RYE QUALITY OF HYBRID AND POPULATION VARIETIES FROM INTENSIVE AND ECOLOGICAL CONDITIONS*

J. Petr, V. Mikšík

Czech University of Agriculture, Faculty of Agrobiology, Food and Natural Resources, Prague, Czech Republic

Three-year trials were established to study milling and baking rye quality, hybrid and population varieties in different cultivation conditions and different intensity of cultivation including ecological system on certified experimental area. Methods of analyses of milling and baking quality were done using Czech Standards (ČSN) identical with those from the European Union and methodological procedures ICC. Thousand-kernel weight (TKW) was higher in population varieties. At higher intensity of cultivation and in more fertile locations TKW was higher in both groups varieties. The higher TKW was recorded in all experimental years from ecological cultivation and again it was higher in population varieties than in hybrid varieties. At the TKW level the share of past weather in the given year (39%) and intensity of cultivation (32%), the share of variety was only 17%. Grain size (2.2 and 2.5 mm) was higher in hybrid varieties but in total it was highest from ecological cultivation. Specific weight (SW, 1 litre in g) was higher in population hybrids, significantly in some years. At increased intensity of cultivation and more fertile conditions it was higher in both groups of varieties. In ecological farming population varieties had also higher specific weight. Weather had a decisive influence in the given year. Protein content was also higher in population varieties at both intensities, above all in increased intensity and fertile locations. The site of cultivation (location) participated the most in the protein content (73%) and the variety (18%). In ecological farming the protein content was on average of three years on the level of intensive cultivation, what is an important difference from wheat, which has significantly lower protein content and gluten quality in ecological farming. The Falling number was higher in hybrid varieties and at higher intensity of cultivation. Similar values were recorded also in ecological cultivation. The Falling number in different experimental years was much different by the site of cultivation, what was associated with a decisive effect of weather in the given year and location. In our experiments the maltose value ranged between 1.7 and 1.9%, what can be assessed favourably. This value was slightly higher in hybrids and under higher intensity of cultivation. It was lowest totally 1.2–1.4% in ecological farming. Weather and intensity of cultivation had a decisive effect. The ash content ranged between 1.37 and 1.47% and the differences were insignificant. The ash content affected also past weather in different years. Rye quality was manifested better in hybrid varieties according to amylograph maximum, particularly increased values were in samples from ecological cultivation. The effect of weather participated by 81% and the variety by 14%. Specific weight of baking (test volume) was influenced favourably by intensity of cultivation, which participated by 27%, but weather by 71%. The values from ecological cultivation were on the same level like in the intensive cultivation. It can be seen from these analyses that most of criteria of milling and baking quality suggest better technological quality of hybrid varieties. Intensity of cultivation contributed to higher TKW, maltose value and specific weight of baking. The share of variety ranged in most criteria between 14 and 18%. All the above investigated parameters except of protein content were affected by weather conditions in the given year, what is confirmed by a known variability of technological rye quality. The finding that technological quality in both groups of rye varieties is a new one in ecological cultivation favourable for milling and baking processing, and thus also for production of rye bioproducts.

rye; technological quality; intensive and ecological cultivation; hybrid and population varieties

INTRODUCTION

Rye cultivation in cereal management of Europe has its stable position despite of a strong fall of sowing areas. It is given by a unique possibility to cultivate it under less favourable conditions, in particular on sandy soils. Among other things, rye is excellent by frost- and winter-hardiness. This was manifested above all in unfavourable winter of 2002/2003, rye overwintered the best of all cereal species. This undemandingness for forecrop and soil fertility allows it to be cultivated in conditions where other cereal species cannot survive economically. Such conditions create relatively a great share in the Czech Republic and rye cultivation can support here sustainability of agricultural activities. Rye bread in our food contributed to increased percentage of pentosanes, in which a protective effect on mucous membrane of intestines and regulation of blood cholesterol (P ř í h o d a , 2005).

