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Relation of morphological and photosynthetic traits durum wheat genotypes under normal and drought stress conditions

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Key words: Chlorophyll content, chlorophyll fluorescence, morphological traits, environmental stress, durum wheat.

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Abstract

The objective of this study was to identify indicators related to drought tolerance through analysis of morphological and photosynthetic traits in Omrabi5, Altar, Yavarus, Fadda, Korifla, Zardak, Stork, Ammar Hurani, Chakmak cultivars of durum wheat genotypes. These traits were chlorophyll content, maximum quantum yield of photosystem II, Biomass and grain yield, length plant, spike length, number of kernel per spike, kernel weight per spike, weight of each spike, awn length, which studied were used to investigate the combined and correlation analysis between these traits in both well-watered and drought stress conditions. The results of combined analysis reflected that treatment effects on chlorophyll content and chlorophyll fluorescence levels were significant at 5%, while that effect of treatment per environments on the biomass yield, length plant, spike length, number of kernel per each spike and length awn traits were significant at 1%, this result showed that the grain yield , number spike per bush, weight kernel per spike traits were significant at 5%. Result of correlation analysis showed that between grain yield trait with number of kernel per spike, and between length plant with spike length, and between number of kernel per spike with kernel weight per spike, and between spike weight trait with number of kernel per spike, and between weight of each spike with kernel weight per spike, had positive and significant correlate at 1% probability. In this case between chlorophyll content and biomass trait with length plant, and between grain yield trait with kernel weight per spike and weight of each spike traits were correlated significant positively at 5%. results showed that chlorophyll content reduced significantly in stress condition, and the most of decrease lookout for sensitive cultivars, It was concluded that photosynthetic response to stimulate water deficit and morphological treats relation could be considered as reliable indicators in screening durum wheat germplasm for drought tolerance.

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Introduction

Drought is one of the most common environmental stresses that limit durum wheat production in drought areas, Abiotic is one of the most important factors that reduced plant photosynthesis(Bigonah hamlabad, 2010). Changes in global climate are forecast to increase the extension of drought prone areas. A viable solution for crop production in these areas is to develop drought tolerant varieties(Bigonah hamlabad *et al*, 2011). physiological approach would be the most attractive way to develop new varieties (Araus *et al.,* 2008), but breeding for specific environments involves a deeper understanding of yield determining process. Drought stress has shown that photosynthesis reduction in such conditions is associated with malfunction of biochemical reactions (Seyed Sharifi *et al*, 2011; Lauer and Boyer, 1992). The photosystem II (PSII) is highly sensitive to environmental limiting factors and PSII reaction center and its chemical reactions being adversely affected by drought stress (Vazan, 2002;Cornic, 1994).There are many constraints during grain filling stage that generally influence cereals yield (Bigonah hamlabad, 2010; Liang *et al,*1997). Photosynthesis, which is the most significant process influence crop production, is also inhibited by drought stress. High photosynthetic rate is considered to be one of the most important breeding strategies for crop improvement (Richards,2000). However, selection for higher rates of leaf photosynthesis has not generally improved the yield in favorable environments, most probably because the source is less limiting than the sink (Abbad *et al.*, 2004) and greater success might be expected for higher rates under water stress. Chlorophyll fluorescence analysis may also provide a sensitive indicator of stress condition in plants. It can also be used to estimate the activity of the thermal energy dissipation in photosystem II, which protects photosytems from the adverse effect of light and heat stress. The measurement of chlorophyll fluorescence *in situ* is a useful tool to evaluate the tolerance of the photosynthetic apparatus to environmental stress (Maxwell *and* Johnson, 2000). Values lower than this are measured when the plant is exposed to stress, indicating a particular phenomenon of photo-damage to PSII reaction centers, and the development of slowly relaxing quenching process (Baker and Rosenqvist, 2004) which reduce the maximum efficiency of PSII photochemistry. Chlorophyll fluoresces measurement is a non-destructive non-time consuming and relatively simple technique for studying the equilibrium between metabolic and energy evolving processes, that maybe affected by both temperature and drought stresses (Ali-Dib *et al.*, 1994; Araus *and* Hogan, 1994; Flagella *et al.*, 1994). FV/FM in a previously dark-adapted leaf that is subjected to light, shows potential or maximum quantum yield in PSII. The extreme photosynthetically photon flux density is an important factor affecting quenching in FV/FM ratio under normal conditions (Lu *et al.,* 2002). Declining slope of FV/FM is a valuable criterion for evaluation of photoinhibition in plants that are subjected to environmental stresses, such as drought and high temperatures accompanied with high radiation intensity (Angelopoulos *et al.*, 1996). It is important to know FV/FM quenching had risen from an increase in Fo or variations of other components. In general, it can be concluded that photo inhibition is responsible for drought stress (Bigonah hamlabad, 2010). Although chlorophyll fluorescence was considered as a useful tool for screening and breeding of durum wheat cultivars under dry conditions (Flagella *et al.*, 1995; Bigonah hamlabad *et al,* 2011). The effect of water stress on yield components of durum wheat at growth stages have been the subject of many studies (Simane *et al.*, 1993; Solomon *et al.*, 2003). However, no study had been conducted on the physiological and morphological response of diverse durum wheat genotypes to water deficit conditions. Therefore, the present study aims to determine water deficit effects on chlorophyll fluorescence parameters in leaves of ten durum wheat (*Triticum tugidium L. durum*) genotypes and to determine the relationship between some morphological and physiological traits and yield under water deficit.

