THE YIELD AND QUALITY OF WINTER WHEAT *(TRITICUM AESTIVUM)* GRAIN AFTER APPLICATION OF MICRNUTRIENTS ON SEED

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Abstract: Fertilization with microelements in a crop production is not generally important until deficiency symptoms appeared on plants. Soil application is expensive and foliar application may not remove a deposit of microelements. Seed coating could be more economical way. Seeds with microelements should be more complex and should provide enough nutrients, especially for the first stage of growth and development. In the experiment, seeds were coated by manganese, copper, zinc, molybdenum and by combination of Mn-Zn-Cu. The same fertilizers were used as foliar nutrition. There was default fertilization with nitrogen for all variants. The control observation was microelements free. The results showed no statistically difference between control variant and seed coating or foliar nutrition in any category (value of N-tester, yield or grain quality). On the other side, there were no deficiency symptoms on plants. Contents of micronutrients in leafs were slightly higher than the control observation. Seed coating with micronutrients has fulfilled its preventive purpose.

Key Words: microelements, micronutrients, wheat, seed coating

INTRODUCTION

The proper and balanced nutrition is essential for optimal growth and development of wheat (as a model crop) and any other plant (Vaněk et al. 2007). The uptake of carbon, hydrogen and oxygen is from air and water. Other nutrients come from the soil. They are divided into macro nutrients (N, P, K, Ca, Mg, S) and microelements according to their content in the soil and especially to their total requirement for the plants (Eyal 2007, Radulov et al. 2009). The total content of microelements in the soil is small, but they are important terms of crop nutrition. Yet the importance of some micronutrients for plants was not detected until the 21st century. Only a few microelements are known to be essential for growth and development of plants (Vaněk et al. 2007). Among the irreplaceable micronutrients belong iron, manganese, zinc, copper, boron and molybdenum. Microelements have mostly a catalytic function. Their deficiency may limit uptake and utilization of the other nutrients, while a deep deficiency may cause physiological disorders (Bergmann 1992, Hlušek et al. 2002).

Supply of microelements in soil is currently decreasing due to intensive agriculture (Fecenko, Ložek 2000). Higher yields led to an overall higher nutrient uptake. Cultivated varieties often require higher levels of available nutrients in the soil, because their ability to acquire nutrients is small. One sided nitrogen fertilization or focus on the N, P, K fertilization, however, lead to a dilution of the concentration of micronutrients in the soil and plants (Neuberg 1978). Intensive tillage, drainage or liming treatment have resulted in stronger immobilization of certain elements, such as Fe, Mn, Zn or Cu. Highly concentrated fertilizers do not always include these nutrients and there was also decrease in organic fertilization. Fertilizing with microelements in practice is mostly ignored until deficiency symptoms appeared on plants. Subsequent foliar application is not optimal, because the influence of deficiency may already result in reduction of yield and quality.

Preventive treatment with microelements to soil or by foliar application is therefore suitable (Vaněk et al. 2007). Such application is economically challenging and in practice is more important fertilizing with macro elements. Seed coating and priming with micronutrients are offered as a relative simple and cheaper alternative (Imran et al. 2008, Singh 2007). Seed coated with microelements should provide plenty of nutrients needed for good germination and emergence (Farooq et al. 2012). Combination with other additives like fungicide could be a complex prerequisite for optimal growth and development. Application of micronutrients on seed may at least be partial prevention of deficiency during the growing season.

The objective of this work was to determine whether application of micronutrient will be reflected in the yields and quality of winter wheat in some way. There was also observed whether deficiency symptoms will appear during vegetation.

MATERIAL AND METHODS

The research was conducted at the experimental field station Žabčice (GPS position of the locality: 49°01'18.6"N 16°37'01.9"E) in the year 2013/2014 through small plot field experiment. The size of one plot was 15 m^2. The soil analysis was performed before start of the experiment. The results show a good to very high content of P, K, Mg and Ca (extraction by Mehlich 3). Content of microelements according to Neuberg is good (see Table 1). Soil pH was close to neutral (6.63).

