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EVALUATION OF GERMPLASM AND NEW BREEDING CULTIVARS AND LINES WINTER WHEAT (*TRITICUM AESTIVUM* L.) FOR DROUGHT TOLERANCE

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Summary. Cultivars, candidate cultivars and lines were examined. They originated from different countries or they were products of the newest selection of winter wheat (*Triticum aestivum* L.) in the Institute of Plants Genetic Resources, Sadovo. The present work presents results on some morphological and physiological indices-flag leaf location, continuation of vegetation period, and water exchange indices including water retention ability of excised flag leaves of the examined genotypes grown in field conditions. In the new wheat cultivars the yield potential and physiological characteristics connected with the adaptation mechanisms for drought resistance should be integrated to the highest degree. A germplasm of different origins is the basis for success of a breeding program in IPGR-Sadovo in order to create new cultivars wheat suitable for drought climatic conditions. Our results showed that cv. 90/Zhong 150 participated in the candidate cv. Nova Zvezda as the parental form. Cv. Flamura participated as the parental form in candidate cv. Vihar. Candidate cv. Strelec was established with participated of cultivar Super Flatua.

Key words: *Triticum aestivum* L.; germplasma; drought tolerance; water exchange indices – water retention ability.

INTRODUCTION

A genetic varied initial material and free exchange of a germplasm are the basis for successful breeding programs (Kronstad, 1996; Rasmusson, 1996; Traxler and Pingali, 1999). However, every breeder has to take into consideration the specific climatic conditions to create high yield cultivars. To create drought tolerant cultivars in possession of a wide ecological plasticity is a major selection problem in IPGR-Sadovo. This breeding direction is prompted by a warm and dry climate during vegetation of winter wheat and local germplasm (Boyadjieva, 2003). The scientists pay attention to the physiological basis for improving yield by abiotic stress

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and the use of physiological indices in the breeding program (Borghi, Perenzin, 1989; Accevedo, 1990; Boyadjieva, 1996). The research carried out by many authors has shown that the water exchange processes of the leaves in the important stage phases of wheat development (heading, grain feeling) are certain criteria for breeding of drought-resistant genotypes (Blaha, 1990; Rachovska, Rachovski, 1995; Chipilski, Stankova, 2005). The assessment of water retention ability from excised leaves has appeared promising for characterizing drought resistance of wheat genotypes because the rate of water loss from excised leaves bestowed drought resistance in wheat by a mechanism of low water loss rate through leaf cuticles. Therefore, an estimate of cuticular transpiration rate could be used for screening wheat genotypes against drought (Clarke, McCaig, 1982; Clarke, Townley-Smith, 1986). Moreover, breeding approaches could improve wheat drought tolerance. Identifying the associations between earliness and drought is of great importance, since early varieties may escape heat damage and drought during anthesis and grain filling which is very common in the Mediterranean region (Kramer, 1980). The aims of the current study were to examine the suitable germplasm as a genetic source to be inserted in our breeding program and characterize cultivars and lines from the latest selection of winter wheat (T. aestivum L.) in IPGR, by water exchange indices and other concomitant features.

MATERIALS AND METHODS

Cultivars, candidate cultivars and lines of winter forms of soft wheat (*Triticum aestivum* L.) were examined during a three-year period (2005-2007) in May and June at the experimental field of the K. Malkov Institute of Plants Genetic Resources (IPGR) near Sadovo. Part of them originated from different countries that took part in an International examination under the guidence of CIMMYT – Ankara. They showed high yield potential and resistence to abiotic stress factors. In addition, products of the newest selection of soft winter wheat (*Triticum aestivum* L.) in IPGR, near Sadovo were examined. The patterns were sown in plots with 1 m^2 reported surfaces, without replications. The length of the experimental units was 2 m, with a distance between planted rows of 25 cm, and distance among plants within rows of 3 cm. The sowing was carried out in the second half of October. The fertilizer rates that were applied in the field included 15 kg/dka N and 8 kg/dka P_2O_5. The Bulgarian cultivars Katya and Sadovo 1 were used as standards in this trial. They were appertaining to soft winter wheat (*Triticum aestivum* L.) as cv. Katya is a drought-resistant standard according to the International Yield Trial for semiarid areas to CIMMYT – Ankara, Turkey. The second cv. Sadovo 1 is a general standard for Bulgaria. The materials were analyzed for the following characteristics:

