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Assessment of Yield and Quality of Some Triticale Genotypes in South-Eastern Anatolia

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ABSTRACT: This research was conducted to assess of yield and its component in different locations some triticale genotypes. The field experiment was arranged to the randomized complete block design with four replications during the 2012-13 growing seasons under Diyarbakir and Mardin ecological conditions. Three triticale cultivars (Ege Yildizi, Fahad-5 and Karma 2000) and two advanced lines (Line DZT-01 and Line DZT-06) were used as material. SPAD, protein content, test weight, thousand kernel weight, starch content, wet gluten, zeleny sedimentation and grain yield were evaluated. According to the findings of research, genotypic differences were found significant for SPAD, grain yield, thousand kernel weight and test weight. The values ranged in genotypes were between 51.8-57.3 in SPAD, 5043.9-6469.3 kg ha^{-1} in grain yield, 35.31-45.81 g in thousand kernel weight, 71.38-78.72 kg hL^{-1} in test weight, 13.1-13.7% in protein content, 64.27-65.94% in starch content, 28.71-30.61% in wet gluten and 40.42-45.67 mL in zeleny sedimentation. Significant positive correlation between protein content with gluten content and zeleny sedimentation in both locations was found. With regard to grain yield and some quality traits of Line DZT-01 and quality traits of Line DZT-06 were highest than commercial cultivars in both locations. Line DZT-01 and Line DZT-06 were found as promising line. These lines can be new cultivar candidates and could be recommended to sown in South-Eastern Anatolia Region of Turkey.

Keywords: Triticale, grain yield, protein content, SPAD,

Güneydoğu Anadolu'da Bazı Tritikale Genotiplerinin Verim ve Kalitesinin Değerlendirilmesi

ÖZET: Bu araştırma bazı tritikale genotiplerinin farklı lokasyonlarda verim ve verim unsurlarını belirlemek için yürütülmüştür. Tarla Denemeleri, 2012-13 üretim sezonunda Diyarbakır ve Mardin ve ekolojik koşullarında tesadüf blokları deneme desenine göre dört tekrarlamalı olarak kurulmuştur. Materyal olarak 3 ticari tritikale çeşidi (Ege Yıldızı, Fahad-5 and Karma 2000) ve iki ileri tritikale hattı **(**Hat DZT-01 ve Hat DZT-06) kullanılmıştır. Çalışmada SPAD, protein içeriği, hektolitre ağırlığı, bin tane ağırlığı, nişasta içeriği, yaş glüten, zeleny sedimantasyon ve tane verimi özellikleri incelenmiştir. Çalışmadan elde edilen sonuçlara göre, SPAD 51.8-57.3, tane verimi 5043.9-6469.3 kg ha^{-1}, bin tane ağırlığı 35.31-45.81 g, hektolitre ağırlığı 71.38-78.72 kg hL^{-1}, protein içeriği %13.1-13.7, nişasta içeriği %64.27-65.94, glüten içeriği %28.71-30.6 ve zeleny sedimantasyon 40.42-45.67mL değerleri arasında değişim göstermiştir. Her iki lokasyonda da protein içeriği ile yaş glüten ve zeleny sedimantasyon özellikleri arasında olumlu ve önemli ilişki belirlenmiştir. İleri tritikale hatları tane verimi ve kalite özellikleri yönünden ticari çeşitlere göre her iki lokasyonda da üstün bulunmuşlardır. Bu nedenle Hat DZT-01 ve Hat DZT-06 yeni çeşit adayı ve Güneydoğu Anadolu bölgesinde ekimi tavsiye edilebilir genotipler olarak belirlenmişlerdir.

Anahtar kelimeler: Tritikale, tane verimi, protein içeriği, SPAD

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INTRODUCTION

Triticale is an established small grain cereal crop that combines the productivity of wheat with the hardiness of rye. Triticale (genus X Triticosecale) was developed by human intervention from crosses between wheat (genus Triticum) and rye (genus Secale). Triticale yields more than its ancestors in two types of marginal conditions such as in the highlands, acid soils, phosphorus deficit soil and high disease foliar severity; and also possible to grow water deficit in the arid and semi-arid condition. Although triticale is grown in many countries of around the world, while the major producers are Poland and Germany, Belarus and France, respectively. According to the data on FAO, (2016) triticale was produced 15.2 million tons from 4.1 million ha land around the world; where, 125 000 tons grains were produced from 37 621 ha land in Turkey. Triticale has a similar role to other cereals. Triticale is higher in energy than barley, and has many desirable nutritional characteristics for all classes of livestock. Small amount of triticale is used for human consumption such as for breakfast cereals, biscuits and cakes. Triticale is better suited to the production of biofuel than wheat. Meyer and Lorenzo del Rio (2004) reported that triticale grain is mostly used for livestock diets. Triticale is a profitable crop because of carries some good characteristics from wheat and rye and can be use in human feeding, however average yield of triticale is very low in Turkey as compared with other producing countries across the globe. Therefore, well managed improvement programs must be conducted for improving in different new varieties in different places under climate and soil conditions. The most important thing that programs need is having the material with different characteristic that able to use as genetic sources. These kind of materials might be useful if they were revealed their characteristics and performances in different ecologies. In this study, grain yield and quality traits of some triticale and relationships of these traits have been evaluated under rainfed conditions of Diyarbakir and Mardin.

