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Research Article

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Evaluation of Agronomical and Quality Traits of Some Triticale Genotypes at Spring Planting under Arid Continental Conditions of the Eastern Black Sea Region

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Abstract This study was conducted in spring planting, under arid conditions of Gumushane, Turkey in 2013 year. The trial was arranged according to the completely randomized block design with three replications. Some evaluated agronomical and quality traits such as plant height (58.3-71.4 cm), spike length (4.80-6.27 cm), test weight (73.0-77.7 kg hl^{-1}), grain moisture (10.4-10.8 %), starch ratio (61.6-64.7 %) and hardness (101.3-110.9 unit) were statistically different; however, other traits like biomass (4.27-4.98 t ha^{-1}), grain yield (1.30-1.64 t ha^{-1}), grain number per spike (22.3-29.2 no), spike yield (1.60-1.82 g $spike^{-1}$), thousand kernel weight (32.6-38.1 g), protein content (11.6-13.0 %), wet gluten content (28.1-30.5 %), zeleny sedim (35.7-47.3 ml) and alveographic energy (203.7-235.2 Joule) had non-significant variations. As a yield component, spike yield showed significant relationships with thousand kernel weight (r = 0.44*), protein content (r = -0.39*), and grain moisture (r = -0.42*) at probability of 0.05 while protein content presented sharp relations with starch ratio (r = -0.85**), wet gluten content (r = 0.88**), zeleny sedim (r = 0.97**), and energy (r = 0.71**) at $P < 0.01$. Especially, negative significant correlation between starch ratio and protein content has indicated that starch accumulation instead of the protein in grain can be decreased the protein ratio.

Keywords Triticale, Quality parameters, Yield components

Introduction

Triticale (X *Triticosecale* Wittmack) is an synthetic amphidiploid of female wheat (*Triticum* ssp.) and male rye (*Secale* ssp.) [1]. Triticale is more resistance to abiotic stress than the other cereals, and it combines the high productivity of wheat and resistance characteristics of rye to biotic and abiotic stress. It can give higher grain yield than the other cool-season cereals and shows more resistance to diseases and pests [2]. Triticale is well adapted and more favorable than wheat and the other cereal species under abiotic stress [3]. It has produced 14.6 million tones from 3.9 million hectare area in the world, 118 thousand tones from 35.4 thousand hectare area in Turkey [4,5]. There are lots of studies regarded with favorability of triticale for bread-making; however, it is not alone recommended for this purpose [6]. For this reason, it can be used for raw material in flour and bread making [7]. Also, spring triticale is the best choice in spring planting because it is more tolerant to drought than the other cool-season cereals [8]. However, facultative and winter triticale are suitable for grazing [9]. It has reported that triticale can be used as a good silage crop in animal feed [10].In this study, agronomical and quality traits of spring triticale and relationships of these traits have been evaluated under arid continental conditions of the Eastern Black SeaRegion.

Materials and Methods

Two triticale cultivars (Tacettinbey and Ege Yildizi) and six triticale lines from Dicle University were used as material. The study was carried out in spring planting under rainfed conditions at the research area of the Vocational School of Siran, the University of Gumushane, Turkey, in 2013 growth season. Gumushane has the continental climate and it was ranked as moderately to severely dry (arid) in 2013, according to the weather forecast reports of Turkish State Meteorological Service [11]. In total, 334.7 mm precipitation before sowing (September to March) and 135.1 mm during the growth season (April to August) was recorded. The trial soil was a sandy loam. Soil contains low organic matter (2.4%), a little alkaline (pH: 8), high lime (25.6%), a bit salt (0.12%), very rich potassium (1.4 t K_2O ha^{-1}), and enough phosphorus (0.06 t P_2O_5 ha^{-1}). Trial was designed as three replicated according to the completely randomized blocks. Sowing was made by hand on 1st April, 2013 and plots which had 5.4 m^2 and six rows with 4 m long. Fertilizer was not used before sowing because of enough phosphorus and potassium content of the soil. Since the previous crop was common wetch (*Vicia sativa* L.) which gave some nitrogen (N) to the trial field, only 60 kg ha^{-1} of N was applied at the stage of booting. Harvest was made by hand in the middle of the August. Agronomical traits and some quality parameters (thousand kernel weight and test weight) were determined according to the methods of Bell and Fischer [12]. Other quality measurements were obtained from NIT (Infratec 1241, FOSS, Hilleroed, Denmark) in the Laboratory of Agricultural Faculty, Dicle University. All analysis items (F-test, LSD-test, comparisons between means, and correlations) were determined by JMP [13].

