GRAIN YIELD, END-USE QUALITY AND STRESS RESISTANCE OF WINTER WHEAT CULTIVARS AGLIKA AND SLAVEYA

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Abstract

During the recent years wheat breeding has been directed mainly towards combining high productivity, end-use quality and biotic and abiotic stress resistance. This is motivated by the actual demand of this type of products by producers and grain dealers. The research work efforts of DAI – General Toshevo lead to the development of cultivars with good combination of the above traits and properties, which are generally difficult to combine. Representative models of such cultivars are Aglika and Slaveya, varieties already introduced in production. The high yields obtained are matched by good quality, which gives certain advantages to the farmers when selling their produce. The two varieties were developed by the pedigree method after using conventional intervarietal hybridization combining the multiple disease resistant Pliska cultivar with genetic material based on the high-quality cultivar Bezostaya – a variety of good drought tolerance. The suitability of cultivars Aglika and Slaveya for mass production was confirmed by a three-year testing within the system of the Bulgarian state varietal testing during the 1990's. After the cultivars were officially released (Aglika in 1997 and Slaveya in 2000), their testing continued both in the DAI trial field and in production fields all over the country to confirm the successful combination between yield and end-use quality. This paper presents data on grain quality, disease resistance and stress tolerance from different trials performed during the last 10 years. The focus is on the high adaptability of the cultivars to various soil and climatic conditions during the years of growing adequate to their high yields and end-use quality. The systematic development, accumulation and combining of valuable breeding materials created at DAI – General Toshevo during the 1970's has lead to the development of such varieties as Aglika and Slaveya; their combinations of biological traits and properties make them competitive to all wheat varieties grown in Bulgaria and in the neighboring countries.

INTRODUCTION

Wheat production in Bulgaria is largest in scale compared to the other agricultural crops. It is a traditional production which ensures completely the annual grain balance in the country and brings good profits to the farmers (Tsenov et al., 2009). The modern dynamic development of technologies for wheat growing and

grain processing into food and bread set increasingly higher requirements to the varietal composition of wheat (Tsenov, 2009[b]). Breeding of new wheat varieties is also a dynamic process with a view of their distribution aimed at optimization of production; it should also be consistent with the global climatic changes (Reynolds et al., 2009). Therefore not only the high potential levels of yield and end-use quality are important, but also their realization and stability over regions and seasons (Fischer and Edmedes, 2010; Williams et al., 2008). Both yield and end-use quality are basic factors for wheat performance because their levels can change dramatically with the climate, soil and the specific meteorological conditions of growing (Drezner et al., 2006; Hristov et al., 2010).

There are numerous investigations related to the nature and regularities of the genotype x environment interaction: location (Hugo-Ferney et al., 2006), year conditions (Lage and Trethowan, 2008), essential elements of the growing technology (Anwar et al., 2007) and similar (Mohammadi and Amri, 2008).

To obtain normal grain yields from winter wheat, the condition of the plants in the crop after their wintering are highly important (Tsenov, 2008[a]). The level of cold resistance is a varietal character which allows breeding approaches for its enhancement (Tsenov and Petrova, 2006). As a result from long-term systematic breeding of several generations of breeders in this direction, there are certain achievements in the increasing of the cold resistance of our wheat biotype (Tsenov et al., 2003; Tsenov et al., 2004).

Performance is especially affected by the tolerance of the wheat cultivar to drought according to its duration and intensity of expression (Mustatea et al., 2003; Zhu et al., 2008). In this relation various approaches are involved for efficient breeding towards increasing the tolerance of the wheat plant to drought because drought is becoming increasingly frequent and unpredictable (Tsenov et al., 2009).

The aim of this investigation was to provide additional data on two bread wheat cultivars, Aglika and Salveya, more particularly on the actual expression of their genetic potential for yield, end-use quality and abiotic stress tolerance.