Materials and methods

Materials

Experiments were undertaken on 10 durum wheat (*Triticum durum* Desf.). Seed's samples was Omrabi5, Altar, Yavarus, Fadda, Korifla, Zardak, Stork, Ammar Hurani, Chakmak cultivars. they were grown under normal (well-watered) and drought (water-stress) conditions in the Genetic Resources Institute in Azerbaijan(AMEA).Treatments arranged as a agriculture experiment based on a Randomized Completely Block Design (RCBD) with 3 replications. Plants were grown in 18 cm diameter and 25 cm length plastic pots filled with a textural class of loom (20% clay, 50% silt and 30% sand). The field capacity and permanent wilting point of the soil were 47% and 11%, respectively. Each pot was filled with 3 kg uniformly air-dried soil. A total of 60 pots, 30 pots were assigned to normal and 30 pots for drought condition. six seeds were sown per pot and the seedlings were thinned to three leaf growth stages. Fertilizing was done based on results of soil analysis in Soil of loom texture and all agricultural operations carried out uniformly in normal and stress condition but water-stress conditions were imposed by deleting the final step of irrigation.

Methods

Chlorophyll content index was measured in the middle of flag leaf, in three times with one week intervals. Measurements were by portable chlorophyll-meter CCM model made by Opti-scince, five flag leaves for each genotype in both well-watered and drought-stress conditions were measured 12th day after apply drought stress. Measurements of chlorophyll fluorescence were performed both on control and stressed plants at the beginning of water stress period. Intact flag leaves of durum wheat plants were adapted to darkness for 15 min using light-with-holding clips. Chlorophyll a fluorescence was measured by a portable fluorimeter OS30-p made by Opti-Scince Company.

Data were also collected for number of kernels per spike, plant height, kernel weight of spink, weight of each spinke, spike length, awn length, air-dried aboveground biomass and grain yield per plant at maturity, plants were harvested and their yield and yield components were determined for each treatment, separately. Statistical analysis was done using MSTAC, SPSS, EXCEL software for means compares and combined analysis. Means were compared using LSD range test.

