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Evaluation of 12 Bread Wheat Varieties for Seed Yield and Some Chemical Properties Grown in Northwestern Turkey

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The quality and yield of wheat grain have been increasingly becoming an important factor in cereal trading throughout the world. Breeders have to make many efforts to breed new cultivars giving more yields with high quality. In this research, grain yield, some agronomic characteristics (spike length, number of spikelets, number of grain per spike, grain weight per spike, harvest index, 1000 grain weight and plant height) and quality traits (hectoliter weight, grain moisture, protein, ash, falling number, gluten, gluten index, sedimentation and modified sedimentation) of 12 bread wheat varieties grown during the growing seasons of 2004-2005 and 2005-2006 were investigated. The purpose of the study was to determine the performances and some chemical compositions related to flour quality of different bread wheat genotypes under the ecological conditions of Biga, located in the northwest part of Turkey and to investigate the correlations among quality parameters. Significant differences for all important traits; yield (4064.7-6141.5 kg ha^{-1}), protein content (10.63-13.18 %), gluten content (28.97- 37.43 %) and gluten index (54.50-94.00 %) were found. High and positive correlations were observed between protein content and some other quality traits (ash, falling number, gluten, sedimentation and modified sedimentation). Tosunbey was the best variety with high yield and quality parameters.

Key Words: *Triticum aestivum*, Wheat flour, Correlation, Seed quality.

INTRODUCTION

Wheat, which is cultivated various agro-climatic regions, from cool rain-fed to hot dry-land areas[1] is one of the most important grains for human kind all over the world. Grain yield is a primary concern for the producers, while functional properties of flour are the main problems with respect to

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milling and baking industries which demand a constant quality of the annual raw material. For these purposes, wheat breeders, using either conventional cross breeding or new molecular techniques, have been doing much efforts in the breeding programs aiming the production of new varieties with more grain yield and higher flour quality, as well as adaptation of new varieties to extreme environmental conditions such as salinity, drought, acidity *etc*.

Technically, the mature grain is a caryopsis, with an outer testa closely attached to the seed[2]. The outer, maternal layer, the embryo and the endosperm are the parts of the seed. An outer aleurone layer and inner columns of starchy endosperm cells are consisted of the endosperm. The embryo, aleurone and pericarp plus testa are removed during the milling process, resulting in the starchy endosperm as the primary contributor to flour[1]. Mature wheat seeds contain 8-20 % protein, including the gluten storage proteins that are enriched in proline and glutamine. The gluten proteins constitute up to 80 % of total flour protein and give characteristics of elasticity and extensibility that are of great importance for functionality of wheat flour[3].

Wheat is the primary component of the diet in many part of the world. The major source of energy, protein, vitamins and minerals are provided by wheat-based foods[4]. With respect to production, consumption and trade, wheat is the leading cereal grain. There was a wheat production of 628.8 million tons on the 218.9 million ha area in 2005 all over the world[5]. World leader countries in production are China, India, US, France and Russia. Wheat is a major field crop in Turkey as well, with regards to annual production and cultivated field area as well as consumption of bread per person day^{-1}. According to statistics[6], cultivated field area (sown + fallow land) was 23,066,000 ha in the country. Of the cultivated field areas, the percentage of cereals was about 60 %. Wheat was grown on 9,268,240 ha, larger than for any other crop, with the total production of about 21,000,000 tons and yield 2.266 kg ha^{-1}. In Çanakkale, the research was conducted in, cultivated wheat area, production and yield was 114.715 ha, 406.778 tons and 3.546 kg ha^{-1}, respectively[7]. Furthermore, there are 23 milling factories in Çanakkale province with the annual production capacity[8] of 290,000 tons year^{-1}.

