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Investigation of Triticale and Wheat Performance under Dry Land Conditions on the Basis of Variations in Agronomic and Morphological Traits

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Authors' contributions

This work was carried out in collaboration between all authors. Author RF performed the experimental measurements, collected the data and wrote the first draft of the manuscript. Author BH designed the study, wrote the protocol and managed the analyses of the study and edited the final draft of the manuscript. Author AD was advisor of the work and revised the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Drought is the most important environmental stresses in arid and semi-arid regions worldwide. Triticale offers ample genetic variation for the improvement of its productivity under limited water conditions. In order to investigate triticale and wheat potential under dry land conditions, response of twenty five wheat, triticale (TRT) and rye genotypes was assayed by scoring agronomic and morphological traits in the field in 2013-2014 growing season.
Study Design: A randomized complete block design with three replications was used to evaluate response of genotypes to dry land farming. Four 3-m long rows with row spacing of 25 cm were used for sowing seeds.
Place and Duration of Study: The experiment was conducted at the Research Farm of the College of Agriculture, Shiraz University, during 2013-2014 growing season.

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Methodology: Two types of traits consisted of morphological and yield related components were measured at the vegetative stage and grain set periods. The data were subjected to the analysis of variance, factor analysis and clustering methods. Descriptive statistics were also calculated.
Results: Two rye genotypes had lower awn length (AWL) compared with triticale and most of wheat genotypes. Grain number per spike ranged from 30.8 to 55.9 in triticale and from 27.0 to 36.8 in wheat. Triticale had higher harvest index (HI) than wheat. HI varied between 19.0% (in TRT826) and 38.0% (TRT825) in triticale. The magnitude of HI in wheat was from 15.6% to 28.1%. TRT816 (10.81 g) and TRT822 (9.48 g) had the highest and TRT804 (3.12 g) had the lowest grain yield (GY) among triticale genotypes. Wheat cultivars were more affected by drought stress condition and had considerably lower grain yield compared with triticale. The highest GY in wheat was found in Shahpasand (2.81 g) which was lower than GY in most of triticales. Results of factor analysis indicated that first factor that explained 39.3% of the total variation had high and positive coefficients for spike yield (SY), biological yield (BY) and grain yield. In cluster analysis, 25 genotypes were classified into 5 main groups. Highest BY, SY, GY and HI means were found in cluster 5. Overall, results showed that triticale performed better than wheat in view of harvest index, grain yield and its components. Results also showed that variations between genotypes are valuable for breeding programs under dry land conditions.

Keywords: Agronomic traits; dry land; morphological traits; rye; triticale; wheat.

1. INTRUDUCTION

Triticale is a synthetic hybrid of the cross between wheat and rye. This valuable crop contains genomes from wheat (tetraploid: AABB or hexaploid: AABBDD) and rye (RR). Usually, hexaploid triticales (AABBRR) are more common than their octaploid (AABBDDRR) counterparts [1]. Grain of triticale is a good source of B vitamins, essential amino acids, proteins and lysine which make it more nutritionally valuable than wheat [2,3,4,5,6]. This hardy crop is interested for agriculture scientists due to its well adaptation to poor, acidic soils, saline and water logged soils, unstable climates, drought and aluminum toxicity.

