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Evaluation of some physiological traits associated with improved drought tolerance in Iranian wheat

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ABSTRACT

In order to evaluation of some physiological traits associated with improved drought tolerance in wheat, twenty Iranian wheat genotypes with wide range of sensitivity to drought, including eighteen varieties of bread wheat (Triticum aestivum L.) and two varieties of durum wheat (Triticum turgidum L.) were used in two separate field experiments in 2009-2010 at the Experimental Station of College of Agricultural in Shiraz University, Iran. Each experiment was conducted as a randomized completed block design with three replications. The experiments only differed with respect to their moisture levels (100% or 45% field capacity). The results showed that drought stress significantly ($P < 0.05$) increased relative water protection (RWP), stomatal resistance (Sr) and canopy temperature depression (CTD), and decreased relative water content (RWC) in the genotypes. Drought tolerant genotypes had higher RWC, RWP, Sr, CTD and cell membrane stability (CMS) as compared to intermediate and susceptible genotypes. Also durum wheat indicated similar behaviors of tolerant bread wheat under drought stress. There were positive and significant correlation between yield stability index (YSI) and physiological traits. YSI had the highest correlation with RWP under stress condition. In this study, RWP and RWC were selected as the best criteria for classification and screening of drought tolerant genotypes and also Azar2 and Alamut genotypes were identified as the most tolerant and susceptible genotypes ,respectively.

Keywords: Wheat, Drought stress, Physiological traits, Pearson correlation, Cluster analysis.

INTRODUCTION

Drought is one of the major environmental factors depressing plant growth and productivity worldwide. recent progressive global climate change and increasing shortage of water resources has made this problem more serious [1, 2]. However in certain tolerant crop plants Physiological and metabolic changes occur in response to drought, which contribute towards adaptation to such unavoidable environmental constraints [3]. Among crop plant, Wheat (*Triticum aestivum* L.) is a staple food for more than 35% of the world population and it is also the first grain crop in Iran [4, 5, 6]. Wheat often experiences drought stress conditions during its growth cycle. Thus, Improvement of wheat productive for drought tolerance is a major objective in plant breeding programs [3, 7, 8]. Plant breeders have always looking appropriate and repeatable indicators to screen germplasms for drought tolerance [9, 10]. Although grain yield is the principle selection index used under drought stress conditions, but breeding for drought tolerance by selecting solely for grain yield may not be successful, because the heritability of yield under drought conditions is low, as well as grain yield and drought resistance are controlled at independent genetic loci. Therefore, the identification of physiological traits associated with drought tolerance should be considered in the breeding programs [1, 3, 11]. Relative water content (RWC), stomatal resistance (Sr) and canopy temperature depression (CTD) are among the main physiological criteria that influence plant water relations and have used been for assessing drought tolerance [12, 13]. In many studies, these parameters have been effective in screening drought resistant genotypes [4, 6, 11, 14]. A decrease in RWC and increase RS and CTD in responses to drought stress had reported by several works [1, 2 13,].

Cell membrane stability index (CMS) is one of the beast indicators for drought tolerance [7]. Associations between osmotic regulation and CMS under drought stress were suggested more recently [3, 10]. Relative water protection (RWP) is another important physiological in assessing the degree of water stress [15]. RWP suggested by Hasheminasab et al. [15] for screening plants with higher capacity for drought tolerance. RWP are indicating plant water status related to water stress, as well as reflecting the metabolic activity in tissues. The objective of the present investigation were to: (i) better understand the effect of drought stress on some physiological traits associated with leaves water status in resistant, intermediate and susceptible Iranian wheat genotypes (ii) identified the efficent physiological traits for screening drought tolerant genotypes (iii) determine the relationships among physiological traits and yield stability index (YSI) under drought stress conditions.

