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AGROECOLOGICAL EFFICIENCY OF THE APPLICATION OF GROWTH REGULATORS IN THE AGROCENOSIS OF SPRING BARLEY IN THE CONDITIONS OF THE RIGHT-BANK FOREST-STEP

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According to the conclusions obtained after the research, it turned out that the use of growth regulators by treating spring barley crops during the tillering period had a positive effect on both the key biometric characteristics of plants and the components that form the yield. In particular, the height of the plants was within 66.3–71.3 cm. This indicator was 2.9–7.9 cm lower than the height of the plants in the control plot, which, on average for the entire research period, was 74.2 cm.

In the variant with the use of Medax Top, SC, the total density of spring barley stems was recorded - 976 stems per m2. As for productive stems, when treated with Medax Top, SC, their number was 433 pcs/m2 throughout the experiment. This is 11-19 stems per m2 more than in the areas with the use of Chlormequat-Chloride 750, SL and Terpal, SL, and 27 stems per m2 more than without treatment. The average length of the ear of spring barley of the Green variety in the control was 7.2 cm, which is 0.4-1.1 cm less than in the variants where the studied growth regulators were used. The length of the ear in cases of using Medax Top, SC reached 8.3 cm, which exceeded the corresponding indicators when using the preparations Chlormequat-Chloride 750, SL and Terpal, SL by 0.4-0.7 cm.

When using Medax Top, SC on spring barley crops of the Green variety, an average of 11.7 grains were recorded per ear, which is 1.3 more than on the untreated plot, and 0.4-0.9 grains more than in the variants where Chlormequat-Chloride 750, SL and Terpal, SL were used, respectively. The highest mass of 1000 grains was observed when Medax Top, SC was applied and was 53.4 g, which is 0.3 g more than in the variant with Chlormequat-Chloride, SL, and 1.2 g higher than the control indicator. The highest grain nature index of 661 g/l was recorded when using Medax Top, SC, which was 9 g/l higher than the grain nature when using Chlormequat-Chloride, SL and 30 g/l higher than the corresponding result of the untreated plot. The use of growth regulators on spring barley crops made it possible to achieve the maximum yield of 4.45 t/ha, using Medax Top, SC at a dose of 1.5 l/ha. The yield increased by 0.83 t/ha compared to the control, ensuring profitability at the level of 31.5%.

Keywords: *spring barley, growth regulator, yield structure, economic efficiency.*
Table 3. Fig. 1. Lit. 10.

Problem statement. Spring barley in Ukraine is grown as a food, feed and technical crop. It is one of the most valuable grain and fodder crops and has a significant share in the balance of concentrated feeds. With an average of 12.2% protein, 77.2% carbohydrates, 2.4% fat and up to 3% ash, barley is a highly nutritious feed for all types of animals, especially for fattening pigs to obtain high-quality bacon (1.2 feed units per kg and 100 g of digestible protein). The amino acid composition of protein is important for its full-fledged use and in terms of the content of amino acids such as lysine and tryptophan, it surpasses the proteins of other grain crops. Modern technology for growing spring barley pays great attention to various methods of treating both seeds and plants with new generation, environmentally friendly preparations to increase yield.

One of the most promising areas of modern crop cultivation technology is the use of plant growth regulators. Growth regulators activate the plant's immune system (spring barley), "mitigate" stress factors that limit yield, increase resistance to drought and excess water at high or low ambient temperatures, accelerate or delay plant maturation, increase the number of ovaries, and promote the redistribution of nutrients to economically important plant organs [6].

The aim of the article is to determine the effectiveness and degree of influence of the use of growth regulators on the quantitative and qualitative indicators of spring barley yield.

Analysis of recent studies and publications. Barley is an important grain and fodder crop. Barley grain is used as a concentrated feed for livestock. Hay and straw are also fed to animals. The grain is used as a substitute for flour, barley, barley groats and coffee. Barley malt is an important raw material for the brewing industry. Bread made from barley is of low quality. It is coarse, poor-quality and dry due to the quality and content of gluten [8].

Mature barley grains usually contain 80-90% dry matter and 10-20% moisture. The total carbohydrate content reaches 82% of the dry matter content of the grain. The carbohydrate complex includes starch (45-66%), hemicellulose (13-15%), fiber (3-5%), gum and mucilage (6-8%), dextrin (2.7-4.2%) and soluble sugars (1.2-2.8%). Starch consists of 15-20% amylose and 80-85% amylopectin. Amylose is the most valuable fraction for the brewing industry, its amount determines the brewing qualities of the variety [1, 3].

