Research Article **Open Access**

Assessment of the impact of micro fertilizers on winter wheat and winter barley crops under the Sevan basin conditions

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Submission Date: January 19th, 2024**; Acceptance Date:** April 5th 2024**; Publication Date:** April 16th, 2024

Please cite this article as: Galstyan M., Matevosyan L., Zadayan M., Ghukasyan A., Harutyunyan S., Sargsyan K., Mkrtchyan A., Osipova R. Assessment of the impact of micro fertilizers on winter wheat and winter barley crops under the Sevan basin conditions. *Bioactive Compounds in Health and Disease* 2024; 7(4): 199-211.

DOI: https://doi.org/10.31989/bchd.v7i4.1292

ABSTRACT

Background: Microelements are crucial for numerous physiological and biochemical processes in plant life. They constitute parts of various vitamins and enzymes, stimulate respiration, and accelerate oxidation and regeneration reactions, positively impacting protein metabolism in plant organisms.

Objective: Considering the significant role of microelements in living organisms, our aim is to investigate the effectiveness of applying microfertilizers and biohumus on the growth, development, and quality of winter wheat and winter barley. We conducted field experiments and laboratory research to analyze the impact of trace element content in the soil at our experimental sites. This research holds particular significance amidst the ongoing global climate changes, emphasizing the urgency and relevance of our study.

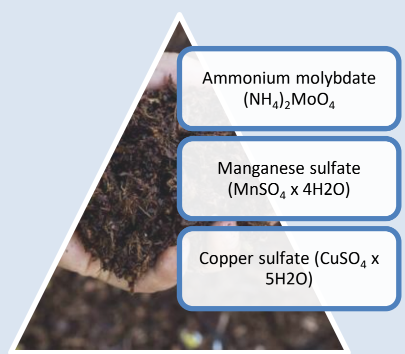
Methods: Field experiments, both in winter wheat and winter barley, were set up with three replications, with the same fertilization scheme. The size of each plot was 30 m^2, and the size of the experimental field in each crop area was 630 m^2 consisting of the following types: 1. Control (non-fertilized); 2. Background: biohummus t/ha; 3. Background+Mn ($MnSO_4$ $4H_2O$); 4. Background +Cu ($CuSO_4.$ $5H_2O$); 5. Background+B (Na_2 B_4O_7.10 H_2O); 6. Background + Mo $(HH_4)_2MoO_4$; 7. Background +Zn ($ZnSO_45H_2O$): Microfertilizers were used for pre-sowing seed treatment.

Results: The three-year results of the studies revealed that the amount of harvest and the quality indicators of these crops increased from the application of molybdenum, manganese, and copper in the sowing of autumn wheat and autumn barley on the background of biohumus. The increase of the autumn wheat crop under the influence of these elements was 3.3-6.4 c/ha (6.9-13.3%), and the increase of the autumn barley grain crop compared to the biohumus background was 2.6-5.4 c/ha. ha, or 6.5-13.4%. A certain increase in the nitrogen content of wheat and barley grains can be seen as an indicator of a protein problem necessary for life. According to research, it was found that the nitrogen content in the grains of spikelets is high in the versions that received molybdenum, manganese, and copper. Specifically, for wheat, the nitrogen content ranges from 2.64-2.68% for Mo, 2.53-2.57% for Cu, and for barley grains, it ranges from 2.16-2.24% for Mo, 2.08-2.10% for Cu, and 2.02-2.07% for Mn. Simultaneously with the studies, it was proved that the crop yield and quality indicators did not undergo significant changes from the application of Zn and B, which is explained by the higher content of the total and mobile forms of these elements in the soil.

