistim, Jasol and Agate-25 K enhanced crop yield from 4.1 to 11.8 centners/ha [2].

In the work of Belopukhov S.L. the treatment of spring barley with biological preparations (Symbiot-Universal 1 ml/t and Trichodermin 5 kg/t) in wet years increased

the yield by 3.3-5.8 centners/ha and also a healthful effect on root rot was observed, while in dry years the application of these preparations had much less effect[1].

A significant increase in various parameters of spring barley yield structure with the application of stimulators was established in the studies by Glukhovtsev V. V, which were conducted in the Krasnodar Territory.

It was found that the yield increase in variants of the experiment was about 14.6-18.2% depending on the variety, type of the preparation and method of its application. Spring barley variety Helios with the use of the stimulator Humate K (from sapropel) provided the largest yield increases [3].

Demidov O. A. studied the effect of treatment of spring barley seed with such stimulators as Epin-extra, Zircon, Cresacin. For spring barley variety Parnas, yield increase was 1.1 centners/ha in the variants with Epin-extra, 1.2 centners/ha in the variants with Zircon, 1.3 centners/ha in the variants with Crezacin.

Epin-extra had the greatest effect on the gluten content of spring barley grain. The amount of gluten increased by 2.7% for the spring barley variety Parnas, 12% and by 14% for the variety Helios. Gluten quality in all variants corresponded to the second group and was characterized as satisfactorily weak. Variants of the experiment did not have a significant effect on the grain unit and grain vitreousness [4].

Alqudah A. M., Koppolu R. in their work concluded that plant stimulators have a significant effect on the yield of spring barley and the formation of its structural elements. In their study, the yield increase ranged from 2.3 to 23.3 centners/ha [7].

According to the data of Demidov O. A., Hudzenko V. M. and Skardak M. O., the treatment of spring barley plants with preparation Silk increased the yield by 3.6-3.7 centners/ha, and the gluten content in grain increased by 1.5% [4].

Sardak M.O. and Demidov O.A. in their research studied the effect of the stimulators Zirkon, Energy M and NV-101 on growth, development, yield and technological indicators of grain on the crops of spring barley and winter wheat Prykumska 140. In 2017, the yield of spring barley increased compared to the control from 3.20 up to 3.30 t/ha.

Application of the preparation Zirkon increased spring barley yield to 3.70-3.93 t/ha, application of the preparation Energy M resulted in the yield from 3.55 to 3.90 t/ha, application of the preparation NV-101 resulted in the yield of spring barley yield from 3.40 to 3.70 t/ha [4].

Therefore, the analysis of modern scientific literature on the effectiveness of growth stimulators for spring barley showed the significant prospects for their use. However, currently insufficient study of the effect of growth stimulators on the yield formation of spring barley varieties under the conditions of the studied farm (Reshetylivka district, Poltava region) determines the relevance of the research in this area. The research results are an important element of adaptation of spring barley cultivation technology to the climatic characteristics of Ukraine, as a consequence, an important condition for stable and high yields.

Research objectives. The aim of the research was to evaluate the influence of bishofite on the yield level and seed quality of spring barley varieties Vakula, Parnas, Helios.

The hypothesis of the research was that treatment of spring barley plants with bishofite solution at the tillering stage promotes better growth, increased final yield of the barley varieties under study, increases the content of nutrients (amino acids and vitamins) in grain after harvesting. The research used theoretical analysis of the scientific literature and generalizations. Statistical data and comparisons. Classification of theoretical material and development of recommendations, field experiment. In the process of work,

depending on the aims and objectives, the appropriate methods of analysis were used: structural and systemic, comparative and factor analysis, based on the application of basic principles of logical and statistical methods of source material evaluation.

The soil of the experimental plot is gray forest, loamy soils according to granulometric composition. Before laying the field experiment, the agrochemical characteristics of the soil was as follows: pH salinity – 5.3; hydrolytic acidity – 7.28 mg-eq/100 g.; humus content in arable layer – 3.2%; alkaline nitrogen – 122.5 mg/kg; mobile phosphorus – 295 mg/kg and exchangeable potassium – 100 mg/kg; total absorbed bases – 20.3 mg equivalent/100 g soil.