Abiotic stresses such as salinity, drought and low temperature significantly affect plants growth [7, 8]. Drought is the most important environmental stresses in arid and semi-arid regions worldwide. Water deficit affects plant ability to produce a harvestable yield [9]. Water resources to produce agronomical crop are becoming scare [10]. One of the major challenges in modern agriculture is improving and breeding the yield of crops under environmental stresses [11]. The efficiency of choice in optimizing programs leading to improving yield can be increased by choosing rapidly and easily measured morphological traits that have positive and direct relation with grain yield [12]. Since the initiation of triticale as a commercial crop in the 1960s, breeders expected it to be more resilient than wheat. Most works on triticale adaptation to abiotic stresses attempted to access reliable information confirming its resistance to stresses. The physiology of drought stress and characterization of drought tolerance have greatly advanced in recent years [13]. Resistance of the reproductive functions under low water status is crucial when stress occurs at the flowering stage. In an unpublished study by Blum [13], hexaploid triticale lines had higher performance under drought stress compared with the best standard wheat cultivars available [13]. Based on Blum [13] studies, triticale offers ample genetic variation for the improvement of its productivity under limited water conditions. Results of a study in Spain for the potential advantage of triticale over wheat in biomass and grain yield support this view [14]. A range of traits has been suggested that could be utilized to increase selection efficiency and indirect selection for improving yield under stress conditions. Morphological and agronomic traits should be highly heritable, greatly correlated with stress tolerance and can be easily assessed. Wherever intensive breeding efforts have been sustained, modern triticale cultivars are on a par with the best common wheats in terms of their yield potential under favorable conditions and are often more productive than most wheats when planted in different types of marginal soils [15]. Comparative studies have not extensively been conducted to assess the advantages of triticale over wheat under water limited conditions. In the study of Roohi et al. [16] four triticale genotypes were compared with three wheat cultivars and results implied the superiority of triticale over wheat on the basis of biomass production and photosynthesis functions. Lonbani and Arzani [8] used four triticale and two wheat genotypes for evaluation of drought tolerance based on variations in water status characters and morphological traits and their results indicated that performance of triticale cultivars was superior to wheat cultivars under both normal irrigation and drought stress conditions. Investigation for genetic variation and the most important traits responsible for drought tolerance should be considered in breeding programs, because grain yield and drought tolerance may be controlled at independent genetic loci. The identification of such variations would help breeders for better understanding mechanism of drought tolerance and provide opportunities for selection of outstanding cultivars that can be involved in programs for production of drought tolerant genotypes. The aims of this study were to (1) investigate variations in triticale, wheat and rye in responses to dry land conditions on the basis of morphological and agronomic traits, (2) determine interrelationships between traits using factor analysis and (3) clustering triticale genotypes on the basis of similarities between responses of genotypes to dry land conditions.

2. MATERIALS AND METHODS

2.1 Experimental Design and Field Assay

Nineteen CIMMYT-derived triticale genotypes (Table 1), four wheat cultivars (Shiraz, Shahpasand, Zarrin and Shiroodi) and 2 rye genotypes were used for cultivation under dry land condition at the Research Farm of the College of Agriculture, Shiraz University, Shiraz, Iran (latitude 29º50′, longitude 52º46′) during 2013-2014 growing season. The experiment was

Table 1. Pedigree of CIMMYT-derived triticales used in this study

Genotype number	Pedigree
802	HUI/TUB//CENT.TURKEY/3/CALL/7/LIRON-2/5/DISB5/3/SPHD/... CTSS02B00107T-21Y-2M-3Y-1M-2Y-0M
804	CMH80.1212/CMH81A.1239/3/YOGUI-3/ERIZO-11//ONA-2/… CTSS02B00253T-34Y-4M-2Y-4M-1Y-0M
806	CMH82.1082/ZEBRA 31/7/LIRON-2/5/DISB5/3/SPHD/PVN//… CTSS02B00268T-53Y-5M-1Y-2M-2Y-0M
807	FD-693/2*FAHAD-4//POLMER-4/3/POLMER-2.1/4/FARAS/… CTSS02B00295T-10Y-1M-2Y-4M-1Y-0M
808	LIRON-2/5/DIS B5/3/SPHD/PVN//YOGUI-6/4/K3R-3/6BULL-10/… CTSS02B00413S-22Y-2M-3Y-1M-1Y-0M
809	LIRON-2/5/DIS B5/3/SPHD/PVN//YOGUI-6/4/K3R-3/6BULL-10/… CTSS02B00413S-22Y-2M-3Y-2M-1Y-0M
810	HX87-244/HX87-225/5/PRESTO//2*TESMO-1/MUSX603/4/… CTSS03SH00028S-25Y-2M-3Y-1M-1Y-0M
812	HX87-244/HX87-225/7/LIRON-2/5/DIS B5/3/SPDH/PVN//… CTSS03SH00030S-13Y-1M-3Y-3M-1Y-0M
813	POPPI-2/TAHARA/4/HADBI-6/3/ARDI-1/TOPO1419//ERIZO-9 CTSS03SH00066S-11Y-1M-1Y-1M-1Y-0M
816	PULLMER-2.2.1*2//FARAS/CMH84.4414/5/DAHBI-6/3/ARDI-1… CTSS04Y00059S-43Y-06M-06Y-6M-2Y-0M
817	PULLMER-2.2.1*//FARAS/CMH84.4414/5/DAHBI-6/3/ARDI-1... CTSS04Y00066S-60Y-06M-06Y-1M-1Y-0M
822	LIRON-2/5/DISB5/3/SPHD/PVN/YOGUI-6/4/KER-3/6/BULL-10/… CTSS04Y00163S-102Y-06M-06Y-2M-3Y-0M
823	PRESTO//2*TESMO-1/MUSX603/4/ARDI-1/TOPO1419//ERIZO-9/… CTSS03Y00091T-050TOPY-49M-1Y-06Y-5M-1Y-0M
825	FAHAD-8-2*2//PTR/PNDT/3/GAUR-3/ANOAS-2//BANT-1/4/… CTSS03Y00100T-050TOPOY-49M-1Y-06Y-2M-4Y-0M
826	LIRON-2/5/DSB5/3/SPHD/PVN//YOGUI-6/4/KER-3/6/BULL-10/… CTSS03Y00033T-A-62M-1Y-06Y-2M-4Y-0M
828	LIRON-2/5/DSB5/3/SPHD/PVN//YOGUI-6/4/KER-3/6/BULL-10/… CTSS03Y00036T-A-1M-2Y-06Y-4M-2Y-0M
829	LIRON-2/5/DSB5/3/SPHD/PVN//YOGUI-6/4/KER-3/6/BULL-10/… CTSS03Y00036T-A-1M-2Y-06Y-5M-3Y-0M

