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Influence of protection systems and regulation of growth processes on the formation of yield of Turanian wheat in the conditions of the Steppe of Ukraine

Oleksandr Vinyukov[1], Olha Bondareva[1], Hanna Likhushyna[1], Volodymyr Orekhivskyi[1], Tetiana Marchenko[2*]

[1] Donetsk state agricultural science station of the National academy of agrarian sciences of Ukraine, Zashchitnikov Ukrainy str. 1, Pokrovsk, Donetsk region, 85307, Ukraine
[2] Institute of Climate Smart Agriculture of the National academy of agrarian sciences of Ukraine, Mayatska doroga Str. 24, Khlybodarske, Odesa region, 67667, Ukraine
* Corresponding author's e-mail: tmarchenko74@ukr.net

ABSTRACT

Durum wheat is important for providing the population with high-quality food products. The variety *Triticum turanicum* Jakubz. is genetically close to durum wheat. It is necessary to study agrotechnological methods for growing Turanian wheat in the eastern part of the Northern Steppe of Ukraine that would contribute to high plant productivity, including the use of growth inhibitors and pesticides. The studies were conducted in 2022–2024 in the field crop rotation of the Donetsk State Agricultural Research Station of the NAAS of Ukraine. The main research method was field. Turan wheat of the Sarmat variety was used. Growth regulators Chlormequat chloride and Tava were, studied at different phases of organogenesis in two protection systems. Protection System 1 included herbicide Sheriff (20 g/ha, beginning of tillering); fungicide Paracelsus (0.5 l/ha, first internode); insecticide Presto (0.4 l/ha, heading). Protection System 2 included tank mixture of Primus (0.5 l/ha, herbicide), Dot (0.5 l/ha, fungicide) and Presto (0.4 l/ha, insecticide) in the second internode phase. The application of growth inhibitors led to a reduction in plant height in all variants of the study. The use of chlormequat chloride in the first internode phase reduced plant height in Protection System 1 by 12.7 cm or 10.3% and in Protection System 2 by 13.7 cm or 11% compared to the control (123.2 cm and 124.0 cm, respectively). The Tava preparation was more effective when applied in the flag leaf phase in Protection system 1, with plant height reduced by 11.3 cm or 9.2% compared to the control. In all variants of using growth regulators, the chlorophyll content was preserved compared to the control by 0.3-0.4 mg/g, depending on the protection system. Spraying crops with Tava during the first internode phase in Protection System 1 contributed to the maximum yield of 3.8 t/ha (an increase of 2.0 t/ha compared to the control). Thanks to Protection System 1, the development of *Septoria tritici* Roberge ex Desm was 0.4% lower compared to Protection System 2, and the number of the main pest of Turanian wheat, the *Anisoplia austriaca* (Herbst, 1783), was reduced to 1.1 copies/m^2 (in the control – 5.3 copies/m^2). The use of growth regulators and pesticides in Turan wheat cultivation technologies has ensured high-quality and stable yields in the steppe regions of Ukraine.

Keywords: *Triticum turanicum* Jakubz., growth inhibitors, pesticides, biometric indicators, yield, phytosanitary condition.

INTRODUCTION

Increasing grain production, along with providing the population with high-quality food products, are priority areas for agricultural development in Ukraine (Penkova, 2015; Kundieieva and Kulish, 2017; Morgun, 2018). In the structure of sown areas, the percentage of crops useful for human nutrition should be increased - durum wheat, millet, buckwheat, chickpeas, lentils, etc. (Buvaneshwari et al., 2003; Mohan and Malleshi, 2006; Biradar et al., 2022; Korkhova, 2024).

Durum wheat is known for its nutritional properties such as gluten quality (Carrillo et al., 2000; Carrillo et al., 2006), mineral content and other substances important for human nutritional needs (Kuznetsova et al., 2019; Aberkane et al., 2021; Ninou et al., 2024).

The species *Triticum turanicum* Jakubz. (*T. turgidum* subsp. *turanicum* Jakubz.), known as Turanian wheat, is genetically close to durum spring wheat (Ebsaa, 2024).

