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The effect of magnesium and nitrogen on the quality parameters of winter wheat yield

Oddziaływanie magnezu i azotu na cechy jakościowe plonu pszenicy ozimej

Summary. The aim of the study was to determine the influence of foliar and soil magnesium fertilisation at two levels of nitrogen fertilisation, 74 and 114 kg N ha^{-1}, on basic quality parameters of winter wheat yield. Four magnesium fertilisation objects were used: 1. the control without magnesium application, 2. foliar-applied 5% $MgSO_4$ 7 H_2O + Wuxal top N, 3. foliar-applied 5% $MgSO_4$ 7 H_2O, 4. soil-applied $MgSO_4$ 7 H_2O. The studies demonstrated a favourable effect not only of nitrogen, but also magnesium, on the major part of the analysed quality traits. From particular magnesium fertilisation objects, the best effects were achieved by the soil application of magnesium, weaker effects after foliar application, in particular in the measures combined with foliar fertiliser Wuxal top N.

Key words: raw protein, protein biological yield, gluten, foliar magnesium fertilisation, removal of magnesium

INTRODUCTION

A foliar nutrition is an efficient and valuable agrotechnical operation that ensures a continuity in nutrients intake within different periods of plant's vegetation. It makes possible to balanced supply in macronutrients and microelements, which determines a smooth metabolism, due to which amounts of assimilates needed for storage substances production (proteins, fats, carbohydrates), increase [Komosa 1990, Michałojć i Szewczuk 2003].

The increase of a yield and its qualitative parameters is a measurable final effect of foliar nutrition [Chwil 2001, Wójcik 1998]. However, it should be on mind that the quantity of supplied nutrients by above ground parts of plants is reduced by a variety of factors. Although 2–3-fold application allows for complete meeting the plant's nutritional requirements for microelements, in the case of macronutrients, it can be considered only as auxiliary to soil fertilization [Chwil 2001, Szewczuk and Michałojć 2003].

Due to the rate and high efficiency, foliar nutrition finds wider and wider group of supporters, namely in reference to post-crop magnesium nutrition in a form of 5% magnesium sulfate solution.

Level of nitrogen fertilization makes up the largest contribution to shaping the technological value of yields. However, under conditions of more and more often magnesium deficits in a soil, extent the plant's nutritional requirements for that component are met, is more important in qualitative evaluation of plant-origin products [Biskupski 1991, Krauze *et al*. 1999, Chwil 2001, Borysewicz *et al*. 2006].

The aim of the study was to analyse the effect of differentiated nitrogen and magnesium fertilisation on the development of basic quality traits in winter wheat yield.

EXPERIMENTAL PROCEDURES

The studies were conducted in RZD Uhrusk based on a three-year field experiment on calciferous soil of $pH_{(KCl)}$ 7.1–7.3 and granulometric composition: sand 49%, silt 8%, fine particles 43%. The soil was characterised by a low abundance of available forms of phosphate and magnesium and a high abundance of potassium. The test plant was winter wheat, cultivar Roma, grown after rape at 2 levels of soil nitrogen fertilisation (74 and 114 kg N ha^{-1}), against the background of which magnesium was soil- or foliar-applied according to the following procedure: 1). the control without magnesium application, 2). foliar-applied 5% $MgSO_4$ 7 H_2O + Wuxal top N, 3). foliar-applied 5% $MgSO_4$ 7 H_2O, 4). soil-applied $MgSO_4$ 7 H_2O. Phosphate and potassium fertilisation was applied pre sowing in the doses of 21 kg P ha^{-1} and 65 kg K ha^{-1}. Magnesium in the form of $MgSO_47H_2O$ was soil-applied, foliar-applied or together with the foliar fertiliser Wuxal top N with the following composition: 12% N, 4% P_2O_5, 6% K_2O and 0.01% B, 0.007% Cu, 0.015% Fe, 0.013% Mn, 0.001% Mo and 0.005 Zn. Foliar nutrition was applied in the dose of 5 l of the fertiliser in 300 l of the solution per ha^{-1}.

