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FORMATION OF YIELD AND SOWING QUALITIES OF WINTER WHEAT SEEDS UNDER THE INFLUENCE OF MICROFERTILIZERS IN THE SOIL AND CLIMATIC CONDITIONS OF THE FOREST-STEPPE OF WESTERN UKRAINE

Ihor VOLOSCHUK, Olexandra VOLOSCHUK, Valentyna HLYVA, Andriy MARUKHNYAK
Institute of Agriculture of Carpathian Region of National Academy of Agrarian Sciences of Ukraine, Lviv, Ukraine

Abstract. The present study investigated the effect of chelated forms of microfertilizers applied in the tillering-shooting phase on the background of mineral nutrition ($N_{90}P_{90}K_{90}$) with the phased application of nitrogen in stages IV and VII of organogenesis on the seed productivity and the sowing qualities of seeds of the winter wheat variety Benefis. The studies were conducted according to the generally accepted methods. The processing and synthesis of research results were performed using Microsoft Excel. The obtained data were processed by the method of dispersive and correlation analysis. The experimental results confirm that the use of chelated forms of microfertilizers contributes to winter wheat seed productivity. Grain yield increases by 0.12 -0.34 t/ha, the yield of conditioned seeds – by 2-6%, seed yield increases by 0.20-0.71 t/ha, the coefficient of seed reproduction – by 0.8-2.9 units, the mass of 1000 seeds – by 0.3-1.8 g. The optimal level of plant nutrition at the expense of better assimilation of trace elements has a positive effect on the formation of sowing qualities of winter wheat, increasing the mass of 1000 seeds by 0.6-2.8 g, seed germination energy – by 1.8-6.3%, laboratory germination – by 0.8-3 0%. The highest efficiency was obtained with the application of the complex microfertilizers Orakul copper chelate (1-2 l/ha), Orakul biocobalt (0.15-0.20 l/ha) and Orakul multicomplex (1-2 l/ha).

Key words: Winter wheat; Microfertilizers; Crop yield; Sowing qualities; Seeds.

INTRODUCTION

One of the components of crop cultivation is the optimization of nutritional conditions. In the cost structure, the essential element is mineral fertilizers, which make up a significant proportion (up to 50%) and on which the relationship of all the others is built. However, in order to ensure an optimal level, apart from macroelements, microelements are also necessary, which are of very important and unchanging value in the fertilizer system (Vernadsky, V.I. 2003; Honchar, L.M. 2006; Borysyuk, B.V. 2008; Kononchuk, N.P. 1986; Tkachuk, K.S. 2005b; Stakhiv, M.P. 2006; Marchuk, I.U. 2012).

For the plant organism, trace elements are divided into necessary (Co, Fe, Cu, Zn, Mn, I, F, Br) and conditionally necessary (Al, Sr, Mo, Se, Ni), the value and localization in the organs of some elements are unknown (Sc, Zr, Nb, Au, La, etc.) **(**Mineev, V.H. 2004**).**

Without trace elements full assimilation of the basic fertilizers (nitrogen, phosphorus and potassium) by plants is not possible, and the peculiarities of their action in physical and biological processes manifest them as biological activators. Despite their very low content in the plant, they play an important role in redox reactions, that is the basis for necessary plant organism processes like respiration and photosynthesis. They are part of the main physiologically active substances, they increase the enzymatic activity of plants, improve the absorption of nutrients. Under their influence, plants become more resistant to adverse environmental conditions, as well as to the diseases and pests (Tkachuk, K.S. 2005a; Demishev, L.F. 2011; Baidenko, I.L. 2012; Zherdetsky, I.M. 2009).

Microfertilizers are necessary components of the integrated use of chemicals - the material basis for the quantity and quality of crop products. A scientifically based system for their use allows us to solve several critical agricultural tasks: ensuring the reproduction of soil fertility, obtaining high-quality products, increasing the profitability of crop production, etc. However, this productivity factor is far from fully involved, since the lack of one of the microelements in plant nutrition is responsible for the formation of low yields and product quality (Hospodarenko, H.M. 2009; Bulygin, S.Yu. 2007; Buryak, Yu.I. 2015).

Most soils have a high absorption capacity of trace elements, so applying them in the form of pure salts is impractical. Such microfertilizers are poorly soluble and are useful only on soils with an acidic and slightly acidic reaction of the soil solution. In neutral and weakly alkaline soils, inorganic salts are converted into slightly soluble and hardly accessible compounds (hydroxides, carbonates) that are not available for plants (Hospodarenko, H.M. 2015; Fateev, A.I. 2013).