conducted in the field under dry land condition. To simulate real dry land conditions, no fertilizer was applied. Annual rainfall at the study site was approximately 278 mm. The soil was sandy clay with EC (0.563 dS m^{-1}), P^+ (15 mg kg^{-1}), total N (0.091%), K (581 $mgkg^{-1}$) and pH of 7.6. Mean temperature between November which was coincident with sowing date and July (grain filling period) varied from 11.1ºC to 22.2ºC. The maximum temperature in June and July exceeded 33ºC. Total rainfall during growing season was approximately 279 mm with no precipitation in June and July. A randomized complete block design with three replications was used for evaluation of response of genotypes to water limited conditions of dry land farming. Four 3- m long rows with row spacing of 25 cm were used for sowing seeds.

Traits comprising of plant height (PH), spike length (SL), awn length (AL), peduncle length (PL) were measured in 10 plants in each plot after the pollination stage. Biological yield (BY), spike yield (SY), number of grain (GN) per spike, 1000 grains weight (TGW), harvest index (HI) and grain yield (GY) per plant were measured after harvesting plants in all experimental plots. Samples for traits measurement were selected from the middle rows to avoid competitions between neighbor plots. For grain yield, 10 plants in each experimental plot were selected and mean grain yield was considered for data analysis. Spike yield was measured by weighing 10 spike per plot.

2.2 Statistical Analysis

Analysis of variance (ANOVA) and mean comparison of traits for different genotypes were performed in SAS software. Multivariate techniques comprised of factor analysis and clustering (Ward's method) were used to investigate the interrelationship between traits and categorizing genotypes based on their similarities in response to drought stress condition [17,18,19]. Cluster analysis for grouping similar genotypes was performed using standardized data of all traits.

3. RESULTS AND DISCUSSION

3.1 Variation between Responses of Triticale, Wheat and Rye to Dry Land Farming

Analysis of variance showed that mean squares for all traits were significant (Table 2). This shows that triticale, wheat and rye genotypes had different responses to dry land condition. Basic statistics for traits showed a considerable variability between all traits (Table 3).

Table 2. Analysis of variance and coefficient of variation (CV) of traits under dry land conditions

DF	Mean square		CV (%)
	Genotype	Error	
	24	48	
PH	517.83**	19.17	6.75
SL	5.56**	0.45	7.13
AWL	574.8**	24.85	8.37
PDL	33.17**	3.26	19.2
BY	12439.96**	928.91	16.17
SY	3728.63**	249.1	16.96
GN	212.9**	62.79	19.64
TGW	47.34**	7.94	7.37
HI	139.03**	13.12	13.08
GY	1610.4**	129.97	21.54

**Significant 1%, DF: Degree of freedom, CV: Coefficient of Variation. Plant Height: PH, Spike Length: SL, Awn Length: AWL, Peduncle Length: PDL, Biological Yield: BY, Spike Yield per Plant: SY, Number of Grain: GN, Thousand Grain Weight: TGW, Harvest Index: HI, Grain Yield: GY*

