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Marzena GIBCZYŃSKA[1], *Andrzej DAWIDOWSKI*[2], *Magdalena SOBOLEWSKA*, *Anna JAROSZEWSKA*, *Leokadia LEWANDOWSKA*[1]

ANALYSIS OF INFLUENCE FARMING SYSTEMS ON CHEMICAL COMPOSITION OF FOUR VARIETY OF TRITICALE WINTER (*XTRITICOSECALE WITTM. EX A. CAMUS*) GRAIN

ANALIZA WPŁYWU SYSTEMÓW UPRAWY NA SKŁAD CHEMICZNY ZIARNA CZTERECH ODMIAN PSZENŻYTA OZIMEGO *(XTRITICOSECALE WITTM. EX A. CAMUS*)

Department of Agronomy, West Pomeranian University of Technology, Szczecin, Poland
[1]Department of General and Ecological Chemistry, West Pomeranian University of Technology, Szczecin, Poland
[2]Grupa Azoty Zakłady Chemiczne „Police" SA, Police, Poland

Streszczenie. Celem badań, przeprowadzonych na podstawie wyników doświadczenia polowego, było porównanie efektów uprawy pszenżyta ozimego w systemach rolnictwa ekologicznego i konwencjonalnego. Porównując oba systemy uprawy, analizowano zmiany zawartości w ziarnie pszenżyta makroskładników: fosforu, potasu, wapnia, magnezu i mikroskładników: manganu, żelaza, cynku i miedzi. Badania dotyczyły ziarna czterech odmian pszenżyta: Benetto, Cultivo, Grenado i Moderato. Doświadczenia polowe przeprowadzono w latach 2010–2011 w Krajowym Instytucie Badawczym do spraw Rybactwa i Rybołówstwa Meklemburgii – Pomorza Przedniego w Gülzow w Niemczech. Ziarno wszystkich odmian pszenżyta, uprawianego w systemie ekologicznym, zawierało więcej fosforu i magnezu. Porównywane systemy uprawy nie różnicowały ilości wapnia i potasu w ziarnie pszenżyta ozimego odmian Benetto, Cultivo, Grenado i Moderato. Nie odnotowano zależności między ogólną zawartością fosforu, wapnia i magnezu a uprawianą odmianą. Ilość potasu ogólnego w ziarnie pszenżyta ozimego różnicował czynnik odmianowy. Ziarno pszenżyta wszystkich czterech odmian uprawianych w systemie ekologicznym charakteryzowało się wyższą, o kilkanaście procent, zawartością żelaza, cynku, manganu i miedzi, w porównaniu z systemem konwencjonalnym.

Key words: winter triticale, macroelements, microelements, farming systems.
Słowa kluczowe: pszenżyto ozime, makroskładniki, mikroskładniki, systemy gospodarowania.

INTRODUCTION

Winter triticale (*xTriticosecale Wittm. ex A. Camus*) is a cereal hybrid from *Poaceae* family. Infertile of wheat and rye hybrids were produced and described for the first time in 1875 as a result of pollination the wheat using rye pollen by an amateur botanist Wilson in Scotland. In 1891 German botanist Rimpau discovered and described prolific triticale hybrid (Ammar et al. 2004). Triticale is a relatively young cereal species and until recently it was

Corresponding author – Adres do korespondencji: Prof. Marzena Gibczyńska, Department of General and Ecological Chemistry, West Pomeranian University of Technology, Szczecin, Juliusza Słowackiego 17, 71-434 Szczecin, Poland, e-mail: Marzena.Gibczynska@zut.edu.pl.

used only for animal feed production. Today, it is increasingly used to make bread (Iwański 2010). Many authors indicate to use it for replacing the wheat bread (Cеglińska et al. 2003, Mierzejewska et al. 2015). This is supported by its greater resistance to stress, and resistance to poor growing conditions (Estrada-Campuzano et al. 2008). According to GUS data, the acreage of winter triticale cultivation in Poland was 1052 thousand hectares in 2014 (GUS 2015). Germany is second after Poland producer of triticale (Food and agriculture organization of the united nations statistics division, http://faostat3.fao.org.).

