EFFECTS OF ORGANIC WHEAT CULTIVATION IN WIDER ROWS ON THE GRAIN YIELD AND QUALITY

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Exact field small-plot trials with winter wheat varieties Ludwig and Sulamit (both the quality group E – elite) in organic farming system in the sugar beet growing region of Central Bohemia were conducted in the years 2005 – 2007 to test the possibility of increasing in the crude protein content in grain and thereby improving of baking quality (row spacing 125, 250 and 375 mm, sowing rates 200, 300 and 400 germinating kernels per m^2) under the change of the wheat stand structure. Statistically significant increase of crude protein content in wheat grain dry matter by approximately 0.7 % was found at widening of row spacing from 125 to 250 mm and by about 1.5 % by widening of row spacing from 125 to 375 mm. So, the treatments cultivated in wider row spacing fulfilled the requirement for crude protein content in grain dry matter of bread making wheat for minimum 11.5 %. Increase of values of sedimentation test Zeleny was found at widening of row spacing from 125 to 375 mm, too. Wheat cultivation in wider rows had no negative impact on the grain yield.

***Key words**: winter wheat, organic cultivation, wider rows, yield, quality*

It is now clearly established that wheat grain quality is a function of grain composition, principally in proteins [TRIBOI et al., 2000]. Also according to PAN et al. [2006] grain nitrogen concentration is one of the main quality parameters of the wheat grain.

Organic techniques of cultivation can have an adverse effect on the technological quality, especially when protein content is an important factor. Lower protein content in the wheat grain limits the possibilities of food, especially baking processing [MOUDRÝ & PRUGAR, 2002]. For wheat under the system of organic farming not using mineral nitrogen fertilizers, it is necessary to find another way that should have allowed increase of protein content and hence, improvement of baking quality.

One of the possibilities is selection of variety. The use of varieties of the quality group E (elite) is above all a prerequisite of success of cultivation of bread making wheat in organic farming, because as reported by PETR et al. [1998], the

varieties with genetically established good milling and baking quality preserve these traits at different cultivation systems, i.e. also at lower inputs.

Protein production in grains, particularly of gliadins and glutenins fractions, is also affected by duration and intensity of plants irradiation in the stand [PETR et al., 1987]. Therefore, different type of wheat stand structure (wider row spacing, lower sowing rates) that should allow as best as possible irradiation benefit, could be one of the options, how to improve baking quality of organic wheat.

The system of wheat cultivation in wider row spacing was tested in Germany, where it had been proved that at wide row spacing not only the protein content is increasing but also the values of sedimentation test. The results of the tests showed that high baking quality can be achieved using this system [FÖRSTER et al., 2004]. HILTBRUNNER et al. [2005] performed the similar research. They reported in their study a statistically significant increase in crude protein content in grain dry matter (by about 1 %) at widening of row spacing from 187.5 to 375 mm. At the sane time they add that no decrease in grain yield was found with row spacing increasing.

MATERIAL AND METHOD

Exact small-plot field trials with two varieties of winter wheat Ludwig and Sulamit (both quality group E – elite) were conducted in the years 2005 – 2007 on the experimental station of Department of Plant Production of CULS Prague in Uhříněves (sugar beet growing region, 295 m above sea level, average annual temperature 8.4°C, average sum of precipitation 575 mm). Clay-loam cambisol has a topsoil deep 250 – 300 mm, with neutral pH; humus content 1.74 – 2.12 %. Experimental station Uhříněves is certified for conductance of experiments in organic farming system.

Experiments were carried out by the method of randomised blocks in four replications; average size of experimental plot was 10 m^2. Row spacing 125, 250 and 375 mm and sowing rate 200, 300 and 400 germinating kernels per m^2 were used in the trial. Pea was the preceding crop. Hoeing at the widest row spacing was used two times during the spring vegetation, other variants were two times harrowed.

After harvest of the trials the yield was assessed, crude protein content in grain dry matter (Czech Standard ČSN ISO 1871), Zeleny´s sedimentation test (ČSN ISO 5529) and grain storage proteins composition - quantitative evaluation of SDS-PAGE electrophoretic analysis according to WRIGLEY [1992] were determined.

Yield results and results of quality evaluation were statistically assessed by analysis of variance of multiple classification (ANOVA) in the SAS system, significance of differences between means of varieties, years, sowing rates and row spacings was verified by LSD test, $\alpha = 0.05$.

RESULTS AND DISCUSSIONS

Increase of crude protein content in grain dry matter was found with increasing row spacing (*tab. 2*). At the row spacing 250 mm higher content of crude protein by 0.7 % was recorded, whereas at the row spacing of 375 mm this value was higher by 1.54 % compared to variant with traditional narrow row spacing of 125 mm. The variants with the widest row spacing fulfilled the

requirements for crude protein content in grain dry matter of bread making wheat - bottom limit 11.5 % according to the Czech Standard ČSN 461100-2; in 2006 and 2007 this requirement was fulfilled also in row spacing of 250 mm.

It follows from the values of testing criterion *F* (*tab. 1*) that the crude protein content in grain dry matter was affected the most by row spacing, followed by the effect of variety and experimental year. On the contrary, crude protein content in grain dry matter was not affected significantly by the sowing rate.

