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Assessing the yield and its relationship with some of the physiologic traits in bread wheat cultivars under terminal drought stress

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ABSTRACT

Climatic factors fluctuations are among the reasons for yield change in crops during various seasons and in different locations. Grains provide 70 percent of the food for humans and these plants are considered as the main basis for human nutrition and survival. In order to assess the yield and study its relationship with some physiologic traits in bread wheat cultivars under terminal drought stress, an experiment in the form of randomized complete block design with three replications was carried out during 2015-2016 crop year in Ardabil IAU Research Farm (5 km west of Ardabil). ANOVA results suggested that there was a significant difference among the studied bread wheat cultivars based on all traits, except for photochemical efficiency of photosystem II (FV/Fm). Results from data mean comparison indicated that the cultivar of Pishtaz had the highest yield and cultivars of Rasad, Soissons and Seri 82 had the best yield after cultivar of Pishtaz. Also, the lowest yield was related to cultivars of Soltan-95 and Kenya-2002. Additionally, results showed that in most physiologic traits, cultivar of Seri 82 had the highest values.

KEY WORDS: TERMINAL DROUGHT STRESS, PHYSIOLOGIC TRAITS, GRAIN YIELD, WHEAT

INTRODUCTION

Population growth phenomenon in developing countries and high variety of foodstuff and its high consumption in developed countries have led an unprecedented increase in demand for foodstuff in the world. (Akhavan, 2006) Grains provide 70 percent of the food for humans and these plants are considered as the main basis for human nutrition and survival. (Emam, 2007) Climatic factors fluctuations are among the reasons for yield change in crops during various seasons and in different locations which lead to complexity in optimization and reaching these goals. (De keeijer, 2003) Plant growth is one of the most complex and most sensitive life phenomena regarding environmental parameters which is the reflection of the plant's response to the

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environmental changes. Decrease in growth under unsuitable environmental conditions is attributed to the disconnect between plant yields. Hence, growth specifically requires proper relationship between metabolic processes in various parts. (Brevedan and Egli, 2003) In Araus et al. (1998) study, the impact of drought stress was significant on F_m and F_0 parameters in consecutive measurements and except for the first measurement, it led to increase in them in all parameters. However, in Paknejad and Nasri (2007) study, F_m and F_0 parameters were not affected by the drought stress. Although in most studies, efficiency of photosystem II decreases due to the drought stress, in Havaux (1999) photosystem II was resistant against drought stress. These results are approved in other studies, too. (Živčák et al., 2008; Christen et al., 2007) According to Živčák et al. (2008), florescence parameters are suitable for studying photosynthesis efficiency in initial stages of drought emergence and after the initial stages of drought, in which the limitation of photosynthesis emerges due to the closure of stomata, florescence parameters could not be used.

Results from Mahmudiyan et al. (2011) suggested that moisture regime has had significant impact on traits of stomatal conductance, grain yield, harvest index, grain production rate and grain weight per ear. There was a significant difference between cultivars and lines of this study based on most physiologic traits. The main objective in this research was to study the impact of physiologic traits on wheat cultivars yield under drought stress.

METHODOLOGY

This experiment was carried out in the form of randomized complete block design with three replications during 2015-2016 crop year in Ardabil IAU Research Farm (5 km west of Ardabil). The region climate is Semi-arid and cold and the temperature during winter is usually subzero. The altitude of this location is 1350 m above sea level and its latitude and longitude are 38.15 N and 48.2 E, respectively. The experienced treatments included 6 various bread wheat cultivars (Rasad, Pishtaz, Kenya-2002, Soltan-95, Soissons and Seri 82). Tillage operation including moldboard plowing, disc, leveler, and furrow, were carried out on the fallow land. In each plot, six lines with a distance of 20 cm were formed and harvested with a length of six meters and seed density of 450 seeds per square meters. The area of each plot was 7.2 square meters and the harvested area was six meters through omitting half a meter from the beginning and the end of each plot in order to exclude the effect of margin. After the bushes grew up and reached the flowering stage, in order to apply the stress and prevent reaching rain, rain exclusion shelter was used. By the beginning of the stress, measuring the fluorescence of chlorophyll, chlorophyll content of leaves, relative water content and stomatal conductance was conducted after pollination stage. Ultimately, after reaching physiological maturity, the grain yield of 1 square meters was calculated.

