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GRAIN QUALITY OF COMMON WHEAT ACCORDING TO VARIETY AND GROWING CONDITIONS IN THE REGION OF DOBRUDZHA

A. IVANOVA, N. TSENOV and I. STOEVA
Dobrudzha Agricultural Institute, BG – 9520 General Toshevo, Bulgaria

Abstract

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Nowadays the quality requirements in the production of grain received by all downstream grain-flour-bread are great mainly because of the strong impact of the conditions on its formation during the different seasons. For this reason, it is necessary to realize the new varieties the maximum of its genetic traits, even under different stress and climatic anomalies. The study is made of the main characteristics of the new quality indices common wheat varieties, developed of Dobrudzha Agricultural Institute – General Toshevo (DAI) which genetic traits belong to different qualitative groups. The study includes two contrasting meteorological terms in the year (2007 and 2008), and varieties grown in four previous crops and three levels of fertilization. The first year of the study (2007) is characterized by a severe and long-lasting drought, and the next (2008) - with favourable conditions during the vegetation of wheat. The effect of agronomy factors on the formation of grain quality in contrasting years was investigated. Analyzed is the change in quality indices of genotypes with contrasting environmental conditions. Established is main role in the formation of the variety of specific weight (TestW), sedimentation (SDS), the resistance of dough (DRes) and valorimetric value (VAL) under favourable conditions during the year. In years with stress (drought), mineral fertilization is essential for the wet gluten content (WGC) and volume of bread (LVol). Under the same conditions, differences between genotypes are aligned due to a stronger variation in quality indices. In years with favourable conditions differences between the studied varieties deepen, they are most pronounced for the specific weight (TestW), sedimentation (SDS) and bread loaf (LVol). Low quality and high quality varieties retain the level of quality, regardless of environmental conditions. The varieties with genetic potential for moderate quality reacted in different ways through their respective indices to the changeable growing conditions.

Key words: wheat- quality- contrasting years

Abreviations: TestW – test weight; SDS – sedimentation value; WGC – wet gluten content; DRes – dough resistance; VAL – valorimetric value; LVol – bread loaf

Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops in the world. Due to its wider adaptability, it can be grown under diverse agro-ecological conditions (Munjal and Dhanda, 2005). Climate changes, however, produce large annual variations in productivity of wheat (European Climate Change Programme, 2007; Kaur and Behl, 2010). Because of climate change, the incidence of extreme weather events has increased in many countries. Extremely high temperatures are the factor causing the greatest problems for agriculture and crop production (Balla et al., 2009; Pepo, 2009b; Marijanovic et al., 2010). The climatic characteristics of Bulgaria also apply more to the areas with arid climates (Slavov and Moteva, 2006).

Drought stress is one of the most important abiotic stresses, generally accompanied by heat stress in dry season (Siddiqui et al., 2008). Drought is a worldwide problem seriously influencing crop productivity (Akhter et al., 2008). Gap in world food production and demand is mainly because of abiotic stresses such as drought, high temperature, frost etc. with drought being a major constraint (Hameed et al., 2010).

Grain quality is expressed through a complex of indices including its physical condition, chemical composition and

E-mail: nick.tsenov@gmail.com

bio-chemical and technological characteristics, which are variety-specific. Environmental conditions are not always favourable for the expression of the quality of the varieties. Grain quality, expressed through its separate indices, is determined genetically. The genetic control of each index is influenced to different degrees by the environment (Williams et al., 2008; Atanasova et al., 2009; Hristov et al., 2010; Tsenov et al., 2010b; Dencic et al., 2011).

The aim of this investigation was to characterize the main quality indices of new wheat varieties during two contrasting years, and to define the behaviour of the individual varieties under contrasting environments.