MATERIALS AND METHODS

Locations and agro-climatic condition

The present study was conducted at Diyarbakir (latitude 37°88´N, longitude 40°27´E, altitude 680 m above sea level) and Mardin (latitude 37°15´N, longitude 40°49´E, altitude 485 m above sea level) of South-Eastern Anatolia, Turkey provinces, during 2012-13 growing season and under rainfed conditions. Meteorological data are given Figure 1. Total rainfall was 571.4 mm and 527 mm in Diyarbakir and Mardin locations, respectively during growing period. The monthly average air temperature was 11.95 $^{\circ}$C in Diyarbakir and 12.68 $^{\circ}$C in Mardin during the research periods (November- June).

Treatments, plant materials, design and experimental procedure

Three commercial triticale cultivars (Ege Yildizi, Fahad-5 and Karma 2000) and two triticale lines which developed by Faculty of Agriculture, University of Dicle (Line DZT-01 and Line DZT-06) were used as a plant material in this study. Sowing was done with a plot drill in the third week of November in both locations. The experiment was conducted in a randomized complete block design with four replications. The size of experiment plot was 4.8 m^2 (4 m long 6 rows with 20 cm apart). Seed rate for all genotypes was 450 m^{-2}. The plots were fertilized with 60 kg N ha^{-1} and 60 kg P_2O_5 ha^{-1} at sowing and 60 kg N ha^{-1} was applied at tillering stage. The trial was harvested by Hege-125 trial harvester machine on 24 June 2013.

Data collected and measurements

Data on grain yield, test weight, thousand kernel weight (1000-kernel weight), chlorophyll content (SPAD value), protein content, starch content, wet gluten and zeleny sedimentation were recorded during experimentation. Grain yields (kg ha^{-1}), chlorophyll content (unit), protein content (%), wet gluten (%), starch content (%), zeleny sedimentation, test weight (kg hL^{-1}) and thousand kernel weight (g) were examined according to Kizilgeci et al., (2017a)

Statistical analysis

Analysis of variance was performed using the SAS 98 statistical package and significant means were separated by the LSD test at the 5% probability level.

