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SELECTION CRITERIA FOR IMPROVING GRAIN YIELD OF WHEAT UNDER RAIN-FED AND IRRIGATED CONDITIONS

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ABSTRACT

Selection criteria that can facilitate grain yield improvement would be considered important plant breeding tools. Knowledge on the association of yield with other agronomical traits is essential in understanding the magnitude and direction of changes expected during selection. Correlation and path coefficients were estimated to evaluate the importance of different agro-morphological traits in wheat, to determine the direct and indirect effects of these components on yield, and to develop selection criteria for higher grain yield. Fourteen wheat genotypes (*Triticum aestivum* L.) were grown under two environments (irrigated and rain-fed). The experiment was performed, based on randomized complete block designs (RCBD) with three replications. Mean grain yield in rain-fed conditions was 11.26% lower than that in irrigated conditions. The genotypes Marvdasht and M-81-13 exhibited the highest grain yield per unit area in rain-fed conditions. A highly significant positive correlation between grain yield and grain/spike (r = 0.836**) and also peduncle length (r = 0.698**) was found in water stress conditions. Therefore grains/spike and peduncle length could be used as reliable criteria for selection of bread wheat genotypes for water stress tolerance. Four main factors accounted for 85% of the total variability in the dependent structure. Factors 1, 2, 3 and 4 explained 27.7%, 19.6%, 19.3% and 18.4% of total variation, respectively. The first factor comprised F_v/F_m, spike/m^2, stomatal conductance and leaf chlorophyll content. Therefore the factor emphasized on photosynthetic components. The second factor included grain yield, grain/spike, spike/m^2, W_{1000}, spike length and spike weight (with positive factor loadings). The suggested name for the factor is yield and yield components. Factor 3, growth characteristics, consisted of biological yield (biomass), plant height, peduncle length and awn length. Factor 4 was named phonological traits because it was significantly affected by days to heading and days to anthesis.

INTRODUCTION

Global warming and concomitant increase in drought affected areas limit plant production in the world. Wheat production is also restricted by drought exposed areas and this loss led to considerable economic and social problems because of its great importance on human nutrition.

Reduction in wheat production (about 50-60%) as a result of severe drought in 2005 was experienced in Portugal and Spain (Isendahl and Schmidt, 2006). Quantitative traits which have economic value are highly influenced by environmental conditions and progresses of breeding in such traits are primarily conditioned by the magnitude and nature of variation and relationships among them (Gandhi *et al.,* 1964). Correlation and path coefficient analysis could be used as an important tool to bring information about appropriate cause and effects relationship between yield and some yield components (Khan *et al.,* 2003). Correlation coefficient determines simple relations among the traits and provides a good measure of the association between characters, but it does not determine always decisive results about determination of plant selection criteria (Cakmakci and Acikgoz, 1998). Sometimes, correlation coefficients give misleading results because of involvement of the third factor in the correlation between two variables. It is, therefore, necessary to analyze the cause and effective relationship between dependent and independent variables to entangle the nature of relationships between the variables. Path analysis enables to partition correlation coefficients to direct and indirect effects and presents a clear picture of the individual contribution of each variable to the yield

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(Borojević and Zegnal, 1980). Pass analysis is used to partition the relative contribution of yield components via standardized partial regression coefficients. The correlation coefficient can be separated into the direct and indirect influences that one variable has on another. Path analysis was used in numerous researches with the aim of determining the effects of important yield components (Naazar *et al.,* 2003; Ahmed *et al.,* 2003). The multivariate statistical technique that can be successfully utilized in understanding the patterned variation in a set of variables based on structural relationships among them. Factor analysis was commonly implicated in cereals (Cagirgan and Yildirim, 1990). Factor analysis determines some features to characterize the variation of the observations and determine natural groups from the varieties studied (Adam and Hwang, 1999). This study was undertaken to evaluate selection criteria for improving grain yield of wheat genotypes under rain-fed conditions using multivariate data analysis.

MATERIALS AND METHODS

Plant material and location

The experiment was carried out in 2009-2010 at the Research Farm of Kermanshah Islamic Azad University (latitude 34º20' N, longtitude 46º20' E, altitude 1351.6 m above sea level). Kermanshah is located in west of Iran and has a mean annual temperature of 13.8ºC and annual rainfall of 478 mm. The amount of rainfall during the growing season was 387.2 mm. The soil texture of the research area was sandy-loam. Fourteen wheat genotypes were planted. Most of the accessions were superior hexaploid wheat genotypes (Najafian *et al.,* 2011). List and pedigree of the wheat accessions are presented in Table 1.

