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CONTENT OF MINERALS IN GRAIN OF SPRING WHEAT CV. KOKSA DEPENDING ON CULTIVATION CONDITIONS

Andrzej Woźniak[1], Bogusław Makarski[2]

[1]Chair of Herbology and Crop Plant Techniques
[2]Chair of Biochemistry and Toxicology
University of Life Sciences in Lublin

Abstract

A study has been undertaken to determine the effect of different cultivation conditions for spring wheat cv. Koksa on the total ash, P, K, Mg, Ca, Fe, Zn, Mn, and Cu in wheat grain. The study was conducted at Uhursk Experimental Farm (51°18'12″N, 23°36'50″E) of the University of Life Sciences in Lublin, in 2008-2010. The experimental factors were: 1) systems of soil tillage: ploughing and ploughless, 2) doses of nitrogen: 90 and 150 kg ha^{-1}, and 3) preceding crop: pea and soy. The objective was to evaluate the impact of different soil tillage systems, doses of nitrogen fertilizers and preceding crops on the content of mineral components in the grain of spring wheat cv. Koksa.

The study demonstrated that ploughless tillage increased the content of total ash, Zn and Cu, while ploughing tillage raised the content of K, Mg and Mn in the grain. A standard dose of nitrogen (90 kg ha^{-1}) facilitated the accumulation of K, Fe, Zn and Cu, whereas a higher nitrogen dose (150 kg N ha^{-1}) elevated the content of total ash and Mn in grain of spring wheat. The grain of wheat cultivated after pea was characterized by a higher content of Ca, Fe and Zn, whereas that cultivated after soy contained more total ash, K and Mn.

Key words: grain of spring wheat, mineral components, soil tillage, nitrogen dose, preceding crop.

dr hab. Andrzej Woźniak, Chair of Herbology and Crop Plant Techniques, University of Life Sciences in Lublin, Akademicka 13, 20-950 Lublin, Poland; e-mail: andrzej.wozniak@up.lublin.pl

ZAWARTOŚĆ SKŁADNIKÓW MINERALNYCH W ZIARNIE PSZENICY JAREJ ODMIANY KOKSA W ZALEŻNOŚCI OD WARUNKÓW UPRAWY

Abstrakt

Badano wpływ zróżnicowanych warunków uprawy pszenicy jarej odmiany Koksa na zawartość w ziarnie popiołu całkowitego oraz P, K, Mg, Ca, Fe, Zn, Mn i Cu. Badania prowadzono w latach 2008-2010 w Gospodarstwie Doświadczalnym Uhrusk (51°18'12″N, 23°36'50″E) należącym do Uniwersytetu Przyrodniczego w Lublinie. Czynnikami doświadczenia były: 1) systemy uprawy roli: płużny i bezpłużny, 2) dawki azotu: 90 i 150 kg ha^{-1}, 3) przedplony: groch i soja. Celem badań była ocena wpływu zróżnicowanych systemów uprawy roli, wielkości dawek nawozów azotowych i przedplonów na zawartość składników mineralnych w ziarnie pszenicy jarej.

Wykazano, że bezpłużna uprawa roli wpłynęła na zwiększenie w ziarnie zawartości popiołu całkowitego, Zn i Cu, natomiast płużna uprawa – K, Mg i Mn. Standardowa dawka azotu (90 kg ha^{-1}) sprzyjała gromadzeniu w ziarnie K, Fe, Zn i Cu, natomiast wysoka dawka (150 kg N ha^{-1}) zwiększała udział popiołu całkowitego i Mn. W ziarnie pszenicy uprawianej po grochu stwierdzono większą zawartość Ca oraz Fe i Zn, natomiast uprawianej po soi – więcej popiołu oraz K i Mn.

Słowa kluczowe: ziarno pszenicy jarej, składniki mineralne, uprawa roli, dawka azotu, przedplon.

INTRODUCTION

Wheat is a cereal of key significance in human nutrition. Wheat flour is mainly used for bread making and pasta production. The quality of this flour is determined by the functional value of grain (raw material), which in turn is affected by the methods and conditions it is achieved with (PELTONEN, VIRTANEN 1994, WOODING et al. 2000).

The content of mineral components in wheat grain depends on cultivar-specific characteristics as well as soil-climatic and agritechnical conditions. Among the latter, the content of ash is affected by mineral fertilization, chemical plant protection against agrophages and soil tillage system (PARIS, GAVAZZI 1972, WOŹNIAK 2010). Mineral content of grain is additionally affected by the class and composition of soil as well as a cultivation site (CUBADDA et al. 1969). As claimed by MORRIS et al. (2009), the content of ash in wheat grain is correlated more strongly with the weather course before harvest and crop localization than with the genotype. Also BUDZYŃSKI et al. (2008) demonstrated stronger dependence of ash content of grain on weather conditions than on cultivar-specific traits. The mineral composition of grain is also influenced by the species and cultivar of wheat, and by the weather during grain maturation (RANHORT et al. 1995, RUIBAL-MENDIETA et al. 2005, GONTARZ 2006). The content of ash additionally depends on cultivation conditions. Grain of wheat cultivated in a monoculture was reported to contain more minerals than wheat from crop rotation, which results from a high contribution of grain with low plumpness (WOŹNIAK 2007). For similar reasons, also ploughless soil tillage and low nitrogen fertilization are reported to increase the content of minerals in grain (WOŹNIAK 2010).