Results and discussion

Results

The results of analysis of variance showed that there is a significant difference in 5% probability level between chlorophyll content (CCI) and fluorescence in this evaluation significant treatments showed that different genotype in upper traits (Table 1). The interaction between genotype and condition was significant at 5% in biomass weight ,plant height , spike length ,number kernel of spike , length awn traits . The interaction effect between genotype and condition was significant at 5% in characteristics kernel weight, number of spike in bush, weight of kernel in each spike. The significant interaction effect genotype and condition showed different yield in conditions of normal (well-watered) and drought (water-stress).block effects were not significant in Chlorophyll content , length spike ,fluorescence, weight kernel, awn length and weight kernel per spike traits, this result showed did not efficiency blocking in yield of traits. Fluorescence and Chlorophyll content traits significant in treatment effects in table 1, so means of this traits compared by LSD at 5% probability (Table2). The result of mean compared showed that the stork cultivar had the most rate of chlorophyll content in both. Drought and normal conditions and placed in A group. Korifera cultivar had the second rate of chlorophyll content in drought stress condition and placed in B group. Zardak cultivar had lowest level of chlorophyll content in drought stress condition and placed in One group respectively, It was the most susceptible culture relative to the chlorophyll content trait in drought stress condition.

Yavarus cultivar had the lowest level of chlorophyll content and located G group this result showed probability of susceptible yavarus cultivar to full-watered condition. Viewpoint of fluorescence chlorophyll all genotypes were the same level and placed in A group.

Table 3 showed result of correlation analysis in normal condition by person method. Yield grain per pots with biomass yield and number kernel per spike with weight kernel per each spike and spike weight were positively significant at 1% probability.Analysis of correlation represent fluorescence trait with grain yield had negatively significant at 5% level. yield grain of pots with kernel weight per each spike and weight spike had positively significant at 5% probability (Table 3).

Table 1a. Analysis variance for different traits in durum wheat under well-watered and drought stress condition.

V.O.S	df	Yield grain		Yield biomass		Chlorophyll content	
Condition Effect	1	0.004	ns	0.360	**	55.1	ns
Block Effect in Condition (E1)	4	0.011	-	0.007	-	88.9	-
Treatment Effect	9	0.007	*	0.340	ns	30.2	*
Condition Effect× Treatment Effect	9	0.016	ns	0.193	**	0.948	ns
Error2	36	0.007	-	0.073	-	0.969	-

**, * and ns, significant at one percent, five percent non-significant respectively.

Table 1b. Analysis variance for different traits in durum wheat under well-watered and drought stress condition.

V.O.S	df	Fluorescence		Plant height		Number of kernel in bush	
Condition Effect	1	7.038	ns	0.033	**	7.038	**
Block Effect in Condition (E1)	4	6.362	-	0.002	-	6.362	-
Treatment Effect	9	1.572	*	0.034	ns	1.572	ns
Condition Effect× Treatment Effect	9	0.579	ns	0.024	**	0.579	**
Error2	36	0.628	-	0.007	-	0.628	-

**, * and ns, significant at one percent, five percent non-significant respectively.

Table 4 represent correlation analysis in drought stress condition by person method, result of this analysis showed that grain yield trait with number of kernel per spike trait and length plant with spike length and number kernel per spike with weigh kernel per spike and weight kernel per spike with weight spike had positively significant at 1% probability (Table 4). In this case chlorophyll content trait with height plant and grain yield with kernel weight per spike and weight of each spike had positively significant at 5% probability.

Table 1c. Analysis variance for different traits in durum wheat under well-watered and drought stress condition.

V.O.S	df	Length spike		Kernel per spike		Weight of kernel per spike	
Condition Effect	1	1.98	*	0.296	ns	0.001	ns
Block Effect in Condition (E1)	4	0.038	-	0.031	-	0.028	-
Treatment Effect	9	3.01	ns	0.351	ns	0.054	ns
Condition Effect× Treatment Effect	9	2.04	**	0.209	**	0.056	*
Error2	36	0.40	-	0.063	-	0.027	-

**, * and ns, significant at one percent, five percent non-significant respectively.

Table 1d. Analysis variance for different traits in durum wheat under well-watered and drought stress condition.