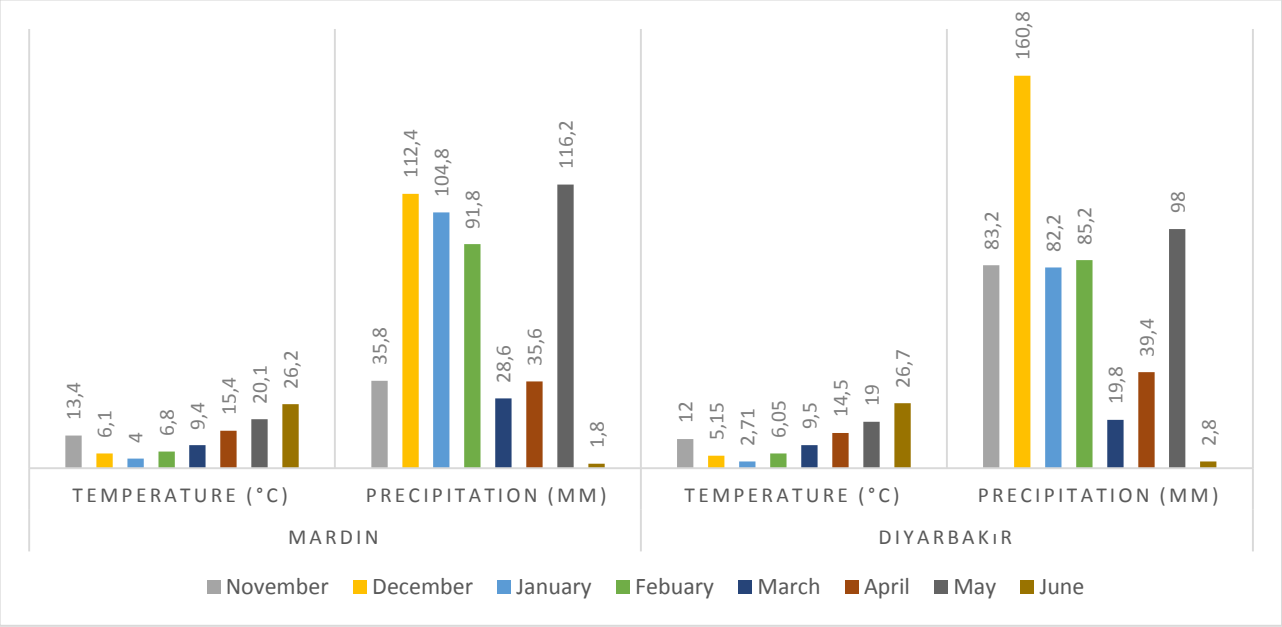

Figure 1. Meteorological data on temperature and precipitation during 2012-13 in both the locations

RESULTS AND DISCUSSION

The combined ANOVA for all studied traits showed highly significant differences among the locations, however SPAD value and thousand kernel weight were found non-significant. The differences among genotypes were found highly significant for SPAD value, grain yield, test weight and thousand kernel weight. Moreover, the genotype x location's interaction was found significant for SPAD, grain yield and thousand kernel weight (Table 1).

The mean SPAD value of all genotypes in both locations were ranged from 51.8 unit (DZT-01) to 57.3 unit (Line DZT-06). Among genotypes, the maximum SPAD value was obtained from Ege Yildizi (60.4 unit) in Diyarbakir location, while the lowest SPAD value was obtained from Line DZT-01 (48.0 unit) in Diyarbakir location. Chlorophyll contents (as SPAD units) were varied under due to different genetic makeup of the genotypes which were varied under two environmental conditions. The results of the present study related to the variation of SPAD value for different genotypes under multiple environmental conditions also confirmed by Giunta et al., (2002) indicated that triticale genotypes were ranged from 45.6 to 50.6 at heading stage.

Among the location, the mean grain yield in the location Mardin (6027.8 kg ha^{-1}) was the highest than in Diyarbakır (5372.2 kg ha^{-1}). The mean grain yield of all genotypes in both locations was changed from 6469.3 kg ha^{-1} to 5043.9 kg ha^{-1}. Whereas, the highest grain yield was obtained from DZT-06 (6557.5 kg ha^{-1}) in Mardin location, followed by Line DZT-01 (6421 kg ha^{-1}) in Diyarbakir location (Table 1). The study results revealed that the location Mardin produced the maximum grain yield than Diyarbakir. In the present study it is also indicated that due to the fact that genotypes have different responses to climatic condition, genotype x location interaction was found important. The observations also indicated that grain yield of triticale is variable parameter, which depends on numerous yield attributes and environmental factors. Various investigations have been noted that grain yield of triticale was significantly influenced by environmental conditions (Mut et al., 2006; Kendal and Sayar, 2016; Kizilgeci et al., 2017a; Kizilgeci et al., 2017b).

Table 1. Mean square estimates and mean performance of SPAD, yield and quality component value of triticale genotypes in Diyarbakir and Mardin locations