Winter triticale varieties grown in Germany are, among others: Benetto, Cultivo, Grenado and Moderato. The Benetto cv. triticale (syn. Sorento) is registered in three countries: Germany, Great Britain, and Slovakia. In Poland, this variety was listed in the register in 2002, and the expiry date of entry was set at 2022 (Gacek 2015). The Cultivo cv. triticale was registered in 2007 in Germany (Breeding Station Lantmännen SW See). It is very compact cultivar with very good frost resistance and above-average quality of the grain; it is distinguished by an outstanding and unprecedented health status among other triticale (Pszenżyto ozime Cultivo krótkosłome, http://osadkowski.pl/). Grenado cv. is the most common in Europe and was awarded with The Gold Medal MTP FARMA in Poznań in 2007. This is a semi-dwarf variety and its advantage is high resistance to soil acidity, which makes that Grenado cv. can also be grown on poor soils. It has very good resistance to lodging. The variety is grown in Poland, France, Germany, and England. In Poland, this variety was registered in 2007 (Gacek 2015). Moderato cv. is the winter triticale cultivar with very high prolificacy. It yields very well on poorer soils and is characterized by good health quality and resistance to fungal diseases. The variety has traditional long straw. Grain of Moderato cv. is of medium thickness with higher protein content, which is why this variety is useful in animal nutrition.

For many years, there is conducted the research on the quality of plant products grown in organic farming system. In September 2005 in Adelaide (Australia), IFOAM General Assembly adopted a resolution concerning a concise definition of organic farming. Organic farming is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions and not using resources with the adverse effects (Definition-Organic-Agriculture, http://www.ifoam.bio). The assumption of this system is mimicking the processes occurring in natural ecosystems both in qualitative and quantitative terms. In organic farming, during the self-regulating natural cycles, crops with high biological quality, comparable to the quality of raw materials derived from natural ecosystems are expected. In contrast to conventional agriculture based on the use of mineral fertilizers, narrow specialization and maximum intensification, the primary goal of organic agriculture is to produce without agrochemicals. It is aimed at achieving the agricultural crops with high nutritional value, while reducing the contamination of agricultural and aqueous environments (Gibczyńska et al. 2002).

The aim of the study carried out on the basis of a field experiment was to compare results obtained during cultivation of winter triticale in the organic and conventional farming systems. Comparing these two systems (organic vs. conventional), changes in the content of macroelements (phosphorus, potassium, calcium, magnesium), and microelements (manganese, iron, zinc and copper) were analyzed in the triticale grain. The study involved four triticale varieties: Benetto, Cultivo, Grenado, and Moderato.

MATERIAL AND METHODS

Conditions of the experiment conducting

The field experiment was performed in 2010–2011 at The National Research Institute for Fisheries Affairs Mecklenburg – Vorpommern in Gülzow (φ = 53°47′N, λ = 12°03'E), Germany. The test plant was winter triticale (Wittm. ex A. Camus). The experiment consisted of two factors: I – four triticale varieties: Benetto, Cultivo, Grenado, and Moderato as well as II – two tillage systems: organic and conventional. Experimental pattern: split plot, number of replicates: 3. The plot area: $24m^2$. The experiment plot was established on the light soil loamy sand and humus content 1.4% (PTG 2011). The experimental soil can be classified as weak acidic – pH KCl = 6.5 (PN-ISO 10390:1997P). Nitrogen total content in soil was 130 mg $N \cdot kg^{-1}$. Moreover, the soil contained phosphorus available 42.0 mg $P \cdot kg^{-1}$ and its abundance can be assessed as poor, while potassium available quantity amounted to 117.0 mg $K \cdot kg^{-1}$, which was medium level.

