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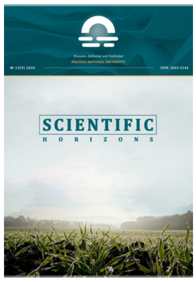

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Sowing properties of sunflower seeds of *Talento* hybrid under the influence of a modified plant growth regulator

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Abstract. The improvement of agricultural crop cultivation technologies enables the production of high sunflower yields with high-quality indicators. One such element is pre-sowing seed treatment. This study aimed to investigate the effect of a plant growth regulator supplemented with calcium on the sowing properties of sunflower seeds. The experiment was conducted under laboratory conditions. For pre-sowing seed treatment, a semi-synthetic film-forming agent with an anti-stress effect was

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used, which was modified with Ca^{2+} ions in the form of calcium chloride. It was established that the encrustation of sunflower seed with a growth regulator stimulates germination processes and activates the initial stages of sunflower organogenesis. This increases the indicators of germinative vigour and germination capacity. Adding calcium to the plant growth regulator contributes to a further increase in the indicators of germinative vigour and seed germination capacity of sunflowers by 5.4% and 7.7%, respectively, compared to the control. At the same time, the hypocotyl length increased by 1.51 times compared to the control, while the root length increased by 1.37 times. The accumulation of organic substances in sunflower seedlings is characterised by an increase in dry matter. When calcium was added to the plant growth regulator, a more intensive accumulation of dry matter in the hypocotyl and root was observed compared to the control and the variant using only the growth regulator. The establishment of a ranking range indicated that, based on the parameters studied, the optimal treatment option for the pre-sowing treatment of sunflower seeds is the application of a plant growth regulator containing calcium ions at a concentration of 1.0 g/L. The use of this preparation is relevant and promising for studying the formation of sunflower plant productivity with increased quality indicators under field conditions

Keywords: germinative vigour; germination capacity; calcium; seedling length; dry matter; ranking range

INTRODUCTION

The production of oilseed crops holds a significant place within the structure of Ukraine's agro-industrial complex, with sunflower being the leading crop. The high adaptability of this crop to arid soil and climatic conditions has contributed to increasing production volumes. However, in light of global warming and climate change, there is a growing need to enhance sunflower's adaptability and resilience to adverse environmental conditions. This has prompted researchers to refine and improve the cultivation techniques for this crop to achieve a stable, high-quality yield.

In their analyses of the weather and climate conditions in southern Ukraine, V. Karamushka *et al.* (2022) and V. Pichura *et al.* (2022) noted significant changes over the past decades: there has been a decrease in precipitation, winters have become milder, and summers hotter with persistent dry hot winds. Under these conditions, plants experience hydrothermal stress. One method to enhance the adaptability of crops to adverse conditions is the pre-sowing seed treatment with plant growth regulators. Studies by S. Guo *et al.* (2021), H. Mostafa and M. Afify (2022) confirm that seed germination is a critical stage in plant life. In their studies, G. Kulyk *et al.* (2022) state that seed encrustation with plant growth regulators activates self-regulation processes, improves germination capacity and enhances resistance to unfavourable abiotic factors. Moreover, this enhances root system development (Vasylenko *et al.,* 2020), improves mineral nutrition (Polyakov & Shcherbak, 2022), and fosters the development of floral primordia and sunflower head growth (Tsylyurik & Ostapchuk, 2023).

To enhance the adaptive capacity of plants, nutrients such as calcium are also used in pre-sowing seed treatments. Calcium ions play a role in forming adaptive responses to stress during plant growth and development, improving osmotic tolerance, heat resistance, cold resistance, and more (Vancostenoble *et al.,* 2022). According to U. Aqeel *et al.* (2022), the action of calcium is due to its ability to induce defensive responses in plants (under certain conditions, it enhances the generation of ROS), superoxide radicals and peroxides, and the subsequent activation of other antioxidant signalling systems. A. Haj Sghaier *et al.* (2023) found that pre-sowing seed treatment with calcium chloride improves plant adaptation to adverse conditions. M. Bourioug *et al.* (2020) observed similar results, noting improvements in seed germination improve germination capacity, biomass production, crop structure, and, consequently, crop yields.

Calcium influences various cellular processes in plants by activating antioxidant enzymes, protein synthesis, and the accumulation of low-molecular-weight protectants. In a study examining the role of calcium under salt stress in tomato plants, K. Tanveer *et al.* (2020) found that calcium application mitigated the negative effects of salinity on germination and growth. This was accompanied by an increase in the maturity index, seedling vigour, dry matter accumulation in roots and seedlings, and an increase in plant height and leaf area. R. Catiempo *et al.* (2021) noted that in the presence of calcium ions under salt stress, seed germination and root growth improved, and the epidermis and xylem layers were better protected from damage.

