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Efficiency of growth regulators in corn crops of the Northern Steppe of Ukraine

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Abstract. The continuous increase in prices for mineral fertilisers for corn limits the use of fertilisers, which leads to the search for unconventional sources of food elements, and in particular, the use of biological natural and synthetic growth stimulators that are not harmful to the environment and allow wider use of the entire genetic potential of corn. The purpose of the study was to examine the influence of various plant growth regulators on the intensity of photosynthesis, development, growth and productivity of corn of various ripeness groups in the steppe of Ukraine. The field scientific study was conducted according to generally accepted methods of research, followed by the use of mathematical processing of experimental data using variance analysis. An increase in the chlorophyll content was identified when Avangard Grow Amino and Avangard Grow Humate preparations were applied compared to Vympel 2 and Alpha Nano Grow by 11.3-23.7%. The increase in grain from the use of growth stimulators on corn was in the early-maturing hybrid DN Pivikha – 0.13-0.37 t/ha (2.7-7.7%), medium-early DN Khortytsia – 0.85-1.08 t/ha (16.6-18.5%), medium-maturing DN Julia – 0.20-0.22 t/ha (3.20-3.4%), medium-late DN Olena – 0.05-0.53 t/ha (0.65-7.6%). Among the preparations used, Avangard Grow Amino and Avangard Grow Humate should be highlighted, which provided a tendency to increase the crude protein content to 6.42-8.4%, or by 0.12-0.48 percentage points more compared to the control (3.53-4.71%), and the crude fat content to 3.73-5.52%, or by 0.20-0.81 percentage points. The use of

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growth stimulators in the conditions of the Northern Steppe of Ukraine on corn, especially Avangard Grow Amino and Avangard Grow Humate on early-maturing and medium-early corn hybrids, allows increasing the gross yield of high-quality grain by 7.6-18.4%

Keywords: corn hybrids; growth stimulators; biometrics; SPAD units; grain yield; crude protein; crude fat; economic efficiency

INTRODUCTION

The increase in manifestations of extreme weather conditions (droughts, high temperatures, dry winds, frosts, etc.) is due to climate changes towards its warming, man-made loads, reduction in the use of mineral and organic fertilisers, which makes it necessary to improve the technology of growing corn to increase its yield, gross grain collections, and quality indicators.

According to T. Marchenko (2019) and Ya. Byelov (2018), corn in all phases of growth and development requires favourable conditions for plant development (nutrition, moisture, heat, etc.), but in extreme conditions there is often a need to increase the stress resistance of corn plants, especially in the Steppe zone of Ukraine, to obtain high grain yields. It is necessary to create favourable conditions for plant growth and protect them from the effects of environmental stress factors, in particular, the use of growth stimulants, microfertilisers, etc. A study conducted by A. Abdo *et al.* (2022) determined that all examined biometrics, crop structure elements, and overall yield were maximal when using 75% NPK + biofertiliser in combination with amino acids or a mixture of humic acids with amino acids, proving the importance of growth stimulants in enhancing the strategy of reducing chemical NPK by 25%. M. Szcsepanek (2018), proved that the Kelpak biostimulator together with Nano Active microfertiliser increased the yield of corn grain by up to 10% compared to the control. Experiments conducted by M. Pashchak *et al.* (2021) show that foliar top dressing with multi-complex microfertiliser Orakul in the BBCH 13-15 phase (3-5 leaves) increased the yield increase by 0.82 t/ha, due to the provision of plants with nutrients during this period.

T. Marchenko *et al.* (2019) proved that the use of growth regulators in the phase of 5-7 maise leaves contributed to the growth and development of plants, increasing grain yield. The increase in the yield of cobs from the introduction of Megafon was 9%, Delfan Plus – 8%, Folik Aminovigor – 6%. Seed treatment with growth stimulants is also highly effective, in particular, according to T. Bortnik *et al.* (2019), Alga 600 growth stimulator, when used in the early stages of plant development, ensures high plant biometrics and grain yield. Through growth stimulators, it is possible to solve an important drought problem for plants by using 5-aminolevulinic acid (5-ALA), zearalenone (ZEN), triacontanol (TRIA), and silicon (Si), which improve the water balance of maise and its photosynthetic activity in soil drought conditions (Ostrowska *et al.,* 2021). Similar results were obtained by V. Palamarchuk *et al.* (2018), where the use of organic balance improved the growth, development of photosynthetic potential and yield of seeds of maise lines, the parent components of promising hybrids, which are usually less resistant to negative environmental factors. In thius case, under irrigation conditions, the maximum grain yield of the parent FAO 420 line was obtained – 7.08 t/ha.

