Bulgarian Journal of Agricultural Science, 16 (No 1) 2010, 22-29
Agricultural Academy

PERFORMANCE OF BULGARIAN WINTER WHEAT VARIETIES FOR MAIN END-USE QUALITY PARAMETERS UNDER DIFFERENT ENVIRONMENTS

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Abstract

ATANASOVA, D., N. TSENOV, I. STOEVA and I. TODOROV, 2010. Performance of Bulgarian winter wheat varieties for main end-use quality parameters under different environments.
Bulg. J. Agric. Sci., 16: 22-29

Twenty two winter wheat varieties were tested for the period 2001–2006. The aim was to follow the response of these varieties under various growing conditions with regard to some quality parameters and to determine which of them were able to realize better their quality potential under changeable environments. The varieties were grown by the Latin square design (6 replicates, each of 15 m^2). The following characters were examined: test weight (TW), wet gluten content (WGC), sedimentation value (SDS), dough resistance (DRes), valorimeric value (Val) and loaf volume (LVol). The most variable by years (85.4%) is dough resistance and test weight was most stable (2.42%). Aglika, Slaveya and Lazarka varieties showed high stability of each quality index. The new varieties Slaveya and Lazarka possessed very good combination of high quality and high ecological stability and can be therefore considered an excellent breeding achievement in this respect.

Key words: winter wheat, end-use quality, cultivars, environments

Introduction

Developing of varieties with good production potential and excellent quality indices which meet the market requirements is the aim of each breeding program (Williams et al., 2008). This problem is especially valid at the current moment due to the increasing world population and the constantly changing climate which is unfavorable for agriculture (Schimmelpfennig et al., 1996). Wheat (*Triticum aestivum* L.), being a crop with long vegetation, is affected by conditions of various nature and direction (Mladenov et al., 1996; Peterson et al. 1998; Tsenov et al., 2004). Especially important is the knowledge on the response of the varieties to specific environmental changes and the possibility to predict their performance in respect to grain quality under certain combination of growing conditions (Stoeva et al., 1992; Yong et al., 2004; Drezner et al., 2006).

Environment is rarely completely favorable for expression of the full genetic potential of a variety. Grain end-use quality expressed through its separate indices, is determined genetically. The genetic control of each index is influenced to different degrees by the

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environment. The percent of this effect as reported by some authors (Panozzo and Eagles, 2000; Eagles et al., 2002) is rather different, although generally high.

The aims of this investigation were: 1) to follow the performance of some wheat varieties developed at DAI – General Toshevo under various growing conditions with regard to some quality parameters; 2) to determine which of them are able to realize better their quality potential under changeable environments.

Material and Methods

The investigation was carried out at the trial fields of DAI, General Toshevo and encompassed the period 2001–2006. Twenty-two winter wheat varieties were included, all developed at DARI. The trial was designed by the method of Latin squares, in 6 replicates with 15 m^2 each. The expression of 6 grain quality indices which give information about various quality aspects was analyzed: test weight (kg) (TW) (BSS 7971-2:2000), sedimentation value of flour (ml) (SDS) (Pumpyanskii, 1971), wet gluten content in grain (%) (WGC) (BSS 13375-88), dough resistance (min) (DRes), valorimeric value (valorimeter, conditional units (Val) (BSS 16759-88), and loaf volume (LVol), determined according to the methods adopted at the DARI laboratory. The differences in the behavior of the studied varieties were determined by analysis of variances and variation analysis with the help of the Statistic Software package Statgraphics XV.

