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PRODUCTIVITY OF WINTER WHEAT USING CHLORMEQUAT-CHLORIDE 750 WITH DIFFERENT OF FEEDING

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At the current stage of the development of agro-industrial production, it is impossible to imagine the cultivation of agricultural plants without the use of various chemical means of influencing the growth and development of plants. Wide use of such drugs requires a comprehensive study of their interaction with other agrotechnological means.

The purpose of the research was to determine the features of the formation of the productivity of soft winter wheat of the Spivanka variety depending on different methods and terms of treatment with the growth regulator Chlormequat-Chloride 750 on different backgrounds of mineral fertilizer in the conditions of the northern part of the Steppe of Ukraine. The following options were used: 1) control without the use of a retardant; 2) seed treatment before sowing (2.0 l/t); 3) seed treatment before sowing (2 l/t) + sowing in the spring after the restoration of spring vegetation (1.5 l/t); 4) treatment of crops with a retardant in autumn at the beginning of the tillering phase (1.5 l/ha); 5) treatment of crops with a retardant in autumn at the beginning of the bushing phase (1.5 l/ha) + after the restoration of spring vegetation (1.5 l/ha); 6) treatment of crops with a retardant in the fall at the beginning of the bushing phase (1.5 l/ha) + after the restoration of spring vegetation (1.5 l/ha) + at the beginning of the tube emergence phase (1.5 l/ha). The predecessor was black steam. The experiment was conducted on the following fertilizer backgrounds: $P_{30}K_{20} + N_{30}$, $N_{30}P_{60}K_{30} + N_{30}$ and $N_{60}P_{90}K_{60} + N_{30} + N_{30}$. Fertilizers were applied for soil cultivation, and top dressing was applied to thawed soil.

It was established that at the end of the autumn vegetation, neither seed treatment nor crop spraying had a significant effect on the growth and development of plants compared to the control. It was established that both during seed treatment and when spraying crops in the fall, winter wheat plants acquired significant changes only when the spring vegetation was restored and, first of all, due to better wintering. Spraying crops was more effective compared to seed treatment before sowing. Thus, compared to the control, seed treatment led to an increase in productivity by 4.5 %, and spraying with a retardant in the spring increased it by 6.7 %. Even greater increases in productivity were obtained when spraying crops with a retardant in autumn and double processing crops in autumn and spring – 8.4 and 10.4 %, respectively. The highest level of productivity was provided by the cultivation of winter wheat on the background of $N_{60}P_{90}K_{60} + N_{30} + N_{30}$ with triple spraying of crops with the retardant Chlormequat-Chloride 750 in autumn at the beginning of the bushing phase, after the recovery of spring vegetation and at the beginning of the phase of emergence into the tube (6.66 t/ha).

Key words: *soft wheat, mineral fertilizers, growth retardant Chlormequat-Chloride 750, biometric indicators, plant survival, productivity.*

Ярчук І.І., Позняк В.В., Лемішко С.М., Черних С.А., Пашова В.Т. Урожайність пшениці озимої при обробці рослин препаратом Хлормекват-хлорид 750 за різних рівнів удобрення

На сучасному етапі розвитку агропромислового виробництва уявити вирощування сільськогосподарських рослин без використання різних хімічних засобів впливу на ріст та розвиток рослин неможливо. Широке застосування таких препаратів вимагає комплексного вивчення їх взаємодії з іншими агротехнологічними засобами.

За мету досліджень було поставлено визначення особливостей формування продуктивності пшениці м'якої озимої сорту Співанка залежно від різних способів і строків обробки регулятором росту Хлормекват-хлорид 750 на різних фонах мінерального удобрення в умовах північної частини Степу України. Були використані наступні варіанти: 1) контроль без застосування ретарданту; 2) обробка насіння перед сівбою (2,0 л/т); 3) обробка насіння перед сівбою (2 л/т) + посівів навесні після відновлення весняної вегетації (1,5 л/т); 4) обробка посівів ретардантом восени на початку фази кущення (1,5 л/га); 5) обробка посівів ретардантом восени на початку фази кущення (1,5 л/га) + після відновлення весняної вегетації (1,5 л/га); 6) обробка посівів ретардантом восени на початку фази кущення (1,5 л/га) + після відновлення весняної вегетації (1,5 л/га) + на початку фази виходу в трубку (1,5 л/га). Попередником був чорний пар. Дослід проводили на таких фонах удобрення: $P_{30}K_{20} + N_{30}$, $N_{30}P_{60}K_{30} + N_{30}$ і $N_{60}P_{90}K_{60} + N_{30} + N_{30}$. Добрива вносили під обробіток ґрунту, а підживлення по таломерзлому ґрунту.

