NARDI FUNDULEA, ROMANIA
www.incda-fundulea.ro
ROMANIAN AGRICULTURAL RESEARCH, NO. 29, 2012
Print ISSN 1222-4227; Online ISSN 2067-5720

YIELD AND QUALITY CHARACTERISTICS OF SOME FOREIGN BREAD WHEAT (*TRITICUM AESTIVUM* L.) CULTIVARS IN TURKEY

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ABSTRACT

When considering introducing new genotypes to a region, determination of their performance and of certain characteristics in the target region is of great value. In this study, we aimed to investigate the grain yield and flour quality characteristics of nine bread wheat cultivars, originated from foreign countries, in the environmental conditions of Çanakkale. Field trials were arranged in a randomised complete block design with three replicates in 2005-2006 and 2006-2007 growing seasons. Data were collected on grain yield and flour quality traits. Based on the results of the two years of study, genotype x year interaction effect was found to be significant, while there was no significant difference between the grain yields of the tested cultivars. The mean grain yield values varied between 3620 and 4324 kg ha^{-1}. There was a significant variation among cultivars with regard to most flour quality traits evaluated. Ranges for the investigated traits were as follows: protein concentration 10.5-12.9%, gluten content 30.9-42.2%, sedimentation value 29.0-38.5 mL, modified sedimentation value 19.0-36.3 mL, ash ratio 0.41-0.68%. The cultivar ZA-75 had an advantage over the other cultivars in sedimentation, gluten and protein concentration. Results showed that the environmental impacts had a significant effect on grain yield, as well as on quality traits.

Key words: wheat breeding, cultivar, introduction, flour quality.

INTRODUCTION

A large part of the yield increase in wheat throughout the world is attributed to the newly bred varieties with higher yielding potential (Roth et al., 1984; Balla et al., 1987; Mustatea and Saulescu, 2011). Using wheat varieties with high genetic potential and choosing the appropriate genotypes for different ecologies should contribute to significant yield increases in Turkey, an important wheat producer country (Toklu et al., 2001). To obtain such an increase, new genotypes tailored by plant breeders should be registered and become available for producers' use. Introduction of new cultivars from other countries or regions has a place in the context of variety development and registration (Yıldırım et al., 2005). Twenty of the 119 registered varieties in Turkish National Variety List as of 2010 are introduction material with foreign origin (Türkan Aydemir, Variety Registration and Seed Certification Center, personal communication, Sept. 2010). Quality traits are taken into consideration in the process of variety registration in most developed countries (Kahraman et al., 2008). Focusing only on grain yield and disregarding the quality may be the main reason for harvesting a low quality wheat crop in Turkey (Bilgin and Korkut, 2005). Therefore, having a high potential not only in yield but also in quality is important for cultivars to be registered, especially for those brought in by means of introduction.

In wheat production, quality traits, as well as grain yield, are affected by genotype, environment and the interaction of these two factors (Peterson et al., 1992). "Quality" in wheat depends on many factors and may have different definitions depending on the end use in industry. When it comes to quality in wheat crop, protein is probably among the first traits to mention. The negative correlation between the grain yield and protein concentration

Received 29 April 2011; accepted 15 February 2012

(Tuğay, 1978; McClung et al., 1986; Cook and Veseth, 1991; Costa and Kronstad, 1994) is one of the most important factors hindering a simultaneous increase in yield and quality through breeding. Protein concentration in grain may vary depending on the location and the year (Aydın et al., 2005). Among the environmental factors, crop management techniques such as fertilization (Öztürk and Gökkuş, 2008) are of importance, just as precipitation and temperature (Anonymous, 1990). Nevertheless, it was reported that the most important factor determining the quality of wheat bread was the genotype, both in dry and irrigated growing areas (Souza et al., 2004). As a general statement, hard winter wheat contains higher levels of protein compared to soft wheat. Wheat varieties with an unsatisfactory flour quality may be blended with hard wheat to obtain a desired level of quality. Flours with relatively lower protein concentration are acceptable for the production of goods such as cookies and crackers (May et al., 1989).