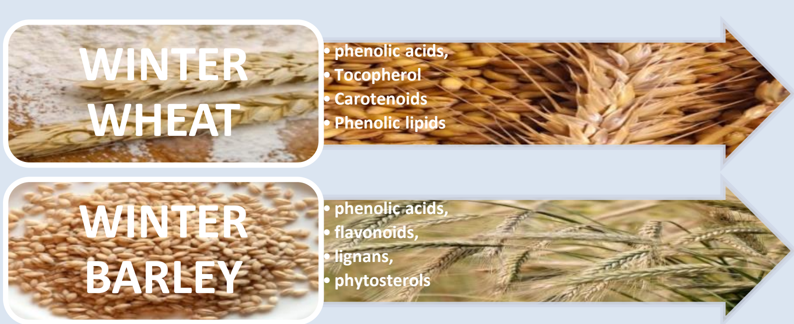
Conclusion: In the practice of fertilizing grain crops such as wheat and barley, it's essential to judiciously use specific micro fertilizers like molybdenum ammonium (NH_4MoO_4), manganese sulfate ($MnSO_4 \cdot 4H_2O$), or copper sulfate ($CuSO_4 \cdot 5H_2O$). These should be applied alongside organic fertilizers to ensure that the crops receive a comprehensive supply of both microelements and macroelements. This approach not only guarantees the production of high-quality crops but also plays a pivotal role in managing the protein content within them, which is crucial for nutritional value and overall crop health.

Keywords: microelements, winter wheat, winter barley, growth and development, yield quantity and quality

ORGANIC FERTILIZERS



The microfertilizers of applications promoted high yields and enhanced the quality characteristics of winter wheat and winter barley crops



INTRODUCTION

The proper organization of the agricultural crop mineral nutrition process, particularly for grain crops, should be focused on achieving a consistent and abundant harvest, enhancing product quality, preserving soil fertility through reproduction, and improving the environmental ecological state [1].

Interest in the sustainability of soil resources has been stimulated by increasing concerns that soil is one of the most critical components of the earth's biosphere, participating in food production and management maintenance of environmental quality [2].

Interest in nutrient absorption and accumulation is derived from the need to increase crop productivity through better nutrition and to improve the nutritional quality of plants as foods and feeds [3].

There are numerous statements stemming from the studies of local and international researchers about the fact that a wide range of mineral and organic fertilizers can positively impact both the quantity and quality of cereal crops, particularly those of intensive varieties. It has been proven that in plant mineral nutrition, apart from macronutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and others, micronutrients like boron (B), manganese (Mn), copper (Cu), zinc (Zn), molybdenum (Mo), and cobalt (Co) also play a significant role. Substances containing microelements are widely used in the cultivation of grains, grain legumes [4-7], and vegetables [8]. In this case, the seeds are treated before sowing or the vegetative plants are sprayed (foliar treatment). Although the latter are assimilated by plants in small amounts, they play a decisive role in the life of animal organisms. Academician V.I. Vernadsky, who laid the foundation for the study of the biological role of microelements at the beginning of the last century, noted that almost all the elements of D.N. Mendeleev's periodic system are necessary for the regular growth and development of humans, animals, and plants. Microelements are indispensable for all living organisms, even when present in minute quantities.

Microelements ensure many physiological and biochemical processes within the lifecycle of plants. These elements are integral components of various vitamins and enzymes. They facilitate respiration, expedite oxidation and regeneration reactions [9-11], and have a favorable impact on protein metabolism within plant organisms. Microelements also play a significant role in enhancing plant resistance to fungal and bacterial diseases. Furthermore, their presence also leads to increased resilience of plants to drought and frost [12,13].

Plants require an enormous number of organic and inorganic substances from outside sources called nutrition. Inorganic plant requirements are obtained directly or indirectly from the soil. The important trace elements necessary in very small quantities by plants for their survival are called micronutrients. These micronutrients are involved in various functions like cell protection, gene regulation, signal transduction, intracellular trafficking, as well as primary and secondary metabolite production. Deficiency of these micronutrients strongly affects the secondary metabolite production and also depends upon the plant species [14].