Considering the experience of Ukrainian and foreign researchers, research in this area was continued, which led to the purpose of the study – to examine the effect of growth-regulating preparations on photosynthesis activity, growth processes, development, and productivity of corn hybrids in the northern steppe of Ukraine.

MATERIALS AND METHODS

The study was conducted at the research field of the Scientific and Educational Centre for Practical Training of the Dnipro State Agrarian and Economic University (hereinafter – DSAEU) in 2020-2022. The soil of the research sites is ordinary low-humus dusty-medium loamy loess chornozem. Chornozem has a high potential and effective fertility (humus content in the 0-30 cm layer – 3.9%, total nitrogen – 0.22%, phosphorus – 0.13%, potassium – 2.2%.

Corn was grown according to the generally accepted technology characteristic of the Steppe zone of Ukraine. The predecessor of corn was winter wheat in grain-fallow-row crop rotation (clean fallow – winter wheat – corn – barley – sunflower). After mowing the predecessor of corn (winter wheat), general background stubble peeling was performed with heavy disc harrows PALLADA 2400 (Ukraine) to a depth of 10.0-12.0 cm. The next processing was ploughing, which was performed with a PLN-3-35 plough (Ukraine) to a depth of 23-25 cm. In spring, pre-sowing cultivation of KSO–4N to a depth of 6-8 cm was conducted, under which the soil herbicide Aspect Pro – 2.2 L/ha was applied, and in the phase of 3-5 leaves, the herbicide Elumis was used at a rate of 1.5 L/ha. Soil fertilisation was conducted in the spring under the cultivation of N15P15K15. The preparations were applied with a small-sized rod sprayer OM-4 (Ukraine) in the phase of 5-7 and 10-12 maise leaves. Before sowing, the corn seed material was etched with a mixture of Maxim XL 035 FS – 1.0 L/T + Vibrance 500 FS – 1.5 L/T + Force Zea 280 FS – 6.0 L/T.

Hybrids of different ripeness groups were used: DN Olena 440 MV FAO 440 of medium-late maturation,

DN Julia 340 MV FAO 340 medium-late, DN Khortytsia FAO 240 medium-early, and DN Pivikha FAO 180 of early maturation. In the phase of 3-5 leaves and 10-12 leaves, preparations based on growth stimulators and microfertilisers were used: Avangard Grow Humate – 1.0 L/ha, Avangard Grow Amino – 1.5 L/ha, Alpha Nano Grow – 50 ml/ha, Vympel 2 – 0.5 L/ha. There was also a control without the use of growth stimulants on corn. Scientific studies were conducted according to generally accepted research methods, the results of which were subjected to mathematical processing using variance analysis (Dospehov, 2013). Among the features of the method, the determination of the chlorophyll content in corn leaves in SPAD units on the SPAD-502 Plus device (Ukraine) is notable.

Experimental plant analysis (both cultivated and wild species), including plant material collection, adhered to institutional, national, or international ethical principles. The authors followed the standards of the Convention on Biological Diversity (1992) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (1979).

RESULTS AND DISCUSSION

The height of corn increased in ascending order from the early-maturing DN Pivikha up to the medium-late DN Olena – 215.0-225.0 cm, that is, it had a dependence on the group of plant maturation. The height of corn did not substantially depend on the introduced growth stimulants, the growth was only 3-8 cm, or 1.4-3.7% compared to the control (without the introduction of preparations). The maximum height of corn was noted for processing with Avangard Grow Humate – 223-225 cm. Images of corn habitus in the BBCH 31-32 phase (11-12 leaves) are presented to visually confirm the increase in biometric indicators of corn (plant height, number of leaves, leaf area). From the size of corn plants, the growth of vegetative mass is visible precisely on the options for using growth stimulants (Fig. 1).