Along with protein concentration, protein quality is an important factor to determine the end use. Protein quality is more dependent on genetic factors and cultivation techniques have relatively little impact (Anonymous, 1990). Gluten ratio and gluten index test are closely related with the flour quality, which is primarily affected by the quality of protein (Curic et al., 2001). One of the important criteria to assess protein quality in wheat is sedimentation value (Zeleny, 1947). Sedimentation value test is used to evaluate wheat varieties with different quality, since it indicates the content and the quality of gluten. The modified of sedimentation test was developed to assess the loss of protein quality caused by pest damage, following attack of sunny pest and stinkbug, two species of pests widespread in Turkey (Atlı et al., 1988). Another trait regarding quality in wheat, ash ratio is closely related with separation ratio of bran and embryo, and the milling efficiency (Matz, 1996). In general, little variation for ash exists among the flours with similar milling efficiencies.

Registering cultivars with foreign origin in a certain country may have several advantages and disadvantages. Over-exploitation of this method would result in retarding domestic breeding programs and depending upon foreign sources, impairing the national seed industry. On the other hand, introduced genotypes may provide quick solutions to problems arisen in a certain area. To avoid possible adaptation problems, decisions should be based on the results of some preliminary field trials. Hence, evaluation of introduction material in yield trials every once in a while would be valuable to provide such possibilities. It is also possible to incorporate some genotypes with certain characteristics into the national breeding programs as gene sources. The objective of this study was to determine the grain yield and quality characteristics of some non-registered wheat cultivars introduced from abroad, in Çanakkale environmental conditions.

MATERIAL AND METHODS

Nine introduced bread wheat cultivars were used in this study as plant material. Among these, Albena, Demetra, Kristal and Todora originated in Bulgaria, Garaboly and Magor originated in Hungary, Vızıja and ZA-75 originated in Serbia; and Yunak originated in Russia. The seeds of the Serbian cultivars were obtained from Gün-Tar Agricultural Seed Company; while the other seven genotypes were kindly provided by Trakya (Thrace) Agricultural Research Institute. The field trial was arranged in a randomised complete block design with three replications and carried out in two years (2005-2006, 2006-2007 growing seasons) in the Dardanos Research Center of Çanakkale Onsekiz Mart University. Experimental plots were 5 m^2, and seeding rate was 220 kg ha^{-1}. Soil of the plots was clay-loam and had a moderate level of organic matter. Temperature and precipitation data recorded in the two experimental years were presented in Figure 1 as deviations from the long term mean values for the respective variables.

The two years varied greatly in terms of yearly precipitation (713 vs 431 mm), and 2006-2007 growing season had a dryer winter period than 2005-2006 season, as well as than the long term means. In terms as temperature, a relatively hotter period was observed in 2007, especially from May to July, when the crop was maturing. After harvest, all kernels from a plot were weighed and the weights were converted to kg ha^{-1} to calculate grain yield. To evaluate quality levels of the cultivars, data were collected on protein concentration (Kjeldahl method; Anonymous, 1980), gluten value (Anonymous, 1982), sedimentation value (Anonymous, 1972), modified sedimentation value (Atlı et al., 1988), and ash ratio (Anonymous, 1994).

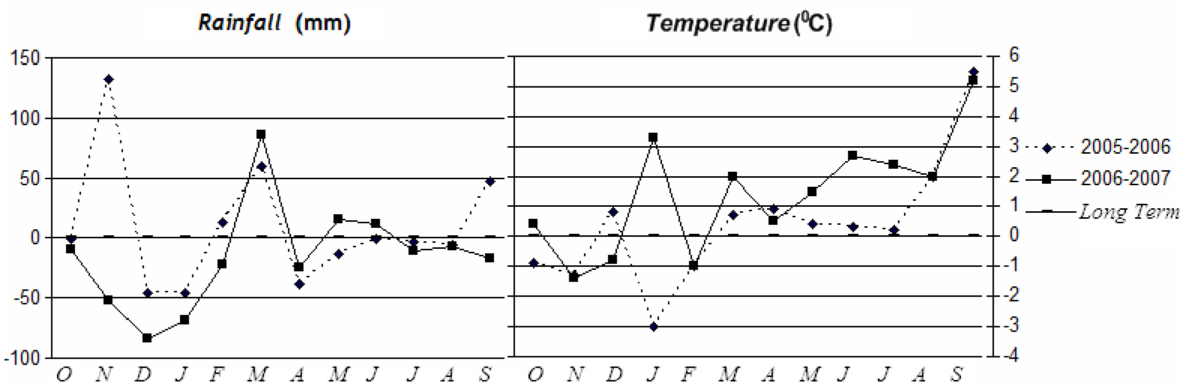

Figure 1. Deviations from the long term means for rainfall and temperature values recorded in the experimental years