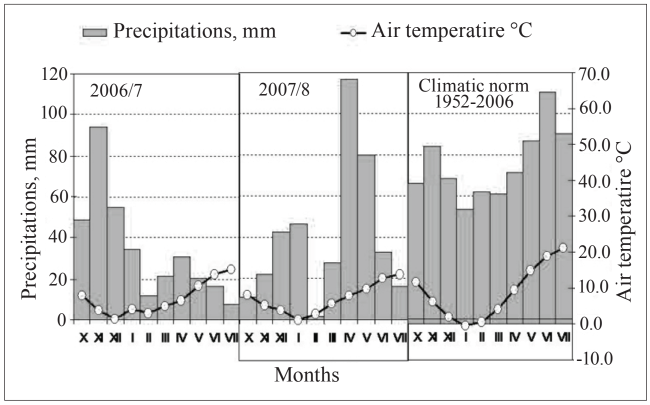

Fig. 1. Meteorological conditions

Material and Methods

The present research is based on a field experiment carried out in the trial field of Dobrudzha Agricultural Institute – General Toshevo (DAI) during two successive years (2007-2008). The trial was designed by the split plot method, in 4 replications, the size of the plot being 22.5 m^2. The sowing was done within the sowing dates optimal for this region with sowing norm 500 germinating seeds/m^2. Eight new common winter wheat varieties (developed at DAI) of different grain quality were studied. During the years of the investigation, the varieties were sown after four predecessors: bean, sunflower, grain maize and silage maize. Three levels of nutrition regime were investigated. The mineral fertilization was applied according to the type of previous crop: N_6P_6 and $N_{10}P_{10}$ after bean; $N_{10}P_{10}$ and $N_{14}P_{14}$ after sunflower, grain maize and silage maize, the check variant being N_0P_0.

The study analyzed the following key characteristics that provide information on various aspects of quality: test weight (kg) (TestW) (BSS 7971-2:2000); sedimentation value (ml) (SDS) (Pumpyanskiy, 1971); wet gluten content in 70% flour (%) (WGC) (BSS 13375-88); dough resistance (min) (DRes); valorimeric value by pharinograph “Brabender” (valorimeter, in conditional units) (VAL) (BSS 16759-88) and bread loaf (cm^3/100 g flour) (LVol) according to the methodology adopted at the Bread making quality laboratory of DAI.

Data was processed with software Statistica, version 7.

The data on the temperature and rainfall regimes are presented in Figure 1. The meteorological conditions during the two years of investigation were compared to the long-term period. Significant differences were found between the two successive years (2007 – 2008) which allow considering them contrasting in meteorological aspect. The temperatures and rainfalls during 2008, as compared to the long-term period (1952 – 2006), characterized this year as very favourable for wheat. The combination of higher mean monthly air temperatures with lower rainfalls marked year 2007 with a long drought. The mean annual sum of precipitation in 2007 was with 105 mm lower than the mean value of the long-term period.

During sowing of wheat (in October), differences in the air temperatures were not established. In November and December of 2007, the measured temperatures were lower than the climatic norm (1952 – 2006), and the temperatures measured in 2008 were higher. January of 2007 was very distinct, with high mean monthly temperature of 5.4^{o}C, the norm being -0.4^{o}C. The spring growth of wheat occurred under higher temperatures during the investigated years in comparison to the climatic norm, with months May, June and July being considerably hotter than the respective periods of 2008.

A determining factor for the development of wheat was the sum and distribution of rainfalls during the growth season. Precipitation was much variable during the years of testing. Only at the beginning of the growth season (October, November and December), the amount of rainfalls in 2007 significantly exceeded the precipitation norm (1952 – 2006), and the respective amount of 2008. The sums of rainfalls during the succeeding growth season were higher in 2008, which characterized this year as favourable. During April – May, when wheat was in critical stages of development (booting – heading), the amount of rainfalls was highest in 2008. This was a prerequisite for a strong start of the investigated genotypes at the beginning of the spring growth season in 2008. During June-July, when wheat was at stage grain filling – maturation, the sum of precipitation was lower than the mean sum of the long-term period (1952 – 2006) bit was higher than the rainfalls in 2007. This created favourable conditions in 2008 for formation of good quality indices of the investigated wheat genotypes.