The area under spring barley in Ukraine is not very large, compared to other cereals: 918.1 hectares were sown in 2022. In 2023, farmers grew spring barley on 808.59 thousand hectares; in 2024, spring barley was grown on 782.9 thousand hectares; in 2023, the yield of spring barley in Vinnytsia region was 4.22 t/ha (2022 - 3.35 t/ha); in 2024, the yield of spring barley in the region was 4.64 t/ha, the total yield was 349.3 thousand t/ha. Barley is one of the leading grain crops in the world, and Ukraine is one of the largest producers and exporters. Due to its valuable biological properties, barley is a raw material for brewing, food production and technical processing [4]. As a valuable raw material for the production of nutritious feed and the food industry, hulled barley has recently gained special importance [6].

One of the main directions of development of the agricultural sector in Ukraine is the intensification of production and the application of new progressive technologies that ensure increased crop yields and resistance to adverse environmental factors. Of great importance for this industry is the development of methods for stabilizing adaptive reactions of plants using biologically active substances of synthetic and natural origin. To realize the potential of productivity, a newly created variety must be accompanied by the recommended cultivation technology taking into account varietal characteristics and soil and climatic conditions. This is especially true for fundamentally new varieties, in particular bare-grain [9].

According to scientists, a significant increase in grain productivity can be obtained through the use of physiologically active substances. It is possible to increase the resistance of plants to abiotic stressors and thus stabilize their productivity by using plant growth regulators with anti-stress action in agrotechnology for pre-sowing seed treatment and spraying of vegetative plants, which contributes to an increase in vegetative and grain productivity [2, 4].

Growth regulators affect plant growth and development, reduce grass height, thicken straw, and prevent lodging. The use of the active ingredients chlormequat chloride and ethephon caused inhibition of plant growth processes, which became more pronounced 4-5 days after treatment and contributed to a decrease in lodging strength [9].

The mechanism of growth-stimulating action of growth regulators on plants is explained by their rapid penetration from the cell membrane into the cell, where they form complexes with intermediate proteins, possibly phytohormone receptors [8].

Growth regulators increase plant resistance to diseases. When used in pre-sowing seed treatment, the toxicity of pesticides for plants is reduced, but their protective effect is not. The role of growth regulators is due to both a direct effect on the microbiota and an effect through the plant root system, which promotes development by 15-17%. The use of growth regulators in the vegetation zone activates the development of many ecological and trophic groups of microbiota, as well as the process of formation of humus compounds [4].

The use of morphological control agents increases the intensity of tillering, prevents lodging, promotes uniform flowering and ripening of grain, increases resistance to diseases, improves grain quality, contributes to the realization of the full productive potential of the variety and saves costs during harvesting.

Research conditions and methodology. The research was conducted in the spring barley agrocenosis in the conditions of the Klekotynske PE of the Zhmerynskyi district of the Vinnytsia region. This territory is classified as the central subzone of the Right-Bank Forest-Steppe and is located in the northern subprovince within the Vinnytsia-Nemyrivskyi subdistrict of the agro-soil district of the Vinnytsia region.

Analyzing the hydrothermal conditions of the spring barley growing season, we can note differences by month. In particular, the average monthly temperature last year during March was 2.2 °C lower than this year's period, while April 2025 was 2.1°C colder than last year. The amount of precipitation that fell in March during the entire period was 35.5-35 mm. In April last year, 3.5 times more precipitation fell compared to this year's figure.

May 2025 was cooler by 3.3 °C, but was marked by a significant amount of precipitation, which was 8.4 times higher than last year's figure. In June last year, the average monthly temperature was 21.1 °C and was 1.7 °C higher compared to the conditions of June 2025. During the first summer month of last year, 80 mm was recorded, which was 4.1 times higher than the conditions in 2025.

***Object of research*:** development of spring barley plants and formation of crop productivity depending on the use of growth regulators.

Subject of research: Mid-ripening variety of spring barley Green. Repetition in experiments 4-fold. Each variant of the experiment occupied an area of 20 m^2. Placement of variants – randomized.

Experimental scheme

1. Control (no treatment)
2. Chlormequat-Chloride 750, SL – 1 l/ha
3. Terpal, SL – 1 l/ha
4. Medax Top, SC – 1.5 l/ha

Spraying of spring barley plants according to the experimental scheme was carried out in the tillering phase. Pesticide testing and technical efficiency of preparations were determined according to the method of S.O. Tribel [7].

Presentation of the main research material.