Triticum turanicum crops are rare, most common in Asian and Mediterranean countries. Research has shown that the biochemical composition of grain is closely related to weather conditions during plant development (Nurmi et al., 2010; Shewry et al., 2010). The species is characterized by high tolerance to heat and atmospheric drought (Rodríguez-Quijano et al., 2010; Laidò et al., 2013; Gospodarenko et al., 2016). This makes it attractive for cultivation in areas with arid climates, which suggests the feasibility of introducing Turanian wheat in the southeast of Ukraine.

Agronomic methods for cultivating Turanian wheat, which will allow for high yields, require study, including the use of biopreparations and plant protection products. Growth regulators, entering the plant, are not just an external stimulant, but an integrated part of its physiological processes. This opens up wide opportunities to increase productivity and resistance to unfavorable conditions by controlling physiological processes in plants (Gamayunova and Panfilova, 2019; Makukha, 2019; Ishchenko, 2021).

There are problems associated with the optimization of physiological processes in plants. Turanian wheat plants up to 135 cm tall with thin straw (3.5–4 mm) are not resistant to lodging. This complicates the harvesting process. A large number of growth inhibitors are available on the market (Liskovskyi et al., 2020; Gamayunova et al., 2022; Olefirenko and Demydov, 2024), but studies of their effect on Turanian wheat plants in the Donetsk region have not been conducted.

The development of a plant protection system is an important issue. Since spring wheat species in the Steppe ripen 10–15 days later than winter wheat, they suffer from massive pest infestation, especially in the last stages of organogenesis (Usov, 2015; Polovyi et al., 2017). Most insecticides cannot be used at the end of the earing phase, and the use of drugs at earlier stages does not provide sufficient protection. That is why the question arose of determining the most appropriate plant protection system for Turanian wheat, which would provide maximum protection of the culture during the stages of organogenesis.

The aim of the research is to study the influence of protection systems and growth inhibitors on the development and yield of Turanian wheat (*Triticum turanicum Jakubz*.) in the Steppe of Ukraine.

MATERIALS AND METHODS

The studies were conducted from 2022 to 2024 in the field crop rotation of the Donetsk state agricultural science station of the National academy of agrarian sciences of Ukraine.

The experiments were repeated three times. The area of the accounting plot was 25 m². The soil was ordinary, heavy loamy chernozem. Humus content was 4.9%, pH was slightly alkaline, close to neutral, total nitrogen content was 0.22, and phosphorus content was 0.14%.

The preceding crop was sunflower. Presowing tillage was aimed at maximizing soil moisture retention and accumulation, as well as weed control.The optimal sowing dates, the impact of different nutrient backgrounds, and seeding rates on the yield and grain quality of Turanian wheat for the conditions of the southeastern part of the Steppe of Ukraine were determined (Manko et al., 2012; Vinyukov et al., 2023; Vinyukov et al., 2024).

The Turanian wheat variety Sarmat (PU No. 230611 dated October 25, 2023) was used in the study. The cultivation technology was generally accepted for spring grain crops in the south-eastern part of the Steppe of Ukraine (Scientifically based system of management of agro-industrial production of Donetsk region, 2007), except for the questions posed for study, and corresponded to zonal and regional recommendations.

Donetsk region is located in the south-eastern part of the Steppe of Ukraine and, according to climatic conditions, belongs to the zone of risky, unstable agriculture (Scientifically based system of management of agro-industrial production of Donetsk region, 2007). Most of the territory has a high level of heat supply and insufficient moisture Insufficient precipitation during critical periods of crop development is usually accompanied by a significant increase in average daily air temperatures over long-term ones. During the period of active vegetation, the amount of precipitation is

290–320 mm, the sum of active air temperatures is 3000–3200 °C, and the hydrothermal coefficient is 0.9. In dry years, the moisture deficit exceeds the long-term indicator by almost 2 times. The region is characterized by uneven precipitation distribution during the period of grain formation and filling. Hydrothermal conditions during the study years did not differ significantly from the long-term average, making it possible to establish the response of Turanian wheat plants to all manifestations of weather conditions typical of the south-eastern part of the Steppe of Ukraine.