Table 3. Basic statistics for traits of study under dry land conditions

Trait	Minimum	Maximum	Mean	SD
PH (cm)	46.2	106.3	64.85	13.45
SL (cm)	7.68	14.22	9.45	1.45
AWL (mm)	17.7	76.2	59.51	14.25
PDL (cm)	3.75	14.76	9.41	3.6
BY (g)	108.0	326	188.46	68.28
SY (g)	42.5	175	93.02	37.12
GN	23.7	55.9	40.35	10.56
TGW (g)	30	45	38.23	4.55
HI (%)	12.08	38.04	27.68	7.34
GY (g)	15.7	108.1	52.92	24.7

Plant Height: PH, Spike Length: SL, Awn Length: AL, Peduncle Length: PDL, Biological Yield: BY, Spike Yield: SY, Number of Grain: GN, Thousand Grain, Weight: TGW, Harvest Index: HI, Grain Yield: GY, Standard Deviation: SD

Traits mean for triticale, wheat and rye genotypes are shown in Table 4. With the exception of Shahpasand, all wheat cultivars had lower PH than triticale genotypes. PH (cm) varied from 54.5 (in TRT804) to 78.2 (TRT816) in triticale genotypes. PH varied between 46.2 and 66.6 in wheat cultivars. Effects of drought are usually reflected in reduced accumulation in plant mass, shorter internodes and damage in various plants [20]. Both rye genotypes were significantly taller than wheat and triticale genotypes. For SL, rye genotypes had longer spike than other genotypes. Among triticales, the commercial cultivar (Sanabad) and ET had highest spike length. Awn length is an important trait for plants dealing with water deficit conditions. TRT806 and a wheat cultivar (Shiraz) had the highest magnitude for AWL (76.2 mm). Both rye genotypes had lower AWL compared with triticale and most of wheat genotypes. Peduncle length (cm) varied between 4.77 and 14.76 in triticales and between 3.75 and 12.85 in wheat cultivars. Rye genotypes had longer PDL (14.53-14.72) than wheat and triticale genotypes. Among internodes, photosynthesis of peduncle which is the last internode of stem is very important in accompanying plants to alleviate adverse effects of drought.

Spike yield (g) varied from 5.8 (TRT804) to 17.5 (TRT816) in triticale and from 4.25 to 5.35 in wheat cultivars. The magnitudes of SY in RYE38 and RYE39 were 7.80 and 12.75 g, respectively. These results show that most of triticales had higher spike yield than wheat and rye genotypes.

Table 4. Mean of traits in triticale, wheat and rye genotypes under dry land conditions

Genotype	PH (cm)	SL (cm)	AWL (mm)	PDL (cm)	BY (g)	SY (g)	GN	TGW (g)	HI (%)	GY (g)
TRT802	66.4	8.79	68.4	9.34	16.065	9.705	44.1	42.5	36.81	5.965
TRT804	54.5	8.55	61.6	6.2	12.8	5.8	40.5	33	24.04	3.1.25
TRT806	60.8	8.42	76.2	8.91	16.05	8.35	39.5	34	33.36	5.81
TRT807	63.3	9.77	62.5	14.76	31.55	15.8	46.2	37	24.55	7.81
TRT808	58.0	8.68	64.2	4.77	18.75	9.275	37.3	41.5	26.26	4.94
TRT809	69.2	9.54	65.2	10.97	25.55	13.26	35	37	30.25	7.67
TRT810	56.9	10.3	67	7.47	23.1	13.05	36.3	38	34.71	7.99
TRT812	63.5	8.73	64.4	11.23	12.4	6.05	46.7	38.5	29.32	3.595
TRT813	64.5	9.04	65.4	9.19	15.25	7.875	54.3	40	31.14	4.745
TRT816	78.2	8.97	52.2	9.25	32.6	17.5	42.7	39.5	33.04	10.81
TRT817	70.8	7.68	64	11.43	19.93	9.2	30.8	45	24.49	4.91
TRT822	63.9	8.73	61.65	9.1	27.725	14.025	40.95	44.8	33.9	9.483
TRT823	57.8	8.84	60	7.33	10.8	5.875	43.8	38.5	32.05	3.475
TRT825	62.6	9.65	23	7.8	14.55	8.85	52.2	35	38.04	5.485
TRT826	61.9	8.95	65.1	5.81	19.9	8.9	39.5	38.5	19.02	3.815
TRT828	64.4	10.2	45.8	6.54	19.55	10.45	50.9	43	31.52	6.065
TRT829	57.3	9.27	65	8.9	18.45	10.5	44.1	40	35.29	6.565
Sanabad (TRT)	70.3	10.78	66.2	14.36	22.35	10.125	55.9	42.5	31.99	6.965
ET (TRT)	60.4	10.42	62.9	13.14	14.61	7.95	36.8	39.5	27.01	4.07
Zarrin (wheat)	48.9	9.28	67.6	4.41	11.05	4.95	36.8	37	22.06	2.49
Shiroodi (wheat)	46.2	9.05	69.5	3.75	12.565	5.35	23.7	35.5	18.05	2.205
Shahpasand (wheat)	66.6	8.16	17.7	12.85	12.05	4.91	31	40.5	23.29	2.81
Shiraz (wheat)	51.2	8.27	76.2	8.51	13.013	4.25	27.05	31	12.08	1.565
RYE38 (rye)	106.3	11.95	45.5	14.72	22.25	7.8	27.7	30	16.63	3.735
RYE39 (rye)	96.4	14.22	53.3	14.53	28.215	12.75	44.9	34	23.07	6.2
LSD (1%)	9.57	1.47	10.89	3.95	6.6	3.45	17.32	6.16	7.91	2.4