MATERIAL AND METHODS

Initial material

Cultivars Aglika and Slaveya originate from cultivar Pliska following its combination with line GP 2558-128 (Aglika = Pliska / GP 2558-128; Slaveya = Pliska 2* / GP 2558-128). Cultivar Pliska was a variety widely used in production during the 1980's and 1990's. It possesses excellent combination between early maturity, high diseases resistance and bread making quality (Tsenov et al., 1998). The other parent is a strong line, which is susceptible to diseases and was developed on the basis of variety Bezostaya 1 (Tsenov et al., 2009). Cultivar Aglika was approved in 1997 and cultivar Slaveya in 2000; both have been grown in production for 10 years, cultivar Aglika occupying about 12 % of the area sown with wheat in Bulgaria.

Methods

The two varieties were investigated under field and laboratory conditions. Grain yield and its components were obtained after several trials of different location and duration. The trials were carried out at DAI, Obraztsov Tchiflik – Ruse and at

several stations of the National Executive Agency of Variety Testing, Field Inspection and Seed Control (NEAVTFISC). The analysis on quality was performed at DAI. The laboratory cold resistance was determined by the methodology of Tsenov and Petrova (1984).

Analyses

The following traits were analyzed: grain yield (GY), number of productive tillers (NPT), 1000 kernel weight (TKW), number of grains per spike (NGS), weight of grain per spike (WGS). The following quality traits were also determined: test weight (TW), wet gluten yield (WGY), sedimentation value of flour (SVF), dough resistance (DR), valorimeter (V) (both determined by pharinograph), and bread volume (BV). Concerning drought resistance, the levels of yield and its components were determined in two contrasting years: 2006, which was very favorable for yield, and 2007, when there was a strong and long drought. Decrease of yield and its components in percent were found out (0.6 – 0.7 %), as well as the index of drought susceptibility (S_{dr}) (Fisher and Maurer, 1978).

Statistical analyses

For direct comparison of the investigated varieties and standards, the descriptive statistics methods were applied using the module XLStat 2009. For the trials with multiple varieties, the method of multiple comparisons was involved (Waller-Duncan test) using software SPSS version 13.

RESULTS AND DISCUSSION

Yield and productivity

Cultivars Aglika and Slaveya are of similar origin. Cultivar Pliska, the variety involved in their development, possesses very high genetic potential for productivity. It was successfully transferred to both cultivars. During the three years of testing within the system of NEAVTFISC (the period of testing for cultivar Aglika was 1995 – 1997; for variety Slaveya – 1998 – 2000) the cultivars demonstrated significantly higher grain yields than the standards for first and second quality groups (Table 1). The high productivity of the cultivars was due to their high field resistance to powdery mildew and rusts, their high tolerance to low winter temperatures and tolerance to soil drought (Tsenov et al., 1998: 2009).

Table1. Relative yield at NEAVTFISC averaged for three years of testing of cultivars Aglika (compared to standard Pobeda) and cultivar Slaveya (compared to standard Sadovo 1)

Locations	Aglika	Slaveya
In North Bulgaria	+15.6	+ 14.6
In South Bulgaria	+14.4	+9.7
Averaged	+15.0	+11.3

The grain yield from Aglika and Slaveya was due to the significantly higher fertility of the spike and the number of grains actually formed per spike (+40.8 and 37.9 % for the two cultivars, respectively), (Table 2). Aglika and Slaveya possess the genetic potential for high number of productive tillers inherited from their parental cultivar Pliska, but in comparison to the standard Sadovo 1 it was with 10 % lower. Similar is the case with the size of grain.

Table2. Competitive varietal testing at DAI during 2000-2009.

