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The influence of nitrogen fertilization on the content of trace elements in grain of some winter wheat cultivars

Wpływ nawożenia azotowego na zawartość pierwiastków śladowych w ziarnie niektórych odmian pszenicy ozimej

ABSTRACT. Three cultivars of winter wheat (Begra, Nike and Rosa) were studied at the following nitrogen application rates: 50, 100 and 150 kg N/ha. Fertilization was applied. Nitrogen was used in a form of ammonium sulphate at three equal rates before sowing, during spring vegetation start and at shooting. Phosphorus and potassium fertilization was applied before the sowing at the rates of 34.9 kg P/ha and 99.6 kg K/ha. Grain achieved from the experiment set by means of randomized blocks and performed on the fields of the Agricultural Experimental Farm, Felin in the years 1997-1999 was the material for study. Wheat grain samples were taken at the stage of full maturity. Grain, after drying, was ground and digested in muffle furnace at 450°C. The ash was dissolved in HCl (1:1) and diluted with 0.1 mol HCl/dm^3. The content of Mn, Cu, Pb, Co, Fe, Ni, Cd and Zn was determined in solutions applying AAS technique. Significant differences between years were found in wheat grains referring to particular elements content, except Cd. Grain accumulated Mn, Pb, Ni and Zn the most in the first year, and Cu, Co and Fe in the second. It was found out that the increase of nitrogen fertilization rate invoked successive increase of Fe and Co content in winter wheat grain. Grain with the lowest fertilization rate of 50 kg N/ha contained the highest levels of Cu and Pb. The greatest concentrations of Mn, Ni and Zn were observed in wheat grain fertilized with 150 kg N/ha. Rosa cv. was distinguished among others with better ability to concentrate Pb, Co, Fe, Ni, Zn in grain, and Begra cv. – Mn.

KEY WORDS: wheat, grain, cultivar, nitrogen fertilization, trace elements

Recent unfavorable changes in crops structure in Poland expressed as 70% cereals share and even greater cultivation intensity in some farms can cause changes in the chemical composition of grain due to, among others, unilateral

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exhaustion of the microelements in the soil [Nowak 2000]. The increase of the yielding level achieved by means of intensive mineral fertilization, especially nitrogen, intensifies the process of microelements removal from the soil [Stanisławska-Glubiak et al. 1996]. The grain of cereals, especially that of wheat, being a valuable and necessary component of food and fodder, is an important source of elements required for proper functioning of human and animal organisms [Stanisławska-Glubiak et al. 1996]. It seems to be interesting to monitor the influence of nitrogen fertilization as a general yield-forming factor on the content of some microelements in wheat grain.

The results present the influence of three nitrogen application rates on some trace elements content in grains of three winter wheat cultivars.

METHODS

Winter wheat grain harvested in the experiment set by means of randomized blocks conducted at the Agricultural Experimental Station, Felin in the years 1997-1998 was the material. Initially, three wheat cultivars: Begra, Nike, Rosa were studied in the experiment at the following application rates: 50, 100 and 150 kg N/ha. Nitrogen fertilization in a form of ammonium sulphate was applied at three equal amounts in the following dates: before sowing, during spring vegetation start and at shooting. Phosphorus and potassium fertilization was applied before sowing at the following rates: 34.9 kg P/ha and 99.6 kg K_2O/ha. The content of several elements was determined in the soil where the experiment was set: Mn 335.0, Cu 2.4, Pb 8.5, Co 2.9, Fe 8445.0, Ni 16.6, Cd 2.9, Zn 58.0 mg/kg of dry matter.

Grain samples were taken at the full maturity stage. Dried wheat grain was ground and mineralized in muffle furnace at 450°C. The ash produced was dissolved in HCl (1:1) and diluted using 0.1 mol HCl/dm^3 solution. The following metal content was determined in solutions applying atomic absorption spectroscopy technique: Mn, Cu, Pb, Co, Fe, Ni, Cd and Zn.

RESULTS

Results of many studies upon the effect of nitrogen fertilization on plants chemical composition are not univocal [Jurkowska et al. 1990, Rabikowska, Piszcz 1996, Singh et al. 1995, Parylak, Wacławowicz 2000]. The data of the authors' experiment also point to a variable reaction of wheat towards nitrogen fertilization in particular years of study. Iron content in grains significantly increased along with the increase of fertilization in the year 1998, and grain with

the lowest nitrogen rate contained the highest amounts of the element in the previous year. In the case of nickel, the same trend in both studied years was observed, its content increased under the influence of elevated fertilization. Nitrogen application rate did not exert a significant influence on cadmium accumulation in 1997 or in 1998 (Tab. 1 and Tab. 2).