Plant Height: PH, Spike Length: SL, Awn Length: AWL, Peduncle Length: PDL, Biological Yield: BY, Spike Yield: SY, Number of Grain: GN, Thousand Grain Weight: TGW, Harvest Index: HI, Grain Yield: GY

Grain number per spike ranged from 30.8 to 55.9 in triticales and from 23.7 to 36.8 in wheat genotypes. RYE38 and RYE39 produced 27.7 and 44.9 grain per spike under dry land conditions. These figures indicated that triticale had higher potential for producing higher grain than wheat and rye. In dry land conditions, high temperatures and low water available may result in anatomical changes such as closure of stomata, reduced size and damaged cells and larger xylem vessels [20]. Such changes and variations depend upon species of plant. Thousand grain weight as the most important grain yield component varied between 33 g (in TRT804) and 45 g (in TRT817) in triticale genotypes. Range of TGW in wheat was from 31 to 40.5 g. Rye genotypes had lower TGW compared with triricale and wheat. Triticale genotypes had higher harvest index than both wheat and rye. In a study [8], comparison of wheat and triticale under drought stress in an area with 140 mm annual precipitation indicated that performance of triticale cultivars was superior to that of wheat cultivars. Harvest index varied between 19.0% (in TRT826) and 38.0% (TRT825) in triticale. The magnitude of HI in wheat cultivars was from 15.6% to 28.1%. Rye genotypes had relatively low HI compared with most of triticale and wheat genotypes. TRT816 (10.81 g) and TRT822 (9.48 g) had the highest and TRT804 (3.12 g) had the lowest GY among triticale genotypes. Wheat cultivars were more affected by water deficit under dry land condition and had considerably lower GY compared with triticales. Three triticale cultivars were cultivated under rain fed and irrigated condition in Eskisehir, Turkey, and results indicated that Karma2000 can be crossed with triticale genotypes for improvement of secondary triticale with high grain yield potential under water limited conditions [21]. In a study, Fayaz and Arzani [22] evaluated five drought tolerant triticale cultivars that were selected based on a preliminary field experiment with 41 triticale genotypes and indicated that triticale performed superior than wheat cultivar considering yield potential under drought stress and normal moisture conditions. Four genotypes of triticale, three wheat cultivars and a newly released barley variety were screened for drought tolerance by Roohi et al. [16] and results showed that biomass yield reduction due to water deficit were 26, 29 and 38% for respectively triticale, wheat and barley. In the present study, the highest GY in wheat cultivars was found in Shahpasand (2.81 g). Evaluation of response of 24 hexaploid triticale lines from the CIMMYT ITYN-nurseries in 1988/89 indicated yield advantage of triticale over wheat under drought stress and large variation of triticale yield [13]. This result was impressive in view of the fact that CIMMYT was not focused on selection for yield under drought conditions in those years. Advantage of triticale over wheat and its drought resistance was previously confirmed by Jessop study [23]. Literatures show that the superiority of triticale to wheat is mainly due to sustain turgor and stomatal conductance at low water potential and also stem reserve utilization for grain filling [13,24].