Results

The meteorological conditions during the years included in the investigation varied both by amount of rainfalls and by mean monthly temperatures (Table 1). The environments during active spring vegetation period have a major effect on the quality indices (Johansson and Svensson, 1998; Gut and Bichonski, 2007) and therefore data for the months from March to July are given. The amount of rainfalls during these months determined 2001 and 2003 as years with insufficient moisture reserves in soil in comparison to the mean long-term period. The rest of the years were characterized with good moisture content, although with different distribution of vegetation rainfalls by

Table 1

Amount of rainfalls (1) and mean monthly air temperatures (^oC) (2) during the investigated period

Months		Average 1953-2006	2001	2002	2003	2004	2005	2006
III	1	35.4	47.8	103.4	23.5	24.4	35.5	68.4
	2	4	9.1	7	1.7	6.3	3.7	5.1
IV	1	42	18.4	36.2	17.9	2.2	21.6	35.5
	2	9.5	9.9	8.8	7.3	10.4	9.6	10
V	1	49.4	28.9	9.1	18.3	93.7	51.3	94.4
	2	14.9	15.2	15.4	17.7	14.1	15.4	14.8
VI	1	63.8	35	25.8	29	71.2	48	29.8
	2	18.8	18.9	20.1	21	18.7	18	19.2
VII	1	52.4	4.8	116.5	48.2	84.6	98.8	63.2
	2	21.1	24.7	23.7	21.8	20.5	21.7	20.7
Sum	1	243	134.9	291	136.9	276.1	255.2	291.3
	2	13.7	15.6	15	13.9	14	13.7	14
Deviation from mean long-term values	1		-108.1	48	-106.1	33.1	12.2	48.3
	2		1.9	1.3	0.2	0.3	-	0.3

months, which affected the manifestation of the quality potential of the varieties. The temperatures also influenced the technological and bread making indices of wheat.

According to the level of the individual indices during the period of investigation, the years 2001 and 2003 were considered favorable, while the rest lead to decrease in grain quality, as a whole. The effect of the year on the indices was ultimately significant (Table 2), without any exception. The effect of the variety was also significant, with the exception of dough resistance. The nature of the latter index is such that it is influenced negatively to a relatively highest degree when more rainfalls are available during grain filling.

The analysis of variance (Table 3) by components revealed considerably higher influence of the year on the variation of the characters: from 64.2 % in test weight to 74.9 % from the total variation in loaf volume. Although slight variation of the genotype was found in dough resistance, its share was decisive: 61.42 % (Table 2). This effect was rather high in comparison to the other indices. The results were to a large extent analogous to that obtained by Mladenov et al. (1996), Peterson et al. (1998), Stoeva and Penchev (1999, 2005), who proved the determining role of the year for the expression of wheat quality potential. Other researches (Stoeva et al., 1992; Stoeva and Penchev, 2002) emphasize the effect of the variety on the total variation.

These seemingly contradictory results are an indication for the specific effect of the external conditions and environment on the formation and manifestation of the wheat quality parameters and the various genetic potentials of the varieties.

Among the characters investigated, test weight varied least by years (CV%=2.42), followed by loaf volume and wet gluten content (10.2 and 12.6 %, respectively) (Table 4). The dough resistance (85.4

Table 2

Variance analysis of factors variety and year in the investigated indices

Source of variation		df	Mean Square	F-Ratio	P-Value
Test weight	Year	5	65.8585	54.01	0.0000
	Variety	13	9.0237	7.4	0.0000
	residual	65	1.21935		
Sedimentation value	Year	5	3761.74	81.93	0.0000
	Variety	13	524.287	11.42	0.0000
	residual	65	45.9152		
Wet gluten content	Year	5	191.827	37.24	0.0000
	Variety	13	10.4884	2.04	0.0312
	residual	65	5.15135		
Dough resistance	Year	5	267.357	9.82	0.0000
	Variety	13	27.6322	1.01	0.4484 ns
	residual	65	27.2334		
Valorimeter	Year	5	3330.84	44.21	0.0000
	Variety	13	186.312	2.47	0.0084
	residual	65	75.343		
Loaf volume	Year	5	82723.6	76.18	0.0000
	Variety	13	6141.48	5.66	0.0000
	residual	65	1085.88		

%) varied most which showed that it was affected to a highest degree by the external changes. Similar results have also been reported by Stoeva et al. (1992); Drezner et al. (2007).

