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The grain quality of winter wheat in organic and conventional farming

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In the years 2003–2005 the field experiment was realized in the maize-barley growing region on degraded Chernozem. Two different farming systems – organic and conventional were compared. The yield and grain quality of winter wheat in organic and conventional farming system were evaluated. Winter wheat was used twice a crop rotation time – after pea and clover. The quality parameters of winter wheat (grain volume weight, protein content, Zeleny test, wet gluten content) were measured after harvest. The yield and grain quality parameters were statistically significantly affected by farming system, forecrop and weather conditions. Grain yield, grain volume weight, protein content and wet gluten content were significantly higher in conventional farming system than in organic one. Even though, grain quality of winter wheat in organic farming corresponded to elite (E) or standard (A) technological quality of wheat according to the Slovak Technological Standard STN 46 1100-2. The yield of winter wheat was increased and grain quality parameters were improved by using pea as the forecrop in comparison to clover.

Keywords: winter wheat, systems of farming, forecrop, yield, grain quality

1 Introduction

Winter wheat is one of the most important cereal crop in conventional and organic agriculture. It is used as food, fodder crop, raw material for production of starch, alcohol and many other products. Wheat is a crop suitable for warmer and dryer areas. Its requirements for a forecrop are high. The best forecrops are clover crops, legumes, root crops and oil plants.

The aim of study was to compare yield and grain quality parameters of winter wheat grown in organic and conventional farming system. The effect of forecrop (pea and clover) on yield and quality of grain was observed.

2 Material and Methods

In the years 2003–2005 the field experiment was realized at Research Station at Borovce near Piešťany. Two different farming systems – organic and conventional were compared. The crop rotation in both systems was the same: pea – winter wheat (catch crops phacelia and white mustard after harvest) – potato – spring barley (clover underseeding) – clover – winter wheat (catch crops phacelia and white mustard after harvest). Organic variant of crop growing was managed by the rules of organic agriculture.

The field experiment was realized in the maize-barley growing region on degraded Chernozem (pH 5.5–7.2, humus content 1.8–2.0 %, good reserve of available potassium, medium content of phosphorus, and high content of magnesium). The average annual air temperature is 9.2 °C (15.5 °C per vegetation period), the average annual sum of precipitation is 593 mm (358 mm per vegetation period).

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The variety of winter wheat Balada (quality class E – elite) was cultivated in both farming systems. The quality parameters of winter wheat grain (grain volume weight, protein content, Zeleny test, wet gluten content) were measured after harvest. The achieved results were evaluated by the statistical method of variance analysis.

3 Results

The average values of grain yield and quality parameters of winter wheat are presented in Table 1. The average yield of winter wheat was 5.7 t ha⁻¹. Grain yield was statistically significantly affected by weather conditions in 2003–2005. The highest value was reached in 2005 (6.79 t ha⁻¹). This year was standard in regard to average air temperature (9.62 °C per year, 16.84 °C per vegetation period) and rainy (average sum of precipitation 622.6 mm per year, 396.4 mm per vegetation period). On the contrary, the year 2003 was extremely warm (average air temperature 10.79 °C per year, 18.58 °C per vegetation period) and very dry (average sum of precipitation 384.3 mm per year, 210.1 mm per vegetation period). Therefore the grain yield in this year was the lowest (4.60 t ha⁻¹). The year 2004 was warm (average air temperature 10.04 °C per year, 16.57 °C per vegetation period) and dry (average sum of precipitation 470.7 mm per year, 202.1 mm per vegetation period).

