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EVALUATION OF SOME PROPERTIES FOR DROUGHT RESISTANCE IN BREAD WHEAT*

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ABSTRACT

One of the most important factors limiting wheat yield is drought, due to inadequate rainfall and its erratic distrubition. The drought which was occurred during especially grain filling in Aegean Region leads to significantly declined yield. For this purpose, bread wheat varieties which were Golia 99, Basribey 95, Cumhuriyet 75, Sagittario, Pamukova 97 and Negev evaluated for drought tolerance. The study was conducted irrigated and rainfed conditions as field and germination observations. The examined characters were evaluated, in terms of resistance to non-irrigated conditions. The plant height, spike number per square meter, grain yield, coleoptile length and radicle length were concluded to be taken into consideration. Cumhuriyet 75, Negev and Sagittario varieties may be more efficient in drought years and these varieties can be said to use succesfully the drought resistance breeding works.

Key Words: Crop physiology drought; wheat; yield; yield components

Ekmeklik Buğdayda Kurağa Dayanıklılık İçin Bazı Özelliklerin Değerlendirilmesi

ÖZET

Buğday verimini sınırlayan en önemli faktörlerden birisi yağışın yetersiz ve düzensiz dağılımından kaynaklanan kuraklıktır. Ege Bölgesi'nde özellikle tane dolumu süresince meydana gelen kuraklık verimin azalmasına neden olmaktadır. Bu nedenle Golia 99, Basribey 95, Cumhuriyet 75, Sagittario, Pamukova 97 ve Negev ekmeklik buğday çeşitleri kuraklığa tolerans için değerlendirilmiştir. Çalışma, sulama ve yağış koşullarında tarlada ve çimlenme gözlemleri olarak yürütülmüştür. İncelenen özellikler susuz koşullarda dayanıklılık açısından değerlendirilmiştir. Bitki boyu, metrekarede başak sayısı, tane verimi, koleoptil uzunluğu ve kökçük uzunluğunun göz önünde bulundurulması gerektiği sonucuna varılmıştır. Cumhuriyet 75, Negev ve Sagittario çeşitlerinin kurak yıllarda daha verimli ve kuraklığa dayanıklı ıslah çalışmalarında başarılı bir şekilde kullanabileceği söylenebilir.

Anahtar Sözcükler: Buğday, kuraklık, ürün fizyolojisi, verim, verim komponenti

INTRODUCTION

Drought stress, which is a natural stress factor, has the highest percentage with 26% part when the usable areas on the earth are classified in view of stress factors. It is followed by mineral stress with 20% part, cold and freezing stress with 15% part. Whole the other stress get 29% part whereas only 10% area is not exposed ant stress factors. Therefore drought stress is one of the most widespread environmental stresses, which affects growing and productivity; it induces many physiological, biochemical and molecular response on plants, so that plants able to develop tolerance mechanisms which will provide to be adapted to limited environmental conditions. Plants exposed to numerous stress factors during their life. These stress factors, which are rarely able to have an effect apart on plants, usually affect plants synchronously. Biotic (pathogen, competition with other organisms) and abiotic (drought, salinity, radiation, high temperature or freezing etc.) stresses cause changes in normal physiological functions of all plants, including economically important cereals as well. All these stress factors reduce biosynthetic capacity of plants and might cause damages that would be able to destroy plants (Kalefetoğlu and Ekmekci, 2005).

Water deficit is considered to be among the most severe environmental stresses and the major constraint on plant productivity; losses in crop yield due to water stress probably exceed the loss from all other causes combined. This deficit has an evident effect on plant growth that depends on both severity and duration of the stress (Rampino et al 2006). Drought induces a diverse set of physiollogical, biochemical and molecular responses in plants, which provide the ability of adaptation to limited environmental conditions, depending on intensity and periods of stress, interactive effects of the other stress types, development stage and genotype of plants (Kalefetoğlu and Ekmekci, 2005).