Cultivar	GY		NPT		TKW		GWS		NGS	
	t/ha	%	n	%	g	%	g	%	n	%
Aglika	8.14	113.7	656	90.5	42.9	87.0	1.22	119.8	29.0	140.8
Slaveya	7.86	109.7	659	90.9	45.2	91.5	1.15	112.6	28.4	137.9
Sadovo 1	*7.16*	*100.0*	*725*	*100.0*	*49.4*	*100.0*	*1.02*	*100.0*	*20.6*	*100.0*
Pobeda	6.98	97.5	686	94.6	45.3	91.7	1.05	103.0	23.1	112.3
Mean	7.07	98.7	705.6	97.3	47.3	95.8	1.0	101.5	21.8	106.1

The data on productivity and its components for cultivars Aglika and Slaveya under the conditions of DAI were significantly high but the question arises is the variation according to the standard the same under the different soil and climatic conditions of Bulgaria. The results from the post-registration testing of a group of varieties at eleven locations in Bulgaria provide an answer. During 2007 – 2009 the variation for grain yield in favor of Aglika and Slaveya according to the standard Sadovo 1 was 11.1 % and 8.2 %, respectively (Table 3). By their grain yield these two cultivars are comparable to the mass production cultivar Yantar.

Table3. Results from post-registration testing at 11 locations of NEAVTFISC during period of 2007 – 2009

Cultivar	Grain yield, t/ha				Error	Significance*
	Minimal	Maximal	Mean	Relative %		
Aglika	2.46	10.62	6.59	111.1	13.9	c
Slaveya	2.17	10.40	6.41	108.2	14.1	bc
Yantar	2.80	10.04	6.16	104.0	13.7	bc
Pobeda	2.68	10.63	5.72	96.7	13.2	a
Sadovo 1	2.94	9.16	5.92	100.0	12.3	b

* Multiple comparison of the values of the separate varieties according to Nemeny

There are several factors contributing to the significantly higher grain productivity. First, this is the higher percent of kernels along the entire length of the spike which actually lead to higher number of grains per spike. Second, the two cultivars have significantly higher model resistance to rusts, which means longer and normal grain filling. As a result cultivars Aglika and Slaveya formed more grains per spike, which were with 3-5 decimal points smaller than the grains of the standard Sadovo 1. This combination of high levels of the productivity components is typical of cultivar Pliska; the combination was successfully transferred to Aglika and Slaveya. Third, the higher resistance to lodging is the reason for higher yields, especially at higher fertilization levels and in moist years.

End-use quality

The results from the investigation of the two cultivars after their registration are given in Table 4. Aglika and Slaveya were compared to the strong wheat standard Pobeda. The two cultivars conceded to the standards Sadovo 1 and Pobeda with only a small difference by test weight.

Table 4. Mean values and some statistical parameters of the investigated quality traits (averaged for 2001 – 2006)

Cultivar	Test weight			Sedimentation of flour			Yet gluten yield		
	Mean	S	CV%	Mean	S	CV%	Mean	S	CV%
Pobeda	82.5*	1.6	2.0	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	17.0
Aglika	81.5^{ns}	2.2	2.7	65*	16.6	25.4	23.5^{ns}	1.86	7.9
Slaveya	80.6^{ns}	2.3	2.8	61*	14.7	24.3	23.0^{ns}	2.34	10.2
Mean	81.1	1.9	2.4	53	14.3	27.3	24.0	3.01	12.6
Cultivar	Dough resistance			Valorimeter			Bread volume		
Pobeda	$3.1^{(-)}$	2.6	84.2	51^{ns}	14.2	27.9	698^{ns}	82.0	11.7
Sadovo 1	$3.0^{(-)}$	1.5	50.8	$49^{(-)}$	11.5	23.5	673^{ns}	74.3	11.0
Aglika	13.1*	11.5	88.0	76*	20.0	26.3	743*	91.0	12.2
Slaveya	8.7*	7.2	82.9	70*	19.7	28.4	714*	69.0	9.6
Mean	5.1	4.36	85.4	55	13.8	25.1	683	71.7	10.5