Fungal diseases are major threats to the most important crops upon which humanity depends. Were there to be a major epidemic that severely reduced yields, its effects would spread throughout the globalized food system [15]. Nutrients are known to influence all physiopathological processes. Recent evidence from molecular medicine and clinical trials has shown that proper nutritional interventions are the gold standard for promoting health span and delaying aging in various species, including yeast, *Drosophila*, rodents, primates, and humans. The development of precision nutrition therapeutics is crucial for slowing age-related biological processes and treating diverse diseases. However, nutritional benefits often vary among individuals, as well as different organs and tissues, presenting challenges in the field [16,17]. This review aims to summarize the various dietary interventions commonly recommended for health span enhancement and disease treatment in preclinical and clinical settings. Grain crops generally have modest requirements for microelements and adequate amounts in the soil are usually found. However, research spanning the last 40 years indicates that even these crops can suffer from fungal diseases if essential microelements like manganese, boron, and copper are deficient in the nutrient medium. This can lead to significant yield reductions and deterioration in crop quality. Consequently, studies aimed at addressing these issues are of great interest and are in line with strategies to enhance national food security [18-21]. The primary goal of this research is, for the first time:

a) to assess the efficacy of the use of micro fertilizers on the growth and yield of winter wheat and winter barley, in terms of the content of microelements in the soils of the experimental sites and climate conditions of the Sevan basin due to global climate changes, as compared to biohumus,

b) to identify through studies the qualitative changes occurring in the vegetative and generative organs of plants (grain, straw) under the influence of microelements,

c) to formulate actionable measures for the utilization of micro fertilizers in the farms situated within that specific region based on the findings of this research.

MATERIALS AND METHODS

The studies were carried out in 2019-2021 in the Tsovak community, Vardenis region, Gegharkunik province (farmer Hayk Spandar Grigoryan). The field experiments were carried out on limed black soils, typical of the region, which are primarily used for cultivating winter grain crops. These soils have a humus content ranging from 4.8% to 5.0% and exhibit a near-neutral environmental pH level within the range of 6.8 to 7.2. They are relatively low in available nitrogen, measuring 4.6 mg per 100 g of soil, moderately supplied with mobile phosphorus at 6.1 mg, and well-endowed with exchangeable potassium, with a level of 39 mg.

Field experiments, both in winter wheat and winter barley, were set up with three replications, with the same fertilization scheme. The size of each plot was 30 m^2, and the size of the experimental field in each crop area was 630 m^2 consisting of the following types:

1. Control (non-fertilized)
2. Background: biohummus t/ha
3. Background+Mn ($MnSO_4$ $4H_2O$)
4. Background +Cu ($CuSO_{4.}$ $5H_2O$)
5. Background+B (Na_2 B_40_7.10 H_2O)
6. Background + Mo $(HH_4)_2MoO_4$
7. Background +Zn ($ZnSO_45H_2O$)

In the field experiments, we used copper sulfate pentahydrate ($CuSO_4{\cdot}5H_2O$), zinc sulfate pentahydrate ($ZnSO_4{\cdot}5H_2O$), and manganese sulfate pentahydrate ($MnSO_4{\cdot}5H_2O$) as microfertilizers. These microfertilizers had active ingredient contents of 25.4%, 22.7%, and 22.8% respectively. We also employed borax ($Na_2B_4O_7{\cdot}10H_2O$) with 11% pure boron content and ammonium molybdate ($(NH_4)2MoO_4$) with a 50% active ingredient content. The microfertilizers were used for pre-sowing seed treatment, and the amounts were determined based on the active ingredients of each microelement. We treated the seeds with equivalent dosages of active ingredients, with the calculation based on the 11% active ingredient content of boron in Borax. This method allows the microelements to adhere to the seeds' outer surface in a thin layer and quickly penetrate them, facilitating easy assimilation by the plants and reducing the need for excessive microfertilizer usage. The soil background in the field experiments consisted of biohumus, which contained 2.0% nitrogen (N), 2.2%

phosphorus (P), and 1.7% potassium (K). This biohumus was incorporated into the soil during autumn sowing [22-24].

The sowing, subsequent cultivation, and harvesting of winter wheat (Bezostaya 1) and winter barley (Alashkert) were conducted by the established agricultural practices and guidelines in the region.

The agrochemical and agrophysical indicators of soil were determined by universal methods. The content of microelements in soil samples was determined with the help of Atomic Absorption Spectrophotometry (AAS). The crop yield of winter barley and winter wheat was determined at harvest using the overall crop count method. The yield data underwent mathematical analysis employing dispersion analysis, which included the determination of the experimental error (Sx,%) and the most significant difference (MSD 0.95, ts).