Among all the factors limiting the wheat productivity, drought remains the single most important factor affecting the world security and sustainability in agricultural production. At least 60 million ha of wheat is grown in marginal rainfed environments in developing countries. For improving yields under dryland conditions, the development of new wheat cultivars with high grain yield potential through identifying drought tolerance mechanism is

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of great significance (Rajaram et al. 1996). The severity of drought experienced by a crop is determined by both the intensity and duration of water is determined by both the intensity and duration of water deficit. Selection mainly for grain yield under drought stress conditions is difficult due to its low heritability resulting from variations in the intensity of the stress throughout the field (Blum, 1988). The improvement of yield under stress must combine a reasonably high yield potential with specific factors which would buffer against a severe yield reduction under stress. It appears that no singular drought-adaptive trait conferring adaptation to dry environments is predictive of plant response to stress and that multiple physiological selection criteria are required (Acevedo and Ceccarelli, 1989). The present study was undertaken to investigate plant traits which are associated with drought tolerance in bread wheat and to determine suitable selection criteria for selecting genotypes tolerant to drought stress conditions.

Moisture deficiency, especially after anthesis, is one of the main constrains of wheat production. Therefore, selection and breeding for drought tolerance has been the main challenge of wheat breeders and wheat scientists throughout the last 50 years. Drought stress is the main problem of the wheat production in many parts of the world.

Drought stress can reduce grain yield. Drought stress may occur throughout the growing season, early or late season, but its effect on yield reduction is highest when it occurs after anthesis. Morphological characters such as root length, tiller, number of spike per m^2, grain per spike number, fertile tillers, tillers per plant, 1000 grain weight, peduncle length, spike weight, stem weight, awn length, grain weight per spike etc. affect the wheat tolerance to the moisture shortage in the soil. Also some physiological characters of the wheat cultivars, such as rate of root respiration increase in higher absisic acid and air CO_2 concentrations and phenological traits such as number of days to heading, anthesis and maturity influence the drought to tolerance of the wheat cultivars. Selecting wheat genotypes that could tolerate drought stress and produce acceptable yield has been the major challenge for the wheatbreeders in the past 50 years. It has been found that under the drought stress conditions, those genotypes showed that the highest harvest index and highest yield stability are drought tolerant.

MATERIALS and METHODS

An experiment was conducted in 2007-2009 at the Field Crops Department of the Faculty of Agriculture at Adnan Menderes University in Aydin, Turkey. Aydin province is stuated at 37° 39' E and 27° 52' N in the west Aegeon Region of Turkey, and typical Mediterranean climatic conditions are dominant in Aydin. Six cultivars, Golia, Basribey, Cumhuriyet 75, Sagittario, Pamukova and Negev were tested in fields and petri. The 9 kg NPK da^{-1} was applied as 15-15-15 fertilizer with sowing and 5 kg NPK da^{-1} was applied as 20-20-0 at tillering stage at the first year of experiment in the field. Trial plots were 5 m x 1.2 m sizes and sowing density was 600 plants per square meter and 20 cm row.The other half of N were given tillering (4.5 kg N da^{-1} as ammonium nitrate) and jointing (4.5 kg N da^{-1} as urea) stages, respectively in the first year. The second year the other parts of N were given tillering (7 kg/da as ammonium nitrate) and jointing (6 kg N da^{-1} as urea) stages, respectively. Irrigated plots to be irrigated during flowering period was 50 mm. Weeds were controlled by Topic (2 ml da^{-1}) in the first year, and Grandstar (20 ml da^{-1}) in the second year. After coming to physiological maturity plants were harvest.

Polyethylene glicol was used for germination test. The 100 seeds were placed every germination plates. Three application was applied (control, 10 % PEG 4000, 16 % PEG 4000). At the end of the fifth day, the germination measurements were made. The experiments were designed in Split-Split Plot Design with 3 replications.