Figure 1. *Corn plant habitus under the influence of plant growth stimulators in 2020*

There was a tendency to increase the number of leaves with the introduction of growth stimulants in comparison with the control without the use of stimulants by 3.5-5.6%, regardless of the corn maturation group. Notably, the number of leaves of corn plants is substantially associated with the biological characteristics of plants, namely, with a gradual increase in the number of leaves from the early-maturing DN Pivikha – 10.70-11.30 pcs./plant and up to the medium-late DN Olena – 13.40-14.40 pcs./plant. The same patterns are inherent in the area of leaves on one plant. That is, their minimum area is typical for the control version of 329.80-538.80 cm^2. The use of stimulants contributed to the trend of increasing the area of leaf blades by 5.30-28.30% without substantial differences between the preparations used since the difference between them was within the smallest substantial difference.

All growth stimulators had a substantial effect on chlorophyll levels in maise leaf blades. An increase in the quantitative indicators of chlorophyll in SPAD units compared to the control was observed in hybrids DN Pivikha by 8.10-9.10 units (17.90-19.60%), DN Khortytsia by 9.21-12.81 units (18.21-23.71%), DN Julia by 2.31-6.62 units (4.7-12.3%), DN Olena by 1.5-6 units (3.2-11.4%). The tendency to increase the content of chlorophyll after the introduction of Avangard Grow Amino and Avangard Grow Humate preparations compared to Vympel 2 and Alpha Nano Grow is notable (Fig. 2).

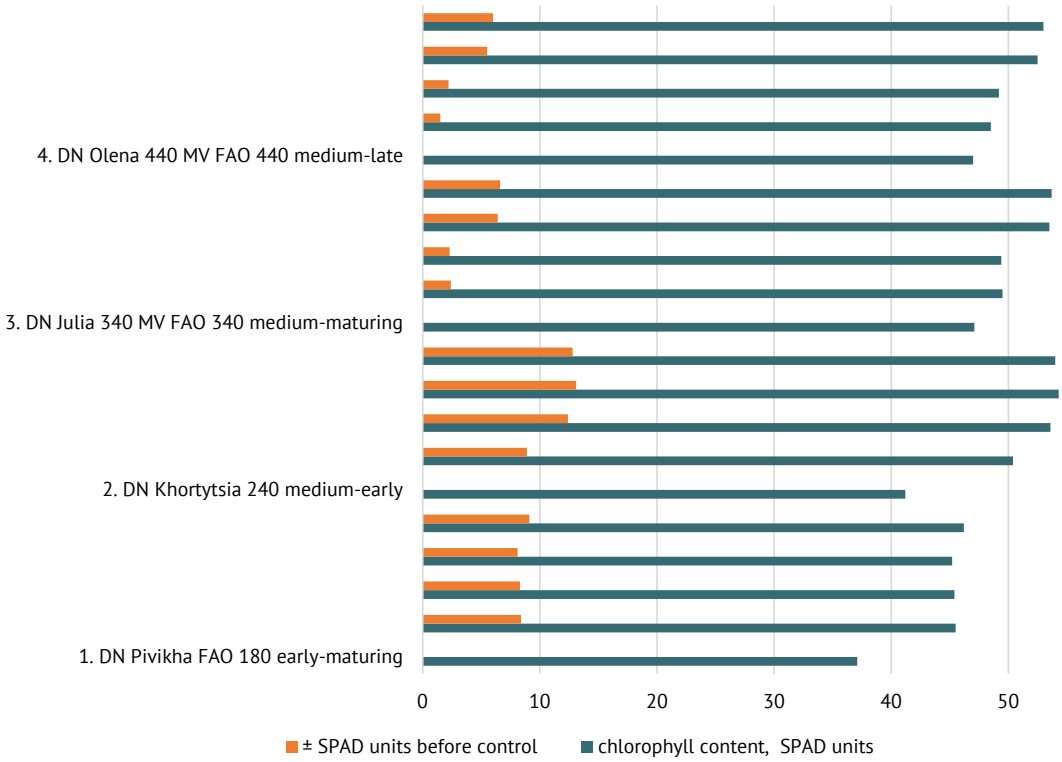

Figure 2. *Dynamics of chlorophyll content under the action of growth stimulators for 2020-2022, (SPAD units)*
Source: *compiled by the authors*