Yield and flour quality of wheat are remarkably influenced by the effects of environment during grain fill. The rate and duration of wheat grain development, protein accumulation and starch deposition are influenced by environmental variables such as water, temperature and fertilizer[1]. Numerous studies indicate that environmental conditions, such as distribution of precipitation[9], growing-season temperature[9-11], light intensity[12] and humidity during grain fill[13], sowing time[14,15], plant density[16,17], fertilizer[18,19] and/or variety[8] are known to have significant effects on wheat yield and

quality. In many parts of the world, including Turkey, high temperatures, insufficient water availability and/or unbalanced distribution of annual precipitation during grain fill in spring are the predominant factors influencing yield and quality as well. In general, the optimum temperature in order to obtain maximum grain yield of wheat is considered to be 15-20 ºC, giving the longest duration of grain fill and the greatest accumulation of starch per kernel[1].

The objectives of the study were to determine grain yield of different bread wheat genotypes grown in a two-year research in northwestern Turkey, to obtain some yield-related traits and to investigate their quality characteristics and their correlations. Accordingly, these are the main goals for the farmers in the region who are willing to get much more productivity per area to get more economic income and for the flour milling industries who are willing to obtain the same quality on a consistent basis of raw materials as they need. This is of great importance in accordance with the baker and the consumer as well.

EXPERIMENTAL

Field trials were conducted during two growing seasons (2004-2005 and 2005-2006) at Biga (26°53'-27°30' East, 40°02'-40°28' North). 12 Bread wheat genotypes (Atli, Demir, Dropia, Flamura, Gelibolu, Gönen, Ikizce, Kasifbey, Saqittario, Tosunbey, Yakar and Yantar) were included in the research. Of these cultivars, Gönen, Kasifbey and Saqittario have been widely grown by the producers whereas the others are new varieties in the region. First year of the study was carried out in Çesmealti village, where some soil characteristics of the experimental field are as follows pH 5.8, organic matter content: 2.4 %, texture: CL and lime: 0.6 %, while second year of the study was carried out in Asagi Demirci village where some soil characteristics of the experimental field are as follows pH 6.3, organic matter content: 3.2 %, texture: CL and lime: 0.5 %, in Biga. The experimental design was a randomized complete block with three replications. The plots consisted of five rows spaced 20 cm and 5 m in length. Plots were fertilized with 120 kg ha^{-1} N (½ at sowing and ½ in the beginning of stem elongation) and 70 kg ha^{-1} P. Because soil K levels were in the excessively high category, no additional K fertilizer was applied. Weeds were controlled as needed with appropriate herbicides. All the observations and measurements were done by three center rows in each plot and the center 3 rows were hand harvested to obtain grain yield in each plot. Data of grain yield (GY) and seven agronomic parameters were collected on spike length (SL), number of spikelets (NS), number of grain per spike (NGS), grain weight per spike (GWS), harvest index (HI), 1000 grain weight (GW) and plant height (PH) and 9 quality parameters were collected on hectoliter weight (HW), grain

moisture (GM), protein (P), ash (A), falling number (FN), gluten (GL), gluten index (GI), sedimentation (S) and modified sedimentation (MS) values. As regards to spice-related parameters, kernels from ten single heads were collected, counted and weighed. Hectoliter weights of the genotypes were performed according to the report of Özkaya and Kahveci[20]. To obtain data on flour quality, firstly, seed moisture was increased to 15.5 % by adding water, then they were ground to get flour using Chopin mill (Moulin Cd Type). The protein content was determined by the Kjeldahl method. The values of ash content (ICC standard method 104), Hagberg falling number (ICC standard method 107), gluten content (ICC standard method 106), gluten index[21], Zeleny sedimentation and modified sedimentation (ICC standard method 116) were taken. All assays were performed in triplicate in the lab. The statistical analyses were performed with SAS software[22] using the PRO GLM model. The least significant difference procedure was done to compare the means at each extraction separately.

RESULTS AND DISCUSSION

Grain yield (GY): According to the grain yields obtained from the varieties used in the study, Tosunbey (6240.0 kg ha^{-1}) and Flamura (5920.0 kg ha^{-1}) gave the highest values whereas Sagittario (4368.3 kg ha^{-1}) gave the lowest value for the first year. As for the second year, the highest yield was obtained from Tosunbey variety (6043.0 kg ha^{-1}), while the lowest were obtained from Ikizce (3802.0 kg ha^{-1}), Kasifbey (3766.7 kg ha^{-1}), Saqittario (3761.0 kg ha^{-1}) and Gönen (3751.0 kg ha^{-1}). The mean GY was 5102.3 kg ha^{-1} for the first year and 4601.1 kg ha^{-1} for the second year. Average grain yield of two years was found 4851.7 kg ha^{-1}. GY differences between the varieties were significantly important (Table-1).