*- significance at P= 0.05; ** at P= 0.01

Yet gluten yield was also lower, though insignificantly. The levels of Aglika and Slaveya for sedimentation, dough resistance, valorimeter and bread loaf were significantly higher than the standard. These higher levels were matched by almost equal variation, similar to the models for almost all investigated quality traits. On the whole, the values of the indices for cultivar Slaveya varied less than the values of Aglika. This is logical because they did not vary significantly but were nevertheless lower (sedimentation 61 as compared to 65; dough resistance 8.7 min as compared to 13.1 min; valorimeter 70 as compared to 76; and bread volume 714 cm^3 as compared to 743 cm^3 for cultivar Aglika). The data on some quality indices (Table 4) eloquently reveal the advantages of Aglika and Slaveya with regard to dough strength. It is typical for both cultivars that they are able to form grain which is not as compact as the grain of the standards, especially of cultivar Pobeda. The values of wet gluten yield were also lower but the variations were not significant; what was most valuable – they varied significantly less. On the other hand, the values of sedimentation, valorimeter and dough resistance were significantly higher and completely met the criteria of strong wheat (Atanasova et al., 2008; 2010).

Tolerance to stress

The tolerance to low temperatures of the two investigated cultivars is given in Table 5. The laboratory cold resistance of Aglika and Slaveya was similar to that of cultivar Bezostaya 1, i.e. to the cold resistance of the standard Sadovo 1. The variation was significantly lower, which is an evidence for the strong and stable genetic control of this property. The high level of tolerance to low negative temperatures is inherited from the parent GP 2558-128; thus this line became equal to the Russian cultivar.

Table5. Percent of surviving plants after chamber freezing according to the methodology of Tsenov and Petrova (1984)

Index	Standards			Aglika	Slaveya
	No 301	Bezostaya 1	Mironovskaya 808		
Minimum	23	38	50	69	71
Maximum	60	83	98	81	90
Mean	58	74	90	75	81

Table6. Plant regeneration after direct freezing during the winter of 2003.

Cultivar	% of surviving plants	Relative %
Pobeda	80	102,3
Aglika	75	108,8
Slaveya	60	111.0
Sadovo 1, Standard	50	100.0

Both cultivars were based on variety Pliska widely used in mass production in the past. Variety Pliska possesses cold resistance at the level of variety No 301; the difference is that the above two cultivars have much more stable expression than it. The combination with the other parent has lead to a significant increase of cold resistance without noticeably decreasing grain yield. Cultivars Aglika and Slaveya inherited the genetic potential for high grain yield from cultivar Pliska. This genetic potential is combined with a higher level of cold resistance. The data for the winter of 2003 when there was direct freezing of wheat under field conditions provide evidence for this (Table 6). Regardless of the different percent of surviving plants without hardening, the two cultivars demonstrated significantly better regeneration capacity than the standard. A high cold resistance of these two cultivars combined with high productivity has also been reported by Tsenov et al. (2003) and Tsenov et al. (2004).

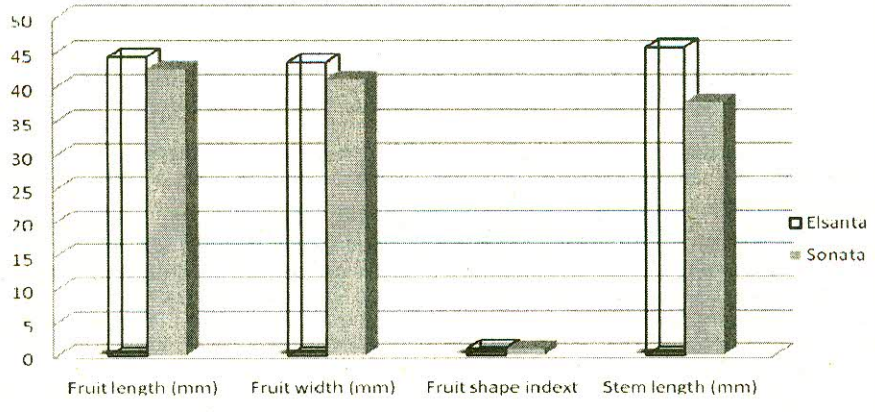
Table7. Drought tolerance of cultivars Aglika and Slaveya under field conditions according to several standard cultivars expressed as decreased of productivity components during two contrasting years of study