In our research, two growth regulators were used Chlormequat chloride and Tava, which were sprayed on plants in different phases of organogenesis.
The protection system provided for two options:
- Protection System 1 – herbicide Sherif (20 g/ha, beginning of tillering); fungicide Paracelsus (0.5 L/ha, first internode); insecticide Presto (0.4 L/ha, earing);
- Protection System 2 – tank mixture of Primus (0.5 L/ha, herbicide), Dot (0.5 L/ha, fungicide) and Presto (0.4 L/ha, insecticide) in the second internode phase.

The main research method was field, which was supplemented by analytical studies, measurements, calculations and observations. The classification of diseases and pests is based on GBIF Backbone Taxonomy (GBIF Secretariat, 2023). Statistical analysis of the results was conducted in Statistica 10.0 (Statsoft Inc., USA).

RESULTS AND DISCUSSION

The main task when using growth inhibitors is the formation of the vegetative part of plants, which is characterized by shortened internodes and, as a rule, an increased leaf surface area. Table 1 demonstrates the effects of the studied drugs on biometric indicators of plants at the full ripeness phase.

The reduction in plant height when using growth inhibitors was observed in all variants. When spraying plants with Chlormequat chloride in the tillering phase, a reduction in plant height was noted compared to the control by 6.8 cm (Protection System 1) and 7.2 cm (Protection System 2). Spraying crops with the same growth regulator in the first internode phase allowed to obtain the lowest plant habit in the experiment – 110.5 cm (Protection System 1) and 110.3 cm (Protection System 2).

The drug Tava was more effective when used in the flag leaf phase, reducing plant height compared to the control by 11.3 cm (Protection System 1) and 11.9 cm (Protection System 2). Spraying plants with this drug in the first internode phase contributed to the reduction of plants compared to the control by 8.3 cm (Protection System 1) and 9.5 cm (Protection System 2).

The amount of chlorophyll present in leaves depending on the protection system and the use of growth inhibitors is shown in Table 2.

Table 1. Biometric indicators of Turanian wheat plants in the phase of full ripeness, 2022–2024

Protection System (A)	Growth regulator usage option (B)	Height, cm	Number of stems, pcs./m^2		Tillering coefficient	
			General	Productive	General	Productive
Protection System 1	Control	123.2	823	420	2.06	1,05
	Chlormequat chloride (full tillering)	116.4	735	525	1.84	1,32
	Chlormequat chloride (first internode)	110.5	718	508	1.80	1,27
	Tava (first internode)	114.9	910	560	2.28	1,40
	Tava (flag leaf)	111.9	963	473	2.41	1,19
Protection System 2	Control	124.0	825	421	2.04	1,05
	Chlormequat chloride (full tillering)	116.8	740	515	1.91	1,37
	Chlormequat chloride (first internode)	110.3	718	510	1.89	1,24
	Tava (first internode)	114.5	896	563	2.19	1,53
	Tava (flag leaf)	112.1	923	444	2.31	1,31
LSD $_{0,5}$: A		0,1	1.3	1.0	0.01	0.01
B		2,0	14.6	11.1	0.07	0.09
AB		0,9	12.0	7.4	0.07	0.08

The study of chlorophyll content in the tillering phase showed no difference between the study options. This is since the use of drugs according to the experimental scheme began precisely with this phase, so the effect on this indicator was not recorded.

Analysis of plant samples at the end of the tube phase showed that the use of growth inhibitors contributed to an increase in the chlorophyll content in the leaves compared to the control. This effect was most noticeable in the options using Chlormequat chloride in the tillering phase: 7.2 mg/g (Protection System 1) and 7.1 mg/g (Protection System 2). The better condition of plants when using growth regulators in Protection System 1 is explained by the action of the fungicide Paracelsus, which was used in the first internode phase.

The study of the chlorophyll content in Turanian wheat leaves in earing phase demonstrates the effect not only of growth regulators, but also of the fungicide that was part of the protection systems. Thus, under Protection System 2, where the fungicide Dot was used later (in the second internode phase), the amount of chlorophyll was higher by 0.1–0.2 mg/g compared to similar options under Protection System 1.

All treatments using growth regulators showed an increase in chlorophyll content by 0.3–0.4 mg/g compared to the control, depending on the protection system.