Yield-related traits: All the yield-related parameters examined in a two-year trial were analyzed and the results for SL, NS, NGS, GWS, HI, GW and PH were presented in Table-2. Results from analyses of variance over two years indicated that the differences among genotypes were significant for all characteristics analyzed.

SL varied with the wide range (8.50-15.02 cm); the highest SL was obtained from cultivars Atli and Demir, whereas the lowest were obtained from Gönen and Yantar. Demir (16.62), Kasifbey (16.58) and Yantar (16.35) varieties reached the highest NS values, while Gelibolu (13.07) and Dropia (12.85) reached the lowest values. NGS was determined in a wide range from 28.87 (the variety Ikizce) to 49.28 (the variety Kasifbey). Demir variety (1.84 g) had the highest GWS, while the lowest GWS was observed at Ikizce and Saqittario varieties with the values of 1.29 g. The highest HI value was calculated from Gelibolu variety (46.8 %), whereas the lowest

TABLE-1
GRAIN YIELDS OF WINTER BREAD WHEAT VARIETIES (kg ha^{-1})

Varieties	2004-2005	2005-2006	Mean
Tosunbey	6240.0 a	6043.0 a	6141.5 a
Flamura	5920.0 a	5387.0 b	5653.5 b
Dropia	5482.0 b	5152.0 c	5317.0 c
Gelibolu	5328.0 bc	5109.0 cd	5218.5 c
Yantar	5385.0 bc	5035.0 d	5210.0 c
Demir	4788.0 de	4537.0 e	4662.5 d
Yakar	4778.3 de	4498.0 e	4638.2 d
Atli	4519.3 ef	4371.0 f	4445.2 e
Kasifbey	5119.7 cd	3766.7 g	4443.2 e
Ikizce	4696.7 ef	3802.0 g	4249.3 f
Gönen	4602.0 ef	3751.0 g	4176.5 fg
Sagittario	4368.3 f	3761.0 g	4064.7 g
Mean	5102.3	4601.1	4851.7
LSD	334.4**	97.84**	139.01*
C.V. %	2.85	1.51	2.47

* and ** = Indicate significance at 5 % and 1 %, respectively.
Means shown by the same letter are not significantly different.

TABLE-2
YIELD COMPONENTS OF WINTER BREAD WHEAT VARIETIES AS TWO-YEAR AVERAGE

Varieties	Yield components						
	SL (cm)	NS (number)	NGS (number)	GWS (g)	HI (%)	GW (g)	PH (cm)
Tosunbey	12.91 bc	13.95 ef	39.28 b	1.54 c	40.1 ef	37.5 d	90.9 c
Flamura	12.93 bc	14.35 de	37.37 c	1.50 cd	43.8 bc	35.1 f	82.5 e
Dropia	12.43 cd	12.85 g	32.55 e	1.32 gh	42.3 d	39.9 c	76.7 f
Gelibolu	11.85 d	13.07 g	34.52 d	1.46 de	46.8 a	44.9 a	78.4 f
Yantar	9.03 e	16.35 a	38.65 bc	1.68 b	39.1 f	44.5 a	87.8 d
Demir	14.78 a	16.62 a	39.50 b	1.84 a	30.9 h	42.1 b	111.5 a
Yakar	11.93 d	15.03 bc	40.32 b	1.40 ef	44.6 b	38.3 d	100.7 b
Atli	15.02 a	15.48 b	34.15 de	1.52 cd	34.4 g	41.5 b	112.4 a
Kasifbey	13.48 b	16.58 a	49.28 a	1.38 fg	40.7 e	33.1 g	84.1 e
Ikizce	12.80 c	13.41 fg	28.87 f	1.29 h	34.4 g	31.3 h	102.3 b
Gönen	8.50 e	14.33 de	36.90 c	1.34 fgh	42.3 d	36.5 e	72.6 g
Sagittario	11.95 d	14.73 cd	33.85 de	1.29 h	42.7 cd	40.3 c	71.7 g
Mean	12.30	14.73	37.10	1.46	40.2	38.8	89.3
LSD 5 %	0.63	0.57	1.77	0.06	1.39	0.91	1.87
C.V. %	4.39	3.32	4.10	3.76	2.98	2.03	1.81

