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Breeding Potentials of Durum Wheat Landraces for Yield and Quality Traits

Damla BALABAN GÖÇMEN* **Alpay BALKAN** **Oğuz BİLGİN** **İsmet BAŞER**

Department of Field Crops, Faculty of Agriculture, University of Tekirdag Namik Kemal, Türkiye

* Corresponding author e-mail: dgocmen@nku.edu.tr

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ABSTRACT

The study was carried out to evaluate yield components and some physiological quality traits for 30 durum wheat landraces (native and foreign originated) and 5 obsolete cultivars in Thrace ecological conditions. Experiments were set up in randomized block design in 3 replicated during the 3 consecutive growing seasons. As a result of the analysis of variance, the differences between the averages of the genotypes for the traits were found to be statistically significant. This indicated that there may be enough variation for traits within landraces. The mean values of genotypes ranged between 2238 kg/ha^{-1} and 3749 kg/ha^{-1} for grain yield, 98.8 cm and 135.3 cm for plant height, 6.04 cm and 8.88 cm for spike length, 26.6 and 35.3 for the number of grains per spike, 0.988 g and 1.494 g for grain weight per spike, 36.1 g and 42.7 g for thousand grain weight, 74.4 kg/hl^{-1} and 79.4 kg/hl^{-1} for test weight and 82.1% and 94.6% for vitreous grain percentage. Although Kahramanmaraş, Dicle, Boğacak, Sorgül, Ionia, Cyprus and Haurani were determined as promising populations for yield and yield components, Siverek, Çanakkale, Tokat, Gaziantep, Yozgat and Urfa landraces had better physical quality. The estimated coefficient of variation and broad sense heritability shifted from 3.9% to 24.52% and from 7.91% to 72.44% for the traits, respectively. Moderately high coefficient of variation, broad sense heritability a genetic advance for plant height, spike length and vitreous grain percentage indicated that selection based on these traits will be more effective and accomplished in the genetic material.

***Keywords*:** Durum wheat, landraces, obsolete cultivar, yield components, physical quality traits

Introduction

Durum wheat is an important raw material in the world food industry, especially in pasta and bulgur. 20% of the world's durum wheat production takes place in Middle East countries, including Turkey. As a result of climate change, it is estimated that the production areas of durum wheat (*Triticum durum* Desf.) will decrease by 19% by 2050 and 48% at the end of the century (Ceglar et al., 2021). This means that production decreases, dependence increases and may cause a threat to food safety for millions of people due to increasing temperatures in the areas where wheat production is made (Tesfaye, 2021). Turkey is one of the most important producer countries in the world in durum wheat production and is also the "gene" centre of durum wheat.

In our country, 15-20% of durum wheat production is carried out on the coast, 25-30% is made in Southeastern Anatolia, and 50-55% is carried out in Central Anatolia and passage zones (Alp and Kün, 1999). Due to its ecological feature, the Southeastern Anatolia Region in Turkey is known as the durum wheat zone of our country. In our country, the share of durum wheat areas in wheat sowing areas is at the level of 8-10% (Anonymous, 2008). While durum wheat production was 60% in previous years in the Thrace region, it has decreased to a level that will be none at today's level (Anonymous, 2009). This is due to the low number of varieties in durum wheat breeding and the inadequacy of variation sources used in breeding. For this reason, it is important to use new genetic resources that have the desired characteristics in the breeding of durum wheat and are well compatible with each other in crossing (Alp, 2005). One of the easiest and most effective ways to develop genetic varieties by expanding the genetic variation is the use of landraces (Gollin et al., 2000; Sönmezoğlu, 2006; Coşkun et al., 2019; Demirel et al., 2019).

As a result of plant breeding activities, although it makes a significant positive contribution to the increase in wheat production depending on the increase in field yield, it also causes the increase and extinction of direct and indirect use of genetic resources (landraces or local wheat population, etc.). It is stated by many researchers that landraces (Mazid et al., 2009) grown on less than 1% of the total wheat cultivation area of Turkey have significant potential in breeding studies (Dotlacil et al., 2010; Jaradat, 2012).

It is important to take advantage of landraces and wild forms to increase variation in breeding studies. They are at risk of extinction due to the development of a large number of high-yielding commercial varieties, the development of technology and the ease of transportation everywhere (Karagöz and Zencirci, 2005). There is a need to protect landraces with genetic diversity and use them as parents in breeding programs (Özberk, 2018).