In organic tillage system of winter triticale, the pre-crop consisted of the mixture of clover with grass, while in conventional system – winter barley. Conventional system used nitrogen fertilization at the amount of 160 kg $N \cdot ha^{-1}$, whereas organic tillage applied manure for fertilization. In conventional system, the plant protection included herbicide Malibe at the dose of 4 $dm^3 \cdot ha^{-1}$, growth regulator CCC 1.2 $dm^3 \cdot ha^{-1}$, and Camposan extra 0.7 $dm^3 \cdot ha^{-1}$.

Plants were sown in the end of September and harvest at the beginning of August in both years of study. The triticale cultivation was carried out in accordance to commonly accepted agricultural practices. Grain samples were collected after harvest using combine-harvester at the amount of 2.5 kg from each plot. Analyses were performed using combined samples made of 3 replicates.

Methodology of chemical analysis

The grain was analysed as for the total content of macroelements i.e. phosphorus, potassium, calcium, magnesium, and microelements i.e. manganese, iron, zinc, cooper**.** Total elements (K, Ca, Mg, Fe, Mn, Zn and Cu) were determined in the seeds after mineralised in a mixture of nitric(V) and chloric(VII) acids in 1 : 1 proportion. The contents of potassium, calcium, magnesium, manganese, iron, zinc and cooper were determined with the use of atomic Absorption Spectrometer apparatus (Thermo Fisher Scientific ICE 3000 Series). Phosphorus was determined by calorimetrically with ammonium molybdate, at wavelength 470 nm (PN -76/R-64781, 1976).

Statistical analysis

The results were statistically analysed with the use of analysis of variance of a completely randomised design. Replications were results from 2 years of investigation. Tukey's confidence half-intervals were calculated at the level p = 0.05. The statistical analysis of the results was conducted using Statistica 10 software.

Climatic conditions

Mean temperature recorded in the during the period of plant growthin the years 2010 and 2011 was similar to the mean from the period 1980–2009 (Table 1).

Table 1. Temperature and sum of rainfall during spring vegetation season in Station in Gülzow compared to muli-year 1980–2009
Tabela 1. Temperatura i sumy opadów w okresie wegetacyjnym, w porównaniu ze średnią wieloletnią (Stacja Gülzow)

Month – Miesiąc	Average monthly temperaturę Średnia temperatura miesięczna [°C]			Average monthly rainfall Średni opad miesięczny [mm]		
	2010	2011	1980–2009	2010	2011	1980–2009
January – Styczeń		1.4	–1.1		36.8	28.6
February – Luty		0.4	–0.4		25.8	28.7
March – Marzec		4.0	3.4		11.5	29.5
April – Kwiecień		11.5	7.5		16.8	31.2
May – Maj		13.8	13.1		36.0	47.4
June – Czerwiec		17.2	16.2		82.2	62.8
July – Lipiec	21.7		18.1	55.2		70.9
August – Sierpień	17.6		13.4	147.7		47.7
September – Wrzesień	13.2		8.7	76.7		32.3
October – Październik	8.8		8.6	34.3		38.9
November – Listopad	4.7		3.7	101.7		42.8
December – Grudzień	–4.3		0.4	25.4		42.1

The amount of precipitation in August and December of 2010 was much higher than that recorded in the multiannual period. In 2011, the amount of precipitation was lower than that recorded for the multiannual period – the period of plant growthin can be classified as very dry (69.7% of the mean value) – Kirschenstein and Baranowski (2010).

RESULTS AND DISCUSSION

Contents of macroelements

Both phosphorus and potassium are elements playing a key role in plant physiological processes taking part mainly in photosynthesis (Marschner 1995). A proper phosphorus nutrition is a determinant of an effective water balance of plants. Quantity of phosphorus and potassium in triticale grain is about 3–5 g $\cdot$ kg^{-1}. Relatively low content of phosphorus in the soil was factor that all triticale varieties grown in the experiment were also characterized by low level of this element in grain and no dependence between total phosphorus content and triticale variety, was noted. Average phosphorus concentration in grain of test plants was 2.85 g P $\cdot$ kg^{-1} d.m. (Table 2). Statistical analysis confirmed the impact of tillage system on phosphorus content in triticale grain. Grain of all tested triticale cultivars grown in organic system contained more phosphorus; the comparison of mean values revealed 25%.

