

## Conference Paper

# The Efficiency of Pre-Sowing Seed Treatment with Trace Element Solutions

Tatiana Smirnova<sup>1</sup>, Irina Temereva<sup>2</sup>, Sergei Panov<sup>1</sup>, and Tatiana Stepanova<sup>2</sup>

<sup>1</sup>Siberian Cossack Institute of Technology and Management (branch) of the Federal State Budget Educational Institution of Higher Education "Moscow State University of Technology and Management named after K. G. Razumovsky (the First Cossack University)", 63 Pushkin street, Omsk, Russia

<sup>2</sup>Federal State Budgetary Educational Institution of Higher Education «Omsk State Agrarian University named after P. A. Stolypin», 1, Institutskaya Sq., Omsk, Russia

**ORCID:**Tatiana Smirnova: <http://orcid.org/0000-0002-1123-0472>**Abstract**

This article analyzes the results of four-year research which examined the effectiveness of pre-sowing treatment (soaking, spraying) of white cabbage seeds with trace element solutions of various concentrations. The research was conducted under laboratory conditions at the Agricultural Chemistry and Soil Science Department of Omsk State Agrarian University with a mid-season-ripening, medium-yielding and high-yielding variety of white cabbage (Sibiryachka 60) found in the Omsk region. 0.02%, 0.04% and 0.05% solutions of  $ZnSO_4 \cdot 7H_2O$  and 0.01%, 0.02%, 0.03% and 0.05% solutions of  $H_3BO_3$  were used in the experiment. The cabbage seeds were soaked in water (control) and in trace element solutions for 6-12-24 hours. The germination energy and germination capacity of the seeds, the zinc distribution, and the biometric indicators of the seedlings and of the cabbage transplant seedlings were determined. The optimal concentrations of the trace element solutions and the optimal duration of pre-sowing treatment were established, which stimulated the development of seedlings and increased seed germination by 5-9%. It was noted that, compared with the control, 2 times more plants reached the 6-leaf phase by the time of planting when transplant seedlings were treated with a boric acid solution in the optimal concentration, and 3.6 times more plants did when fertilized with zinc. Based on the results the following is recommended for implementation in production: soaking seeds in a 0.03% solution of  $H_3BO_3$ ; soaking seeds in a 0.04% solution of  $ZnSO_4$ ; soaking time - 6 hours; a 1:2 ratio of seeds to the solution; and concentration of solutions per element for boron – 0.005% and zinc – 0.01%.

**Keywords:** white cabbage, seeds, micro-fertilizers, pre-sowing treatment.

Corresponding Author:

Tatiana Smirnova

renpiorhin@yandex.ru

Published: 5 April 2021

Publishing services provided by  
Knowledge E

© Tatiana Smirnova et al. This article is distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use and redistribution provided that the original author and source are credited.

Selection and Peer-review under the responsibility of the DonAgro Conference Committee.

**OPEN ACCESS**

## 1. Introduction

Optimization of mineral nutrition of plants and gaining full-value yields is impossible without rational use of macro- and micro-elements [1–3]. Micro-elements such as boron

and zinc play an important role in the life cycle of plants. The correct course of many biochemical processes in plant organisms and, as a result, the formation of high and high-quality yields is impossible without them. The role of trace elements in the processes of fertilization and fruit formation is very important. The generative function of plants cannot be successfully implemented in the absence of boron and zinc in the nutrient medium: the course of physiological processes, the composition of plasma in seed cells, and the entering intensity of water and chemical elements change [4, 5].

Currently, there is a decrease in the varietal and sowing qualities of white cabbage seeds [6, 7], which excludes the possibility of gaining high-quality agricultural products. The labor intensity of vegetable seeds cultivation, their low and unstable productivity, and as a result, a great need for raw materials and a continuing shortage of high-quality seeds should be noted [8]. In this regard, measures aimed at increasing the yield of white cabbage and the quality indicators of its seedlings are relevant to eliminate the indicated problems. As a result, in the complex of measures aimed at improving the efficiency of white cabbage production, an important role should be assigned to agrotechnical measures for the use of boron and zinc-containing fertilizers.

One of the ways to use micro-nutrient fertilizers is the pre-sowing treatment of seeds by powdering, spraying, and soaking, which provides plants with the opportunity to obtain these elements at the very beginning of growth [9–11]. However, at present, there is a problem of increasing the seed quality due to their pre-sowing treatment, associated with the need to justify the choice of trace elements, their optimal doses and duration of treatment [12–14].

