

DOI: <https://doi.org/10.31073/mivg202601-446>

Available at (PDF): <https://mivg.iwpim.com.ua/index.php/mivg/article/view/446>

UDC: 633.174:631.67:631.811.98

## EFFECTIVENESS OF GROWTH REGULATORS ON IRRIGATED SORGHUM CROPS

**Yu.O. Tarariko<sup>1</sup>, Dr. of Agricultural Sciences, P.V. Pysarenko<sup>2</sup>, Dr. of Agricultural Sciences, R.M. Vasylenko<sup>3</sup>, Ph.D. in Agricultural Sciences, R.V. Saydak<sup>4</sup>, Ph.D. in Agricultural Sciences, Yu.V. Soroka<sup>5</sup>, Ph.D. in Agricultural Sciences, I.O. Bidnyna<sup>6</sup>, Ph.D. in Agricultural Sciences**

<sup>1</sup> Institute of Water Problems and Land Reclamation of NAAS, Kyiv, 03022, Ukraine; <https://orcid.org/0000-0001-8475-240X>; e-mail: [urtar@bigmir.net](mailto:urtar@bigmir.net);

<sup>2</sup> Institute of Water Problems and Land Reclamation of NAAS, Kyiv, 03022, Ukraine; <https://orcid.org/0000-0002-2104-2301>; email: [pavel\\_pisarenko74@ukr.net](mailto:pavel_pisarenko74@ukr.net);

<sup>3</sup> Institute of Climate-Oriented Agriculture of NAAS, Odesa, Ukraine; <https://orcid.org/0009-0000-1903-4444>; e-mail: [ruslan-18a@ukr.net](mailto:ruslan-18a@ukr.net);

<sup>4</sup> Institute of Water Problems and Land Reclamation of NAAS, Kyiv, 03022, Ukraine; <https://orcid.org/0000-0002-0213-0496>; e-mail: [saidak\\_r@ukr.net](mailto:saidak_r@ukr.net);

<sup>5</sup> Institute of Water Problems and Land Reclamation of NAAS, Kyiv, 03022, Ukraine; <https://orcid.org/0000-0001-6228-4131>; e-mail: [agroresurs@bigmir.net](mailto:agroresurs@bigmir.net);

<sup>6</sup> Institute of Water Problems and Land Reclamation of NAAS, Kyiv, 03022, Ukraine; <https://orcid.org/0000-0001-8351-2519>; e-mail: [irinabidnina@ukr.net](mailto:irinabidnina@ukr.net)

Received: 14.12.2025. Revised: 13.02.2026. Accepted: 24.03.2026. Published: 30.06.2026

**Abstract.** *In the conditions of increasing climatic aridity of the southern region of Ukraine, the relevance of improving grain sorghum cultivation technologies aimed at increasing the efficiency of water use and forming stable crop productivity is increasing. The aim of the study was to determine the impact of growth regulators and complex Nanovit super fertilizer in chelate form on water consumption, the formation of crop structure and grain productivity of grain sorghum under irrigation conditions.*

*Field studies were conducted in 2016–2018 at the experimental field of the Institute of Climate-Oriented Agriculture of the NAAS on dark chestnut medium loamy slightly saline soil. The object of the study was the early-ripening grain sorghum variety Pivdenne. The effect of growth regulators Regoplant, Grainactiv-C and Vermystym on the background of N<sub>90</sub> application, as well as their combination with foliar feeding with the Nanovit super complex fertilizer, was studied.*

*It was found that the use of the studied preparations did not cause significant changes in the total plant water consumption (4104–4296 m<sup>3</sup>/ha), but contributed to an increase in the efficiency of water use. The lowest water consumption coefficient was obtained with the combined use of the Regoplant preparation and the Nanovit super fertilizer – 477,3 m<sup>3</sup>/t, which is 32,5% less compared to the control. The use of biostimulants had a positive effect on the formation of crop structure, in particular, it increased the length of the panicle, the number and weight of grains in it, as well as the weight of 1000 seeds. The highest grain productivity was provided by the combined use of the Regoplant preparation with foliar feeding with Nanovit super fertilizer on the background of N<sub>90</sub> application, when the grain yield was 9,2 t/ha, which was 55,9% higher than in control variant. Under these conditions, the feed value of the products also increased: the yield of feed units reached 12,4 t/ha, digestible protein – 0,59 t/ha, and the protein content in grain – 10,8%.*

*The results obtained indicate the high efficiency of using growth regulators in combination with chelate microfertilizers in the technology of growing grain sorghum under irrigation conditions and confirm the feasibility of their use to increase crop productivity and optimize the use of water resources.*

**Keywords:** grain sorghum, growth regulators, chelate microfertilizers, irrigation, water consumption, yield, feed value

**Problem statement.** In the conditions of climate change in the southern region of Ukraine, characterized by a significant increase in temperature and unstable and insufficient precipitation, the cultivation of drought-resistant and highly productive grain sorghum is of

extremely important in grain production. It is successfully used for feeding cattle, pigs, horses, sheep, poultry and pond fish.

In terms of nutritional value, grain sorghum does not differ significantly from barley and corn [9]. Its grain contains up to 80% starch,

© Tarariko Yu.O., Pysarenko P.V., Vasylenko R.M., Saydak R.V., Soroka Yu.V., Bidnyna I.O., 2026



12–14% protein, 3,5–4,5% fat, 2,4–4,8% fiber and 1,2–3,2% ash. The energy nutritional value of 100 kg of sorghum grain is 118–130 feed units.