In rye that is not so variable in species and varieties are rather related, such progress in breeding was not obtained like in wheat, and hence, an effect of intensifica-

* The finishing of this study was supported by the grant NAZV QG 50034.

tion factors could not be manifested. Technological quality stability of wheat and the possibility of preparation of a wide assortment of bread and baking suited better to industrial baking large-scale production. Not earlier than in the 1970s in Poland when Dankowskie varieties were bred what was a remarkable progress. However, a revolutionary change occurred after obtaining of hybrid varieties in Germany. These hybrids exceed population varieties in yields by 10–20% and they are fast distributed in practice. In the State Variety Book in the Czech Republic there are five population varieties and five hybrid varieties. In connection with their coming, processors are interested in their quality as well. This was an aim of this study – to compare technological quality of hybrid and population varieties from different agroecological conditions, different intensity of cultivation including ecological system.

Milling and baking quality of rye is different than wheat quality. A lot of indicators are similar in milling quality but baking quality cannot be determined by an unambiguous criterion like it is with wheat, for example gluten content and gluten quality. During purchase and stock market trades moisture, specific weight, admixtures, and impurities, Falling number and sprouted grain. Millers note also grain colour, shape of grains as wells as colour changes that disclose occurrence of pathogens. The occurrence of ergot needs a special attention.

Specific – test weight – is widely used but for baking quality of rye it is not in a direct relationship. It is only an orientation criterion and is related to yield of flours, i.e. to milling quality. 730 g of weight per 1 litre is presented as a basic value (73 kg of 1 hectolitre). The grain is smaller at lower values and is in correlation with higher ash content (Příhoda et al., 2003a).

Requirements for rye quality do not present grain size, i.e. percentage of grain size 2.2 mm and 2.5 mm but higher percentage of great and uniform grain is advantageous for milling. It is also associated with thousand-kernel weight that is variety quality but is strongly subjected to weather effect.

In baking quality we mentioned above that proteins of rye grain has no typical properties of wheat gluten. Rye gluten, too, cannot be washed out. The protein content is related to dough yield due to greater viscosity of flour. Literary data do not contain optimum scale of the protein content in rye. Příhoda et al. (2003b) presented 9–14%. 8–12% are presented usually. Vilíkovský found in the Czech Republic an average content to be 10.4%, in current varieties and conditions of cultivation that the protein content is lower and is ranging between 7% and 8%, as it can be seen from analyses of ÚKZÚZ (the Central Institute for Supervising and Testing in Agriculture Brno (Jurečka, Beneš, 2000–2002; Jurečka et al., 2003, 2004).

The maltose content is related to baking quality and optimal are 2–3%. Higher content should mean a certain degree of overgrowing.

The Falling number has been introduced in recent years, i.e. expressing properties of starch-amylase complex, what is a very serious criterion of rye quality. The Czech National Standard (ČSN) states the scale 120–170 seconds. Low values show a certain degree of overgrowing (also a hidden overgrowing), what is unfavourably manifested in bread quality, volume and shape. It is a variety property but also strongly dependent on past weather in the given year, so the values of Falling number by the years are fluctuating. After Oberforster (2001) there is a relationship of Falling number to amylograph values. Amylograph maximum is registered (viscosity maximum) in amylograph units (AU) and the temperature of gelation. Literary data give most frequently the scale 400–700 AU (Matějovský, 1947) or 500–800 AU (Oberforster, 2001). These values are expressing internal quality, rye is conditioning exterior and vaulting of bread, porosity of soft inside of loaf, and colouring crust of bread.

MATERIAL AND METHODS

We obtained samples of selected hybrid varieties (Fernando, Picasso and Rapid) and population varieties (Dankowskie Nowe, Selgo and Albedo) from testing stations, where variety trials are establishing for ÚKZÚZ: Hradec nad Svitavou, Nechanice near Hradec Králové and Lípa near Havlíčkův Brod and from experiments that are conducted at the Experimental Station of the Czech University of Agriculture in Prague-Uhříněves in ecological system. We obtained samples from two intensities of cultivation from each station: I – the basic intensity with the treated seed and basic rate of nitrogen is used for fertilization, the herbicide was used but without treatment with fungicides and morphoregulators. The station II – increased intensity where the seed is treated, herbicide was applied, nitrogen rate was increased by 30 kg and the stands were treated with two sprayings with fungicides and morphoregulator. Ecological cultivation keeps the principles of international organisation IFOAM (International Federation of Organic Agriculture Movement) and the Methodology of the Ministry of Agriculture of the Czech Republic for ecological agriculture, i.e. without fertilization and treatment with pesticides.