Table 1 List and pedigree of 14 wheat genotypes grown in rain-fed and irrigated tirals

Genotype No.	Name/Pedigree	Origin
1	OR F1.158/FDL//BLO/3/SHI4414/CROW/4/C ICWH99381-0AP-0AP-0AP-OMAR-6MAR	DARSI
2	PYN/BAU//VORONA/HD2402	DARSI
3	TEVEE'S'//CROW/VEE'S'	DARSI
4	HAMAM-4	DARSI
5	STAR/SHUHA-4	DARSI
6	M-83-6	ANRRC
7	M-79-7	ANRRC
8	M-81-13	ANRRC
9	M-83-17	ANRRC
10	WS-82-9	ANRRC
11	Pishtaz	ANRRC
12	Shiraz	ANRRC
13	Marvdasht	ANRRC
14	Bolani	ANRRC

DARSI: Dry land Agricultural Research Sub-Institute

The experiment was performed, based on randomized complete block designs (RCBD) with three replications, in irrigated and rain-fed conditions. The genotypes were sown in six rows of 3 m length, spaced 25 cm apart in early November. The final stand density was 400 plants per m^2. All of phosphorus (50 kg ha^{-1}, P_2O_5) and half of total nitrogen (45 kg ha^{-1}, N) were applied at the sowing time. The other half of the N was split and given at tillering (as urea) and booting (as ammonium nitrate) stages, respectively. Seeds were pretreated with Mancozeb as a fungicide to minimize the probability of seed- and soil-borne diseases. Experimental plots were hand weeded. Plants in rain-fed plots didn't receive any water except rainfall during the experiment. In irrigated plots, three supplement irrigations were applied during flowering and grain filling period. Spike length, awn length, peduncle length, plant height, grains/spike, days to heading, days to anthesis and grain yield were measured. Peduncle length (cm) was determined as average height of peduncle from the last node of the main stem to the initial tip of the spike. Plant height (cm) was measured from soil surface to the end of spike without considering awn length. Stress intensity (SI) was calculated using the relationship $1-\left(\frac{\overline{Ys}}{\overline{Yp}}\right)$ where $\overline{Ys}$ and $\overline{Yp}$ are the mean yields of all genotypes under stress and irrigated conditions, respectively (Fischer and Maurer, 1978). To avoid border effects, central three rows were used to measuring the traits. At maturity, plants in 1 m^2 of middle part of each plot were hand harvested and oven dried at 80°C for 48 h. Grain yield per unit area for each treatment at each replicate was determined.

Statistical analysis

Combined analysis of variance appropriate to RCBD was carried out using SAS (version 9.1). Environments (rain-fed and irrigated) were considered as fixed effects. Duncan test was used for mean comparisons. Correlation among characters was calculated by SPSS software. Path coefficients were estimated according to Dewey and Lu (1959), where grain yield was kept as resultant variable and other contributing characters as causal variables. Factor analysis using a varimax orthogonal rotation (Cattel, 1965) was performed using SPSS (version 14).

RESULTS

Combined analysis of variance

Combined analysis of variance (Table 2) showed that the environment was not significant source of variation of the

Table 2 Combined analysis of variance for traits of 14 wheat genotypes under rain-fed and irrigated conditions

		Mean squars							
Source of Variation	df	Spike length	Awn length	Plant height	Peduncle length	Days to heading	Days to anthesis	Grains/spike	Grain yield
Environment (E)	1	0.005	0.046	108.22	4.86	0.64	25.78	1.01	2738.2
Error (R/E)	2	0.054	2.42**	68.56	4.98	0.89	2.32	8.04	3107.1
Genotype (G)	13	1.86**	10.1**	726.9**	58.3**	13.1**	5.17	177.8**	5817.6**
E×G	13	0.33	0.2	41.06	8.38	1.33	2.13	24.96	2585.7
Error (R×G/E)	26	0.47	0.31	54.11	10.47	0.89	1.85	24.98	2295.7
CV (%)		7.76	9.49	7.31	10.12	0.67	0.88	14.28	19.25

*, ** significant at 0.05 and 0.01, respectively

measured traits. Stress intensity (SI) was estimated to be 0.112, indicating a moderate water deficit stress. The results of combined analysis of variance for spike length, awn length, peduncle length, plant height, days to heading, grains/spike and grain yield indicated that genotypic differences were significant (P<0.01). Two-way interaction of environment × genotype was not significant for the measured traits. No significant effects were detected for days to anthesis (Table 2).