Було встановлено, що на момент припинення осінньої вегетації, а ні обробка насіння, а ні обприскування посівів суттєвого впливу на ріст і розвиток рослин порівняно з контролем не мали. Було встановлено, що як при обробці насіння, так і при обприскуванні посівів восени суттєвих змін рослини пшениці озимої набули лише при відновленні весняної вегетації і перш за все за рахунок кращої перезимівлі. Більш ефективним виявилось обприскування посівів порівняно з обробкою насіння перед сівбою. Так, порівняно з контролем обробка насіння призвела до збільшення урожайності на 4,5 %, а обприскування ретардантом навесні підвищило її на 6,7 %. Ще більші прибавки урожайності отримані при обприскування посівів ретардантом восени та подвійної обробки посівів восени і весною – 8,4 і 10,4 %, відповідно. Найвищий рівень урожайності забезпечило вирощування пшениці озимої на фоні $N_{60}P_{90}K_{60}+N_{30}+N_{30}$ з потрійним обприскуванням посівів ретардантом Хлормекват-хлорид 750 восени на початку фази кущення, після відновлення весняної вегетації та на початку фази виходу в трубку (6,66 т/га).

***Ключові слова:** пшениця м'яка, мінеральні добрива, ретардант росту Хлормекват-хлорид 750, біометричні показники, виживаність рослин, урожайність.*

Formulation of the problem. The processes of regulating the growth and development of plants have long been studied by many researchers. The development of this topic gained special intensity with the discovery of phytohormones and the creation of their synthetic analogs [1, 2, 3]. Choosing the optimal dose of soil fertilization is one of the effective factors that determine obtaining a high level of grain yield. In our experiments, we studied the issue of combining the background of soil fertilization under winter wheat crops and the action of the retardant Chlormequat-Chloride 750 in order to increase the yield of this crop.

Analysis of the latest researches, publications. Wheat is one of the crops that require high soil fertility and can provide high productivity only under conditions of a sufficient supply of mineral fertilizers [4, 5, 6]. 120 kg of nitrogen compounds, 45-50 kg of phosphorus, and 50-75 kg of potassium are used to obtain 4.5-5.0 t/ha of wheat grain on black earth soils [7, 8]. Most researchers believe that after the best predecessors in the steppe zone, the best conditions for the mineral nutrition of plants are created with the use of moderate (75-90 kg/ha NPK) doses of fertilizers [9, 10]. Thus, according to A.O. Lytovchenko [11] in the conditions of the southern Steppe of Ukraine, the application of mineral fertilizers: $N_{30}P_{30}$ before sowing, N_{30} (ammonium nitrate) in the phase of emergence of plants in the tube, and N_{30} (urea) in the phase of earing ensures the formation of a stable yield of winter wheat grain at the level of 3.0-5.0 t/ha.

However, as is known, relatively high doses of mineral fertilizers applied to winter wheat on the best predecessors can in some years cause significant plant lodging. As a result, the yield and quality of grain is significantly reduced. One of the ways to solve this problem is the use of growth regulators. In world practice, they have been used for a long time to combat the lodging of grain crops, increase resistance to adverse factors of the external environment (frost and drought resistance), accelerate or slow down growth processes, increase productivity, and harvest quality [12, 13, 14]. The peculiarity of phytohormones is their high specificity, which makes it impossible to replace their action on the biochemical and physiological processes of plants by some other means or growing conditions [15].

Numerous studies have shown that the use of growth regulators is an effective means of increasing the productivity of grain crops [16, 17, 18]. Such growth retardants as chlor-choline-chloride and chlormequat-chloride inhibit the linear growth of the stem of cereal crops by 10-35 %, with simultaneous thickening and an increase in the strength of the lower internodes [19, 20. 21].

In addition to reducing stem height, retardants enhance the growth of the root system by stimulating the growth of existing roots and promoting greater branching of the root system. Treatment of plants with retardants reduces the area of the leaf surface, but increases the specific weight of the leaves: the area of the leaf surface decreases, but at the same time there was a thickening of the leaf plate itself, which contributes to increasing the grain productivity of plants [22, 23].