Calcium compounds have been shown to enhance the productivity of rice plants by increasing seed germination capacity, seedling biomass, and reducing lipid peroxidation products. The accumulation of bioactive compounds (polyphenols, flavonoids, and γ-aminobutyric acid) is improved, cell viability is increased, and the antioxidant capacity of germinated rice is enhanced due to the activation of enzymes. Similar enhancements in endogenous antioxidant activity and enzyme activity during seed germination in lettuce were observed by E. Ademola *et al.* (2020), who also noted a reduction in lipid peroxidation. Improvements in growth processes under calcium ion treatment have been observed not only under salt stress but also under drought conditions when plants experience hydrothermal stress (Silveira *et al.,* 2020). Such drought conditions are typical of the growing season in the Southern Steppe of Ukraine.

A review of the literature on the selected topic revealed that the aspect of increasing the adaptive capacity of sunflower plants has been insufficiently studied. Therefore, the aim of this research was to investigate the effect of a plant growth regulator, modified with calcium ions, on the sowing properties of sunflower seeds of the *Talento* hybrid and to determine the optimal calcium concentration for pre-sowing seed treatment.

MATERIALS AND METHODS

The research was conducted in the Soil and Plant Product Quality Monitoring Laboratory at the Agrotechnology and Ecology Research Institute of the Dmytro Motornyi Tavria State Agrotechnological University. In investigating the effectiveness of calcium and its positive impact on plants, the authors relied on existing literature concerning calcium's efficacy and beneficial effects. This led to the consideration of improving the AKM plant growth regulator by incorporating calcium ions and testing its effectiveness on the sowing quality of sunflower seeds under laboratory conditions.

The plant growth regulator AKM is included in the list of pesticides and agrochemicals approved for use in Ukraine (2023). It is a semi-synthetic film-forming agent with an anti-stress effect. The formulation contains distinol 0.015 g/L (dimethyl sulfoxide + ionol), polyethylene glycol (PEG) – 1500 (440 g/L) and PEG – 400 (190 g/L), the remainder being water. AKM was modified by adding Ca^{2+} ions in the form of calcium chloride. The seed material was encrusted with the resulting preparation one day before the start of the experiment at the recommended concentration of 200 ml/ton. The working solution was applied at a rate of 10 L/ton of seed. The treated sunflower seeds were germinated in rolls on filter paper in a TS-80 thermostat of Ukrainian manufacture at a temperature of +20°C (DSTU 4138-2002). Between two layers of moistened paper, one hundred seeds were placed with the embryo facing downwards in three replications. The experimental design is presented in Table 1. The experiment was replicated four times, according to the methodology for conducting plant science experiments by V. Lypovy *et al.* (2020).

Table 1. *Experimental design of the laboratory study*

Variant	Seed treatment preparation
1	Water (control)
2	AKM
3	AKM + Ca (0.25 g/L)
4	AKM + Ca (0.50 g/L)
5	AKM + Ca (0.75 g/L)
6	AKM + Ca (1.00 g/L)
7	AKM + Ca (1.25 g/L)
8	AKM + Ca (1.50 g/L)
9	AKM + Ca (1.75 g/L)
10	AKM + Ca (2.00 g/L)

Source: *developed by the authors*

The research was conducted on sunflower seeds of the *Talento* hybrid (originator – *Syngenta*), using standard methodologies. This is a high-oleic hybrid for the Clearfield system, with an oleic acid content in the oil of up to 90%, belonging to the mid-early maturity group. It is recommended for cultivation in the Steppe and Forest-Steppe zones. The hybrid was registered in 2016. Sample selection and preparation for analysis, as well as the determination of seed germinative vigour and laboratory germination, were carried out according to the standard methodology (DSTU 4138-2002, 2004). Seed germinative vigour was counted on the fourth day of germination, and germination capacity – on the eighth day. Biometric indicators of sunflower seedlings (hypocotyl and root length) were measured using a standard methodology (Palamarchuk *et al.,* 2022). Dry matter content was determined gravimetrically (DSTU 4138-2002, 2004). Statistical evaluation of the data was performed using the Student's t-test and the "Agrostat" program.

A multi-criteria optimisation method was employed to determine the most effective pre-sowing seed treatment for sunflowers. This method is based on the application of a decision-making mechanism that considers multiple criteria, allowing for the exclusion of the influence of measurement units of seed quality indicators, as well as the magnitudes of acceptable value ranges for each indicator when selecting the pre-sowing treatment method for sunflower seeds (the objective function). The data for selecting the best pre-sowing treatment for sunflower seeds have a two-sided alternative-criteria classification with criterion values f_j and characterise the sowing quality indicators A_j – in quantitative scales and dimensionless form.

Experimental research on plants (both cultivated and wild), including the collection of plant material, adhered to institutional, national, or international guidelines. The authors complied with the standards set forth by the Convention on Biological Diversity (1992) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (1979).