Results & Discussion

Genotypes showed significant differences for only plant height and spike length among agronomical traits (Table 1). According to the Table 2, plant height varied between 58.3 cm (Line 2) and 71.4 cm (Tacettinbey cv.). Yagbasanlar *et al* [2] observed the plant height as the range of 127 to 132 cm according to the years under winter planting conditions in Mediterranean Region. But, in our study, plant heights of all the genotypes were very small. Because, in spring planting, some agronomical traits may be reduced by the decrease of the precipitation. Biomass ranged from 4.27 t ha^{-1} (DZ9-01 line) to 4.98 t ha^{-1} (Line 2) while grain yield ranged between 1.30 t ha^{-1} (Tacettinbey cv.) and 1.64 t ha^{-1} (Line 11). Also, harvest index changed 30.3 % (A-3 line) to 35.2% (A-13 line); however, these traits were not statistically different each other. In the study, spike length varied from 4.80 cm (A-13 line) to 6.27 cm (Tacettinbey cv). Differences between the genotypes for grain number per spike (GNPS) and spike yield (SY) were not statistically significant; however, GNPS ranged from 22.3 no (A-3 line) to 29.2 (Ege Yildizi) while SY changed between 1.60 g (A-3 line) and 1.82 g (A-13 line). These lower data resulted from very low precipitation (135.1 mm) in the growth season of spring triticale. Kalbarczyk [14] emphasized that above 205 mm precipitation is needed for an average yield during the period from planting to harvesting in spring triticale. Also, Fayaz and Arzani [15] reported that emphatic decreases (%) under moisture stress can be observed in some agronomical characters such as plant height (3 – 22 %), biomass (6 – 32 %), grain yield (24 – 55 %), harvest index (19 – 36 %), GNPS (10 – 36 %), and SY (24 – 51 %).Genotypes showed statistical significant differences for test weight, grain moisture, starch ratio, and hardness among quality traits (Table 3). According to the Table 4, thousand kernel weight (TKW) changed between 32.6 g (Line 2) and 38.1 g (DZD-09 line); however, differences were not significant for TKW. Test weight ranged from 73.0 kg hl^{-1} (Tacettinbey) to 77.7 kg hl^{-1} (DZ9-01 line). Ciftci *et al*. [16] reported that test weight of the triticale lines changed between 66.1 and 72.6 kg hl^{-1}. Protein content (P) of the genotypes ranged 11.6 % (A-3 line) and 13.0 (Ege Yildizi). While protein content of a spring triticale were found as 12.2 % by Knapowski e*t al*. [17], it was found as 13.7 % in another triticale cultivar by Wrobel [18]. Grain moisture changed between 10.4 % and 10.8%. Starch ratio (S) of the genotypes changed from 61.6 % (Tacettinbey and Ege Yildizi) to 64.7 % (A-3 line). However, the changing of the wet gluten content (WG), zeleny sedim (S_z), and alveographic energy (W) were not significant; these traits showed a range like so: WG, 28.1 % (A-3 line) to 30.5 % (Ege Yildizi); S_z, 35.7 mL (A-13 line) to 47.3 mL (Ege Yildizi); and W, 203.7 Joule (A-3 line) to 235.2

Joule (Line 2). Some researchers found lower values of protein, wet gluten, and sedimentation in their studies. Another quality trait, hardness (H) ranged from 101.3 (DZ9-06 line) to 110.9 (DZ9-01 and Line 11) [6, 17,19].