The plants were harvested at full ripeness. Based on grain and straw yield [Chwil 2001], the harvest index was calculated. Following the mineralization of the plant material in concentrated sulphuric acid with an addition of perhydrol, magnesium was determined in winter wheat grain and in straw using the ASA method. Based on magnesium content in grain and straw, the total removal of magnesium was calculated. Wet gluten and raw protein were determined using the Kjeldahl method (N x 5.7).

The experimental data were processed statistically in accordance with the programme for two-factor experiments. The conclusion-making process was based on Tukey's multiple range test.

RESULTS AND DISCUSSION

In wheat cultivars growing for consumption purposes, the primary task of an agricultural producer is to obtain a large amount of protein. The protein biological yield is directly affected by the protein content in grain and the weight of grains obtained in the final yield. Among plant nutrients commonly applied in fertilisation, nitrogen, in addition to its dominant role in yield formation, modifies also to the largest degree the pro-

tein content in grain and its amino acid composition [Biskupski 1991, Podolska and Grabiński 2004]. Over the recent years, however, more and more opinions have appeared in scientific literature indicating a significant role of magnesium in the development of certain quality traits of agricultural crops [Krauze *et al*. 1999, Świgoń *et al*. 2000, Soral-Śmietana *et al*. 2001].

Table 1. Characteristics of quality parameters of winter wheat yield under the conditions of nitrogen and magnesium fertilisation
Tabela 1. Charakterystyka parametrów jakościowych plonu pszenicy ozimej w warunkach nawożenia azotem i magnezem

Fertilization level of nitrogen Poziomy nawożenia azotem	Objects of magnesium fertilization Obiekty nawożenia magnezem				Mean values Średnio
	1	2	3	4	
Content of raw protein in grain – Zawartość białka surowego (g · kg^{-1})					
I – 74 kg N · ha^{-1}	99.73	94.03	105.43	96.90	99.02
II – 114 kg N · ha^{-1}	110.20	106.77	108.67	107.90	108.38
Mean values Średnio	104.97	100.40	107.05	102.40	-
LSD P = 0.05	among objects – między obiektami			nsd	
	among levels – między poziomami			4.32	
	level × object – poziom × obiekt			nsd	
Protein biological yield – Plon biologiczny białka (kg · ha^{-1})					
I – 74 kg N · ha^{-1}	518.61	554.80	562.06	594.00	557.37
II – 114 kg N · ha^{-1}	716.30	758.04	811.74	830.83	779.23
Mean values Średnio	617.46	656.42	686.90	712.42	-
LSD P = 0.05	Among objects – między obiektami			51.40	
	Among levels – między poziomami			26.92	
	Level × object – poziom × obiekt			nsd	
Content of gluten – Zawartość glutenu (g · kg^{-1} d.m. – s.m.)					
I – 74 kg N · ha^{-1}	246.30	263.70	275.70	279.30	226.20
II – 114 kg N · ha^{-1}	278.70	288.70	296.00	305.00	291.10
Mean values Średnio	262.50	276.20	285.80	292.20	
LSD P = 0.05	among objects – między obiektami			14.70	
	among levels – między poziomami			7.70	
	level × object – poziom × obiekt			nsd	

The studies conducted on the influence of nitrogen and magnesium fertilisation on the development of the main quality parameters in winter wheat growing show that the application of a larger dose of nitrogen significantly increased both the protein content in winter wheat grain and the protein biological yield (Tab. 1). In the studies, no direct influence on the protein content resulting from magnesium fertilisation was found, however, a favourable effect of this component, foliar-applied (object 4) and soil-applied

(object 5), on the protein biological yield was obtained. It is related to the physiological role of these components in a plant. Nitrogen is the main component of protein and it directly increases the content of many protein fractions in grain [Biskupski 1991, Krauze *et al*. 1999, Podolska i Grabiński 2004]. On the other hand, magnesium, as a component element of chlorophyll, may indirectly contribute to the increase in total protein yield through the growth of biomass and the higher efficiency of photosynthesis [Krauze *et al*. 1999, Chwil 2000, 2001]. In all the objects with the application of magnesium in fertilisation, higher wheat grain yield and a better harvest index were obtained (Tab. 2). The highest grain yield was obtained as a result of the soil application of magnesium before the sowing [Chwil 2001].