In industrialized countries, 60-80 % of the acreage devoted to the cultivation of grain crops is treated with these substances [24]. The use of growth-regulating drugs showed that they are also an important reserve for intensifying the production of winter wheat grain and improving its quality [2, 25].

Formulation of the task. The effectiveness of retardants largely depends on the scheme of their application: the method of treatment of seeds or plants, the phase of plant development, when the treatment takes place, the number of treatments [26, 27]. The introduction into the production of new drugs, modern varieties, and improvement of the technology of growing winter wheat causes the need to carry out comprehensive research in order to determine the most effective ways of using fertilizers in combination with the use of physiologically active substances.

Materials and methods. Field experiments were started in 2012 with the soft winter wheat variety Spivanka on the experimental field of the Educational and Scientific Center of the Dnipro State Agrarian and Economic University, which is located in the Dnipropetrovsk region and belongs to the northern part of the Steppe of Ukraine.

The goal was to determine the features of the formation of the productivity of soft winter wheat of the Spivanka variety depending on different methods and terms of treatment with the growth regulator Chlormequat-Chloride 750 on different backgrounds of mineral fertilizer. The following options were used: 1) control without the use of a retardant; 2) seed treatment before sowing (2.0 l/t); 3) seed treatment before sowing (2 l/t) + sowing in the spring after the restoration of spring vegetation (1.5 l/t); 4) treatment of crops with a retardant in autumn at the beginning of the tillering phase (1.5 l/ha); 5) treatment of crops with a retardant in autumn at the beginning of the bushing phase (1.5 l/ha) + after the restoration of spring vegetation (1.5 l/ha); 6) treatment of crops with a retardant in the fall at the beginning of the bushing phase (1.5 l/ha) + after the restoration of spring vegetation (1.5 l/ha) + at the beginning of the tube emergence phase (1.5 l/ha).

The predecessor was black steam. The experiment was conducted on the following fertilizer backgrounds: $P_{30}K_{20} + N_{30}$, $N_{30}P_{60}K_{30} + N_{30}$ and $N_{60}P_{90}K_{60} + N_{30} + N_{30}$. Fertilizers were applied for soil cultivation, and top dressing was applied to thawed soil.

The soil of the experimental field is an ordinary low-humus, heavy-loam chernozem in the forest. Humus content – 4.0 %, total nitrogen – 0.23 %, phosphorus – 0.12 %, potassium – 2.0 %.

Field experiments were conducted according to generally accepted methodology (Yeschenko at al., 2014). The technology of growing winter wheat corresponded to the zonal recommendations for the conditions of the northern Steppe, except for the issues raised for study.

In the experiments, the growth retardant Chlormequat-Chloride 750 was used, which reduces the apical dominance of the main stem, forms more side stems, which develop evenly and do not lag behind the main stem in growth, that is, synchronous tillering is ensured.

Results and discussion. The growth retardant Chlormequat-Chloride 750 in the autumn period for all the years of research did not reveal a significant effect on the biometric indicators of plants (Table 1). During this period, the height of the plants as a whole, according to the experiment, ranged from 18.7 to 20.3 cm. The effect of the drug Chlormequat-Chloride 750 on the height of the plants was only from 0.5 to 4.6 %. Mineral fertilizers had a slightly greater effect, up to 8.6 %. Such indicators can be explained by the fact that in this period the plants do not yet experience competition in the fight for the radiant energy of the sun, and the effect of the drug has not yet fully manifested itself.

Table 1

The condition of winter wheat plants at the end of autumn vegetation

Variant of soil fertilization	Plant height, cm	Weight of 100 completely dry plants, g	Quantity per plant, pcs.		The depth of the tiller knot, cm
			stems	nodal roots	
Without the use of a retardant					
$P_{30}K_{20}$	18,8	10,6	1,7	1,1	2,0
$N_{30}P_{60}K_{30}$	19,2	11,0	2,0	1,1	2,3
$N_{60}P_{90}K_{60}$	19,4	11,4	2,1	1,2	2,5
Treatment of seeds with a retardant before sowing (2 l/t)					
$P_{30}K_{20}$	18,7	10,6	1,9	1,2	2,1
$N_{30}P_{60}K_{30}$	19,1	11,1	2,0	1,2	2,4
$N_{60}P_{90}K_{60}$	19,9	11,5	2,2	1,6	2,6
Spraying crops with a retardant at the beginning of the tillering phase (1.5 l/ha)					
$P_{30}K_{20}$	18,7	10,6	1,8	1,2	2,0
$N_{30}P_{60}K_{30}$	19,1	11,2	2,0	1,2	2,4
$N_{60}P_{90}K_{60}$	20,3	11,5	2,2	1,4	2,5

Indicators of plant mass also turned out to be insignificant in disagreement. Fluctuations in the experiment as a whole ranged from 10.6 to 11.5 g. The proportion of the retardant effect in the experiment as a whole during this period did not exceed 1.8 %.