Table 1: Mean squares according to the ANOVA for agronomical traits of eight triticale genotypes.

Sources of Variation	Df	PH	BM	GY	HI	SL	GNPS	SY
Genotypes	7	50.0*	0.231	0.040	10.12	0.86*	13.84	0.02
Replicates	2	42.5	0.340	0.009	6.60	0.15	54.93	0.10
Error	14	14.7	0.306	0.044	10.2	0.21	17.94	0.05
CV (%)		5.6	12.2	14.6	9.9	8.5	16.9	13.0

PH, Plant Height; BM, Biomass; GY, Grain Yield; HI, Harvest Index; SL, spike length; GNPS, grain number per spike; SY, spike yield; Df, degree of freedom; CV, coefficient of variation; Significance levels:*, P<0.05.

Table 2: Means for agronomical traits of eight triticale genotypes.

Genotypes	PH (cm)	BM (t ha^{-1})	GY (t ha^{-1})	HI (%)	SL (cm)	GNPS (no)	SY (g)
Tacettinbey	71.4 a*	4.29	1.30	30.4	6.27 a	25.6	1.72
Ege Yildizi	69.8 ab	4.35	1.34	30.8	5.95 ab	29.2	1.70
A-3	65.9 abc	4.85	1.47	30.3	4.87 d	22.3	1.60
A-13	64.4 bcd	4.38	1.33	35.2	4.80 d	23.1	1.82
DZ9-01	64.0 bcd	4.27	1.40	32.8	4.97 cd	23.4	1.67
DZ9-06	63.7 bcd	4.46	1.46	32.7	5.27 bcd	26.0	1.81
Line 2	58.3 d	4.98	1.54	31.3	5.27 bcd	25.1	1.69
Line 11	62.9 cd	4.75	1.64	34.4	5.70 abc	25.6	1.70
Mean	65.0	4.54	1.44	32.2	5.39	25.1	1.72
$LSD_{0.05}$	6.73	NS	NS	NS	0.81	NS	NS

PH, Plant Height; BM, Biomass; GY, Grain Yield; HI, Harvest Index; SL, spike length; GNPS, grain number per spike; SY, spike yield;LSD, least significant difference; *: Means with the same letter are not significantly different at P <0.05; NS, non-significant

Table 3: Mean squares according to the ANOVA for quality traits of eight triticale genotypes.

Sources of Variation	Df	TKW	TW	P	M	S	WG	S_z	W	H
Genotypes	7	11.80	7.30**	0.63	0.07*	4.34**	2.09	57.0	309.4	36.4*
Replicates	2	37.57	0.02	0.19	1.10	1.08	1.21	16.98	980.0	2.34
Error	14	10.61	0.30	0.34	0.02	0.62	1.61	45.25	274.6	10.92
CV (%)		9.3	0.7	4.8	1.5	1.3	4.4	16.7	7.3	3.1

TKW, thousand kernel weight; TW, test weight; P, protein content; M, grain moisture; S, starch ratio; WG, wet gluten content; S_z, zeleny sedim; W, alveographic energy; H, hardness; Df, degree of freedom; CV, coefficient of variation; Significance levels:*, P<0.05; **, P<0.01.

Table 4: Mean values for quality traits of eight triticale genotypes.

Genotypes	TKW (g)	TW (kg hl^{-1})	P (%)	M (%)	S (%)	WG (%)	S_z (mL)	W (Joule)	H (unit)
Tacettinbey	33.5	73.0 d	12.5	10.8 a	61.6 c	29.3	45.3	230.2	108.8 ab
Ege Yildizi	34.9	75.9 bc	13.0	10.6 ab	61.6 c	30.5	47.3	234.6	109.4 a
A-3	34.5	77.5 a	11.6	10.4 b	64.7 a	28.1	36.3	203.7	106.0 abc
A-13	35.8	76.8 ab	11.8	10.4 b	64.4 ab	29.0	35.7	227.1	103.4 bc
DZ9-01	37.6	77.7 a	12.0	10.5 b	63.8 ab	28.9	40.0	223.3	110.9 a
DZ9-06	38.1	77.1 a	11.8	10.6 ab	64.2 ab	28.2	36.4	226.1	101.3 c
Line 2	32.6	75.4 c	12.4	10.4 b	63.2 b	29.5	42.5	235.2	107.4 ab
Line 11	33.5	75.3 c	11.9	10.4 b	63.7 ab	28.2	39.1	232.7	110.9 a
Mean	35.1	76.1	12.1	10.5	63.4	29.0	40.3	226.6	107.2
$LSD_{0.05}$	NS	0.96	NS	1.5	1.38	NS	NS	NS	5.79