MATERIALS AND METHODS

Plant materials and experimental conditions

Eighteen bread wheat genotypes (*Triticum aestivum* L.) including six drought tolerant genotypes (Azar2, Pishtaz, Toos, Chamran, Kavir and Koohdasht), six intermediate (Roshan, Alvand, Tabasi, Niknejad, cross adl and Darab2) and six susceptible (Shiraz, Shiroudi, Flat, Bahar, Zarin and Alamut) and two durum wheat genotypes (*Triticum turgidum* L.) including Simareh and Yavarus were used in two separate field experiments in 2009-2010 at the Experimental Station of College of Agricultural in Shiraz University (52o 46' E, 29o 50' N, altitude 1,810 m above sea level). Each experiment was conducted as a randomized completed block design with three replications. Each plot consisted of six 4 m long rows spaced 30 cm apart. Four middle rows were left intact for grain yield determination, and the two outside rows were used for sampling. Soil of experimental station had sandy-clay texture with EC=0.563 $ds.m^{-2}$ and pH=7.6. The moisture level in one of the experiments was optimum (100% field capacity) while the second experiment was conducted under drought stress (45% field capacity). The amount of water needed for irrigation was calculated from the method of Avja and Micheal [16]. The characteristics of climates at the experimental station during 2009-2010 are shown in Table 1. From two outside rows, flag leaves of plants at flowering stage were harvested and weighed for assessment of physiological traits.

Table 1. Mean temperature, precipitation distribution and total irrigation for each experiment

Month	Year	Mean temperature (°C)	Effective Rainfall (mm)	Irrigation (mm)	
				Non- stress	Stress
November	2009	10.62	10.5	131	131
December	2009	5.66	129	-	-
January	2009	5.1	17	-	-
February	2010	6.13	54.5	-	-
March	2010	10.4	37.5	43	19.35
April	2010	12.23	24.5	70.42	31.69
May	2010	17.04	13	113.1	50.89
June	2010	22.58	0	60.4	27.18
Total			286	417.92	260.11
Total water used				703.92	546.11

Grain yield and yield stability index (YSI)

Grain yield was recorded at physiological maturity stage. The physiological maturity stage was considered when 90% of seed changed color from green to yellowish and stopped photosynthetic activity. Yield stability index (YSI) was calculated using the formula suggested by Bouslama and Schapaugh [17] as:

$$YSI = Ys / Yp$$

Where, Ys and Yp represent yield under stress and non-stress conditions, respectively.

Relative water content (RWC)

A sample of 10 leaves were taken randomly from the flag leaves of each genotype and fresh weight (F_W) was measured. Then, samples were placed in distilled water for 24 h and reweighed to obtain turgid weight (T_W). Leaf samples were oven dried and weight in 70°C for 72 h (D_W). RWC was calculated using the following formula [18].

$$RWC\ (\%) = \left[\frac{F_W - D_W}{T_W - D_W}\right] \times 100$$

Canopy temperature depressing (CTD)

Canopy temperature measurements were made using a hand-held infrared thermometer (KaneMay Model Infratrace 800, USA). Four measurements were taken per plot at approximately 0.5 m from the edge of the plot and approximately 0.5 m above the canopy with an approximately 30-60° from the horizontal. Two to seven days after irrigations in each experiment, canopy temperatures (CT) were measured between 12:00 to 14:00 hours on cloudless, bright days. Ambient temperatures (AT) were measured with a common thermometer held at plant height. CTD was calculated using the following formula [19]:

$$CTD = AT - CT$$

Stomatal resistance (Sr)

Three random plants were selected in each plot and the Stomatal resistance (mol m^{-2} s^{-1}) was measured with a portable photosynthesis system (LCi). All measurements were made on the portion of the flag leaf exposed to full sunlight, at about halfway along its length. The measurements were also made over the same time period as the canopy temperature depressing.

Relative water protection (RWP)

Ten leaves were taken randomly from each genotype and weighted (Fresh weight, F_W). The leaves were then wilted at 25°C for 8 h (This time can be different for various plant species) and weighed again (Withering weight, W_W). Then the samples were oven dried in 70°C for 72 h and reweighed (Dry weight, D_W). RWP was calculated using the formula suggested by Hasheminasab et al. [15].

$$RWP\ (\%) = \left[\frac{W_W - D_W}{F_W - D_W}\right] \times 100$$

Cellular membrane stability (CMS)

Cellular membrane stability estimated according to Sairam [7]. Two sets of leaf tissues (0.1 g) were placed in 10 ml of double-distilled water. One set was kept at 40°C for 30 min and its conductivity recorded using a conductivity bridge (C1). The second set was kept in a boiling water bath (100°C) for 10 min and its conductivity recorded (C2). The membrane stability index was calculated as:

$$CMS = \frac{\left(1 - \frac{D1}{C2}\right)}{\left(1 - \frac{C1}{C2}\right)} \times 100$$

Where C1 and C2 are the first and second measurement of the conductivity measured under control conditions and D1 and D2 are the respective values for drought stress.