SL = Spike length, NS = Number of spikelets, NGS = Number of grain per spike, GWS = Grain weight per spike, HI = Harvest index, GW = 1000 grain weight and PH = Plant height.
Means shown by the same letter are not significantly different.

value was calculated from Demir (30.9 %). The highest 1000 grain weights were weighed at the varieties of Gelibolu and Yantar, while the lowest was weighed at variety Ikizce. The highest PHs were measured for the varieties, Atli (112.4 cm) and Demir (111.5 cm), the shortest for the varieties, Gönen (72.6 cm) and Saqittario (71.7 cm).

Quality parameters: In respect of all the quality traits studied, the differences among the varieties were found out significant (Table-3). The highest HW was obtained from Yakar, whereas the lowest was obtained from Kasifbey and Ikizce. Tosunbey gave rise to highest GM, while Gönen gave rise to lowest. Tosunbey has a higher amount of P, while Yakar has a lowest amount of P. With respect to ash, Gönen with 0.65 % has the highest value, whereas Yakar with 0.51 % has the lowest value. FN values of the varieties ranged from 493.5 min (Ikizce variety) to 428.3 min (Yakar variety). GL value of cultivar Demir (37.43 %) was the highest, while Yakar (28.97 %) was the lowest. Tosunbey produced the highest GI value; in contrast, Yantar produced the lowest GI value. The highest sedimentation was observed from Saqittario, whereas the lowest was observed from Atli. The MS varied from 62.0 mL (Dropia) to 39.5 mL (Atli).

TABLE-3
QUALITY PARAMETERS OF WINTER BREAD WHEAT VARIETIES AS TWO-YEAR AVERAGE

Varieties	HW (g)	GM (%)	P (%)	A (%)	FN (min)	GL (%)	GI (%)	S (mL)	MS (mL)
Tosunbey	80.7ab	12.40a	13.18a	0.55f	478.3b	32.68de	94.0a	50.0ab	60.2ab
Flamura	76.7fg	11.85bc	12.98ab	0.63abc	472.2bc	35.92b	80.7ef	52.3a	61.3ab
Dropia	79.0d	12.01abc	12.87abc	0.62abc	474.2bc	34.50c	76.7f	52.5a	62.0a
Gelibolu	79.8c	12.13ab	12.00de	0.59de	458.0d	30.68f	85.7bcd	45.5cd	56.3cd
Yantar	77.8e	12.05abc	12.53bcd	0.60cd	445.3e	35.93b	54.5h	38.8ef	48.3e
Demir	77.4ef	12.01abc	12.40cd	0.62abc	437.0f	37.43a	67.2g	42.8de	46.8e
Yakar	81.0a	12.03abc	10.63h	0.51g	428.3g	28.97g	86.7bc	45.5cd	55.3d
Atli	80.0bc	12.07abc	11.30fg	0.61bcd	467.8c	32.00e	68.7g	36.2f	39.5f
Kasifbey	76.0g	11.88bc	10.97gh	0.56ef	448.3e	31.95e	83.0cde	45.0cd	53.7d
Ikizce	76.3g	12.05abc	12.10d	0.64ab	493.5a	34.28c	68.3g	47.8bc	53.3d
Gönen	77.7e	11.68c	11.52ef	0.65a	444.5ef	30.82f	81.8de	42.0de	49.3e
Saqittario	77.4ef	11.93bc	12.12d	0.63ab	468.8c	32.90d	88.2b	53.0a	58.8bc
Mean	78.3	12.01	12.05	0.60	459.7	33.17	77.9	46.0	53.8
LSD 5 %	0.80	0.43	0.53	0.03	8.01	0.87	4.14	4.14	3.08
C.V. %	0.89	3.12	3.86	4.20	1.50	2.27	4.57	7.76	4.94

HW = Hectoliter weight, GM = Grain moisture, P = Protein, A = Ash, FN = Falling number, GL = Gluten, GI = Gluten index, S = Sedimentation and MS = Modified sedimentation.
Means shown by the same letter are not significantly different.