During the conducted studies, the effect of the use of growth regulators in spring barley crops on biometric indicators of the crop, in particular plant height (Table 1), was recorded. When using growth regulators in the tillering phase, in spring barley crops of the Green variety, the plant height was 66.3-71.3 cm, which is 2.9-7.9 cm lower than the plant height in the control, which was recorded at 74.2 cm during the years of research.

In the variant using Medax Top, SC, the height of spring barley plants was 66.3 cm, which is 2.1-5 cm lower than the plant height in the variants using Chlormequat-Chloride 750, SL and Terpal, SL, respectively.

Table 1

Dependence of biometric indicators of spring barley on the use of growth regulators, 2024-2025

Version	Height of spring barley plants, cm	Number of stems, pcs/m^2	
		general	productive
Control	74,2	864	406
Chlormequat-Chloride 750, SL - 1.0 l/ha	68,4	942	422
Terpal, SL - 1.0 l/ha	71,3	911	414
Medax Top, CS - 1.5 l/ha	66,3	976	433

Source: based on own research

When counting the number of spring barley stalks, their higher number was noted where growth stimulants were used, compared to the control option. In particular, the total number of stems of spring barley of the Green variety was the largest in the variant using the drug Medax Top, SC - 976 pcs/m^2, which is 34-65 pcs/m^2 more than when applying the drugs Chlormequat-Chloride 750, SL and Terpal, SL and 11.4% higher than this indicator in the control.

Productive stems of spring barley of the Green variety when sprayed with the drug Medax Top, SC were 433 pcs/m^2 during the research period, which is 11-19 pcs/m^2 higher than this indicator in the variants Chlormequat-Chloride 750, SL and Terpal, SL and 27 pcs/m^2 more than in the control.

The reduction in stem height due to the use of growth stimulants had a positive effect on the components of yield indicators throughout the entire period of our experiments (Table 2). Namely, the average spike length in the untreated version reached 7.2 cm, which was 0.4-1.1 cm less than in those experiments where the aforementioned substances were used to control growth. As for the spike length, when using Medax Top, SC it reached 8.3 cm, exceeding by 0.4-0.7 cm the indicators recorded when treated with the preparations Chlormequat-Chloride 750, SL and Terpal, SL.

Table 2

The effect of growth regulators on the length and number of grains in the ear of spring barley, 2024-2025

Version	Ear length, cm		Number of grains in an ear, pcs.	
	average +/- to control	average +/- to control	average +/- to control	average +/- to control
Control	7,2	–	10,4	–
Chlormequat-Chloride 750, SL - 1.0 l/ha	7,9	+0,7	11,3	+0,9
Terpal, SL - 1.0 l/ha	7,6	+0,4	10,8	+0,4
Medax Top, CS - 1.5 l/ha	8,3	+1,1	11,7	+1,3

Source: based on own research

The number of grains per ear increased when spring barley crops were sprayed with growth regulators in the tillering phase. In experiments using Medax Top, KS, an average value of 11.7 grains per ear was recorded, which exceeds the control indicator by 1.3 units and is higher by 0.4–0.9 units compared to the variants where Chlormequat-Chloride 750, RK and Terpal, RK were used, respectively.

Comparing how the use of growth regulators affected the weight of a thousand grains and baking qualities (nature) of spring barley, an increase in these characteristics was noted in the tested groups. The highest weight of a thousand grains was recorded when using Medax Top, SC, reaching 53.4 grams. This is 0.3 g more than in the variant using Chlormequat-Chloride, SL, and 1.2 g more than in the control sample (see Fig. 1).

Medax Top was used, SC provided grain quality – 661 g/l. This is 9 g/l more than the variant from the plot treated with Chlormequat-Chloride, SL, and as much as 30 g/l more than the control.

The latest methods of cultivating spring barley are designed to ensure consistently high grain yields, which is achieved by creating ideal conditions for the vegetation and ripening of this crop. The use of complex growth regulators in combination with properly selected nutrition significantly improves the quality of crop elements, thereby increasing its overall productivity, while minimizing the use of financial and human efforts.