The accumulation of nutrients by plants in vegetative organs made it possible to form appropriate indicators of productivity and yield due to the use of protection systems and plant growth inhibitors (Table 3).

The most common plant diseases in the steppe zone of Ukraine include *Ustilago tritici* (Bjerk.) Rostr., *Blumeria* Golovin ex Speer, *Puccinia dispersa* Erikss. & Henning, *Bipolaris sorokiniana* Shoemaker, *Septoria tritici* Roberge ex Desm, *Drechslera* S.Ito, 1930 (Table 4).

Comparing the protection systems, it was found that at the expense of earlier use of fungicidal in the Protection System 1 development of *Septoria tritici* Roberge ex Desm was lower by 0.4% compared to the Protection System 2, where the fungicide was used in a later phase of plant development.

Currently, pests usually cause the greatest damage to crop. The most common among the pests of cereals in the years of research were *Oscinella pusilla* (Meigen, 1830), *Schizaphis graminum* (Rondani, 1852), *Oulema melanopus* (Linnaeus, 1761), *Phyllotreta vittula* (Redtenbacher, 1849), *Eurygaster integriceps* Puton, 1881 *Anisoplia austriaca* (Herbst, 1783) (Table 4). During the seedling-tillering period, Turanian wheat plants were colonized by *Oscinella pusilla* (Meigen, 1830) та *Phyllotreta vittula* (Redtenbacher, 1849).

During the research, the colonization of crops by pests did not exceed the established ETH, so they did not cause significant damage. Oscinella pusilla (Meigen, 1830) – 11.2 copies/100 sweeps of the net (the Protection System 1), 13.1 copies/100 sweeps of the net (the Protection System

Table 2. Chlorophyll content in leaves of Turanian wheat plants depending on the protection system and use of growth regulators, 2022–2024

Protection System (A)	Growth regulator usage option (B)	Chlorophyll content in leaves (mg/g)		
		Tillering	Emergence into a tube	Earing
Protection System 1	Control	7.2	6.8	6.2
	Chlormequat chloride (full tillering)	7.3	7.2	6.5
	Chlormequat chloride (first internode)	7.2	7.0	6.5
	Tava (first internode)	7.3	7.0	6.5
	Tava (flag leaf)	7.0	6.9	6.5
Protection System 2	Control	7.2	6.8	6.2
	Chlormequat chloride (full tillering)	7.3	7.1	6.6
	Chlormequat chloride (first internode)	7.3	7.0	6.6
	Tava (first internode)	7.2	7.0	6.6
	Tava (flag leaf)	7.2	6.9	6.6
$LSD_{0.5}$: A B AB		0.02 0.06 0.07	0.01 0.05 0.06	0.01 0.02 0.02

Table 3. Yield structure indicators and yield of Turanian wheat of the Sarmat variety depending on the elements of growing technology, 2022–2024

Protection System (A)	Growth regulator usage option (B)	Length on the ear, cm	Weight of grain in the ear, g	Number of grains in the ear, pcs.	Weight of 1000 grains, g	Yield, t/ha	Increase	
							t/ha	%
Protection System 1	Control	6.0	1.060	21	50.52	1.8	-	-
	Chlormequat chloride (full tillering)	5.9	1.247	23	54.22	3.6	1.8	100.0
	Chlormequat chloride (first internode)	5.6	1.237	23	58.92	3.2	1.4	77.7
	Tava (first internode)	6.4	1.379	25	57.44	3.8	2.0	111.1
	Tava (flag leaf)	6.4	1.145	25	54.51	3.3	1.5	83.3
Protection System 2	Control	5.9	1.014	20	50.72	1.6	-	-
	Chlormequat chloride (full tillering)	5.9	1.303	24	54.30	3.3	1.7	106.3
	Chlormequat chloride (first internode)	5.8	1.354	23	58.85	2.8	1.2	75.0
	Tava (first internode)	6.4	1.387	24	57.81	3.2	1.6	100.0
	Tava (flag leaf)	6.4	1.265	23	55.01	2.9	1.3	81.3
$LSD_{0.5}$: A		0.02	0.01	0.02	0.03	0.1		
B		0.5	0.04	0.7	0.5	0.8		
AB		0.4	0.05	0.6	0.2	0.9		