It has been established that sorghum grain is more effective in fattening pigs, which is superior to barley in terms of yield and cost [11]. However, in extreme conditions, the crop yield shortfall, as noted by researchers, can reach 30–40% or more [2].

Increasing the resistance of grain sorghum plants to adverse factors is not always possible to solve by selecting varieties or hybrids adapted to local soil and climatic conditions. The maximal potential crop productivity is possible only by using a complex of optimized modern agrotechnical measures. An important component of the technology of growing grain sorghum, which contributes to increasing the resistance of plants to environmental stress factors and increasing yield, can be the use of foliar feeding with complex fertilizers in the form of chelates and growth regulators. In modern crop production, they are increasingly used due to their sufficient efficiency at minimal water consumption rates. As noted, such preparations protect plants from stress, increase resistance to diseases, stimulate the microbiological activity of the rhizosphere, increase yield and improve product quality [2, 3, 4].

**Analysis of recent research and publications.** The issue of increasing the adaptability and productivity of sorghum (*Sorghum bicolor* L.) in the context of global climate change occupies a prominent place in modern agronomic research. Considerable attention of researchers is focused on water regime management. In particular, B.A. Asmamaw and K. Georgis [14] prove that the use of special agrotechnical measures in combination with deficit irrigation allows maintaining stable yields of green mass of sorghum, maximizing the efficiency of water use. This approach correlates with the conclusions of A. Farhadi et al. [16], who emphasize that moderate water stress not only saves resources, but can also positively affect the nutritional value of feed depending on the genetic characteristics of the crop.

An important direction is the neutralizing of the impact of abiotic stresses. Studies conducted by M.E. Abu-Ria et al. [12, 13] demonstrate the high efficiency of humic acids as mediators of drought tolerance. It has been established that humic compounds stabilize physiological processes of sorghum at critical reproductive stages, providing higher resistance compared to corn. At the same time, M. Chiranjeevi et al. [15] emphasize the role of rhizosphere bacteria

in improving the architectonics of the root system and nutrient uptake under biotic conditions.

Modern nutrition strategies are shifting towards highly available forms of elements. P. Huang [18] and P. Niharika [19] substantiate the advantages of chelated forms of microelements, in particular amino acid chelates, which have a higher absorption rate and act as biostimulants. The role of microelement synergism and growth regulators in the formation of quantitative and qualitative indicators of sorghum yield in different climatic zones is described in detail in the works of Z. Rashid [20] and Zahida R. [21].

Studies by Y. Guo et al. [17] indicate the importance of the microbial component of the soil. It was found that partial replacement of mineral nitrogen with organic fertilizers not only increases yield, but also optimizes the structure of microbial organisms, which ensures the sustainability of the agroecosystem.

According to the results of studies in non-irrigated conditions of the South of Ukraine, treatment of grain sorghum plants with a 0,01% solution of succinic acid during the period of inflorescence formation increased the seed productivity of various hybrids by 10,9–13,0% compared to the control [4].

It was also found that complex fertilizers containing macro- and microelements increase crop resistance to moisture deficit and low and high temperatures, as well as promote the absorption of nutrients from the soil and reduce disease susceptibility [8].

Such fertilizers are produced with a different set of nutrients, which makes it possible to apply them given the conditions and characteristics of a particular crop. The use of a new line of foliar fertilizers Nanovit in the form of EDTA chelates based on the active complex “NANO-ACTIV”, to which Nanovit Super belongs, is of particular interest. By the manufacturer’s characteristics, Nanovit Super stimulates the growth and development of plants, provides intensive absorption of nutrients from the soil, increases crop resistance to drought, diseases, pests and physiological stresses, and also ensures increased yield and product quality. Its composition includes: N – 122 g/l; K (K<sub>2</sub>O) – 61; Mg (MgO) – 30; B – 4,50; Cu – 4,50; Fe – 0,90; Mn – 0,44; Mo – 0,024; Zn – 2,60 g/l.

It has been established that, with full provision of plants with nutrients, sorghum requires a significant amount of productive moisture for the formation of vegetative mass, high grain yield and nutrient output [1]. As researchers note, a large amount of it is used by plants in a critical

period: 10 days before the start of panicle ejection and within 10 days after flowering. The duration of this period is 20–25% of the growing season, and moisture consumption reaches 45–50% of the total water consumption [5]. Lack of moisture during this period affects the physiological processes and the formation of grain yield [10].

Despite thorough studies of individual factors (irrigation, nutrition, biostimulation), the complex effect of a combination of amino acid chelates and humic preparations against the background of various strategies of deficit irrigation in the conditions of specific soil and climatic zones of Ukraine remains insufficiently studied. The efficiency of moisture use by a crop is reflected by the coefficients of water consumption (the amount of water that ensures the formation of a unit of yield) and irrigation efficiency (the amount of water that ensures an increase in yield compared to non-irrigated conditions), as well as the indicator of water use efficiency (the amount of production that a unit of moisture used forms). All of them depend on the amount of total water consumption during the growing season and crop yield [7]. However, the effect of the studied stimulating preparations on water consumption and productivity of grain sorghum under irrigated conditions of the southern region of Ukraine remains unstudied.

**Research objectives and methods.** The research objective was to determine the effect of growth regulators and complex fertilizer in chelated form Nanovit super on water consumption, grain yield and feed value of grain sorghum under irrigation conditions.