Cultivar	GY			WGS			NGS		
	2007	06_07, %	S_{dr}	2007	06_07, %	S_{dr}	2007	06_07, %	S_{dr}
Yantar ①	6.72 b	72.1 a	1.02 b	1.38 a	82.6 a	1.05 a	34.4 a	95.1 a	1.10 a
Sadovo 1 ②	6.63 c	70.0 b	0.99 b	0.88 c	67.0 c	0.85 c	20.6 c	75.3 c	0.87 c
Pobeda ③	6.14 c	67.1 c	0.95 c	0.87 c	61.8 c	0.78 c	22.3 c	72.9 c	0.85 c
Aglika	7.15 d	73.1 a	1.04 a	1.20 b	71.8 c	0.91 b	30.1 c	80.6 c	0.94 b
Slaveya	6.47 c	73.3 a	1.04 a	1.26 b	77.9 b	0.86 c	32.4 a	70.8 c	0.82 c
Mean	**6.95**	**69.1**	**1.00**	**1.24**	**80.1**	**1.02**	**30.1**	**86.1**	**1.00**

①– highly tolerant standard, ②– moderately tolerant standard, ③ susceptible standard

The data on the tolerance of the two cultivars (Table 7) include grain yield, grain weight per spike and number of grains per spike. The comparison showed that by grain yield the performance of Aglika and Slaveya was the same as that of the drought-tolerant Yantar. There was a higher decrease of grain weight per spike of the two varieties – 29.2 % for Aglika and 22.9 % for Slaveya as compared to 17.4 % for Yantar. The decrease was however lower in comparison to the other standards such as Sadovo 1 and Pobeda.

Graf 1. Physical fruit properties of strawberry cultivars



For the trait number of grains per spike the decrease was rather high: 19.4 % for Aglika and 29.2 % for Slaveya in contrast to only 4.9 % for Yantar. On the other hand, the levels of yield realized and the two components investigated in 2007 were close to that of Yantar. In this respect even the yield from cultivar Aglika was significantly higher in spite of the higher decrease, and in cultivar Slaveya the number of grains was similar to that of Yantar. The data presented in the table show that the two cultivars concede on the whole to the drought-tolerant variety Yantar and possess a moderate level of soil drought.

References

Anwar, J. S. Khan, I. Rasul, M. Zulkiffal, M. Hussain, (2007). Effect of sowing dates on yield and yield components in wheat, using stability analysis, International J. Agri. And Biology 9(1): 129-132.

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(1): 22-29.

Atanasova D., V. Dochev, N. Tsenov, I. Todorov, (2009). Influence of genotype and environments on quality of winter wheat varieties in Northern Bulgaria, Agricultural Science and Technology, 1(4): 121-125

Drezner, G., Dvojkovic K., Horvat D., Novoselovic D., Lalic A., Babic D., Kovacevic J., (2006). Grain yield and quality of winter wheat genotypes in different environments. Cereal Research Communications, 34 (1): 457-460.

Fischer, R.A., G.O. Edmedes, 2010. Breeding and cereal yield progress, Crop Science 50(S):85-98

Hristov N, N. Mladenov, V. Djuric, A. Kondic-Spika, A. Marjanovic-Jeromela and D. Simic, 2010. Genotype by environment interactions in wheat quality breeding programs in southeast Europe, Euphytica 174(3): 315-324

Hugo-Ferney, G. A. Morgunov, A. Aigul, (2006). Evaluation of grain stability, reliability and cultivar recommendations in spring wheat (*Triticum aestivum* L.) from Kazakhstan and Siberia, Journal of European Agriculture 7(4): 649-660.

Lage J. and R. M. Trethowan, (2008). CIMMYT's use of synthetic hexaploid wheat in breeding for adaptation to rainfed environments globally, Australian Journal of Agricultural Research, 59:461–469

Mohammadi R. and A. Amri, (2008). Comparison of parametric and non-parametric methods for selecting stable and adapted durum wheat genotypes in variable environments, Euphytica 159(3): 419-432.