Data were analysed based on the following model using proc ANOVA procedure of SAS V8 statistical package program (SAS Inst., 1999).

$$Y_{ijk} = \mu + S_i + R_j(S_i) + G_k + SxG_{ik} + e_{ijk}$$

where: Y_{ijk} – observation value; μ – general mean; S_i – effect of i^{th} year (I = 1, 2); $R_j(S_i)$ – effect of j^{th} replication in i^{th} year (j = 1, 2, 3; I = 1, 2); G_k – effect of k^{th} genotype (k = 1, 2,…10); SxG_{ik} – year x genotype interaction effect; e_{ijk} – random error. Canonical Discriminant Analysis (CDA) was utilized to evaluate the genotypes for the investigated traits. SAS V8 statistical package program was used for this analysis, and the graphics were done by use of macros (Friendly, 2006). Pearson correlation test by proc CORR procedure was used to investigate the relationships among the traits of interest

RESULTS AND DISCUSSION

General

Variance analysis showed significant genotype, year and interaction effects on gluten, sedimentation and modified sedimentation. The main source of variation for ash and protein concentration was the year. Grain yield was significantly affected by genotype x year interaction (Table 1).

Table 1. Analysis of variance (*P* values) of 2-year data for the investigated traits

Source of variation	Degrees of freedom	Gluten content	Sedimentation value	Modified sedimentation	Protein concentration	Ash ratio	Grain yield
Rep. (Year)	4	0.5932	0.3898	0.0054	0.5803	0.6677	<0.0001
Genotype	8	<0.0001	<0.0001	<0.0001	0.1266	0.3385	0.3272
Year	1	<0.0001	<0.0001	<0.0001	0.0006	0.0433	<0.0001
G x Y	8	<0.0001	<0.0001	0.0002	0.0844	0.5718	0.0066
Model	32	<0.0001	<0.0001	<0.0001	0.0196	0.3975	<0.0001

Genotype effects

In the CDA graph showing the genotype means of the investigated traits (Figure 2), first two canonical dimensions explain a total of 91.8% of the variation. A large portion of this (62.8%) is explained by the first dimension. Year means were not included in this analysis and the relative discussion was done based on the mean values presented in table 2. It seems that the magnitude of change in the gluten content from year to year was different in different genotypes (Table 2). Simic et al. (2006) argued that genotype had significant effects on wet gluten/protein ratio and gluten index, the qualitative properties of gluten. Magor, Todora and ZA-75 had relatively higher levels of gluten. ZA-75 showed the highest sedimentation value (Figure 2). Sedimentation value is an index reflecting gluten quality and genetic effects are known to be more important on it than environmental effects. High sedimentation value is an indicator of high quality, since the flour with such quality yields large volume breads (Kahraman et al., 2008). It is widely accepted that sedimentation value should be at least 20 mL for a wheat variety to yield a minimum quality of bread flour (Diepenbrock et al., 2005). Mean values for modified sedimentation indicated that Albena, Demetra and Magor were superior to rest of the cultivars (Table 2), while in the CDA graphs only Albena and Demetra appeared to be superior (Figure 2). This may be due to the high levels of ash and gluten ratios in Magor; because the nature of discriminant analysis causes this genotype to be located based on the traits with the highest values.

Table 2. Mean values and multiple comparison test results for the investigated traits