Field and laboratory studies were conducted according to the methods of the research work in 2016–2018 on irrigated lands of the Institute of Climate-Oriented Agriculture of the NAAS of Ukraine [6, 7]. Soils were dark chestnut, slightly saline, medium loamy with a humus layer depth of 45–50 cm. The humus content in the arable soil layer (0–30 cm) was 2,8–3,4%, hydrolyzed nitrogen – 4,5–5,5%, mobile phosphorus – 4,0–6,0 mg, exchangeable potassium – 40 mg/100 g of soil. The lowest moisture content in 0–50 cm soil layer was 23,2%, in 0–100 cm soil layer was 21,5%, and in 0–150 cm soil layer was 21,3%. The wilting moisture content was 11,4; 11,6; 11,9% compared to absolutely dry soil weight, respectively. To determine the feed value of grain, a certified analytical laboratory of the Institute was used. The accounting area of the plot was 20 m<sup>2</sup>.

The object of the study was the early-ripening grain sorghum variety Pivdenne.

Sowing was carried out in the first decade of May in a wide-row method with a row spacing of 70 cm. Concomitant fertilizer – N<sub>90</sub> in the form of ammonium nitrate was applied during pre-sowing cultivation. Growth regulators were applied for the first time in the 5–7 leaf phase and for the second time in the 8–10 leaf phase. On average, the total irrigation rate over three years was 1900 m<sup>3</sup>. Irrigation was carried out with a DDA-100MA sprinkler. Such preparations as Regoplant (seed treatment rate was 250 ml/t and during vegetation it was 50 ml/ha), Grainaktiv-S (seed treatment rate was 0,1 l/t and during vegetation it was in a ratio of 1:1000), and Vermystym (seed treatment rate was 10 l/t and during vegetation it was 8 l/ha) were used. The active ingredient of the Regoplant preparation is a complex of biologically active compounds (polysaccharides, 15 amino acids, analogues of phytohormones of cytokinin and auxin nature), biogenic trace elements, potassium salt of alpha-naphthylacetic acid and aversectin C. The active ingredient of the Vermistim preparation includes such biocomponents as: humates, fulvic acids, amino acids, vitamins and natural phytohormones. The composition of Grainaktiv-C preparation mainly consists of polyguanidine compounds in aqueous solution. Treatment of sorghum plants with Nanovit super fertilizer was carried out in the tillering and panicle ejection phases with a rate of 2 l/ha.

**Research results and their discussion.** It was established that the use of growth-regulating preparations Regoplant, Grainaktiv-S and Vermistim as well as the complex fertilizer Nanovit super when growing grain sorghum of the Pivdenne variety under irrigation conditions did not have a significant impact on the total water consumption of plants, only a tendency to its increase was observed (Fig. 1, Table 1).

Treatment of seeds and vegetative plants with growth-regulating preparations provided moisture consumption on average around 4118–4246 m<sup>3</sup>/ha versus 4104 m<sup>3</sup>/ha in the control variant, i.e. by 14–142 m<sup>3</sup>/ha, or by 0,3–3,5% higher.

The combined use of biostimulants with foliar feeding when applying Nanovit super fertilizer led to an increase in total water consumption to 4209–4296 m<sup>3</sup>/ha, which was 1,2–2,2% higher than the variables obtained in the variants when using only growth regulators.

The use of stimulators when applying of nitrogen fertilizer at a dose of N<sub>90</sub> in the pre-sowing period contributed to a decrease in moisture consumption for the formation of a yield unit.

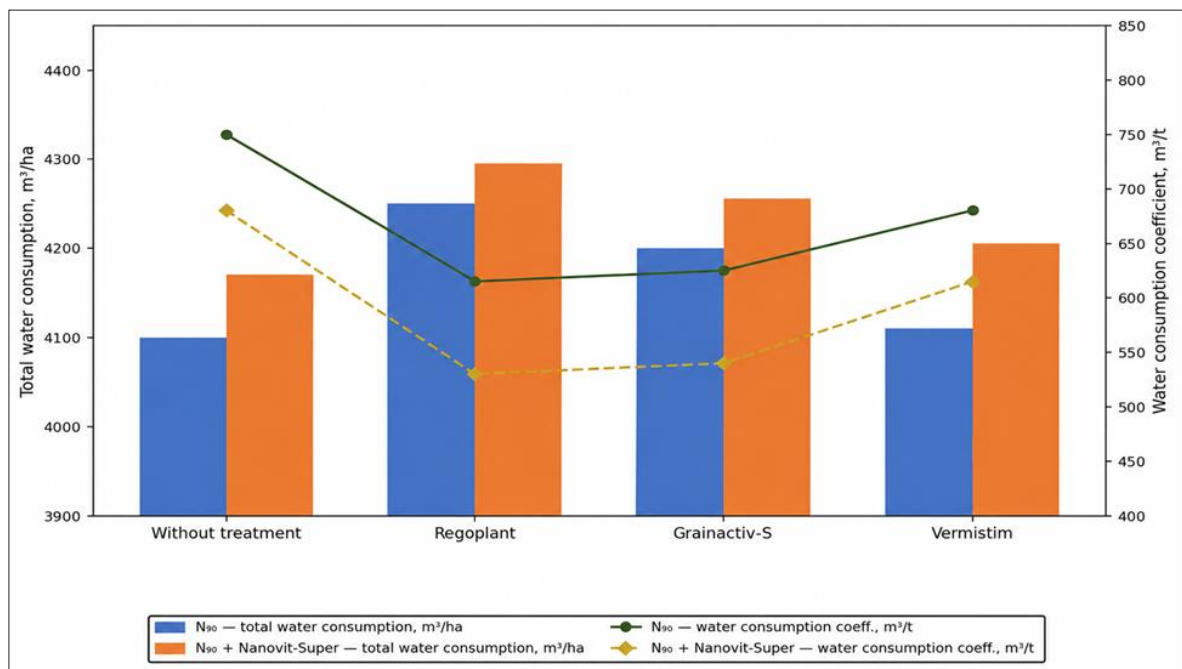


Fig. 1. Water consumption of grain sorghum depending on growth regulators (average for 2016–2018)