The accumulation of above-ground mass was not significantly affected by mineral fertilizers, up to 0.2 g per 100 completely dry plants.

In the autumn period, no changes were also found in the number of stems and nodular roots under the action of the growth retardant. A significant increase in these indicators occurred only when mineral fertilizers were used. So, on average, when increasing the dose from $P_{30}K_{20}$ to $N_{60}P_{90}K_{60}$, the number of stems increased by 20.5 %, and the number of knotted roots by 19.7 %. Although quantitatively, this increase was by 0.4 and 0.2 units, respectively. Also, in the autumn period, no effect of the drug on the depth of the bush node was found.

The effect of the growth retardant Chlormequat-Chloride 750 began to manifest somewhat during the recovery of spring vegetation. On average, plant survival rates increased over four years of research (Table 2). Thus, the percentage of above-ground mass that remained as a result of seed treatment with the drug on a low background ($P_{30}K_{20} + N_{30}$) increased by 3.1 %, on the background of $N_{30}P_{60}K_{30}$ + N30 – by 4.5 %, and on the background of $N_{60}P_{90}K_{60} + N_{30} + N_{30}$ 3.3 %. When spraying crops with a retardant at the beginning of the tillering phase, compared to the control (without treatment), the percentage of surviving plants increased by 4.5; 5.3 and 3.8 %, respectively.

Table 2

The condition of winter wheat plants depending on treatment with a retardant on different fertilization backgrounds after the restoration of spring vegetation – at the end of the tillering phase

Option of soil fertilization	Plant height, cm	Weight of 100 completely dry plants, g	Quantity per plant, pcs.			The percentage of above-ground mass that is preserved
			alive stems	dead stems	new nodal roots	
Without the use of a retardant						
$P_{30}K_{20} + N_{30}$	24,4	42,6	4,0	0,21	2,3	67,5
$N_{30}P_{60}K_{30} + N_{30}$	25,9	44,9	4,2	0,21	2,6	71,2
$N_{60}P_{90}K_{60} + N_{30} + N_{30}$	27,8	48,0	4,4	0,17	2,7	75,0
Treatment of seeds with a retardant before sowing (2 l/t)						
$P_{30}K_{20} + N_{30}$	23,8	42,2	4,0	0,17	2,5	70,6
$N_{30}P_{60}K_{30} + N_{30}$	26,5	44,0	4,4	0,17	2,9	75,7
$N_{60}P_{90}K_{60} + N_{30} + N_{30}$	27,0	48,9	4,5	0,15	2,9	78,3
Spraying crops with a retardant at the beginning of the tillering phase (1.5 l/ha)						
$P_{30}K_{20} + N_{30}$	23,4	43,1	4,2	0,17	2,5	72,0
$N_{30}P_{60}K_{30} + N_{30}$	26,3	43,9	4,5	0,18	2,9	76,5
$N_{60}P_{90}K_{60} + N_{30} + N_{30}$	27,0	49,1	4,6	0,14	2,9	78,8

The use of Chlormequat-Chloride 750 also had an effect on reducing the number of dead stems. So, in general, according to the experiment, the death of stems decreased by 11.8-19.1 %.

Under the influence of the drug, the number of both all stems and those that overwintered slightly increased. A slight increase in the roots formed in the spring was also recorded.

In the spring, there was no significant difference in the height of plants treated with the drug and control plants. This is due to the fact that although the control plants had slightly longer leaves, the ends of the leaves were more affected, and measurements were made only on the length of the living part of the leaves.

Increasing the rate of application of mineral fertilizers contributed to the improvement of all the studied indicators.

According to the scheme of the experiment, additional spraying of crops with Chlormequat-Chloride 750 was carried out in the spring – 1) after the restoration of spring vegetation and 2) after the restoration of spring vegetation and at the beginning of the tube emergence phase.

