YIELDS AND SELECTED QUALITY PARAMETERS OF WINTER WHEAT (*TRITICUM ESTIVUM* L.) IN ORGANIC CROPPING SYSTEM AS AFFECTED BY FORECROPS IN THE YEARS 2006-2008

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Abstract: *The aim of the study was to evaluate yields and selected qualitative parameters of winter wheat cultivated after three different forecrops in the years 2006-2008. Stationary field experiment was established on a loamy luvi-haplic chernozem in a maize–barley growing region in South - Western Slovakia. The tested variety Bardotka is known as a variety with good content of gluten and high values of sedimentation test. The weather conditions statistically modified qualitative parameters of winter wheat grain (crude protein, wet gluten, fall number, sedimentation test, ** P<0.01). The forecrops statistically significantly influenced grain yields and thousand-grain weight (** P<0.05). The average grain yield was 5.99 t/ha. The average yield after alfalfa was 6.48 t/ha and 5.86 t/ha after spring barley (winter wheat was amended by farm manure) and winter wheat yield after pea was 5.65 t/ha. The highest crude protein content as well as wet gluten content, fall number and sedimentation test were after spring barley. The lowest values of all selected qualitative parameters were determined after pea. In the years 2006-2008 the most suitable quantitative parameters of winter wheat grown in the organic farming system were obtained after alfalfa. The best effect on the qualitative parameters of winter wheat had spring barley followed by farm yard manure application.*

Key words: *winter wheat, forecrops, grain yields, qualitative parameters*

INTRODUCTION

Today we can not speak about economical development without taking into consideration the environment. The development of agriculture must fit into the potential of the ecosystems and must not harm the consumers' health.

Organic farming offers an alternative that can eliminate many of the environmental problems of conventional agriculture. Organic farming is one of the expanding agrarian sectors in the Slovak Republic. Significant environmental benefits of organic farming have already been described (e.g. Hole et al. 2005). However there are also increasing conflicts, both between long term conservation of abiotic resources and biodiversity on the one hand and short term economic production constraints on the other, as well as between different objectives of nature conservation (Bachinger, Stein-Bachinger, Fuchs, 2006).

High flour yield of good baking value is principally determined by the raw material quality. The technological value of wheat grain is predominantly relative to the genetic properties of the cultivated cultivars. Their influence is, however, greatly modified by the cropping management and weather conditions prevalent during the vegetative period as well as the type of soil, fertilisation, etc. (Gil, Narkiewicz-Jodko, 1998). The importance of crop rotation should also not be neglected because winter wheat belongs to crops that are very demanding as far as the forecrops are concerned. All aforementioned factors can be, to a certain extent, influenced by the grower. There are some factors that cannot be controlled in a direct way. They involve both the amount and the time distribution of rainfalls in the course of the growing season. In this context the problem of the occurrence of draught periods and their impacts on plant production is being more and more discussed, also under the climatic conditions of Central Europe. High weather conditions variability has influenced the yields and qualitative parameters of winter wheat in the Slovak conditions also during the investigated years.

The aim of the paper was to evaluate the effect of three forecrops on grain yields and selected qualitative parameters of winter wheat variety Bardotka in the years 2006 -2008.

MATERIAL AND METHOD

The stationary field experiment was established in the year 1990 at Borovce near Piešťany town (western part of the Slovak Republic) on a loamy luvi-haplic Chernozem with good content of available potassium, medium content of available phosphorus and high content of available magnesium. The areas has a continental climate with the average annual temperature 9.2 ^{0}C (15.5 ^{0}C during the vegetation period) and mean annual precipitation 593 mm (358 mm during the vegetation period). The area is classified as maize-barley growing region. The experimental design consists in a split plot arrangement with two replications. There were two six strips of field tested in the experiment: a1) alfalfa - alfalfa – winter wheat – sugar beet – spring barley – maize for grain, a2) maize for grain – spring barley – winter wheat - spring barley – pea - winter wheat. Farm yard manure at the rate of 40 t/ha was applied after spring barley. The harvested area of one plot represented 75 m^2 (3x25 m). The agro technical operations were realized in accordance with the Law NR SR No. 421/2004 about organic farming. The model variety of winter wheat was variety Bardotka with the quality standard E, the sowing rate was 500 viable kernels per square meter at a row distance of 125 mm. Experimental plots were harvested at full maturity. Crude protein content was determined by the Dumas method (% N x 5.7) according to the Slovak Technical Standard STN 46 1011. Selected indicators of baking quality included: test weight of grain according to the Slovak Technical Standard STN 46 1011-5, sedimentation index according to Zeleny (STN – ISO 5529), fall number according to the STN – ISO 3093, wet gluten content according to the STN 461011-9.