The Station Hradec is situated in potato-growing region 450 m above sea level, average annual air temperature is 6.5 °C, with annual sum of precipitation 624 mm. The station Lípa is situated in cereal-growing region 505 m above sea level, annual temperature is 7.7 °C, sum of precipitation 632 mm. The Station Nechanice is placed in fertile sugar-beet growing region 235 m above sea level, average annual temperature is 8.1 °C, sum of precipitation 616 mm. Uhříněves, too, is situated in sugar-beet growing region 295 m above sea level, average annual temperature is 8.3 °C, sum of precipitation 575 mm. The detailed past weather in experimental years and on different sites is presented in the study written by Petr (2005).

Fernando was registered in the Czech Republic in 2001. It is a semi-late hybrid variety suitable for all re-

Table 1a. Significance of the effect of location in all studied quality indicators in 2003

Location	TKW g	Specific weight g	Protein %	Falling number s	Maltose value %	Ash %	Amylograph max. AU	Test volume cm^3
Uhříněves Eco.	37.15 B	73.6 AB	12.29 G	179.4 AB	1.22 A	0.8 A	456.2 AB	711.2 A
Lípa	31.6 A	73.5 A	9.66 A	218.4 B	1.70 B	0.83 AB	421.6 AB	709.3 A
Hradec	32.3 C	74.2 AB	9.60 A	165.7 A	1.75 B	0.79 A	367.7 A	729.1 A
Nechanice	33.10 A	74.7 B	10.82 B	195.9 AB	1.54 B	0.88 B	478.1 B	706.8 A
F-test	10.51	3.42	43.33	5.38	10.65	8.19	2.72	1.28
Value *p* (a)	0.0000	0.0024	0.0000	0.0027	0.0000	0.0001	0.0535	0.2913

Means denoted by different letters (A, B, C) are expressing significant differences at the level of significance $\alpha = 0.05$ after Bonferroni's method. For example: mean denoted in Table A is not statistically significantly different from AB, but is different from B, BC and C etc.

Table 1b. Significance of the effect of varieties – hybrids and populations in all studied quality indicators in 2003

Varieties	TKW g	Specific weight g	Protein %	Falling number s	Maltose value %	Ash %	Amylograph max. AU	Test volume cm^3
Hybrid	31.7 A	73.2 A	9.95 A	215.6 B	1.59 A	0.83 A	484.2 B	714.5 A
Population	34.4 B	74.9 B	10.75 B	167.1 A	1.61 A	0.83 A	370.3 A	714.6 A
F-test	14.76	31.72	7.82	43.33	10.65	8.19	2.72	1.28
Value *p* (a)	0.0003	0.0000	0.0007	0.0000	0.823	0.919	0.0002	0.988

Means denoted by different letters (A, B, C) are expressing significant differences at the level of significance $\alpha = 0.05$ after Bonferroni's method. For example: mean denoted in Table A is not statistically significantly different from AB, but is different from B, BC and C etc.

Table 1c. Significance of the effect of cultivation intensity (I – lower and II – higher) in all quality indicators 2003

Varieties	TKW g	Specific weight g	Protein %	Falling number s	Maltose value %	Ash %	Amylograph max. AU	Test volume cm^3
Intensity I	31.3 A	73.7 A	9.76 A	192.0 A	1.61 B	0.81 A	430.0 A	690.2 A
Intensity II	33.3 B	74.6 A	10.28 A	194.7 A	1.71 B	0.86 A	414.9 A	740.0 B
Ecology	37.1 C	73.6 A	12.29 B	179.3 A	1.22 A	0.80 A	456.25 A	711.2 A
F-test	20.73	3.55	31.60	0.39	12.44	4.41	0.36	19.32
Value *p* (a)	0.0000	0.0357	0.0000	0.6822	0.0000	0.017	0.696	0.0000

Means denoted by different letters (A, B, C) are expressing significant differences at the level of significance $\alpha = 0.05$ after Bonferroni's method. For example: mean denoted in Table A is not statistically significantly different from AB, but is different from B, BC and C etc.

gions, less resistant to lodging and rye rust. Picasso was registered in 2001 and has similar properties like Fernando. Rapid is the oldest certified hybrid variety (1994) in the Czech Republic and by its properties it is not different from the previous varieties. Dankowskie Nowe is the oldest certified population variety in the Czech Republic (1977). Medium-early, winter-resistant variety resistant to lodging, suitable for more intensive conditions. Albedo is semi-late population variety from the year 1991, suitable for higher-situated regions. Selgo is later population variety of 1997 suitable for all regions of the Czech Republic.