Statistical analysis of data

Analysis of variance, cluster analysis and Pearson correlations coefficients in all the measurements was conducted by SPSS software version 16.0 (SPSS, 2007). Means were separated using Tukey's test at $P < 0.05$. A combined analysis of variance was used to compare the effects of stress and non-stress, and genotypes by moisture conditions interaction.

RESULTS AND DISCUSSION

In developing a breeding program to improve the drought resistance of a crop plant it is necessary to gain knowledge concerning the physiological mechanisms of tolerance [3, 12]. Relative water content (RWC) is considered to be a reliable physiological parameter for quantifying plant water stress response [13, 18]. The results of present study showed that there were significant ($P < 0.01$) differences among genotypes for RWC when grown under drought stress condition (table 2). Geravandi et al. [5] observed significant differences in RWC among wheat genotypes under drought stress. RWC significantly ($P < 0.01$) decreased under drought stress. The highest RWC were observed in genotypes Pishtaz, Yavarus, Azar2, Toos, Kavir and Koohdasht (group 1), and the lowest in Shiroudi, Shiraz, Zarin, and Bahar (group 3) under stress condition. The intermediate ratios were observed in Alvand, Niknejad Cross Adl and Roshan (group 2). From table 2, we observed that genotypes in group 1, group 2 and group 3 had the highest, intermediate and lowest yield stability index (YSI), respectively. This shows that tolerant genotypes had a higher water retention capacity under stress [3]. Higher RWC had been reported to play a role in the stress tolerance in wheat [14], barley [20] and alfalfa [21]. The results also reflected that RWC was a suitable indicator for screening drought tolerant genotypes. Sairam and Srivastava [22] observed variation in relative water content in wheat genotypes and suggested that water stress tolerance was closely associated with RWC rate.

Canopy temperature depressing (CTD) has been used as a selection indicator for tolerance to drought and high temperature stress in plant breeding which used mass selection in early generations, generally [6, 19, 23]. In this study, the differences in CTD among genotypes were significant ($P < 0.01$) in both stress and non-stress conditions. CTD significantly ($P < 0.01$) increased under water stress condition (Table 2). CTD also significantly ($P < 0.05$) rose in all genotypes with exception of Shiraz. Increase in CTD might have occurred due to increased respiration and decreased transpiration resulting from stomatal closure [13]. Tolerant genotypes (group 1) including Yavarus, Pishtaz, Azar2, Simareh, Toos, and Chamran indicated higher CTD among these 20 genotypes (Table 2). Golestani and Assad [1] have been reported that higher canopy temperature during grain filling period in wheat is an important physiological principle for high water stress tolerance. Durum wheat had higher CTD as compared to bread wheat under stress and non-stress conditions. According to table 2, Durum wheat also showed higher YSI than bread wheat. An increasing number of reports provide evidence on the association between high CTD and sustained yield or biomass under drought stress conditions across different cultivars of crop plants [6, 24, 25].

Stomatal resistance (Sr) was also influenced by water stress (Table 2). Sr increased significantly ($P < 0.01$) under water stress condition. Turan et al. [26] reported that during a salt stress, the plant had to close their stomata due to water loss. The highest Sr were observed in Azar2, Pishtaz, Toos, Yavarus and Koohdasht (group 1), and lowest in Shiraz, Bahar, Zarin, Flat, Alamut and Shiroudi (group 3) while Alvand, Niknejad, Tabase, Darab2 and Cross Adl (group 2) showed intermediate responses under stress condition. Azar2 showed the highest Sr among all genotypes in both stress and non-stress conditions (Table 2). Stomatal resistance and leaf growth inhibitions were among the earliest responses to drought and protected plants from extensive water loss, which might result in cell dehydration and death [21, 27]. Dong et al. [25] showed that the measurement of stomatal resistance could be an effective criterion for determination the degree of resistance in plants.