In view of the above, the objective of the study has been to evaluate the impact of different soil tillage systems, doses of nitrogen fertilizers and preceding crops on the content of mineral components in grain of spring wheat cv. Koksa.

MATERIAL AND METHODS

The experimental material was grain of spring wheat of cultivar Koksa, obtained from a field experiment conducted in 2008-2010 at the Experimental Farm in Uhrusk (51°18'12"N, 23°36'50"E) of the University of Life Sciences in Lublin. The above cultivar belongs to the class of high quality wheat (A) with good milling quality and very good flour strength as well as with high resistance to sprouting.

The experiment was conducted on limestone soil formed from light clay rich in available forms of phosphorus and potassium, of a slightly alkaline pH (pH=7.2). The experimental factors were: 1) systems of soil tillage: ploughing and ploughless, 2) doses of nitrogen: 90 and 150 kg ha^{-1}, and 3) preceding crop: pea and soy. Soil tillage in the ploughing system consisted in cultivation skimming after preceding crop harvest and deep fall ploughing. In the springtime, the soil cultivation included harrowing, pre-sowing nitrogen fertilization and ploughing pre-sowing preparation with a cultivation kit. For comparison, soil tillage in the ploughless system involved the substitution of skimming and fall ploughing by spraying Roundup 360 SL herbicide (active subtsance glifosat) in a dose of 4 dm^3 ha^{-1}, whereas cultivating measures applied in the springtime were the same as in the ploughing system. Fertilization with nitrogen was applied in two doses, i.e. 90 and 150 kg ha^{-1}, and on 4 dates. The standard dose (90 kg) was divided as follows: 1 – before sowing 40 kg ha^{-1}, 2 – propagation stage (23/24 in the BBCH scale) 20 kg ha^{-1}, 3 – shooting stage (32/33 in the BBCH scale) 20 kg ha^{-1}, 4 – ear formation stage (52/53 in the BBCH scale) 10 kg ha^{-1}. The higher dose of nitrogen (150 kg ha^{-1}) was applied at the same stages, with the broadcasting doses of 60, 40, 30 and 20 kg ha^{-1}.

Plant protection measures were identical on all plots and consisted in the eradication of fungal diseases with Alert 375 SC fungicide (flusilazole + + carbendazim) applied in a dose of 1.0 dm^3 ha^{-1} at the shooting stage (32/33 BBCH) and Tilt Plus 400 EC (propiconazol + fenpropidin) – 1.0 kg ha^{-1} at the ear formation stage (53/54 BBCH). Weed eradication in the wheat fields was performed with Aminopielik D 450 SL herbicide (2,4-D + dicamba) applied in a dose of 3.0 dm^3 ha^{-1} at the propagation stage of wheat (23/24 BBCH).

Determinations of the content of mineral components in wheat grain were conducted after dry mineralization of the samples at a temperature of 600°C. The resultant ash was dissolved in 5 mL of 6M HCl, then filled up to the volume of 50 ml with redistilled water. Measurements were carried out with Atomic Absorption Spectrometry, with excitation in acetylene-air flame in a UNICAM 939 apparatus.

The results were elaborated statistically with the analysis of variances, whereas differences were estimated with Tukey's test at a significance level of p=0.05.

RESULTS AND DISCUSSION

The content of mineral components in grain of spring wheat was found to be differentiated by the applied soil tillage systems (Table 1). The grain originating from ploughless tillage was characterized by a significantly higher content of total ash (1.85%) than that from plots cultivated in the ploughing system (1.77%). Likewise, Kraska (2011) demonstrated a higher content of ash in wheat grain originating from fields subjected to conservation (ploughless) rather than to intensive (ploughing) tillage. It may thus be speculated that the ash content of the grain of wheat cultivated in the ploughless system is determined by a poorer development of the kernel endosperm compared to the grain from plots with the ploughing tillage. Also our previous study (Wo•niak 2010) demonstrated that wheat grain from plots with

Table 1

Mineral content in grain of spring wheat cv. Koksa depending on the soil tillage systems (means from 2008-2010)

Specification	Soil tillage systems		Mean
	ploughing	ploughless	
Total ash (%)	1.77 *a**	1.85 *b*	1.81
P (g kg^{-1})	2.59 *a*	2.56 *a*	2.58
K (g kg^{-1})	3.36 *a*	3.29 *b*	3.32
Mg (g kg^{-1})	1.13 *a*	1.03 *b*	1.08
Ca (g kg^{-1})	0.56 *a*	0.57 *a*	0.57
Fe (mg kg^{-1})	40.42 *a*	40.16 *a*	40.29
Zn (mg kg^{-1})	34.07 *a*	35.71 *b*	34.89
Mn (mg kg^{-1})	25.76 *a*	24.18 *b*	24.97
Cu (mg kg^{-1})	6.62 *a*	7.21 *b*	6.92

* Means followed by the same letter are not significantly different at p=0.05.

ploughless tillage was characterized by lower density and poorer uniformity than grain from ploughing tillage.