The effectiveness of stimulants on corn in terms of chlorophyll content decreased over time after their use, especially this can be noted on medium-ripening DN Julia and medium-late DN Olena, which have a slightly longer growing season compared to early-ripening and medium-early hybrids, which gives grounds for repeated (additional) use of stimulants in later phases of corn growth and development for further prolongation of the action of preparations, and ultimately to an increase in chlorophyll content and grain yield. The results of this study are also confirmed by other researchers (Szulc *et al.,* 2021; Zabolotna *et al.,* 2022). The examined elements of the crop structure (the length of cobs, the number of rows of grains, the number of grains from the cob, the mass of grains from the cobs, and the mass of a thousand grains) tended to increase and, depending on the maturation group of corn, these indicators increased from early-maturing to medium-late. Elements of the crop structure generally depended on growth stimulators, which is also confirmed by many researchers (Sukhomud *et al.,* 2019).

In the control version, all hybrids had minimal values of the length of cobs, the use of stimulants allowed to slightly increase this indicator by 0.50-1.70 cm (2.60-8.60%). Directly proportional to the length of the cobs, there was also an increase in the number of grains per cob, depending on the action of growth stimulators in the early-maturing hybrid DN Pivikha by 31.2-56.4 pcs. (6.6-11.3%), medium-early DN Khortytsia – 47.8-71.9 pcs. (11.4-16.1%), medium-maturing DN Julia – 102.7-102.9 pcs. (18.9-18.8%), and in medium-ripening DN Olena – 43.3-104.6 pcs. (8.5-18.4%). The same patterns were identified when determining the mass of grain from one cob and the mass of a thousand grains. The mass of grains from the cob grew under the influence of growth stimulants in corn by an average of 5.610-30.10 g (7.820-31.420%), and the mass of a thousand grains by 5.410-50.20 g (2.6-18.9%). Notably, the plant growth stimulators Avangard Avangard Grow Humate and Grow Amino tended to maximise the growth of these elements of the crop structure.

The content of chlorophyll in maise leaf blades substantially correlated with grain yield, this pattern is also confirmed by various researchers (Gong *et al.,* 2021). With an increase in the content of chlorophyll, grain yield increased. The increase from the use of stimulants was in the early-maturing hybrid DN Pivikha – 0.13-0.35 t/ha (2.7-7.7%), medium-early DN Khortytsia – 0.85-1.08 t/ha (16.6-18.5%), medium-maturing DN Julia – 0.18-0.20 t/ha (3.18-3.4%), medium-late DN Olena – 0.05-0.53 t/ha (0.65-7.6%).

The use of growth stimulators on corn allowed improving the grain quality of hybrids of different ripeness groups (Table 1). The use of almost all plant growth stimulators examined allowed improving the quality of corn grains of different ripeness. The obtained experimental data directly correlated with biometric indicators, elements of the crop structure and grain yield. Thus, the use of growth stimulators increased the content of crude protein in DN Pivikha

by 0.03-0.65 percentage points, DN Khortytsia – 0.58-1.04 percentage points, DN Julia – 0.1-0.74 percentage points, DN Olena – 0.15-0.68 percentage points, the maximum increase in crude protein was observed in the medium-early hybrid DN Khortytsia. Among the preparations used, Avangard Grow Amino and Avangard Grow Humate should be highlighted, which tended to increase the crude protein content to 6.42-8.4%, or 0.12-0.48 percentage points more. As for hybrids, the maximum values of crude protein content were noted in the early-maturing hybrid DN Pivikha – 7.75-8.4%. There is also a tendency to reduce the content of crude protein with the lengthening of the growing season from early-maturing hybrid to medium-late, which is likely due to a gradual slowdown in the action of preparations over time and requires additional research using additional (third) application of preparations on later hybrids.