1. Biological – length of vegetation period (number of days beginning from 01.01 to heading).
2. Morphophysiological – flag leaf location (by Feekes).
3. Physiological – water retention ability of the leaves (Udovenco, 1988):

   $\mathbf{A_1}$ = B–b/A.100(%) – quantity of evaporated water, compared to total water in the flag leaf.

A_2 = B–b/C.100(%) – quantity of evaporated water, compared to dry mass of the flag leaf.

A_3 = B–C/C.100(%) – quantity of water retention, compared to dry mass of the flag leaf.

Where: **B** – initial weight of the leaves [g]; **b** – weight of the leaves after wilt (3h -25°C), [g]; **A** – water content in the leaves before wilt [g]; **C** – dry weight of the leaves (8h -105°C) [g].

The report on flag leaf location and length of the vegetation period of *Tr. aestivum* was carried out by visual estimation at the growth stage of heading. The water exchange indices data were statistically analyzed using analysis of variance T-test of program Statistica, version 5 for Windows.

RESULTS AND DISCUSSION

The present results on the flag leaf location and the length of the vegetation period indicated that cultivars and lines Katya (Bul.), TJB 916-46 (Mex./USA), Atay (Tur.), Petya, IPGR/Maria and Stojer (Bul.) were for the most part with vertically flag leaf location in an experimental sowing (Table1). The Mexican cultivars Tepoca and Bacanora, likewise Bulgarian cultivars and lines Sadovo 552, Yunak, Nova Zvezda, Belica and Hrabrec showed

Table 1. Vegetation period and flag leaf location.

Pattern	Origin	Flag leaf location (on scale)	Veget. period - number of days beginning from 01.01 to heading	Pattern	Flag leaf location (on scale)	Veget. period - number of days beginning from 01.01 to heading
Katya- St .	Bulgaria	1	135	Katya- St .	1	135
TJB 916-46	Mex. / Or.	1	139	Stojer	1	134
Atay 85	Turkey	1	139	Petya	1	135
Tepoca	Mexico	3	139	IPGR/ Maria	1	137
Bacanora 88	Mexico	3	132	Nova Zvezda	3	137
Gerek 79	Turkey	5	139	Yunak	3	132
85- ZHONG 56	China	5	139	Sadovo 552	3	137
CA 8055	China	5	135	Belica	3	135
F 4105-W-2-1	Romania	5	134	Hrabrec	3	136
Zargoon	Pakistan	5	137	PP 752	5	137
Rayon	Mexico	5	135	Maria	5	135
90-ZHONG 150	China	7	132	Jubilej 120	5	135
SERI 82	Mexico	7	132	Strelec	5	135
Super flatua	USA / Or.	7	134	Momchil	5	135
S x L / Glenson	USA	7	132	Sadovo 1 St .	7	135
F.10.S-1	Romania	7	134	Dorita	7	136
F4141/ W 1-133	Romania	7	135	Vihar	7	132
Flamura 80	Romania	7	135	Prelom	7	136
Sadovo 1 St .	Bulgaria	9	135	Boryana	7	134
Bezostaya 1	Rusia	9	137			
F 338	Romania	9	136			
F.9.70. / Maya S	Mex. / Or.	9	134			