Results

Winter wheat varieties with potential for both bread and noodle end-use applications have been developed though understanding environmental effects on grain quality still represents a challenge (Pierre et al, 2008). Wheat grain quality has been found to be determined by both genetics and environmental conditions (Gut & Bichomski, 2007; Peymanpour et al., 2010). The independent impact of the factors involved in this investigation (variety, previous crop and fertilization) on the quality indices during the two contrasting years is given in Table 1. The effect of the agronomy factors on the formation of quality was statistically significant. The independent effect of the variety was better expressed in 2008, which was a year with favourable conditions for the development of the genotypes. The role of the variety was determining for formation of the following traits: sedimentation (SDS), valorimetric value (VAL) and bread loaf (LVol). In 2007, under conditions of drought, the genotype was most significant for bread loaf (LVol). The independent effect of the previous crop had lower though also significant effect on the investigated quality indices. This factor had considerably greater effect on the formation of quality of the studied genotypes in the year with stress. A similar regularity has been noted in our previous investigations on wheat productivity and the related traits under stress (Ivanova and Tsenov, 2011; Ivanova and Tsenov, 2012). The role of the previous crop was most important for the formation of bread loaf (LVol) under conditions of drought. This factor had lowest effect on test weight (TestW), and almost equal effects on dough resistance (DRes) during the two years of investigation. The quality indices are genetically determined and are dependent on the involved genotypes but they may vary depending upon environment and agronomy practices, including fertilization. Nitrogen fertilization represents not only the most important yield-stimulating procedure but also the most important variable, which affects quality of the yield. Progressive increase in doses of the component is not always equivalent to its increased quality. Therefore, determination of optimum nitrogen doses remains to represent a current problem (Ralcewicz et al., 2009; Tanacs et al., 2010; Ivanova and Tsenov, 2011). In this investigation, fertilization was a powerful factor, which was favorable for the quality of the studied genotypes under stress. Mineral fertilization also had significant effect for the expression of the following quality indices under drought: sedimentation (SDS), valorimetric value (VAL), bread loaf (LVol). However, in the contrasting year (the year with favorable conditions) the role of the variety was greater than that of fertilization for the formation of the same indices.

Discussion

In Bulgaria, as elsewhere in the world, the interest to the researches on wheat quality is a permanent one due to the variety of factors, which affect its formation (Atanasova et al., 2010; Tsenov et al., 2010b). Grain quality is expressed as a complex of indices specific for each particular cultivar (Paunescu and Boghici, 2008; Kirchev et al., 2009; Stoeva and Ivanova, 2009; Peymanpour et al., 2010). The wheat cultivars differed significantly by the investigated quality indices depending of the year conditions. In order to compare the respective genotypes by their variation of quality indices, the cultivars were analyzed during each year of the investigation.

Test weight (TestW) is an index used for evaluation of grain quality (Figure 2). The higher the test weight, the higher the flour yield is. We established in our previous investigations that this index is formed under the influence of the meteorological conditions of the year (Ivanova et al., 2007;

Table 1
ANOVA – main effects of factors in the investigated indices of quality

Indices \ Source	Years	Intercept	Variety	Previous crop	Fertilization	Error
TestW	2007	1266492.7	32.1**	3.3**	16.7**	0.7
	2008	1266996.3	89.3**	0.6*	0.5ns	0.2
SDS	2007	196113.8	895.1**	722.1**	1367.2**	37.6
	2008	298151	1965.7**	184.4**	150.6**	14.6
WGC	2007	50174	36.1**	105.5**	442.5**	3.5
	2008	65062.5	55.2**	48.4**	102.3**	2.1
DRes	2007	1016	27.2**	35.6**	72.7**	3.7
	2008	2524.6	97.0**	40.4**	17.4*	5.5
VAL	2007	252457.6	669.9**	710.8**	1270.9**	56.8
	2008	350295.8	1746.0**	449.5**	161.8*	44.2
LVol	2007	39999053	48498.6**	22993.8**	75646.4**	1954.6
	2008	43470416.7	66973.8**	3659.0*	23254.2**	1271.5