Table 1. *Grain quality of different corn hybrids under the influence of growth stimulators for 2020-2022*

Hybrids	Preparations	Seed yield, t/ha	Crude protein, %	Raw fat, %	Grain moisture content, %
DN Pivikha early-maturing	Control (no stimulators)	4.37	7.75	4.02	14.08
	Vympel 2	4.49	7.78	4.68	13.91
	Alpha Nano Grow	4.64	7.92	4.76	13.82
	Avangard Grow Amino	4.73	8.21	4.82	14.03
	Avangard Grow Humate	4.73	8.40	4.81	13.83
DN Khortytsia medium-early	Control (no stimulators)	4.72	6.08	3.55	14.02
	Vympel 2	5.08	6.66	5.06	13.06
	Alpha Nano Grow	5.56	7.12	4.33	14.14
	Avangard Grow Amino	5.74	6.86	4.48	14.01
	Avangard Grow Humate	5.79	7.10	4.45	13.93
DN Julia 340 medium-ripening	Control (no stimulators)	5.77	6.32	3.53	14.34
	Vympel 2	5.96	6.55	3.73	14.04
	Alpha Nano Grow	5.97	6.43	4.43	14.12
	Avangard Grow Amino	5.95	6.42	4.11	14.32
	Avangard Grow Humate	5.94	7.06	4.10	14.18
DN Olena 440 medium-late	Control (no stimulators)	6.18	6.05	4.71	14.50
	Vympel 2	6.68	6.20	4.77	14.53
	Alpha Nano Grow	6.41	6.62	5.38	13.80
	Avangard Grow Amino	6.22	6.73	5.52	14.44
	Avangard Grow Humate	6.29	6.60	5.17	14.45
	$HI_{P0.5\ t/ha/\%}$	0.19	0.18	0.13	-

Source*: compiled by the authors*

The content of crude fat had an inverse correlation with the content of crude protein, that is, there was an increase in its content on the medium-late hybrid compared to early-maturing ones. In the medium-late hybrid DN Olena, the maximum fat content of 4.71-5.38% was obtained, while the remaining hybrids were slightly inferior by 0.32-1.18 percentage points. Growth stimulants increased the content of crude fat compared to the control (3.53-4.71%) to 3.73-5.52%, or by 0.21-0.81 percentage points, the most positive trend here was the preparations Avangard Grow Humate, Avangard Grow Amino, and Vympel 2. Corn hybrids of different maturation periods against the background of different preparations containing growth stimulators and microfertilisers were marked by different grain yields, which depended on the biological properties of hybrids, the use of growth stimulators and microfertilisers, which ultimately determined the amount of production costs that are necessary for conducting technological cycles of work in the technology of growing corn hybrids with different maturation periods (Table 2).

Table 2. *Economic performance indicators of corn cultivation under the influence of growth stimulants on average for 2020-2022*

Hybrids	preparation options	Seed yield, t/ha	Grain sales price UAH/t	preparation costs, UAH/ha	Production costs total, UAH/ha	Cost of gross output, UAH/ha	Net profit, UAH/ha	Profitability level, %	Percentage point surcharge
DN Pivikha early-maturing	Control (no stimulators)	4.37	7900	-	19900	34523	14623	73.4	-
	Vympel 2	4.49	7900	200.0	20100	35471	15371	76.4	3.0
	Alpha Nano Grow	4.64	7900	275.0	20175	36656	16481	81.6	8.2
	Avangard Grow Amino	4.73	7900	282.0	20182	37367	17185	85.1	11.7
	Avangard Grow Humate	4.73	7900	133.0	20033	37367	17334	86.5	13.1
DN Khortytsia medium-early	Control (no stimulators)	4.72	7900	-	19900	37288	17388	87.3	-
	Vympel 2	5.08	7900	200.0	20100	40132	20032	99.6	12.3
	Alpha Nano Grow	5.56	7900	275.0	20175	43924	23749	117.7	30.4
	Avangard Grow Amino	5.74	7900	282.0	20182	45346	25164	124.6	37.3
	Avangard Grow Humate	5.79	7900	133.0	20033	45741	25708	128.3	41.0
DN Julia 340 medium-ripening	Control (no stimulators)	5.77	7900	-	19900	45583	25683	129.0	-
	Vympel 2	5.96	7900	200.0	20100	47084	26984	134.2	5.2
	Alpha Nano Grow	5.97	7900	275.0	20175	47163	26988	133.7	4.7
	Avangard Grow Amino	5.95	7900	282.0	20182	47005	26823	133.8	4.8
	Avangard Grow Humate	5.94	7900	133.0	20033	46926	26893	134.2	5.2
DN Olena 440 srednepizny	Control (no stimulators)	6.18	7900	-	19900	48822	28922	145.3	-
	Vympel 2	6.68	7900	200.0	20100	52772	32672	162.5	17.0
	Alpha Nano Grow	6.41	7900	275.0	20175	50639	30464	150.9	5.6
	Avangard Grow Amino	6.22	7900	282.0	20182	49138	29001	143.4	-1.9
	Avangard Grow Humate	6.29	7900	133.0	20033	49691	29658	148.0	2.7