RESULTS AND DISCUSSION

The use of the encrustation method with modern preparations for pre-sowing seed treatment activates self-regulation processes and enhances the sowing quality of seeds as well as their resilience to adverse external factors. In this study, it was found that encrustation of sunflower seeds with the growth regulator AKM stimulated germination processes, as evidenced by a 2.2% increase in germinative vigour compared to the control (Fig. 1). A similar effect with increased seed germinative vigour under the influence of AKM was also observed in the studies of O. Yeremenko and O. Onyshchenko (2020). The addition of calcium to AKM further enhanced this indicator, especially in the variant with a calcium ion concentration of 1.0 g/L, where germinative vigour was 5.4% higher than the control and 3.2% higher compared to the variant where only AKM was used. High calcium concentrations of 1.75 g/L and 2.0 g/L led to a decrease in germinative vigour by 2.2-7.7% compared to all other variants in the study. When determining the laboratory germination capacity of sunflower seeds, it was established that pre-sowing seed treatment contributed to an increase in this indicator by 5.4% compared to the control (Fig. 2). Moreover, the best effect was observed in the variant combining the plant growth regulator AKM with calcium ions at a concentration of 1.0 g/L.

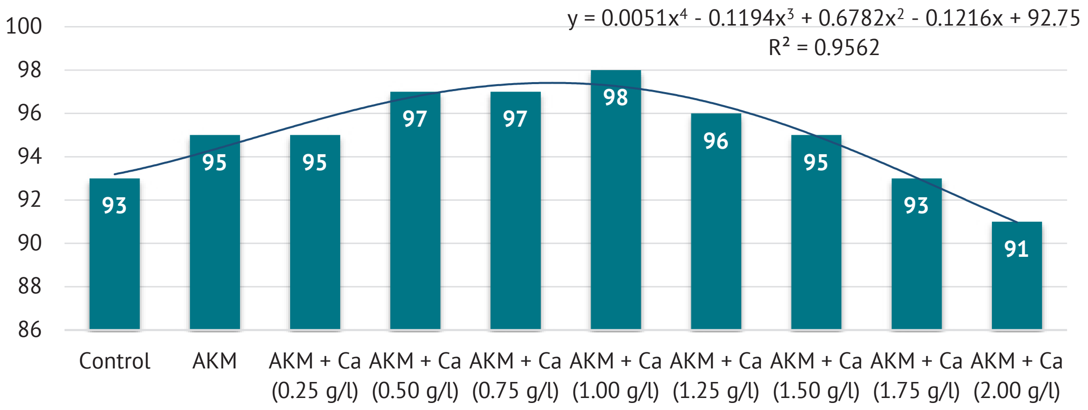

Figure 1. *Effect of the plant growth regulator AKM + Ca on the germinative vigour of Talento hybrid sunflower seeds (approximated polynomial curve of the 4th degree)*
Source: *developed by the authors*

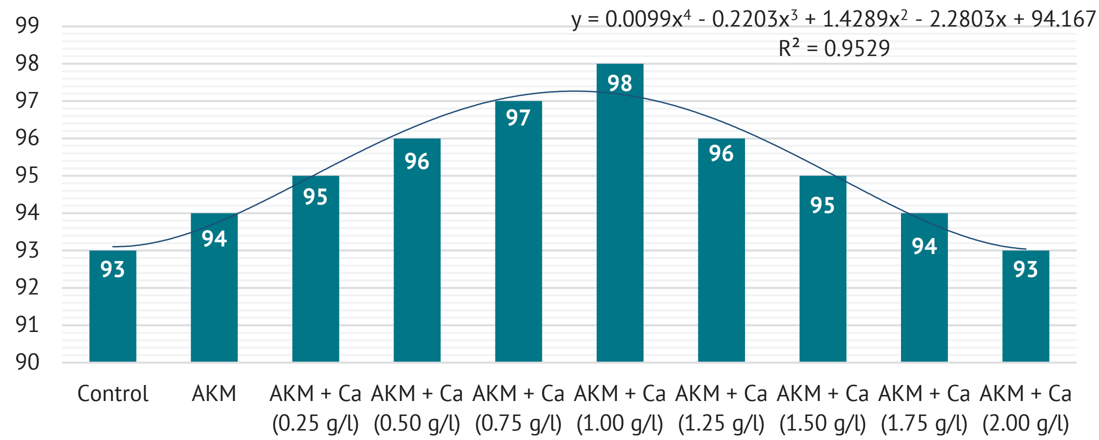

Figure 2. *Effect of the plant growth regulator AKM + Ca on the laboratory germination capacity of Talento hybrid sunflower seeds (approximated polynomial curve of the 4th degree).*
Source: *developed by the authors*

A significant advantage of this seed treatment is the absence of a difference between the germinative vigour and germination capacity percentage of the seeds. This lack of difference in field conditions contributes to a 1-2-day reduction in the sowing-to-emergence period and results in more uniform emergence.

For field trials, it is recommended to treat sunflower seeds with the plant growth regulator AKM saturated with calcium ions at a concentration of 1.0 g/L. When constructing an approximated polynomial curve of the 4th degree of the influence of pre-sowing seed treatment on germinative vigour and laboratory germination capacity, a strong functional dependence was established, where R^2 = 0.95-0.96. Similar results for pre-sowing seed treatment with calcium chloride were obtained by scientists K. Reddy *et al.* (2023), who confirmed the positive impact of calcium ions on seed germination capacity, especially under stress conditions. Subsequently, such treatment contributes to the improvement of both morphological and productive traits of crops. E. Ademola *et al.* (2020) explain the positive effect of calcium ions on improving seed germination processes by enhancing the activity of antioxidant enzymes and reducing lipid peroxidation.