Potassium as a component that is uptaken by plants at large quantities, affects the plant's wintering and controls the water balance, thus enhances the plant's resistance to drought. Grain of winter triticale was characterized by high content of potassium and its mean value was 5.05 g K $\cdot$ kg^{-1} d.m., presumably it was the result of plant's varietal features and soil abundance in this element. Results subject to statistical processing did not reveal any significant influence of the tillage system on potassium content in winter triticale grain (Table 2). According to the remark presented by Ścigalska et al. (2000) that content of the total potassium in triticale grain is differentiated by the varietal factor, grain of experimental winter triticale varieties (Benetto, Cultivo, Grenado, and Moderato) also contained different amounts of total potassium. The most abundant appeared to be Grenado cv. containing 5.48 g K $\cdot$ kg^{-1} d.m., on average (Table 2). Dziamba et al. (2001), when analyzing the chemical composition of winter triticale grain of two cultivars (Presto and Bogo) in a view of some macronutrient contents, lined up their concentrations in a following sequence: K > Mg > Ca.

Table 2. Influence of farming systems (FS) and variety (V) on content macroelements in winter triticale grain [g · kg^{-1} d.m.]. Mean for 2010–2011
Tabela 2. Wpływ systemu uprawy (SU) i odmiany (O) na zawartość makroskładników w ziarnie pszenżyta [g · kg^{-1} s.m.]. Średnia dla lat 2010–2011

Element Pierwiastek	Farming systems System uprawy	Variety – Odmiany				Mean Średnia
		Benetto	Cultivo	Grenado	Moderato	
Phospohorus Fosfor	organic ekologiczny	3.14	3.30	3.27	2.98	3.17
	conventional konwencjonalny	2.34	2.70	2.69	2.40	2.53
Mean Średnia		2.74	3.00	2.98	2.69	2.85
$LSD_{0.05}$ for – dla:		FS – 0.42 V – n.s. FS x V – n.s.				
Potassium Potas	organic ekologiczny	4.81	4.67	5.74	4.81	5.01
	conventional konwencjonalny	5.02	4.67	5.23	5.41	5.08
Mean Średnia		4.91	4.67	5.48	5.11	5.05
$LSD_{0.05}$ for – dla:		FS – n.s. V – 0.35 FS x V – 0.55				
Calcium Wapń	organic ekologiczny	0.29	0.31	0.28	0.26	0.29
	conventional konwencjonalny	0.31	0.24	0.29	0.21	0.26
Mean Średnia		0.30	0.27	0.28	0.24	0.27
$LSD_{0.05}$ for – dla:		FS – n.s. V – n.s. FS x V – n.s.				
Magnesium Magnez	organic ekologiczny	1.04	0.97	1.20	0.91	1.03
	conventional konwencjonalny	0.85	0.84	0.90	0.79	0.85
Mean Średnia		0.95	0.91	1.05	0.85	0.94
$LSD_{0.05}$ for – dla:		FS – 0.12 V – n.s. FS x V – n.s.				

n.s. – not significant difference – r.n. – różnica nieistotna.

The average concentration of calcium in winter triticale grain was 0.27 mg Ca · kg^{-1} d.m., which was relatively low. For instance, Brzozowska (2006) in work analyzing the effect of herbicides and nitrogen fertilization manner on macroelements contents in grain of winter triticale, reported that for Bogo cv., the amount of calcium was at low level of about 0.5 mg Ca · kg^{-1} d.m. Compared cultivation systems, as well as varieties, did not differentiate the calcium content in winter triticale grain. Calcium concentration in grain of triticale remained at a stable level. This dependence correlates with the proposal presented by Gibczyńska et al. (2002), who did no fine any univocal interrelation between amount of exchangeable calcium form in soils and type of the farming system (organic vs. conventional).