Table 4. Phytosanitary condition of Turanian wheat of variety Sarmat (2022–2024)

Harmful organisms	Protection Systems		
	Control	Protection System 1	Protection System 2
Development of diseases, %			
Bipolaris sorokiniana Shoemaker	0.80 ± 0.03	0.30 ± 0.02	0.70 ± 0.03
Blumeria Golovin ex Speer	0.00	0.00	0.00
Puccinia dispersa Erikss. & Henning	0.00	0.00	0.00
Septoria tritici Roberge ex Desm	2.30 ± 0.05	1.10 ± 0.03	1.50 ± 0.04
Drechslera S.Ito, 1930	0.20 ± 0.01	0.00	0.00
Pests, copies/m^2, copies/ear, copies/100 sweeps of the net			
Oscinella pusilla (Meigen, 1830)	15.10 ± 0.80	11.20 ± 0.40	13.10 ± 0.70
Schizaphis graminum (Rondani, 1852)	4.70 ± 0.60	3.50 ± 0.30	1.50 ± 0.10
Oulema melanopus (Linnaeus, 1761)	4.20 ± 0.70	3.10 ± 0.50	1.00 ± 0.20
Phyllotreta vittula (Redtenbacher, 1849)	25.90 ± 0.90	12.00 ± 0.50	22.70 ± 0.70
Eurygaster integriceps Puton, 1881	0.40 ± 0.03	0.00	0.10 ± 0.01
Anisoplia austriaca (Herbst, 1783)	5.30 ± 0.50	1.10 ± 0.20	3.50 ± 0.30

2); Phyllotreta vittula (Redtenbacher, 1849) – 12.0 copies/m2 (the Protection System 1), 22.7 copies/m^2 (the Protection System 2).

In the later phases of plant development, crops were damaged by *Oulema melanopus* (Linnaeus, 1761) та *Schizaphis graminum* (Rondani, 1852). Their number in the experiments was lower than the ETH due to the action of the insecticide. However, due to the use of insecticide in the Protection System 2 earlier than in the Protection System 1, the number of pests was lower by 2.0 copies/m^2 – *Schizaphis graminum* (Rondani, 1852) and 2.1 copies/m^2 – *Oulema melanopus* (Linnaeus, 1761). During the years of research, no significant spread of *Eurygaster integriceps* Puton, 1881 was noted.

The greatest damage to Turanian wheat crops is caused by *Anisoplia austriaca* (Herbst, 1783), the greatest activity of which is observed precisely in the phase of milky-wax ripeness. The use of protection systems has improved the phytosanitary condition of crops. Protection System 1, in which insecticide was used at the beginning of the earring, ensured a decrease in the number of *Anisoplia austriaca* (Herbst, 1783) by 4.2 copies/m^2. Spraying crops with the insecticide Presto when the plants form the second internode (Protection System 2) reduced the number of pests by 1.8 copies/m^2.

Studies (Shewry et al., 2010; Nurmi et al., 2010; Shewry et al., 2011; Hussain et al., 2018) have shown that the biochemical composition of grain is closely related to weather conditions during its development. It has been established that high temperatures negatively affect grain yield (Ferris et al. 1998; Barnabas et al. 2008; Hussain et al. 2018).

Microbial preparations contribute to increased plant biomass, phytopathogen control and increased plant productivity on arid lands (Cardoso et al., 2018; Oleńska et al., 2020; Goudarzi et al., 2023; Ferioun et al., 2025).

Growth regulators, entering the plant, become not just an external stimulant, but an integrated part of its physiological processes. This opens up wide possibilities for controlling growth of plant, as well as for increasing productivity and resistance to adverse conditions (Glick, 2012; Makukha, 2019; Abdelaal et al., 2021; Ishchenko, 2021). In the leading agricultural countries of the world, about 15–20% of crops are obtained with the use of plant growth regulators (Oliynyk et al., 2013; Khodanitska et al., 2014; Nepran et al., 2021). Application of growth inhibitors allows you to control plant height, strengthen stems, reduce the risk of lodging, and increase resistance to stressful conditions.