Table 1 Content of nutrient ($mg \cdot kg^{-1}$) in soil before start of the experiment (Žabčice, 2013)

P	K	Ca	Mg	Cu (DTPA)	Zn (DTPA)	Mn (DTPA)	Mo (total)
134	298	4007	458	1.28	2.23	30.42	0.44

DTPA = diethylene triamine pentaacetic acid, extraction by Lindsay and Norwell

The basic fertilization with P and K was made before sowing. The soil preparation was carried out by the conventional way with plowing. The crop rotation in the experiment was wheat after wheat (variety Midas) and the sowing was done on 7th October, 2013. Variants of fertilization investigated in the experiment are displayed in Table 2. The work is primarily focused on the seed coating with micronutrient, foliar application was added for better comparison. The nitrogen fertilization was uniform for all variants – 60 $kg \cdot ha^{-1}$ N in limestone ammonium nitrate (LAN) during tillering (11th March), 40 $kg \cdot ha^{-1}$ N in LAN during stem elongation (4th April) and 40 $kg \cdot ha^{-1}$ N in urea ammonium nitrate during booting (6th May).

Table 2 Variants of fertilization used in the experiment (Žabčice, 2013–2014)

Variant	Micronutrient application	
	Dose	Period
Control (micronutrient free)	-	-
MANGAN Forte	3 $l \cdot t^{-1}$	On seed
KUPROSOL	3 $l \cdot t^{-1}$	On seed
ZINKOSOL Forte	3 $l \cdot t^{-1}$	On seed
MOLYSOL	1 $l \cdot t^{-1}$	On seed
MIKROKOMPLEX	3 $l \cdot t^{-1}$	On seed
F. app. MANGAN Forte	2 $l \cdot t^{-1}$	Spring
F. app. KUPROSOL	2 $l \cdot t^{-1}$	Spring
F. app. ZINKOSOL Forte	2 $l \cdot t^{-1}$	Spring
F. app. MOLYSOL	1 $l \cdot t^{-1}$	Spring
F. app. MIKROKOMPLEX	4 $l \cdot t^{-1}$	Spring
F. app. MIKROKOMPLEX	4 $l \cdot t^{-1}$	Autumn
MIKROKOMPLEX + F. app. MIKROKOMPLEX	4 $l \cdot t^{-1}$	On seed + Spring

F. app. = foliar application. Autumn application was performed on November 4th, spring application on April 4th

The harvest was done on 19th July, 2014. The yield and quality parameter of wheat grain (N-substances, gluten, density and sedimentation value) was investigated in the experiment. The obtained results were statistically evaluated with the help of Statistica 12 Cz software.

The composition of used preparation: MANGAN Forte contained 11% Mn, KUPROSOL contained 5% Cu, ZINKOSOL Forte contained 11% Zn, MOLYSOL contained 4% Mo, MIKROKOMPLEX contained 6.5% Mn, 4.8% Zn and 1.2% Cu.

RESULTS AND DISCUSSION

Grain yield

Average yields of winter wheat in the experiment reached 6.73 $t \cdot ha^{-1}$, which is slightly higher than the national average 6.61 $t \cdot ha^{-1}$. Good yields were influenced by good soil and climatic condition. However, there was no statistically significant difference between the investigated variants (see Table 3). Only one option, MIKROKOMPLEX + MIKROKOMPLEX (f. app., spring) achieved slightly higher yield than the control. This results support the idea about a positive synergy between individual elements. The amount of micronutrients applied on seed was very small, which in combination with overall very good soil and climatic condition could be a reason why this treatment did not influence the yields.