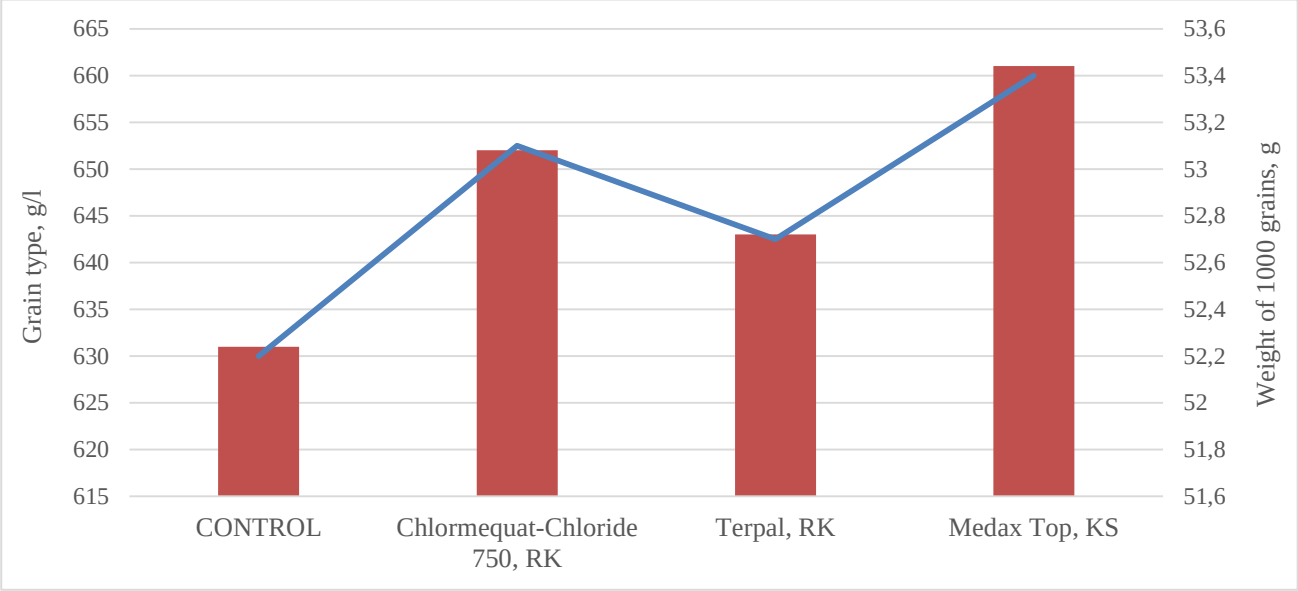

Fig. 1. Dependence of the mass of 1000 grains and the nature of spring barley grain on the background of the application of growth regulators, 2024-2025.

Source: based on own research

The economic efficiency of the results of studies on the use of growth regulators in the tillering phase of spring barley is presented in table 3.

Table 3

Economic efficiency of using growth regulators in spring barley crops of Green variety per 1 ha, 2025

Indicators	Version			
	Control	Chlormequat-Chloride 750, SL - 1.0 l/ha	Terpal, SL - 1.0 l/ha	Medax Top, CS - 1.5 l/ha
Yield, t/ha	3,62	4,24	4,02	4,45
Yield increase, t/ha	–	0,62	0,4	0,83
Price per 1 t	5000	5000	5000	5000
Product cost, UAH	18100	21200	20100	22250
Production costs, UAH	15580	16300	16465	16916
including additional	–	720	885	1336
of which for protection	–	520	685	1136
Cost of 1 t, UAH	4303,9	3844,3	4095,8	3801,3
Conditionally net profit, UAH	2520	4900	3635	5334
including additional	–	2380	1115	2814
Profitability level, %	16,2	30,1	22,1	31,5

Source: based on own research

When applying growth regulators to spring barley crops, the highest yield – 4.45 t/ha was obtained when applying Medax Top, KS, at a rate of 1.5 l/ha. The yield increase, compared to the control, was 0.83 t/ha, which provided a profitability of 31.5%.

When applying Chlormequat-Chloride 750, RK at a rate of 1.0 l/ha, the yield was 4.24 t/ha. The yield increase, compared to the untreated plot, was 0.62 t/ha, and the profitability was –30.1%. The lowest yield in the experiment – 4.02 t/ha was recorded when applying Terpal, RK at a rate of 1.0 l/ha. The yield increase, compared to the untreated plot, was 0.4 t/ha, profitability - 22.1%.

Conclusions and prospects for further research. According to the conclusions of recent scientific research, the treatment of spring barley crops with growth regulators in the tillering phase turned out to be favorable for plant growth indicators, as well as key components of the future harvest.