Cell membrane injury is considered as the most damaging factor in every living organism under various stresses [28]. The degree of cell membrane injury induced by water stress may be easily estimated through measurements of electrolyte leakage from the cells [7]. In our study, there were significant ($P< 0.01$) differences among genotypes for cell membrane stability (CMS). From table 2, it was observed that tolerant genotypes including Pishtaz, Toos, Koohdasht and Kavir (group 1) demonstrated higher CMS, genotypes Alvand, Cross Adl, Tabase and Roshan (group 2) had intermediate CMS and genotypes Zarin, Alamut, Shiroudi, Bahar and Shiraz (group 3) showed lower CMS. A decrease in membrane stability reflected the extent of lipid peroxidation caused by reactive oxygen species [22, 23]. Based on table 2, the lowest CMS were observed in Zarin and highest in Pishtaz. In this connection it had been reported that tolerant and intermediate genotypes were superior to susceptible ones in maintaining membrane stability and lower membrane injury under drought stress condition [20, 21, 29]. Geravandi et al. [5] also reported that CMS was a good indicator for screening of drought tolerant wheat.

Results in Table 2 demonstrated that the differences in Relative water protection (RWP) of genotypes were significant ($P < 0.01$) in both stress and non-stress conditions. Relative water protection (RWP) also enhanced significantly ($P < 0.01$) under water stress condition.

From Table 2, it was observed that genotypes Simareh, Pishtaz, Azar2, Kavir, Koohdasht, Yavarus and Toos (group 1) had the highest RWP under drought stress. Genotypes Alvand, Niknejad, Cross Adl, Tabase, Darab2 and Roshan (group 2) had intermediate RWP and genotypes Shiraz, Flat, Bahar, Zarin, Alamut and Shiroudi (group 3) had lower RWP. The highest and lowest RWP was observed by Simareh and Shiraz, respectively. As seen in Table 2, Simareh and Shiraz had the highest and lowest YSI in all genotypes, respectively. It is clear that drought genotypes can maintain more water in their tissues which reduces transpiration rate [1, 30, 31]. Dedio [32] studied on five cultivars of wheat to evaluated leaf water content under different levels of soil moisture stress. He found that water retaining ability of leaf was under the control of dominant genes and concluded that drought resistant cultivars maintained higher leaf water content under drought stress.

The results of grain yield (GY) showed that there were significant ($P < 0.05$) differences among genotypes when grown under drought stress and non-stress conditions (table 2). GY significantly ($P < 0.01$) decreased under stress condition. Drought tolerant genotypes (group 1) on average had the highest GY and lowest in susceptible ones (group 3) While genotypes in group 2 showed intermediate responses (table 2). Clearly, the results of GR were consistent with other physiological indicators as measured under water stress condition. These results were similar to works of Amiri and Assad [4] in wheat, Razi and Assad [9] in sunflower, Ashkani et al. [11] in safflower, Kocheva et al. [20] in barley and Zlatev et al. [27] in been.

Table 2. mean of grain yield (GR), yield stability index (YSI), relative water content (RWC), canopy temperature depression (CTD), stomatal resistance (Sr), relative water protection (RWP) and cell membrane stability (CMS) in 20 Iranian wheat genotypes under non-stress and stress conditions