Obtained results were evaluated by variance analysis, differences testing by Tukey test.

RESULTS AND DISCUSSION

Weather conditions are listed in the table 1.

Table 1

Weather conditions in Borovce near Piešťany in the years 2006-2008

Average temperatures and precipitations in the year 2006												
Month	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
Temperature (°C)	-4.82	-2.51	2.1	11.53	14.75	18.99	22.96	17.31	17.21	12.38	7.43	3.07
Precipitations (mm)	56,1	30,1	25,3	52,7	66,5	136,2	0,5	83,7	0	30	49,4	13,3
Average temperatures and precipitations in the year 2007												
Month	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
Temperature (°C)	3,47	4,32	7,65	11,32	16,5	20,36	21,28	20,6	12,78	8,64	2,76	-1,00
Precipitations (mm)	53,1	36,2	56	0,0	58,9	55,7	33,8	93,6	109,6	34	36,2	32
Average temperatures and precipitations in the year 2008												
Month	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
Temperature (°C)	1,48	2,46	4,71	11,07	16,84	21,16	21,35	20,72	15,27	10,65	6,55	2,27
Precipitations (mm)	25,5	15,1	47,8	31,2	36,4	65,9	89,6	71	50,5	33,1	37	29

The three-year results showed that the average grain yield was 6.00 t/ha (Table 2). In the years 2006 and 2007 there were not significant differences in the obtained grain yields of winter wheat. Significantly higher grain yields were in the year 2008 in comparison with the years 2006 and 2007 (** $P<0.01$).

The highest grain yield was obtained after alfalfa (6.48 t / ha), followed by spring barley (5.86 t / ha) and the lowest grain yield was after pea (5.65 t / ha). Lower yields after alfalfa in the years 2006 and 2007 were caused by the precipitation deficiency and its very unequal distribution in the spring time. Therefore alfalfa could not use its potential to fix atmospheric nitrogen and its ability to leave a bulk of crop residues with good quality for the further crop growing.

Table 2

Grain yields of winter wheat, variety Bardotka in the years 2006-2008 (t/ha)

Forecrop/Year	2006	2007	2008	Average
Alfalfa	5.96	5.91	7.58	6.48a
Pea	5.09	4.85	7.01	5.65b
Spring barley	5.47	4.92	7.18	5.86ab
Average	5,51a	5.22a	7.26b	5.99

LSD 0.05 forecrop 0.71; LSD 0.01 year 0.99

The average grain yield after pea was 5.65 t/ha. It was statistically lower than the average grain yield obtained after alfalfa, the difference represented 9.6 %. Winter wheat belongs to crops that are very demanding for a good forecrop. Repeated growing of winter wheat after cereal caused lower yields. This decrease may be also dependent on concentration of cereals in the crop rotation and might be compensated by organic fertilizers or green manure application. These factors arrangement may also cause increased pressure of infectious diseases and weeds suppression.

We applied 40 t/ha of farm yard manure after spring barley in the autumn period. The average grain yield of winter wheat after spring barley was 5.86 t/ha, the highest grain yield was in the year 2008 (7.18 t/ha).

The average grain yield was higher after spring barley (40 t/ha of farm yard manure applied in the autumn period after spring barley harvest as a compensation of deteriorative effect of this forecrop) than after pea (3.72 % difference).

The average thousand-grain weight (TGW) in the experiment was 44.18g. This indicator was statistically influenced by the forecrop. The year conditions did not influence statistically significantly TGW. After the forecrop pea there was statistically significantly higher TGW (46.20 g) than after spring barley (42.20 g).

Table 3

TGW of winter wheat in the years 2006-2008 (g)

Forecrop/Year	2006	2007	2008	Average
Alfalfa	44.75	43.05	44.65	44.15ab
Pea	46.25	45.75	46.60	46.20b
Spring barley	40.95	44.90	40.75	42.20a
Average	43.98a	44.57a	44.00a	44.18

LSD 0.05 forecrop 3.46

The weather conditions influenced significantly not only grain yields of winter wheat but also qualitative parameters of winter wheat in our conditions. Our investigations are in line with Muchova (2001) who confirmed the strong impact of weather conditions on almost all characters of quality of winter wheat mainly in the ripening stage.