Source*: compiled by the authors*

Thus, the total costs in the technological cycle of corn cultivation in the experimental field of the Scientific and Educational Centre for Practical Training of DSAEU amounted to 19900 UAH/ha (material costs, labour remuneration, depreciation charges). The cost of the preparations used in the experiment, as of the 2022 marketing year, was: Vympel 2 – 400 UAH/L, Alfa Nano grow – 550 UAH/0.1 L, Avangard Grow amino – 188 UAH/l, Avangard Grow Humate – 133.0 UAH/l. As can be seen from Table 2, the maximum total production costs were for the use of Avangard Grow amino – 282 UAH/ha (in total – 20182 UAH/ha) and Alfa Nano grow – 275.0 UAH (in total – 20175 UAH/ha) due to the slightly higher cost of these preparations.

With the same production costs of 19900-20182 UAH/ha, different-maturing hybrids did not form the same grain yield (an increase in yield from early-maturing to medium-late hybrid), and economic indicators changed accordingly. The maximum yield, and accordingly the profitability of grain production, was provided by the medium-late hybrid DN Olena – 145.3-148.0%. Slightly inferior to the medium-early DN Khortytsia and medium-maturing DN Julia, and with minimal yield indicators (4.37-4.73 t/ha), the minimum profitability of grain production was provided by the early-maturing hybrid DN Pivikha – 73.4-86.5%. Economic indicators are obtained from the effect of stimulants on corn plants. The maximum increase in percentage points (p.p.) of profitability from the use of preparations in relation to control was obtained on early-maturing DN Pivikha (3.0-13.1 percentage points) and medium-early Dn Khortytsia (12.3-41.0 percentage points) hybrids. Avangard Grow Humate (1.0 L/ha) had the best economic indicators here with the best increase in p.p. in relation to the control (+13.1-41.0 VP).

Medium-ripening DN Julia and medium-late DN Olena hybrids had a minimal increase in profitability from the preparations used, only 4.7-5.2 and 2.7-

17.0 p.p., respectively, due to small grain increases from the use of preparations. On these corn hybrids, the best results were provided by Vympel 2, which provided an increase in the level of profitability by 5.2-17.0 percentage points. The best effectiveness of preparations on early-maturing and medium-early hybrids can be explained by the better effect of preparations at the beginning of the growing season of the plant and its gradual attenuation over time. Medium-ripening and medium-late hybrids, to the extent of their biological characteristics, have a longer growing season, and accordingly require a more extended prolongation of the action of preparations, that is, it is necessary to additionally apply preparations in later phases of growth and development to obtain the greatest increase in grain and increase the level of profitability of grain production.

