SELECTION OF BREAD WHEAT VARIETIES FOR ORGANIC FARMING, BAKING QUALITY PARAMETRES BEING EMPHASIZED

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Organic methods growing bread wheat may have negative effects on the technological value, especially in the case of the crucial crude protein content. The aim of paper is to identify diferences in quality of 8 varieties recomended in conventional or organic conditions in Austria and 2 strains. Obvious effect of year on the quality, set up in statistics, was confirmed for qualitative parametres. The correlation analysis also provides similar figures. Effect of the year in a negative correlation to crude protein content (r=-0,66), whereas in a positive correlation to starch content (r=0,78) and falling number (r=0,86). Effect of the variety is represented by unclear correlation coefficients. Correlation analysis of selected qualitative parametrs of wheat shows an obvious relation between crude protein content and wet gluten content (r=0,93) and Zeleny - sedimentation value (r=0,82). On the other hand, starch content is in a negative correlation to crude protein content (r=-0,71), wet gluten content (r=-0,75) and Zeleny - sedimentation value (r=-0,62). According to the test results, any effect of the variety on the qualitative parametres was not obviously proved in statistics carried out in low-input systems (organic farming systems). It may be noted it is suitable to choose the content and quality of protein as selective criteria of the selection of varieties. Level of the qualitative parametres is never reduced below the quality level of worse-quality varieties grown in the same (similar, low-input) conditions. On the other hand, elite varieties provide grains characterized by better baking quality, but lower yield level than the other ones. This fact has to be taken into account, when suitable varieties for different use purpose being selected (food, feed and industry processing).

***Key words**: bread wheat, baking quality, organic farming*

Organic (low-input) farming system is described as a farming system connected with a limited amount of nutrients (nitrogen especially) and absence of the split nitrogen application [KÖPKE, 2005]. The early spring ability of nitrogen absorbtion is the main problem of growing of winter varieties; cold soil is characterized by a low microbial activity. The nutrient mineralization (of nitrogen, especially) is limited in this period [MOUDRÝ, 2003]. The efficient nitrogen absorbtion is also very important from the point of view of the quality of yield and evolution of plants in early stages of growth [REENTS, 2002].

Cultivars should therefore have the ability to perform under a low input of organic fertilizers, a good root system, the ability to interact with beneficial soil microorganisms and to suppress weeds, and the ability to produce a healthy crop and healthy propagules [LAMERTS van BUEREN et al., 2002, 2003].

Organic yield is about 20-30 % lower than the conventional [MOUDRÝ, 1997; MÄDER et al., 2002; LAMMERTS van BUEREN, 2002]. The quality and stability of the yield are the main priorities for organic farming which does not lay stress on the quantity of production. Farmers usually need to grow "reliable" and "solid" varieties which are able to tolerate potential fluctuations in the weather and the potential pressure of diseases; they must in any case be able to provide sufficient yield of grains and straw [LAMMERTS van BUEREN, 2002].

The high baking quality of the organic varieties is characterized by the proportion and total content of crude protein, high value of the Zeleny - sedimentation value, flour binding capacity and flour yield, Falling number and test weight. The baking quality of wheat is a complex feature; the breeding of such varieties (to a high quality) is a long and difficult process [FOSSATI et al., 2005]. Organic methods of farming may have negative effects on the technological value, especially in the case of the crucial crude protein content [MOUDÝ & PRUGAR, 2002].

Modern cultivars of wheat do not satisfy all the requirements and demands of organic agriculture. Therefore, more attention should be given to the breeding of specific cultivars adapted to the agronomic conditions on organic farms and complying with the philosophy of organic farming [LAMMERTS van BUEREN, 2002]. Nowadays, new breeding programmes are emerging because the conventional varieties of bread wheat have a very different genetic background [KUNZ & KARUTZ, 1991]. LAMMERTS van BUEREN et al. [2003] points out that, in order to avoid the use of chemical fertilizers and pesticides in organic agriculture, agroecological principles should be applied to enhance the self-regulatory capacity of the agroecosystems. Organic farmers require cultivars that can be multiplied and grown in the organic farming system with no undue negative effect on the health and function of the agroecosystem [KUNZ & KARUTZ, 1991].

The aim of paper is to identify diferences in quality of varieties recomended in conventional or organic conditions in Austria and showed that the system of variety certification in organic farming should be different from conventional one.