Correlations: Simple correlation coefficient analyses of quality parameters revealed, as shown in Table-4, that a highly significant correlations (at the level of 0.1 %) were determined between HW with A and GL, P with FN, GL, S and MS, ash with GL, FN with S, GL with GI, GI with S and MS and S with MS. No correlations between GM with other traits were detected. Correlations between HW with GI were found out to be at the level of 1 %.

Tables 5 and 6 show the analyses of variance for yield and yield component traits and quality parameters of the bread wheat varieties.

A high significant variability for all traits existed among the grown varieties in our conditions. It was found that there were significant differences between wheat varieties in terms of their grain yield, yield components and flour quality, because of their genotypic variations under various environmental conditions. Our overall data indicate that the grain yield, yield-related traits and quality characteristics recorded in the two growing seasons are largely dependent on the genotypes and on their adaptability to the environment in which the research was conducted. In our study, the grain yield of the wheat varieties (mean values) varied from 6141.5 to 4064.7 kg ha^{-1}. Cultivar Tosunbey (6141.5 kg ha^{-1}) gave the highest GY, followed by cultivars Flamura (5653.5 kg ha^{-1}), Dropia (5317.0 kg ha^{-1}) and Gelibolu (5218.5 kg ha^{-1}) whereas Gönen (4176.5 kg ha^{-1}) and Saqittario (4064.7 kg ha^{-1}) produced the lowest. In some national and international studies are reported about differences for grain yield among the varieties[8,23-30]. The GY of the first year was higher than the second year, this is certainly due to the precipitation received during the grain filling period (total rain fall: April-May; 80.9 mm for 2005 and 20.5 mm for 2006).

The mean values as two-year average for agronomic characteristics of the genotypes used in the research SL, NS, NGS, GWS, HI, GW and PH varied within a broad range, from 15.02 cm to 8.50 cm, 16.62 to 12.85, 49.28 to 28.87, 1.84 g to 1.29 g, 46.8 to 30.9 %, 44.9 g to 31.3 g and 112.4 cm to 71.7 cm, respectively. All the agro-traits studied indicated that differences between the varieties were highly significant (Table-2).

We should take into account not only wheat grain yield but also their quality characteristics together. There have been numerous studies for many years by agronomist and technologist to define, understand and measure wheat quality. Flour proteins have been known to be crucial with respect to bread making quality[29-34]. The gluten proteins which comprise gliadin and glutenin, are primer wheat storage proteins. Gliadin and glutenin are considered particularly important for the viscoelasticity on dough. As presented in Table-3, it was obtained that quality parameters of the cultivars examined were significantly important and HW, GM, P, A, FN, GL, GI, S and MS ranged between 81.0 and 76.0 g, 12.40 and 11.68 %, 13.18 and 10.63 %,

TABLE-4
CORRELATIONS BETWEEN QUALITY PARAMETERS OF THE VARIETIES

	HW	GM	P	A	FN	GL	GI	S
GM	0.26782*	–						
P	-0.04747 ns	0.09207 ns	–					
A	-0.44594***	-0.19652 ns	0.24060*	–				
FN	-0.13714 ns	0.04700 ns	0.45478***	0.27837*	–			
GL	-0.45618***	0.03801 ns	0.57583***	0.39957***	0.14414 ns	–		
GI	0.30079**	0.02649 ns	-0.06885 ns	-0.27146*	0.05360 ns	-0.50710***	–	
S	-0.08179 ns	-0.05658 ns	0.36066***	-0.03444 ns	0.35615***	0.13460 ns	0.32333***	–
MS	0.02680 ns	0.02345 ns	0.38004***	-0.15142 ns	0.27597*	0.02892 ns	0.48335***	0.77816***

ns, *, ** and *** indicate not significant, significance at 5 %, 1 % and 0.1 %, respectively.

