Efficiency of Giberelonand Cytodef-100 phytohormones in the crop structure and productivity of sunflower in edaphoclimatic conditions of the Republic of Tatarstan

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Abstract. The studies were carried out to assess the effect of foliar dressing with Cytodef-100 and Giberelonphytohormones on fruit elements and gross yield of sunflower oil in edaphoclimatic conditions of the Republic of Tatarstan. The study was conducted in the sunflower crops of the Avenger hybrid in the Republic of Tatarstan in 2019–2021. The agrochemical indicators of typical gray-forest soil were as follows: humus content according to Tyurin – 3.0%, mobile phosphorus – 160 and exchange potassium – 145 mg/kg of soil according to Kirsanov. The soil medium response was close to neutral (pH 6.6). The results of the studies show that the total diameter of sunflower heads increases from 10.9 cm in the control sample to 13.3 cm in the joint use of 3 agrochemicals in the phase 4-8 of sunflower leaves: Euro-Lightningherbicide (1.2 kg/ha) + Cytodef-100 (150 g/ha) + Giberelon (50 g/ha). At the same time, the diameter of the empty part of the heads has a clear downward trend: from 2.2 cm to 1.7 cm in the latter version. The increase in marketable products due to the combined use of Cytodef-100 antistress drug and Giberelonphytohormone solution in combination with chemical weeding was 15.2% compared to the control sample (spraying of sunflower crops with Euro-Lightning (1.2 kg/ha) without Agrosintez LLC products.

1 Introduction

Phytohormones belonging to the class of gibberellins have a wide range of biological activity: they stimulate the division and expansion of plant cells, which leads to rapid growth of stems and an increase in the number of productive branches; they regulate flowering and fruiting.

Giberelonhasadvantagesthatcansignificantlyexpandth escopeofapplicationofgibberellinsincropproduction, including in field crops for the following reasons:

- maximum effect of application is achieved within 2-3 weeks and is quite long;
- specially developed formulation of Giberelon allows maintaining the active substance in an active and stable state;
- minimal costs of use compared to similar expensive drugs;
- compatible with pesticides and various types of liquid fertilizers used in the same period.

Plants are often subjected to various stresses during their growth and development, which leads to significant losses in yield and product quality (for example, nutrient absorption through the root system is disrupted even with sufficient amounts of them in the soil). Additional energy is required to overcome stress against the main metabolic process. The introduction of Cytodef-100 phytohormone in vegetative plants can reduce stress, improve growth and formation processes, increase yield and quality of products.

2 Materials and Methods

Stationary field experiments were conducted in 2019–2021 on the basis of Agrobiotekhnopark (Narmonka village, Laishevsky municipal district of the Republic of Tatarstan) with coordinates: latitude – 55.5244865824 and longitude – 48.274901646, and laboratory tests – at the Center for Agroecological Research of Kazan SAU.

The agrochemical indicators of the typical gray-forest soil were as follows: humus content according to Tyurin – 3.0%, mobile phosphorus – 160 and exchanged potassium – 145 mg/kg of soil according to Kirsanov. The soil medium response was close to neutral (pH 6.6).

The air temperature in May and June 2019was higher by 3 and 2 °C, respectively, compared to long-term average annual data. During the critical period of moisture consumption (June-July)the precipitation rate was only 58 and 83%, respectively, which negatively affected the yield of the studied object.

The agrometeorological conditions of 2020 were characteristic of the Republic of Tatarstan. The

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beginning of May was characterized by high temperature, and the second half – by a large amount of precipitation and average heat supply. A slight amount of precipitation fell in June, especially in the third decade(only 4% of the norm).

Unlike the long-term average annual indicators, July turned out to be cool, especially with low heat supply in the 1st and 2nd decades. At the beginning of August (1st and 2nd decades), low heat supply was combined with permanent rainfall (165 and 248% of the norm).

The agrometeorological conditions of 2021 were significantly different from the long-term average annual indicators: high average daily temperature in May (18.7 °C), June (23.4 °C), July (22.6 °C) and August (22.4 °C) versus 13.3; 18.1; 20.2 and 17.6 °C, respectively, of the norm. The growing season of 2021 was aggravated by moisture deficiency (53.3%). Despite this, sunflower, as a drought-resistant crop, was able to resist extremely unfavorable environmental factors and ensured 1.82 to 2.13 t/ha of commercial oilseeds.

The technology of cultivating sunflower was generally accepted in field experiments: the predecessor was winter rye for grain, which harvesting followed by a primary tillage; in spring – moisture closure, introduction of NPK to the planned yield of 2 t/ha; seeding on May 16 with a pneumatic seeder Spring 8 (Favorite) with the seeding depth of 6 cm, width – 70 cm between rows with a seed distance in rows – 26 cm (55 thousand pcs/ha) of germinating seeds. The experiment was carried out according to the methodology of Pustovoit All-Russian Research Institute of Oil Crops (2010).