The cultivars revealed low variation of test weight by years. Dobroudjanka, Pobeda, Preslav, Iveta, Sadovo 1, Albena, Lazarka, Slavyanka 196 had values above the mean of the group (Table 4 and Figure 1). Variety Vratsa had the highest test weight (79.0) and also had the highest standard deviation and the highest variation coefficient. This was an indication that the variety was most susceptible to environmental fluctuations.

The sedimentation value varied within 30 (Kristal) - 65 (Aglika). The varieties Zlatitsa, Lazarka, Neda, Bolyarka and Kristal had the lowest deviation from the mean value and their variation was respectively lowest. These varieties were least influenced by external changes. With the exception of variety Lazarka, this variation was partially due to the lower values of the above index.

The variation of wet gluten content was within 21.6 (Kristal) - 26.8 (Galateya). Highest mean values were demonstrated by Galateya, Slavyanka 196, Dobroudjanka, and Pobeda, which belonged to the group of strong wheats. Varieties Iveta, Aglika, Bolyarka, and Lazarka had the lowest variation values by year; they were simultaneously the most stable by this index.

Some varieties like Preslav, Progress, Kristal, Sadovo 1 and Bezostaya 1 had the widest range of variability (Figure 1) and therefore were the most susceptible to environmental changes. Stoeva and Penchev (2002) determined Galateya as most stable

Table 3

Variance component analysis for quality indices

Source	TW	SDS	WGC	DRes	Val	LVol
Year	64.23	67.4	68.72	38.58	71.13	74.95
Variety	35.77	32.6	31.28	61.42	28.87	25.05

Table 4

Mean values, standard deviation (S) and variation coefficient (CV%) of the characters

Varieties	Test weight			SDS			Wet gluten content		
	Mean	S	CV%	Mean	S	CV%	Mean	S	CV%
1	2	3	4	5	6	7	8	9	10
Albena	82.0*	1.6	2	54^{ns}	17.1	31.8	23.9^{ns}	3.03	12.6
Preslav	82.3*	2.3	2.9	57^{ns}	19.7	34.5	22.6$^{(-)}$	4.7	20.8
Progres	80.4^{ns}	3.1	3.9	64*	22.8	35.7	24.7^{ns}	4.8	19.4
Dobroudjanka	82.7*	1.4	1.7	60*	27	44.7	25.9*	5.41	20.9
Anna	80.0$^{(-)}$	1.3	1.7	46$^{(-)}$	14.3	31.4	22.6$^{(-)}$	3.4	15.1
Kristal	80.2$^{(-)}$	2.9	3.7	30$^{(-)}$	10.9	35.8	21.6$^{(-)}$	5.41	25
Demetra	81.6^{ns}	2	2.5	62*	20.7	33.7	24.4^{ns}	3.61	14.8
Pryaspa	80.1$^{(-)}$	1.8	2.3	42$^{(-)}$	14.8	35.4	23.6^{ns}	3.59	15.2
Slavyanka 196	81.8*	2.4	2.9	59*	17.5	29.8	26.5*	4.95	18.7
Pliska	79.4$^{(-)}$	2.2	2.7	41$^{(-)}$	14.4	35.2	23.3^{ns}	4.22	18.1
Pobeda	82.5*	1.6	2	52^{ns}	14.7	28.3	25.1*	3.78	15.1
Sadovo 1	82.0*	2.1	2.6	47$^{(-)}$	10.9	23.4	24.3^{ns}	4.13	17
Bezostaya 1	81.6^{ns}	1.8	2.3	50^{ns}	19.4	38.5	23.9^{ns}	4.27	17.9

(continued)

Table 4 (continued)