RESULTS AND DISCUSSION

The phenological observations conducted throughout the vegetation period showed that microelements did not exert a notable influence on the germination of winter wheat and winter barley. Germination rates remained consistent across all fertilized and unfertilized variants, with no discernible differences observed over the course of three years. Nonetheless, following germination, the growth of plants exhibited disparities. Research findings revealed that winter wheat and barley plants reached the tuber stage with a notably darker green hue and exhibited more vigorous growth, particularly in plots enriched with copper, molybdenum, and manganese, compared to the background type. According to the results of biometric measurements, the plants stood out for their height and lushness. In the field experiments with winter wheat, at the same growth stage, the average plant height in the control plot measured 48.4 cm, while in the background plot, it was 56.4 cm. However, in the copper, manganese, and molybdenum-treated plots, the plant height notably increased to 58.2, 58.0, and 61.0 cm. It is interesting to note that the plants in the zinc-treated plot had similar heights to those in the background plot, ranging from 56.2 to 56.6 cm. We observed similar trends in the impact of microelements in the winter barley experiments. On average, the plant height in the background plot was 2.5 to 6 cm lower compared to the plots treated with manganese, copper, and molybdenum. What's noteworthy is that molybdenum resulted in the highest growth and development of both grain crops in all the plots. This is because the microelement Mo was introduced through ammonium molybdate ($(NH_4)_2MoO_4$), and the NH4+ ion released from it acted as a nitrogen nutrition, contributing to plant growth and development. As a result, this nitrogen contribution led to increased crop yields, both in terms of grain and straw, which wasn't observed with other microelement compounds used. Additionally, there seems to be a significant difference in the soil microelement content data. The combined levels of manganese, copper, and molybdenum fall considerably below the Clarke values for these elements. Conversely, the levels of boron and zinc surpass the Clarke values, as depicted in Table 1.

Therefore, these microelements, boron and zinc, did not have a significant effect on plant growth and development. As can be see from the data in the table on the agrochemical indicators of microelements (Table 1), the total content of manganese in the topsoil ranges from 690-780 mg/kg and is lower than clarke by 70-160 mg/kg, copper is 10 – 13 against the Clarke of 20 mg/kg, the total content of molybdenum in the topsoil is 1.3 mg/kg against the Clarke of 3mg/kg, whereas the zinc content ranges from 48-52mg/kg, which is equal to or 2mg/kg is higher than the Clarke value for that element (50mg/kg), and the total amount of boron is 9.8-10.3mg/kg against the Clarke of 10. In simpler terms, when the microelement content in the soil falls below the specified clarke level for that element, micro fertilizers containing that microelement, like copper, manganese, and ammonium molybdate, had a substantial positive impact on the growth and development of winter wheat and winter barley. However, when it comes to zinc and boron, which were already present in the topsoil at levels equal to or higher than the Clark standards, micro fertilizers containing these elements, such as zinc sulfate and borax, had minimal to no effect on the growth and development of the tested crops. The alterations observed in the yield (both grain and straw) and the chemical composition of the grains following the pre-sowing treatment of winter wheat and winter barley seeds with micro fertilizers can be attributed to these conditions.

The data from the annual field trials of winter wheat and winter barley highlight a steady influence of microfertilizers on the yields of both grain and straw, as shown in Tables 2 and 3. The three-year winter wheat experiments, detailed in Table 2, reveal that using copper, manganese, and molybdenum along with a biohumus background significantly boosted the yields of both grain and straw. On the flip side, zinc (Zn) and boron (B) had very little influence on crop yield. So, if the background plot of winter wheat produced 48.0 dt/ha, the addition of copper, manganese, and molybdenum resulted in grain yield increases of 3.3 dt/ha (6.9%), 3.8 dt/ha (7.9%), and 6.4 dt/ha (13.3%), respectively, compared to the background plot. However, zinc only led to a minimal increase of 0.2 dt/ha (0.4%), and boron (B) didn't have any noticeable effect, yielding 0 dt/ha. It is noteworthy that a similar effect of microelements was also observed in winter barley crops (Table 3). In the context of a biohumus background where the average barley yield stood at 40.2 dt/ha over three years, the introduction of copper, manganese, and molybdenum led to significant increases in grain yield, specifically by 6.5% (2.6 dt/ha), 8.0% (3.2 dt/ha), and 13.4% (5.4 dt/ha), respectively. Conversely, under the influence of zinc and boron, the yield either remained unchanged (with a decrease of 0.4 dt in the case of zinc) or saw a slight increase of 0.2 dt in the case of boron. The impacts of zinc (Zn) and boron (B) in both winter wheat and winter barley fields were essentially negligible and fell within the margin of experimental error.