Mean magnesium content in winter triticale grain amounted to 0.94 Mg · kg^{-1} d.m. The study results revealed the influence of the cultivation system on magnesium amount in grain of winter triticale. Grain of all tested triticale varieties grown in organic system contained more magnesium, and comparison of average values gave 21% (Table 2). Convergent data were presented by Nazaruk et al. (2009): based on the studies upon hay in Poland, they unveiled that feed from organic farms contained larger number of samples with higher phosphorus, calcium, and magnesium contents. Like for calcium, tested cultivars did not differentiate magnesium concentration in winter triticale grain. Some explanation of this convergence can be the fact that both metals are from the same group of periodic table and are subject to the same chemical reactions.

Analysis of phosphorus, calcium, and magnesium amounts changes in grain of winter triticale (Benetto, Cultivo, Grenado, and Moderato) did not show any interaction between farming systems vs. varieties (Table 2).

Contents of microelements

Macroelements play in a plant mainly the structural functions, while microelements enter numerous enzymes or their activators and take part in regulation of biochemical processes (Zarzecka 2004).

Iron in plants can be found on the second and third oxidation level and both cations (Fe^{3+} and Fe^{2+}) act as catalysts, namely in nucleic acid metabolism. Among four observed microelements in winter triticale grain, iron occurred in largest quantities as compared to other microelements, i.e. from 30.3 to 46.0 mg Fe · kg^{-1} d.m. The most iron (40.0 mg Fe · kg^{-1} d.m., on average) was found in grain of Grenado cv. Ścigalska et al. (2011), when testing winter triticale of Woltario cv. reported that iron content in grain amounted to about 43.9–52.5 mg Fe · kg^{-1} d.m. The statistical analysis results indicated higher content of this element in grain of Grenado cv. (Table 3). Analyzing the influence of the tillage system, average quantity of iron in grain of winter triticale grown in organic system was by 11% higher (Table 3).

Basic functions of zinc in the plant are related to the synthesis of carbohydrates, proteins, and phosphates (Lindsay 1972). According to Kabata-Pendias (2011), mean zinc content in wheat and barley grain amounts respectively to 24 and 26 mg Zn · kg^{-1} Bednarek et al. (2008) reported that cereal grain contain relatively large quantities of the metal (wheat – 27; rye – 31; oats – 29; triticale – 22 mg · kg^{-1} d.m.). Kucharczyk and Moryl (2010) based on the study related to the assessment of metal contents at plants originating from the area of Mine and Power Plant 'Turów' influences, reported average zinc content for triticale grain as 18 mg Zn · kg^{-1} d.m. Concentration of zinc in grain of four tested winter triticale cultivars (Benetto, Cultivo, Grenado, and Moderato) was from 19.8 to 30.9 mg Zn · kg^{-1} d.m. indicating a good grain abundance in this microelement and at the same time differentiation dependent on the cultivar. Jeroch et al. (1993) found that intensively fertilized pasture grasses contain 30 mg Zn · kg^{-1} d.m. and achieved results confirm the usefulness of triticale as a fodder. Except from Cultivo cv., grain of other three triticale varieties grown in organic farming system contained more zinc and comparison of average values revealed the difference of 16% (Table 3).

Manganese is considered one of the most important catalysts in photosynthesis processes at C3-type plants, to which all cereals belong. In general, manganese quantity in cereal grain in Poland ranges within 10–45 mg · kg^{-1} d.m. (Kabata-Pendias 2011). Content of manganese in grain of the four tested triticale cultivars was lower and amounted from 3.74 to 8.96 mg Mn · kg^{-1} d.m. Achieved study results are the confirmation of the thesis that manganese concentration of triticale grain is differentiated by the varietal features. The largest amounts of manganese at the level of 8 mg Mn · kg^{-1} d.m was determined in grain of Cultivo cv. triticale, while the lowest for Moderato cv. (Table 3). When comparing the mean manganese contents, grain of winter triticale grown under organic system conditions contained by 13% more this element than from conventional farming system (Table 3).