Growth stimulators and microfertilisers that were examined in the experiment (Avangard Grow Amino, Avangard Grow Humate) are relatively new preparations and are practically not examined in the conditions of Ukraine and the world, so there is little data on their effectiveness, except for the declared characteristics of the originator, in addition, they are contradictory due to the specific features of climatic conditions and elements of corn cultivation technology. A number of Ukrainian and foreign researchers note that plant growth stimulators in combination with microfertilisers are highly effective preparations that increase the stress resistance of corn plants and increase its yield, which is also confirmed by the data of this study (Marchenko *et al*., 2019; Gong *et al.,* 2021). The increase in corn grain from the use of growth-stimulating preparations in the early-maturing hybrid DN Pivikha was 0.13 – 0.37 t/ha (2.7-7.8%), medium-early DN Khortytsia – 0.85-1.08 t/ha (16.6-18.5%), medium-maturing DN Julia – 0.18-0.22 t/ha (3.18-3.4%), medium-late DN Olena – 0.05-0.51 t/ha (0.65-7.6%). Foreign researchers have similar results regarding the use of growth stimulants and microfertilisers. Thus, in particular, according to the authors J. Xue *et al.* (2020), the growth regulator Megamix N10 provided a grain increase of 30-32.5%, and the growth regulator Aminocate 30% provided a grain increase of 23.7-24.7% in relation to the control without preparation treatment.

Experiments conducted by O. Laszlo & R. Olepir (2022) show an increase in the yield of corn grains from the plant growth regulator Vympel and Oracle at the level of 8% or more. In the control variants without the use of stimulants, the corn yield was 3.79 t/ha. Seed treatment with Vympel-K + Orakul tank mixture at a rate of 1.0 l/t increased the yield by 0.250 t/ha, respectively, while plant treatment in phases 3-5 and 7-8 leaves increased the grain yield by 0.290 and 0.330 t/ha. The preparations showed an increased growth-stimulating effect in the early stages of plant growth and development. Experiments by H. Ebrahimi *et al.* (2020) proved that the use of plant growth stimulators has improved the use of fertilisers by plants, because they increase the efficiency of nutrient availability and perception by maise plants. Experiments on growth stimulators with corn in China have shown that the growth stimulator EDAH+DA-6 suppresses stem elongation, promotes stem thickening, and increases mechanical strength and the number of vascular bundles (Gong *et al*., 2021). Corn lodging under EDAH+DA-6 treatment decreased by 6.95% compared to control plants, and grain yield increased by 15.51%. In addition, Edah+DA-6 introduction substantially improved the quality of corn. Similar results regarding the thickening of the corn stem and increasing its strength are confirmed by other Chinese researchers (Seknon *et al*., 2020).

According to the results of these studies, it is possible to increase the stress resistance of plants to environmental conditions and level the problems by optimising the technological elements of corn cultivation, introducing new modern biological growth stimulators of corn that have been poorly examined or not examined at all (Avangard Grow Humate, Avangard Grow Amino, Vympel 2), which contribute to accelerated growth, increased resistance to extreme temperatures, improved leaf development, increased chlorophyll content, increased crude protein and fat content in corn grain, and ultimately, an increase in grain yield and quality.

CONCLUSIONS

The use of growth stimulants did not substantially increase the height of maise plants, only by 3.0-8.0 cm (1.5-3%) compared to the control. The maximum height of plants is typical for areas treated with Avangard Grow Humate – 223.0-225.0 cm. There is a tendency to increase the number of leaves when applying growth stimulants by 3.50-5.60%, regardless of the corn ripening group. There were also trends of increasing the area of leaf blades by 5.30-28.30% without substantial differences between the preparations.

The maximum increase in chlorophyll content was provided by Avangard Grow Amino and Avangard Grow Humate compared to Vympel 2 and Alpha Nano grow. In particular, the hybrids DN Pivikha by 8.2-9.2 units of SPAD (17.8-19.7%), DN Khortytsia – by 9.3-12.9 units of SPAD (18.3-23.8%), DN Julia – by 2.4-6.7 units of SPAD (4.7-12.3%), DN Olena – by 1.5-6 units of SPAD (3.1-11.3%). The additional volume of corn grain from the use of growth stimulators in various hybrids showed the following results: in the early-maturing hybrid DN Pivikha, this increase ranged from 0.13 to 0.37 tonnes per hectare (which is 2.7 – 7.8%); in the medium-early DN Khortytsia – from 0.85 to 1.08 tonnes per hectare (16.6-18.5%); in the medium – maturing DN Julia-from 0.18 to 0.22 tonnes per hectare hectares (3.18-3.4%); and in the medium-late DN Olena – from 0.05 to 0.51 tonnes per hectare (0.65-7.6%).