In the future, the influence of fertilizers and growth regulators became more and more significant. The analysis of the elements of the crop structure (Table 3) showed that the number of plants that survived until the end of the growing season increased both with increasing the level of soil fertilization and with the use of Chlormequat-Chloride 750. Thus, the number of plants per 1 m2 of crops with an increase in the rate of fertilizers with $P_{30}K_{20} + N_{30}$ to $N_{60}P_{90}K_{60} + N_{30} + N_{30}$ without treatment with the drug increased by 9.8 %, and when spraying crops twice in autumn and spring – by 13.3 %. The drug itself, if we compare the control (without treatment) and the option with spraying crops twice in autumn and spring, contributed to an increase in the density of plant standing by 19.8 %. The lowest number of plants per square meter of crops on average for all fertilization backgrounds was found in the control plots, where they were not treated with the retardant, and in the plants treated with the retardant Chlormequat-Chloride 750 before sowing (194.0 and 202.3 pcs./m^2).

As well as the number of plants, such indicators as the number of all stems and the number of productive stems per unit area also changed. The density of productive stems, as one of the determining indicators of plant productivity in the conditions of the Steppe, was the greatest when using increased rates of mineral fertilizers, as well as when using a growth retardant, especially with double cropping. So, on average, over the years of research without the use of the drug under the influence of fertilizers, the number of productive stems increased by 13.8 %, and the use of the drug increased this indicator, depending on the rate of fertilizers, from 17.7 to 18.6 %.

The mass of grain from an ear when grown on the background of $P_{30}K_{20} + N_{30}$ ranged from 1.02 to 1.04 g and increased on the background of $N_{60}P_{90}K_{60} + N_{30} + N_{30}$ to 1.05–1.06 g. On average, for all fertilizer options in the control, this indicator was 1.04 g, various options for the use of the retardant increased it slightly – up to 1.05 g.

The mass of 1000 grains increased both under the influence of increased rates of fertilizer application and due to the use of a growth retardant. The smallest mass of 1000 grains was formed by winter wheat crops from control plots, as well as plots using seeds treated with a retardant (43.7 and 43.8 g). This indicator slightly increased on the option with seed treatment before sowing and additional spraying of crops in spring, as well as on the option with spraying of crops in autumn. The weight of 1000 grains on these variants was 44.0 and 44.5 g, respectively. An even greater mass of 1,000 grains was formed by plants treated with a retardant in autumn and spring (once or twice) – 45.2-45.4 g.

Relatively high indicators of the main elements of the crop structure ensured the formation and high yield of winter wheat (Table 4).

Table 3

The main elements of the grain yield structure of winter wheat plants depending on treatment with the retardant Chlormequat-Chloride 750 under different fertilization conditions

Variant		Number of plants, pcs./m²	The number of productive stems, pcs./m²	Grain weight, g	
application of retardant *	fertilization			from one ear	1000 psc.
1. Control	$P_{30}K_{20} + N_{30}$	185,2	562,1	1,02	42,4
	$N_{30}P_{60}K_{30} + N_{30}$	193,3	611,5	1,05	43,7
	$N_{60}P_{90}K_{60} + N_{30} + N_{30}$	203,4	639,9	1,06	44,9
2. Seed treatment before sowing	$P_{30}K_{20} + N_{30}$	192,6	589,3	1,04	43,1
	$N_{30}P_{60}K_{30} + N_{30}$	203,5	644,8	1,05	43,5
	$N_{60}P_{90}K_{60} + N_{30} + N_{30}$	210,8	663,7	1,05	44,9
3. Seed treatment before sowing and spraying of crops in the spring	$P_{30}K_{20} + N_{30}$	202,8	625,3	1,04	43,1
	$N_{30}P_{60}K_{30} + N_{30}$	213,2	662,7	1,05	43,9
	$N_{60}P_{90}K_{60} + N_{30} + N_{30}$	224,1	694,5	1,06	44,9
4. Spraying crops in autumn	$P_{30}K_{20} + N_{30}$	203,9	631,2	1,04	43,6
	$N_{30}P_{60}K_{30} + N_{30}$	212,1	667,3	1,05	44,5
	$N_{60}P_{90}K_{60} + N_{30} + N_{30}$	229,0	717,8	1,06	45,3
5. Spraying crops in autumn and spring	$P_{30}K_{20} + N_{30}$	213,2	658,5	1,04	44,2
	$N_{30}P_{60}K_{30} + N_{30}$	232,3	722,7	1,05	45,3
	$N_{60}P_{90}K_{60} + N_{30} + N_{30}$	240,1	748,2	1,05	46,0
6. Spraying crops twice in autumn and spring	$P_{30}K_{20} + N_{30}$	215,1	661,3	1,04	44,5
	$N_{30}P_{60}K_{30} + N_{30}$	230,4	713,8	1,05	45,6
	$N_{60}P_{90}K_{60} + N_{30} + N_{30}$	243,6	758,6	1,06	46,0