Winter wheat takes with the harvest a significant amount of nutrients from the soil, so for the formation of 1 ton of grain it is necessary: 28-37 kg of nitrogen, 11-13 kg of phosphorus, 20-27 kg of potassium, 5 kg of calcium, 4 kg of magnesium, 3.5 kg of sulfur and 5 g of boron, 8.5 g of copper, 270 g of iron, 82 g of manganese, 60 g of zinc, 0.7 g of molybdenum (Voloshchuk, I.S. 2017).

MATERIALS AND METHODS

The studies were carried out in the Laboratory Seed Production of the Institute of Agriculture of Carpathian Region of NAAS (National Academy of Agricultural Sciences) during 2015-2017.

The plough layer on the experimental plots was characterized by the following agrochemical parameters: humus content (by Tyurin) - 1.9%, salt extract pH (potentiometric method) - 4.8, hydrolytic acidity (by Kappen-Hilkovits) - 2.93 mg eq. / 100 g of soil, the content of mobile phosphorus and potassium (by Kirsanov) - 98 and 86 mg per 1 kg of soil, easily hydrolyzed nitrogen (by Cornfield) - 88 mg per 1 kg of soil.

Weather conditions in the years of research had specific characteristics. Summer, except for June, and autumn 2015 were wet. The winter period was warm; in February the air temperature was 0.9 ° C with a norm of 4.3 ° C. The temperature regime of the spring months was within the average long-term data, and the summer was very hot. The average annual rainfall was 87% of the norm, in May they exceeded it by 145%, September - 144%, November - 186%. The year 2016 was marked by a high temperature regime of on 1.79 ° C and less rainfall (55.7% of the average long-term indicator). September weather conditions were characterized by increased temperature conditions and sufficient moisture, which contributed to the intensive growth and development of plants. Autumn was cold and very wet. In October, the air temperature was lower by 1.2 ° C with precipitation amounts of 259.3%, and in November by 0.2 ° C, precipitation - 174.4%. The temperature regime of the winter months of 2017 was within the average long-term data with slightly lower precipitation in January. The transition through 5 ° C took place in the first ten days of March with a slight decrease to 3.2 ° C in the second at the norm (0.1 ° C), which contributed to the restoration of the spring vegetation of winter grains. Higher temperature conditions with less precipitation (68.4% of the average long-term data) were observed in April. June, July and August were warm and dry.

The area of the experimental plot was 56 m^2, the accounting one - 50 m^2. Placement variants were systematic, repetition - 3-fold. The seeding rate of winter wheat seeds - 5.5 million viable seeds / ha.

Sowing qualities of seed varieties corresponded to DSTU 4138-2002 (State Standard of Ukraine) (Crop … 2003).

The studies were conducted according to generally accepted methods. Processing and synthesis of research results were performed using Microsoft Excel. The obtained data were processed by the method of dispersive and correlation analysis (Dospekhov, B.A. 1985).

Composition of microfertilizers: Orakul copper chelate (Cu - 100 g / l, N - 89 g / l, SO_3 - 126 g / l, calamine - 200 g / l), the application rate is 1-2 l / ha; Orakul biocobalt (Co - 50 g / l, SO_3 - 67, N - 24 amino acids - 130 g / l) the application rate of 0.15-0.20 l / ha; Orakul biozinc (Zn - 120 g / l, N - 52, SO_3 - 73, amino acids - 281 g / l) application rate 0.5-1.0 l / ha; Orakul biomanganese (Mn - 50 g / l, SO_3 - 75, N - 30 amino acids - 139 g / l) application rate of 2-3 l / ha; Orakul multicomplex (N – 184 g / l, P_2O_5 - 66, K_2O - 44, SO_3 - 36, Fe - 6, Cu - 8, Zn - 8, B - 6, Mn - 6, Co - 0.05, Mo - 0.12 g / l) application rate 1-2 l / ha.

RESULTS AND DISCUSSIONS

Weather conditions for the period of seed formation 2015-2017 were favorable for the obtaining of biologically valuable seeds (Table 1). With the sum of active temperatures in the 1st decade of June - July II it was 521 ° C in 2015, this indicator was higher by 15 ° C, in 2016 - by 53 ° C, and in 2017 - by 38 ° C. For the average long-term rainfall (98 mm) for this period, during all years the sum of precipitation was lower by 17 mm in 2015, 16 mm in 2016 and 41 mm in 2017.