The average value of crude protein was 10.02 %. The highest value of crude protein was after spring barley (10.73 %). Winter wheat has high consumption of nitrogen, mainly in the second period of the vegetation period and in the ripening stage. We can very hardly influence that in organic farming systems by qualitative additional fertilizing by commercial nitrogen fertilizers. The utilizing of nitrogen in the process of mineralization might be influenced very strongly by the weather conditions.

Due to the favourable weather conditions distribution (precipitations and temperatures) during the year 2008 we reached the optimum nutrient regime in the period where qualitative parameters of winter wheat were formed. The farm yard manure application after spring barley positively influenced soil adsorption complex properties. Nitrogen releases from farm yard manure and subsequent uptake probably caused higher content of protein as well as wet gluten in the grain of winter wheat after spring barley compared with the other two forecrops. On the contrary in the year 2007 the deficit of rainfalls in the months April and May may have caused a decreased nitrogen mineralization, resulting in a lower content of crude protein and wet gluten content.

There were lower grain yields after spring barley in the years 2006-2008 however the qualitative parameters (crude protein, wet gluten, sedimentation test) were the highest in comparison with the qualitative parameters of winter wheat obtained after pea and alfalfa.

Table 4

Crude protein content (%) and wet gluten content (%) after three forecrops in the years 2006-2008

	Crude protein (%)				Wet gluten (%)			
Forecrop / Year	2006	2007	2008	Average	2006	2007	2008	Average
Alfalfa	9.61	10.80	9.92	10.11	20.25	25.35	20.30	21.97
Pea	9.23	9.16	9.32	9.24	18.75	19.20	17.30	18.42
Spring barley	11.07	9.07	12.06	10.73	26.20	17.65	29.50	24.45
Average	9.97	9.67	10.43	10.02	21.73	20.73	22.37	21.61

LSD 0.05 forecrop 0.71; LSD 0.01 year 0.99

The data shown in Table 4 indicate that the average value of wet gluten was 21.61 %. The highest content of wet gluten was after spring barley (24.45 %). The highest value of wet gluten after spring barley was in the year 2008 (29.50 %).
The lowest values of crude protein as well as wet gluten were observed after pea compared with the other forecrops.

The enzymes activity in the grain is expressed by the fall number. A grain with the fall number over 400 s requires increased activity of amylolytic enzymes. In our experiment the average value of fall number was 382 s. The most suitable values of this indicator were observed after alfalfa (379 s) and pea (368 s).

The sedimentation test according to Zeleny was in average 41.8 ml. There were lower values of sedimentation test after pea (38.8 ml) comparing alfalfa (41.0 ml) and spring barley (45.5 ml). The weather conditions influenced the values of sedimentation test. The most suitable weather conditions were in the year 2006 (47.5 ml), the average content of sedimentation test represented 41.9 ml.

Table 5

Falling number (s) and Sedimentation test (ml) after three forecrops in the years 2006-2008

	Fall number (s)				Sedimentation test (ml)			
Forecrop / Year	2006	2007	2008	Average	2006	2007	2008	Average
Alfalfa	337	422	378	379	44.0	43.0	36.0	41.0
Pea	328	401	375	368	40.5	34.0	42.0	38.8
Spring barley	382	401	411	398	58.0	31.5	47.0	45.5
Average	349	408	388	382	47.5	36.2	42.0	41.9

LSD 0.01 forecrop 28.15
LSD 0.01 year 28.15
LSD 0.05 year x forecrop 49.9

LSD 0.01 year 9.70
LSD 0.05 year x forecrop 17.19

CONCLUSIONS

- Weather conditions of the analysed years statistically modified qualitative parameters of winter wheat grain (crude protein, wet gluten, fall number, sedimentation test, ** $P<0.01$).
- Forecrops significantly influenced grain yields and TGW (** $P<0.05$) in the years 2006 – 2008.
- Interaction year x forecrop modified fall number and sedimentation test of winter wheat (** $P<0.05$).
- The most suitable quantitative parameters of winter wheat grain were obtained after alfalfa.
- The best effect on the qualitative parameters of winter wheat had the forecrop spring barley followed by farm yard manure application.

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