Ivanova and Tsenov, 2009; Ivanova and Tsenov, 2010). Under the drought of 2007, the variation of test weight was higher. Under the same conditions, most of the varieties fell into similar groups with insignificant differences between them. This shows that under conditions of drought the differences between the varieties become less distinct in spite of their genetic potential. Their values varied from 80.3 kg to 82.3 kg on the average. Under the favorable conditions of 2008, the greater part of the varieties formed higher test weight: Bolyarka and Neda from 81.2 kg to 81.8 kg, and Slaveya, Svilena and Yanitsa – more than 82 kg. Varieties Karina and Merilin had lower test weight regardless of the year conditions. Variety Dona demonstrated interesting behavior: during the two contrasting conditions, it had the same test weight of 83 kg at a level higher than that of the other varieties.

On the whole, the index test weight of the varieties decreased under stress in comparison to the values of this index under favourable conditions for formation of quality (year 2008). The year conditions affected the absolute values of the index but did not significantly change the relative variations between the investigated varieties.

Sedimentation (SDS) is a typical index, which characterizes flour quality. The variations in the values of this index were high (Figure 3). Under the drought conditions of 2007, the variation was again higher and the values were lower in comparison to 2008, and differences between the values of the varieties again were not very distinct. The investigated genotypes fell within similar, statistically insignificant groups. Under the favourable conditions of 2008, all varieties increased their sedimentation value. These conditions classified the genotypes into separate, distinct groups, only varieties Bolyarka, Neda, Karina and Yanitsa having close values (from 46 ml to 54 ml). The increase was lowest in variety Svilena (from 30-37 ml in 2007 to 35-40 ml in 2008). Variety Neda demonstrated relatively stable mean level of sedimentation during the two contrasting years (about 47 ml), and variety Merilin had the maximum level of sedimentation value. The highest increase of the values of the index (from 58 ml in 2007 to 78 ml in 2008) was observed in this genotype.

In 2007, the varieties were divided into two groups only: the first one included Bolyarka, Svilena, Karina and Yanitsa, and the other group included the rest of the varieties. This means that under stress the sedimentation values did not correspond to the genetic potential of the individual varieties. In 2008, the groups were four and entirely corresponded to the genetics of the investigated varieties: the first group included variety Merilin, the second – Slaveya and Dona, the third – Bolyarka, Neda, Karina and Yanitsa, and the fourth – Svilena.

Yet gluten content (WGC) is an indirect index of wheat bread making quality, which indicates the protein content and the nutrition value on the one hand, and on the other, it guarantees the respective amount of gluten in flour. The investigated wheat varieties formed different amounts of gluten depending on the year (Figure 4). The variation in the values of this index was high regardless of the year. In 2007, the variations between the varieties were not so high. Variety Svilena had lowest amount of gluten in grain (18.1 – 22.2%), while varieties Slaveya, Neda, Karina and Dona had almost equal amounts of 24% each. The favorable conditions of 2008 contributed to the higher values of this index in all varieties. The only exception was variety Slaveya. The variation for