Table 1. *The sum of effective temperatures (° C) and the amount of precipitation (mm) for the period of seed ripening (2015-2017)*

Year	Air temperature in decades, ° C			Sum of effective temperatures, ° C	Precipitation, mm			Amount of precipitation, mm
	III June	I July	II July		III June	I July	II July	
2015	16.1	18.3	19.2	536	14.9	9.0	56.7	81
2016	18.6	20.6	18.2	574	19.8	14.1	47.7	82
2017	20.4	16.9	18.6	559	10.4	32.4	13.7	57
Average long-term indicators	17.2	16.7	18.2	521	33.0	32.0	33.0	98

Studying the effectiveness of the chelated forms of microelements in the winter wheat nutrition system, we found that, depending on the composition of the microfertilizer, the presence of these microelements in the soil, their digestibility by plants and weather factors, their influence was different.

From the data table 2 shows a significant increase in grain yield under the influence of foliar application of microelements, which in 2015 for SSD_{05} 0.03 (Smallest significant difference) ranged from 0.16 t / ha (Orakul Biozinc) to 0.21 t / ha (Orakul multicomplex). The best weather conditions in 2016 contributed to the formation of high grain yield of winter wheat of the Benefis variety compared with the previous year by 0.32 t / ha. The effectiveness of the used trace elements compared with the control (without treatment) was also higher by 0.12-0.44 t / ha (SSD_{05} 0.06). In 2017, this indicator ranged from 7.29 t / ha at the control (without foliar plant nutrition) to 7.67 t / ha (Orakul multicomplex), the difference between the variants was 0.10-0.38 t / ha (SSD_{05} 0.08).

Table 2. *The effect of foliar application of micronutrients on grain yield of winter wheat of the Benefis variety (2015-2017), t / ha*

Experience variant	Application rate, l / ha	Year						Average	
		2015		2016		2017			
		t / ha	± to control	t / ha	± to control	t / ha	± to control	t / ha	± to control
Control (without crop treatment)	water 400	7.05	-	7.32	-	7.29	-	7.22	-
Orakul copper chelate	1-2	7,22	0,17	7,68	0,36	7,54	0,25	7,42	0,26
Orakul biocobalt	0.15-0.20	7.23	0.18	7.52	0.20	7.39	0.10	7.38	0.16
Orakul biozinc	0.5-1.0	7.21	0.16	7.44	0.12	7.37	0.08	7.34	0.12
Orakul biomanganese	2-3	7.22	0.17	7.56	0.24	7.42	0.13	7.40	0.18
Orakul multicomplex	1-2	7.43	0.21	7.76	0.44	7.67	0.38	7.40	0.34
Average		7.23		7.55		7.45			
SSD_{05}		0.03		0.06		0.08			

Note. The phase of the microfertilizers application: tillering - shooting.

Compared with the control, for three years of research, a reliable increase in grain yield was obtained using all the studied microelements. The highest yield was from the use of Orakul copper chelate - 0.26 t / ha and Orakul multicomplex - 0.34 t / ha. The increase in yield from the use of Orakul biocobalt and Orakul biozinc was within the limits of error and a reliable 0.06 t / ha between the microfertilizers Orakul biozinc and Orakul biocobalt (SSD_{05} 0.04).

Microfertilizers applied in foliar feeding of plants against the background of mineral nutrition positively influenced the yield of conditioned seeds (Table 3). If on the control, this indicator was 70%, then with the use of microfertilizers it increased by 2-6% (SSD_{05} 4.46). The highest yield of conditioned seeds was with the use of microfertilizers Orakul multicomplex - 75%.

Table 3. *The effect of foliar application of trace elements on the yield of conditioned seeds of winter wheat Benefis variety (2015-2017), %*

Experience variant	Application rate, l / ha	Year						Average	
		2015		2016		2017			
		%	± to control	%	± to control	%	± to control	%	± to control
Control (without crop treatment)	water 400	70	-	71	-	70	-	70	-
Orakul copper chelate	1-2	74	4	76	5	75	5	75	5
Orakul biocobalt	0.15-0.20	71	1	74	3	73	3	73	3
Orakul biozinc	0.5-1.0	71	1	73	2	72	2	72	2
Orakul biomanganese	2-3	73	3	75	4	74	4	74	4
Orakul multicomplex	1-2	75	5	77	6	76	6	76	6
Average		73		74		73		73	
SSD_{05}		1.0		1.5		1.0			

Note. The phase of the microfertilizers application: tillering - shooting.

The yield of seeds on the experiment variants ranged from 5.08 to 5.79 t / ha with SSD_{05} of 0.08-0.10 depending on the yield of conditioned seeds (fig.).

Compared to the control (without crop treatment), the microfertilizer Orakul copper chelate contributed to a greater increase in seed yield by 0.52 t / ha, due to less damage to plants by diseases.