1. Effect of growth regulators on water consumption of grain sorghum (soil layer 0–50 cm, average for 2016–2018)

Growth regulators (B)	Total water consumption, m³/ha	Water consumption coefficient, m³/t	Share of water consumption components, %		
			Soil reserves	Precipitation	Irrigation rate
Ground – $N_{90}$ (A)					
Without treatment	4104	707,6	19,1	34,6	46,3
Regoplant	4246	598,0	21,8	33,5	44,7
Grainactiv-S	4202	627,2	21,0	33,8	45,2
Vermystim	4118	675,1	19,3	34,5	46,2
Ground + Nanovit-super (A)					
Without treatment	4168	622,1	20,3	34,1	45,8
Regoplant	4296	477,3	22,7	33,1	44,2
Grainactiv-S	4255	525,3	21,9	33,4	44,7
Vermystim	4209	601,3	21,1	33,8	45,1
LSD 5%: A	14,9	16,2			
B	21,0	22,9			

The use of the Regoplant biostimulator provided the lowest water consumption coefficient – 598,0 m³/t and in combination with foliar feeding with Nanovit super fertilizer – 477,3 m³/t, which is 15,5 and 32,5% less than in the control variant, respectively.

In the variant with treatment with the Grainactiv-S preparation, water consumption for the formation of a yield unit decreased by 11,4 (in the control) and 25,8% (when applying Nanovit-super fertilizer), and amounted to 627,2 and 525,3 m³/t, respectively.

The use of Vermystim reduced the water consumption coefficient by only 4,6 (in the control) and 15,0% (when applying Nanovit-super fertilizer), and its rate was 675,1 and 601,3 m³/t respectively.

In the structure of total water consumption, the smallest share fell on soil reserves of the 0–50 cm layer – 19,1–22,7%, while the share of precipitation was 33,1–34,6%, and irrigation – 44,2–46,3%. The use of growth regulators contributed to an increase in the share of soil moisture used; when treating with Regoplant, it

increased from 19,1% in the control to 21,8%, with Grainactiv-S – to 21,0%, with Vermistim – to 19,3% in irrigated variants.

Under conditions of foliar feeding with Nanovit Super fertilizer, moisture consumption from the 0–50 cm layer increased by 6,3%, and in the case of combined use with Regoplant it increased by 18,8%, with Grainactiv-S – by 14,7%, with Vermystim – by 10,5% and reached the highest values – 22,7, 21,9 and 21,1%, respectively.

The application of growth regulating agents to irrigated grain sorghum crops had a positive effect on plant height and yield components. Plant height increased by 3–9 cm when growth regulators were used, reaching 124–127 cm, and by 7–11 cm when combined with foliar application of the complex fertilizer Nanovit Super, reaching 131–135 cm (Table 2).

The greatest increase in plant height was provided by the Regoplant preparation – both when applying N<sub>90</sub> (133 cm) and when combining with Nanovit super fertilizer (135 cm).

Growth regulators increased the length of the panicle by 3,7–8,5%, the number of seeds in the panicle by 5,7–16,9%, their mass by 10,0–24,5% (up to 29,6–33,5 g), the mass of 1000 seeds by 4,0–6,8%, which led to an increase in the mass of grain from 1 m<sup>2</sup> by 6,9–24,6% – up to 644,2–751,0 g, depending on the type of growth regulator.

Foliar fertilization of sorghum plants with complex fertilizer in chelate form caused an increase in panicle length, number and mass of grains in it, as well as the mass of 1000 seeds by 4,4–10,8%, while the mass of grains per 1 m<sup>2</sup> increased by 15,2% and reached 694,3 g.

The combined use of growth regulators with foliar feeding with Nanovit super fertilizer turned

out to be more effective. Under these conditions, the length of the panicle increased by 4,1–4,5% compared to the variants where the plants were treated only with growth regulators. The number of seeds in the panicle also increased by 3,3–8,1%, their mass by 9,1–13,4% (up to 32,3–38,0 g), the mass of 1000 seeds by 4,1–5,0%, and the mass of grain from 1m<sup>2</sup> by 10,2–24,5% (up to 748,7–935,0 g). The highest efficiency in forming the crop yield was provided by the the Regoplant preparation while the lowest one was recorded when applying the Vermystim preparation.

The use of growth regulators Regoplant, Grainactiv-S, Vermystim and multicomponent fertilizer Nanovit super on irrigated crops contributed to an increase in sorghum grain productivity. In the control variant without the use of growth regulators and fertilizers, the average grain yield over the years of research was 5,9 t/ha, the yield of feed units was 8,0 t/ha, digestible protein was 0,30 t/ha, starch content was 75,2%, and protein content was 8,1% (Table 3).

Treatment of seeds and vegetative plants with growth regulators when applying N<sub>90</sub> before sowing increased grain yield by 0,5–1,7 t/ha (NIRP<sub>05</sub> = 0,21 t/ha) compared to the control. At the same time, the yield of feed units increased by 8,7–30,0%, digestible protein – by 30,0–73,3%, starch content – by 1,2–2,8%, and protein content – by 7,4–19,7%.

The highest efficiency was provided by the growth regulators Regoplant and Grainactiv-S, with grain yield of 7,4–7,6 t/ha, feed unit yield of 10,1–10,4 t/ha, digestible protein of 0,45–0,52 t/ha, starch content in grain of 76,3–77,3%, and protein content of 9,1–9,7%. (Fig. 2).