Table 3. Influence of farming systems (FS) and variety (V) on content micro-elements in winter triticale grain [mg · kg^{-1} d.m.]. Mean for 2010–2011
Tabela 3. Wpływ systemu uprawy (SU) i odmiany (O) na zawartość mikroskładników w ziarnie pszenżyta [mg · kg^{-1} s.m.]. Średnia dla lat 2010–2011

Element Pierwiastek	Farming systems System uprawy	Variety – Odmiany				Mean Średnia
		Benetto	Cultivo	Grenado	Moderato	
Iron Żelazo	organic ekologiczny	38.2	38.1	46.0	37.0	39.8
	conventional konwencjonalny	40.2	38.3	33.9	30.3	35.7
Mean Średnia		39.2	38.2	40.0	33.7	37.8
$LSD_{0.05}$ for – dla:		FS – 2.95 V – 4.52 FS x V – 6.26				
Zinc Cynk	organic ekologiczny	32.1	26.8	30.1	21.9	27.7
	conventional konwencjonalny	21.1	30.9	19.8	23.5	23.8
Mean Średnia		26.6	28.9	25.0	22.7	25.8
$LSD_{0.05}$ for – dla:		FS – n.s. V – 0.35 FS x V – 0.55				
Manganese Mangan	organic ekologiczny	6.88	8.96	7.72	5.06	7.16
	conventional konwencjonalny	7.32	7.80	6.47	3.74	6.33
Mean Średnia		7.10	8.38	7.10	4.40	6.74
$LSD_{0.05}$ for – dla:		FS – 0.52 V – 0.67 FS x V – 0.88				
Cooper Miedź	organic ekologiczny	3.32	3.50	3.43	3.22	3.37
	conventional konwencjonalny	2.87	2.99	3.08	2.74	2.92
Mean Średnia		3.10	3.25	3.26	2.98	3.14
$LSD_{0.05}$ for – dla:		FS – 0.31 V – n.s. FS x V – n.s.				

n.s. – not significant difference – r.n. – różnica nieistotna.

For plants, copper is only available in the form of Cu^2+ ion and relatively less mobile. The role of copper in cereals is multidirectional and it is an important factor in the prevention of plant health. According to Bednarek et al. (2008), mean copper content in cereal grain in not polluted regions is 3.7 mg · kg^{-1} d.m. Kabata-Pendias (2011) claim that copper concentration in Polish cereals ranges from 2.6 to 6.0 mg · kg^{-1} d.m. Present study showed that copper content in winter triticale grain was within above range oscillating from 2.74 to 3.50 mg · kg^{-1} d.m., which was about 10 times lower than that of zinc. Metals are absorbed by the same mechanism and can mutually suppress absorption through the roots (Graham 1981). Statistical analysis of the study results shows a significant effect of tillage system. Triticale grain of all four varieties (Benetto, Cultivo, Grenado, and Moderato) grown under organic system was characterized by higher copper content than in conventional farming; comparing the average values, the difference was 15%. Referring to the copper abundance, no influence of the four tested cultivars on changes in the element content in winter triticale grain, was observed (Table 3).

Analysis of the microelements changes in winter triticale grain (Benetto, Cultivo, Grenado, and Moderato) revealed that only in the case of copper, no interaction between farming systems and varieties, was found (Table 3).

CONCLUSIONS

1. Grain of all triticale varieties grown in an organic manner contained more phosphorus and magnesium and comparing the average values, differences were 25% and 21%, respectively. Compared tillage systems did not differentiate calcium and potassium concentrations in grain of winter triticale varieties (Benetto, Cultivo, Grenado, and Moderato).
2. When analyzing the macroelements contents in the grain of triticale varieties (Benetto, Cultivo, Grenado, and Moderato), there was no relationship between overall content of phosphorus, calcium and magnesium vs. cultivated variety. The total potassium amount in triticale grain was differentiated by the varietal factor, the most abundant triticale variety was Grenado cv.
3. Referring to the three studied microelements (iron, zinc and manganese), a relationship between their total contents and cultivated variety as well as cultivation system, was recorded. Grain of all four triticale cultivars (Benetto, Cultivo, Grenado, and Moderato) grown in the organic system was characterized by higher, by several percent, content of these metals as compared with conventional farming system.
4. Grain of all four triticale varieties (Benetto, Cultivo, Grenado, and Moderato) grown in organic manner was characterized by higher copper concentration than in conventional system, as well as no differentiation due to the varietal feature, was observed.