V.O.S	df	Weight spike		Own length	
Condition Effect	1	0.002	ns	8.208	ns
Block Effect in Condition (E1)	4	0.006	-	1.51	-
Treatment Effect	9	0.008	ns	11.9	ns
Condition Effect× Treatment Effect	9	0.011	ns	4.52	**
Error2	36	0.006	-	1.42	-

**, and ns, significant at one percent and non-significant respectively.

Table 2. Average traits chlorophyll content and fluorescence by LSD test at the five percent level in both well-watered and drought stress condition.

Row	Cultivar	Chlorophyll content		Fluorescence	
		Well-watered	Water stress	Well-watered	Water stress
1	Omrabi5	13 G	4 H	0/796A	0/871A
2	Altar	15 E	6 F	0/801A	0/803A
3	yavarus	13 G	4 G	0/795A	0/787A
4	fadda	10 H	11C	0/801A	0/794A
5	korifera	24 B	5 G	0/796A	0/815A
6	zardak	8 I	7 E	0/803.A	0/788A
7	stork	26 A	18 A	0/802A	0/808A
8	Ammar1	15 D	11 C	0/796A	0/803A
9	hurani	18 C	15 B	0/800A	0/817A
10	ckakmak	14 F	10 D	0/793A	0/783A

Table 3. Correlation analysis using Pearson method under well-watered Condition.

chlorophyll content	fluorescence	grain yield	Biomass yield	length plant	spike length	number of kernel per spike	Kernel weight per spike	weight of each spike	Awn length	
1										chlorophyll content
-.022	1									fluorescence
.147	-.637(*)	1								grain yield
.580	-.527	.780(**)	1							Biomass yield
.280	.134	-.100	.064	1						length plant
.144	.180	-.064	-.051	.320	1					spike length
.074	-.104	.562	.277	.539	.315	1				number of kernel per spike
-.013	-.234	.681(*)	.286	.191	.403	.877(**)	1			Kernel weight per spike
-.059	-.301	.670(*)	.285	.054	.483	.799(**)	.939(**)	1		weight of each spike
.116	-.555	.378	.059	-.343	-.091	.120	.377	.387	1	Awn length

**, * , significant at one percent, five percent respectively.

Figure 1 showed rate chlorophyll content of 10 varieties in both unstressed and drought stress condition, we consider as by accession drought stress reduced chlorophyll content rate noteworthy, cultivar of 2, 5, 7 and 9 had the highest chlorophyll content in normal condition. Chlorophyll content reduced more in 1, 2, 3, 5 and 7cultivar. Figure 2 showed means of fluorescence chlorophyll in both drought stresses and watered condition, fluorescence chlorophyll trait increased in drought stress condition. Results showed that fluorescence chlorophyll increased significantly in stress condition, and the most of increase lookout for sensitive cultivars (Figure 2).The cultivars of 1, 5, 7, 9 had the most fluorescence chlorophyll, and the most of increase was rather for the drought resistant 1 and 5 cultivars (Figure 2).

Table 4. Correlation analysis using Pearson method drought stress condition.

chlorophyll content	fluorescence	grain yield	Biomass yield	length plant	spike length	number of kernel per spike	Kernel weight per spike	weight of each spike	Awn length	
1										chlorophyll content
-.200	1									fluorescence
.174	.193	1								grain yield
.609	.040	.411	1							Biomass yield
.649(*)	-.495	.178	.636(*)	1						length plant
.598	-.431	-.048	.431	.861(**)	1					spike length
-.020	-.170	.773(**)	.131	.338	.181	1				number of kernel per spike
.080	-.237	.757(*)	.212	.458	.261	.981(**)	1			Kernel weight per spike
.215	-.298	.723(*)	.365	.617	.379	.922(**)	.949(**)	1		weight of each spike
-.239	.225	.310	-.017	.076	.260	.534	.526	.342	1	Awn length