## 2. Effect of mineral nutrition and growth regulators on the yield of grain sorghum

Growth regulators (B)	Plant height, cm	Grain mass per 1 m <sup>2</sup> , g	Mass of grain from one panicle, g	Number of seeds from one panicle, pcs.	Panicle length, cm	Weight of 1000 seeds, g
Ground – N <sub>90</sub> (A)						
Without treatment	124	602,7	26,9	1090	18,9	24,9
Regoplant	133	751,0	33,5	1274	20,5	26,6
Grainactiv-S	132	718,3	32,1	1233	20,1	26,3
Vermystim	127	644,2	29,6	1152	19,6	25,9
Ground + Nanovit-super (A)						
Without treatment	128	694,3	29,8	1138	20,1	26,3
Regoplant	135	935,0	38,0	1377	21,4	27,7
Grainactiv-S	134	856,7	35,6	1297	21,0	27,6
Vermystim	131	748,7	32,3	1190	20,4	27,2
LSD 5%: A	0,92	32,84	0,68	22,74	0,14	0,10
B	1,3	46,44	0,91	32,16	0,19	0,14

3. Grain sorghum productivity depending on mineral nutrition and the use of growth regulators (average for 2016–2018)

Growth regulators (B)	Grain yield, t/ha	Yeild, t/ha		Content, %	
		feed units	digestible protein	starch	protein
Ground – N <sub>90</sub> (A)					
Without treatment	5,9	8,0	0,30	75,2	8,1
Regoplant	7,6	10,4	0,52	77,3	9,7
Grainactiv-S	7,4	10,1	0,45	76,3	9,1
Vermystim	6,4	8,7	0,39	76,1	8,7
Ground + Nanovit-super (A)					
Without treatment	6,8	9,1	0,43	76,3	9,5
Regoplant	9,2	12,4	0,59	77,8	10,8
Grainactiv-S	8,6	11,8	0,52	77,6	10,2
Vermystim	7,2	9,8	0,46	77,6	9,8
LSD 5%: A	0,18				
B	0,21				

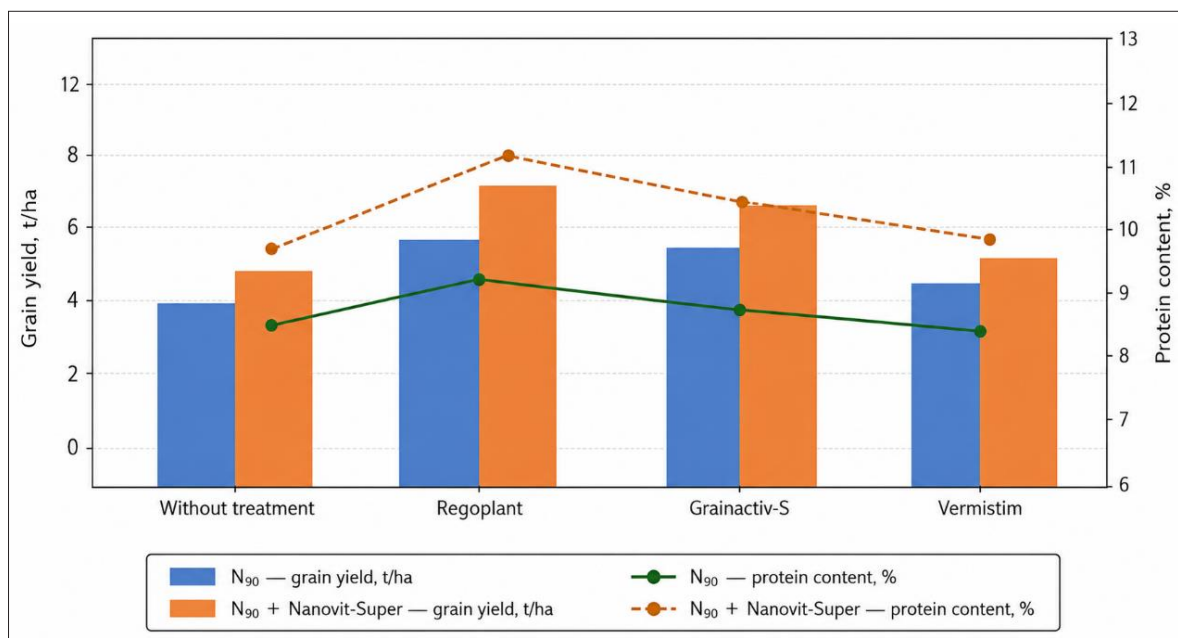


Fig. 2. Yield and protein content of grain sorghum depending on mineral nutrition and the use of growth regulators (average for 2016–2018)

Under these conditions, grain yield decreased within the experimental error (by 0,2 t/ha), feed unit yield by 2,9%, digestible protein by 13,5%, starch content by 1,3%, and protein content by 6,2%. The smallest increase in grain sorghum productivity was provided by the Vermystim preparation, when grain yield was 6,4 t/ha, feed unit yield was 8,7 t/ha, digestible protein was 0,39 t/ha, starch content in grain was 76,1%, and protein content was 8,7%.

Foliar feeding of sorghum plants with Nanovit super fertilizer when applying N<sub>90</sub> during the pre-sowing period increased grain yield compared to the control by 0,9 t/ha (NIP<sub>05</sub> = 0,18 t/ha), the yield of feed units by 1,1 t/ha (13,7%), digestible

protein by 0,13 t/ha (43,3%), and starch and protein content in grain insignificantly – by 1,1 and 1,4%, respectively. By all indicators, this variant exceeded the results of treatment with the Vermystim preparation.