similar results. Cultivars Rayon (Mex.), Gerek 79 (Tur.), CA 8055 (China), 85-Zhong 56 (China), Zargon (Pak.), F4105-W-2-1 (Rom.), Momchil, Jubilej 120, PP 134/Maria and Strelec (Bul.) took an intermediate position. The cultivars and lines Sadovo1 (Bul.), Bezostaya 1 (Rus), Prelom (Bul.), Boryana, Dorita and Vihar (Bul.) had the most strongly expressed planophyt flag leaf location (Table 1). The cultivars Rayon (Mex.), Bacanora 88 (Mex.), SERI 82 (Mex.), F.9.70./Maya S (Mex.), 90-Zhong 150 (China), SxL/Glenson (USA), Super flatua (USA), F.10.S-1 (Rom.), F4105-W-2-1 (Rom.), Boryana, Yunak (Bul.), and the line Vihar (Bul.) delineated with a shorter vegetation period (1-3 days) than Katya (Table 1). Katya is one of the earliest mature cultivars in IPGR-Sadovo. The cultivars CA 8055 (China), F4141/ W1-133 (Rom.), Flamura 80 (Rom.), PP 134/Maria, Hrabrec, Petya, Momchil, Strelec and Sadovo 1 (Bul.) were equal to Katya. The other cultivars and lines had a later vegetation period (1-4 days) than Katya (Table 1). Table 2 shows the results on the water retention ability of excised flag leaves of the same genotypes grown under field conditions. These wheat genotypes were characterized at two critical stages of development, heading and grain filling, as follows:

A_1 – quantity of evaporated water, compared to total water in the flag leaf: During the heading phase the Mexican cultivars Bacanora 88-17.4 %, Tepoca-21.5%, Rayon-22.7%, and Chinese cultivars 90 Zhong-150-18.6%, 85-Zhong 56-18.8% showed advantage over the drought-resistant cultivar Katya (Stankova, 1987), and much better than Sadovo 1. The cultivars F338, Flamura 80 and F4141/W-133 which descend from Romania and the newest cultivars and lines Hrabrec, Maria, IPGR/Maria, Vihar, Belica, Strelec, Petya, Dorita, Yunak and Nova zvezda created in IPGR-Sadovo, showed good results, too. During grain filling phase (Table 2) the tested cultivars from the international examination kept a leading position in comparison with cultivars Katya and Sadovo 1. The genotypes Nova zvezda, Petya, Hrabrec and Strelec from IPGR-Sadovo showed similar results.

A_2 – quantity of evaporated water, compared to the flag leaf dry mass, and **A_3** – quantity of water retention, compared to the flag leaf dry mass: The ability of the different genotypes of wheat to accumulate more dry mass in the leaves is accepted as an essential index of their tolerance towards drought (Babenko, 1990). This explains the importance of **A_2** and **A_3** that show simultaneously both indications, the percent of evaporated water and dry mass gained in the wheat flag leaf. The observed trend was maintained for the water exchange indices. It should be noticed that the performance of the Chinese cultivars 90-Zhong 150 and 85-Zhong 56 based on index A_2 was good enough compared to the other genotypes at both phases studied. The genotypes from IPGR-Sadovo were stable regarding the evaporated water at the phase of grain feeling, the best of them being Nova zvezda, Strelec, Hrabrec, Maria, Petya and Dorita. The cultivars from Mexico, China and Romania were leading with regard to the quantity of water retention (index **A_3**) in both phases studied. Among the Bulgarian varieties and lines, Nova zvezda, Petya, Momchil, Boryana, Stojer and Vihar could be distinguished, especially at the phase of grain feeling. We consider that the line Nova zvezda has the potential for drought tolerance

Table 2. Water exchange indices – average data (2005-2007).