A promising strategy for improving plant growth involves the use of bacteria, which simultaneously reduces dependence on synthetic fertilizers and pesticides (Aquino, 2021). The results of Chami et al. showed that co-inoculation of durum wheat with P. polymyxa strains had a positive effect on yield parameters (+41.1% in the first season and +16.6% in the second) and quality traits compared to untreated samples. It was demonstrated that co-inoculation of TRQ8 and TRQ65 in wheat stimulated growth in the early stages of development and improved (compared to untreated samples) parameters such as stem length (8–12%) and chlorophyll content (7%) (Chami et al., 2024).

Bioinoculants enhance photosynthetic efficiency by stimulating chlorophyll pigment synthesis pathways, which improves physiological stability and crop yield (Ahluwalia et al., 2021; Abideen et al., 2022; Zaib et al., 2022).

As our studies have shown, for System 1 in the variants with the use of Chlormequat chloride showed a decrease in spike length compared to the control (by 0.1 cm when using a growth inhibitor in the tillering phase and by 0.4 cm in the first internode phase). When spraying crops with the growth regulator Tava, the spike length of Turanian wheat increased by 0.4 cm to the control. A tendency for growth regulators to affect spikelet length was also seen in protection system 2. Thus, Chlormequat chloride did not contribute to an increase in this indicator, and Tava increased it by 0.5 cm. The number of grains in the spike differed between variants, as well as between protection systems. Thus, with protection system 1, the largest number of grains in the experiment was recorded, which was 25.0 copies, which is 1.0 more than in the variants where protection system 2 was used. This is primarily due to the prolonged action of the insecticide, which ensured the preservation of grains from grain beetles *Anisoplia austriaca* (Herbst, 1783).

When comparing the effect of growth inhibitors and the timing of their application, it was found that these drugs increased the number of grains in the ear compared to the control. Thus, for Protection System 1, the drug Chlormequat chloride, regardless of the variant, increased this indicator by 2.0 grains, and Tava — by 4.0 grains. When using pesticides in a tank mixture in the second internode phase, the number of grains in the ear when spraying crops with growth inhibitors also increased compared to the control by 3.0–4.0 pcs.

The use of pesticides and spraying crops with growth inhibitors contributed to the formation of better productivity indicators than in the control, and the corresponding grain yield. The obtained research data (Andreichenko and Kornicheva, 2024) indicate that biostimulants have an effect on increasing the yield of spring barley. Thus, when treating seeds with preparations, the yield increases by 0.18–0.25 t/ha or by 6.4–8.9%, when spraying plants in the tillering phase by 0.24–0.32 t/ha or by 8.6–11.4%. The highest productivity was established in the variant with spraying of plants at the end of tillering with the biostimulant Agrostimulin and was 3.12 t/ha, while in the control variant it was 2.80 t/ha.

As our studies have shown, the greatest impact of the studied variants was noted when determining the mass of 1000 grains. Regardless of the protection system, all studied options for the use of growth inhibitors contributed to an increase in this indicator compared to the control. The largest increase in the weight of 1000 grains was observed when spraying crops with Chlormequat chloride in the first internode phase, where the excess of this indicator was 8.4 g (Protection System 1) and 8.1 g (Protection System 2).

Protection System 1 contributed to the highest yield depending on the test variant. Spraying crops in the first internode phase by Chlormequat-chloride resulted in an increase of 1.4 t/ha, and during the tillering phase — 1.8 t/ha. Highest yield in the research was obtained when spraying crops with Tava in the first internode phase (+2.0 t/ha compared to control), and its application in the second internode phase gave an increase of 1.5 t/ha. Under Protection System 2, the highest grain increases were obtained when spraying plants in the tillering phase with the drug Chlormequat-chloride (+1.7 t/ha to the control) and when spraying crops in the first internode phase with the drug Tava (+1.6 t/ha compared to control).

The realization of the yield potential of grain crops is largely determined by their phytosanitary condition, which causes varying degrees of plant disease, damage by pests and the presence of unwanted vegetation - weeds in crops. For a protection system to be economically effective, it must be adapted to the weather conditions of the year, soil fertility, the intensity of crop and weed growth, and the spread and extent of damage to plants by pests and diseases (Nishimoto, 2019; Fedorenko et al., 2021). Knowledge of the biology of harmful organisms, as well as the economic threshold of their harmfulness, is extremely important in this regard (Strygun and Suddenko, 2016). The results of studies (Krivenko and Shushkivska, 2020) on the species composition and density of insect populations in modern entomocomplexes showed that 78% of the identified species are phytophagous, 17% are entomophagous, and 5% are neutral species.