REFERENCES

Ammar K., Mergoum M., Rajaram S. 2004. The history and evolution of triticale, in: Triticale improvement and production. Eds. M. Mergoum, H. Gomez Macpherson. Rome, FAO Plant Production and Protection Paper, 1–10.

Bednarek W., Tkaczyk P., Dresler S. 2008. Zawartość metali ciężkich jako kryterium oceny jakości ziarna pszenicy ozimej [Heavy metals contents as a criterion for assessment of winter wheat grain quality]. Acta Agrophys. 12(2), 315–326. [in Polish]

Brzozowska I. 2006. Wpływ herbicydów i sposobu nawożenia azotem na zawartość makroelementów w ziarnie pszenżyta ozimego [Influence of herbicides and nitrogen application method on the content of macroelements in winter triticale grain]. Pam. Puł. 142, 9–17. [in Polish]

Ceglińska A,. Cacak-Pietrzak G., Haber T. 2003. Porównanie jakości pieczywa pszenżytniego, pszennego i żytniego [Comparison of the quality of wheat rye, wheat and rye]. Prz. Piekar. Cukier. 11, 4–6. [in Polish]

Definition-Organic-Agriculture, http://www.ifoam.bio/en/organic-landmarks/definition-organic-agriculture, access: 01.02.2016.

Dziamba J., Jackowska I., Małuszyńska E., Kwiatkowski J. 2001. Następczy wpływ pochodzenia materiału siewnego na skład chemiczny ziarna pszenżyta [Consequent influence of sowing material origin on chemical composition of triticale grain]. Biul. Inst. Hod. Rośl. 218/219, 293–297. [in Polish]

Estrada-Campuzano G., Miralles D., Slafer G.A. 2008. Genotypic variability and response to water stress of pre- and post-anthesis phases in triticale. Eur. J. Agron. 28(3), 171–177.

Food and agriculture organization of the united nations statistics division, http://faostat3.fao.org, access: 01.02.2016.

Gacek E.S. 2015. Lista odmian roślin rolniczych. Słupia Wielka, Centralny Ośrodek Badania Odmian Roślin Uprawnych, 49–50. [in Polish]

Gibczyńska M., Bural G., Mocarski N. 2002. Ocena zawartości kationów wymiennych w glebie z gospodarstw ekologicznego i konwencjonalnego [Assay of exchangeable cation content in soil of an ecological and conventional farm]. Folia Univ. Agric. Stetin., Agricultura. 226(90), 43–50. [in Polish]

Graham R.D. 1981. Absorption of copper by plant roots, in: Copper in Soils and Plants. Eds. J.F. Loneragan, A.D. Robson, R.D. Graham. New York, Academic Press, 141.

GUS. 2015. Rocznik Statystyczny Rzeczypospolitej Polskiej 2015 [Demographic Statistical Yearbook of the Republic Poland 2015]. [in Polish]

Iwański R. 2010. Wyroby piekarskie z mąk niestandardowych, http://www.food.rsi.org.pl/dane/Wyroby_piekarskie.pdf, access: 01.02.2016. [in Polish]

Jeroch H., Flachowsky G., Weissbach F. 1993. Futtermittelkunde. Stuttgart, Fischer Verlag Jena.

Kabata-Pendias A. 2011. Trace elements in soil and plants. [b.m.], CRC Press, Taylor & Francis, 1–505.