As to the use of the microfertilizer Orakul biocobalt, the seed yield was higher by 0.28 t / ha, and as to the use of the Orakul biozinc by 0.20 t / ha, the Orakul biocobalt by 0.40 t / ha. The highest yield increase was ensured by microfertilizer Orakul multicomplex - 0.71 t / ha.

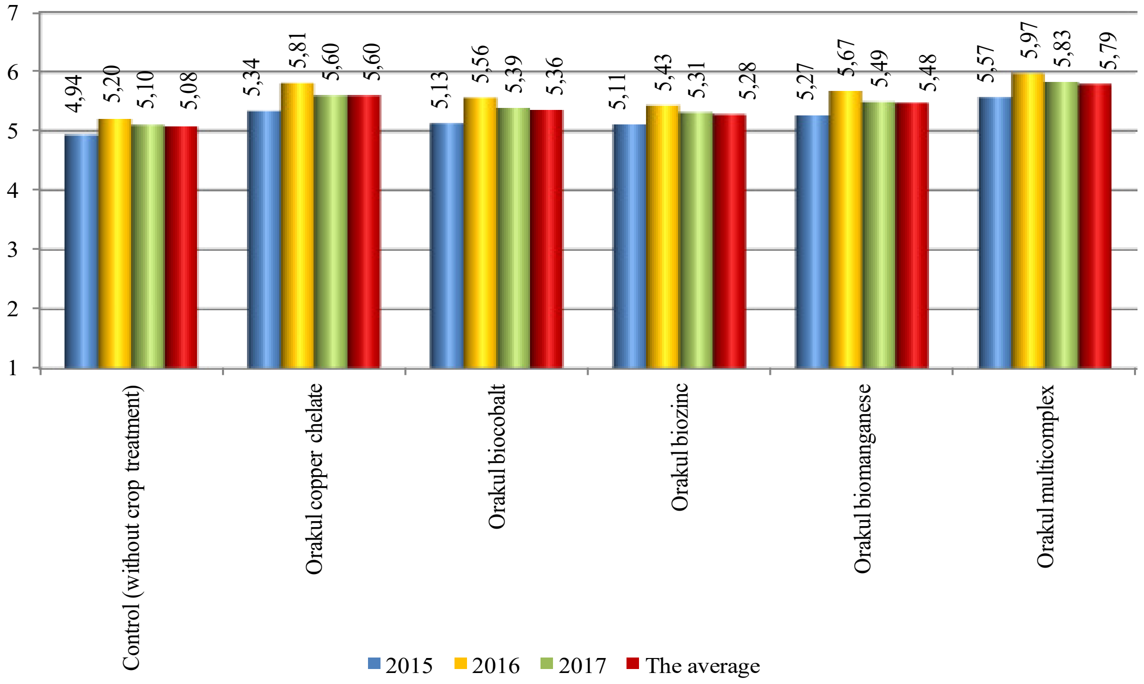

Fig. *The yield of winter wheat seeds depending on the use of chelated forms of microelements (2015-2017), t / ha*

For foliar feeding of plants with microfertilizers, the coefficient of seed reproduction was reliably increased by 0.8 units (Orakul biozinc) - 2.9 units (Orakul multicomplex) (SSD_{05} 0.7–0.8) compared with the control (without crop treatment) (Table. 4).

Table 4. *The effect of foliar application of microelements on the coefficient of seed reproduction of winter wheat Benefis variety (2015-2017), units*

Experience variant	Application rate, l / ha	Year						Average	
		2015		2016		2017			
		units	± to control	units	± to control	units	± to control	units	± to control
Control (without crop treatment)	water 400	19.8	-	20.8	-	20.4	-	20.3	-
Orakul copper chelate	1-2	21.4	1.6	23.2	2.4	22.6	2.2	22.4	2.1
Orakul biocobalt	0.15-0.20	20.5	1.0	22.2	1.4	21.6	1.2	21.4	1.1
Orakul biozinc	0.5-1.0	20.4	0.9	21.7	0.9	21.2	0.8	21.1	0.8
Orakul biomanganese	2-3	21.1	1.3	22.7	1.9	22.0	1.6	21.9	1.6
Orakul multicomplex	1-2	22.3	2.5	23.9	3.1	23.3	2.9	23.2	2.9
Average		20.9		22.4		21.9			
SSD_{05}		0.8		0.7		0.7			

Note. The phase of the microfertilizers application: tillering - shooting.