MATERIAL AND METHOD

In the experimental years 2006 and 2007, with 8 varieties (Capo, Eriwan, Element, Eurofit, Clever, Ludwig, Epsilon, Element) and 2 strains (SE 304/05, SE 320/05) of bread wheat comes from conventional and breeding programmes of Austrian breeding stations in small plot trials (10 m^2) with two replications were executed at location in South Bohemia, experimental fields of University of South Bohemia in České Budějovice (USB). The characteristics of the trial station: altitude of 388 m; mean air temperature of 8,2 °C; total precipitation of 620 mm; sunshine duration of 1564,3 hours; pH ($CaCl_2$) of 6,3; P - 138 $mg.kg^{-1}$; K - 155 $mg.kg^{-1}$; Mg - 163 $mg.kg^{-1}$; Ca - 1557 $mg.kg^{-1}$. The experiments were carried out in low input growing system (practically not certificied organic farming system), without mineral fertilizers and pesticides. The forgoing crop was legumes-ceral mixture, in regular periods of 4 years was dose of manure. The quality parametres were analised by NIR spectroscopy system. The data were analysed in STATISTICA programme.

RESULTS AND DISCUSSIONS

Ten varieties of bread wheat were tested; according to the achieved average figures, the volume weight was considered as a stable feature (CV 2,9% - 2006, 2,7% - 2007). It was reduced under the level of 737,3 $g.l^{-1}$. On the other hand, the yield was fluctuating (nearly 20 % of CV). The average yield achieved 3,79 t/ha in 2006 and 4,51 t $t.ha^{-1}$ (Table 1). There were considerable differences between the varieties; e.g. Strain 320/05 variety provided the yield of 5,757 $t.ha^{-1}$, contrary to Econom variety which provided the yield of 2,102 $t.ha^{-1}$. Crude protein yield per hectare showed very interesting figures too (*table 1*). Capo variety achieved the highest figures in both tested years. On the other hand, Element variety, which has the highest crude protein content and the highest baking quality provided very low yield and low crude protein yield (*table 1*).

Table 1

Grain and crude protein yield, hectoliter weight

Variety	Number of spike (1m^2)		Yield ($t.ha^{-1}$)		Hectoliter weight ($g.l^{-1}$)		Crude protein yield ($kg.ha^{-1}$)	
	Year							
	06	07	06	07	06	07	06	07
Capo	307	446	4,47	4,935	764	810	554	498
Eriwan	258	303	3,670	4,115	764	791	414	386
Element	214	247	2,705	3,684	733	804	392	412
Eurofit	218	350	4,213	4,402	721	791	560	431
Clever	344	412	2,515	4,652	698	738	266	409
Ludwig	266	392	3,585	5,674	711	785	408	*573*
Epsilon	256	355	4,305	4,679	727	770	512	430
Econom	244	311	4,748	2,102	718	761	508	193
304/05	233	416	4,015	5,105	733	779	538	484
320/05	356	392	3,683	5,757	744	780	408	558
mean	269,6	362,4	3,79	4,51	731,3	780,9	456	437
SD	49,978	61,256	0,726	1,061	21,417	20,979	94,017	106,8
CV (%)	18,5	16,9	19,2	23,5	2,9	2,7	20,6	24,4
Upper quartile of crude protein yield (2006 = 538 $kg.ha^{-1}$, 2007 = 498 $kg.ha^{-1}$)								

The crop stand had, therefore, the limited ability of the production of nitrogenous elements. SLAFER's hypothesis [SLAFER *et al.*, 1990] also confirms these results. He states the fact that the increase of the yield level (caused by the breeding process) leads to "a dilution" of nitrogen and reduction of the nitrogen concentration in grain.

There was any obvious influence of the genotype proved neither on the total yield, nor on the volume weight during the process of bread wheat growing in low-input farming system (*table 2*). On the other hand, there was the evident strong effect of the year on the volume weight ($p < 0,01$) (it was caused by the long-lasting rainy weather in the harvest period). ZIMOLKA *et al.* [2005] also confirms this fact.