Landraces are considered to be important genetic sources in increasing genetic diversity for the varieties to be developed by showing better adaptation in regions where abiotic and biotic stress factors are located (Soriano et al., 2018; Maccaferri et al., 2019). To increase the effectiveness of continuity and plant breeding programs in plant production, the protection of landraces and the prevention of genetic erosion are of great importance (Kabbaj et al., 2017). It is known that wheat landraces grown in different regions of Turkey have high adaptation capabilities and good quality characteristics. In the studies, it has been shown that there are very useful sources in the breeding studies of landraces because of their significant diversity among populations (Aoun et al., 2019; Chacon et al., 2020). When landraces are comprehensively characterized for genetic diversity and population structure, it has great potential to identify new resources of resistance against biotic and/or abiotic stresses (Marone, 2021). Wild relatives, landraces and other germplasms are important genetic sources in determining new sources of genetic resistance against diseases (Grandillo et al., 2007).

It is of great importance to give priority to the breeding of high-quality varieties for the increase in wheat production (Sözen and Yağdı, 2005; Tekdal et al., 2011). Wheat landraces have very good performance for quality characteristics in our country. However, to benefit from following the purpose and to use it as a gene source in breeding studies, its genetic structures must be determined well (Tanksley and McCouch, 1997; Eserkaya, 2010). Some of the landraces can reveal hopeful performances under modern production conditions for grain yield and quality characteristics (Brush, 1995; Karakaxas et al., 1998). In addition to being the preferred material in breeding programs, the increase in the use of nutritional values increases the importance of durum wheat landraces day by day (Trad et al., 2022). This study, it is aimed to investigate the usability of native and foreign landraces in agronomic performance and variability levels and wheat breeding programs.

Materials and Methods

In the study, 5 foreign origins (Myrina, Limnos, Cyprus, Ionia and Haurani), 25 native origins (Manisa, İzmir, Bursa, Çanakkale, Denizli, Mersiniye, Sorgül, Menceki, Urfa, Han 27, Siverek, Şırnak Akkaya, Dicle, Devedişi, Boğacak, İskenderun, Kahramanmaraş, Mardin, Adıyaman, Gaziantep, Tokat, Erzincan, Akbuğday, Amasya and Yozgat) durum wheat landraces and 5 obsolete durum wheat varieties (Beyaziye, Gökgöl 79, Berkmen 469, Japiga and Mondur) were used as genetic material. Landraces and obsolete durum wheat varieties were provided from the genetic stock from native and foreign sources of Tekirdag Faculty of Agriculture, Department of Field Crops.

The trials were carried out in Tekirdağ ecological conditions in 2006-2007, 2007-2008 and 2008-2009 growing periods according to the randomized blocks experimental design with 3 replications. Each genotype was sown in 5 m^2 plots with 500 plants per square meter. 20 kg/da^{-1} 20.20.0 fertilizer before planting sowing, 10 kg/da^{-1} urea (46%) during the tillering period, 15 kg ammonium nitrate during the booting period and 15 kg/da^{-1} ammonium nitrate (26%) fertilizer in the pre-heading period were given as fertilizer in the study. In the study, grain yield, plant height, spike length, number of grains per spike, grain weight per spike, thousand grain weight, test weight and vitreous grain percentages were investigated.

The data obtained from the landrace and obsolete cultivar were analysed according to the randomized blocks experimental design, and the differences between the means were determined by the DUNCAN (0.05) significance test (SAS Institute, 1999). In the estimation of variance components, Johnson et al., (1955) mean square values were used according to the method described. Coefficient of variation (Burton, 1952), coefficient of genetic and phenotypic variation (Singh and Choudhury, 1985), heritability broad sense (Falconer and Mackay, 1996) and genetic progress (Allard, 1960) values were estimated.

Results and Discussion

As a result of the analysis of variance, the differences between the averages of the durum wheat landraces and obsolete cultivars for the grain yield, yield components and some physical quality characteristics were found to be statistically significant (Table 1).

The plant height in the landraces and obsolete cultivar varied between 98.8 cm and 135.3 cm. It is seen that landraces have taller plant heights with an average plant height of 119.6 cm. It is seen that especially Kahramanmaraş landrace with 98.8 cm plant height and Dicle, Han 27, Siverek, Ionia and Cyprus durum wheat landraces with short plant heights can be a material that has the potential to be used in direct and indirect breeding studies for plant height.

The spike length varied between 6.04 cm and 8.88 cm in landraces, and there were populations with longer spikes than the average of 6.77 cm obsolete cultivars. It is understood that the populations of İskenderun, Erzincan, Ionia, Boğacak, Dicle and Menceki which have longer spikes than the obsolete variety Berkmen 469 (7.78 cm), may be the right material to be used in direct and indirect breeding studies for spike length.