Analysis of variance

The results of analysis of variance (Table 3) showed significant genotypic differences for awn length, peduncle length and days to heading (P<0.01) and for plant height, days to anthesis, grains/spike and grain yield (P<0.05) in irrigated conditions. Significant variation among genotypes was observed for grain yield (P<0.05) and for awn length, plant height, days to heading and grains/spike (P<0.01) in the stress conditions.

Table 3 Analysis of variance for some morphological and phenological characters of wheat genotypes in irrigated and rain-fed conditions

		Mean of Squares							
	df	Spike length (cm)	Awn length (cm)	Plant height (cm)	Peduncle length (cm)	Days to heading	Days to anthesis	Grains/spike	Grain yield (gm^{-2})
Irrigated conditions									
Replication	1	0.099	3.64	108.82	6.89	0.035	0.321	3.18	4282.98
Genotype (G)	13	1.35	4.93**	287.4*	49.74**	8.035**	4.826*	96.6*	5108.40*
Error	13	0.319	0.367	95.22	8.72	0.80	1.09	27.07	2770.36
Rain-fed conditions									
Replication	1	0.008	1.21*	28.30	3.08	18.5	4.32	12.89	1931.24
Genotype (G)	13	0.84	5.32**	480.6**	43.96	6.36**	2.47	116.2**	3295.01*
Error	13	0.626	0.253	13.1	12.21	0.98	2.62	26.88	1821.05

, significant at P<0.05 and P<0.01, respectively*

No significant effects were observed for spike length under stress and non-stress conditions (Table 3).

Mean comparisons

Mean comparison of eight traits under rain-fed and irrigated conditions are shown in Table 4. All the measured traits values recorded under water stress conditions were slightly lower than those under non-stress conditions. Peduncle length under irrigated conditions ranged from 41.52 (Marvdasht) to 25.18 (Bolani), with an average of 32.25. The highest peduncle length was recorded for Marvdasht (G13) followed by M-81-13 (G8), PYN (G2), M-83-6 (G6) and STAR (G5) under irrigated conditions. Under water stress conditions, ORF1.158 (G1) and WS-82-9 (G10) had the shortest peduncle. The highest peduncle length was observed for Marvdasht followed by M-83-6 and M-81-13 in the environment (Table 4). Grain yield was positively correlated with peduncle length (r = 0.599** and r =0.698**) in the irrigated and rain-fed environments, respectively (Table 5 and Table 6).

The highest spike length under both irrigated and rain-fed conditions was recorded for M-81-13 followed by Marvdasht (Table 4). Spike length was positively correlated with grains/spike (r = 0.544, P< 0.05) and grain yield (r = 0.505, P< 0.05) under irrigated conditions. In rain-fed site, spike length had positive correlation with grains/spike (r = 502, P< 0.05), grain yield (r = 0.511, P< 0.05), length of awn (r = 520*, P< 0.05) and length of peduncle (r = 536*, P< 0.05) (Tables 5 and 6).

No significant correlation was found between awn length and grain yield under irrigated conditions. Highest awn length was observed for Marvdasht, M-81-13, PYN and M-83-6 in irrigated conditions. In rain-fed site, Marvdasht followed by M-81-13, STAR and M-83-6 had the highest awn length (Table 4). A positive correlation was found between awn length and grain yield (r = 0.577*, P< 0.05) under rain-fed conditions (Table 6). Plant height under irrigated conditions ranged from 142 (Hamam-4) to 81.4 (STAR), with an average of 101.93. The highest plant height was recorded for Hamam-4 followed by ORF1.158, TEVEES and WS-82-9. Under water stress conditions, plant height was reduced, and the most affected wheat genotypes were STAR, Shiraz, Pishtaz and Marvdasht with general mean of 99.15.

The relationships between plant height and peduncle length were significant (r = 0.66** and r = 0.506*) under irrigated and rain-fed, respectively. Adversely, negative significant correlations were noted among plant height with grains/spike and grain yield (r = -0.536* and r = -0.64**) under irrigated and (r = -0.553* and r = -0.578*) under rain-fed conditions (Table 5 and Table 6).