3 Results and Discussion

The sunflower height and accumulation of its biomass does not fully reveal the advantages or disadvantages of the preparations, since the density of the plant stand before harvesting and the weed infestation of crops have a great influence on the formation of highly productive agrocenoses and production with the lowest costs for post-harvest sunflower oilseeds conditioning [1, 2, 3] (Table 1).

The high ground germination capacity and the ability of the sunflower to self-regulate the density of the plant stand by the end of the growing season should be emphasized before the analysis of data in Table 1. Of the 55 thousand pcs/ha of planted seeds, about 50 thousand/ha of seedlings were obtained (field germination – 90% against 80-85% for spring wheat). From 44.8 to 45.8 thousand pcs/ha remained for harvesting of this amount. Such a significant dyewood of plants (4.2–5.2 thousand pcs/ha) is explained by the fact that not all plants withstand the competition for sunlight, moisture, and nutrients).

Table 1. Preservation of plants for harvesting and weed infestation of crops.

Variant	Plant stand density, thousand pcs/ha	Weed infestation of crops	
		pcs m^2	g/m^2
Control without PPP treatment (background – zero tillage)	44.8	6.9	7.4
Spraying of plants with Cytodef-100 (200 g/ha) + herbicide in phase 4-8 of real leaves	45.2	5.4	6.1
Spraying of plants in 4-8 leaf rosette phase of real leaves with Giberelon (75 g/ha) + herbicide	45.0	5.7	6.6
Spraying of plants in phase 4-8 of real leaves with Cytodef-100 (150 g/ha) + Giberelon (50 g/ha) with herbicide	45.8	4.8	5.2
HCP_{05}	0.27		

Nevertheless, there is a direct relationship between the height and density of the sunflower stand with weed infestation of crops: the higher the height and density of the stand, the smaller both the total number of weeds and their dry weight [4, 5, 6]. Depending on the above factors, the total number of weeds decreases from 6.9 pcs/m^2in the control sample to 4.8 pcs/m^2in the version with spraying of crops with imidazoline herbicides in combination with additional feeding of plants with the anti-stress Cytodef-100 (150 g/ha) and Giberelonphytohormone (50 g/ha).

In general, the combination of chemical weeding with one inter-row cultivation, although they did not ensure the complete purity of sunflower crops from weeds according to the Isaev scale, they corresponded to the class of poorly weeded (less than 11 pcs/m^2).

The study of sunflower fruiting elements is of great practical importance, since the productivity of this crop depends on the parameters of the head (its total diameter, its productive area), the quantity and weight of productive seeds in the head and a thousand-seed weight [7, 8, 9] (Table 2).

Table 2. Change in sunflower fruiting elements under the action Cytodef-100 and Giberelon.

Variant	Head diameter, cm		Seed weight, g/head	Thousand-seed weight, g	Biologicalyield, t/ha
	total	empty			

		part			
Control without PPP treatment (background – zero tillage)	10.9	2.2	41.1	37.9	1.84
Spraying of plants with Cytodef-100 (200 g/ha) + herbicide in phase 4-8 of real leaves	12.6	1.8	43.6	42.8	1.97
Spraying of plants in 4-8 leaf rosette phase of real leaves with Giberelon (75 g/ha) + herbicide	11.2	2.0	42.8	41.6	1.93
Spraying of plants in phase 4-8 of real leaves with Cytodef-100 (150 g/ha) + Giberelon (50 g/ha) with herbicide	13.3	1.7	44.7	43.7	2.05

Fig. 1. General view of field experiments with sunflower.

The results of the studies show that the total diameter of the heads increases from 10.9 cm in the control sample to 13.3 cm in case of the joint use of 3 agrochemicals in the phase 4-8 of sunflower leaves: Euro-Lightning (1.2 kg/ha) + Citadef -100 (150 g/ha) + Giberelon (50 g/ha).

At the same time, the diameter of the empty part of the heads has a clear downward trend: from 2.2 cm to 1.7 cm in the last version. There is a correlation relationship between the parameters of heads and the weight of seeds in one head, as well as between the thousand-seed weight. Large seeds with a thousand-seed weight of 43.7 g are formed in large heads, which exceeds the control sample by 15.3%. Most importantly, the productivity of each head increases from 41.1 to 44.7 g (a very significant increase in the productivity of sunflower heads under the action of preparations from Agrosintez LLC).

On the other hand, the structural analysis of the fruit elements allows calculating the biological yield of sunflower oilseed raw materials. To do this, it is enough to multiply the average density of the stem by the weight of seeds in one head. The calculations confirm the high efficiency of the variants in which the spraying was carried out with the anti-stress Cytodef-100.

For example, in the second version of the experiment (Euro-Lightning 1.2 kg/ha + Cytodef 200 g/ha), the biological yield of sunflower oilseeds was 1.97 t/ha versus 1.84 in the control and 1.93 t/ha in the combination of herbicidal treatment with the addition of Giberelon– 75 g/ha.