TABLE-5
ANALYSES OF VARIANCE FOR YIELD AND YIELD COMPONENTS OF THE GENOTYPES AS TWO-YEAR AVERAGE

Source	Mean square								
	DF	SL (cm)	NS (number)	NGS (number)	GWS (g)	HI (%)	GW (g)	PH (cm)	GY (kg ha^{-1})
Genotype(G)	11	22.67***	10.48***	156.14***	0.16***	134.11***	109.65***	1237.06***	2529609.03***
Year (Y)	1	0.29	3.21***	101.29***	0.75***	107.80***	86.46***	18.81**	4522026.89***
G X Y	11	0.41	0.18	1.73	0.10***	4.55***	2.48***	7.24***	201171.43***

** and *** Indicate the significance level of 1 and 0.1 %, respectively and GY: Grain yield.

TABLE-6
ANALYSES OF VARIANCE FOR QUALITY PARAMETERS OF THE GENOTYPES AS TWO-YEAR AVERAGE

Source	Mean square									
	DF	HW (g)	GM (%)	P (%)	A (%)	FN (min)	GL (%)	GI (%)	S (mL)	MS (mL)
Genotype(G)	11	17.95***	0.18	3.94***	97.25***	2221.42***	37.59***	759.25***	177.97***	273.65***
Year (Y)	1	5.50***	0.00	0.01	48.34***	193.39**	4.81***	12.93	95.68***	46.72**
G X Y	11	0.91	0.10	0.19	10.13	150.75***	5.99***	106.67***	62.86***	67.27***

** and *** Indicate the significance level of 1 and 0.1 %,, respectively.

0.65 and 0.51 %, 493.5 and 428.3 min, 37.43 and 28.97 %, 94.0 and 54.5 %, 53.0 and 36.2 mL and 62.0 and 39.5 mL in order. For some similar traits, various results were reported. Significant differences among nine wheat varieties were observed in a study conducted by Daglioglu and Sümeroglu[35]; GL, GI, S and FN values ranged between 17.4 and 36.0 %, 43.0 and 97.6 %, 13.3 and 47.0 mL and 319 and 532 min, respectively. Çagindi *et al.*[36] determined some quality traits of six bread wheat varieties grown in 3 different locations over two years and found that GM, S, GL and GI varied from 9.1 to 11.7 %, 10 to 46 mL, 14 to 41 % and 15 to 100 % in order. Another researcher studied 15 wheat varieties in a two-year trial to determine the quality traits of the genotypes and found out that GM, A, P, GL, S and FN were 9.3-11.0 %, 0.43-0.79 %, 9.3-15.1 %, 23.5-42.1 %, 19.5-58.5 mL and 410-715 min, respectively[37].

Table-4 indicates that strong positive and significant correlations at the level of 0.1 % between P and FN, GL, S and MS and positive and significant at the level of 5 % with ash were obtained while there was no correlation between P and HW and GI. Çagindi *et al.*[36] and Bushuk *et al.*[38] found out significant correlation between protein and sedimentation values as well.

In wheat production, there are mainly five sides from different points of view, including those of the grower, the trader, the flour miller, the baker and the consumer, so it is very difficult such a complicated concern to meet their own expectations which vary many and depends on various factors. Development of high yielding cultivars with good end-use quality has been a major concern for the breeders. As a result, the data of this study, based on a two-year trial, revealed that significant variations were observed among genotypes with a broad range of grain yield, yield-related traits and quality characteristics. Two-year results suggested that cultivar Tosunbey which is a new variety for the region in which the study conducted gave rise to the highest grain yield with good quality characteristics, following cultivars Flamura and Dropia and than Gelibolu which have not also been grown in the region. Widespread cultivars in the region, Gönen, Saqittario and Kasifbey, resulted in considerably low grain yield and quality parameters compared to the new varieties.

Genotype × environment interactions are not desirable[39]. Tosunbey was the best yielding variety with high flour quality in both growing seasons. It could be advisable to test such varieties under different conditions and to determine the genetic stability over the years.

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