Pattern / Origin	Heading			Grain filling			Pattern	Heading			Grain filling		
	A_1 [%]	A_2 [%]	A_3 [%]	A_1 [%]	A_2 [%]	A_3 [%]		A_1 [%]	A_2 [%]	A_3 [%]	A_1 [%]	A_2 [%]	A_3 [%]
Katya -St.	20.0	44.9	184.4	39.4	70.9	105.3	Katya-St.	20.5	42.7	166.7	43.4	75.3	98.8
Bacanora 88-Mex. (R)	18.3^{*}	40.2^{-}	180.2^{*}	35.9^{*}	65.5^{*}	129.7^{+}	Hrabrec (R)	23.1^{*}	46.7^{*}	154.9^{*}	42.5^{*}	69.9^{*}	95.9^{*}
85- ZHONG 56-Ch.(R)	18.8^{*}	41.7^{*}	185.5^{*}	32.3^{*}	54.2^{-}	114.2^{+}	Vihar (R)	23.3^{*}	50.4^{*}	164.5^{*}	44.7^{*}	76.6^{*}	101.1^{*}
90-ZHONG 150-Ch.(R)	19.2^{*}	42.8^{*}	182.4^{*}	33.7^{*}	55.6^{-}	122.6^{+}	Belica (R)	23.5^{*}	52.1^{+}	169.9^{*}	43.6^{+}	73.4^{*}	97.4^{*}
Tepoca-Mex. (R)	22.2^{*}	52.8^{*}	189.1^{*}	34.8^{*}	59.1^{-}	122.0^{*}	Strelec (R)	24.1^{+}	53.8^{+}	169.5^{*}	42.6^{*}	70.3^{*}	94.5^{*}
F 4105-W-2-1-Rom. (R)	22.2^{*}	50.3^{*}	187.3^{*}	35.5^{*}	72.5^{*}	123.8^{+}	Petya (R)	25.3^{+}	55.4^{+}	164.7^{*}	40.3^{*}	73.0^{*}	108.1^{*}
Rayon-Mex. (R)	22.3^{*}	51.8^{*}	166.4^{*}	42.0^{*}	66.5^{*}	112.3^{*}	IPGR/Mar. (MS)	25.4^{+}	54.8^{+}	162.0^{*}	47.1^{*}	83.8^{*}	93.3^{*}
Zargoon-Pak. (R)	23.0^{*}	48.6^{*}	168.6^{*}	34.4^{*}	63.6^{*}	119.5^{*}	Yunak (R)	25.4^{+}	54.1^{+}	161.1^{*}	46.9^{*}	81.1^{*}	100.8^{*}
Flamura 80-Rom. (R)	24.5^{*}	53.0^{+}	167.4^{*}	40.5^{*}	70.8^{*}	123.6^{+}	Maria (R)	25.4^{+}	55.6^{+}	163.2^{*}	44.8^{*}	72.8^{*}	89.9^{*}
F 338-Rom. (R)	24.7^{*}	56.5^{*}	159.9^{-}	40.2^{*}	69.0^{*}	102.8^{*}	Dorita (R)	25.4^{+}	56.4^{+}	164.7^{*}	44.7^{*}	74.8^{*}	92.9^{*}
F4141/W1-133-Rom. (R)	25.2^{*}	58.7^{+}	175.9^{*}	37.9^{*}	71.9^{*}	107.7^{*}	N. zvezda (R)	26.6^{+}	56.6^{+}	157.0^{*}	36.9^{-}	68.7^{*}	119.6^{+}
TJB 916-46-Mex./O. (MS)	25.4^{*}	58.1^{+}	184.1^{*}	37.8^{*}	74.9^{*}	121.0^{*}	PP 752 (S)	27.5^{+}	59.4^{+}	156.3^{*}	49.4^{*}	76.3^{*}	80.7^{-}
CA 8055-Chi. (MS)	26.5^{*}	61.3^{*}	180.0^{*}	47.8^{*}	92.2^{+}	109.5^{*}	Sadovo1 (S) St.	27.6^{+}	54.8^{+}	146.4^{-}	52.0^{+}	81.9^{*}	85.9^{-}
Sadovo 1- St . (S)	27.6^{+}	53.6^{+}	150.7^{-}	46.3^{*}	76.3^{*}	91.5^{-}	Jubilej 120 (S)	27.8^{+}	58.4^{+}	150.7^{-}	52.9^{+}	81.6^{*}	75.7^{-}
Super flatua-USA (MS)	27.7^{*}	61.2^{+}	165.7^{-}	39.8^{*}	77.2^{*}	114.2^{*}	Stojer (MS)	28.4^{+}	64.4^{+}	162.5^{*}	44.5^{*}	76.3^{*}	101.9^{*}
Atay 85-Tur. (MS)	28.1^{*}	66.8^{+}	182.9^{*}	39.7^{*}	68.2^{*}	104.4^{*}	Prelom (MS)	28.4^{+}	59.9^{+}	151.3^{*}	47.4^{*}	75.7^{*}	84.8^{-}
F.10.S-1-Rom. (MS)	28.2^{*}	60.8^{*}	158.8^{-}	40.9^{*}	70.5^{*}	119.7^{*}	Boryana (MS)	28.7^{+}	64.9^{+}	160.2^{*}	44.3^{*}	79.5^{*}	101.9^{*}
Bezostaya 1-Rus. (S)	28.4^{+}	58.9^{+}	149.8^{-}	38.9^{*}	73.1^{*}	111.7^{*}	Sadovo 552 (S)	30.5^{+}	65.7^{+}	150.5^{-}	52.7^{+}	86.5^{+}	77.7^{-}
SERI 82-Mex. (S)	29.7^{*}	59.1^{*}	132.0^{*}	47.8^{*}	92.2^{+}	109.5^{*}	Momchil (MS)	31.4^{+}	66.8^{+}	145.3^{-}	43.8^{*}	78.8^{*}	102.6
S x L/ Glenson-USA (S)	29.9^{+}	56.8^{+}	159.0^{*}	39.3^{*}	67.1^{*}	101.0^{*}							
F.9.70./Maya S-Mex. (S)	30.0^{*}	60.4^{+}	145.2^{-}	37.1^{*}	76.3^{*}	106.1^{*}							
Gerek 79-Tur. (S)	30.3^{+}	66.7^{+}	159.7^{*}	38.6^{*}	60.9^{*}	105.2^{*}							
	$\pm$ SD; $P < 0.05$; * – NSD							$\pm$ SD; $P < 0.05$; * – NSD					