To identify alterations in the chemical composition of winter wheat and winter barley plants attributed to the application of micronutrients, laboratory analyses were conducted on plant samples (grain and straw) in both 2019 and 2020. The results of these analyses, categorized by year and crop, are presented in Tables No. 4 and No. 5. The data in the tables reveal that, in comparison to the background plot, the impact of micronutrients on the overall quantity of grain and straw ash of wheat and barley did not lead to notable alterations. However, there were significant variations in the levels of phosphorus and potassium therein. The content of phosphorus and potassium is especially high in the grain yield of molybdenum and manganese treated plots, which is related to the rapid transformation of mineral phosphorus into organic in plants under the influence of these elements and accumulation in reproductive organs (grains). Hence, while the phosphorus content in the wheat grain from the plots receiving the mentioned elements falls within the range of 0.58-0.62%, it is notably lower at 0.45-0.48% in the background plots [25,26].

A comparable contrast is evident in the case of winter barley grains. While the phosphorus content in the background plots ranged from 0.39-0.44%, it notably increased to 0.50-0.53% and 0.57-0.59% in the plots receiving manganese and molybdenum, respectively.

Table 1. Agrochemical Indicators in Soils at the Experimental Sites

Soil type, experimental site and crop	Soil sampling depth, cm	Hummus %	Physical Clay %	Microelements concentration, mg/kg									
				B		Mn		Zn		Cu		Mo	
				clarke	concentration	clarke	concentration	clarke	concentration	clarke	concentration	clarke	concentration
Black soil, Tsovak, winter wheat	0-22	4,8	38,8	10	9,8	850	690	50	48	20	15	3	1,3
Black soil, Tsovak, winter barley	0,22	5,0	39,0	10	10,3	850	780	50	52	20	13	3	1,3

Table 2. Impact of Pre-Sowing Treatment of Winter Wheat Seeds with Microfertilizers on Yield, categorized by years

Types of plots	2019				2020				2021				Mean of three years			
	Yield, dt/ha		Grain crop supplement		Yield, dt/ha		Grain crop supplement		Yield, dt/ha		Grain crop supplement		Yield, dt/ha		Grain crop supplement	
	grain	straw	dt/ha	%	grain	straw	dt/ha	%	grain	straw	dt/ha	%	grain	straw	dt/ha	%
Control	24,8	50,0	-	-	28,4	53,2	-	-	26,6	51,0	-	-	26,6	51,4	-	-
Background: Biohumus 5 t/ha	49,2	92,8	-	-	47,8	93,0	-	-	47,0	96,2	-	-	48,0	94,0	-	-
Background+Zn	49,0	96,8	-0,2	-0,4	47,6	94,0	-0,2	0,4	47,4	93,6	0,4	0,8	48,2	94,8	0,2	0,4
Background +Cu	52,2	102,0	3,0	6,1	50,2	98,0	2,4	5,0	51,5	100,0	4,5	9,6	51,3	100,0	3,3	6,9
Background +Mn	52,4	103,0	3,2	6,5	51,0	100,0	3,2	6,7	52,0	100,0	5,0	10,6	51,8	101,0	3,8	7,9
Background +B	48,0	94,5	-1,2	-2,4	47,4	94,0	-0,4	-0,8	48,6	99,5	1,6	3,4	48,0	96,0	0,0	0,0
Background +Mo	54,6	107,0	5,4	11,0	53,8	105,0	6,0	12,6	54,8	118,0	7,8	16,6	54,4	110,0	6,4	13,3
Sx, %	1,4				1,0			1,5								
MSD $_{0,95,\ dt}$	1,3				0,9			1,6								