Locations	Genotypes	SPAD	Grain Yield (kg ha^{-1})	Protein Content (%)	Test Weight (kg hL^{-1})	Wet Gluten (%)	Zeleny Sedimentation (mL)	Starch Content (%)	Thousand Kernel Weight (g)
Diyarbakir	DZT-01	48.0c	6421.0a	14.7	77.81a	33.23	49.65	65.62a	40.08bc
Mardin	DZT-01	55.6ab	6267.5a	11.6c	80.01a	24.17c	38.55ab	66.26a	39.48ab
Mean	DZT-01	51.8b	6469.3a	13.1	78.510a	28.71	44.10ab	65.94a	39.78b
Diyarbakir	DZT-06	55.8ab	4588.6c	14.5	77.01a	34.43	48.38	64.71ab	49.58a
Mardin	DZT-06	58.9a	6557.5a	12.9a	78.54b	26.79a	42.96a	65.95ab	42.05a
Mean	DZT-06	57.3a	5573.1bc	13.7	77.45a	30.61a	45.67a	65.04ab	45.81a
Diyarbakir	Ege Yildizi	60.4a	5173.9bc	14.2	76.36a	33.96	50.19	64.13ab	41.85b
Mardin	Ege Yildizi	53.5b	6317.3a	12.0bc	79.74ab	24.90bc	38.72ab	65.64bc	41.80a
Mean	Ege Yildizi	56.9a	5745.6b	13.1	77.86a	29.43ab	44.45a	65.18ab	41.83
Diyarbakir	Fahad-5	54.6ab	5590.9ab	13.8	75.98a	33.11	45.90	64.07ab	41.28b
Mardin	Fahad-5	55.4b	5745.0ab	12.2b	79.63ab	25.27bc	34.93b	65.48c	44.29a
Mean	Fahad-5	55.0ab	5668.0bc	13	78.72a	29.19ab	40.42	64.78ab	42.78ab
Diyarbakir	Karma 2000	53.7bc	5086.4bc	14.2	69.26b	32.74	50.42	62.73b	35.90c
Mardin	Karma 2000	56.0ab	5001.5b	13.2a	73.50c	25.68ab	39.85ab	65.80bc	34.73b
Mean	Karma 2000	54.9ab	5043.9c	13.7	71.38b	29.21ab	45.14a	64.27b	35.31c
	Diyarbakir Mean	54.50	5372.2b	14.27a	75.28b	33.50a	48.91a	64.25b	41.74
	Mardin Mean	55.90	6027.8a	12.39b	78.28a	25.36b	39.00b	65.82a	40.47
	Genotype	38.145*	20828.1**	0.971	75.064**	4.039	34.220	3.001	121.617***
	Location	18.906	42979.94**	35.195***	90.177**	662.38***	980.80***	24.704**	16.078
	Genotype x Location	56.190**	80786.7*	1.266	2.093	1.624	12.801	1.801	29.717*
	CV (%)	5.66	11.09	5.67	4.05	5.51	8.73	1.973	7.940
	LSD (5 %)	3.228	652.37	0.78	3.209	1.674	3.96	1.325	3.368

The protein content (PC) of triticale is an important parameter. The mean protein content of all genotypes in both locations was varied from 13 to 13.7 % and the maximum protein content was obtained from Line DZT-01 (14.7 %) in Diyarbakir location, while the minimum protein content obtained from also Line DZT-01 (11.6 %) in Mardin location. The mean protein content was changed from 14.2 to 14.7 % in Diyarbakır location and from 11.6 to 13.2 % in Mardin location (Table 1). Results showed that protein content was lower in Mardin location. However, low variation for this trait was observed among genotypes in Diyarbakir condition. Barutcular et al., (2016) reported that

the protein content is affected by location, variety and environmental conditions.

The mean test weight (TW) genotypes of both locations was changed from 71.37 kg hL^{-1} (Karma 2000) to 78.72 kg hL^{-1} (Fahad-5). The mean test weight in Mardin location (78.28 kg hL^{-1}) was higher than in Diyarbakir location (75.28). The test weight was varied from 69.26 kg hL^{-1} (Karma 2000) to 77.81 kg hL^{-1} (Line DZT-01) in Diyarbakir and from 73.50 kg hL^{-1} (Karma 2000) to 80.01 kg hL^{-1} (Line DZT-01) in Mardin (Table 1). Among the genotypes, the Line DZT-01 had highest test weight in both locations. The test weight of triticale grain depends on the grain size, shape and density. Results of studies on different genotypes of triticale carried out by Mut et al. (2005), test weight ranged from 65.9 to 71.9 kg hl^{-1}.

Wet gluten content (WGC) and gluten quality are the main factors affecting the viscoelastic properties of triticale flour doughs. According to the wet gluten, the Line DZT-06 scored the highest mean value in both locations (30.61%), while the Line DZT-01 revealed the lowest mean of both locations (28.71%). The range of WGC was 32.74 (Karma 200) to 34.43 % (Line DZT-06) in Diyarbakir location, while it reaches up to 24.17 (Line DZT-01) to 26.79% (Line DZT-06). These results showed that the wet gluten content in grains of all genotypes was influenced by the environmental condition in both locations. Kizilgeci et al., (2017a, b) also reported that the gluten content of grain was highly affected by environmental conditions and varied between 26.97 and 41.04 %.

The zeleny sedimentation (ZS) value assessment provides information on the protein quantity and the quality of flour. The average zeleny sedimentation value of both locations was varied from 40.42 to 45.67 mL. The maximum zeleny sedimentation (50.42 mL) was achieved from the cultivar Karma 2000 in Diyarbakır location and the lowest value (34.93 mL) was achieved from Fahad-5 in Mardin location. The mean zeleny sedimentation in Diyarbakir location (48.91mL) was higher than in Mardin location (39.00 mL). Similar to other quality parameters, Zeleny sedimentation in grains of all genotypes was influenced by the environmental condition in both locations. In an another observation, Kizilgeci et al., (2017a) found that zeleny sedimentation of some triticale genotypes varied between 42.29 and 50.38 mL in Diyarbakir condition and between 50.08 and 64.23 ml in Mardin condition. Similarly, Atli (1999) noted that the difference sedimentation value in different genotypes were varied due to genotype as well as the climatic factor.