While the number of grains per spike in the landraces and obsolete varieties of durum wheat varied between 26.6 and 35.3 units in the experiment, the grain weights per spike were between 0.988 g and 1.494 g. Devedişi, Boğacak, İskenderun, Tokat and Yozgat populations, which give higher values than the obsolete variety Berkmen 469 (32.9 units), which has the highest value for grain number in spike, are the prominent populations.

The thousand kernel weight was changed between 36.10 and 42.70 g for the landraces and varied from 38.2 to 42.7 g for the obsolete cultivars. Among the 35 genotypes in the study, Sorgül and Dicle populations, Gökgöl 79 and Berkmen 469 obsolete cultivars gave higher thousand kernel weight over 42 g. Han 27 (36.1 g), Limnos (36.5 g) and Japiga (38.2 g) were the genotypes that gave the lowest thousand kernel weight. It is understood that the landraces and most of the obsolete cultivars gave close averages for thousand grain weight in the study.

It is seen that the test weights of the landraces and the majority of the obsolete cultivars are below the desired values (Table 1). Test weight values varied between 74.4 kg/hl^{-1} and 79.4 kg/hl^{-1} for the genotypes. Gökgöl 79 (78.7 kg/hl^{-1}) variety gave the highest test weight and Dicle, Siverek and Menceki landraces gave similar values.

In the study, vitreous grain percentages ranged from 82.1% to 94.6% for landraces. The vitreous grain average of obsolete cultivars was 91.5%. Similar values were determined for vitreous grain percentage in the obsolete variety Beyaziye (94.3%), which gave the highest vitreous grain percentage, and in Çanakkale, Urfa, Gaziantep and Yozgat populations.

While the grain yield means of landraces varied between 2238-3749 kg/ha^{-1}, obsolete cultivars gave average yields ranging from 2437 to 3639 kg/ha^{-1}. While Gökgöl 79 had the highest grain yield with 3639 kg/ha^{-1} among the obsolete varieties, the durum wheat landrace Dicle took place on this variety with a yield of 3749 kg/ha^{-1}. İzmir, Bursa, Denizli, Sorgül, Boğacak, Amasya, Cyprus and Haurani landraces gave statistically similar results with Gökgöl 79. The estimated parameters to determine the variability level of the genetic material in the research are given in Table 2.

The presence of a sufficiently large variation in a population indicated that the population has suitable genotypes that can be used successfully in breeding programs. Dotlacil et al., (2000) explained that a minimum coefficient of variation of 10% can be considered a sign of wide variation. The coefficients of variation for the examined characters ranged from 3.9% to 24.52%. As seen in Table 2, the high coefficients of variation for grain weight per spike, grain number per spike, grain yield, spike length, plant height and thousand grain weight indicated that there may be sufficient variation for breeding studies in existing populations. On the other hand, it is seen that there is not enough variation for test weight and vitreous grain percentage in landraces. In addition, it is seen that the estimated phenotypic variation coefficients for the examined traits are larger than the genotypic variation coefficients. This shows that environmental factors have a higher effect than genotypic factors in the emergence of these traits. The phenotypic and genotypic coefficients of variation were close values for ear length, grain weight per spike, thousand grain weight and vitreous grain percentage traits.

Heritability estimates indicate the response to selection based on the phenotype of different traits. Johnson et al., (1955) stated that using heritability values together with genetic advance estimates is more beneficial than using heritability values alone in estimating the effect of selection.

The estimated broad-sense heritability for the traits examined in the study ranged from 7.91% to 72.44%. The highest heritability values were estimated for plant height (72.44%), vitreous grain percentage (61.73%), and spike length (61.43%), respectively. Generally, low and moderate heritability may be due to the type of genetic material and the environment of the growing region. In addition, high heritability estimated for plant height, spike length and vitreous grain percentage and high genetic advance values show that the genotypic effect is higher in the formation of these traits, and the selection to be made can be more effective and successful.

When populations are evaluated according to the data obtained, Kahramanmaraş, Dicle, Siverek, Ionia, Cyprus and Han 27 for plant height; Menceki, Dicle, Devedişi, Boğacak, İskenderun, Erzincan, Ionia and Cyprus for the number of grains per spike; Çanakkale, Denizli, Devedisi for the number of grains per spike; Boğacak, İskenderun, Ionia, Tokat, Adıyaman and Yozgat for grain weight per spike; Menceki, Çanakkale, Denizli, Sorgül, Dicle, Gaziantep and Tokat for test weight; Çanakkale, Gaziantep, Urfa and Yozgat for vitreous grain percentage and Dicle, İzmir, Bursa, Denizli, Sorgül, Amasya and Boğacak for grain yield were determined as beneficial populations for breeding studies.