The main elements were determined in accordance with current standards. DSTU ISO 14255: 2005 – Soil quality. Determination of nitrate nitrogen, ammonium nitrogen and total soluble nitrogen in air-dry soils using calcium chloride solution for extraction. DSTU 4114–2002 – Soils. Determination of mobile phosphorus and potassium compounds by the modified Machigin method. DSTU ISO 14254: 2005 – Soil quality. Determination of metabolic acidity in barium chloride extracts [14].

The grain quality of the studied barley varieties and its chemical composition were carried out according to the following standards. Mass fraction of proteins was determined by Kjeldahl method, fat content – by Soxhlet method, starch content – by Evers method, ash content– by GOST 27494-87, sugar content – by iodometric method, dietary fibres content – by GOST R 54014-2010, fat – by GOST 30418-96, composition of individual amino acids – by ion-exchange liquid chromatography on an automated amino acid analyzer TT 339 (Czech Republic), microelements – by spectroscopy on X-ray fluorescent analyzer, water-soluble vitamins by HPLC(high performance liquid chromatography) method by GOST 26753.1– 93 and GOST RF 50929-96, particle size – by GOST 27560-87, mass fraction of moisture – by DSTU 7045: 2009, acidity – by DSTU 7045:2009, gas-forming capacity by volumetric method on an AG-1M device, water-absorbing capacity by centrifugation.

The experiment was conducted with such spring barley varieties as Helios, Vakula, Parnas and included treatment of the studied spring barley varieties with bishofite solution in different concentrations and without treatment (control). The main properties of the varieties are shown in Table 1. Grain quality of spring barley met the requirements of DSTU-3769-98. Barley. Specifications. Seed germination in laboratory conditions was determined according to DSTU 4138-2002. Sprouting energy and germination ability seed met the requirements of GOST 12038-84.

Presentation of the research material. Field trials lasted for 3 years (2017-2019) in the fields of the farm “Horobets” – Shylivka village, Reshetylivka district, Poltava region. The area of experimental crops was 1 ha.

The weather conditions in the research years were different. Meteorological conditions of the growing season of 2017 were unfavourable for barley growth and development. 65.9% of the norm was recorded in May, 1.6% in June and 7.8% in July. Monthly average temperatures in all months of the growing season were above the monthly average. 2018 was optimal in terms of temperature and moisture conditions for growth and development of spring barley. Meteorological conditions were slightly worse in 2019. Natural light and moisture conditions were 60% of full moisture capacity (WAC). The germination temperature was maintained between +22 and +24°C.

Spring barley plants were manually treated with a solution of bishofite. Agronomic technique of spring barley cultivation corresponded to the recommended for the farms of Poltava region. Sowing was carried out with a SH-16 seeder in the ordinary row method followed by rolling with ring-crowfoot rollers. Seed that met the requirements

of the first class of seeding standard were used for sowing. Sowing depth was 5-7 cm, mineral nutrition background was $N_{30}P_{30}K_{30}$. Before harvesting the experimental plot, the density of productive stems was taken into account and sheaves were selected to assess the main elements of the yield structure. The plots were harvested during the period of full grain ripening using a small Wintersteiger harvester (table 1).

Table 1

Characteristics of the studied spring barley varieties

Spring barley variety	Vegetation period, days	Yield potential, centners/ha	Seeding rate, kg/ha	Weight of 1000 grains, г	Resistance to lodging, grade	Drought resistance, grade	Resistance to shedding, grade
Parnas	84–94	85–95	180	46–54	9	8	9
Vakula	80–91	92–96	180	44–50	7	8	8
Helios	90–93	89–93	180	47–50	9	7	8

Yield is one of the main indicators of the effectiveness of growth stimulators in the cultivation of spring barley. For the period of 2017-2019, there is a tendency to increase the yield of spring barley after growth stimulator treatment compared with the control.