	Gluten content (%)			Sedimentation value (mL)		
	2005	2006	Mean	2005	2006	Mean
Albena	37.1 c-e	31.5 d	34.3 c	36.0 bc	33.0 b	34.5 b
Demetra	35.3 ef	32.2 d	33.8 c	36.0 bc	37.7 a	36.8 a
Garaboly	40.6 ab	32.1 d	36.4 b	33.0 c	33.3 b	33.2 b
Kristal	32.2 f	29.8 d	30.9 d	20.7 e	20.7 f	20.7 e
Magor	42.6 a	38.8 b	40.7 a	37.7 ab	30.0 c	33.8 b
Todora	39.6 a-d	42.3 a	40.9 a	28.3 d	28.7 cd	28.5 d
Vızıja	38.8 b-d	35.9 c	37.4 b	32.3 c	25.7 e	29.0 cd
Yunak	36.3 de	31.9 d	34.1 c	34.7 bc	27.0 de	30.8 c
ZA-75	40.1 a-c	44.2 a	42.2 a	40.3 a	36.7 a	38.5 a
Mean	38.1 A	35.4 B		33.2 A	30.2 B	
	Modified sedimentation value (mL)			Protein concentration (%)		
	2005	2006	Mean	2005	2006	Mean
Albena	41.7 a	31.0 a	36.3 a	11.7	10.4	11.1
Demetra	40.7 a	29.0 ab	34.8 ab	10.6	11.5	11.0
Garaboly	32.0 b	26. 7 bc	29.3 cd	10.2	11.4	10.8
Kristal	19.7 d	19.3 f	19.0 g	10.0	11.9	10.9
Magor	40.3 a	25.7 cd	33.0 a-c	11.3	12.3	11.8
Todora	24.7 cd	20. 3 ef	22.5 fg	9.7	11.9	10.8
Vızıja	29.0 bc	20.3 ef	24.7 ef	10.2	10.9	10.5
Yunak	32.3 b	23.0 de	27.7 de	10.3	11.5	10.9
ZA-75	42.7 a	22.0 ef	32.3 bc	11.7	12.3	12.0
Mean	33.6 A	24.2 B		10.6 B	11.6 A	
	Ash ratio (%)			Grain yield (kg/ha)		
	2005	2006	Mean	2005	2006	Mean
Albena	0.43	0.40	0.42 b	5489 a-c	2775 bc	4132
Demetra	0.48	0.40	0.44 ab	4461 bc	2779 bc	3620
Garaboly	0.58	0.30	0.44 ab	4356 c	3487 a	3921
Kristal	0.40	0.43	0.42 b	4781 a-c	3282 a	4032
Magor	0.80	0.56	0.68 a	4748 a-c	2618 bc	3683
Todora	0.50	0.53	0.52 ab	5709 ab	2447 bc	4078
Vızıja	0.60	0.20	0.40 b	5759 ab	2387 c	4073
Yunak	0.40	0.40	0.40 b	4562 a-c	2580 bc	3571
ZA-75	0.45	0.37	0.41 b	5833 a	2816 b	4324
Mean	0.52 A	0.40 B		5078 A	2777 B	

Note: Mean values with different lower case letters within a column, and mean values with different upper case letters within a line are significantly different at 0.05 significance level.

ZA-75 had a high a value of protein, though the difference was not significant statistically. Most genotypes had higher ash ratios in the first year of the study, though the year term was not significant in ANOVA. Magor was the cultivar with the highest ash ratio based on the 2-year data. In terms of grain yield, ZA-75 had a high value; however, the differences among the genotypes were non-significant (Figure 2).

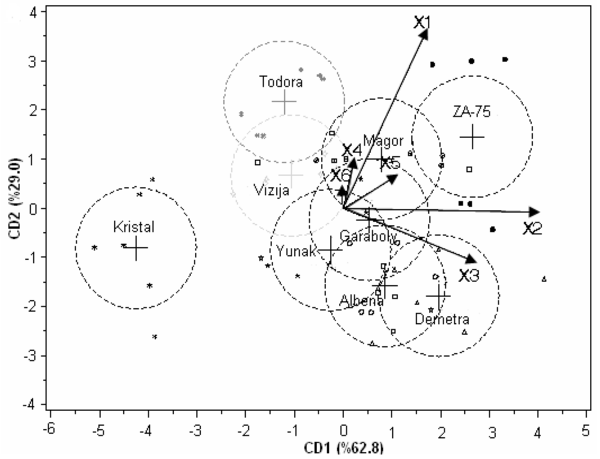

Figure 2. Canonical Discriminant graph for the investigated traits based on 2-year means
X1 – Gluten content; X2 – Sedimentation value; X3 – Modified sedimentation value; X4 – Protein concentration; X5 – Ash ratio; X6 – Grain yield.

Genotype x year interaction

Variance analysis results indicated that genotype x year interaction effect was significant for all traits but protein and ash content. When the year means were compared, first year values were higher for gluten, sedimentation, modified sedimentation, ash and grain yield, while some cultivars behaved contrarily. For example, Todora and ZA-75 had higher levels of gluten in the second year. Most of the traits showed this kind of variation; however, grain yield values were higher in the first year for all of the 9 genotypes. The main reason for this was probably the lower amount of precipitation in the second year. High temperatures, especially during the anthesis, also had an adverse effect on the grain yield in the second year of the study. The significant genotype x year interaction for grain yield was due to the fact that the ranking of the genotypes differed across the years. In 2005-2006 season, cultivars ZA-75 and Vızıja were in the highest yielding group; while ZA-75 was moderate and Vızıja was a low-yielding genotype in 2006-2007 season. One may conclude that these two genotypes suffer significant yield losses in drought seasons.