3.2 Factor Analysis

In factor analysis, three factors with eigenvalues greater than one were selected. The first three factors explained 78% of the total variation in original data (Table 5). In a study in wheat, [25], three main factors were accounted for 74.4% of the total variations in the dependent structure and factors were called as biological yield, spike length and harvest index, respectively. In the present study, First factor that explained 39.3% of the total variation had high and positive coefficients for SY, BY and GY. Therefore, this factor can be called yield factor and selection of genotypes based on coefficients in this factor results in higher grain yield [26]. Second factor accounted for 24.7% of total variation. Coefficients of traits in this factor imply that it is a contrast between grain yield components (negative coefficients) and morphological traits (PH, SL and PDL) with positive coefficients. This result shows contrast association of morphological and grain yield variations under dry land conditions. As a consequence, selections based on coefficients in factor 2 results in higher plant height and spike length and reduced grain yield components. The third factor explained 14% of the total variation in original data. Factor 3 had highest coefficient (0.57) for GN and AWL (-0.56). This shows that this factor can be called grain number factor.

3.3 Cluster Analysis

Results of Ward's method for cluster analysis led to a tree dendrogram with 25 genotypes (Fig. 1). Analysis of variance for between group mean squares showed that splicing the vertical axis close to 37.8 similarity leads to the best possible clustering (Fig. 1). At this level of similarity, five groups of genotypes were detected and Euclidean distances between clusters are presented in Table 6. Means of traits in genotypes assigned to five clusters are shown in Table 7. Clustering technique is usually used to identify genotypes or variables which can be classified into main groups based on similarities or dissimilarities. This technique is useful in parental selection in breeding programs for drought tolerance and crop modeling. In Leila and Khateeb [25] study, in a distance between 55.9% and 74.0% similarity levels, the examined ten variables were agglomerated into three clusters based on variations between wheat genotypes evaluated under drought stress conditions.

Cluster 1 comprising of 4 genotypes had lowest magnitude for plant height. Members of this cluster can be used in hybridization programs for transferring semi-dwarfness into genotypes with high grain yield. Cluster 1 had also highest AWL. Cluster 4 had highest magnitudes for SL and PDL. Cluster 5 comprised of 5 genotypes (TRT816, TRT822, TRT807, TRT809 and TRT810) and showed highest BY, SY, GY and HI means. This cluster along with clusters 3 and 2 showed non- significant differences for GN. Therefore, it can be concluded that members of cluster 5 were more potent for grain yield improvement compared with genotypes in other clusters and crossing genotypes between clusters 1 and 5 leads to semi-dwarf high yielding genotypes for cultivation under dry land conditions.

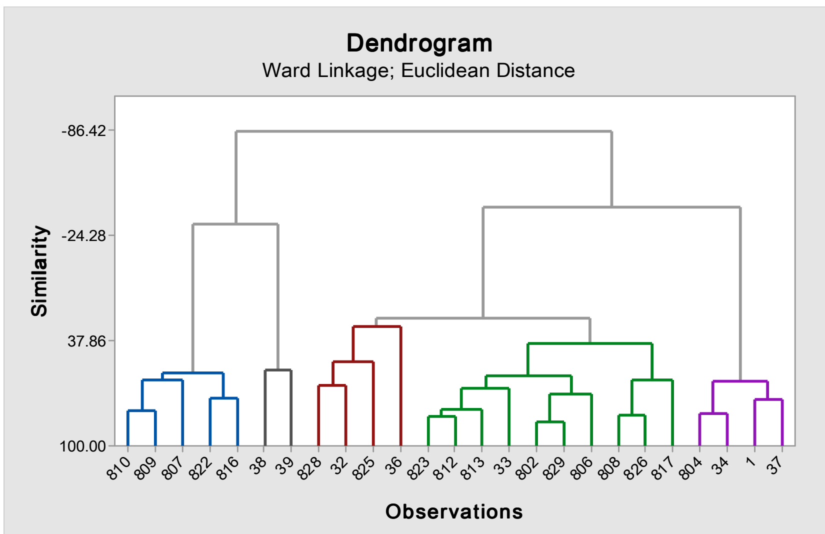

Fig. 1. Tree dendrogram depicting similarities between genotypes base on variations in all traits. Numbers in horizontal axis refer to genotype codes in Table 1

Table 5. Rotated (Varimax rotation) factor loadings and communalities for traits under dry land conditions