The highest grains/spike under both irrigated and rain-fed conditions was recorded for Marvdasht followed by M-81-13 and M-83-6 (Table 4). Grain yields of stress conditions varied from between 183.1 to 283.8 gm^{-2} and in non stress site, ranged between 186.4 and 319.1 gm^{-2}. Mean grain yield in non-stress and stress environments was 263.72 and 234.05, respectively (Table 4). Average grain yield in rain-fed conditions numerically was 11.26% lower than that in irrigated conditions. Marvdasht had the highest grain yield in both conditions, while the lowest grain yield was belonged to ORF1.158 and Hamam-4 (Table 4). Marvdasht, M-81-13, PYN and M-83-6 were the most productive in irrigated conditions but in rain-fed site, Marvdasht followed by M-81-13, M-83-6, STAR, M-79-7 and TEVEES had highest grain yield.

In the present study, path analysis was used to work out the direct and indirect effects of three characters on grain yield (Table 7). Investigation of direct and indirect

Table 4 Mean comparison of eight traits under rain-fed and irrigated conditions

	Genotypes	Days to anthesis	Days to heading	Peduncle length (cm)	Plant height (cm)	Awn length (cm)	Spike length (cm)	Grains/Spike	Grain yield (gm^{-2})
Irrigated conditions	ORF1.158	152.5a	142.5a	28.62de	116.3b	5.5c	8.77c	26.5d	186.4d
	PYN	156.0a	142.5a	37.22ab	100.9cd	7.11a	9.22ab	39.9abc	299.2a
	TEVEES	155.5a	143a	27.47e	112.9b	6.51abc	9.10ab	34.1bcd	222.3cd
	Hamaam-4	156.0a	142a	29.25cde	142a	6.39abc	8.74c	31.1bcd	220.2cd
	STAR	155.0a	142a	29.75cde	81.40f	6.22abc	7.92c	35.6abcd	243bcd
	M-83-6	155.0a	138.5c	36.38abc	103c	6.89ab	9.11ab	43ab	291.6ab
	M-79-7	154.5a	142a	35.33abcd	102.2cd	5.62bc	8.24c	41.8abc	271.4bc
	M-81-13	155.5a	141ab	39.95a	95.35cde	7.18a	10.54a	44.8a	299.7a
	M-83-17	153.5a	139bc	30.65bcde	87.7ef	6.23abc	8.72c	33.8bcd	262.7bc
	WS-82-9	154.5a	137.5c	27.90e	111.2b	6.35abc	9.22ab	41.3abc	276.5bc
	Pishtaz	152.5a	138c	32.05bcde	89.7ef	0.8d	7.95c	29.8cd	226.7cd
	Shiraz	155.0a	141ab	30.25bcde	87ef	5.76abc	8.12c	37.7abcd	261.1bc
	Marvdasht	154.5a	141ab	41.52a	94.2de	7.12a	10.33a	47.4a	319.1a
	Bolani	154.5a	137.5c	25.18e	103.2c	5.83abc	7.97c	26.08d	224.4cd
	Mean	154.6	140.5	32.25	101.93	5.94	8.95	36.49	263.72
Rain-fed conditions	ORF1.158	152.5dc	141.5abc	23.85e	109.1abc	4.90e	8.54ab	27.65de	183.1bc
	PYN	155.5ab	143a	31.5abcde	103.6abc	0.70f	9.26ab	28.5cde	195.1bc
	TEVEES	153.5bcd	142.5ab	30.4abcde	110.6abc	5.71cde	7.35b	30.6bcde	255.4ab
	Hamaam-4	156.5a	143a	32.58abcd	120.5a	5.50de	8.36ab	24.5e	194.8bc
	STAR	152.5dc	140.5bcd	32.45abcd	78.3d	6.95ab	9.10ab	35.7bcde	272.2ab
	M-83-6	152.5dc	140cd	38.31a	98.7abcd	6.89ab	9.21ab	41.4ab	273.3ab
	M-79-7	153.5bcd	142abc	33.18abc	101.5abcd	6.20abcd	8.25ab	40.8abc	267.6ab
	M-81-13	154.0bc	142abc	37.58ab	90.2cd	7.05a	9.75a	48.4a	275.1ab
	M-83-17	151.0d	140.5bcd	29.05bcde	88.65cd	6.38abcd	8.37ab	39.8abcd	249.5b
	WS-82-9	151.0d	137e	24.46e	114.1ab	6.32abcd	9.82a	37.6abcd	226.9b
	Pishtaz	154.5abc	139dc	32.35abcd	89.8cd	6.68abcd	8.57ab	35.7bcde	196.3bc
	Shiraz	153.5bcd	139dc	26.07cde	90.6bcd	5.97bcde	8.77ab	40.2abcd	222.1b
	Marvdasht	152.0cd	141.5abc	38.63a	88.2cd	7.22a	9.58a	48.6a	283.8a
	Bolani	153.0bcd	139dc	32.76abcd	104.3abc	6.09abcd	9.00ab	27.7de	204b
	Mean	153.2	140.75	30.66	99.15	5.89	8.87	36.22	234.05