The highest efficiency was achieved with the combined use of multicomponent fertilizer with growth regulators. Under such conditions, the grain yield was 7,2–9,2 t/ha, which was 22,0–55,9% higher than in the control and 12,5–21,0% higher than in the variants when using only growth regulators. At the same time, the yield of feed units reached 9,8–12,4 t/ha, digestible protein – 0,46–0,59 t/ha, starch content – 77,6–77,8%, protein content in grain – 9,8–10,8%.

Maximum productivity was provided by the combined use of Nanovit super fertilizer with Regoplant preparation. The increase in grain yield compared to the control was 55,9%, the yield of feed units – 55,0%, digestible protein – 96,7%, starch content – 3,5%, and protein content – 33,3%.

The use of Grainactiv-S preparation in combination with Nanovit super fertilizer provided a grain yield of 8,6 t/ha, which exceeded the control by 45,8% and was accompanied by a significant increase in the content of nutrients. However, compared to the variant where the Regoplant and Nanovit super preparations were used together, grain yield was lower by 6,5%, the yield of feed units – by 4,8%, digestible protein – by 11,9%, and a tendency to a decrease in the content of starch and protein in grain was also observed.

The combined use of the Vermystim preparation with the Nanovit super fertilizer provided the smallest increase in crop productivity compared to the control variant. Grain yield increased by 22,0% and amounted to 7,2 t/ha, the yield of feed units – by 22,5%, digestible protein – by 53,3%, starch content in grain – by 3,2%, and protein content – by 21,0%.

The obtained research results confirm the important role of biostimulants and chelated forms of microelements in increasing the adaptability and productivity of grain sorghum in irrigated agriculture. Despite the fact that the use of growth regulators did not cause significant changes in the total water consumption of plants, it significantly affected the efficiency of water use, which was manifested in a significant decrease in the water consumption coefficient.

The reduction in water consumption for the formation of a yield unit is probably associated with the activation of physiological processes in plants under the influence of biostimulants. Growth regulators are able to stimulate photosynthetic activity, improve the functioning of the root system and increase the intensity of nutrient absorption. As a result, plants form greater biomass and higher productivity with the same or similar water consumption rates.

The combined use of growth regulators with foliar feeding when applying a complex fertilizer in chelate form turned out to be especially effective. The high efficiency of chelate microelements is explained by their rather high bioavailability and ability to quickly be included in the metabolic processes of plants. This contributes to the intensification of photosynthesis, activation of enzymatic systems and improvement of the transport of assimilates to the generative organs.

Improving the physiological state of plants under the influence of the studied preparations was reflected in the formation of crop structure.

In particular, the increase in the length of the panicle, the number of grains in it and their mass indicates a more efficient use of plastic substances during the formation of generative organs. Similar patterns are shown in the works of Z. Rashid [20] and R. Zahida [21], who established the positive effect of growth regulators and microelements on the formation of sorghum productivity.

In addition, the obtained results are consistent with the studies of P. Huang [18] and P. Niharika [19], who proved that the use of chelate forms of trace elements increases the intensity of physiological processes in plants and contributes to an increase in crop yield. According to M.E. Abu-Ria and co-authors [12, 13], the use of organic biostimulants also contributes to an increase in the resistance of sorghum to water stress and optimizes the course of physiological processes during critical periods of crop development.

The obtained results are also consistent with modern concepts of increasing the efficiency of water use in irrigated agriculture, according to which the key role is played not only by the amount of moisture used, but also by the efficiency of its transformation into yield. In this context, a significant reduction in the water consumption coefficient with the use of growth regulators and chelate fertilizers proves the significant potential of such preparations in increasing the water productivity of agrocenoses.

Thus, the results of the conducted studies confirm the feasibility of the integrated use of growth regulators and chelate microfertilizers in the technology of growing grain sorghum. The combination of these agronomic techniques ensures the improvement of the physiological state of plants, increased efficiency of water use and the formation of high crop productivity under irrigated conditions.

**Conclusions.** The use of growth regulators and complex fertilizers in chelate form Nanovit super when growing grain sorghum of the Pivdenne variety under irrigation did not have a significant effect on the total plant water consumption, but significantly reduced the water consumption coefficient and increased crop grain productivity.

The highest agronomic efficiency was provided by the combined use of the Regoplant preparation along with the Nanovit super fertilizer when applying N<sub>90</sub>. Under these conditions, the grain yield was 9,2 t/ha, that is by 55,9% higher than in the control, the yield of feed units reached 12,4 t/ha, digestible protein was 0,59 t/ha, grain protein content was 10,8%, grain starch content was 77,8%, and the water consumption coefficient decreased to 477,3 m<sup>3</sup>/t, which was the best value among all the studied variants.

**Conflicts of interest:** the authors declare no conflict of interest.

**Use of artificial intelligence:** the authors confirm that they did not use artificial intelligence technologies during the creation of this work.