The fact that grain weight per spike, number of grains per spike, grain yield, spike length, plant height and thousand grain weight characteristics have high coefficients of variation indicates that there is sufficient variation in these characteristics in populations. The calculated high heritability for plant height, spike length and vitreous grain percentage, and high genetic advance values show that parents and genotype selections based on these characteristics can be more effective and successful.

As result, Dicle, Boğacak, Cyprus, Haurani, Amasya and Denizli populations showed superior characteristics for grain yield and yield characteristics, and Çanakkale, İzmir, Sorgül, Menceki, Dicle, Amasya, Gaziantep and Yozgat populations showed superior characteristics for quality characteristics. It is seen that these populations are potential populations to obtain new varieties as a generator in crossbreeding in durum wheat breeding studies or directly by pure line selection.

Table 1. Average values of genotypes in the traits examined.

Genotypes	Plant Height	Spike Length	Number of Grains per Spike	Grain Weight per Spike	Thousand Grain Weight	Test Weight	Vitreous Grain Percent	Grain Yield
Beyaziye	115.1 d-h	6.86 g-l	32.2 a-d	1.328 a-f	40.3 abc	76.1 c-h	94.3 a	2887 d-l
Gökgöl 79	103.6 abc	6.80 h-m	30.2 a-d	1.419 a-d	42.2 a	78.7 ab	90.0 d-i	3639 ab
Berkmen 469	107.9 b-e	7.78 b-e	32.9 abc	1.476 ab	42.7 a	78.2 a-d	94.0 ab	3504 abc
Japiga	115.9 d-i	6.34 j-m	30.2 a-d	0.988 j	38.2 abc	76.1 c-h	90.1 c-i	2437 lm
Mondur	111.1 c-f	6.06 lm	28.2 cd	1.200 d-j	40.7 abc	76.3 b-h	89.2 f-i	2494 klm
Average	**110.7**	**6.77**	**30.7**	**1.282**	**40.8**	**77.1**	**91.5**	**2992**
Manisa	129.5 lmn	6.97 e-k	28.0 cd	1.039 hij	40.6 abc	76.4 b-h	82.1 l	2949 c-l
İzmir	126.6 k-n	7.37 b-h	30.4 a-d	1.206 c-j	41.3 ab	77.7 a-f	92.9 a-e	3384 a-d
Bursa	119.9 f-k	7.09 d-j	31.0 a-d	1.202 d-j	39.5 abc	76.8 a-h	91.4 a-g	3106 a-j
Çanakkale	124.8 i-m	7.21 b-i	35.3 a	1.454 abc	41.6 a	75.4 fgh	94.6 a	2681 f-m
Denizli	127.8 k-n	7.74 b-e	33.0 abc	1.292 a-g	41.1 ab	77.0 a-g	90.7 b-h	3120 a-i
Mersiniye	115.8 d-i	6.54 i-m	26.6 d	1.123 f-j	40.7 abc	76.8 b-h	92.9 a-e	2842 d-l
Sorgül	114.6 d-h	7.59 b-h	31.6 a-d	1.231 b-i	42.7 a	77.6 a-f	89.8 e-i	3323 a-e
Menceki	128.0 k-n	7.81 a-d	28.4 cd	1.198 d-j	41.2 ab	78.0 a-e	87.2 ij	2959 c-l
Urfa	121.1 g-l	7.70 b-f	29.6 a-d	1.200 d-j	40.4 abc	76.1 c-h	93.3 abc	2574 h-m
Han 27	109.8 b-e	6.90 f-k	31.7 a-d	1.190 d-j	36.1 c	74.4 h	89.9 e-i	2529 j-m
Siverek	107.3 a-d	7.73 b-e	32.6 abc	1.312 a-g	41.4 a	78.6 abc	83.7 kl	2960 c-l
Şırnak Akkaya	119.6 f-k	7.03 d-k	32.6 abc	1.186 d-j	41.2 ab	75.4 fgh	92.2 a-f	2575 h-m
Dicle	101.3 ab	7.82 a-d	31.9 a-d	1.494 a	42.0 a	79.4 a	85.2 jkl	3749 a
Devedişi	127.2 k-n	7.14 c-j	34.3 ab	1.163 e-j	41.3 ab	77.7 a-f	92.6 a-e	2238 m
Boğacak	112.8 d-g	7.84 a-d	33.3 abc	1.361 a-f	40.8 abc	77.3 a-g	93.0 a-e	3140 a-h
İskenderun	124.8 i-m	8.88 a	33.4 abc	1.283 a-g	40.8 abc	74.4 h	92.4 a-f	2596 g-m
Kahramanmaraş	98.8 a	7.02 d-k	31.1 a-d	1.277 a-h	39.2 abc	76.3 b-h	93.2 a-d	3039 b-k
Mardin	123.6 h-m	6.27 klm	29.9 a-d	1.001 ij	39.3 abc	76.8 b-h	87.4 hij	2805 d-m
Adıyaman	128.1 k-n	7.20 b-i	30.4 a-d	1.351 a-f	40.5 abc	76.3 b-h	91.8 a-f	2681 f-m
Gaziantep	122.0 h-l	7.39 b-h	32.2 a-d	1.078 g-j	39.8 abc	77.1 a-g	94.2 a	2993 c-l
Tokat	125.8 j-n	7.28 b-i	33.1 abc	1.304 a-g	41.4 a	76.2 b-h	92.1 a-f	2777 e-m
Erzincan	131.7 mn	8.01 ab	31.1 a-d	1.206 c-j	40.8 abc	75.8 d-h	92.0 a-f	2552 i-m
Akbuğday	124.9 i-n	7.47 b-h	29.2 bcd	1.322 a-f	39.5 abc	77.4 a-f	92.2 a-f	3030 b-k
Amasya	121.8 g-l	7.72 b-e	29.1 bcd	1.251 a-h	40.7 abc	77.0 a-g	91.6 a-g	3170 a-g
Yozgat	124.2 i-m	7.52 b-h	33.1 abc	1.348 a-f	41.1 ab	74.4 h	94.0 ab	2939 c-l
Myrina	116.8 e-j	7.36 b-h	27.9 cd	1.216 c-j	39.1 abc	77.2 a-g	90.2 c-i	2668 f-m
Limnos	135.3 n	6.86 g-l	29.0 bcd	1.269 a-h	36.5 bc	75.7 e-h	85.3 jk	2648 g-m
Cyprus	107.2 a-d	7.66 b-g	29.9 a-d	1.201 d-j	38.5 abc	75.2 fgh	83.1 kl	3239 a-f
Ionia	102.2 ab	7.96 abc	31.8 a-d	1.378 a-e	39.2 abc	76.4 b-h	88.3 g-j	2789 d-m
Haurani	115.0 d-h	6.04 m	29.8 a-d	1.304 a-g	39.7 abc	74.9 gh	82.8 kl	3123 a-i
Average	**119.6**	**7.37**	**31.0**	**1.248**	**40.3**	**76.6**	**90.1**	**2906**