** Note: 1 – without the use of a retardant; 2 – seed treatment before sowing; 3 – seed treatment before sowing and spraying of crops in the spring; 4 – spraying crops with a retardant in autumn at the beginning of the tillering phase; 5 – spraying of crops with a retardant in the fall at the beginning of the bushing phase and after the restoration of spring vegetation; 6 – spraying of crops with a retardant in the fall at the beginning of the bushing phase, after the recovery of the spring vegetation and at the beginning of the emergence phase.*

The application of the growth retardant in the average of the options, provided that a small rate of mineral fertilizers – $P_{30}K_{20} + N_{30}$ was applied, contributed to the formation of productivity at the level of 5.74 t/ha. Increasing the application rate to $N_{30}P_{60}K_{30} + N_{30}$ gave an additional 0.40 t/ha, and for the application of $N_{60}P_{90}K_{60} + N_{30} + N_{30}$ – 0.62 t/ha.

On average, according to the fertilizer options, when treating seeds before sowing, the grain yield increased by 0.24 t/ha compared to the control, and by 0.39 t/ha with additional spraying of crops in the spring. Spraying crops in the fall provided an increase in yield by 0.52 t/ha, and additionally in the spring (once and twice) by 0.62 and 0.65 t/ha, respectively.

The highest productivity was obtained by growing winter wheat on the background of $N_{60}P_{90}K_{60} + N_{30} + N_{30}$ with the treatment of crops with the retardant

Chlormequat-Chloride 750 in the fall at the beginning of the bushing phase and after the restoration of the spring vegetation (6.58 t/ha), or with the treatment with the retardant in the fall at the beginning of the bushing phase, after the restoration of spring vegetation and at the beginning of the phase of emergence into the tube (6.66 t/ha).

Table 4

The yield of winter wheat when using the retardant Chlormequat-Chloride 750 under different nutritional backgrounds, t/ha

Retardant application option (B)	Fertilizer option (A) *			Average by factor B
	1	2	3	
Control	5,38	5,71	5,95	5,68
Seed treatment before sowing	5,62	5,97	6,16	5,92
Seed treatment and spraying of crops in spring	5,74	6,12	6,34	6,07
Spraying crops in autumn	5,83	6,29	6,47	6,20
Spraying crops in autumn and spring	5,94	6,37	6,58	6,30
Spraying crops twice in autumn and spring	5,94	6,39	6,66	6,33
Average by factor A	5,74	6,14	6,36	-
HIP_{05} A – 0,12-0,25; B – 0,13-0,31; AB – 0,22-0,37 т/га				

** Note: 1 – P30K20 + N30; 2 – N30P60K30 + N30; 3 – N60P90K60 + N30 + N30.*

Conclusions. The conducted studies showed that at the first stages of plant growth and development, treatment with the retardant Chlormequat-Chloride 750 seeds (2 l/t), as well as spraying crops in the autumn period (1.5 l/ha) did not affect the height of winter wheat plants at the end of the third stage of organogenesis, but led to an increase in plant mass (by 4.5 % on average). The effect of the drug led to an increase in the survival of plants and the total number of stems after overwintering, compared to the control. Spraying crops was more effective compared to seed treatment before sowing. Thus, compared to the control, seed treatment led to an increase in productivity by 4.5 %, and spraying with a retardant in the spring increased it by 6.7 %. Even greater increases in productivity were obtained when spraying crops with a retardant in autumn and double processing crops in autumn and spring – 8.4 and 10.4 %, respectively. The highest level of productivity was provided by the cultivation of winter wheat on the background of $N_{60}P_{90}K_{60}+N_{30}+N_{30}$ with triple spraying of crops with the retardant Chlormequat-Chloride 750 in autumn at the beginning of the bushing phase, after the recovery of spring vegetation and at the beginning of the phase of emergence into the tube (6.66 t/ha). A slightly lower yield on the same background of mineral nutrition was obtained when spraying crops with the drug in the fall and after the recovery of spring vegetation (6.58 t/ha), as well as when spraying crops with a retardant in the fall at the beginning of the bushing phase (6.47 t/ha).

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