#### References

1. Bondarenko, V.P. (1981). Produktivnist tsukrovoho sorho na kashtanovykh gruntakh zalezho vid volohozabezpechenosti posiviv, hustoty roslyn i mineralnykh dobryv [Productivity of sweet sorghum on chestnut soils depending on water availability, plant density and mineral fertilizers] (Extended Abstract of Cand. Agric. Sci. Diss.). Kyiv [in Ukrainian].
2. Bukhanova, L.A., & Zarienkova, N.V. (2014). Zastosuvannia regulatoriv rostu i mikrodobryv na posivakh soi [Application of growth regulators and micronutrient fertilizers on soybean crops]. *Kormovyrobnytstvo*, 6, 21–24 [in Ukrainian].
3. Baranov, V.F., Ugo Togo Korren, et al. (2006). Vplyv stymyliatoriv rostu roslyn na produktyvnist soi [Effect of plant growth stimulants on soybean productivity]. *Maslichnye kultury: naukovotekhnichniy biuletyn VNIIMKu*, 104–106 [in Ukrainian].
4. Domaratskyi, Ye.O., Bazalii, V.V., Boiko, M.O., & Pichura, V.I. (2024). Ahrobiolohichne obgruntuvannia vyroshchuvannia zernovykh kultur v zoni Stepu za umov klimatychnykh zmin [Agrobiological substantiation of grain crop cultivation in the Steppe zone under climate change conditions]: monohrafiia. Kherson: OLDI-PLiuS [in Ukrainian].
5. Kliuchnykov, N.A., Rybalkin, A.A., & Isakov, I.Ya. (2001). Zernove sorho Khazine – ultraranniostyhyli sort dlia vkrai zasushlyvykh raioniv [Grain sorghum Khazine – an ultra-early ripening variety for extremely arid regions]. *Kukurudza i sorho*, 6, 23 [in Ukrainian].
6. Vozhekhova, R.A. (Ed.). (2014). Metodyka polovykh i laboratornykh doslidzhen na zroshyvanykh zemliakh [Methods of field and laboratory research on irrigated lands]. Kherson: Hrin D. S. [in Ukrainian].
7. Romashchenko, M.I., Zhuravlov, O.V., & Shatkovskyi, A.P. (Eds.). (2023). Metodolohichni zasady ta tekhniko-tekhnolohichni aspekty realizatsii optymalnykh rezhymiv zroshennia v umovakh zminy klimatu [Methodological principles and technical-technological aspects of implementing optimal irrigation regimes under climate change conditions]: monohrafiia. Odesa [in Ukrainian].
8. Zubets, M.V. (Ed.). (2010). Naukovi osnovy ahropromysloвого vyrobnytstva v zoni Stepu Ukrainy [Scientific foundations of agro-industrial production in the Steppe zone of Ukraine]. Kyiv: Ahrarna nauka [in Ukrainian].
9. Ishyn, A.H., et al. (2008). Osoblyvosti tekhnolohii vyroshchuvannia sorhovykh kultur u zasushlyvykh raionakh Pivdennoho Skhodu Yevropeiskoi chastyny Rosii [Peculiarities of sorghum crop cultivation technology in arid regions of the South-East of the European part of Russia]: rekomendatsii FDNu NDISKh “Rossorho”. Saratov [in Ukrainian].
10. Perhaiev, O., & Reinshein, L. (2004). Potentsial sorhovykh kultur [Potential of sorghum crops]. *Ahromyr*, 14, 1–2 [in Ukrainian].
11. Cherenkov, A.V., et al. (2011). Sorhovi kultury: tekhnolohiia, vykorystannia, hibrydy ta sorty [Sorghum crops: technology, utilization, hybrids and varieties]: rekomendatsii ISHhSZ NAAN Ukrainy. Dnipropetrovsk [in Ukrainian].
12. Abu-Ria, M.E., Shukry, W.M., El-Sawah, A.M., & Al-Amri, S.M. (2024). Mitigation of drought stress in maize and sorghum by humic acid: Differential growth and physiological responses. *BMC Plant Biology*, 24 (1), Article 514. doi: 10.1186/s12870-024-05184-4.
13. Abu-Ria, M.E., Shukry, W.M., El-Sawah, A.M., & Al-Amri, S.M. (2025). Differential physiological responses of *Zea mays* and *Sorghum bicolor* to drought stress: Insights into the ameliorative role of humic acid at the reproductive and yield stages. *Journal of Plant Growth Regulation*, 44 (11), 6061–6082. doi: 10.1007/s00344-025-11813-5.
14. Asmamaw, B.A., & Georgis, K. (2026). Application of various agricultural practices on sorghum forage yield and its association with water use efficiency under deficit irrigation conditions. *Scientific Reports*. DOI: 10.1038/s41598-025-32544-3 [in English].
15. Chiranjeevi, M., Goudar, G.D., Krishnaraj, P.U., & Yalavarthi, N. (2024). Study on effect of plant growth promoting rhizobacteria on sorghum (*Sorghum bicolor* L.) under gnotobiotic conditions. *Frontiers in Microbiology*, 15, 1374802. doi: 10.3389/fmicb.2024.1374802.
16. Farhadi, A., Soufizadeh, S., Alahdadi, I., & Mazaheri, D. (2023). Irrigation management strategies to enhance forage yield, feed value, and water-use efficiency of sorghum cultivars. *Plants*, 12 (11), Article 2154. doi: 10.3390/plants12112154.

17. Guo, Y., Wang, X., Zhang, J., Li, Y., Li, Z., & Zhou, B. (2024). Short-term organic fertilizer substitution increases sorghum yield by improving soil physicochemical characteristics and regulating microbial community structure. *Frontiers in Plant Science*, 15, Article 1492797. doi: 10.3389/fpls.2024.1492797.

18. Huang, P., Zhang, J., Wang, X., Li, Y., & Zhou, B. (2024). Efficacy of chelated micronutrients in plant nutrition. *Communications in Soil Science and Plant Analysis*, 55 (22), 3609–3637. doi: 10.1080/00103624.2024.2397019.