Milling and baking rye quality was assessed by Czech Standards (ČSN) and methods of the International Association for Cereal Science and Technology – ICC. Grain analyses according to the Czech Standard ČSN 461011, analyses according to the Czech Standard ČSN 560512, Falling number after the Czech Standard ISO 3093, amylograph analysis after ICC 148.

Statistical methods applied

The results obtained were evaluated using the statistical programme Statgraphics Plus for Windows (version 5.1 Plus from the company Manugistics, Maryland, USA) using the methods of analysis of variance of simple and triple classification and regression analysis.

The results of significance are presented directly in the text of the given results and in discussion. An example of outline of significance for the year 2003 is presented in Tables 1a, b, c.

Linear model of expression of the function was preferred in regression analysis before the others. The text gives the values of correlation coefficient.

RESULTS AND DISCUSSION

We proved in the previous study (Petr et al., 1999; Petr, 2005) that hybrid varieties in rye are more yielding than population varieties. Higher yielding capacity was manifested at all experimental sites and at both intensities of cultivation together with ecological cultivation. We evaluated milling and baking quality from harvested grain of these experiments by analysis of main quality criteria. We wanted to know the differences in both groups of varieties, effect of intensity of cultivation on rye quality and also the rye quality from ecological agriculture, and thus also the possibility of utilization of rye for bio-bread production (Tables 2–5).

Thousand-kernel weight (TKW) is not a purchasing criterion but it is a certain indicator of variety. It is studied during registration and testing of certified varieties. TKW in population varieties ranged between 35.4 g and in hybrid varieties 33.2 g from these experiments conducted at ÚKZÚZ (Central Institute for Supervising and Testing in Agriculture) in the period 1996–2003. In our three-year trials population varieties had TKW 30.1 g identical in both intensities. Hybrid varieties had the TKW value 29.7 g in hybrid varieties in the first intensity and 31.6 g in the second intensity. In 2001 TKW value was the lowest of all experimental years, because the past weather in May and June was unfavourable (draught) for spike productivity. There was neither difference between both intensities, nor between groups of varieties. In subsequent years TKW was higher and significantly higher in the second intensity of cultivation with greater fertilization and protection against leaf and spike diseases. TKW value was affected for 32% by intensity of cultivation, past weather in the given year – 39%, variety 17% and location 12%. TKW was also significantly higher in ecological cultivation, in population varieties 35.4 g and in hybrid varieties 34.2 g. Lower number of spikes per area unit always brings by law compensation of yield components by increased TKW. Higher thousand-kernel weight may be related to higher flour yielding capacity. Hýža and Palík (1984) present the relationship to the content of antinutritive substances where in grains with higher TKW was lower content of alkylresorcinols. More important criterion for milling processing is a grain size expressed by the share of grain size 2.2 and 2.5 mm. Greater share of front grains makes easier purification and milling. Our analyses showed greater share in hybrid varieties 88–89% than in population varieties 80%. This share reached even 91–95% in ecological cultivation and in state variety trials 90% Jurečka, Beneš (2000–2002) and Jurečka et al. (2003, 2004). There is a certain associa-

Table 2. Quality parameters of hybrid and population rye varieties from ecological and intensive cultivation average for the years 2001–2003