Limiting the negative impact of harmful organisms is one of the important factors in increasing grain production (Tsygankova, 2013). Pests and diseases accompany grain crops from sowing to harvesting and even after harvesting. The results of their impact on plants are manifested in the form of spots, plaque, transformation of ears and grain into soot mass, rotting, reduced productivity, and even complete death of plants. Annual grain yield losses from diseases and pests in the Steppe of Ukraine are from 20 to 30%, and higher in years of significant spread (Dolya et al., 2024).

The results of the analysis of various scientific studies show that most grain yield losses in the Steppe zone are caused by numerous fungal pathogens (Dermenko, 2009; Voloshuk, 2012; Pohorila, 2019). Wheat grains can get infected with mycoflora at different times, like during the growing season, harvest time (especially when it's really humid), threshing, or when storing seeds with high moisture content. Mycoflora on seeds can be saprophytic (Penicillium, Mucor, Alternaria, Aspergillus, etc.) and pathogenic (Helminthosporium, Fusarium, Septoria, etc.).

During the course of the research, it was established that diseases such as *Blumeria* Golovin ex Speer та *Puccinia dispersa* Erikss. & Henning did not develop on Turanian wheat crops due to unfavorable weather conditions for them. The intensity of *Bipolaris sorokiniana* Shoemaker and *Septoria tritici* Roberge ex Desm has not exceeded ETH (Economic Threshold of Harmfulness) over the years of research.

The high degree of damage caused by insects of grain crops in the steppe zone of Ukraine is associated with a wide variety of harmful species due to favorable climatic conditions for their intensive reproduction. This has significant consequences for plants and crops (Kendall, 1995; Canhilal et al., 2005; Fedorenko et al., 2008).

Both systems provide protection of Turanian wheat from pests at the stages of organogenesis, but the most positive effect was achieved with the first system, which allowed to significantly reduce the number of the main pest of Turanian wheat - *Anisoplia austriaca* (Herbst, 1783).

Thus, the studies established the feasibility of using growth regulators and pesticides in the cultivation of wheat, which not only ensured plant resistance to lodging, but also contributed to the formation of better plant productivity indicators in the conditions of the Ukrainian Steppe. Thus, research has confirmed the advisability of using growth regulators and pesticides in the cultivation of *Triticum turanicum* Jakubz., which ensured plant resistance to lodging and contributed to high plant productivity indicators in the conditions of the steppe of Ukraine.

CONCLUSIONS

Analysis of samples of Turanian wheat plants at full maturity showed that the use of growth inhibitors resulted in a reduction in plant height in all variants. The use of chlormequat chloride in the first internode phase reduced plant height in Protection System 1 by 12.7 cm or 10.3% and in Protection System 2 by 13.7 cm or 11% compared to the control. The Tava preparation was more effective when applied at the flag leaf stage in Protection System 1, reducing plant height by 11.3 cm or 9.2% compared to the control.

In all variants of using growth regulators, the chlorophyll content was preserved compared to the control by 0.3–0.4 mg/g, depending on the protection system.

Spraying crops with Tava during the first internode phase in Protection System 1 contributed to the maximum yield of 3.8 t/ha (an increase of 2.0 t/ha compared to the control).

Progression of *Septoria tritici* Roberge ex Desm under Protection System 1 was 0.4% lower compared to Protection System 2, where the fungicide was applied at a later stage of plant development.

Both systems provide protection for Turanian wheat during the stages of organogenesis, but the most positive effect of protection was achieved under Protection System 1, which allowed reducing the number of the main pest of Turanian wheat, *Anisoplia austriaca* (Hebst, 1783), to 1.1 copies/m^2 (on the control – 5.3 copies/m^2).

The use of growth inhibitors and pesticides in Turanian wheat cultivation has ensured plant resistance to lodging and high-quality, stable yields in the steppe conditions of Ukraine.

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