## 2. Methods and Equipment

The four-years research was conducted under laboratory conditions at the Agricultural Chemistry and Soil Science Department of Omsk State Agrarian University. For processing (soaking in solutions of trace elements, spraying), seeds obtained in field experiments without the use of fertilizers were used. In each variant, 100 pieces of seeds were processed in four-fold repetition, using glass dishes. Duration of seed soaking - 6-12-24 hours, solution concentrations:  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$  – 0.02, 0.04, 0.05%;  $\text{H}_3\text{BO}_3$  – 0.01, 0.02, 0.03, 0.05%. For seed spraying, a 0.05% solution of  $\text{H}_3\text{BO}_3$  was used at a consumption of 2 liters per centner. When processing seeds, the ratio of their weight to the solution was 1:2. Bidistilled water was used for the preparation of  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$  (c.p.) and  $\text{H}_3\text{BO}_3$ (c.p.) solutions and seed treatment at the control. The germination energy and germination rate were determined according to GOST 12038-84, the length of the root

and sprout of seedlings - according to the method of P. Wellington. The determination of zinc in seed husks and seedlings was carried out by atomic and absorption method in the Institute of Soil Science and Agrochemistry of Novosibirsk. Experimental data were processed by the dispersion method [15].

### 3. Results and Discussion

Soaking cabbage seeds in 0.02% boric acid solution for 24 and 12 hours did not affect their sowing qualities (table 1).

TABLE 1: Effect of phosphorus on the yield of potato tubers (t/ha)

Variant	24 hours		12 hours	
	Germination energy	Germination	Germination energy	Germination
Soaking				
H <sub>2</sub> O	87.0	90.5	93.0	96.0
0.02% solution H <sub>3</sub> BO <sub>3</sub>	87.6	93.0	92.4	95.0
0.05% solution of H <sub>3</sub> BO <sub>3</sub>	77.6	85.0	72.0	90.0
HCP <sub>05</sub>	4.0	4.2	4.4	3.8
Spraying				
H <sub>2</sub> O	87.7	93.3	–	–
0.05% solution of H <sub>3</sub> BO <sub>3</sub>	86.3	89.6	–	–
HCP <sub>05</sub>	3.3	3.9	–	–

The H<sub>3</sub>BO<sub>3</sub> solution with a 0.05% concentration of had a negative effect. Soaking seeds in this solution led to a decrease in germination energy by 9.0%, and germination – by 5.5% in comparison with the seeds of the control variant. Spraying seeds with 0.05% boric acid solution did not affect their germination energy and germination rate. Thus, it is advisable to consider soaking as a more effective variant for pre-sowing seed treatment, under the condition of using the trace elements solutions of optimal concentrations.

When analyzing biometric indicators of sprouts of cabbage seeds, it was found that the use of 0.02% H<sub>3</sub>BO<sub>3</sub> solution for soaking seeds during 12 hours leads to an increase in the root length of seedlings by an average of 1.0 cm (+31% to control), and the sprout length by 0.7 cm (+44% to control) (table 2).

Thus, the results of laboratory experiments indicate the need for a differentiated approach to the use of H<sub>3</sub>BO<sub>3</sub> solutions for pre-sowing treatment of cabbage seeds.

TABLE 2: Effect of soaking (12 h) on cabbage seed germination

Variant	Length, cm	
	sprout	root
H <sub>2</sub> O	1.6	3.2
0.02% solution H <sub>3</sub> BO <sub>3</sub>	2.3	4.2
0.05% solution of H <sub>3</sub> BO <sub>3</sub>	1.5	3.5
HCP <sub>05</sub>	0.2	0.2

On this basis, the studies also evaluated the effect on the germination energy and germination of 0.01–0.05% boric acid solutions when soaking cabbage seeds in them for 6 hours. A statistically confirmed positive result, consisting in an increase in seed germination rates, was observed when using 0.02, 0.03 and 0.05% boric acid solutions (table 3).

TABLE 3: germination and germination energy of cabbage seeds when soaked in H<sub>3</sub>BO<sub>3</sub> solutions for 6 hours, %

Variant	Germination energy	Germination
H <sub>2</sub> O	45.0	62.2
0.01% solution of H <sub>3</sub> BO <sub>3</sub>	43.3	60.0
0.02% solution H <sub>3</sub> BO <sub>3</sub>	51.7	68.3
0.03% solution of H <sub>3</sub> BO <sub>3</sub>	48.9	71.1
0.05% solution of H <sub>3</sub> BO <sub>3</sub>	52.8	66.7
HCP <sub>05</sub>	3.1	4.4

The positive result from the application of 0.02–0.05% H<sub>3</sub>BO<sub>3</sub> was noticeable already at the stage of determining the energy of seed germination (+4-8% to control) and remained until the determination of germination (+5-9% to control). Maximum seed germination was observed when 0.03% boric acid solution was used. Data on pre-sowing treatment of seeds for 12 hours with 0.02, 0.04 and 0.05% ZnSO<sub>4</sub> solutions are presented in table 4.