Under field conditions, the growth and development of barley plants as well as the phytosanitary state of the crops were monitored in order to determine the effectiveness of bishofite with different concentrations according to the generally accepted methods.

Field germination ability, density and winter hardiness were determined by counting the number of germinated seeds on plots sown since autumn (0.25 m^2). Field germination ability was calculated as a percentage of the number of seeds that sprouted normally to the number of seeds sown. The degree of germination and growth of spring barley depending on the concentration of bishofite in the studied fields of farm “Horobets” is shown in table 2.

Table 2

Spring barley germination and growth rate depending on bishofite concentration (average for 2017-2019), %

Concentration of bishofite or without it	Vakula		Parnas		Helios	
	Seed vigour (x±Sx)	Laboratory germination (x±Sx)	Seed vigour (x±Sx)	Laboratory germination (x±Sx)	Seed vigour (x±Sx)	Laboratory germination (x±Sx)
Control	59.1 ±0.2	88.4±0.2	62.6 ±0.5	87.6±0.3	62.5 ±0.1	86.2±0.1
0.1	65.2±0.3	89.2±0.4	64.5±0.1	87.6±0.2	65.2±0.2	89.2±0.2
0.2	68.9±0.4	91.4±0.2	69.1±0.2	93.7±0.4	70.5±0.5	90.6±0.3
0.5	71.0±0.2	93.2 ±0.2	73.0±0.3	95.5 ±0.3	70.0±0.3	91.8 ±0.3
0.7	72.6±0.1	94.5±0.4	74.3±0.3	93.9±0.1	71.2±0.4	93.6±0.2
1.0	77.1 ±0.5	99.7±0.5	75.7 ±0.3	96.4±0.2	78.6 ±0.3	97.4±0.2
1.2	73.2±0.2	91.3±0.3	73.7±0.3	90.4±0.4	74.1±0.3	90.1±0.2
1.5	69.2±0.3	89.1±0.2	69.6±0.3	90.2±0.3	71.2±0.1	8.6±0.3
2.0	54.2±0.4	84.2 ±0.1	56.2±0.1	83.1 ±0.2	62.6±0.3	83.1 ±0.2

The preservation of plants after overwintering was calculated as the percentage of overwintered plants to the number of plants in the complete sprouting phase. Disease

development and spreading were accounted for using the generally accepted methods in phytopathology. Thus, the degree of infestation of spring barley plants with powdery mildew was determined according to the Peterson scale, septoriosis according to the scale developed by M. N. Vasetska. The solution with bishofite concentration of 1.0% had the optimum stimulating effect on germination of spring barley seeds (Fig. 1, Table 1). In this case, germination and growth of spring barley seeds were 7% higher compared to the control, and germination energy was 30% higher.

Under laboratory conditions, the weight of grain in one ear, weight of 1000 grains, grain unit, vitreousness, content and quality of crude gluten, crude protein content were determined. The quality of spring barley grain was evaluated by the system of indicators in accordance with the requirements of GOST according to the methods adopted in Ukraine. Sampling was made according to GOST 12035–85, the grain unit according to DSTU 3769–98; determination of colour and odour according to GOST 10967–75; infection rate [DSTU 13586.6–93; GOST 13586.4–83]; content of impurities [GOST 30483–97]; moisture content [GOST 13586.5–93]; weight of 1000 grains – GOST 10842–89. Grain vitreousness – GOST 10987–76; gluten content and quality – GOST 28796–90. Crude protein content – GOST 10846–91. Grain moisture content was determined according to GOST 13586.5–93.