The content of crude protein under the influence of stimulants tended to increase, in particular, in DN Piv-

ikha by 0.03-0.65 p.p. (percentage points), DN Khortytsia 0.58-1.04 p.p., DN Julia – 0.1-0.74 p.p., DN Olena – 0.15-0.68 p.p., preparations Avangard Grow Amino and Avangard Grow Humate provided the greatest increase in the content of crude protein up to 6.42-8.4%, or 0.13-0.48 percentage points more. The use of a medium-late hybrid of corn DN Olena provides maximum indicators of crude fat content of 4.71-5.38%, the rest of the hybrids are slightly inferior by 0.32-1.18 percentage points. Growth stimulants (Avangard Grow Humate, Avangard Grow amino, Vympel 2) contribute to an increase in the content of crude fat compared to the control (3.53-4.71%) to 3.73-5.52%, or by 0.3-0.81 p.p. The medium-late hybrid DN Olena reaches the highest level of profitability in corn grain production, which is 145.3-148.0%. Slightly lower indicators in the medium-early DN Khortytsia and medium-maturing DN Julia. Growth stimulators, and especially Avangard Grow Humate, have a maximum increase in percentage points (VP) of profitability on the early-maturing hybrid DN Pivikha (3.0-13.1 VP) and medium-early DN Khortytsia (12.3-41.0 VP).

Changing climatic conditions and constant updating of the composition of different-maturing hybrids and preparations based on growth stimulants cause the continuation of research in this area to identify the most optimal variants of preparations to increase the level of yield and its quality.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Ефективність регуляторів росту в посівах кукурудзи Північного Степу України

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Анотація. Безперервне зростання цін на мінеральні добрива під кукурудзу обмежує використання добрив, що веде до пошуку нетрадиційних джерел внесення елементів живлення, а зокрема використання біологічних природних та синтетичних стимуляторів росту, які не шкідливі для довкілля і дозволяють ширше використовувати весь генетичний потенціал кукурудзи. Мета роботи полягала у вивченні впливу різних регуляторів росту рослин на інтенсивність фотосинтезу, розвиток, ріст і продуктивність кукурудзи різних груп стиглості в Степу України. Проводили польові наукові дослідження за загально прийнятими методиками дослідної справи із наступним використанням математичної обробки експериментальних даних за допомогою дисперсійного аналізу. Виявлено збільшення умісту хлорофілу при внесенні препаратів Авангард Гроу Аміно і Авангард Гроу Гумат у порівнянні з Вимпел 2 і Альфа Нано Гроу на 11,3-23,7 %. Прибавка зерна від використання стимуляторів росту на кукурудзі становила у ранньостиглого гібриду ДН Пивиха – 0,13-0,37 т/га (2,7-7,7 %), середньораннього ДН Хортиця – 0,85-1,08 т/га (16,6-18,5 %), середньостиглого ДН Джулія – 0,20-0,22 т/га (3,20-3,4 %), середньопізнього ДН Олена – 0,05-0,53 т/га (0,65-7,6 %). Серед використаних препаратів слід виділити Авангард Гроу Аміно та Авангард Гроу Гумат які забезпечували тенденцію до підвищення умісту сирого протеїну до 6,42-8,4 %, або на 0,12-0,48 в.п. (відсоткові пункти) більше та умісту сирого жиру порівняно з контролем (3,53-4,71 %) до 3,73-5,52 %, або на 0,20-0,81 в.п. Використання стимуляторів росту в умовах Північного Степу України на кукурудзі, особливо Авангард Гроу Аміно і Авангард Гроу Гумат на ранньостиглих та середньоранніх гібридах кукурудзи дозволяє збільшити валові збори зерна високої якості на 7,6-18,4 %

Ключові слова: гібриди кукурудзи; стимулятори росту; біометричні показники; одиниці SPAD; врожайність зерна; сирий протеїн; сирий жир; економічна ефективність