Table 3 Average grain yields of winter wheat and their statistical significance according to Tukey test (Žabčice, 2014)

Seed coating with micronutrients	n	Yield ($t \cdot ha^{-1}$)	Statistical significance of differences	Relative %
Control	4	6.73 ± 0.1	a	100
MANGAN Forte	4	6.54 ± 0.6	a	97.2
KUPROSOL	4	6.55 ± 0.2	a	97.3
ZINKOSOL Forte	4	6.63 ± 0.3	a	98.5
MOLYSOL	4	6.68 ± 0.2	a	99.3
MIKROKOMPLEX	4	6.72 ± 0.1	a	99.6
Foliar application	**n**	**Yield ($t \cdot ha^{-1}$)**	**Statistical significance of differences**	**Relative %**
Control	4	6.73 ± 0.1	a	100
F. app. MANGAN Forte	4	6.32 ± 0.6	a	93.9
F. app. KUPROSOL	4	6.68 ± 0.1	a	99.3
F. app. ZINKOSOL Forte	4	6.66 ± 0.3	a	99.0
Foliar app. MOLYSOL	4	6.53 ± 0.2	a	97.0
F. app. MIKROKOMPLEX, Spring	4	6.67 ± 0.1	a	99.1
F. app. MIKROKOMPLEX, Autumn	4	6.48 ± 0.5	a	96.3
MIKROKOMPLEX	**n**	**Yield ($t \cdot ha^{-1}$)**	**Statistical significance of differences**	**Relative %**
Control	4	6.73 ± 0.1	a	100
MIKROKOMPLEX, on seed	4	6.72 ± 0.1	a	99.6
F. app. MIKROKOMPLEX, Spring	4	6.67 ± 0.1	a	99.1
F. app. MIKROKOMPLEX, Autumn	4	6.48 ± 0.5	a	96.3
MIKROKOMPLEX + F. app. MIKROKOMPLEX, Spring	4	6.78 ± 0.2	a	100.7

Some similar papers from abroad also show inconclusive results (Baloch et al. 2014, Johnson et al. 2005). Other foreign experiments (Bameri et al. 2012, Farajnia, Benam 2007, Gomaa et al. 2015, Malakouti 2008, Sarakhsi, Behrouzyar 2014, Wiatrak 2013, Zeidan et al. 2010) indicates increasing yields after micronutrient application on seed, to the soil or on leafs. However, yields from these works are averaging only about 3 t · ha^{-1}. It must be noted that these experiments were conducted mainly in developing countries in Africa, Asia or in poorer soil in America. These locations are characterized mainly by drought and nutrient deficiency in soil. The content of organic matter in the soil is also low. In such conditions, even a small amount of fertilizer with right application method could be a good perception for influencing the yields.

Qualitative parameters of wheat grain

The average volume weight of wheat grain in the experiment amounted to 799.4 g · l^{-1}. There was no statistically difference between the control and any other variants. The content of N-substances (average 13.54%) and gluten (average 31%) in grain was statistically insignificant too. Sedimentation values were also statistically indifferent. Individual variants and their results are shown in Table 4. The application of micronutrient have not influenced quality of grain probably because high content of nutrient in soil and optimal weather conditions for growth and development of plants. As mentioned before, the amount of micronutrient applied was also very small.

Table 4 Average values of qualitative parameters of winter wheat grain (Žabčice, 2014)