TABLE 4: Effect of soaking on germination and germination energy of cabbage seeds

Variant	Germination energy	Germination	Length, cm	
			sprout	root
	%			
H <sub>2</sub> O	93.0	96.0	1.6	3.2
0.02% solution of ZnSO <sub>4</sub>	76.0	93.0	1.8	0.6
0.04% solution of ZnSO <sub>4</sub>	72.0	92.0	1.8	0.6
0.05% solution of ZnSO <sub>4</sub>	72.0	92.0	2.2	0.6
HCP <sub>05</sub>	4.4	3.8	0.2	0.2

According to the results of the experiment, the use of  $ZnSO_4$  solutions of all the studied concentrations has a strong inhibitory effect on the development of the seed corcule in the initial period, which is expressed in a 17-21% decrease in seed germination energy compared to the seeds of the control variant. At the moment of determining seed germination, the negative impact of zinc-containing solutions was manifested in a significant reduction in the size of the seedlings root. The accumulation of zinc in seed husks and certain parts of seedlings at the highest concentration of the trace element solution used is of special interest (table 5).

TABLE 5: Effect of soaking on the zinc content in seed husks and seedlings, mg/kg of dry matter

Variant	Root	Embryonic stem	Leaves	Seed husks
H <sub>2</sub> O	9.2	15.6	4.2	3.7
0.05% solution of ZnSO <sub>4</sub>	30.4	34.8	12.7	10.5

When the time of interaction of seeds with  $ZnSO_4$  solutions is reduced to 6 hours, the toxicity of the trace element is not observed. In this case,  $ZnSO_4$  solutions with a concentration of 0.04–0.05% stimulate the development of seedlings, increasing seed germination by 5-7% from the initial one (table 6).

TABLE 6: Germination energy and seed germination when soaked in  $ZnSO_4$  solutions for 6 hours, %

Variant	Germination energy	Germination
H <sub>2</sub> O	45.0	62.2
0.02% solution of ZnSO <sub>4</sub>	47.8	66.1
0.04% solution of ZnSO <sub>4</sub>	46.1	69.5
0.05% solution of ZnSO <sub>4</sub>	50.0	66.7
HCP <sub>05</sub>	3.1	4.4

Cabbage seeds obtained by soaking in 0.03%  $H_3BO_3$  solution and 0.04%  $ZnSO_4$  solution for 6 hours, after air drying, were sown in the ground on the day of processing in order to obtain seedlings. Evaluation of the formed seedlings showed that plants from seeds enriched with trace elements in terms of analyzed indicators were superior to the plants from the control variant (table 7).

Under the influence of boron, the number of plants in the 6-leaf phase at the time of planting in the field exceeded the control indicator by 2, and under the influence of zinc – by 3.6 times. Active development of seedlings under the influence of trace elements should be considered as an indirect sign of an increase in the rate of biochemical reactions in plants. The number of plants from their total number with a weight of more than 10 g at the time of evaluating seedlings in variants with trace elements was 40-55% higher than the same indicator of the control variant (table 8).

TABLE 7: Effect of optimal concentrations of solutions for pre-sowing seed treatment on the growth of cabbage seedlings

Variant	Number of plants in % of the total number in the phase		
	4-leaf	5-leaf	6-leaf
H <sub>2</sub> O	30	55	15
0.04% solution of ZnSO <sub>4</sub>	5	40	55
0.03% solution of H <sub>3</sub> BO <sub>3</sub>	25	45	30

TABLE 8: Effect of seed soaking on the formation of aboveground mass of cabbage seedlings

Variant	Number of plants in % of the total number with a weight	
	more than 10 g	less than 10 g
H <sub>2</sub> O	25	75
0.04% solution of ZnSO <sub>4</sub>	80	20
0.03% solution of H <sub>3</sub> BO <sub>3</sub>	65	35

The positive effect of trace elements is also reflected in the results of the experiment presented in table 9.

TABLE 9: Average weight of the aboveground part of one cabbage seedling plant

Variant	Weight		V, %
	g	%	
H <sub>2</sub> O	8.3	100.0	15.0
0.04% solution of ZnSO <sub>4</sub>	14.4	173.0	17.0
0.03% solution of H <sub>3</sub> BO <sub>3</sub>	16.4	198.0	19.0
HCP <sub>05</sub>	4.5	–	–

Cabbage seedlings from seeds that underwent pre-sowing treatment were more stocky, strong, with a thick stem (4–5 mm) and a well-developed leaf surface. The aboveground weight of seedlings from seeds treated with solutions of zinc sulfate and boric acid is 1.7–2 times more than the weight of plants that was not treated with trace elements. The variation (V, %) of indicators was 15-19%.