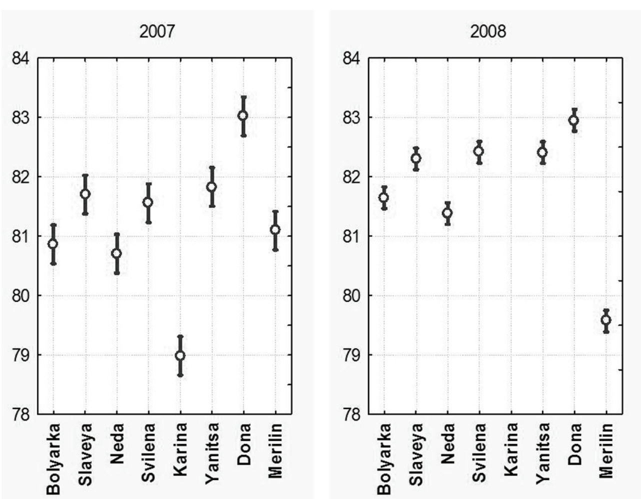

Fig. 2. Test Weight (kg) of the investigated varieties in contrasting years

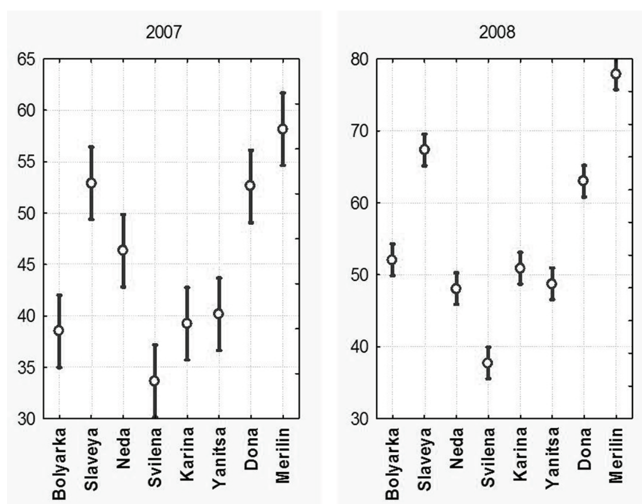

Fig. 3. Sedimentation value (ml) of the investigated varieties in contrasting years

gluten in this genotype was relatively stable regardless of the year conditions (22.9 – 25%). Under the good conditions during this year variety Merilin had highest mean value of this index – about 28.8%.

In the two contrasting years variety Svilena had the lowest amount of gluten, variety Dona had highest amount under drought, while variety Merilin – under good conditions.

Dough resistance (DRes) is another quality index, which characterizes the strength of wheat dough (Figure 5). The variation of the values of this index was high for all investigated genotypes in the two contrasting years. Under the unfavourable conditions of 2007 variety Merilin exceeded all other varieties with highest dough resistance (a mean of 6.50 min), while variety Karina demonstrated the lowest (a mean of 1.80 min). In the rest of the genotypes, the mean values were from 1.90 min (Svilena) to 4.10 min (Neda). In 2008, dough resistance was higher in most varieties. Only in variety, Neda a decrease with about 1 min was observed, and the range of variation of variety Svilena was almost the same in the two contrasting years (0.80 – 3.30 min). Under the favourable conditions of 2008 variety Slaveya demonstrated the highest increase of dough resistance, with almost 6 min. Under these conditions this was the maximum value among all investigated genotypes (9.80 min), followed by variety Merilin (9.10 min).

Under favourable conditions variety Slaveya had the best dough resistance, and variety Svilena – the lowest. Varieties Bolyarka and Slaveya, which possess higher quality potential, sharply increased the values of this trait under favourable conditions. The high-quality variety Merilin was not influenced by the conditions of grain filling with regard to this index. The same may be considered valid for varieties Svilena and Karina.