Seed coating with micronutrients	n	Volume weight (g · l^{-1})	Content of N-substances (%)	Content of gluten (%)	Sedimentation Value (ml)
Control	4	798.5	13.52	31.00	38.25
MANGAN Forte	4	799.8	13.57	31.17	39.50
KUPROSOL	4	806.8	13.47	30.87	38.00
ZINKOSOL Forte	4	803.5	13.50	30.93	37.75
MOLYSOL	4	794.3	13.55	31.10	37.75
MIKROKOMPLEX	4	798.0	13.60	31.23	39.75
Foliar application	**n**	**Volume weight (g · l^{-1})**	**Content of N-substances (%)**	**Content of gluten (%)**	**Sedimentation Value (ml)**
Control	4	798.5	13.52	31.00	38.25
F. app. MANGAN Forte	4	798.3	13.45	30.80	36.50
F. app. KUPROSOL	4	795.2	13.60	31.25	38.25
F. app. ZINKOSOL Forte	4	798.0	13.65	31.38	40.25
Foliar app. MOLYSOL	4	799.5	13.50	30.85	37.25
F. app. MIKROKOMPLEX, Spring	4	792.5	13.40	30.65	38.00
F. app. MIKROKOMPLEX, Autumn	4	809.0	13.52	30.95	38.00
MIKROKOMPLEX	**n**	**Volume weight (g · l^{-1})**	**Content of N-substances (%)**	**Content of gluten (%)**	**Sedimentation Value (ml)**
Control	4	798.5	13.52	31.00	38.25
MIKROKOMPLEX, on seed	4	798.0	13.60	31.23	39.75
F. app. MIKROKOMPLEX, spring	4	792.5	13.40	30.65	38.00
F. app. MIKROKOMPLEX, autumn	4	809.0	13.52	30.95	38.00
MIKROKOMPLEX + F. app. MIKROKOMPLEX, spring	4	797.3	13.63	31.28	38.25

Nutritional status of vegetation

The plants analysis performed in tillering (before fertilization) shows slightly higher content of majority nutrient in leafs after seed coating with microelements (see Table 5). The symptoms of deficiency were not observed during the vegetation. Seed coating with micronutrients has fulfilled its preventive purpose. Slightly lower content of zinc and manganese can be associated with basic fertilization with P. Higher content of phosphorus in soil in combination with soil pH between 5.5–6.9 leads to a formation of less soluble compound and has a negative effect to nutrient uptake.

Table 5 Results of plants analysis performed in tillering stage of winter wheat (Žabčice, 2014)

Variant	% in dry matter						mg · kg $^{-1}$ in dry matter			
	N	P	K	Ca	Mg	S	Zn	Mn	Mo	Cu
Control	0.94	0.21	2.18	0.286	0.102	0.13	13.9	57.6	<0.215	2.8
MANGAN Forte	1.30	0.19	2.19	0.328	0.105	0.14	13.6	52.3	-	-
KUPROSOL	1.82	0.24	2.58	0.361	0.116	0.16	14.9	58.7	-	3.68
ZINKOSOL Forte	1.64	0.24	2.49	0.343	0.111	0.16	11.9	53.5	-	-
MOLYSOL	1.83	0.25	2.45	0.336	0.113	0.18	14.7	58.4	<0.216	-
MIKROKOMPLEX	1.17	0.21	2.27	0.305	0.098	0.14	13.3	59.6	-	2.83
F. app. MIKROKOMPLEX autumn	1.51	0.240	2.44	0.296	0.102	0.14	11.4	62.8	-	2.74

CONCLUSION

A statistical evaluation of the results shows that the control observation is not significantly different from any other variant in any category. The marketing year 2013/2014 was optimal for growth and development of crops in terms of temperatures, rainfalls and their distribution. Content of nutrients found in the soil before the foundation of the experiment shows a good to very good supply. These factors together with a very small amount of microelements applied on seed or leafs are the reason why the treatment is not reflected in yields or grain quality. The different effects of micronutrient to individual indicators can be then influenced not only by themselves, but also by local differences in the soil.

Some foreign experiments conducted on soils with nutrient deficiency and drought observed in most cases increasing yields after micronutrient application. If this experiment should continue on our territory, change or addition of a new locality will be necessary for more relevant results. For the overall evaluation of the application method is also required a multiannual experiment. A possible solution in terms of unavailability of suitable soils (nutrient deficiency) in experimental stations could be working with some agricultural cooperative. The experiment could be performed in field terms on suitable locality.

The symptoms of deficiency were not observed during the vegetation. Seed coating with micronutrients has fulfilled its preventive purpose.

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