Variable	Factor 1	Factor 2	Factor 3	Communality
PH	0.48	0.72	0.39	0.91
SL	0.39	0.71	0.35	0.81
AWL	-0.09	-0.11	-0.56	0.33
PDL	0.44	0.47	0.3	0.51
BY	0.81	0.22	-0.5	0.95
SY	0.91	0.05	-0.28	0.9
GN	0.56	-0.38	0.57	0.77
TGW	0.34	-0.79	-0.05	0.74
HI	0.63	-0.58	0.38	0.87
GY	0.94	-0.15	-0.25	0.96
Cumulative Var (%)	39	64	78	

Plant Height: PH, Spike Length: SL, Awn Length: AWL, Peduncle Length: PDL, Biological Yield: BY, Spike Yield: SY, Number of Grain: GN, Thousand Grain Weight: TGW, Harvest Index: HI, Grain Yield: GY.

Table 6. Euclidean distance between clusters of genotypes under dray land conditions

	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Cluster 2	3.44			
Cluster 3	3.19	2.25		
Cluster 4	5.55	4.56	3.15	
Cluster 5	5.24	5.14	5.58	6.49

Table 7. Means for traits in 5 clusters of genotypes under dry land condition

Trait	MS (model)	MS (error)	Mean				
			Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
PH (cm)	901.4**	26.85	50.24[c]	62.19[b]	66.03[b]	101.35[a]	66.31[b]
SL (cm)	7.91**	0.64	8.78[b]	8.88[b]	9.7[b]	13.09[a]	9.46[b]
AWL (cm)	680.49**	93.81	68.73[a]	65.28[a]	38.18[b]	49.4[ab]	61.71[a]
PDL (cm)	29.62**	7.34	5.72[b]	9.01[ab]	10.39[ab]	14.63[a]	10.31[ab]
BY (g)	18982.6**	1179.47	12.357[b]	16.223[b]	17.125[b]	25.233[a]	28.105[a]
SY (g)	5772.04**	337.04	5.088[c]	8.368[bc]	8.584[bc]	10.275[b]	14.727[a]
GN	133.34**	58.48	32.01[a]	41.69[a]	47.5[a]	36.3[a]	40.23[a]
TGW (g)	47.8**	9.38	34.13[ab]	39.8[a]	40.25[a]	32[b]	39.25[a]
HI (%)	141.82**	27.24	19.06[b]	29.48[ab]	31.21[a]	19.85[ab]	31.3[a]
GY(g)	2432.56**	157.64	2.347[c]	4.79[bc]	5.331[b]	4.968[bc]	8.753[a]

*** Significant at 1%. Plant Height: PH, Spike Length: SL, Awn Length: AWL, Peduncle Length: PDL, Biological Yield: BY, Spike Yield: SY, Number of Grain: GN, Thousand Grain Weight: TGW, Harvest Index: HI, Grain Yield: GY*

4. CONCLUSION

Response of 25 triticale, wheat and rye genotypes to water deficit was investigated under dry land conditions. Two types of agronomic and morphological traits were assayed in three types of genotypes. Results showed that significant differences were found between triticale, wheat and rye. Such variation between genotypes is valuable for amendatory programs under dry land condition. In factor analysis, three factors totally explained 78% of variations in original data. First factor had high and positive coefficients for spike yield, biological yield and grain yield. Therefore, selection of genotypes on the basis of coefficients in this factor results in higher grain yield. Overall, investigation of responses of genotypes indicated that some of triticale genotypes performed better than wheat in view of the magnitude of harvest index, grain yield and its components under dry land conditions and that triticale can be an alternative for cultivation under low water potential and dry land conditions where wheat growth seriously affected by end-season drought stress.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kuleung C, Baenziger PS, Dweikat I. Transferability of SSR markers among wheat, rye, and triticale. Theor Appl Genet. 2004;108(6):1147-1150.
2. Bird SH, Rowe JB, Choct M, Stachiw S, Tyler P, Thompson RD. *In vitro* fermentation of grain and enzymatic digestion of cereal starch. Recent Adv Animal Nut. 1999;12:53-61.
3. McKevith B. Nutritional aspects of cereals. Nutrition Bulletin. 2004;29(2):111-142.
4. Glatthar J, Heinisch JJ, Senn T. Unmalted triticale cultivars as brewing adjuncts: Effects of enzyme activities and composition on beer worth quality. J Sci Food Agric. 2005;85(4):647-654.
5. McGoverin CM, Snyders F, Muller N, Botes W, Fox, G, Manley M. A review of triticale uses and the effect of growth environment on grain quality. J Sci Food Agric. 2011;91(7):1155-1165.
6. Rakha A, Åman P, Andersson R. Dietary fiber in triticale grain: Variation in content, composition, and molecular weight distribution of extractable components. J Cereal Sci. 2011;54(3):324-331.
7. Lata C, Prasad M. Role of DREBs in regulation of abiotic stress responses in plants. J Exp Bot. 2011;62(14):4731-4748.