Table 2

ANOVA, values of the test criterion *F* (factors genotype and year - parametres crude protein yield, grain yield, hectoliter weight)

Factor	Parametre		
	Crude protein yield	Grain yield	Hectoliter weight
Genotype	0,933^{n}	0,580^{n}	0,569^{n}
Year	0,1708^{n}	3,13^{n}	27,372*
Notes: *statistically significant α = 0,01; n – statistically insignificant			

According to *table 3*, the selected parameters of the baking quality of the varieties, grown in low-input farming system are considered as the most stable ones. Starch content is considered as the most stable parameter (CV 1,4 % - 2006, 1,3 % - 2007) contrary to falling number (the most fluctuating feature, especially in 2006 – rainy year, CV = 47,2 %). Zeleny sedimentation value is another parameter influenced by the reaction of the varieties grown in low nitrogen-input farming system. There are considerable differences between the varieties; CV = 24,1 % in 2006, CV = 29,2 % in 2007. Concerning crude protein content and wet gluten content, they are not so fluctuating ones.

There were favourable weather conditions for crude protein content in 2006 [BUREŠOVÁ, PALÍK, 2006]. It reached 12,6 % in average in 2006 and 9,7 % in average in 2007. There were the varieties providing extraordinary values, e.g. Element variety (14,5% - 2006 and 11,2% - 2007) and the varieties showing below-average figures, e.g. Clever variety (10,6% - 2006 and 8,8% - 2007). According to the example mentioned above, the selection of an unsuitable variety could have the negative effect on protein content (3,9 % in 2006 or 2,4 % in 2007) in low-input farming system. Element variety had the highest wet gluten content in 2006 and 2007 too, from the point of view of the correlation coefficient (r = 0 ,93) between crude protein content and wet gluten content (*table 3*).

Zeleny sedimentation value characterises viscoelastic qualities of proteins and the quality of proteins; it allows the fermentation process in dough [ZIMOLKA *et al.*, 2005]. There is the positive correlation between crude protein content and Zeleny sedimentation value (r = 0,82). Element variety is also supposed to be the most perspective one from the point of view of the protein duality (51 ml – 2006 and 38 ml – 2007). On the other hand, Clever variety has the lowest figures (24 ml

– 2006 and 12 ml – 2007). Starch content increased in less favourable year for protein creation (there was no obvious negative dependance between protein content and starch content, r = -0,71). In 2006, the variety which contained the least crude protein (Clever) had the highest starch content. Falling number was obviously influenced (p < 0,01) by the year; in 2006, the harvest was 2 weeks later because of rainy weather and a lot of varieties fall short of the requirements of the quality norm be embedded in the quality group B – bread (160 s.) [ZIMOLKA et al., 2005]. The example of 2006 may demonstrate the differences in resistance to lodging between the varieties. E.g. Strain 320/05 variety reached the value of 217 s. in 2006 and Econom variety was characterized by the low falling number (62 s.) in the same land-climatic conditions and the same year (*table 3*).

Table 3

Selected parametres of gaking quality

Variety	Crude protein content (%)		Wet gluten content (%)		Zeleny – sedimentation value (ml)		Starch content (%)		Falling number (s)	
	Year									
	06	07	06	07	06	07	06	07	06	07
Capo	12,4	10,1	24,6	18,0	47	28	64,9	67,6	95	217
Eriwan	11,3	9,4	20,7	15,5	39	29	63,8	66,1	204	272
Element	14,5	11,2	29,1	20,1	51	38	63,3	66,8	124	354
Eurofit	13,3	9,8	22,3	17,2	34	30	64,9	65,1	111	305
Clever	10,6	8,8	21,8	17,0	24	12	65,5	66,5	76	268
Ludwig	11,4	10,1	22,8	18,4	29	28	64,8	68,1	65	407
Epsilon	11,9	9,2	23,6	17,0	30	23	64,1	66,1	79	325
Econom	10,7	9,2	20,9	16,6	31	18	64,9	66,6	62	330
304/05	13,4	9,5	25,9	16,3	46	21	62,7	65,6	147	227
320/05	11,1	9,7	20,9	17,3	38	22	65,0	67,0	217	329
mean	12,6	9,7	23,3	17,3	36,9	24,9	64,4	66,6	118	303
SD	1,30	0,67	2,67	1,27	8,88	7,26	0,88	0,89	55,7	58,4
CV (%)	10,4	6,9	11,5	7,31	24,1	29,2	1,4	1,3	47,2	19,2

According to *table 3*, the stability of the selected parameters of the baking quality of the varieties, grown in low-input farming systems is evident. Starch content is the most stable parameter (CV 1,4 % - 2006, 1,3 % - 2007). Falling number was the least stable (the most fluctuating) parameter, especially in 2006 (CV = 47,2 %). Zeleny sedimentation value is another parameter influenced by the reaction of the varieties in low nitrogen-input farming system. There are considerable differences between the varieties; CV = 24,1 % in 2006, CV = 29,2% in 2007. Concerning crude protein content and wet gluten content, the fluctuation is not so important.