**, * , significant at one percent, five percent respectively.

Discussion

In the present study, number of kernel per spike and Kernel weight per spike and weight of each spike were positively and significantly correlated with grain yield per plant. This positive relationship between grain yield and morphological traits under water deficit condition indicate that low growth rate of plants is one of the limiting factors of yield under water deficit conditions (Simane *et al.*, 1993; Villegas *et al.*, 2001). Therefore, genotypes with greater growth rate under such condition would 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).Chlorophyll fluorescence parameters were not associated with grain yield and aboveground biomass yield under water deficit condition. Chlorophyll content reduced significantly in stress condition, and the most of decrease lookout for sensitive cultivars. chlorophyll content reduced in genotype number 1, 2, 3, 5, 7 based chart 1 this occur can be result of the relevant to the destruction of light phase of reaction in photosynthesis(Rong-hua 2006). The results showed that net photosynthesis was severely reduced under water deficit condition. These results are in agreement with Condon *et al.* at 2002. Chlorophyll fluorescence analysis is a sensitive indicator of the tolerance of the photosynthetic apparatus to environmental stress (Maxwell and Johnson, 2000). Chlorophyll fluorescence parameters in this study were sensitive to water deficit at tillering and grain-filling stages. Similarly, the fluorescence ratio, which characterizes the maximum yield of the primary photochemical reaction in dark-adapted leaves and frequently used as a measure of the maximal photochemical efficiency of PSII (Krause and Weis, 1991), was reduced under water deficit condition. The patterns of changes in fluorescence parameters observed in this study are supported by the pattern of change reported by many authors under drought conditions (Long *et al.*, 1994; Aruas *et al.*, 1998;Zlatev and Yordanov, 2004).The genetic variability found for these morphological traits among durum wheat genotypes studied also suggest opportunity for selection superior genotype in water-limited environments. Results showed that chlorophyll content reduced significantly in stress condition, and the most of decrease lookout for sensitive cultivars, It was concluded that chlorophyll content and fluorescence and morphological treats relation could be considered as reliable indicators in screening durum wheat germplasm for drought tolerance.

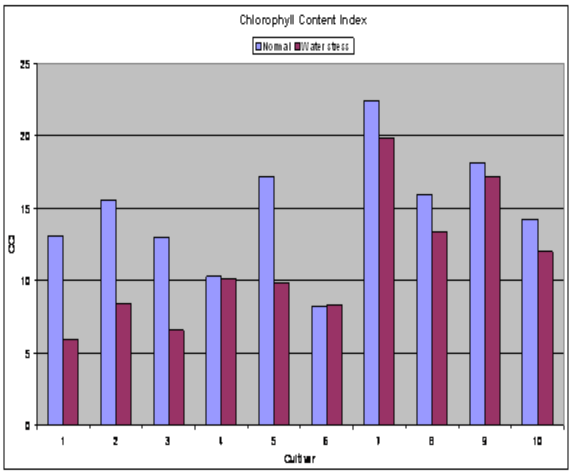

Fig. 1. Chlorophyll Content Average under Well-watered and drought stress in 10 varieties of durum wheat.

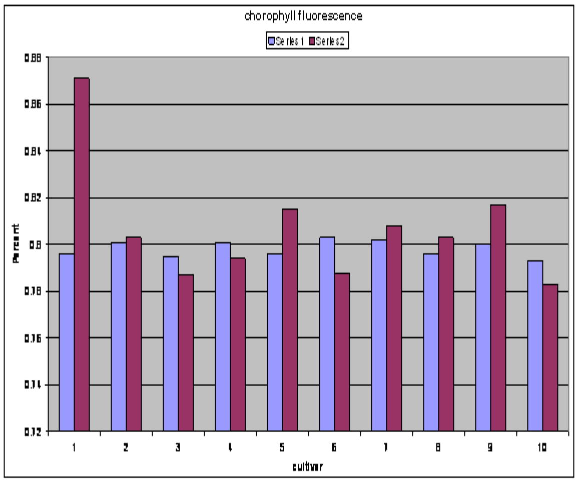

Fig. 2. Fluorescence Average Content Average under Well-watered and drought stress in 10 varieties of durum wheat.

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