effects of some characters showed that grain/spike had the highest positive direct influence (0.72) on GY. W1000 had also positive effect (0.177) on GY. The positive direct effect of W1000 was neutralized by negative indirect effects of plant height, grains/spike. Four main factors accounted for 85% of the total variability in the dependent structure. Factors 1, 2, 3 and 4 explained 27.7%, 19.6%, 19.3% and 18.4% of total variation, respectively (Table 8). The first factor comprised F_v/F_m, spike/m^2, stomatal conductance and leaf chlorophyll content. Therefore the factor emphasized on photosynthetic components. The second factor included grain yield, grain/spike, spike/m^2, W1000, spike length and spike weight (with positive factor loadings). The suggested name for the factor is yield and yield components. Factor 3, growth characteristics, consisted of biological yield (biomass), plant height, peduncle length and awn length. Factor 4 was named phonological traits because it was significantly affected by days to heading and days to anthesis.

DISCUSSION

Negative significant correlations of plant height with grains/spike and grain yield under irrigated and rain-fed conditions were in agreement with Sio-Se Mardeh et al. (2006) that showed the negative relationship of plant height with grain yield and grains/spike in wheat cultivars. Several studies indicated that semi-dwarf stature is preferred in late season drought conditions (Fischer and Maurer, 1978; Richards, 1996). Van Ginkel et al. (1998) also found that many grains/spike was criteria to high grain yield only in irrigated conditions and it was negatively correlated with grain yield under late season drought condition. Bogale et al. (2011) reported a significant and positive correlation between plant height and peduncle length. Peduncle length has been suggested as useful indicator of yield capacity in dry environments. The significant and positive correlation observed between peduncle length and grain yield in the present study.

Table 5 Correlation coefficients between morphological and phonological traits under irrigated (non-stress) conditions

	Spike length	Awn length	Plant height	Peduncle length	Days to heading	Days to anthesis	Grains/spike
Length of awn	0.508						
Plant height	0.270	-0.121					
Length of peduncle	0.506	0.349	0.66**				
Days to heading	-0.08	-0.228	0.087	0.347			
Days to anthesis	-0.209	-0.337	0.302	0.181	0.416		
Grain/spike	0.544*	-0.072	-0.536*	-0.181	-0.223	-0.223	
Grain yield	0.505*	0.245	-0.64**	0.599**	-0.163	-0.195	0.581*

, significant at P<0.05 and P<0.01, respectively*

Table 6 Correlation coefficients among morphological and phonological traits under rain-fed conditions

	Spike length	Awn length	Plant height	Peduncle length	Days to heading	Days to anthesis	Grains/spike
Awn length	0.520*						
Plant height	0.183	-0.035					
peduncle length	0.536*	0.448	0.506*				
Days to heading	-0.224	-0.307	0.341	0.092			
Days to anthesis	-0.188	-0.290	0.248	0.024	0.411		
Grains/spike	0.502*	0.351	-0.553*	-0.044	-0.253	-0.071	
Grain yield	0.511*	0.577*	-0.578*	0.698**	-0.171	-0.226	0.836**

, significant at $P<0.05$ and $P<0.01$, respectively*

This result suggested that peduncle length could be good indicator of grain yield for breeding purpose in areas where water is limited for an extended period of the growing season in bread wheat. This founding is in agreement with Bogale et al. (2011) and in conformity with previous reports that showed peduncle length as an indirect selection criterion in wheat under drought conditions (Kaya *et al.,* 2002). Kaya et al. (2002) and Bogale et al. (2011) have been found a strong positive correlation between peduncle length and grain yield. In other cases, such relationship has been found inverse (Briggs and Aytenfisu, 1980) or no relationship (Villeagas *et al.,* 2006) depending on environment.