Mustatea P. N Saulescu, G. Ittu, G. Păunescu, I. Stere, N. Tanislav, M. Zamfir, I. Voinea (2003). Genotypical differences in wheat response to drought under conditions of the year 2002, Romanian Agricultural Research, 19-20: 39-48

Reynolds, M., m.J. Foulkes, G.A. Slafer, P. Berry, M. A. J. Parry, J.W. Snape, W.J. Angus, (2009). Raising yield potential in wheat, Journal of Experimental Botany 60(7): 1899-1918

Tsenov N, D. Atanasova and T. Gubatov, (2010). Analysis of genotype x environment interactions for grain yield in Bulgaria-grown winter wheat, Cereal Research Communications, (in press)

Tsenov N, I. Stoeva, K. Kostov, I. Panayotov, I. Todorov, T. Petrova, I. Iliev, V. Kiryakova, (2009). Registration of Slaveya wheat variety Plant Science 46(5): 468-474 (In Bul.)

Tsenov N, T. Gubatov and V. Peeva, 2006. Study on the genotype x environment interaction in winter wheat varieties II. Grain yield, Field Crop Studies, 3(2): 167-175.

Tsenov N., T. Petrova and E. Tsenova, (2009). Breeding for increasing the stress tolerance of winter common wheat in Dobrudzha Agricultural Institute, Field Crops Studies 5(1):59-69 (In Bul.)

Tsenov, A., D. Petrova, (1984). Methods for evaluation of breeding material of winter wheat and grain bean crops to stress effects Plant Science 21(5): 77-86 (In Bul.)

Tsenov, N. (2006)[A]. Behavior of DAI bread wheat varieties in severe winter conditions Agronom Magazine 2: 12-14. (In Bul.)

Tsenov, N. (2006)[B] Optimal structure of varieties - prerequisite for successful growing of wheat under stress conditions, National Scientific conference, "Improving the competitiveness of Bulgarian agriculture - research priorities" Sofia, 12 September, pp. 66-71. (In Bul.)

Tsenov, N. (2009). Program for development of cereal production in Bulgaria in the period of 2009-2013, Sofia, Ministry of Agriculture and Food, pp. 48. (In Bul.)

Tsenov, N. and T. Petrova, (2006). Tolerance to drought and cold of winter wheat varieties created in Dobrudja Agricultural Institute, National Scientific conference, "Improving the competitiveness of Bulgarian agriculture - research priorities" Sofia, 12 September, pp. 60-65. (In Bul.)

Tsenov, N. I. Stoeva, K. Kostov, T. Petrova, I. Iliev, S. Mihovaq I. Stoyanov, (1998). New original wheat varieties – Aglika, Plant Science, 35: 342-346. (In Bul.)

Tsenov, N., T. Petrova, E. Tsenova, (2003). Breeding for improving the cold tolerance of bread wheat Scientific Conference, St, Zagora, 3-4 June, 191): 126-132.

Tsenov, N., T. Petrova, E. Tsenova, (2004). Breeding for improving the abiotic stress tolerance of winter bread wheat, National Conference of Seed Production, Breeding and Seed control for seed properties, Sofia, pp. 26-39. (In Bul.)

Williams, R.M., O'Brien, L., Eagles, H.A., Solah, V.A. and Jayasena, V. (2008). The influence of genotype, environment, and genotype x environment interaction on wheat quality. Australian Journal of Agricultural Research , 59(2): 95-111.

Zhu L, Zong Liang A,F, Xing Xu, Shu Hua Li, Ji Hai Jing, and P. Monneveux, (2008). Relationships between carbon isotope discrimination and leaf morphophysiological traits in spring-planted spring wheat under drought and salinity stress in Northern China, Australian Journal of Agricultural Research, 2008, 59, 941–949.