H. Choe *et al.* (2021), in addition to improved germination processes, also reported a better accumulation of antioxidant components (polyphenols, flavonoids, γ-aminobutyric acid) in seedlings in the presence of calcium ions, which activate enzymes, reduce oxidative stress, and improve cell viability. During germination, the embryo utilises the stored nutrients of the achene. In this process, division zones appear on the radicle, cells stretch and differentiate, nutrients and physiologically active substances of the seed are assimilated, and the seedling grows. The activity of growth processes at the initial stages of organogenesis is characterised by the length of the seedlings, especially in variants with pre-sowing treatment of the studied components (Table 2).

Table 2. *Biometric parameters of sunflower seedlings of Talento hybrid*

Variant	Length, cm	
Control	Hypocotyl	4.11 ± 0.16
	Root	7.93 ± 0.31
AKM	Hypocotyl	4.80 ± 0.20
	Root	9.85 ± 0.39
AKM + Ca (0.25 g/L)	Hypocotyl	4.92 ± 0.24
	Root	9.92 ± 0.36
AKM + Ca (0.50 g/L)	Hypocotyl	5.27 ± 0.24
	Root	10.10 ± 0.47
AKM + Ca (0.75 g/L)	Hypocotyl	5.52 ± 0.23
	Root	10.36 ± 0.43
AKM + Ca (1.00 g/L)	Hypocotyl	6.20 ± 0.30
	Root	10.83 ± 0.51
AKM + Ca (1.25 g/L)	Hypocotyl	5.83 ± 0.27
	Root	10.42 ± 0.43
AKM + Ca (1.50 g/L)	Hypocotyl	5.23 ± 0.21
	Root	9.75 ± 0.40
AKM + Ca (1.75 g/L)	Hypocotyl	4.70 ± 0.17
	Root	9.02 ± 0.38
AKM + Ca (2.00 g/L)	Hypocotyl	4.18 ± 0.14
	Root	8.49 ± 0.39

Source: *developed by the authors*

The shortest hypocotyl and root lengths were observed in the control group of sunflower seedlings. The application of AKM resulted in a 16.8% increase in hypocotyl length and a 24.2% increase in root length. A significant impact on seedling growth was observed in variants where calcium was added to AKM. This was particularly evident at concentrations of 0.75, 1.0, and 1.25 g/L, where the hypocotyl length was 1.34-1.51 times higher than the control, and root length was 1.31-1.37 times higher compared to the control. A higher concentration of calcium (2.0 g/L) inhibited growth processes. For instance, the hypocotyl and root lengths in this variant were 14.8% and 16.0% lower, respectively, compared to the variant treated with the regulator alone.

The research revealed that a well-formed, biologically complete reserve of nutrients in seeds significantly influences the initial growth and development of a plant. This reserve determines the direction and intensity of physiological and biochemical processes not only in the initial period of plant growth and development but also throughout the entire growing season (Matskevych *et al.,* 2022). Sunflower seedlings consist of water and dry matter, which is represented by mineral and organic compounds. The increase in dry matter in plants characterises the efficiency of the assimilatory apparatus, the accumulation of macronutrients, the formation of reproductive organs, and, consequently, the formation of yield (Kalenska *et al.,* 2023). The dry matter content in the seedlings of the studied crop is shown in Figure 3.

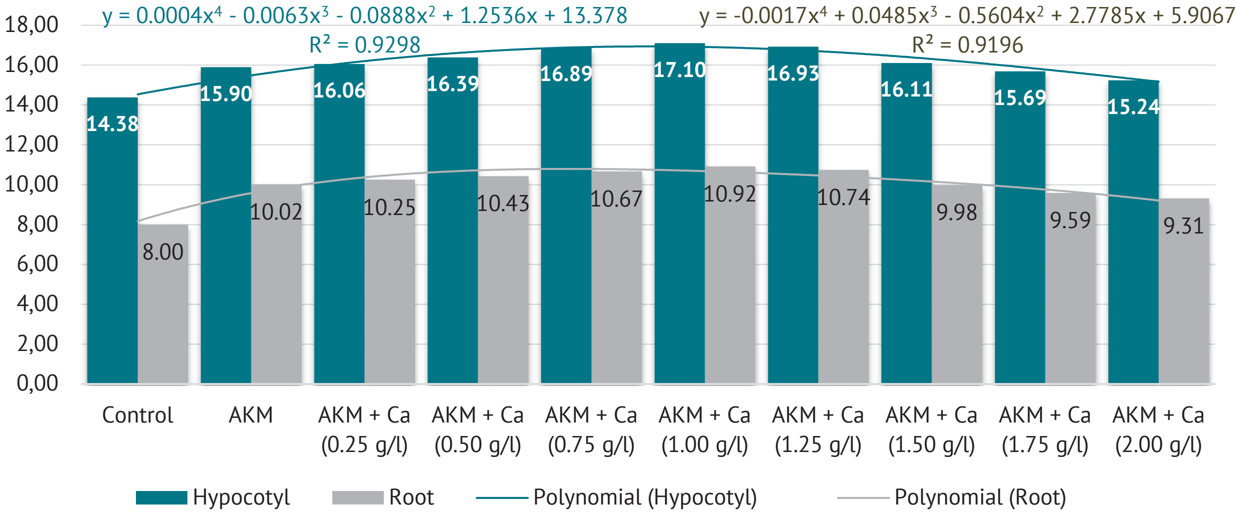

***Figure 3.** Dry matter content (%) in sunflower seedlings of the Talento hybrid (approximated polynomial curve of the 4th degree)*