1	2	3	4	5	6	7	8	9	10
Vratsa	79.0(-)	4.7	6	52ns	15.3	29.6	24.9ns	4.08	16.4
Aglika	81.5ns	2.2	2.7	65*	16.6	25.4	23.5ns	1.86	7.9
Galateya	81.5ns	2.4	2.9	57ns	11.1	19.4	26.8*	3.47	12.9
Slaveya	80.6ns	2.3	2.8	61*	14.7	24.3	23.0ns	2.34	10.2
Iveta	82.0*	1.8	2.2	63*	20.5	32.6	23.4ns	1.64	7
Bolyarka	80.7ns	1.9	2.4	48(-)	9.6	19.9	23.0ns	2.12	9.3
Neda	79.8(-)	2.2	2.8	48(-)	8.1	17.1	23.9ns	3.29	13.8
Zlatitsa	79.8(-)	1.9	2.5	41(-)	4.8	11.6	22.5(-)	2.39	10.6
Lazarka	81.9*	1.9	2.4	59*	8	13.6	24.7ns	2.41	9.8
Mean	81.1	1.9	2.4	53	14.3	27.3	24	3.01	12.6
	Dough resistance			Valorimeter			Loaf volume		
Albena	3.1(-)	2.9	95.8	49(-)	14.9	30.5	654(-)	72.3	11
Preslav	6.3ns	11.6	184.4	54ns	23.6	44.1	598(-)	73.9	12.3
Progres	5.6ns	5.9	106.5	60*	22.3	37.5	652(-)	78.8	12
Dobroudjanka	7.5*	11.3	150.6	59ns	25.9	44	696ns	94.8	13.6
Anna	3.3ns	2.9	87.4	49(-)	16.3	33.1	648(-)	81.3	12.5
Kristal	1.8(-)	0.7	40.9	45(-)	4.7	10.5	641(-)	93	14.5
Demetra	7.5*	11.2	149.4	61*	21.7	35.9	685ns	74	10.8
Pryaspa	2.2(-)	1.5	70.3	43(-)	11.6	27.1	638(-)	73.9	11.5
Slavyanka 196	3.6ns	2.6	73.3	55ns	12.1	22.2	688ns	68.4	9.9
Pliska	2.1(-)	1.5	71.4	46(-)	9.8	21.3	701ns	105.2	15
Pobeda	3.1(-)	2.6	84.2	51ns	14.2	27.9	698ns	82	11.7
Sadovo 1	3.0(-)	1.5	50.8	49(-)	11.5	23.5	673ns	74.3	11
Bezostaya 1	7.5*	12.3	163.7	55ns	25.7	46.8	714*	103.5	14.4
Vratsa	3.2(-)	2.8	85.8	50(-)	15.1	30.3	690ns	77.7	11.2
Aglika	13.1*	11.5	88	76*	20	26.3	743*	91	12.2
Galateya	4.7ns	2.1	45.5	57ns	7.2	12.6	739*	89.5	12.1
Slaveya	8.7*	7.2	82.9	70*	19.7	28.4	714*	69	9.6
Iveta	11.3*	11.2	99.3	71*	22.7	31.9	715*	65.4	9.1
Bolyarka	2.5(-)	1	41.6	49(-)	6.2	12.7	679ns	60.4	8.8
Neda	2.7(-)	0.6	21.1	49(-)	4.7	9.6	670ns	68.7	10.2
Zlatitsa	2.3(-)	0.7	29.5	47(-)	6.6	14.2	637(-)	83.8	13.1
Lazarka	7.4*	4.6	61.7	66*	11	16.7	763*	62.2	8.1
Mean	5.1	4.36	85.4	55	13.8	25.1	683	71.7	10.5

* - significantly higher value than mean; (-) significantly lower value than mean, ns- value not different from mean. All differences are at P=95 %.