The valorimetric values (VAL) is a complex value, which characterizes wheat quality (Figure 6). Its variation in the individual varieties was higher under drought. This is the reason for the difficult differentiation of the investigated genotypes. A group of varieties (Svilena, Karina, Bolyarka and Yanitsa) with similar mean values within 41-49 conditional units can be outlined, as well as another one (Dona, Neda and Slaveya) with values from 53 to 55 conditional units.Variety Merilin stood out among all other varieties with mean valorimetric value of 66 conditional units. The favorable conditions

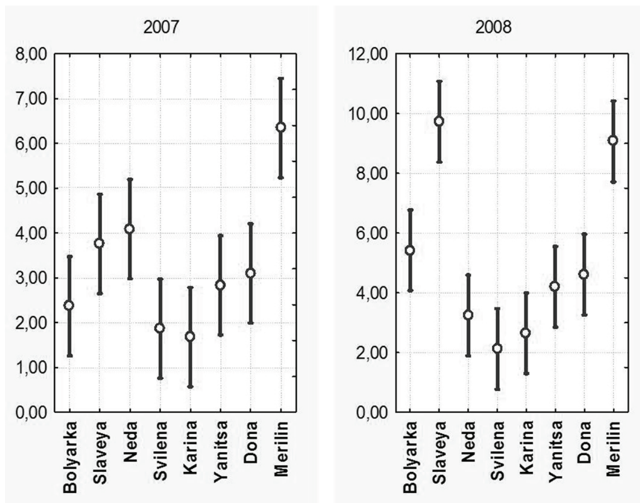

Fig. 5. Dough Resistance (min) of the investigated varieties in contrasting years

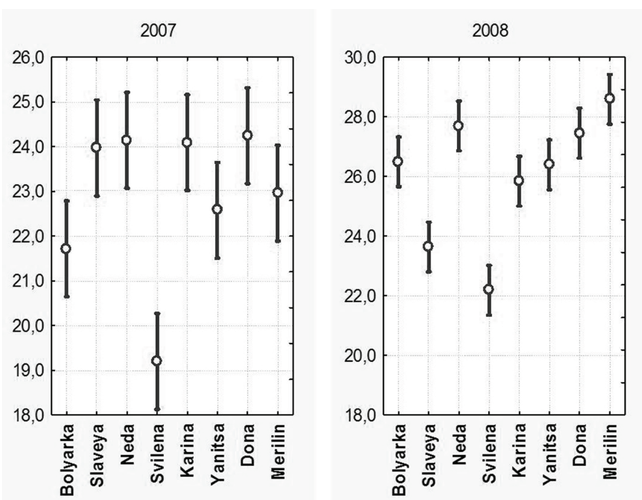

Fig. 4. Wet Gluten Content (%) of the investigated varieties in contrasting years

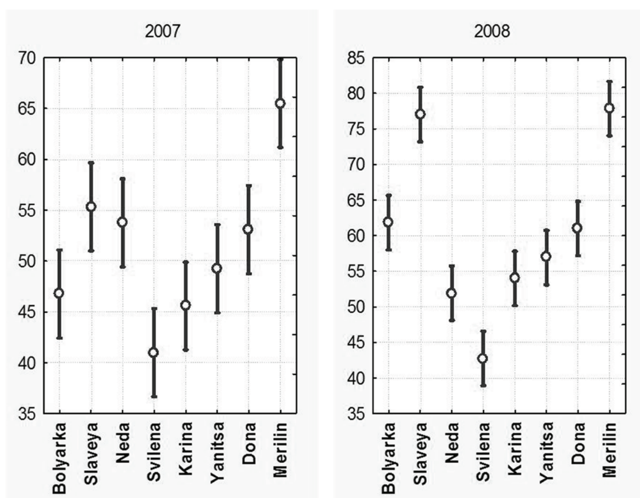

Fig. 6. Valorimetric value (conditional units) of the investigated varieties in contrasting years

during the next year increased the differentiation among the varieties and increased the values of this index. The valorimetric values of varieties Karina, Yanitsa and Dona increased proportionally. The increase was highest in variety Slaveya – with 22 conditional units, and lowest in Svilena – with 2 conditional units. Variety Neda had relatively stable valorimetric value in the two contrasting years (about 53 conditional units), and variety Merilin demonstrated the maximum value of this index (about 78 conditional units).