Table 3. Impact of Pre-Sowing Treatment of Winter Barley Seeds with Microfertilizers on Yield, categorized by years

Versions	2019				2020				2021				Mean of three years			
	Yield, dt/ha		Grain crop supplement		Yield, dt/ha		Grain crop supplement		Yield, dt/ha		Grain crop supplement		Yield, dt/ha		Grain crop supplement	
	grain	straw	dt/ha	%	grain	straw	dt/ha	%	grain	straw	dt/ha	%	grain	straw	dt/ha	%
Control	22,8	39,0	-	-	23,9	40,6	-	-	26,2	42,8	-	-	24,3	40,8	-	-
Background: biohumus 5 t/ha	38,6	77,0	-	-	39,6	80,0	-	-	42,4	87,2	-	-	40,2	81,4	-	-
Background+Zn	38,8	76,8	0,2	0,5	39,6	79,6	0,0	0,0	41,0	80,0	-1,4	-3,3	39,8	78,8	-0,4	-
Background +Cu	41,0	82,0	2,4	6,2	42,6	85,0	3,0	7,6	44,8	91,0	2,4	5,7	42,8	86,0	2,6	6,5
Background +Mn	42,0	85,6	3,4	8,7	44,0	88,8	4,4	11,1	43,6	92,0	1,2	2,8	43,4	88,8	3,2	8,0
Background +B	39,0	76,6	0,4	1,0	40,0	79,0	0,4	1,0	42,2	86,2	-0,2	-0,5	40,4	80,6	0,2	0,5
Background +Mo	44,2	89,2	5,6	14,5	45,0	92,0	5,4	13,6	47,6	93,0	5,2	12,3	45,6	91,4	5,4	13,4
Sx, %	0,8				1,2				1,3							
MSD $_{0,95, dt}$	1,0				1,2				0,9							

Table 4. Impact of Microelements on Certain Parameters of the Chemical Composition of Winter Grain Yield, %

Types of plots	2019								2020							
	grain				straw				grain					straw		
	ash	N	P_2O_5	K_2O	ash	N	P_2O_5	K2O	ash	N	P_2O_5	K_2O	ash	N	P_2O_5	K_2O
Control	2,00	1,73	0,31	0,29	5,3	0,24	0,20	1,00	1,82	1,72	0,29	0,36	5,3	0,28	0,22	1,2
Background: biohumus 5 t/ha	2,95	2,45	0,48	0,64	6,9	0,56	0,28	1,40	2,89	2,40	0,45	0,60	7,3	0,62	0,30	1,35
Background+Zn	2,98	2,43	0,51	0,63	7,0	0,57	0,28	1,39	2,92	2,41	0,46	0,58	7,4	0,62	0,30	1,40
Background +Cu	3,04	2,57	0,57	0,65	7,2	0,59	0,27	1,42	2,96	2,53	0,48	0,61	7,4	0,64	0,29	1,42
Background +Mn	3,09	2,64	0,60	0,65	7,2	0,60	0,30	1,43	2,95	2,62	0,58	0,63	7,6	0,66	0,30	1,42
Background +B	2,97	2,44	0,51	0,63	6,8	0,56	0,23	1,38	2,89	2,40	0,44	0,60	7,2	0,62	0,28	1,33
Background +Mo	3,20	2,68	0,62	0,70	7,3	0,62	0,29	1,45	2,99	2,64	0,59	0,68	7,5	0,64	0,34	1,46

Table 5. Impact of Microelements on Certain Parameters of the Chemical Composition of Winter Barley Yield, %