A_1 – quantity of evaporated water compared to total water in the flag leaf.
A_2 – quantity of evaporated water compared to dry mass of the flag leaf.
A_3 – quantity of water retention compared to dry mass of the flag leaf.

R – resistant to dehydration.
MS – mean sensitive to dehydration.
S – sensitive to dehydration.

due to its ability to keep water resources and more effective metabolism in plant cells. The Mexican cultivars Tepoca, Bacanora 88, as well as the Chinese cultivars 90-Zhong 150, 85-Zhong 56, and some Romanian cultivars F4141/W1-133 and Flamura 80 showed positive results concerning the water exchange indexes and location of the flag leaves as well as the continuation of the vegetation period indicating potential for adaptation towards the unfavorable growing conditions in the Sadovo area with natural conditions of warm and dry temperature-water rate during vegetation (Boyadjieva, 1999). The examination of the newest selection of winter wheat (T.aestivum L.) in IPGR showed that cultivar Petya and lines Nova zvezda and Strelec had potential for drought tolerance (Chipilski and Andonov, 2009). It is important to understand the concept that a germplasm of different origins and genetic diversity is critical to enhance and maintain the yield potential of wheat and may provide new sources of resistance and tolerance to biotic and abiotic stresses (Skovmand and al., 2002**)**. This is the basis for success of the breeding program in IPGR-Sadovo. This was confirmed in some cases in the present study, especially by the obtained and statistically processed results for dehydration of the flag leaves during grain filing (critical phase). Cultivar 90/Zhong 150 participated in creating the candidate cultivar Nova Zvezda as a parental form. The results concerning cultivars 90/Zhong 150 and Nova zvezda showed the same trend and proved to SD<0.05%, than standard Katya. The results were similar between cultivar Flamura (parental form of Vihar) and line Vihar, but were not statistically significant at the same growth phase. A similar analogy was not found for the parental cultivar Super flatua and the candidate cultivar Strelec.

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