The genotypes did not show significant differences for grain protein concentration; while the general mean of the genotypes was higher in the second year than the first year's mean, as opposed to the other five traits that had higher values in the first year. One can deduct that the high temperatures during the grain filling period in the second year reduced starch accumulation and grain yield, whereby positively affecting the protein concentration of the kernels. Stone et al. (1996) reported that high temperatures lower dough quality, despite resulting in higher protein concentrations. An earlier study (Correll et al., 1994) supports these results. Relatively lower values for the traits expressing dough quality, such as gluten, sedimentation, and modified sedimentation in the second year of our study may be due to the adverse effects of the high temperatures starting from May of 2007.

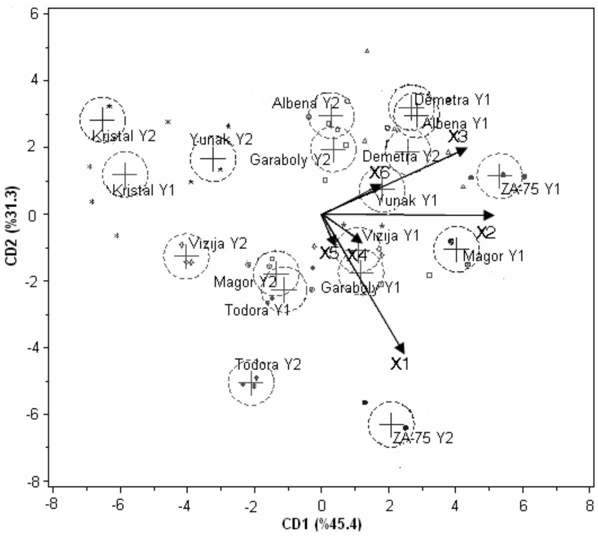

Figure 3. Canonical discriminant graph for the investigated traits based on genotype by year interaction
X1 – Gluten content; X2 – Sedimentation value; X3 – Modified sedimentation value; X4 – Protein concentration; X5 – Ash ratio; X6 – Grain yield.

Relationships among the traits

The correlation analysis indicated a significant change of correlation coefficients among the traits in different years. Variation in the performances of the genotypes due to the environmental differences from year to year was probably the main reason for these changes. Especially the correlation of gluten content with the other traits stands out when the table 3 is examined.

Table 3. Pearson correlation coefficients among the investigated traits

Trait	Year	X1	X2	X3	X4	X5
X2	2005	0.55**				
	2006	0.27				
	2-years	0.42**				
X3	2005	0.43*	0.88***			
	2006	-0.33	0.64***			
	2-years	0.25	0.76***			
X4	2005	0.37*	0.11	0.09		
	2006	0.12	-0.01	-0.00		
	2-years	0.29*	0.12	0.21		
X5	2005	0.14	0.49**	0.36	-0.04	
	2006	0.39*	0.02	-0.22	0.28	
	2-years	0.11	0.14	-0.10	-0.03	
X6	2005	0.04	0.01	-0.14	0.03	0.25
	2006	-0.40*	0.01	0.17	-0.15	-0.08
	2-years	0.18	0.20	0.36	0.21	-0.22

*) $p<0.05$; **) $p<0.01$; ***) $p<0.001$

X1 – Gluten content; X2 – Sedimentation value;

X3 – Modified sedimentation value; X4 – Ash ratio;

X5 – Protein concentration; X6 – Grain yield.

The analysis using the first year data showed that gluten content had positive correlations with sedimentation value, modified sedimentation value and ash ratio. Based on the second year data, it had a positive correlation with protein concentration, while negatively correlated with grain yield. Combined data yielded positive correlations of gluten content with sedimentation value and ash ratio. Among the other traits, sedimentation value showed a positive correlation with modified sedimentation in both years. It is also possible to observe the correlations in graphical results (Figures 2 and 3). For example, sedimentation (X2) and modified sedimentation (X3) vectors had similar directions and lengths, indicating that these two variables were positively correlated. Another relationship that seems significant was between sedimentation value and protein concentration, in the first year data.