Year	Varieties	Intensity	TKW g	Grain size %	Specific weight g	Protein %	Falling number s	Maltose value %	Ash %	Maximum amylograph unit AU	Test volume cm^3
2001	Varieties	I	26.7	64.2	690	9.79	144	2.0	1.88	180	
	Populations	II	27.0	57.0	672	9.55	146	1.9	1.85	201	664
	Varieties	I	22.8	79.4	712	9.82	148	1.9	1.74	198	
	Hybrids	II	27.7	75.2	703	9.31	157	2.0	1.72	254	652
	Populations	EKO	41.5	99.6	740	8.11	183	1.5	1.79	375	580
	Hybrids	EKO	39.0	99.7	738	7.76	176	1.2	1.64	431	620
2002	Varieties	I	31.8	86.4	744	9.97	290	1.5	1.59		
	Populations	II	29.7	83.7	740	9.80	325	1.6	1.57		772
	Varieties	I	36.3	94.0	753	10.50	274	1.7	1.61		
	Hybrids	II	35.6	92.7	746	10.14	295	1.8	1.59		777
	Populations	EKO	29.9	85.9	713	9.26	255	0.75	1.86		820
	Hybrids	EKO	27.3	75.8	688	9.39	252	1.8	1.83		775
2003	Varieties	I	31.9	95.7	745	10.1	166	1.5	0.83	359	690
	Populations	II	33.8	97.4	751	10.7	168	1.8	0.86	335	746
	Varieties	I	29.9	95.0	726	9.3	223	1.7	0.80	485	706
	Hybrids	II	31.6	96.9	739	9.7	220	1.9	0.86	468	740
	Populations	EKO	38.1	98.7	742	12.4	156	1.2	0.76	435	720
	Hybrids	EKO	36.5	98.5	730	12.2	204	1.2	0.85	485	700
Average for the years 2001–2003	Varieties	I	30.1	81.4	726	9.95	200	1.7	1.43	270	690
	Populations	II	30.1	79.3	721	10.01	213	1.7	1.42	268	727
	Varieties	I	29.7	89.4	730	9.87	215	1.8	1.37	342	706
	Hybrids	II	31.6	88.2	729	9.71	224	1.9	1.39	361	723
	Populations	EKO	36.5	94.7	731	9.92	198	1.2	1.47	405	706
	Hybrids	EKO	34.2	91.3	718	9.78	210	1.4	1.44	458	698

Table 3. Quality parameters of rye hybrid and population varieties from ecological and intensive cultivation of 2001

Location	Intensity	Varieties	TKW g	Grain size %	Specific weight g	Protein %	Falling number s	Maltose value %	Ash %	Maximum amylograph value AU	Test volume cm^3
Hradec	I	Population	30.8	83.7	702	8.40	144	1.8	1.75	163	
	I	Hybrid	26.6	79.3	691	8.25	146	1.9	1.73	185	
Hradec	II	Population	32.4	89.1	715	8.64	121	1.8	1.66	153	666
	II	Hybrid	28.8	83.8	704	8.28	127	1.9	1.68	180	642
Nechanice	I	Population	19.9	23.8	662	12.30	142	2.6	2.08	195	
	I	Hybrid	15.6	14.2	630	11.93	157	1.9	2.13	210	
Nechanice	II	Population	27.3	59.3	706	12.06	166	2.1	1.90	200	640
	II	Hybrid	22.6	51.2	692	11.32	172	2.2	1.87	267	640
Lípa	I	Population	29.6	85.2	708	8.69	147	1.6	1.81	181	
	I	Hybrid	26.4	77.7	695	8.48	137	2.1	1.71	207	
Lípa	II	Population	33.0	89.8	716	8.76	156	1.8	1.66	240	686
	II	Hybrid	31.7	90.6	715	8.33	172	1.9	1.62	315	680
Uhříněves	Eko	Population	41.5	99.6	740	8.11	183	1.5	1.79	375	580
	Eko	Hybrid	39.0	99.7	738	7.76	176	1.2	1.64	431	620

Table 4. Quality parameters of hybrid and population rye varieties from ecological and intensive cultivation of 2002

Location	Intensity	Varieties	TKW g	Grain size %	Specific weight g	Protein %	Falling number s	Maltose value %	Ash %	Test volume cm^3
Hradec	I	Population	33.3	87.6	752	9.62	296	1.5	1.62	
	I	Hybrid	32.0	87.8	749	9.1	323	1.8	1.59	
Hradec	II	Population	36.7	92.7	753	10.1	281	1.8	1.59	770
	II	Hybrid	36.5	92.8	749	9.84	296	1.9	1.57	775
Nechanice	I	Population	30.3	85.2	737	10.34	284	1.6	1.57	
	I	Hybrid	27.5	79.6	732	10.5	328	1.4	1.55	
Nechanice	II	Population	35.9	95.4	754	10.83	268	1.7	1.63	775
	II	Hybrid	34.8	92.7	744	10.44	293	1.7	1.62	780
Uhříněves	Eko	Population	29.9	85.9	713	9.26	255	0.75	1.86	820
	Eko	Hybrid	27.32	75.8	688	9.39	252	1.8	1.83	775