Table 2. Harvest index of winter wheat under the conditions of nitrogen and magnesium fertilisation
Tabela 2. Indeks żniwny pszenicy ozimej pod wpływem nawożenia azotem i magnezem

Fertilization level of nitrogen Poziomy nawożenia azotem	Objects of magnesium fertilization Obiekty nawożenia magnezem				Mean values Średnio
	1	2	3	4	
Harvest index – Indeks żniwny					
I – 74 kg N · ha^{-1}	0.44	0.47	0.48	0.47	0.46
II – 114 kg N · ha^{-1}	0.42	0.48	0.45	0.45	0.45
Mean values – Średnio	0.43	0.47	0.46	0.46	-
LSD P = 0.05	among objects – między obiektami			0.03	
	among levels – między poziomami			nsd	
	level × object – poziom × obiekt			nsd	
Removal of magnesium – Wynos magnezu (kg Mg · ha^{-1})					
I – 74 kg N · ha^{-1}	4.85	6.10	5.86	6.13	5.74
II – 114 kg N · ha^{-1}	6.72	7.34	7.72	8.21	7.50
Mean values – Średnio	5.78	6.72	6.79	7.17	-
LSD P = 0.05	among objects – między obiektami			0.64	
	among levels – między poziomami			0.33	
	level × object – poziom × obiekt			nsd	

The application of Mg in fertilisation increases the removal (Tab. 2) of this component in total yield [Marcinkowski 1995, Chwil 2000]. Thereby, it contributes to the increase of the share of this very desirable component in the human food chain, given that a much larger content of magnesium occurs in grain than in straw, what is indicated by other studies [Marcinkowski 1995, Chwil 2000, Soral-Śmietana *et al*. 2001]. The gluten content in flour depended on the dose of nitrogen and the method of magnesium application. Numerous studies have proved that, within the range between the low dose and the average dose of nitrogen, a higher gluten content occurs at higher levels of nitrogen fertilisation [Podolska and Grabiński 2004, Borysewicz *et al*. 2006]. The application of a high dose of nitrogen in fertilisation, in spite of the fact that it increases total protein

and gluten content in grain, is often accompanied by a decrease of technological value due to other quality parameters such as the increased ash content [Podolska i Grabiński 2004]. In the conducted experiment, a favourable influence of both foliar and soil magnesium fertilisation on the increase in content of the most valuable protein fraction, that is gluten, was demonstrated. As far as the control object is concerned, 8.9% higher gluten content was obtained under the conditions of foliar magnesium nutrition of the plants, and this content was higher by 11.3% in the system of soil magnesium fertilisation.

CONCLUSIONS

1. Larger protein contents occurred at the higher level of nitrogen fertilisation. But no significant changes in the trait in question under the influence of magnesium fertilisation were found.

2. Nitrogen and magnesium fertilisation had a favourable effect on such indicators as: harvest index, protein biological yield and gluten content.

3. Each of the used methods of magnesium application contributed to the increase of its share in the food chain link, but the best effects were obtained under the conditions of soil magnesium application.

REFERENCES

Biskupski A., 1991. Wpływ nawożenia azotem na plonowanie oraz zawartość białka ogólnego w ziarnie zbóż ozimych. Frag. Agron., 4(32), 84–90.

Borysewicz J., Budzyński W., Dubis B., 2006. Wpływ nawożenia azotem na plon i technologiczną jakość wybranych odmian pszenicy ozimej. Druga Ogólnopolska Konferencja Naukowa „Jakość a wykorzystanie ziarna zbóż", 18–19 października, Puławy, 9–10.

Chwil S., 2000. Wpływ intensywności nawożenia mineralnego na plon pszenicy ozimej oraz zawartość magnezu w glebie i roślinie. Biul. Magnezol. 5(4), 278–283.