RESULTS and DISCUSSIONS

Drought, which is generally defined as the rainfall values below the average of underground and surface water values, is in the first place of the natural disasters in the world. Human activities like burning of fossil fuel, destroying forests, industrial activities cause increasing the “greenhouse gases” such as carbon dioxide, methane, ozone and dinitrogen and as a result of that the climatic changes increases in the world. Drought, which may cause reduction in feeding capacity of the natural resources and as a result of that millions people may die due to starvation, is the major threat for all biologic life. For this reason, research works on determination the plant species tolerant to drought, determining the tolerance mechanisms, conservation and transformation of the gene resources of the plants resistant to drought will play an important role in preventing the drought particularly caused by global warming, to become a major problem for all organisms in the future (Kalefetoglu and Ekmekci, 2005).

Plants are exposed to numerous stress factors during their lives, which is of a significant effect on the growth of plants. Biotic stress (pathogen, salinity, radiation, high temperature or freezing etc.) cause changes in normal physiological functions of all plants, including econonically important cereals as well.

The study was conducted irrigated and rainfed conditions as field trials and germination observations. Firstly, plant height, number of spikes

per square meter and grain yield at field conditions were analyzed. The first year of trial showed that application and variety factors and interaction were occured statisticially significant. The application and variety factors were significant in the second year (Table 1). The plant height for all varieties were decreased under drought conditions. Golia had been the least affected variety by drought. On the other hand, Negev had been the most affected variety (Table 2). The bread wheat (*Triticum aestivum* L.), durum wheat (*T. turgidum* L.), triticale (*X Tritosecale* Wittmack) and barley (*Hordeum vulgare* L) determined both under drought and non-drought conditions. Drought susceptibility appeared to be related to variation in height (Fischer and Wood, 1979).

The results of analysis of variance for the number of spikes per square meter were statisticially important both application and variety factors and interaction in both years (Table 3). Drought conditions have led to a decrease in the number of spikes per square meter. Negev has been most affected variety at drought conditions (Table 4). Drought and high temperatures has a negative effect on the number of spikes per square meter and number of grains per spike and thousand grain weight (Garcia del Moral et al. 2003). Similarly, the number of spikes per square meter of wheat in irrigated areas (589 number) was emphasized more than non irrigated areas (505 number) (Cekic, 2007). Guttieri et al (2001) were revealed that drought affects all the agronomic characters except for spike density.The first and second year grain yield data of the experiment showed that application and variety factors and interaction were occured statisticially significant (Table 5). Drought stress decreased amount of grain yield and genotype x environmental interaction for grain yield was significant (Shahryari et al. 2008). Drought conditions led to a reduction in grain yield in both years. It was observed that Negev was the most affected variety by the lack of water. The grain yield was decreased with drought conditions in the second year. The highest yield was observed in Cumhuriyet 75. Basribey had been adversely affected in drought conditions (Table 6). Similarly, the study was conducted to determine the effects of drought on the grain yield. Results showed that the grain yield was decreased 1.5-33.3 % (Baric et al. 2006).

Gupta et al. (2001) observed that drought at grain filling period was caused to decrease grain number, harvest index and grain yield. In the other hand the drought at jointing stage was decreased the plant height and tiller number.The variance analysis of coleoptile length showed that the application, variety and application x variety interaction were statisticially significant (Table 7). Poliethylene glikol was caused to reduction of coleoptile length. Increasing the dose of PEG increased the reduction in coleoptile length (Table 8). Similarly Karahan (1996), was revealed that the coleoptile lengths were 4.6 cm and 0.1 cm at 20 % PEG and 30 % PEG applications respectively compared with control (10.8 cm).

The variance analysis of radicle length showed that the application, variety and applicationxvariety interaction were statisticially significant (Table 9). Polyethylene glycol applications have led to reduction of radicle length. The radicle length was decreased with increasing dose of PEG 4000 has continued. The

Table 1. The results of analysis of variance for plant height.

Variation Source	df	Calculated means of square 2007-2008	2008-2009
Block	2	0.5	6.8
Application (A)	1	277.8 **	1042.2 *
Error 1	2	0.6	10.7
Variety (B)	5	33.1 **	549.0 **
AxB	10	8.4*	19.3
Error 2	20	1.8	9.6
General	35		

*, ** Significant $p<0.05$ and 0.01, respectively.