Table 5. Quality parameters of rye hybrid and population varieties from ecological and intensive cultivation of 2003

Location	Intensity	Varieties	TKW g	Grain size %	Specific weight g	Ash %	Falling number s	Maltose value %	Ash %	Maximum amylograph unit AU	Test volume cm^3
Hradec	I	Population	31.9	93.1	737	9.96	132	1.68	0.81	284	704
	I	Hybrid	31.2	96.0	723	9.27	173	1.78	0.73	380	726
Hradec	II	Population	32.9	96.1	755	9.94	151	1.92	0.85	318	764
	II	Hybrid	32.2	97.1	747	9.12	184	1.69	0.82	443	740
Nechanice	I	Population	32.6	96.6	761	10.80	181	1.50	0.85	478	660
	I	Hybrid	29.1	92.9	739	9.75	247	1.63	0.84	610	687
Nechanice	II	Population	36.1	98.4	751	11.8	169	1.50	0.91	362	744
	II	Hybrid	32.0	96.9	738	10.6	222	1.45	0.94	457	740
Lípa	I	Population	31.3	97.5	739	9.51	187	1.48	0.83	316	708
	I	Hybrid	29.5	96.3	717	9.02	250	1.74	0.85	467	667
Lípa	II	Population	32.6	97.8	746	10.35	185	1.88	0.83	326	732
	II	Hybrid	30.6	96.9	733	9.51	254	1.84	0.82	506	740
Uhříněves	Eko	Population	38.1	98.7	742	12.40	156	1.21	076	435	720
	Eko	Hybrid	36.5	98.5	730	12.22	204	1.24	0.85	485	700

tion with TKW but we did not proved any correlation. The past weather and stand structure play again a decisive role here.

Specific weight (SW), expressed in our study by weight one litre of grain in grams is still considered as a basic input criterion of quality in purchase of rye. Statistical evaluation showed a decisive effect of weather in the given year. Bushuk (1976) reported that weather is not related to baking quality but to milling quality when at higher SW flour yielding is also higher. Vladyka and Tuček (1939) associate higher specific weight even with greater grain size, its thin shell, soft surface and higher starch content. Lower specific weight followed in hybrid varieties from our analyses what coincides with the results from state variety trials (Jurečka, Beneš, 2000–2002; Jurečka et al., 2003, 2004).

At more locations and years specific weight was significantly higher at the second – higher intensity of cultivation. The similar situation was in more fertile conditions. In ecological farming specific weight was practically identical like in the intensive cultivation (intensity I and II) and reached the required value 730 g. In additions, we present a relationship of specific weight to ash content.

The protein content was in majority cases significantly higher in population varieties, in the intensity of cultivation II and also in more fertile conditions. Similarly, in ecological farming the protein content was higher in population varieties and higher in the other systems of cultivation. The highest content of proteins was in 2003 that was most favourable for three-year period. Site of cultivation played a significant role in the protein content (72%), variety only 18%. As it was mentioned above rye proteins affect much less the quality of rye baking than wheat proteins. In spite it, many authors report the relationship of the protein content to baking properties of flour. The effect of weight yield of bread dough, evidently due to higher viscosity of flour. Correlation between protein content and amylograph maximum (correlation coefficient 0.25) was not proved in our calculations of simple regression nor by the relationship to specific weight of baking (correlation coefficient 0.29). The range of protein content in our experiments was 9.7–10.1% (N x 5.83), what coincides with the data reported by other authors (Matějovský, 1947; Hlaváček, 1948; Hýža, Lekeš, 1990). The protein content was in the above range for rye from ecological cultivation, what is a great difference to wheat where in ecological farming the protein content and quality decreased.

In the present system Falling number belongs to important criteria in the present system of evaluation of rye quality. It manifests a certain degree of activity of alpha amylase, degree of sprouting, and hence it has a relationship to baking quality. It proves the correlation coefficient found to amylograph maximum 0.74. Average values of three-year study show significantly higher viscosity values in hybrid varieties. The effect of intensity of cultivation on Falling number was not proved by statistical analysis in three-year evaluation. The values are ranging between 200–224 seconds. The differences between locations are not significant, too. Similarly, it is in ecological cultivation. Differences are small in average values but the differences are evident in different years and locations in dependence on past weather. Results of statistically significant differences in the values of Falling number in different years. On the level of Falling number weather participated by 97% and 3% formed the site of cultivation. It is similar with Falling number from state variety trials where Falling number was also higher in hybrid varieties ranging from 180 to 200 seconds.