The above mentioned results are in congruency with the conclusions made by PETR et al. [1987] and BICANOVÁ et al. [2006], that by different stand structure, which occurs at cultivation in wider row spacing, it is possible to support the synthesis of protein in the wheat grain in organic farming.

Table 1

Effects of different factors (variety, row spacing, sowing rate, year) on the grain yield, crude protein content in grain dry matter and Zeleny´s sedimentation test (ANOVA, calculated values of testing criterion *F*)

	Grain yield	Crude protein content	Zeleny´s test
Variety	89.40**	35.28**	52.86**
Row spacing	4.98*	53.86**	17.56**
Sowing rate	46.91**	0.01	0.31
Year	50.00**	22.44**	27.08**

** statistical significance α = 0.01; * statistical significance α = 0.05

A significant role for baking use is played not only by amount, but also but quality of the wheat protein. The quality of protein complex in view of baking utilization is very well characterized by Zeleny´s sedimentation test. The Czech Standard 461100-2 gives 30 ml as a bottom limit of Zeleny´s test of baking wheat. It is evident from our results (*tab. 2*) that both evaluated varieties Ludwig and Sulamit exceeded this value.

With an increase of row spacing also increased values of Zeleny´s test, but the bottom limit for baking wheat was fulfilled even in variants cultivated in traditional narrow rows. It is apparent from the values of testing criterion F (*tab. 1*) that the values of Zeleny´s test were affected the most by variety, followed by experimental year and row spacing. The effect of sowing rate on the Zeleny´s test was statistically insignificant. These results giving evidence of prevailing genotype dependence of Zeleny´s test are in accordance with conclusions made by MATUZ [1998] and KADAR & MOLDOVAN [2003].

Another characterization of baking quality of wheat protein complex can be quantitative evaluation of SDS-PAGE electrophoretic analysis of storage proteins. It follows from our results (*tab. 3*), that with row spacing widening increased percentage of HMW glutenin subunits, that are responsible for the dough elasticity, and decreased percentage of residual albumins and globulins, that affected quality of dough rather negatively. Except the quality of production in cultivation of organic wheat in wider rows, it is necessary to pay attention to the grain yield.

Table 2

LSD test for the wheat grain yield, crude protein content in grain dry matter and Zeleny´s test – significance of differences among averages of varieties, row spacings, sowing rates and experimental years (LSD, α = 0.05)

		Grain yield ($t.ha^{-1}$)	Sign.	Crude protein content in grain dry matter (%)	Sign.	Zeleny´s test (ml)	Sign.
Variety	Ludwig	5.80	a	11.14	a	38.39	a
	Sulamit	5.01	b	11.86	b	45.15	b
d_{min}		0.16		0.28		1.87	
Row spacing (mm)	125	5.35	ab	10.76	a	38.63	a
	250	5.28	a	11.45	b	41.35	a
	375	5.59	b	12.30	c	45.33	b
d_{min}		0.24		0.39		2.76	
Sowing rate (germinating grains . m^{-2})	200	4.85	a	11.50	a	42.08	a
	300	5.57	b	11.52	a	41.24	a
	400	5.80	b	11.49	a	42.04	a
d_{min}		0.30		0.37		2.48	
Year	2005	5.70	a	10.96	a	43.86	a
	2006	5.70	a	11.61	b	44.50	a
	2007	4.81	b	11.94	b	36.94	b
d_{min}		0.24		0.36		2.72	

d_{min} = least significant difference

It is evident from the values of testing criterion F (*tab. 1*) that the grain yield was the most affected by the variety, followed by the experimental year and sowing rate. Effect of row spacing on the grain yield was significantly lower.

In wheat cultivation in wider row spacing, particularly 375 mm, a strong competition between plants and reduction of the cumber of plants during vegetation are manifested. So, it can be said that in congruency with conclusions made by FÖRSTER et al. [2004], in wheat cultivation in wider row spacing lower sowing rates can be applied (approximately 300 germinating grains per m^2) than are usually applied in wheat cultivation in traditional narrow row spacing, without significant impact of this reduction of sowing rate on the grain yield.

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CONCLUSIONS

Our results confirmed the possibility to increase the crude protein content in grain dry matter and improvement of baking quality of winter wheat in organic farming system under the change of the stand structure – cultivation of wheat in wider row spacing. Variants cultivated in wider row spacing fulfilled the requirement for crude protein content in grain dry matter of bread making wheat for minimum 11.5 % (Czech Standard). Wheat cultivation in wider rows had no negative impact on the grain yield.

Table 3

The effect of row spacing on percentage of storage protein subunits in the wheat grain (quantitative evaluation of SDS-PAGE electrophoresis of storage proteins) Average of 2005 – 2007

Variety	Row spacing (mm)	HMW glutenins (%)	LMW glutenins (%)	Residual albumins + globulins (%)
Ludwig	125	16	71	13
	250	18	70	12
	375	22	73	5
Sulamit	125	18	69	13
	250	21	72	7
	375	25	70	5

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