The ploughless soil tillage caused a significant increase in the content of Zn and Cu in grain, as compared to the ploughing system. The reason was that the availability of microelements in well-aerated soils is lower than in less-aerated soils, hence it may be presumed that multiple aeration of ground in the ploughing system depressed the availability of Zn and Cu, unlike in the ploughless tillage. In turn, in the ploughing system the grain was characterized by higher content of K, Mg and Mn. The higher concentration of K and Mg in the grain may be explained by their higher availability to plants for they more easily migrate into deeper soil layers, especially of the intensively pulverized soil in the ploughing system. The availability of manganese (Mn) was diminished in both cases due to the alkaline pH of soil. The differentiated content of Mn in grain may be attributed to a different moisture content of soil in both tillage systems.

Furthermore, the content of mineral components in wheat grain were observed to be differentiated by nitrogen fertilization (Table 2). Grain from the plots fertilized with the higher dose of nitrogen (150 kg ha^{-1}) was characterized by a significantly higher content of ash and Mn than grain from plots fertilized with the standard nitrogen dose (90 kg ha^{-1}). Similar dependencies were observed by Jackowska and Borkowska (2002). In turn, the standard dose of nitrogen led to a significant increase in the content of K, Fe, Zn and Cu in grain compared to the higher nitrogen dose. As indicated by the literature data, low content of nitrogen in soil restricts the availability of some microelements, and thereby decreases their content in grain (Jackowska and Borkowska 2002).

Table 2

Mineral content in grain of spring wheat cv. Koksa depending on the dose of nitrogen (means from 2008-2010)

Specification	Dose of nitrogen (kg ha^{-1})		Mean
	90	150	
Total ash (%)	1.79 *a**	1.85 *b*	1.82
P (g kg^{-1})	2.62 *a*	2.57 *a*	2.59
K (g kg^{-1})	3.32 *a*	3.18 *b*	3.25
Mg (g kg^{-1})	1.11 *a*	1.07 *a*	1.09
Ca (g kg^{-1})	0.57 *a*	0.56 *a*	0.57
Fe (mg kg^{-1})	41.69 *a*	39.86 *b*	40.78
Zn (mg kg^{-1})	36.16 *a*	35.04 *b*	35.60
Mn (mg kg^{-1})	24.46 *a*	25.01 *b*	24.74
Cu (mg kg^{-1})	7.32 *a*	7.01 *b*	7.17

*Designations as in Table 1.

The content of ash as well as macro- and microelements in the grain examined was also significantly affected by the preceding crops (Table 3). On the plots with soy grown before wheat, the wheat grain was characterized by significantly higher content of total ash, K and Mn than on the plots with pea as the preceding crop. In contrast, grain of wheat cultivated after pea was characterized by considerably higher content of Ca, Fe and Zn. In a study by GONTARZ (2006), the highest content of ash was reported in grain of spring wheat harvested from a plot after 3 consecutive self-forecrops, whereas a significantly lower one – after pea followed by potato and single self-forecrop. The content of ash and minerals was also differentiated by the year of study and advanced agricultural technology. The intensive level of agricultural measures (increased fertilization with nitrogen and chemical protection against macrophages) resulted in an increased ash content of the grain, compared to the minimal level.

Table 3

Mineral content in grain of spring wheat cv. Koksa depending on the preceding crop (mean from 2008-2010)

Specification	Forecrop		Mean
	pea	soy	
Total ash (%)	1.76 *a**	1.88 *b*	1.82
P (g kg^{-1})	2.66 *a*	2.53 *a*	2.59
K (g kg^{-1})	2.89 *a*	3.62 *b*	3.25
Mg (g kg^{-1})	1.09 *a*	1.09 *a*	1.09
Ca (g kg^{-1})	0.59 *a*	0.54 *b*	0.57
Fe (mg kg^{-1})	42.43 *a*	39.11 *b*	40.77
Zn (mg kg^{-1})	37.30 *a*	33.89 *b*	35.60
Mn (mg kg^{-1})	24.35 *a*	25.15 *b*	24.75
Cu (mg kg^{-1})	7.14 *a*	7.19 *a*	7.16

*Designations as in Table 1.

CONCLUSIONS

1. The content of mineral compounds in the grain of spring wheat cv. Koksa was found to be differentiated by soil tillage systems. Ploughless tillage facilitated the accumulation of total ash, Zn and Cu, whereas ploughing tillage encouraged the accumulation of K, Mg and Mn in the grain.

2. The standard dose of nitrogen (90 kg ha^{-1}) raised the content of K, Fe, Zn and Cu in the grain of spring wheat, whereas the higher dose of nitrogen (150 kg N ha^{-1}) elevated the content of total ash and Mn.

3. The content of minerals in the grain of spring wheat significantly depended on a preceding crop. On the plot with pea grown before wheat, the wheat grain was characterized by significantly higher content of Ca, Fe and Zn, whereas on the plot with soy as a forecrop, the content of total ash, K and Mn was higher.

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