Maltose in rye grain is producing relatively fast during rye germination, so its high content indicates rye damage by overgrowing. Maltose content 2–3% is considered as acceptable. 3–3.5% show a slight overgrowing and the content > 3.5% means a great overgrowing. In our experiments the maltose content was 1.7–1.9%. Its content was significantly higher than in the other years in unfavourably year 2001. It indicates an effect of weather in the given year like in Falling number. The maltose content was insignificantly higher in hybrid varieties, and mostly without significant effect of cultivation intensity. In some cases only maltose values were higher in the second intensity of cultivation. The share of past weather was in this criterion 46% and intensity of cultivation was 43%. In ecological farming the maltose content was lower 1.2–1.4%.

The ash content is associated with classification of flours and there may be great differences in its yielding capacity. Some phosphorus compounds cause acidity of flours. Average values in the ash content were recorded in the range of 1.37 to 1.47%. The differences were significant in different years, what manifest a marked influence of weather (97%). In fertile region also was significantly higher ash content. On the contrary, it much fell in 2003, because there was a great share of large grains. There were no significant differences among groups of varieties. However, the relationship of the ash content and specific weight was confirmed as it was recorded by Příhoda et al. (2003a, b). Correlation coefficient was highly significant (0.96).

We studied the condition of saccharide-amylase complex using amylograph and amylograph maximum is presented in our results herein. It followed from them that significantly higher values were in hybrid varieties. The effect of cultivation intensity and locations was not manifested significantly but in more fertile conditions the values were higher. In favourable year of 2003, too, the values were highest. Again, past weather had the greatest effect (81%) on the level of amylograph maximum. The variety participated only by 14%. An attention can be paid to the data of amylograph maximum from ecological cultivation where was higher viscosity that is a significant property of baking quality of flour. We found the same for Falling number. Both these values were better just in samples from ecological cultivation. We mentioned above the relationship to Falling number.

Specific weight of baking in rye has not such an expressive value like in wheat. There is a certain favourable effect of higher intensity of cultivation on the size of baking in experiments. The weight of baking from ecological cultivation is not much different from intensive systems what shows that good baking quality is reached from ecological cultivation. Significant differences among groups of varieties were not proved but great and significant differences were between experimental years. The year 2001 was the worst of all and the years 2002 and 2003 were markedly best ones. The share of weather in the given year was 71%, intensity of cultivation 27%. Correlation between maltose content and specific weight of baking (test volume) (0.17) and Falling number and specific weight of baking (0.45) was not confirmed.

The effect of past weather in the experimental year should be mentioned in final evaluation of quality indicators of rye. It was manifested more significantly in 2001 at the experimental station Nechanice when thousand-kernel weight (TKW) fell significantly and hence also the share of front grain of grain size 2.2 and 2.5 and also specific weight due to dry and very warm May. Then tiny grain of rye had also higher protein content. The content of maltose increased together with ash content. In remaining years past weather during vegetation was close to long-term average except above-average precipitation in summer months in the years 2001 and 2002, what did not affect the rye quality.

If we sum up evaluation of different factors in rye cultivation on its technological quality, then past weather had a decisive effect in all indicators. The site of cultivation was the only exception in the protein content. The share of variety in the quality was ranging between 14 and 18%.

Acknowledgement

The authors thank workers of testing stations at Hradec nad Svitavou, Lípa near Havlíčkův Brod, and at Nechanice, who under previous consent of the Division of Variety Testing of the Central Institute for Supervising and Testing (ÚKZÚZ) in Brno provided grain samples and needed data.

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Received for publication on May 18, 2005
Accepted for publication on July 13, 2005

PETR, J. – MIKŠÍK, V. (Česká zemědělská univerzita, Fakulta agrobiologie, potravinových a přírodních zdrojů, Praha, Česká republika):

Kvalita žita odrůd hybridů a populace z intenzivních a ekologických podmínek.

Scientia Agric. Bohem., *37*, 2006: 1–8.