Concerning qualitative parameters, there is the obvious influence of the year (*table 4*). The genotype has any obvious effect neither on crude protein content, nor on the other baking quality parameters. The amount of protein complex of wheat grain depends on the environmental factors, not on the genotype. TRIOBI et al. [2000] states the finding that the variety has a small effect on the proportion of nitrogenous elements (not more than 4 %).

Table 4

ANOVA, values of the test criterion *F* (factors genotype and year - selected parametres of baking quality)

Factor	Quality parameter				
	Crude protein content	Wet gluten content	Zeleny – sedimentation value	Starch content	Falling number
Genotype	0,525^{n}	0,342^{n}	1,122^{n}	0,378^{n}	0,122^{n}
Year	26,564*	40,475*	11,217*	29,239*	52,838*
Notes: *statistically significant α = 0,01 (*) ; statistically insignificant (^{n})					

The correlation analysis also provides similar figures (*table 5*). The effect of the year is in the negative correlation to the protein content (r = -0,66), to wet gluten content (r = -0,46) and it is in the positive correlation to starch content (r = 0,78) and to falling number (r = 0,86). The effect of the variety is represented by low and unobvious correlation coefficients.

Table 5

Correlation analysis of selected qualitative parameters versus factor of year and variety

Factor	Crude protein content	Wet gluten content	Zeleny – sedimentation value	Starch content	Alveograph energy	Falling number
Year	-0,66*	-,075*	-0,46^{n}	0,78*	-0,44^{n}	0,86*
Variety	0,01^{n}	0,10^{n}	0,01^{n}	-0,16^{n}	0,06	0,10^{n}
Statistically significant correlation at α < 0,05 (*); statistically insignificant (^{n})						

Correlation analysis of selected qualitative parametrs of wheat (*table 6*) shows the obvious relation between crude protein content and wet gluten content (r = 0,93) and Zeleny - sedimentation value (r = 0,82). The demonstrated figures are in accordance with Krejčířová's results [KREJČÍŘOVÁ *et al.*, 2006]. She states the fact that there are more close relations in low-input farming system than in conventional one. On the other hand, starch content is in the negative correlation to crude protein content (r = -0,71), wet gluten content (r = -0,75) and Zeleny - sedimentation value (r = -0,62). The results have not proposed any obvious effect of the variety on the qualitative parameters in low-input farming system.

Table 6

Correlation analysis of selected qualitative parametrs of wheat

	C	W	Z	S	A	F
Crude protein content (C)	1					
Wet gluten content (W)	0,93*	1				
Zeleny – sedimentation value (Z)	0,82*	0,77*	1			
Starch content (S)	-0,71^{n}	-0,75^{n}	-0,62^{n}	1		
Alveograph energy (A)	0,70*	0,75*	0,66*	-0,38^{n}	1	
Falling number (F)	-0,53*	-0,66**	-0,25^{n}	0,64*	-0,49^{n}	1
Statistically significant correlation at α < 0,05 (*);α < 0,01 (**);statistically insignificant (^{n})						

CONCLUSIONS

When evaluating the results, we may demonstrate the following findings. The baking quality is reduced in organic (low-input) farming system; crude protein content and Zeleny sedimentation value decrease. On the other hand, starch content is not influenced by the farming system. Resistance to lodging, expressed in falling number figures, is influenced by the reaction of the variety in certain conditions in certain years.

The selection of elite varieties (with high protein content and favourable Zeleny sedimentation values) can be recommended for low-input farming system (e.g. Element variety). Elite varieties respond to the absence of the supportive instruments (soluble nitrogenous fertilizers) by the reduction of crude protein content. However, the reduction of crude protein content is not as considerable as the reduction of crude protein content in case of less qualitative variety grown in the same conditions. On the other hand, elite varieties provide grains characterized by better baking quality, but lower yield level than the other ones. This fact has to be taken into account, when suitable varieties for different use purpose being selected (food, feed and industry processing).

Acknowledgement: This work was supported by the MSM 6007665806 and grant of National agency of agricultural research NAZV QG 50034.

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