Starch plays a major role in some baking products. When investigated starch content of the locations, conducted the field experiment, the highest starch content (SC) was obtained from Mardin location (65.82%), whereas the lowest starch content was observed in Diyarbakir location (64.25%). The maximum mean starch content was obtained from Line DZT-01(65.94%), whereas the minimum starch content was obtained from Karma 2000 variety (64.27%). The starch content value of study was changed from 62.73 to 66.26% among locations. Klassen et al., (1971) found that starch content of mature grain ranged from 49.1 to 57.1%. Kučerová (2007) reported that the starch content was influenced by year, site and genotype.

The two-location average data belonging to thousand kernel weight (TKW) has been given in Table 1. The average of both locations for TKW varied between 35.31and 45.81g and the maximum TKW was obtained from Line DZT-06 (49.58g) in Diyarbakir location, while the minimum TKW obtained from Karma 2000 variety (34.73g) in Mardin location. The mean TKW was changed from 35.90 to 49.58g in Diyarbakır location and from 34.73 to 44.29g in Mardin location (Table 1). The variation of TKW among triticale genotypes may be due to the differences in the genetic make-up of the varieties. As well as the environmental factors in

both locations. The result of the present study related to TKW is similar to the findings of Kizilgeci et al., (2017a) who reported TKW of some triticale genotypes changed from 29.89 to 45.21g due to different environmental conditions.

Correlation coefficients between all investigated traits were given Table 2. Grain yield was found significantly correlated with TW (r=0.512*) and TKW (r=0.707*) in Mardin location. Similarly, Oral and Ulker (2016) and Furan et al., (2005) observed a positive association of TKW with grain yield. Significant positive correlated between PC with WGC and ZS in both locations but significant negatively varied with TW (-0.712) in Mardin location and with SC (r=0.510*) in Diyarbakir. WGC also showed a significant positive correlation with ZS in both locations. Correlation coefficient of SC was negative significant with ZS (-0.567**) in Diyarbakir location and with TKW (r= -0.449*) in Mardin location.

Table 2. Correlation coefficients between grain yield and quality component of triticale genotypes evaluated in Diyarbakir and Mardin locations

Traits	Locations	SPAD	GY	PC	TW	WGC	ZS	SC	TKW
SPAD	Diyarbakir	1							
	Mardin								
GY	Diyarbakir	**-0.449***	1						
	Mardin	-0.115							
PC	Diyarbakir	0.020	-0.135	1					
	Mardin	0.325	-0.097						
TW	Diyarbakir	-0.029	0.330	0.136	1				
	Mardin	-0.114	**0.512***	**-0.712***					
GC	Diyarbakir	0.269	-0.085	**0.748****	0.241	1			
	Mardin	0.355	0.204	**0.824*****	-0.278				
ZS	Diyarbakir	0.243	0.051	**0.691****	0.006	**0.546***	1		
	Mardin	0.276	0.192	**0.571****	-0.213	**0.731****			
SC	Diyarbakir	-0.311	0.202	**-0.510***	0.304	-0.424	**-0.567****	1	
	Mardin	0.276	-0.269	-0.194	-0.005	-0.244	0.255		
TKW	Diyarbakir	0.151	-0.432	0.038	0.272	0.131	-0.248	0.211	1
	Mardin	0.040	**0.707****	-0.170	**0.614****	0.196	0.001	**-0.449***	

*p< 0.05 (Significant at the 5% level), **p< 0.01 (Significant at the 1% level); ***p< 0.001 (Significant at the 0.1% level); GY: grain yield, PC: protein content, TW: test weight, WGC: wet gluten content, ZS: zeleny sedimentation, SC: stach content, TKW: thousand kernel weight

CONCLUSION

From the results and discussion of present study, it is indicated that genotypes were remarkably influenced by the changes at the grain yield and quality component. The highest values of grain yield were obtained in Mardin while the lowest values were observed in Diyarbakır location. In both location, Line DZT-01 produced the highest grain yield. The greatest disadvantage of triticale is that there is currently a limited market for the grain. This disadvantage can remove where growers can use the crop for livestock on farm. With regard to grain yield and some quality traits of Line DZT-01 and quality traits of Line DZT-06 were highest than commercial cultivars in both locations. Line DZT-01 was found as promising line. These lines can new cultivar candidates and could be recommended to sown in South Eastern Anatolia Region of Turkey.

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