Table 3

Characteristics of seed quality of the studied spring barley varieties, 2017–2019

Indicator	Indicators of spring barley variety					
	Without treatment with bishofite			After treatment with bishofite		
	Vakula	Parnas	Helios	Vakula	Parnas	Helios
Husk content, %	6.93	5.91	7.96	4.67	5.03	6.65
Content of impurities, %	1.6	1.2	0.9	0.7	0.8	0.7
Determination of color and odour	Stand the trial					
Infection rate, %	0.5	0.4	0.7	0.4	0.3	0.5
Number of plants before harvest, pcs/m^2	305	303	315	332	316	327
Productive tilling capacity	1.4	1.6	1.5	1.8	1.9	1.9
The number of spikelets in the ear (average value), pcs.	12	11	11	15	15	14
The number of grains in the spikelet, pcs.	24	25	24	29	33	29
Ear weight (average value), g	1.10	1.17	1.08	1.16	1.23	1.18
Productive stems, pcs / m^2	427	486	502	456	496	522
Grain uniformity,%	77.8	83.6	85.1	82.3	84.1	86.2
The content of small grains,%	4.5	3.6	3.8	3.6	3.3	3.2
Vitreousness of grain,%	33	65	48	36	58	54
Protein content in grain,%	14.0	14.3	13.9	15.2	14.8	15.7

The increase in all indicators of the studied barley varieties after treatment of plants with bishofite solution was observed (table 3). It was also found that treatment of plants with bishofite solution in concentration of 1.0% can significantly improve growth, yield and preservation of plants. Thus, if in 2017 this indicator averaged 62%, in 2019 – 66.8%, in the variants with bishofite treatment its value increased respectively to 65.5% and 69.1%.

On average over the research years, the maximum yield was obtained in the variants with the treatment of plants with bishofite solution in concentration of 1.0%.

Table 4

Changes in yield and chemical composition of spring barley grain after treatment with bishofite

Indicators	Studied spring barley varieties					
	Without treatment with bishofite			After treatment with bishofite		
	Helios	Parnas	Vakula	Helios	Parnas	Vakula
Yield, centners/ha	45.4	41.6	43.8	55.4	52.6	53.8
Yield increase, t/ha	0.4	0.5	0.3	0.7	1.2	0.9
Starch content, %	62.4	63.2	59.3	65.3	66.7	67.0
Oil, %	2.54	2.64	2.73	2.67	2.77	2.89
β-glucans, %	6.54	6.65	6.50	6.65	6.70	6.78
Lysine, mg/100 g	3.8	3.9	4.0	4.2	4.0	4.2
Histidine, mg/100 g	2.5	2.7	2.7	2.7	3.2	3.5
Arginine, mg/100 g	3.9	4.0	3.8	4.2	4.1	4.3
Threonine, mg/100 g	1.7	2.0	2.2	2.4	2.5	2.7
Serine, mg/100 g	1.9	2.1	2.3	2.2	2.5	2.6
Glutamic acid, mg/100 g	26.7	27.4	26.3	27.0	27.2	27.5
Alanine, mg/100 g	5.8	6.0	5.9	6.4	6.6	6.4
Valine, mg / 100 g	2.9	3.1	3.0	3.4	3.5	3.3
Glutamine, mg / 100 g	3.9	4.1	4.0	4.2	4.4	4.4
Leucine, mg/100 g	2.0	1.9	2.2	2.3	2.6	2.8
Carotene, mg/kg	0.1	0.2	0.1	0.2	0.3	0.3
B9 (folic acid), mg/kg	0.30	0.33	0.34	0.36	0.38	0.39
B1 (thiamine), mg/kg	3.7	3.8	3.6	4.2	4.2	4.4
B3 (pantothenic acid), mg/kg	45.1	45.6	46.3	47.3	46.3	47.2
B4 (choline), mg/kg	712	734	745	733	745	743
B6 (pyridoxal) mg/kg	2.1	2.3	2.2	2.6	2.8	2.7
B7 (H, biotin), mg/kg	0.08	0.09	0.10	0.12	0.13	0.15
E (tocopherols), mg/kg	20.2	21.2	20.8	23.1	22.8	22.6

Treatment of spring barley plants with bishofite solution resulted in a significant change in grain quality after harvesting (table 4). Thus, an increase in content of starch, vegetable oil and essential amino acids is observed for all studied barley varieties. The increased content of water-soluble B vitamins in spring barley grain should also be emphasised. This is explained by the fact that nitrogen is a component of the organic molecules in the grain. A similar trend was found for barley grain of all studied varieties.