Table 2. Estimated phenotypic and genotypic coefficients of variation, components of variance, heritability in broad sense (h^2BS), genetic advance (GI) and genetic advance as % of the mean for the traits examined.

	Ave.	Min.	Max.	CV (%)	PVC (%)	GVC (%)	Variance components			h^2BS (%)	GA*	GA (%)
							σ^2_{ph}	σ^2_{g}	σ^2_{e}/r			
PH	118.343	84.2	150.1	11.30	74.72	54.13	88.424	64.054	39.447	72.44	14.03	11.86
SL	7.284	5.0	10.3	12.78	4.98	3.06	0.363	0.223	0.243	61.43	5.94	81.55
SGN	31.006	16.0	53.0	20.80	13.17	1.04	4.083	0.323	10.337	7.91	0.33	1.11
SGW	1.256	0.5	2.04	24.52	1.19	1.004	0.015	0.005	0.420	33.33	0.08	6.37
TCW	40.385	27.9	52.2	9.15	10.93	5.06	4.413	2.045	13.460	46.34	2.01	4.98
TW	76.613	67.0	83.0	3.97	1.93	0.004	1.482	0.265	25.540	17.88	0.45	0.59
GVP	90.283	66.0	98.0	5.62	14.24	8.79	12.854	7.935	30.093	61.73	4.56	5.05
GY	2918.3	1578	4946	20.80	41.40	17.50	120818.2	51058.0	972.800	42.26	195.50	6.70

PH: Plant height, SP: Spike length, SGN: Grain number per spike, SGW: Grain weight per spike, TCW: Thousand grain weight, TW: Test weight, PGV: Vitreous grain percentage, GY: Grain yield.

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