8. Lonbani M, Arzani A. Morpho-physiological traits associated with terminal drought stress tolerance in triticale and wheat. Agron Res. 2011;9(1-2):315-329.
9. Fleury D, Jefferies S, Kuchel H, Langridge P. Genetic and genomic tools to improve drought tolerance in wheat. J Exp Bot. 2010;61(12):3211-3222.
10. Hura T, Grzesiak S, Hura K, Thiemt E, Tokarz K, Wędzony M. Physiological and biochemical tools useful in drought-tolerance detection in genotypes of winter triticale: Accumulation of ferulic acid correlates with drought tolerance. Annals Bot. 2007;100(4):767-775.
11. Tanksley SD, McCouch SR. Seed banks and molecular maps: Unlocking genetic potential from the wild. Science. 1997;277: 1063-1066.
12. Blum A. Crop responses to drought and the interpretation of adaptation. Plant Growth Reg. 1997;20:135-148.
13. Blum A. The abiotic stress response and adaptation of triticale—A review. Cereal Res Commu. 2014;42(3):359-375.
14. Estrada-Campuzano G, Slafer GA, Miralles DJ. Differences in yield, biomass and their components between triticale and wheat grown under contrasting water and nitrogen environment. Field Crops Res. 2012;128:167-169.
15. Ammar K, Mergoum M, Rajaram S. The history and evolution of triticale. In: Triticale Improvement and Production (eds. Mergoum, M. and Mergoum, H.) 2-9. FAO. Beauchamp, C. and Fridovich, I. 1971. Superoxide dismutase: Improved assays and an assay applicable to acrylamide gels. Analyt Bioch. 2004;44(1):276-287.
16. Roohi E, Tahmaseb-Sarvestani Z, Modarres –Sanavy SAM, Siosemardeh A. Comparative study of the effect of soil water stress on photosynthetic function of triticale, wheat and barley. J Agric. Sci. Tech. 2013;15:215-228.
17. Johnson RA, Dean WW. Applied multivariate statistical analysis. Englewood Cliffs, N.J.: Prentice Hall; 1992.
18. Humphreys MO. A genetic approach to the multivariate differentiation of perennial ryegrass (*Lolium perenne* L.) populations. Heredity. 1991;66:437-443.
19. Walton PD. Factor analysis of yield in spring wheat (*Triticum aestivum* L.). Crop Sci. 1972;12:731–733.
20. Lipiec L, Doussan C, Nosalewicz, Kondracka K. Effect of drought and heat stresses on plant growth and yield: A review. Int Agrophys. 2013;27:463-477.
21. Kultu I, Kinaci G. Evaluation of drought resistance indicates for yield and its components for three triticale cultivars. Journal of Tekirdag Agricultural Faculty. 2010;7(2):95-103.
22. Fayaz N, Arzani A. Moisture stress tolerance in reproductive growth stages in triticale (*X triticosecale* Wittmark) cultivars under field conditions. Crop Breed J. 2011;1:1.
23. Jessop RS. Stress tolerance in newer triticales compared to other cereals. In: Guedes-Pinto H, Darvey N., Carnide VP (eds), Triticale: Today and Tomorrow. Developments in Plant Breeding. Kluwer Academic Publishers, Dordrecht, The Netherlands. 1996;419-428.
24. Barary M, Warwick NWM, Jessop RS, Taji AM. Variation for osmotic adjustment in Australian triticale cultivars. 11th Australian Agronomy Conference, 2-6 February 2003, Geelong, Victoria, Autralia, Poster. Available:http://www.regional.org.au/au/asa/2003/p/9/barary.htm
25. Leila AA, Khateeb SA. Statistical analysis of wheat yield under drought conditions. J Arid Env. 2005;61:483-496.
26. Khajavi A, Aharizad S, Ahmadizadeh M. Genetic diversity of promising lines of barley based on pheno-morphological traits in Ardabil area. Int J Adv Biol Biomed Res. 2014;2(2):456-462.

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