The above authors pointed out Aglika and Iveta as highly susceptible to various environmental conditions varieties.

our investigation. The mean value of the group of varieties was within 1.8 (Kristal) - 13.1 min (Aglika). In some years the maximum values of this character

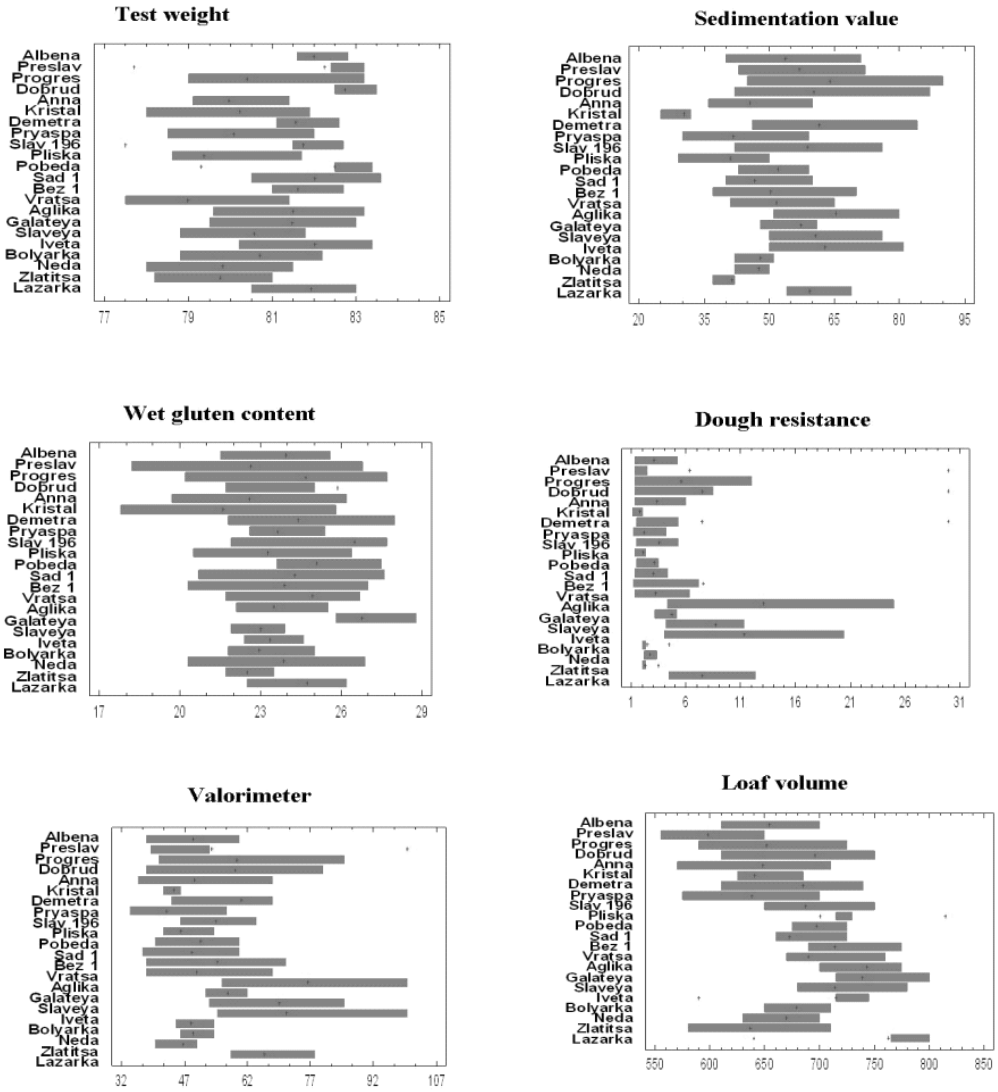

Fig. 1. Variation of quality indexes during the period of study

reached 30 min. Some varieties with high dough resistance (Dobroudjanka, Demetra, Bezostaya 1, Aglika, Slaveya, Iveta and Lazarka) showed high variability by year in both positive and negative directions according to their genetic potential. In this group of high-quality wheat varieties a relatively low variation was observed in Lazarka, Aglika and Slaveya. In the rest of the varieties from this group variability was high (Table 4). Neda, Zlatitsa, Kristal, Bolyarka, Sadovo1 were the most stable by year; probably they had low means of this index.