***Source:** developed by the authors*

Laboratory experiments revealed that the dry matter content in the hypocotyls of sunflower seedlings was higher than in the roots. The use of a plant growth regulator for pre-sowing seed treatment did not have a significant impact on the dry matter content in the hypocotyl. However, the modification of AKM with calcium ions contributed to a better accumulation of dry matter in the hypocotyl. Specifically, in treatment variants with calcium ion concentrations of 0.5-1.25%, a significant increase of 1.14-1.19 times in this indicator was observed compared to the control.

The accumulation of dry matter in the root was significantly higher than the control, ranging from 1.25 to 1.37 times across all treatment variants. Moreover, the maximum accumulation of dry matter was observed in the hypocotyl and root of sunflower seedlings treated with a calcium ion concentration of 1.0 g/L. Increasing the calcium ion concentration to 2.0 g/L tended to decrease the rate of dry matter accumulation in sunflower seedlings. The construction of an approximated polynomial curve of the 4^{th} degree revealed a strong functional relationship between dry matter accumulation in the hypocotyl and root and the effect of pre-sowing seed treatment with the plant growth regulator AKM in combination with calcium ions, where $R^2 = 0.92 - 0.93$. The corresponding equations are presented in Figure 3.

Similar effects of calcium ions on biometric indicators in tomato plants were observed by A. Singh *et al.* (2020), who noted an increase in fresh and dry mass of roots and shoots in seedlings, as well as an increase in membrane stability index. M. Ashraf *et al.* (2022) in their research also reported an increase in biomass of agricultural crop seedlings, root and shoot length in the presence of calcium compounds, along with increased seed germination, better preservation of carotenoids and phenolic compounds, reduced chlorophyll degradation, and decreased oxidative stress intensity. Scientists T. Mulaudzi *et al.* (2020) found that the presence of calcium ions mitigated the effects of salt stress during the germination of *Sorghum bicolour*. The authors noted improvements in seed germination, root growth, and seedling growth, and highlighted the effectiveness of Ca^{2+} in protecting the xylem from damage. A comparative assessment of the research results established a ranking range for the experimental variants (Table 3).

***Table 3.** The results of the values of objective functions ϕ(x1)...ϕ(x10) when choosing the optimal variant of pre-sowing treatment of sunflower seeds*

Alternatives		Criteria, A_j												Values of the objective functions, $\phi(x_i)$	Rank
Experiment variant f_1		Germinative vigor (%), A_1		Seed germination capacity (%), A_2		Hypocotyl length (cm), A_3		Root length (cm), A_4		Dry matter content of hypocotyls (%), A_5		Dry matter content of the root (%), A_6			
		$\hat{f}_1$	f_2	$\hat{f}_2$	f_3	$\hat{f}_3$	f_4	$\hat{f}_4$	f_5	$\hat{f}_5$	f_6	$\hat{f}_6$			
x_1	Control	93.00	0.30	93.00	0.30	4.11	0.05	7.93	0.07	14.38	0.12	8.00	0.07	5.09	10

Table 3. Continued

Alternatives		Criteria, A_j												Values of the objective functions, $\phi(x_i)$	Rank
Experiment variant f_1		Germinative vigor (%), A_2		Seed germination capacity (%), A_2		Hypocotyl length (cm), A_3		Root length (cm), A_4		Dry matter content of hypocotyls (%), A_5		Dry matter content of the root (%), A_6			
		$\hat{f}_1$	f_2	$\hat{f}_2$	f_3	$\hat{f}_3$	f_4	$\hat{f}_4$	f_5	$\hat{f}_5$	f_6	$\hat{f}_6$			
x_2	AKM	95.00	0.50	94.00	0.40	4.80	0.34	9.85	0.62	15.90	0.53	10.02	0.65	2.96	7
x_3	AKM+Ca 0.25 g/L	95.00	0.50	95.00	0.50	4.92	0.39	9.92	0.64	16.06	0.58	10.25	0.71	2.68	6
x_4	AKM+Ca 0.50 g/L	97.00	0.70	96.00	0.60	5.27	0.53	10.10	0.7	16.39	0.67	10.43	0.77	2.03	4
x_5	AKM+Ca 0.75 g/L	97.00	0.70	97.00	0.70	5.52	0.64	10.36	0.77	16.89	0.80	10.67	0.83	1.56	2
x_6	AKM+Ca 1.00 g/L	98.00	0.80	98.00	0.80	6.20	0.92	10.83	0.91	17.10	0.86	10.92	0.91	0.80	1
x_7	AKM+Ca 1.25 g/L	96.00	0.60	96.00	0.60	5.83	0.77	10.42	0.79	16.93	0.81	10.74	0.85	1.58	3
x_8	AKM+Ca 1.50 g/L	95.00	0.50	95.00	0.50	5.23	0.52	9.75	0.60	16.11	0.59	9.98	0.64	2.65	5
x_9	AKM+Ca 1.75 g/L	93.00	0.30	94.00	0.40	4.70	0.30	9.02	0.38	15.69	0.48	9.59	0.52	3.62	8
x_{10}	AKM+Ca 2.00 g/L	91.00	0.10	93.00	0.30	4.18	0.08	8.49	0.23	15.24	0.35	9.31	0.44	4.50	9
f_j^-		90.00		90.00		3.99		7.69		13.95		7.76			
f_j^+		100		100		6.39		11.15		17.61		11.25			
$f_j(\tilde{o}^{\grave{e}})$			1		1		1		1		1		1		
$f_j^{\tilde{i}\tilde{i}\grave{o}}$		100 (max)		100 (max)		6.39 (max)		11.15 (max)		17.61 (max)		11.25 (max)			