Table 1. Elements content in winter wheat grains harvested in 1997

Treatment	Element mg/kg of dry matter							
	Mn	Cu	Pb	Co	Fe	Ni	Cd	Zn
Application rate kg N/ha								
50	46.21	2.298	0.669	0.149	64.73	0.429	0.051	35.04
100	43.14	1.721	0.387	0.155	52.13	0.393	0.053	35.59
150	46.73	2.104	0.406	0.158	54.91	0.552	0.054	37.61
LSD 0.05	0.36	0.024	0.024	0.007	0.08	0.012	ns	0.40
Cultivar								
Begra	49.76	1.416	0.483	0.151	63.07	0.273	0.050	36.81
Nike	43.26	2.182	0.425	0.134	53.38	0.376	0.054	32.65
Rosa	43.05	2.524	0.553	0.178	55.33	0.726	0.054	38.79
Mean	45.36	2.041	0.487	0.154	57.26	0.458	0.053	36.08

Table 2. Elements content in winter wheat grains harvested in 1998

Treatment	Element mg/kg of dry matter							
	Mn	Cu	Pb	Co	Fe	Ni	Cd	Zn
Application rate kg N/ha								
50	33.87	2.143	0.492	0.175	53.64	0.493	0.051	31.65
100	35.08	2.058	0.393	0.172	84.96	0.498	0.051	29.93
150	35.72	2.069	0.388	0.218	85.96	0.541	0.053	30.73
LSD 0.05	0.16	0.014	0.034	0.003	0.99	0.031	ns	0.49
Cultivar								
Begra	36.42	1.740	0.197	0.164	64.04	0.619	0.052	32.15
Nike	32.12	1.910	0.374	0.177	66.76	0.372	0.051	26.32
Rosa	36.14	2.618	0.702	0.224	93.76	0.540	0.051	33.84
LSD 0.05	0.22	0.013	0.041	0.009	0.30	0.029	ns	0.46
Mean	34.89	2.089	0.424	0.188	74.85	0.510	0.051	30.77

Among the varieties studied, Rosa cv. contained the most Cu, Pb, Co, Ni and Zn in 1997, and also Fe in the following year.

Taking into account the mean values for two years, the increase of fertilization rate affected the increase of Co and Fe content in wheat grains (Tab. 3). Kruczek [1992] found a reverse tendency: the share of Fe in grains decreased when the nitrogen rate was elevated.

Table 3. Two-year mean values of elements content in winter wheat grains depending on nitrogen application rates and cultivars

Treatment	Element mg/kg of dry matter							
	Mn	Cu	Pb	Co	Fe	Ni	Cd	Zn
Application rate								
50 kg N/ha	40.04	2.221	0.581	0.162	59.19	0.461	0.051	33.35
100 kg N/ha	39.11	1.890	0.390	0.164	68.55	0.446	0.052	32.76
150 kg N/ha	41.23	2.087	0.397	0.188	70.44	0.547	0.054	34.17
Cultivar								
Begra	43.09	2.578	0.340	0.158	63.56	0.446	0.051	34.48
Nike	37.69	2.046	0.400	0.149	60.07	0.374	0.053	29.49
Rosa	39.60	2.511	0.628	0.201	74.55	0.633	0.053	36.32
Mean	40.13	2.065	0.456	0.170	66.06	0.484	0.052	33.43

The results obtained by Stanisławska-Glubiak et al. [1996] point to the decrease of copper concentration along with the increase of mineral fertilization level. In the present experiment, the highest amounts of Cu were found in grains after applying the lowest rate. The lowest nitrogen rate 50 kg N/ha, as compared to higher rates 100 and 150 kg caused an increase of Pb concentration in grains almost by 50%. In the case of Ni and Zn, the highest amounts of these elements were found after application of 150 kg N/ha. Nitrogen fertilization did not significantly influence Cd content.

On the basis of two-year studies, it may be stated that Begra cv, was characterized by a better ability to accumulate Mn in grains than Nike cv. or Rosa cv. The latter variety was distinguished by an inclination to concentrate six of other elements studied, namely Pb, Co, Fe, Ni, Cd, Zn.

Significant differences between years were found in wheat grains referring to the content of particular elements, except for Cd. Grain accumulated more Mn, Pb, Ni and Zn in the first year, and Cu, Co and Fe in the second.

CONCLUSIONS

1. The increase of nitrogen rate caused a successive increase of Fe and Co content in winter wheat grains.

2. Wheat fertilized with the lowest rate contained the highest amounts of Cu and Pb.

3. The highest concentrations of Mn, Ni and Zn were found in winter wheat grains when the application rate was 150 kg N/ha.

4. Rosa cv. was characterized by a higher ability to concentrate Pb, Co, Fe, Ni and Zn in grains than other cultivar Begra cv. – Mn.

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