The mean values of valorimeter varied within 43 (Pryaspa) - 76 conditional units (Aglila). Several varieties (Dobroudjanka, Bezostaya 1, Preslav, Iveta and Progress) showed a relatively high deviation from the mean value of the group and had the highest variation coefficients, which defined them as highly changeable by year. The strong varieties (with high values of the index) can be separated into three groups: I – stable (low variation) - Lazarka; II – with moderate variation – Aglika and Slaveya; III – highly changeable by genotype – Demetra and Iveta.

Concerning loaf volume, the varieties Lazarka, Aglika, Galateya, Iveta, Slaveya, and Bezostaya 1 were the most valuable. Some other as Bolyarka, Lazarka, Iveta, Slavyanka 196, Neda and Slaveya were the most stable by this index. What is most essential is that their high stability is well combined with high loaf volume, with the exception of Bolyarka and Neda. Such good combination of high level of the character and high stability has also been reported by Stoeva and Penchev (2002) for varieties Slavyanka 196, Galateya, Iveta and Slaveya.

Discussion

Each of the investigated indices provides information about a part of the "grain quality" complex. Therefore it is important to follow the level of the varieties as a whole, as well as their performance under changeable environment. Varieties Aglika, Slaveya, Iveta, Lazarka, Dobroudjanka and Demetra are high qualitative cultivars in respect to most of the indices. In comparison to the standards Pobeda and Slavyanka 196, they showed significantly higher values of the individual indices, with the exception of wet gluten content. Generally, the varieties with highest quality accumulated lowest gluten in grain, even in comparison to medium and low-quality wheats. Similar tendency in the breeding of new quality varieties has been reported by Panayotov and Rachinsky (2002).

Especially high were the values of these varieties for the indices dough resistance and valorimeter, which determine grain quality to a highest degree (Trethowan et al., 2001). The high values were in excellent combination with a lower variation than that of the group for all indices. This defines Aglika, Slaveya, Iveta and Lazarka, as varieties possessing high stability with regard to grain, flour and quality of bread.

On the other hand varieties Progress, Dobroudjanka and Demetra were also proved to be quality wheats, their values of most of the indices being just a little lower than that of the above mentioned group. This quality, however, was related to high variation of their values, a variation higher than in the standards. The new varieties Galateya and Bolyarka demonstrated similar grain quality, stable by year in comparison to varieties Sadovo 1 and Pryaspa grown in mass production in Bulgaria. The probable reason for such a high plasticity is the presence of a common parent in the pedigree of the two varieties – Bezostaya 1, which showed stability by dough resistance, valorimetric value and loaf volume in this investigation as well. Our data confirmed the results of Stoeva et al. (2006) and Atanasova et al. (2008), who have reported high stability of quality in varieties Aglika and Galateya. Varieties Anna, Kristal, Neda and Zlatitsa conceded considerably to the grain quality of the main varieties for Bulgaria mentioned above, although they belong to the same group. Besides, their quality was very slightly affected by the environment, which is explainable by their low quality.

Conclusion

The investigation revealed considerably higher influence of the year on the variation of the main end-use quality parameters under Bulgarian conditions.

Aglika, Slaveya and Lazarka are valuable varieties with their high stability of all quality indices during the entire period of study. Their performance was similar to that of the most stable variety Slavyanka 196, but for the dough resistance, valorimeric value and loaf volume the new varieties were significantly better. The new varieties Slaveya and Lazarka are an excellent achievement of DARI breeding due to the favorable combination of high quality and high stability by years.

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Received June, 2, 2009; accepted for printing December, 22, 2009.