RESULTS AND DISCUSSION

ANOVA results suggested that there was a significant difference between the studied wheat cultivars based on traits of leaf chlorophyll rate, water loss from separated leaf and grain yield at one percent probability level, and based on traits of leaf stomatal conductance, relative water content, harvest index and biologic yield at five percent probability level. Also, results indicated that there was no significant difference between the cultivars based on photochemical efficiency of photosystem II (FV/Fm) (Table 1).

Bakhshande et al. (2006) showed that there was a significant difference between the studied genotypes based on the traits of the harvest index and biologic yield at 5%. Amini (2003) reported a significant difference between the studied genotypes based on the traits of the number of days to heading, bush height, maturity time, number of seeds per ear, thousand kernel weight and grain yield at 1%. 'Abdoli et al. (2013) reported there was

Table 1. Analysis of variance the traits in different cultivars of wheat

S.O.V	DF	Mean Square							
		Leaf Chlorophyll Rate	Leaf Stomatal Conductance	photochemical efficiency of photosystem II (FV/Fm)	Relative Water Content	Water Loss from Separated Leaf	Biologic Yield	Harvest Index	Grain Yield
Replication	2	151.01	626.69	1.58	28.49	0.08	1.55	10.80	0.16
Treatment	5	147.85**	2692.35*	3.06 ns	121.91*	211.60**	10.27*	35.99*	0.82**
Error	10	15.84	589.11	1.58	33.75	23.54	2.002	10.66	0.13
C.V %		12.28	15.40	1.63	6.67	9.77	10.54	18.97	15.18

* and ** respectively significant 5% and 1%

Table 2. Mean comparison of genotypes for the studied traits

Genotype	Studied traits						
	Leaf Chlorophyll Rate	Leaf Stomatal Conductance	Relative Water Content	Water Loss from Separated Leaf	Biologic Yield	Harvest Index	Grain Yield
Rasad	22.49 c	154.47 ab	87.17 ab	57.35 ab	14.97 ab	11.11 b	2.32 ab
Pishtaz	28.70 bc	119.53 b	89.38 ab	42.63 c	16.39 a	19.34 ab	3.25 a
Kenya-2002	43.37 a	169.33 ab	75.09 b	49.42 abc	12.93 ab	16.22 ab	2.12 b
Soltan-95	32.43 abc	177.44 ab	86.91 ab	41.86 c	11.75 b	16.45 ab	1.64 b
Soissons	31.46 bc	127.25 bc	90.97 ab	44.47 bc	12.03 b	20.45 a	2.42 ab
Seri 82	36.04 ab	197.30	93.32 a	62.16 a	12.45 ab	19.71 ab	2.25 ab

not a significant difference between the studied cultivars based on the trait of photochemical efficiency of photosystem II. Gale et al. (2002) also observed that there was not any change in photochemical efficiency of photosystem II due to the drought stress application among various wheat cultivars.

LEAF CHLOROPHYLL RATE

Data mean comparison indicated among the studied wheat cultivars, the highest leaf chlorophyll rate with a mean of 43.37 CCI was related to the cultivar of Kenya -2002 and it was put in group A along with cultivars of Soltan-95 and Seri 82, and they didn't show any significant difference based on this trait. Also, the cultivar of Rasad with a mean of 22.49 CCI had the lowest leaf chlorophyll rate.(Table 2).

Gregersen and Holm (2007) expressed that the chlorophyll content decreases during water stress and cultivars with higher chlorophyll content show a higher resistance in this stress condition. Chlorophyll content not being suitable for assessing resistant towards drought was expressed by Zarei (2007).

LEAF STOMATAL CONDUCTANCE

Data mean comparison indicated among the studied wheat cultivars, the highest leaf stomatal conductance with a mean of 197.30 mm/cms was related to the cultivar of Seri 82 and it was put in group A along with cultivars of Rasad, Kenya-2002 and Soltan-95, and they didn't show any significant difference based on this trait. Also, the cultivar of Pishtaz with a mean of 119.53 mm/cms had the lowest leaf stomatal conductance, and it was put in group B along with the cultivar of Soissons (Table 2).