Fig. 2. Cytodef-100, VRP 150 g/ha + Giberelon, 50 g/h.

However, the highest results are obtained when they are used together. In this case, the biological yield of oilseeds increases to 2.05 t/ha, exceeding the control sample by 11.4% (yield increase – 0.2 t/ha).

It is known that the biological yield, as well as the bunker yield, do not provide for a clear conclusion on the studied problem. Thus, it is necessary to determine the volume of commercial products from 1 hectare of arable land, which is calculated taking into account the humidity and weed content of the final products according to GOST 22391-2015 (Table 3).

Table 3. Impact of Cytodef-100 and Giberelon phytohormone on gross oilseeds with baseline values.

Variant	Actual	Gross	Increase

	humidity, %	commercial yield, t/ha	t/ha	%
Control without PPP treatment (background – zero tillage)	10.3	1.78	–	–
Spraying of plants with Cytodef-100 (200 g/ha) + herbicide in phase 4-8 of real leaves	8.1	1.95	0.17	9.6
Spraying of plants in 4-8 leaf rosette phase of real leaves with Giberelon (75 g/ha) + herbicide	8.8	1.90	0.12	6.7
Spraying of plants in phase 4-8 of real leaves with Cytodef-100 (150 g/ha) + Giberelon (50 g/ha) with herbicide	7.0	2.05	0.27	15.2
HCP_{05}		0.20		

According to GOST 22391-2015,the purchasing centers accept sunflower oilseed raw materials and pay its cost based on humidity of 7%, weed impurity of 1% and oilseed impurity of 3%. In our studies, the weed and oilseed impurity in the obtained products corresponded to the basic indicators. Therefore, the only difference between the test variants was humidity, which ranged from 10.3% in the control sample to 7.0% in the last test variant. Therefore, the biological yield of the control sample determined at the test sites was reduced by 3.3%, in the second variant– by 1.1%, in the third – by 1.8, and in the last variant the actual humidity corresponded to GOST. Consequently, the studied preparations not only increase the productivity of arable land, but also accelerate the harvesting ripeness of sunflower. The above pattern was noted even in 2021 with a hot and arid growing season.

Table 4. Content of raw fat and gross yield of sunflower oil depending on the use of antistress and phytohormone preparations of Agrosintez LLC.

Variant	Rawfat, %	Gross yield of sunflower oil, kg/ha	Increase	
			kg/ha	%
Control without PPP treatment (background – zero tillage)	45.3	806.3	-	-
Spraying of plants with Cytodef-100 (200 g/ha) + herbicide in phase 4-8 of real leaves	46.0	897.0	90.7	11.2
Spraying of plants in 4-8 leaf rosette phase of real leaves with Giberelon (75 g/ha) + herbicide	45.8	870.2	63.9	7.9
Spraying of plants in phase 4-8 of real leaves with Cytodef-100 (150 g/ha) + Giberelon (50 g/ha) with herbicide	46.1	945.1	138.8	17.2

As a result, the increase in marketable products under the action of the combined use of Cytodef-100 anti-stress drug and Giberelonphytoharmon solution in combination with chemical weeding amounted to 15.2% compared to the control sample (spraying of sunflower crops with Euro-Lightning (1.2 kg/ha) without addition of Agrosintez LLC drugs.

It should also be noted a reliable increase in the actual yield with basic indicators and in the variants of the separate use of the studied drugs, especially the Cytodef-100 anti-stress preparation at the rate of 200 g/ha – an increase in commercial sunflower oilseed raw materials of 0.17 t/ha.

In terms of raw fat content, sunflower oilseeds are divided into 3 classes (GOST 22391-2015).

Class 1 – at least 50%;

Class 2 – at least 45%;

Class 3 – at least 40%;

According to this classification, our final products in all variants of the experiment corresponded to the second class (raw fat content – at least 45%). At the same time, we should note the dynamics of growth in the accumulation of raw fat as the yield of sunflower increases under the influence of Agrosintez LLC products.

4 Conclusion

The use of phytohormone preparations in order to reduce biotic and abiotic adverse environmental factors is a promising direction in modern crop production.

Thus, the results of 2-year studies showed that the use of Giberelon and Cytodef-100 phytohormone preparations on sunflower crops in the edaphoclimatic conditions of the Republic of Tatarstan increased plant preservation rate and reduced weed infestation of crops. Besides, these drugs had a positive effect on the structure of the sunflower crop. Thus, in the variant with the spraying of plants in phase 4-8 of the real leaves with Cytodef-100 (150 g/ha) + Giberelon (50 g/ha) together with the herbicide, the weight of seeds in 1 head was 44.7 g, and in the control – only 41.1 g. Ultimately, the positive effect of the studied preparations was reflected in the gross yield of vegetable oil. In case of the combined use of Cytodef-100 (150 g/ha) and Giberelon (50 g/ha), the gross vegetable oil yield was 945.1 kg/ha, which is 138.8 kg/ha or 17.2% higher than the control.

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