It was found that 100 g of grain of the variety Helios obtained after bishofite treatment satisfied the biological need of an adult in vitamins B_1 and B_3 by 32-40% and in carotenes by 0.2-0.4% depending on the experiment variant. The integral change in the content of vitamins B_4, B_6 and B_5 in spring barley grain after treatment with bishofite solution increased from 16-18% to 17-37% respectively; for other vitamins – from 7-13% to 9-21%.

Conclusions and suggestions. Positive effect of bishofite solution on growth, yield and grain quality of spring barley varieties Helios, Parnas and Vakula was established. Treatment with 1.0% bishofite solution is the most effective. Spraying with bishofite solution was carried out in the tillering phase. The application of natural bishofite (magnesium chloride salt) accelerated the phenological phases of the studied varieties of spring barley, which contributed to the reduction of the growing season as a whole, and this, in turn, allowed a more rational use of agricultural machinery for harvesting.

Therefore, to increase the yield and seed quality of spring barley varieties, we recommend to use 1% solution of bishofite for pre-sowing seed treatment and spraying of crops in the tillering phase, which provides a leveled sowing area and the stable yields. It should be noted that all the studied varieties had higher yields compared to the control. Further research will consist of determining the peculiarities of the effect of bishofite solutions on the ontogenesis stages and the terms of the phenological phases of growth and development of spring barley plants.

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ВПЛИВ СТРОКУ СІВБИ І НОРМИ ВИСІВУ НАСІННЯ НА УРОЖАЙНІСТЬ СУЦВІТТЯ ШАВЛІЇ МУСКАТНОЇ В УМОВАХ ЗАХІДНОГО ЛІСОСТЕПУ

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У статті наведено результати польових та лабораторних досліджень впливу строку сівби і норми висіву насіння на врожайність суцвіть шавлії мускатної у розрізі трьох років дослідження, виконаного в умовах Західного Лісостепу. За результатами дослідження встановлено, що найсприятливішими для росту, розвитку рослин і формування продуктивності шавлії мускатної виявились умови 2020 року, які забезпечили врожайність суцвіть у межах 3,3-6,5 т/га залежно від варіанту досліду.

Доведено, що серед строків сівби більш ефективним виявився весняний (друга декада квітня); за результатами визначення мінливості апробаційних ознак цей чинник впливав на 26-27%.

Дослідженнями встановлено, що за роками спостерігалась аналогічна тенденція впливу досліджуваних факторів на урожайність суцвіть шавлії мускатної. Оптимальні значення у середньому за три роки отримано в межах 5,5 та 5,2 т/га на варіантах весняного строку сівби за норми висіву насіння 8 та 10 кг/га відповідно. Показники на цих варіантах перевищували контрольний варіант відповідно на 17 та 10,6%. На всіх інших досліджуваних варіантах спостерігалося зменшення врожайності культури на 8,5–38,2% порівняно із контрольним варіантом (весняний строк сівби нормою висіву насіння 6 кг/га). Мінімальне зниження врожайності відмічено за норми висіву насіння 4 кг/га як у разі весняного, так і літнього строку сівби. Дисперсійний аналіз показав, що фактори дослідження достовірно впливали на врожайність суцвіть шавлії мускатної протягом усіх трьох років.

За отриманими експериментальними показниками зроблено висновки, що в умовах Західного Лісостепу доцільно вирощувати шавлію мускатну як ефіроолійну, лікарську та ароматичну рослину. За вирощування шавлії мускатної в умовах зони на фоні добрив $N_{60\text{-}90}P_{60\text{-}90}$, внесених під культивацію та підживлень ($N_{30}P_{30}$ – у перший рік у фазу утворення розетки листя, $N_{30\text{-}45}P_{30\text{-}45}$ – на другий рік у період відновлення вегетації), сіяти шавлію мускатну слід навесні (у другій декаді квітня) нормою висіву 8 кг/га, що забезпечує врожайність суцвіть у межах 4,2–6,5 т/га.

Ключові слова: *шавлія мускатна, строк сівби, норма висіву, врожайність суцвіть, мінливість апробаційних ознак.*