19. Niharika, P., et al. (2025). Amino acid-chelated micronutrients: a new frontier in crop nutrition and abiotic stress mitigation. *Plant Science Today*. DOI: 10.14719/pst.8302.

20. Huang, P., Zhang, J., Wang, X., Li, Y., & Zhou, B. (2024). Efficacy of chelated micronutrients in plant nutrition. *Communications in Soil Science and Plant Analysis*, 55 (22), 3609–3637. doi: 10.9734/jeai/2021/v43i930732.

21. Zahida, R., Sharma, S., Kumar, R., Lone, B. A., & Ahmad, L. (2024). Optimizing sorghum yield and quality: A study on the role of plant growth regulators and micronutrient management strategies. *Journal of Scientific Research and Reports*, 30 (11), 208–222. doi: 10.9734/jsrr/2024/v30i112548.

УДК: 633.174:631.67:631.811.98

## ЕФЕКТИВНІСТЬ РІСТ-РЕГУЛЮЮЧИХ ПРЕПАРАТІВ НА ЗРОШУВАНИХ ПОСІВАХ СОРГО ЗЕРНОВОГО

Ю.О. Тараріко<sup>1</sup>, д-р с.-г. наук, П.В. Писаренко<sup>2</sup>, д-р с.-г. наук, Р.М. Василенко<sup>3</sup>, канд. с.-г. наук, Р.В. Сайдак<sup>4</sup>, канд. с.-г. наук, Ю.В. Сорока<sup>5</sup> канд. с.-г. наук, І.О. Біднина<sup>6</sup>, канд. с.-г. наук

<sup>1</sup> Інститут водних проблем і меліорації НААН, Київ, 03022, Україна;  
<https://orcid.org/0000-0001-8475-240X>; e-mail: [urtar@bigmir.net](mailto:urtar@bigmir.net)

<sup>2</sup> Інститут водних проблем і меліорації НААН, Київ, 03022, Україна  
<https://orcid.org/0000-0002-2104-2301>; email [pavel\\_pisarenko74@ukr.net](mailto:pavel_pisarenko74@ukr.net)

<sup>3</sup> Інститут кліматично орієнтованого сільського господарства НААН, Одеса, Україна;  
<https://orcid.org/0009-0000-1903-4444>; e-mail: [ruslan-18a@ukr.net](mailto:ruslan-18a@ukr.net)

<sup>4</sup> Інститут водних проблем і меліорації НААН, Київ, 03022, Україна;  
<https://orcid.org/0000-0002-0213-0496>; e-mail: [saidak\\_r@ukr.net](mailto:saidak_r@ukr.net)

<sup>5</sup> Інститут водних проблем і меліорації НААН, Київ, 03022, Україна;  
<https://orcid.org/0000-0001-6228-4131>; e-mail: [agrosurs@bigmir.net](mailto:agrosurs@bigmir.net)

<sup>6</sup> Інститут водних проблем і меліорації НААН, Київ, 03022, Україна  
<https://orcid.org/0000-0001-8351-2519>; e-mail: [irinabidnina@ukr.net](mailto:irinabidnina@ukr.net)

**Анотація.** В умовах посилення кліматичної посушливості південного регіону України зростає актуальність удосконалення технологій вирощування зернового сорго, спрямованих на підвищення ефективності використання водних ресурсів та формування стабільної продуктивності культури. Метою дослідження було визначити вплив ріст-регулюючих препаратів та комплексного добрива у хелатній формі Нановіт супер на водоспоживання, формування структури врожаю та зернову продуктивність сорго зернового в умовах зрошення. Польові дослідження проводили у 2016–2018 рр. на дослідному полі Інституту кліматично орієнтованого сільського господарства НААН на темно-каштановому середньосуглинковому слабосолонцюватому ґрунті. Об'єктом дослідження був ранньостиглий сорт сорго зернового Південне. Вивчали дію ріст-регулюючих препаратів Регоплант, Грейнактив-С та Вермистим на фоні внесення  $N_{90}$ , а також їх поєднання з позакореневим підживленням комплексним добривом Нановіт супер.

Встановлено, що застосування досліджуваних препаратів не спричиняло істотних змін сумарного водоспоживання рослин ( $4104\text{--}4296\text{ м}^3/\text{га}$ ), однак сприяло підвищенню ефективності використання водних ресурсів. Найменший коефіцієнт водоспоживання отримано за сумісного застосування препарату Регоплант і добрива Нановіт супер –  $477,3\text{ м}^3/\text{т}$ , що на  $32,5\%$  менше порівняно з контролем. Застосування біостимуляторів позитивно впливало на формування елементів структури врожаю, зокрема збільшувало довжину волоті, кількість та масу зерна в ній, а також масу  $1000$  насінин. Найвищу зернову продуктивність забезпечувало сумісне використання препарату Регоплант із позакореневим підживленням добривом Нановіт супер на фоні  $N_{90}$ , за якого врожайність зерна становила  $9,2\text{ т}/\text{га}$ , що на  $55,9\%$  перевищувало контрольний варіант. За цих умов

також підвищувалися показники кормової цінності продукції: вихід кормових одиниць досягав 12,4 т/га, перетравного протеїну – 0,59 т/га, а вміст білку в зерні – 10,8 %.

Отримані результати свідчать про високу ефективність використання ріст-регуляторів у поєднанні з хелатними мікродобривами у технології вирощування зернового сорго в умовах зрошення та підтверджують доцільність їх застосування для підвищення продуктивності культури й оптимізації використання водних ресурсів.

**Ключові слова:** сорго зернове, ріст-регулятори, хелатні мікродобрива, зрошення, водоспоживання, урожайність, кормова цінність