Chwil S., 2001. Wpływ dolistnego i doglebowego stosowania magnezu na wielkość i strukturę plonu pszenicy ozimej. Biul. Magnezol. 6(2), 118–124.

Jaśkiewicz B., 2004. Organizacyjno-ekonomiczne uwarunkowania zbóż jakościowych w różnych regionach Polski. VIII Konferencja Naukowa IUNG „Jakość Towarowych Surowców Roślinnych Wyzwaniem dla Nauki i Praktyki Rolniczej, 31 maja – 1 czerwca, Puławy 2004, 45–46.

Komosa A., 1990. Wpływ niektórych właściwości chemicznych roztworów oraz stanu odżywienia roślin na skuteczność nawożenia dolistnego pomidora szklarniowego., Rozpr. Nauk. 210, Wyd. AR Poznań, 109 ss.

Krauze A., Bowszysz T., Witalis M., 1999. Wpływ nawożenia magnezem na wartość odżywczą ziarna pszenicy. Biul. Magnezol. 4(1), 111–115.

Marcinkowski T., 1995. Magnez w łańcuchu troficznym gleba–roślina–bydło mleczne. Wiad. Inst. Mel. Użyt. Ziel., 18(3), 83–97.

Michałojć Z., Szewczuk C., 2003. Teoretyczne aspekty dolistnego dokarmiania roślin. Acta Agroph., 85, 9–17.

Podolska G., Grabiński J., 2004. Możliwości kształtowania cech jakościowych zbóż chlebowych poprzez zabiegi agrotechniczne. VIII Konferencja Naukowa IUNG „Jakość Towarowych Surowców Roślinnych Wyzwaniem dla Nauki i Praktyki Rolniczej, 31 maja – 1 czerwca, Puławy, 107–112.

Soral-Śmietana M., Świgoń A., Markiewicz K., 2001. Eksperymentalny produkt z mąki pszennej o obniżonej zawartości sodu a wzbogacony w wapń i magnez. Biul. Magnezol. 6(2), 165–175.

Świgoń A., Soral-Śmietana M., Markiewicz K., 2000. Complexin of calcium, magnesium and zinc with wheat polymers and their in vitro enzyme susceptibility. Ist International IUPAC Symposium, 9-11 October, Warszawa, 75–76.

Szewczuk C., Michałojć Z., 2003. Praktyczne aspekty dolistnego dokarmiania roślin. Acta Agroph. 85, 19–29.

Wójcik P., 1998. Pobieranie składników mineralnych przez części nadziemne roślin z nawożenia pozakorzeniowego. Post. Nauk Roln. 1, 49–64.

Streszczenie. Uwzględnienie magnezu w nawożeniu obok podstawowych składników nawozowych (NPK) zwiększa plonowanie roślin oraz wartość technologiczną ziarna konsumpcyjnego pszenicy ozimej. Nawożenie tym składnikiem powoduje zwiększenie zawartości magnezu w ziarnie, a tym samym większy wynos z plonami, co przyczynia się do zwiększenia udziału magnezu w ogniwie łańcucha pokarmowego. Celem pracy było określenie wpływu nawożenia magnezem stosowanego dolistnie i doglebowo na dwóch poziomach nawożenia azotowego 74 i 114 kg N ha^{-1} na podstawowe parametry jakościowe plonu pszenicy ozimej. Zastosowano cztery obiekty nawożenia magnezem: 1) kontrola – bez magnezu, 2) 5% $MgSO_4$ 7 H_2O + Wuxal top N stosowany dolistnie, 3) 5% $MgSO_4$ 7 H_2O stosowany dolistnie, 4) $MgSO_4$ 7 H_2O stosowany doglebowo. Badania wykazały korzystne oddziaływanie na większość analizowanych cech jakościowych nie tylko azotu, ale również magnezu. Z poszczególnych obiektów nawożenia magnezem najlepsze efekty uzyskano, stosując magnez doglebowo, słabsze po aplikacji dolistnej, szczególnie w zabiegach łączonych z nawozem dolistnym Wuxal top N.

Słowa kluczowe: białko surowe, plon biologiczny białka, gluten, dolistne nawożenie magnezem