RELATIVE WATER CONTENT

The highest relative water content rate (93.32 percent) was related to the cultivar of Seri 82 and it was put in group A along with cultivars of Rasad, Pishtaz, Soltan 98, and Soissons. On the other hand, the lowest relative water content was related to the cultivar of Kenya-2002 with a mean of 75.09 percent (Table 2).

According to the results of the research conducted by 'Abdoli et al. (2013), it was determined that leaf relative water content rate decreased by 8.3 percent in drought stress. Also, they reported that there was a significant difference observed between studied cultivars based on leaf relative water content.

WATER LOSS FROM SEPARATED LEAF

The cultivar of Seri 82 had the highest water loss from separated leaf (with a mean of 62.16 oercent) and it was in the best group along with the cultivars of Rasad and Kenya-2002. On the other hand, the lowest water loss from separated leaf with means of 41.86 and 42.63 percent was related to the cultivars of Soltan-95 and Pishtaz (Table 2).

BIOLOGIC YIELD

Data mean comparison showed that the cultivar of Pishtaz with a mean of 16.39 tons per hectare had the highest biologic yield and it was put in the best group along with the cultivars of Rasad, Kenya-2002 and Seri 82, and they did not show any significant difference in this trait. On the other hand, the cultivars of Soltan-95 and Soissons were in the one statistical level and had the lowest biologic yield (Table 2).

In drought stress, accelerated aging of photosynthetic tissues and also decrease in current photosynthesis of the plant lead to a decrease in biomass production. Emam et al. (2007) and Pireivatlou et al. (2010) reported results related to a decrease in biologic yield due to the drought stress.

HARVEST INDEX

Mean comparison indicated that the highest harvest index (20.45 percent) was related to the cultivar of

Soissons and it did not show any significant difference with the cultivars of Pishtaz, Kenya-2002, Soltan-95 and Seri 82 and they were put in one statistical level. Also, the cultivar of Rasad with a mean of 11.11 had the lowest harvest index (Table 2).

Decrease in harvest index in drought stress condition after flowering is attributed to the decrease in access to the current processed materials during grain filling period. (Emam, 2011; Emam and Niknejhad, 2011) Decrease in harvest index due to the terminal drought stress has been reported by other researchers as well. (Emam, 2011; Wang et al., 2001) In drought stress condition, decrease in photosynthetic activities ultimately leads to a decrease in the transfer of produced materials to the seeds and this leads to a decrease in harvest index. (Gooding et al., 2003).

GRAIN YIELD

Data mean comparison showed that the cultivar of Pishtaz with a mean of 3.25 tons per hectare had the highest grain yield and it was put in one group along with the cultivars of Rasad, Soissons and Seri 82, and they didn't show any significant difference based on this trait. On the other hand, the lowest grain yield was from the cultivars of Soltan-95 and Kenya-2002 which were in the same statistical level and in the last ranking (Table 2).

Abdoli and Saeidi (2012) showed that irrigation cut after pollination decreases the grain yield and thousand kernel weight to 33.9% and 26.4% respectively in various wheat cultivars.

Results from Ramezanpour and Dastfal (2004) showed that 25 and 50 percent of decrease in the water lead to 21.8 and 40.7 percent decrease in grain yield, respectively. Also, biologic yield index decreased by 16.4 and 32.2 percent, respectively.

CONCLUSION

Since modification of grain yield is usually difficult due to its low heritability, suitable physiologic properties should be searched for in order to maximize the relationship with formation of grain yield in various environmental conditions. It seems that by studying phonologic traits, such as relative water content, chlorophyll content, photochemical efficiency of photosystem II, stomatal conductance and water loss from separated leaf, cultivars resistive to drought stress could be easily identified. Based on retrieved results, the cultivar of Pishtaz is the most yielding cultivar in water drought condition and planting it by the farmers in Ardabil Region, in addition to leading a higher yield comparing to the other studied cultivars, could entail a lower risk in drop in production in case of drought stress emergence during grain filling stage. Accordingly, cultivars of Rasad, Soissons ans Seri 82 are in the next ranks.

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