Source: *developed by the authors*

The optimal treatment for pre-sowing sunflower seed treatment in this experiment was found to be the combination of the plant growth regulator AKM and calcium at a concentration of 1.0 g/L, achieving the first rank (φ (x_1) = 0.80). The second and third ranks were assigned to the treatments of AKM+Ca with active substance concentrations of 0.75 and 1.25 g/L, respectively, as confirmed by the objective function values φ (x_2) = 1.56 and φ (x_3) = 1.58. The control sunflower seeds, based on a comprehensive assessment of sowing quality indicators, were found to be the least suitable for sowing, receiving the tenth rank.

Therefore, the pre-sowing treatment of *Talento* hybrid sunflower seeds with the modified plant growth regulator AKM and a calcium ion concentration of 1.0 g/L exhibited superior seed quality compared to other treatment variants. The impact of calcium ions on seed germination processes is indisputable. However, under various stress conditions, researchers have noted different optimal calcium concentrations. T. Mulaudzi *et al.* (2020) observed that the exogenous application of 5 mM Ca^{2+} was most effective in increasing the salt stress tolerance of *Sorghum bicolour*. To mitigate the negative effects of salt stress on sorghum plants, a concentration of 50 mM $CaCl_2$ was noted. X. Chen *et al.* (2021) also highlighted the positive impact of calcium chloride application on the germination and growth of tomato plants under saline conditions. However, the optimal calcium concentration in this case was found to be 10 mM.

Therefore, the research findings confirm the data of other scientists regarding the influence of growth regulators and calcium ions on the seed quality of sunflowers. The obtained data suggest the promising potential for further research into the effects of the modified plant growth regulator AKM+Ca under field conditions, where the productivity of sunflowers and the quality of the harvested product will be studied. This will allow for the provision of a high-quality food supply to the population.

CONCLUSIONS

Encrusting sunflower seeds with a growth regulator stimulates germination processes, increasing germinative vigour by 2.2% and germination capacity by 3.3% compared to the control. Saturating the regulator with calcium ions (1.0 g/L) further increases these indicators by 5.4% and 7.7%, respectively. Pre-sowing seed treatment activates the initial stages of organogenesis in sunflowers. The application of the preparation increases hypocotyl length by 16.8% and root length by 24.2% compared to the control. The addition of calcium ions (0.75, 1.0, and 1.25 g/L) to AKM increases hypocotyl length relative to the control by 1.34 to 1.51 times and root length by 1.31 to 1.37 times. High concentrations of calcium (2.0 g/L) inhibited growth processes and caused a decrease in germinative vigour by 4.4%, a reduction in hypocotyl length (by 14.8%), and a reduction in root length (by 16.0%), compared to pre-sowing seed treatment of sunflower with a plant growth regulator. The use of a plant growth regulator modified with calcium ions (0.5-1.25 g/L) promoted the intensive accumulation of dry matter in the hypocotyl by 1.14-1.19 times and in the root by 1.30-1.37 times relative to the control. When constructing the ranking range, it was determined that the optimal treatment for pre-sowing sunflower seed processing, based on the investigated indicators, was the application of the growth regulator with a calcium ion concentration of 1.0 g/L. Therefore, further study of the effects of the plant growth regulator in combination with calcium ions under field conditions is both appropriate and promising for obtaining high sunflower seed yields with improved quality.

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None.

CONFLICT OF INTEREST

None.

REFERENCES

[1] Ademola, E., Sershen, B.V., & Norman, W. (2020). Effects of inorganic salt solutions on vigour, viability, oxidative metabolism and germination enzymes in aged cabbage and lettuce seeds. *Plants*, 9(9), article number 1164. doi: 10.3390/plants9091164.

[2] Aqeel, U., Parwez, R., Aftab, T., Khan, M.M.A., & Naeem, M. (2022). Exogenous calcium repairs damage caused by nickel toxicity in fenugreek (*Trigonella foenum-graecum* L.) by strengthening its antioxidant defense system and other functional attributes. *South African Journal of Botany*, 150, 153-160. doi: 10.1016/j.sajb.2022.07.025.