Kirschenstein M., Baranowski D. 2010. Częstość okresów przeciętnych, suchych i wilgotnych w Słupsku [The frequency of average, dry and wet periods in Słupsk]. Słup. Pr. Geogr. 7, 103–114. [in Polish]

Kucharczak E., Moryl A. 2010. Zawartość metali w roślinach uprawnych pochodzących z rejonu zgorzelecko-bogatyńskiego. Cz. 2. Arsen, chrom, cynk, miedź [Contents of metals in cultivated plants in Zgorzelec-Bogatynia region. Parts 2. Arsenic, chromium, zinc, copper]. Ochr. Śr. Zas. Natur. 43, 7–16. [in Polish]

Lindsay W.L. 1972. Zinc in soils and plant nutrition. Adv. Agron. 24, 147–186.

Marschner H. 1995. Mineral Nutrition of higher plants. London, Academic Press, 66.

Mierzejewska S., Bać S., Kopeć A. Jaroszewicz E., Przepórka-Stepuk J. 2015. Badanie przydatności mąki i śruty pszenżytniej, jako surowców do produkcji chleba [Study the suitability of flour and grinding triticale grain as raw materials for bread production]. Inż. Przetwór. Spoż. 2/4, 21–23. [in Polish]

Nazaruk M., Jankowska-Huflejt H., Wróbel B. 2009. Ocena wartości pokarmowej pasz z trwałych użytków zielonych w badanych gospodarstwach ekologicznych [Evaluation of nutritive value of fodders from permanent grasslands in organic farms]. Woda Środ. Obszar. Wiej. 1(25), 61–76. [in Polish]

PN -76/R-64781. 1976. Pasze sypkie. Oznaczanie fosforu. [in Polish]

PN-ISO 10390: 1997P. Jakość gleby. Oznaczanie pH. [in Polish]

Pszenżyto ozime Cultivo krótkosłome, http://osadkowski.pl/upload/cultivo-1028.pdf, access: 01.02.2016. [in Polish]

PTG. 2011. Systematyka gleb Polski [Polish spil classyfication]. Soil Sci. Ann. 62(3), 193. [in Polish]

Ścigalska B., Pisulewska E., Kołodziejczyk M. 2000. Zawartość makro- i mikroskładników w ziarnie odmian pszenżyta jarego [Content of macro- and microelements in grain of spring triticale cultivars]. Folia Univ. Agric. Stetin., Agricultura 206(82), 287–292. [in Polish]

Ścigalska B., Puła J., Łabuz B. 2011. Zawartość pierwiastków śladowych w ziarnie pszenżyta uprawianego w płodozmianie i monokulturach zbożowych [Content of trace elements in grains of triticale grown in crop rotation and cereal monocultures]. Fragm. Agron. 28(3), 112–119. [in Polish]

Zarzecka K. 2004. Zawartość żelaza i manganu w bulwach ziemniaków w zależności od sposobu zwalczania chwastów [Content of iron and manganese in tubers of potato cultivated using different weed control methods]. Acta Sci. Pol., Agricultura 3(1), 165–17. [in Polish]

Abstract. The aim of the study carried out on the basis of a field experiment was to compare results obtained during cultivation of winter triticale in the organic and conventional farming systems. Comparing these two systems (organic with conventional), changes in the content of macroelements (phosphorus, potassium, calcium, magnesium), and microelements (manganese, iron, zinc and copper) were analyzed in the triticale grain. The study involved four triticale varieties: Benetto, Cultivo, Grenado, and Moderato. The field experiment was performed in 2010–2011 at The National Research Institute for Fisheries Affairs Mecklenburg – Vorpommern in Gülzow, Germany. Grain of all triticale varieties grown in an organic systems contained more phosphorus and magnesium. Compared tillage systems did not differentiate calcium and potassium in grain of triticale Benetto, Cultivo, Grenado, and Moderato varieties. No relationship was found between the total content of phosphorus, calcium and magnesium vs. cultivars. The total potassium content in triticale grain was differentiated by the varietal factor. The triticale grain of all tested varieties (Benetto, Cultivo, Grenado, and Moderato) grown in organic system was characterized by higher – by ten or so per cents – iron, zinc, manganese, and copper contents as compared to the conventional systems.