V tříletých pokusech jsme sledovali mlynářskou a pekařskou kvalitu žita, odrůd hybridů a populace v různých pěstitelských podmínkách a z různé intenzity pěstování včetně ekologického způsobu na certifikované pokusné ploše. Metody rozborů mlynářské a pekařské jakosti byly dělány podle českých norem (ČSN) shodných s EU a metodických postupů ICC.

Hmotnost tisíce zrn (HTZ) byla vyšší u odrůd populace. V některých letech byl tento rozdíl průkazný. Při vyšší intenzitě pěstování a v úrodnějších lokalitách byla HTZ obou skupin odrůd vyšší, v některých letech průkazně vyšší. Nejvyšší HTZ byla ve všech pokusných letech z ekologického pěstování a opět u odrůd populace vyšší než u odrůd hybridů. Na úrovni HTZ se nejvíce podílel průběh počasí v daném roce (39 %) a intenzita pěstování (32 %); odrůda se podílela jen 17 %.

Vyrovnanost zrna (podíl nad síty 2,2 a 2,5 mm) byla vyšší u odrůd hybridů, ale celkově nejvyšší byla u ekologického pěstování.

Objemová hmotnost (1 litru v g) byla vyšší u odrůd populace, v některých letech průkazně. Také při zvýšené intenzitě pěstování a v úrodnějších podmínkách byla vyšší u obou skupin odrůd. V EZ měly odrůdy populace také vyšší OH. Rozhodující vliv měl průběh počasí v daném roce.

Obsah bílkovin byl také vyšší u odrůd populace při obou intenzitách, zejména ve zvýšené intenzitě a na úrodných lokalitách. Na obsahu bílkovin se nejvíce podílelo místo pěstování (lokalita) – 73 % a odrůda – 18 %. V EZ byl obsah bílkovin v průměru tří let na úrovni intenzivního pěstování, což je pozoruhodný rozdíl oproti pšenici, která má v EZ podstatně nižší obsah bílkovin i kvalitu lepku. Číslo poklesu bylo vyšší u odrůd hybridů a při vyšší intenzitě pěstování. Podobné hodnoty byly i z ekologického pěstování. V jednotlivých pokusných letech se číslo poklesu průkazně lišilo podle místa pěstování, což souviselo s rozhodujícím vlivem počasí v daném roce a lokalitě.

Obsah maltózy byl v našich pokusech v rozsahu 1,7–1,9 %, což lze hodnotit velmi příznivě. Mírně vyšší byl u hybridů a při vyšší intenzitě pěstování. V ekologickém pěstování byl celkově nejnižší – 1,2–1,4 %. Vliv počasí a intenzita pěstování měly rozhodující vliv.

Obsah popelovin se pohyboval v rozmezí 1,37–1,47 % a rozdíly byly neprůkazné.Obsah popelovin ovlivňoval také průběh počasí v jednotlivých letech.

Podle amylografického maxima se jevila lepší jakost žita u odrůd hybridů, zvýšené hodnoty byly zejména u vzorků z ekologického pěstování.Vliv počasí se podílel 81 % a odrůda 14 %.

Měrný objem pečiva byl příznivě ovlivněn intenzitou pěstování, která se podílela 27 %, ale počasí 71 %. U ekologického pěstování byly hodnoty na stejné úrovni jako při intenzivním pěstování.

Z těchto rozborů vyplývá, že většina kritérií mlynářské a pekařské jakosti žita svědčí o lepší technologické jakosti hybridních odrůd. Intenzita pěstování přispěla k vyšší HTZ, obsahu maltózy a měrnému objemu pečiva. Podíl odrůdy na většině kritérií se pohyboval mezi 14 až 18 %. Všechny sledované ukazatele jakosti byly až na obsah bílkovin ovlivněny podmínkami počasí v daném roce, což potvrzuje známou variabilitu technologické jakosti žita.

Novým poznatkem je zjištění, že při ekologickém pěstování je technologická kvalita u obou skupin odrůd žita příznivá pro mlynářské a pekárenské zpracování a tím pro produkci žitných bioproduktů.

žito; technologická jakost; intenzivní a ekologické pěstování; odrůdy hybridů a populace

Contact Address:

Prof. ing. Jiří Petr, DrSc., Česká zemědělská univerzita v Praze, Fakulta agrobiologie, potravinových a přírodních zdrojů, Kamýcká 129, 165 21 Praha 6-Suchdol, Česká republika, e-mail: jpetr@af.czu.cz