[3] Ashraf, M.A., Rasheed, R., Hussain, I., Hafeez, A., Adrees, M., ur Rehman, M.Z., Rizwan, M., & Ali, S. (2022). Effect of different seed priming agents on chromium accumulation, oxidative defense, glyoxalase system and mineral nutrition in canola (*Brassica napus* L.) cultivars. *Environmental Pollution*, 309, article number 119769. doi: 10.1016/j.envpol.2022.119769.

[4] Bourioug, M., Ezzaza, K., Bouabid, R., Alaoui-Mhamdi, M., Bungau, S., Bourgeade, P., Alaoui-Sossé, L., Alaoui-Sossé, B., & Aleya, L. (2020). Influence of hydro - and osmo-priming on sunflower seeds to break dormancy and improve crop performance under water stress. *Environmental Science and Pollution Research,* 27, 13215-13226. doi: 10.1007/s11356-020-07893-3.

[5] Catiempo, R.L., Photchanachai, S., Bayogan, E.R.V., & Wongs-Aree, C. (2021). Impact of hydropriming on germination and seedling establishment of sunflower seeds at elevated temperature. *Plant, Soil & Environment,* 67(9), 491-498. doi: 10.17221/163/2021-PSE.

[6] Chen, X., Zhang, R., Xing, Y., Jiang, B., Li, B., Xu, X., & Zhou, Y. (2021). The efficacy of different seed priming agents for promoting sorghum germination under salt stress. *PloS One*, 16(1), article number e0245505. doi: 10.1371/journal.pone.0245505.

[7] Choe, H., Sung, J., Lee, J., & Kim, Y. (2021). Effects of calcium chloride treatment on bioactive compound accumulation and antioxidant capacity in germinated brown rice. *Journal of Cereal Science*, 101, article number 103294. doi: 10.1016/j.jcs.2021.103294.

[8] Convention on Biological Diversity. (1992, June). Retrieved from https://zakon.rada.gov.ua/laws/show/995_030#Text.

[9] Convention on International Trade in Endangered Species of Wild Fauna and Flora. (1979, June). Retrieved from https://zakon.rada.gov.ua/laws/show/995_129#Text.

[10] DSTU 4138:2002. (2004). *Crop seeds. Methods of quality determination.* Retrieved from https://online.budstandart.com/ua/catalog/doc-page?id_doc=91465.

[11] Guo, S., Klinkesorn, U., Lorjaroenphon, Y., Ge, Y., & Na Jom, K. (2021). Effects of germinating temperature and time on metabolite profiles of sunflower (*Helianthus annuus* L.) seed. *Food Science & Nutrition,* 9(6), 2810-2822. doi: 10.1002/fsn3.1983.

[12] Haj Sghaier, A., Khaeim, H., Tarnawa, Á., Kovács, G.P., Gyuricza, C., & Kende, Z. (2023). Germination and seedling development responses of sunflower (*Helianthus annuus* L.) seeds to temperature and different levels of water availability. *Agriculture*, 13(3), article number 608. doi: 10.3390/agriculture13030608.