## 4. Conclusion

Optimal concentrations of solutions of boron - and zinc-containing fertilizers that have a positive effect on the germination energy, germination of cabbage seeds, and biometric indicators of seedlings and transplant seedlings were established.

Based on the research results, we consider it possible to recommend it for production:

- soaking seeds in 0.03% solution of  $H_3BO_3$ ;
- soaking seeds in a 0.04% solution of  $ZnSO_4$ ;
- duration of soaking – 6 hours;
- the ratio of seeds to the solution is 1:2;
- the concentration of solutions per element for boron – 0.005%, zinc – 0.01%.

## Acknowledgement

The authors are grateful for technical support to the center for collective use of scientific equipment “Agricultural and Technological Research” of the Omsk State Agrarian University.

## Conflict of Interest

The authors have no conflicts of interest.

## References

- [1] Bobrenko, I. A., *et al.* (2017). Improving Competitiveness of the Wheat Production Within the Siberian Region. *Journal of Advanced Research in Law and Economics*, vol. 8, issue 24, pp. 426–436.
- [2] Temereva, I. V. and Smirnova, T. B. (2018). Peculiarities of Biosynthesis of Dry Substances by Various Potato Varieties on Meadow and Black Soil of Omsk Irtysk Region. *Bulletin of the Kazan State Agrarian University*, vol. 2, issue 49, pp. 48-51.
- [3] Temereva, I. V. and Smirnova, T. B. (2020). Reaction of Different Potato Varieties to Natural Fertility and Fertilizers During Cultivation on Meadow-Chernozem Soil. *Bulletin of Omsk State Agrarian University*, vol. 1, issue 37, pp. 83-89.
- [4] Anspok, P. I. (1990). *Microfertilizers*. Leningrad: Agropromizdat.
- [5] Aristarkhov, A. N. (2011). Models for Determining the Need for Micro-Fertilizers in Agriculture. *Fertility*, vol. 3, pp. 47-50.
- [6] Obukhova, G. S. (1998). Vegetable Growing in Russia: State and Prospects of Development. *Potato and Vegetables*, vol. 4, pp. 2–3.
- [7] Startseva, L. V. (2018). High Sowing Quality of Vegetable Seeds is the Basis of Import Substitution in the AIC of the RF. *Potato and Vegetables*, vol. 8, pp. 37–38.

- [8] Litvinov, S. S. and Ludilov, V. A. (2000). How to Get Vegetable Seed Production out of the Crisis. *Potato and Vegetables*, vol. 1, pp. 26–27.
- [9] Bobrenko, I. A., Vakalova, E. A. and Goman, N. V. (2013). The Effectiveness of Dusting Seed with Micro-Nutrients (Zn, Cu, Mn) in the Cultivation of Spring Wheat in Conditions of Forest-Steppe of Western Siberia. *Omsk Scientific Bulletin*, vol. 1, issue 118, pp. 166–170.
- [10] Boldysheva, E. P., Bobrenko, I. A. and Goman, N. V. (2015). The Efficiency of Processing of Seeds Copper, Zinc and Manganese at Cultivation of a Winter Rye on Meadow-Chernozem Soil in the Conditions of Western Siberia. *Omsk Scientific Bulletin*, vol. 1, issue 138, pp. 142–144.
- [11] Sklyarova, M. A. (2014). The Effectiveness of Various Methods of Applying Zinc for Corn in the Meadow-Chernozem Soil of the Omsk region. *Bulletin of Omsk State Agrarian University*, vol. 1, issue 13, pp. 28–31.
- [12] Goman, N. V., Popova, V. I. and Bobrenko, I. A. (2016). Efficiency of Micro-Fertilizers for Winter Wheat. *Bulletin of Kazan State Agrarian University*, vol. 1, issue 112, pp. 114-117.
- [13] Ermokhin, Y. I. and Shoikin, O. D. (2015). On Soil Fertility and Application of Mineral Fertilizers in the Omsk Region. *Omsk Scientific Bulletin*, vol. 1, issue 138, pp. 93–96.
- [14] Abeuov, S., *et al.* (2019). Diagnosis of Potatoes' Requirements for Nitrogen Fertilizers on Chestnut Soils of Northern Kazakhstan. *Advances in Social Science, Education and Humanities Research. The Fifth Technological Order: Prospects for the Development and Modernization of the Russian Agro-Industrial Sector*, vol. 393, pp. 455–458.
- [15] Dospekhov, B. A. (2011). *Methodology of Field Experience*. Moscow: Agropromizdat.