The height of the plants was 66.3-71.3 cm, which is 2.9-7.9 cm lower compared to the control, which was recorded at 74.2 cm during the years of research. The total number of stems was the largest in the variant using the drug Medax Top, SC - 976 pcs / m^2. Productive stems when sprayed with the drug Medax Top, SC were 433 pcs / m^2 during the research period, which was 11-19 pcs / m^2 higher than this indicator for the variants Chlormequat-Chloride 750, SL and Terpal, SL and 27 pcs / m^2 more than in the control. The length of the spike in the control was on average 7.2 cm, which is 0.4-1.1 cm less than the variants using the studied growth regulators. The length of the spike in the Medax Top, SC variant was 8.3 cm, which was 0.4-0.7 cm higher than the corresponding indicators when using the preparations Chlormequat-Chloride 750, SL and Terpal, SL. When applying the preparation Medax Top, SC, there were an average of 11.7 grains in the spike, which is 1.3 pcs more than in the control and 0.4-0.9 pcs more than in the variants with the application of Chlormequat-Chloride 750, SL and Terpal, SL, respectively. The highest weight of 1000 grains was when using the drug Medax Top, SC and was 53.4 g, which was 0.3 g higher than the weight of 1000 grains in the variant Chlormequat-Chloride, SL and 1.2 g higher than the corresponding indicator of the control variant. The highest grain nature - 661 g/l was recorded in the variant with the introduction of the drug Medax Top, SC, which was 9 g/l higher than the grain nature in the variant with the introduction of Chlormequat-Chloride, SL and 30 g/l higher than the corresponding indicator of the control variant. The introduction of growth regulators provided the highest yield - 4.45 t/ha when applying Medax Top, SC, at a rate of 1.5 l/ha. The yield increase, compared to the control variant, was 0.83 t/ha, with a profitability level of 31.5%.

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АНОТАЦІЯ

АГРОЕКОЛОГІЧНА ЕФЕКТИВНІСТЬ ЗАСТОСУВАННЯ РЕГУЛЯТОРІВ РОСТУ В АГРОЦЕНОЗІ ЯЧМЕНЮ ЯРОГО В УМОВАХ ПРАВОБЕРЕЖНОГО ЛІСОСТЕПУ

Згідно з висновками, отриманими після здійснення досліджень, з'ясувалося, що застосування регуляторів росту шляхом обробки посівів ячменю ярого у період кущіння мало позитивний вплив як на ключові біометричні характеристики рослин, так і на складові елементи, що формують урожайність. Зокрема висота рослин була у межах 66,3–71,3 см.

Цей показник виявився на 2,9–7,9 см меншим, ніж висота рослин на контрольній ділянці, яка, в середньому за весь період досліджень становила 74,2 см.

На варіанті із застосуванням Медакс Топ, КС зафіксовано загальну густоту стебел ярого ячменю – 976 стебел на м^2. Щодо продуктивних стебел, то при обробці Медакс Топ, КС їхня кількість становила 433 шт./м^2 впродовж досліду. Це на 11-19 стебел на м^2 більше, ніж на ділянках із застосуванням Хлормекват-Хлорид 750, РК та Терпал, РК, і на 27 стебел на м^2 більше, ніж без обробки. Середня довжина колосу ярого ячменю сорту Грін на контролі була 7,2 см, що на 0,4-1,1 см менше від варіантів, де застосовувалися досліджені регулятори росту. Довжина колосу у випадках застосування Медакс Топ, КС сягала 8,3 см, що переважало відповідні показники при використанні препаратів Хлормекват-Хлорид 750, РК та Терпал, РК на 0,4-0,7 см.

При застосуванні засобу Медакс Топ, КС на посівах ярого ячменю сорту Грін, у середньому фіксували 11,7 зернин у колосі, що є на 1,3 більше, аніж на ділянці без обробки, та на 0,4-0,9 зернин більше, ніж у варіантах, де використовували Хлормекват-Хлорид 750, РК та Терпал, РК відповідно. Найбільша маса 1000 зерен спостерігалася за внесення Медакс Топ, КС і становила 53,4 г, це на 0,3 г більше, ніж у варіанті з Хлормекват-Хлорид, РК, та на 1,2 г перевищувало показник контролю. Найвищий показник натури зерна 661 г/л — було зафіксовано при застосуванні Медакс Топ, КС, що на 9 г/л перевершувало натуру зерна за використання Хлормекват-Хлорид, РК і на 30 г/л — відповідний результат необробленої ділянки.

Застосування регуляторів росту на посівах ярого ячменю дало змогу досягти максимального показника врожайності – 4,45 т/га, за використання Медакс Топ, КС у дозі 1,5 л/га. Урожайність зросла на 0,83 т/га відносно контролю, забезпечивши рентабельність на рівні 31,5%.

Ключові слова: ячмінь ярий, регулятор росту, структура врожаю, економічна ефективність.

Табл. 3. Рис. 1. Літ. 10.

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