[13] Kalenska, S., Dmytryshak, M., Mokriyenko, V., Antal, T., & Mazurenko, B. (2023). *Crop production with the basics of forage production and agrometeorology*. Kyiv: Printeco.
[14] Karamushka, V., Boychenko, S., Kuchma, T., & Zabarna, O. (2022). Trends in the environmental conditions, climate change and human health in the southern region of Ukraine. *Sustainability,* 14(9), article number 5664. doi: 10.3390/su14095664.
[15] Kulyk, G., Trykina, N., & Malakhovska, V. (2022). Formation of productivity of sugar beets when using growth regulator Biolan in Central Ukraine. *Scientific Progress & Innovations,* 1, 55-61. doi: 10.31210/visnyk2022.01.06
[16] Lypovy, V., Mazur, O., & Mordvaniuk, M. (2020). *Methodology and organization of scientific research in agronomy with the basics of intellectual property*. Vinnytsia: VC VNAU.
[17] Matskevych, V., Filipova, L., & Oleshko, O. (2022). *Physiology and biotechnology of plants*. Bila Tserkva: BNAU.
[18] Mostafa, H., & Afify, M.T. (2022). Influence of water stress on engineering characteristics and oil content of sunflower seeds. *Scientific Reports,* 12, article number 12418. doi: 10.1038/s41598-022-16271-7.
[19] Mulaudzi, T., Hendricks, K., Mabiya, T., Muthevhuli, M., Ajayi, R.F., Mayedwa, N., & Iwuoha, E. (2020). Calcium improves germination and growth of Sorghum bicolor seedlings under salt stress. *Plants*, 9(6), article number 730. doi: 10.3390/plants9060730.
[20] Palamarchuk, V., Doronin, V., Kolisnyk, O., & Alekseev, O. (2022). *Basics of seed science (theory, methodology, practice)*. Vinnytsia: Druk Printing House.
[21] Pichura, V., Potravka, L., Vdovenko, N., Biloshkurenko, O., Stratichuk, N., & Baysha, K. (2022). Changes in climate and bioclimatic potential in the steppe zone of Ukraine. *Journal of Ecological Engineering*, 23(12), 189-202. doi: 10.12911/22998993/154844.
[22] Polyakov, O., & Shcherbak, A. (2022). Sunflower productivity under the influence of mineral fertilizers and growth regulators. *Scientific & Technical Bulletin of the Institute of Oilseed Crops NAAS*, 33, 111-122. doi: 10.36710/IOC-2022-33-11.
[23] Reddy, K.V., Bara, B.M., & Lavanya, G.R. (2023) Effect of seed hardening on seed germination and morphological parameters in linseed (*Linum usitatissimum* L). *International Journal of Environment and Climate Change,* 13(10), 2874-2881. doi: 10.9734/ijecc/2023/v13i102953.
[24] Silveira, N.M., Ribeiro, R.V., Prataviera, P.J.C., Pissolato, M.D., Pieretti, J.C., Seabra, A.B., & Machado, E.C. (2020). Germination and initial growth of common bean plants under water deficit as affected by seed treatment with S-nitrosoglutathione and calcium chloride. *Theoretical and Experimental Plant Physiology,* 32, 49-62. doi: 10.1007/s40626-020-00166-x.
[25] Singh, A., Banerjee, A., & Roychoudhury, A. (2020). Seed priming with calcium compounds abrogate fluoride-induced oxidative stress by upregulating defence pathways in an indica rice variety. *Protoplasma,* 257, 767-782. doi: 10.1007/s00709-019-01460-5.
[26] Tanveer, K., Gilani, S., Hussain, Z., Ishaq, R., Adeel, M., & Ilyas, N. (2020) Effect of salt stress on tomato plant and the role of calcium. *Journal of Plant Nutrition,* 43, 28-35. doi: 10.1080/01904167.2019.1659324.
[27] Tsylyurik, O., & Ostapchuk, Ya. (2023). Growth regulators in sunflower crops of the Northern Steppe of Ukraine. *Agrarian Innovations,* 22, 108-117. doi: 10.32848/agrar.innov.2023.22.18.
[28] Vancostenoble, B., Blanchet, N., Langlade, N.B., & Bailly, C. (2022). Maternal drought stress induces abiotic stress tolerance to the progeny at the germination stage in sunflower. *Environmental and Experimental Botany*, 201, article number 104939. doi: 10.1016/j.envexpbot.2022.104939.
[29] Vasylenko, M., Ternovy, Yu., Shvidenko, I., & Dushko, P. (2020). Application of the biological stimulator of plant growth *"Ekosti"* in agricultural production. *Agroecological Journal*, 3, 96-101. doi: 10.33730/2077-4893.3.2020.211532.
[30] Yeremenko, O., & Onyshchenko, O. (2020). Dynamics of changes in biometric indicators of sunflower plants depending on basic tillage methods and growth regulator in the Southern steppe of Ukraine. *Bulletin of Poltava State Agrarian Academy*, 4, 93-103. doi: 10.31210/visnyk2020.04.11.

Посівні властивості насіння соняшнику гібриду *Talento* за дії модифікованого регулятору росту рослин

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Анотація. Удосконалення технологій вирощування сільськогосподарських культур дає змогу отримувати високі врожаї соняшнику з високими показниками якості. Одним з таких елементів є передпосівна обробка насіння. Метою досліджень було вивчення впливу регулятора росту рослин з додаванням кальцію на посівні властивості насіння соняшнику. Дослід проведений у лабораторних умовах. Для передпосівної обробки насіння використовували напівсинтетичний плівкоутворюючий препарат антистресової дії, який модифікували іонами Ca^{2+} у вигляді хлориду кальцію. Було встановлено, що інкрустація насіння соняшнику регулятором росту стимулює процеси проростання і активізує початкові етапи органогенезу соняшнику. При цьому збільшуються показники енергії проростання і схожості насіння, спостерігається збільшення довжини гіпокотилю і довжини кореня. Додавання кальцію до регулятору росту рослин сприяє додатковому збільшенню показників енергії проростання і схожості насіння соняшнику на 5,4 % і 7,7 %, порівняно з контролем. При цьому довжина гіпокотилю збільшується відносно контролю у 1,51 рази, а довжина коренів у 1,37 рази. Накопичення пластичних речовин у проростках соняшнику характеризує приріст сухої речовини. При додаванні кальцію до регулятора росту рослин спостерігається більш інтенсивне накопичення сухої речовини гіпокотилю і сухої речовини кореня, порівняно з контролем і варіантом досліду з використанням тільки регулятору росту. При побудуванні ранжируваного ряду встановлено, що за досліджуваними показниками для передпосівної обробки насіння соняшнику оптимальним варіантом досліду є варіант обробки регулятором росту рослин з вмістом іонів кальцію 1,0 г/л. Використання даного препарату є актуальним і перспективним для вивчення формування продуктивності рослин соняшнику з підвищеними показниками якості у польових умовах

Ключові слова: енергія проростання; схожість; кальцій; довжина проростків; суха речовина; ранжируваний ряд