CONCLUSIONS

Foreign material may be of importance in wheat breeding programs. Such genotypes can be utilized as gene sources or directly used as a new variety upon registration. At this point, one of the matters to take into account is how these genotypes would be affected by the pest populations in the new environment. We observed no significant disease or insect effect on any of the 9 genotypes, although no such data were collected in this study. The cultivars evaluated in this study showed some significant differences in terms of grain yield and quality traits, although on average for both years the cultivar effect was not significant for grain yield, protein concentration and ash content. Among the studied cultivars, ZA-75 stands out with high yield and quality and possibly could be recommended for growing in the area. Results indicated that variation of weather conditions from year to year may have significant impact on both grain yield and quality traits. Notable climatic differences between the years, such as having a rainy period during heading in the first year, and above-average temperatures during grain filling in the second year, were the major reasons for the large variations observed in the traits of interest. It can be argued that the high temperatures recorded especially in the second year of the study negatively affected both the quality traits and grain yield.

REFERENCES

Anonymous, 1972. ICC Standard No: 116. *Determination of the sedimentation value (according to Zeleny) as an approximate measure* *of baking quality.* Standard Methods of the International Association for Cereal Chemistry (ICC). Verlag Moritz Schafer, Detmold.

Anonymous, 1980. ICC Standard No: 105/1. *Method for the determinations of crude protein in cereals and cereal products for food and for feed.* Standard Methods of the International Association for Cereal Chemistry (ICC). Verlag Moritz Schafer, Detmold.

Anonymous, 1982. ICC Standard No: 137. *Mechanical determinations of the wet gluten content of wheat flour (Glutomatic).* Standard Methods of the International Association for Cereal Chemistry (ICC). Verlag Moritz Schafer, Detmold.

Anonymous, 1990. *Cereals.* PBI Cambridge, Plant Breeding International, Cambridge.

Anonymous, 1994. ICC Standard No: 104/1. *Determination of ash in cereal and cereal products.* Standard Methods of the International Association for Cereal Chemistry (ICC). Verlag Moritz Schafer, Detmold.

Atlı, A., Köksel, H. and Dağ, A., 1988. *Unda süne ve kımıl zararının belirlenmesi için geliştirilen yöntemler ve bu yöntemlerin uygulanabilirliği üzerine araştırmalar.* Tarla Bitkileri Merkez Araştırma Enstitüsü Yayınları. Genel Yayın No: 1988/3, Arş. Yayın No: 1988/2, Tarım Matbaası.

Aydın, N., Mut, Z., Bayramoğlu, H.O., and Özcan, H., 2005. *Ekmeklik Buğday (Triticum aestivum L.) Çeşit ve Hatlarının Karadeniz Koşullarında Verim ve Kalite Özelliklerinin Belirlenmesi*, Ankara Üniversitesi, Ziraat Fakültesi, Tarım Bilimleri Dergisi, 11(3): 257-262.

Balla, L., Szunics, L., and Bedo, Z., 1987. *Hızlandırılmış Buğday Islah Yöntemleri.* TÜBİTAK Türkiye Tahıl Sempozyumu, 6-9 Ekim, 415-428, Bursa.

Bilgin, O. and Korkut, K.Z., 2005. *Determination of some bread quality and grain yield characters in bread wheat (Triticum aestivum L.).* International Journal of Agriculture & Biology, 7(1):125-128.

Cook, R.J. and Veseth, R.J., 1991. *Wheat health management.* The American Phytopathological Society, St. Paul, Minnesota 55121, USA.

Correll, R., Butler, J., Spouncer, L., and Wrigley, C., 1994. *The relationship between grain protein content of wheat and barley and temperatures during grain filling.* Australian J. of Plant Physiology, 21: 869-873.

Costa, J. M. and Kronstad, W.E., 1994. *Association of grain protein concentration and selected traits in hard red winter wheat populations in the Pacific Northwest.* Crop Sci., 34: 1234-1239.

Curic, D, Karlovi, D. Tuak, Petrovi, D., and Dugum, J., 2001. *Gluten as a Standard of Wheat Flour Quality*. Food Tech. Biotechnol., 39(4): 353-361.

Diepenbrock, W., Ellmer, F., and Léon, J., 2005. *Ackerbau, Pflanzenbau und Pflanzenzüchtung*. UTB 2629, Verlag Eugen Ulmer, Stuttgart.