provide the highest grain yield. Favorable conditions during growth may permit an expansion of the last internodes as well as a higher yield (Gupta *et al.,* 2001). The positive and significant correlation between grain yield and awn length in rain-fed conditions emphasizes the role of awn photosynthesis in grain filling. The superiority of Marvdasht in producing comparatively greater grain yield as an adapted genotype could be attributed to higher grains/spike, spike length, awn length and peduncle length of this genotype in both irrigated (non-stress) and rain-fed (stress) environments. We found a highly significant positive correlation between grain yield and grain/spike (r = 0.836**) and also peduncle length (r = 0.698**) in water stress conditions.

Table 7 Direct and indirect effects of three characters on wheat yield

Traits	Direct Effect	Indirect Effect			
		Grains/spike	Plant height	Hundred Seed Weight	Total
Grains/spike	0.72	-	0.147	-0.03	0.837
Plant height	-0.265	-0.398	-	0.087	-0.579
Hundred Seed Weight	0.177	-0.122	-0.13	-	-0.072

Table 8 Main factors and factor loadings for wheat variables

Traits	1st Factor	2nd Factor	3rd Factor	4th Factor
Biological yield	0.298	0.190	0.772	0.473
Grain yield	0.235	0.842	0.145	-0.181
Spike length	-0.012	0.533	-0.156	-0.122
Awn Length	0.1005	0.138	0.590	-0.569
Plant height	-0.795	-0.33	0.772	0.248
Peduncle length	-0.391	0.227	0.591	0.301
Days to anthesis	0.0334	-0.588	0.023	0.871
Days to heading	0.0382	-0.537	0.056	0.818
Grain/spike	0.373	0.605	0.191	0.171
Leaf chlorophyll content	0.904	-0.041	0.006	-0.078
Fv/Fm	0.836	-0.361	-0.507	-0.233
Stomatal conductance (gs)	0.784	-0.359	-0.551	-0.774
Spike weight	0.081	0.523	0.530	0.289
Spike/m^2	0.092	0.591	0.584	0.101
W1000	-0.205	0.613	0.294	0.025
Variance (%)	27.7	19.6	19.3	18.4
Accumulative Variance		47.3	66.6	85

The positive relationship between grain yield and morphological traits (spike length, peduncle length, awn length and grains/spike) under water stress conditions indicated that low growth rate of plants is one of the limiting factors of yield under the conditions (Siman *et al.,* 1993; Villegas *et al.,* 2001). Therefore, genotypes with greater growth rate under such conditions would

Therefore grains/spike and peduncle length could be used as reliable criteria for selection of bread wheat genotypes for water stress tolerance.

Based on Path analysis (Table 7), grain/spike and W1000 had positive direct effect on grain yield and therefore can be used as reliable criteria in selection of water stress tolerant wheat genotypes. Noor et al. (2003)

and Farshadfar and Farshadfar (2008) also reported positive and direct effects of seeds and pods per plant on chickpea grain yield. Study of relationships of grain yield with component traits is very important for breeders to decide upon selection strategies. Four main factors explained 85% of the total variance caused in the characters. The data in Table 8 show that photosynthetic components, growth and biomass characteristics had high contribution in wheat grain yield. Toker and Cagiran (2004), were reported biological yield, plant height, harvest index and pods per plant should be used in selection process to increase grain yield in chickpea breeding programs. In their study, three factors determined 92.9% of total variation. In our study, factor analysis reduced a large number of correlated variables to a small number of important factors and also illustrated the relationships between correlated characters in the dependent structure. Similar results also were found by Niari Khamssi et al. (2012), who reported the higher leaf chlorophyll content and stomatal conductance under drought-stress conditions could possibly be the proper photosynthetic criteria for screening the drought-tolerance wheat genotypes under field experiments.

CONCLUSSION

As a result of moderate water deficit stress (according to SI), there were no significant differences between studied traits under rain-fed and irrigated conditions. Therefore, under low stress intensity and drought avoidance, there is no necessary for supplementary irrigation to obtain higher grain and this can help for saving the water. Marvdasht was the superior wheat genotype under the both rain-fed and irrigated conditions.

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