The various indicators of seeds sowing qualities were formed under the influence of microfertilizers (Table 5). If on the control, the mass of 1000 seeds (without crop treatment) was 42.5 g, then with their use it increased in 2015 by 0.3-2.2 g, in 2016 - by 0.1-2.8 g, and in 2017 - 0.6-2.3 g. The highest average index of 1000 seeds mass provided microfertilizers - Orakul multicomplex (45.3 g), Orakul copper chelate (44.6 g), the increase to control was 2.8 and 2.1 g. According to SSD_{05} 0.31-0.55 reliable was the increment of 1000 seeds mass for all variants of the experiment. A significant increase (SSD_{05} 1.1-1.9) of the average seed germination energy to the control was with the use of Orakul copper chelate by 4.5%, Orakul biocobalt - 2.8%, Orakul biozinc - 1.8%, Orakul biomanganese - 2.2%, Orakul multicomplex - 6.3%.

The high level nutrition of winter wheat plants is due to mineral fertilizers applied at the rate of $N_{90}P_{90}K_{90}$ with phased nitrogen application in IV and VII stages of organogenesis and microfertilizers in the phase tillering - shooting ensured high laboratory germination of seeds. If on the control this indicator was 92.5%, then with the application of Orakul copper chelate it increased by 2.0%, and for the Orakul biocobalt it increased by 1.8%. Laboratory germination was low with the use of the Orakul biozinc - 93.3%, or 0.8% to the control, and the highest one for the Orakul multicomplex - 95.5% (to the control, 3.0%).

Table 5. *The effect of foliar application of microfertilizers on indicators of sowing qualities of winter wheat seeds Benefis variety (2015-2017)*

Experience variant	Application rate, l / ha	Mass 1000 seeds		Germination energy		Laboratory germination	
		g	± to control	%	± to control	%	± to control
Control (without crop treatment)	water 400	42.5	-	81.1	-	92.5	-
Orakul copper chelate	1-2	44.6	2.1	85.6	4.5	94.5	2.0
Orakul biocobalt	0.15-0.20	43.9	1.4	83.9	2.8	94.3	1.8
Orakul biozinc	0.5-1.0	43.1	0.6	82.9	1.8	93.3	0.8
Orakul biomanganese	2-3	43.6	1.1	83.3	2.2	93.8	1.3
Orakul multicomplex	1-2	45.3	2.8	87.4	6.3	95.5	3.0
Average		43.8		84.0		94.0	
SSD_{05}		0.44		1.5		1.3	

Note. The phase of the microfertilizers application: tillering - shooting.

CONCLUSIONS

The experimental results confirm that the use of chelated forms of microfertilizers in the phase of tillering - shooting on the background of mineral nutrition of plants at the rate $N_{90}P_{90}K_{90}$ with phased application of nitrogen in IV and VII stages of organogenesis contributes to winter wheat seed productivity. The grain yield increases by 0.12-0.34 t / ha, the yield of conditioned seeds - by 2-6%, seed yield increases by 0.20-0.71 t / ha, the coefficient of seed reproduction - by 0.8-2.9 units, the mass of 1000 seeds - by 0.3-1.8 g. The optimal level of plant nutrition at the expense of better assimilation of trace elements has a positive effect on the formation of seeds sowing qualities, increasing the mass of 1000 seeds by 0.6-2.8 g, seed germination energy - 1.8-6.3%, laboratory germination - 0.8-3.0%. The highest efficiency was obtained with the application of complex microfertilizers Orakul copper chelate (1-2 l / ha), Orakul biocobalt (0.15-0.20 l / ha) and Orakul multicomplex (1-2 l / ha).

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INFORMATION ABOUT AUTHORS:

VOLOSCHUK Ihor https://orcid.org/0000-0002-2944-8656

PhD in agriculture, Laboratory of Seed Production, Institute of Agriculture of Carpathian Region, National Academy of Agrarian Sciences of Ukraine, Lviv, Ukraine

VOLOSCHUK Olexandra https://orcid.org/0000-0002-2509-9452

PhD in agriculture, Laboratory of Seed Production, Institute of Agriculture of Carpathian Region, National Academy of Agrarian Sciences of Ukraine, Lviv, Ukraine

HLYVA Valentyna https://orcid.org/0000-0002-9033-6549

PhD in agriculture, Laboratory of Seed Production, Institute of Agriculture of Carpathian Region, National Academy of Agrarian Sciences of Ukraine, Lviv, Ukraine

MARUKHNYAK Andriy https://orcid.org/0000-0001-8561-9010

PhD in agriculture, Laboratory of Breeding of Grain and Forage Crops, Institute of Agriculture of Carpathian Region, National Academy of Agrarian Sciences of Ukraine, Lviv, Ukraine

Corresponding author: olexandravoloschuk53@gmail.com

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