cultivars	GR (Kg ha^{-1})		YSI (%)	RWC (%)		CTD (^{o} C)		Sr (mol m^{-2} s^{-1})		RWP (%)		CMS (%)
	Non-stress	Stress		Non-stress	Stress	Non-stress	Stress	Non-stress	Stress	Non-stress	Stress	
Bahar	7896.1 ab	3856.6 hi	0.49 c	0.818 ab	0.598 f-h	3.20 k-o	5.30 e-i	8.33 kl	18.89 g-k	0.546 n	0.689 g-l	0.576 c-f
Chamran	5573.5 a-d	4190.3 d-i	0.76 a-c	0.797 ab	0.658 c-g	2.20 l-r	6.40 a-e	12.13 h-l	20.56 f-j	0.674 h-m	0.783 a-e	0.702 a-c
Cross Adl	8130.8 a	5016.4 e-i	0.63 a-c	0.856 ab	0.625 d-h	1.73 n-s	3.93 h-l	11.37 i-l	27.78 c-g	0.642 i-m	0.754 b-h	0.661 a-d
Shiraz	7848.2 ab	3707.5 hi	0.49 c	0.861 a	0.591 gh	2.76 k-q	3.63 i-m	5.27 l	18.56 g-k	0.678 h-m	0.657 i-m	0.564 d-f
Kavir	6692.3 a-d	5419.3 c-h	0.81 ab	0.854 ab	0.657 c-g	2.80 k-p	6.23 a-f	6.59 l	26.00 c-g	0.699 e-k	0.802 a-d	0.723 ab
Shiroudi	5981.3 b-f	4291.7 f-i	0.74 a-c	0.819 ab	0.581 h	2.05 m-s	5.07 e-j	11.11 i-l	26.11 c-g	0.603 l-n	0.697 e-l	0.554 d-f
Koohdasht	4440.6 f-i	3297.8 i	0.78 ab	0.819 ab	0.687 cd	2.73 k-q	6.27 a-f	12.59 h-l	33.33 c-e	0.610 k-n	0.802 a-d	0.723 ab
Darab2	6544.3 a-e	4229.0 f-i	0.65 a-c	0.857 ab	0.665 c-f	1.86 m-s	5.40 d-i	10.13 j-l	26.00 c-g	0.615 k-n	0.782 a-f	0.722 ab
Simareh	6573.9a-e	5756.7 c-g	0.88 a	0.807ab	0.679 c-e	4.30 g-k	6.40 a-e	7.80 kl	28.23 c-g	0.654 i-m	0.855 a	0.675 a-d
Flat	7178.1 a-c	5092.6 d-i	0.72 a-c	0.823 ab	0.658 c-g	0.567 rs	5.60 c-h	6.36 l	22.33 e-i	0.643 i-m	0.690 g-l	0.651 a-e
Niknejad	5788.1 c-g	3952.4 f-i	0.72 a-c	0.806 ab	0.652 c-g	1.43 o-s	4.43 f-k	9.88 j-l	25.44 c-g	0.621 j-n	0.750 b-h	0.749 ab
Yavarus	5444.9 c-h	4467.8 f-i	0.82 ab	0.856 ab	0.693 cd	4.06 g-l	7.77 ab	12.70 h-l	33.75 cd	0.665 h-m	0.808 a-c	0.641 b-e
Roshan	7354.6 a-c	5774.3 c-g	0.79 ab	0.820 ab	0.654 c-g	0.317 rs	6.40 a-e	12.59 h-l	32.56 c-e	0.638 i-m	0.796 a-d	0.738 ab
Azar2	5436.0 c-h	4664.6 e-i	0.86 a	0.817 ab	0.677 c-e	0.867 q-s	6.93 a-e	13.69 h-l	48.33 a	0.657 i-m	0.810 a-c	0.705 a-c
Tabasi	5805.1 c-g	4151.3 f-i	0.73 a-c	0.816 ab	0.597 f-h	1.20 p-s	7.93 a	13.06 h-l	25.33 c-g	0.686 h-l	0.777 a-g	0.667 a-d
Zarin	7816.6 ab	4361.7 f-i	0.57 bc	0.832 ab	0.591 gh	0.800 rs	5.73 c-h	8.19 kl	21.00 e-j	0.603 l-n	0.697 e-l	0.501 f
Alamut	7985.6 a	3860.5 g-i	0.49 c	0.836 ab	0.631 c-h	0.233 s	5.90 c-g	11.31 i-l	23.44 d-h	0.607 k-n	0.683 h-l	0.528 ef
Toos	6704.8 a-d	5392.3 c-h	0.84 ab	0.806 ab	0.667 c-f	1.67 n-s	6.90 a-e	7.93 kl	35.00 b-c	0.723 c-i	0.796 a-d	0.725 ab
Pishtaz	5939.2 b-f	4322.6 f-i	0.74 a-c	0.804 ab	0.701 c	1.47 o-s	7.27 a-d	10.97 i-l	44.44 ab	0.693 f-l	0.830 ab	0.787 a
Alvand	7788.3 ab	5396.1 c-h	0.72 a-c	0.785 b	0.608 e-h	3.40 j-n	7.33 a-c	10.90 i-l	30.67 c-f	0.587 mn	0.713 d-j	0.662 a-d
Total	6646.1 a	4560.0 b	0.71	0.825 a	0.644 b	1.98 a	6.04 b	10.15 a	28.39 b	0.642 a	0.759 b	0.663