Table 1 The average values of grain yield and quality parameters of winter wheat 2003–2005

	Farming system		Forecrop		Year		
	organic	convent.	pea	clover	2003	2004	2005
Grain yield (t ha ⁻¹)	5.55 a	5.87 b	5.98 a	5.44 b	4.60 a	5.76 b	6.79 c
Grain volume weight (g l ⁻¹)	814.81 a	819.96 b	821.04 a	813.73 b	802.69 a	846.56 b	802.91 a
Protein content (%)	11.74 a	12.18 b	12.42 a	11.50 b	13.13 a	10.85 b	11.90 c
Zeleny test (ml)	49.67 a	50.37 a	50.95 a	49.08 a	42.05 a	47.33 b	60.67 c
Wet gluten content (%)	32.13 a	34.62 b	34.90 a	31.85 b	39.86 a	30.34 b	29.92 b

The average values signed with different bold letters (**a b c**) are statistically significantly different at significance level $\alpha = 0.01$, the average values signed with different non-bold letters (a b c) are statistically significantly different at significance level $\alpha = 0.05$

Farming system significantly affected yield. In conventional system, there was higher value of grain yield (5.87 t ha⁻¹) than in organic one (5.55 t ha⁻¹). Some authors present 20–30 % decrease in yields in organic agriculture (Mäder et al., 2002; Lacko-Bartošová et al., 2005; de Ponti et al., 2012). Our results were different. The grain yield of winter wheat in organic variant was lower just by 5.5 % in comparison to conventional one.

Pea and clover are considered to be appropriate forecrops for winter wheat (Lacko-Bartošová et al., 2005). Our results showed that using pea as the forecrop significantly increased yield and positively influenced quality parameters of grain. The grain yield of winter wheat grown after pea was higher (5.98 t.ha⁻¹) than after clover (5.44 t ha⁻¹).

The year statistically significantly affected grain quality parameters of winter wheat. Zimolka et al. (2005) declare that volume weight of ripe grain is rapidly reducing at the time of rainy weather. Our results confirmed this thesis. July in 2004 was very dry (15.9 mm). On the contrary, July in 2003 and 2005 was rainy (95.7 mm and 96.9 mm). The highest value of grain volume weight was recorded in 2004 (846.56 g l⁻¹), significantly higher than in 2003 (802.69 g l⁻¹) and 2005 (802.91 g l⁻¹). The highest protein content in grain (13.13 %) were achieved in extremely warm and very dry year 2003. Significantly lower values were noted in 2004 (10.85 %) and 2005 (11.90 %). The results are in accordance with conclusions demonstrated by Zhao et al. (2005) that water stress at the time of grain filling can induce

increase in protein content in grain. Similarly significantly higher wet gluten content in grain was recorded in 2003 (39.86 %) than in 2004 (30.34 %) and 2005 (29.92 %). Zeleny test reflects quality of proteins in grain of wheat. The significantly highest value of this parameter was noted in 2005 (60.67 ml), the lowest one in 2003 (42.05 ml). Although Zeleny test is a specific characteristic of variety, it can be influenced by year (Zimolka et al., 2005).

Grain volume weight (814.81 g l⁻¹ in organic system, 819.96 g l⁻¹ in conventional one), protein content (11.74 % in organic system, 12.18 % in conventional one) and wet gluten content (32.13 % in organic system, 34.62 % in conventional one) were significantly affected by farming system. The effect of farming system on Zeleny test (49.67 ml in organic system, 50.37 ml in conventional one) was not statistically significant (Table 1). Several studies declare significantly lower protein content in grain of wheat grown in organic farming systems (Hildermann et al., 2009; Osman et al., 2011). The statistically significant but small difference in protein content between compared systems could be explained by the grown variety Balada that belongs to elite quality varieties of winter wheat. Some of these varieties can keep their high quality properties even in conditions of organic farming.

Using pea as the forecrop positively influenced all of evaluated grain quality parameters of winter wheat. Grain volume weight, protein content and wet gluten content were significantly higher in grain of winter wheat grown after pea than after clover (Table 1). The effect of forecrop on Zeleny test was not statistically significant.

4 Conclusions

The yield and grain quality parameters of winter wheat were statistically significantly affected by farming system, forecrop and weather conditions in the years 2003 – 2005. Grain yield, grain volume weight, protein content and wet gluten content were significantly higher in conventional farming system than in organic one. Even though, grain quality of winter wheat in organic farming corresponded to elite (E) or standard (A) technological quality of wheat according to the Slovak Technological Standard STN 46 1100-2. The yield of winter wheat was increased and grain quality parameters were improved by using pea as the forecrop in comparison to clover.

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