Types of plots	2019								2020							
	Grain				Straw				Grain				Straw			
	ash	N	P_2O_5	K_2O	ash	N	P_2O_5	K_2O	ash	N	P_2O_5	K_2O	ash	N	P2O5	K_2O
Control	1,85	1,49	0,29	0,27	4,8	0,18	0,16	1,20	1,73	1,42	0,27	0,32	5,0	0,23	0,19	1,0
Background: biohumus 5 t/ha	2,16	2,15	0,399	0,41	5,7	0,39	0,24	1,42	2,0	1,95	0,44	0,50	6,1	0,49	0,26	1,29
Background+Zn	2,16	2,16	0,38	0,42	5,7	0,40	0,23	1,39	2,0	1,90	0,44	0,50	6,0	0,49	0,25	1,20
Background +Cu	2,18	2,17	0,43	0,57	6,0	0,44	0,26	1,42	2,1	2,0	0,49	0,59	6,2	0,52	0,27	1,32
Background +Mn	2,18	2,20	0,50	0,59	6,2	0,45	0,26	1,43	2,1	2,1	0,57	0,60	6,2	0,53	0,27	1,31
Background +B	2,17	2,16	0,39	0,42	5,5	0,38	0,23	1,39	2,0	1,95	0,45	0,51	6,0	0,50	0,24	1,22
Background +Mo	2,23	2,23	0,53	0,64	6,4	0,50	0,27	1,44	2,2	2,2	0,59	0,65	6,8	0,57	0,30	1,34

The potassium content in both the grains and straw of both crops in the field experiments is significantly higher in the plots treated with copper (Cu), manganese (Mn), and molybdenum (Mo) compared to the background plots. Conversely, the presence of boron (B) and zinc (Zn) elements either resulted in equal or decreased levels of potassium (K). Overall, nitrogen plays a pivotal role in determining the quality parameters of the crop. An observable increase in its presence in grains can be viewed as a positive indicator for addressing the essential protein requirements necessary for sustaining life [27-29]. Our research has revealed that the nitrogen content in both grains and straw of grain crops is elevated in versions where molybdenum (Mo), manganese (Mn), and copper (Cu) were applied. Specifically, for wheat, the nitrogen content ranges from 2.64-2.68% for Mo, 2.53-2.57% for Cu, and for barley grains, it ranges from 2.16-2.24% for Mo, 2.08-2.10% for Cu, and 2.02-2.07% for Mn. In the background plots for winter wheat, the nitrogen content ranged from 2.40-2.45%, while for winter barley background plots, it was within the range of 1.94-1.98%.

CONCLUSION

After analyzing the results from our three-year field experiments on microfertilization of grain crops and the chemical composition of the resulting grain and straw, we've arrived at several pivotal conclusions: The application of molybdenum, manganese, and copper to winter wheat and winter barley on a biohumus background resulted in elevated crop yields. As per the experimental data, in the plots where these elements were applied, there was an increase in the yield of autumn wheat grain by 3.3-6.4 dt/ha (6.9-13.3%) and an increase in the autumn barley grain crop by 2.6-5.4 dt/ha (6.5-13.4%).

The application of zinc (Zn) and boron (B) did not result in an increase in the yield of the examined cereal crops. This is primarily attributed to the levels of total and mobile forms of these elements in the soils at the experimental sites. Based on the chemical composition data of winter wheat and winter barley crops (grain and straw), it can be observed that in comparison to the biohumus background, the application of molybdenum, manganese, and copper led to an increase in the content of nitrogen, phosphorus, and potassium in the crops. Conversely, zinc (Zn) and boron (B) did not exert a significant influence on these elements' content.

When fertilizing cereal crops grown in the Sevan basin, it is advisable to utilize on top of organic fertilizers only such micro fertilizers as ammonium molybdate [$(NH_4)2MoO_4$], manganese sulfate ($MnSO_4$ x 4H2O), or copper sulfate ($CuSO_4$ x 5H2O). The application of these substances will not only promote high yields but also enhance the quality characteristics of winter wheat and winter barley crops.

List of abbreviations: zinc (Zn) and boron (B), nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and others, micronutrients like boron (B), manganese (Mn), copper (Cu), zinc (Zn), molybdenum (Mo), and cobalt (Co).

Competing interests: The authors declare that they have no competing interests.

Authors' contributions: MG and SH discussed the idea of the article and compiled the content. MG and LM studied many literary sources. AG, RO, and AM performed analyses. KS, LM, and MZ made calculations and compiled tables. MZ edited the article. All authors read and approved the final version of the manuscript.

Competing Interests: There are no conflicts of interest to declare.

Acknowledgments and funding: We are thankful to the administration of the Center for Agricultural Research and Certification” SNCO for supporting our research.

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