Values followed by the same letter in each column and two columns (non-stress and drought stress) related to same indicator are not significantly different according to Tukey's test (probability level of %5).

Table 3. Pearson correlations coefficients between assessed traits in wheat genotypes under drought stress condition

	RWC	RWP	Canopy	Sr	CMS	YSI
RWC	1					
RWP	0.790**	1				
Canopy	0.409 ^{NS}	0.560*	1			
Sr	0.629**	0.653**	0.536*	1		
CMS	0.732**	0.769**	0.33 ^{NS}	0.576*	1	
YSI	0.643**	0.808**	0.577*	0.619**	0.674**	1

** and **: Significant at the 0.05 and 0.01 probability levels, respectively. NS = Non-significant.*

Pearson correlation analysis

The Pearson correlation among physiological traits had been determined under drought stress condition (Table 3). The results showed that all studied physiological traits had positive and significant correlation with YSI. The results were consistent with previous findings that indicated these physiological traits could be effective in screening of drought tolerant genotypes [2, 4, 5, 9, 20, 30]. YSI had the highest positive and significant correlation with RWP (r = 0.808**) under drought stress. There are several reports in the literature that underlined the significant relationship between the ability to maintain leaf water content and drought tolerance in several plants [11, 14, 21, 27]. Also, RWP demonstrated top positive and significant correlation with RWC (r = 0.79**) among all studied traits. Several reports indicated that RWC were closely related with yield stability in wheat [1, 22, 24]. Thus, RWC is an effective indicator to drought tolerance. Since RWP and RWC were measured with unlike methods (RWP and RWC were determined based on leaf withering weight and leaf turgid weight, respectively), thus the assessment of these indicators together could be more useful to screening drought tolerant genotypes. RWP had positive and significant correlations with Sr (r = 0.653**) and CTD (r = 0.560*). Dong et al. [25] in wheat and Yousfi et al. [21] in alfalfa reported that under stress conditions, higher Leaf water retention was a resistant mechanism to drought which the result was a reduction in stomatal conductance and transpiration rate. Also, there were positive and significant correlations between Sr and CTD (r = 0.619). In this connection it has been reported decreased water uptake closes stomates which reduces transpiration causes an increasing in canopy temperature [1, 13, 19]. According to table 3, CMS showed the highest positive and significant correlation with RWP (r = 0.769**) and closely followed by RWC (r = 0.732**) among all physiological traits. In previous literature, several reports provides evidence on the relationship between high rate of osmotic adjustment (OA) and CMS under water-limited conditions across different cultivars of crop plants [20, 21, 22, 23].

Cluster analysis

Cluster analysis showed that the genotypes based on RWC, RWP, CTD, Sr and CMS divided into four groups with 8, 6, 4 and 2 genotypes, respectively under drought stress condition (Fig. 1). As seen in dendrogram, Genotypes were located in the third and fourth groups demonstrated the highest YSI (Table 2) in comparison with other genotypes. So it is apparent these groups identified as superior groups in drought tolerance. Also all genotypes with except Chamran were in the second group had the lowest YSI while all genotypes were located in the first group with except Kavir and Simareh showed the intermediate YSI. The result of cluster analysis clearly indicated that these physiological traits could be useful for classification of genotypes for drought tolerance. Our findings were consistent with results were obtained by other researchers [6, 14, 29].