TKW, thousand kernel weight; TW, test weight; P, protein content; M, grain moisture; S, starch ratio; WG, wet gluten content; S_z, zeleny sedim; W, alveographic energy; H, hardness. LSD, least significant difference;*: Means with the same letter are not significantly different at P <0.05; NS, non-significant.

Table 5: Correlation coefficients between all evaluated traits of triticale genotypes (n = 24).

Traits	BM	GY	HI	SL	GNPS	SY	TKW	TW	P	M	S	WG	S_z	W	H
PH	0.08	-0.01	-0.14	0.46**	0.18	0.22	-0.04	-0.31	0.06	0.51*	-0.37	0.06	0.05	-0.33	0.08
BM		0.65**	-0.14	0.05	0.14	0.41*	0.08	0.09	-0.22	-0.22	0.23	-0.24	-0.17	-0.09	0.03
GY			0.42*	0.09	0.27	0.35	0.11	0.05	-0.17	-0.24	0.22	-0.15	-0.05	0.10	0.03
HI				-0.26	-0.10	0.06	0.04	0.17	-0.10	-0.04	0.19	-0.07	-0.03	0.17	-0.16
SL					0.72**	0.41*	-0.13	-0.70**	0.22	0.08	-0.50*	0.11	0.22	0.13	0.13
GNPS						0.74**	0.20	-0.22	-0.02	-0.34	-0.08	0.00	-0.01	0.13	-0.11
SY							0.44*	-0.05	-0.39*	-0.42*	0.32	-0.31	-0.36	-0.04	-0.28
TKW								0.34	-0.41*	-0.30	0.41*	-0.36	-0.36	-0.13	-0.24
TW									-0.34	-0.19	0.58**	-0.24	-0.33	-0.27	-0.21
P										0.25	-0.85**	0.88**	0.97**	0.71**	0.49*
M											-0.49*	0.16	0.17	-0.31	0.06
S												-0.67**	-0.81**	-0.43*	-0.51*
WG													0.84**	0.69**	0.28
Sz														0.75**	0.57**
W															0.29

PH, plant height; BM, biomass; GY, grain yield; HI, harvest index; SL, spike length; GNPS, grain number per spike; SY, spike yield; TKW, thousand kernel weight; TW, test weight; P, protein content; M, grain moisture; S, starch ratio; WG, wet gluten content; S_z, zeleny sedim; W, alveographic energy; H, hardness. *, ** Significant at $P < 0.05$, $P < 0.01$, respectively.

Correlation coefficients between all traits were given on Table 5. In this connecttion, grain yield was found significant positive correlated with biomass (r = 0.65**) and harvest index (r = 0.42*), but non-significant positive correlated with spike yield (r = 0.35). Fayaz and Arzani [15] found similar relationships among grain yield, biomass, harvest index, and spike yield. Also, negative correlations of the TKW with P, WG, S_z, and H show that smaller grained and lower starchy genotypes present higher values of protein, gluten, sedimentation, and hardness.In addition, negative significant correlations of S with P, WG, S_z, W, and H emphasize the contrast relation between starch quantity and other quality traits. Similar findings were reported by Knapowski *et al*. [17].

Conclusion

A strong negative correlation between starch ratio and protein content has indicated that starch accumulation instead of the protein in grain filling period of spring triticale under abiotic stress (low moisture) can be decreased some quality criteria such as wet gluten content, sedimentation, energy, and hardness.

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