In 2008 varieties Bolyarka and Slaveya sharply increased their values of this index, which was partially valid also for variety Dona. Variety Merilin exhibited to a maximum degree its high quality regardless of the year conditions ranking invariably first among all other genotypes.

Bread loaf (LVol) is one of the most important indices for evaluation of the bread making properties of wheat (Figure 7). The investigated varieties had different values of this index in the two contrasting years. Under the drought conditions of 2007, variety Svilena had the lowest bread loaf (a mean of 510 cm^3/100 g flour). Under these conditions the greater part of the genotypes had similar mean values ranging from 630 cm^3/100 g flour to 670 cm^3/100 g flour (Bolyarka, Neda, Karina, Yanitsa and Merilin).Varieties Slaveya and Dona differed sharply from the other varieties of the second group forming highest bread loaf (a mean of 710 cm^3/100 g flour). In 2008, when the conditions were favourable, the differentiation of the investigated genotypes became even more expressed. The good conditions of this year divided the varieties into separate groups, their values being higher. Lowest increase of bread loaf was observed again in variety Svilena, and varieties Yanitsa and Dona decreased their bread loaf under these conditions. Variety Slaveya formed highest bread loaf (a mean of 770 cm^3/100 g flour). Variety Neda exhibited specific behaviour by keeping the variation of the above index within relatively stable range during both contrasting years (630-680 cm^3/100 g flour).

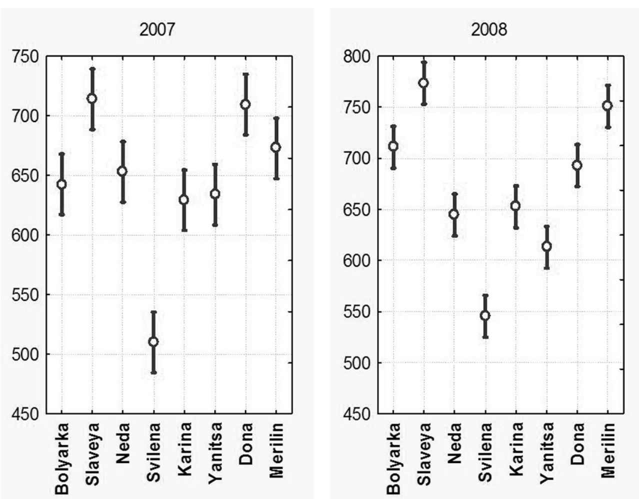

Fig. 7. Loaf Volume (cm3/100 g flour) of the investigated varieties in contrasting years

The difference in the bread loaf of the investigated varieties as a result from the drought decreased relatively due to the higher variation within the respective varieties. In the two contrasting years variety Svilena had the lowest bread loaf, and variety Slaveya had the highest.

Conclusions

In years with favorable conditions the variety is a key factor for the following quality indices of the investigated wheat genotypes: test weight (TestW), sedimentation value (SDS), dough resistance (DRes) and valorimetric value (VAL), while in years with contrasting conditions (drought) mineral fertilization had determining effect for wet gluten content (WGC) and bread loaf (LVol).

The year conditions unfavourable for wheat leveled up the differences between the varieties as a result from the higher variation of the quality indices of each variety.

The favourable year conditions deepened the differentiation between the genotypes and classified them into separate groups. The genotype specificity was most expressed in the following quality indices: test weight (TestW), sedimentation value (SDS) and bread loaf (LVol).

The varieties with genetic potential for moderate quality reacted in different ways through their respective indices to the changeable growing conditions. The low-quality varieties (Svilena and Karina) and the high-quality varieties (Merilin, Dona and Slaveya) preserved their genetic potential in the formation of the respective quality indices regardless of the environment.

In both contrasting years of this investigations variety Svilena showed the lowest values of the investigated indices, while varieties Slaveya and Merilin demonstrated the highest. Variety Neda exhibited specific behaviour by maintaining the same level of quality regardless of the year conditions.

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