Friendly, M., 2006. *Data ellipses, HE plots and reduced-rank displays for multivariate linear models: SAS software and examples.* Journal of Statistical Software, 17(6): 1-43.

Kahraman, T., Avcı, R., and Öztürk, I., 2008. *Islah Çalışmaları Sonucu Geliştirilen Bazı Ekmeklik Buğday Hatlarının Tane Verimi ve Bazı Kalite Özelliklerinin Belirlenmesi.* (Ülkesel Tahıl Sempozyumu, 2-5 Haziran 2005, Konya: 732-737).

Matz, S.A., 1996. *Chemistry and technology of cereals as food and feed.* 2nd, Van Nostrand Reinhold, New York.

May, L., Van Sanfdord, D.A. and Fınney, P.L., 1989. *Soft wheat milling and baking quality in a soft red winter x hard red winter wheat population.* Cereal Chem., 66(5): 378-381.

McClung, A.N., Cantrell, R.G., Quick, J.S. and Gregory, R.S., 1986. *Influence of Rht1 semidwarf gene on yield, yield components and grain protein in durum wheat.* Crop Sci., 26: 1095-1099.

Mustatea, P., and Saulescu, N.N., 2011. *Estimation of genetic trends in yield and agronomic traits of recent Romanian winter wheat (Triticum aestivum L.) cultivars, using direct comparisons in multiyear, multi-location yield trials*, Romanian Agricultural Research, 28: 17-24.

Öztürk, İ. and Gökkuş, A., 2008. *Azotla Gübrelemenin Bazı Ekmeklik Buğday Çeşitlerinin Verimi ve Kalitesine Etkileri.* Tarım Bilimleri Dergisi, 14(4): 334-340.

Peterson, C.J., Graybosch, R.A., Baenziger, P.S., and Grombacher. A.W., 1992. *Genotype and environment effects on quality characteristics of hard red winter wheat.* Crop Sci., 32: 98-103.

Roth, G.V., Marshall, H.G., Hatley, O.E., and Hill, R.R., 1984. *Effect of management practices on grain yield, test weight and lodging of soft red winter wheat.* Agron. J., 76: 379-383.

SAS Inst., 1999. *SAS V8 User Manual.* SAS Institute, Cary NC.

Simic G., Horvat, D., Zurkovic, Z., Drezner, G., Novozevolic, D., and Dvojkovic. K., 2006. *The Genotype effect on the ratio of wet gluten content to total wheat grain protein.* Journal Central European Agriculture, 7(1): 13-18.

Souza, E.J., Martin, J.M., Guttieri, M.J., O'Brien, K.M., Habernicht, D.K., Lanning, S.P., McLean, R., Carlson, G.R., and Talbert, L.E., 2004. *Influence of genotype, environment, and nitrogen management on spring wheat quality.* Crop Sci., 44: 425-432.

Stone, P. J., Gras, P.W., and Nicolas, M.E., 1996. *The influence of recovery temperature on the effects of a brief heat shock on wheat. iii. Grain protein composition and dough properties.* The University of Melbourne, Parkville, 3052, VIC., Australia.

Toklu, F., Genç, I., Yağbasanlar, T., Özkan, H., and Yıldırım, M., 2001. *Çukurova koşullarında son 21 yıllık dönemde (1980-2000) yetiştirilen ticari ekmeklik buğday çeşitleri ve seleksiyon hatlarında verim potansiyelindeki değişimin belirlenmesi üzerine bir araştırma*. Türkiye IV Tarla Bitkileri Kongresi, 17-21 Eylül 2001, Tekirdağ: 53-59.

Tuğay, M.E., 1978. *Dört ekmeklik buğday çeşidinde ekim sıklığı ve azotun verim, verim komponentleri ve diğer bazı özellikler üzerine etkileri.* Ege Üniv. Ziraat Fak. Yayınları No. 316, İzmir.

Yıldırım, A., Sakin, M.A., and Gökmen, S., 2005. *Tokat Kazova Koşullarında Bazı Ekmeklik Buğday Çeşit ve Hatlarının Verim ve Verim Unsurları Yönünden Değerlendirilmesi*. GOP Üniversitesi Ziraat Fakültesi Dergisi, 22 (1): 63-72.

Zeleny, L., 1947. *A simple sedimentation test for estimating the bread-baking and gluten qualities of wheat flour.* Cereal Chem., 24: 465-475.