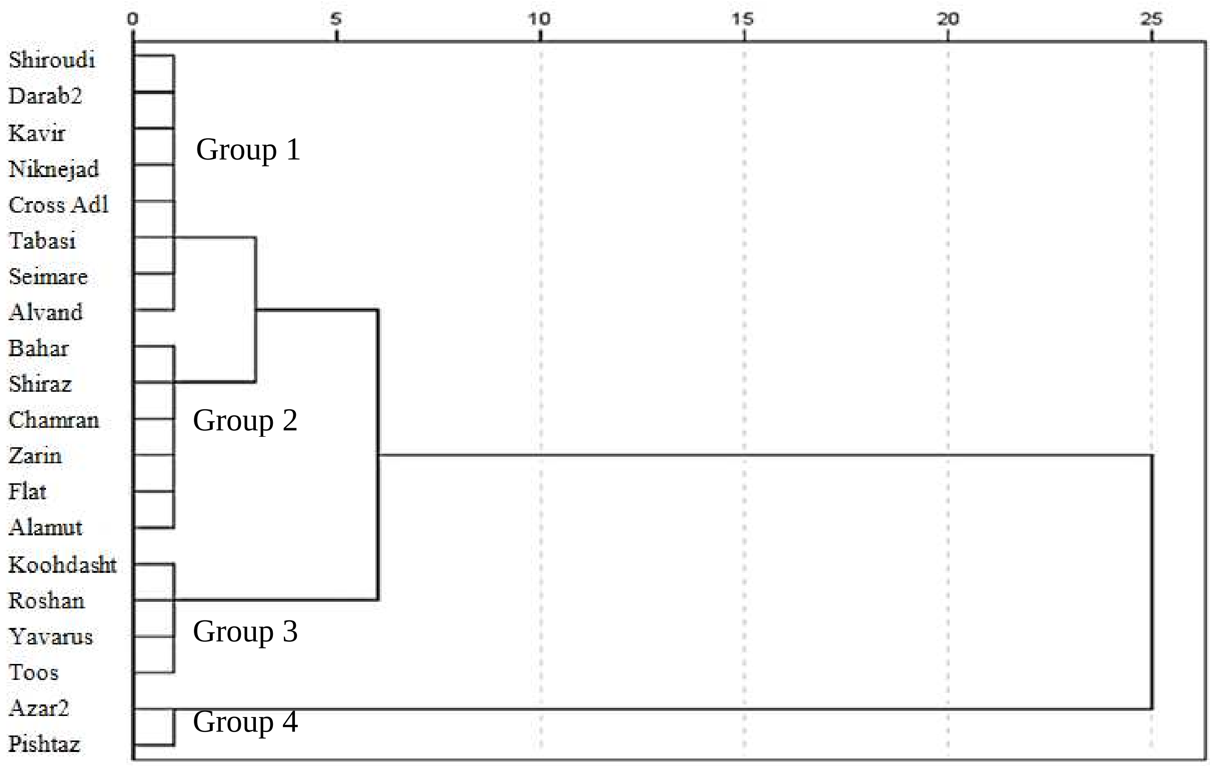

Fig. 1. Dendrogram of cluster analysis of 20 Iranian wheat genotypes classified based on RWC, RWP, CTD, Sr and CMS(*Yield in drought condition***)**

CONCLUSION

The results obtained from the present study show that there were significant differences among genotypes for all physiological traits when grown under drought stress condition. Drought stress significantly ($P < 0.05$) increased RWP, SR and CTD and decreased RWC in wheat genotypes. Drought tolerant genotypes had the highest RWC, RWP, SR, CTD and CMS under stress condition while susceptible genotypes showed lowest rate of these traits. Intermediate tolerant genotypes showed a moderately response. Also durum wheat genotypes indicated similar behaviors of tolerant bread wheat under drought stress. There were positive and significant correlations between YSI and physiological traits. YSI had the highest correlation with RWP ($r = 0.808^{**}$) under stress and also RWP demonstrated top positive and significant correlation with RWC ($r = 0.79^{**}$) among all studied traits. Cluster analysis classified the genotypes into four groups. The findings of our study showed that assessed of physiological traits could be effective for classification and screening of drought tolerant genotypes. In finally, RWP and RWC were selected as the best criteria for predicting drought tolerant genotypes and also Kavir and Alamut genotypes were identified as the most tolerant and susceptible genotypes ,respectively.

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