Table 2. The mean values for plant height (cm).

	2007-2008		2008-2009		
Varieties	Irrigated	Rainfed	Irrigated	Rainfed	Average
Golia	100.2 a	105.4 a	111.0	126.1	118.6 a
Basribey	98.6 ab	104.5 ab	89.5	101.0	95.3 c
Cumhuriyet 75	92.6 d	102.5 bc	103.3	108.6	106.0 b
Sagittario	96.4 bc	100.8 cd	89.2	102.6	95.9 c
Pamukova	94.2 cd	99.3 d	106.9	117.9	112.4 a
Negev	98.8 a	101.7 c	86.8	100.7	93.8 c
Average			97.8 b	109.5 a	
	$LSD_{(AxB)}$=2.3		$LSD_{(A)}$=3.7	$LSD_{(B)}$=4.7	

radicle lengths of Golia, Basribey, Cumhuriyet 75 and Sagittario were decreased in both doses of PEG 4000 (Table 10). Results of studies conducted in wheat showed that the PEG effect on radicle length had many variation (Kalaycı et al. 1998). The bread wheat genotypes in the study were subjected to drought stresss, which occured during the growing season, but with increases in drought conditions due to the low

Table 3. The results of analysis of variance for the number of spikes per square meter

Variation Source	df	Calculated means of square 2007-2008	2008-2009
Block	2	2.6	7.9
Application (A)	1	23149.6**	53762.1 **
Error 1	2	2.2	1.1
Variety (B)	5	26293.2**	6798.2 **
AxB	10	2416.7 **	2599.2 **
Error 2	20	5.2	0.1
General	35		

** Significant p<0.01.

Table 4. The mean values for number of spikes per square meter (number/m^2).

	2007-2008		2008-2009	
Varieties	Irrigated	Rainfed	Irrigated	Rainfed
Golia	378.3 e	480.1 e	479.5 e	521.8 c
Basribey	490.2 d	504.3 d	481.3 d	520.8 d
Cumhuriyet 75	520.6 c	520.8 c	483.2 c	519.5 e
Sagittario	572.8 a	620.9 a	503.9 b	619.5 b
Pamukova	513.4 b	563.5 b	506.9 a	620.1 a
Negev	380.1 f	470.1 e	503.8 b	620.7 a
	$LSD_{(AxB)}$=2.2		$LSD_{(AxB)}$=0.6	

Table 5. The results of analysis of variance for the gain yield.

Variation Source	df	Calculated means of square 2007-2008	2008-2009
Block	2	43.5	0.0
Application (A)	1	315806.5 **	108175.2 **
Error 1	2	99.7	2.5
Variety (B)	5	2209.6 **	42177.8 **
AxB	10	12741.5 **	19596.8 **
Error 2	20	50.1	5.0
General	35		

** Significant p<0.01.

Table 6. The mean values for grain yield (kg da^{-1})

	2007-2008		2008-2009	
Varieties	Irrigated	Rainfed	Irrigated	Rainfed
Golia	425.0 d	680.3 e	431.3 e	537.3 f
Basribey	620.1 b	825.2 a	422.6 f	747.6 b
Cumhuriyet 75	640.5 a	760.0 c	728.6 a	753.4 a
Sagittario	630.3 ab	735.7 d	559.4 b	619.8 d
Pamukova	620.0 b	720.3 d	531.6 d	658.5 c
Negev	470.7 c	800.0 b	548.8 c	563.5 e
	$LSD_{(AxB)}$=2.3			

Table 7. The results of analysis of variance for coleoptile length.

Variation Source	**df**	**Calculated means of square**
Application (A)	**2**	**5.6 ** **
Varieties (B)	**5**	**0.6 ** **
AxB	**10**	**0.6 ** **
Error	**36**	**0.0**
General	**53**	

** Significant p<0.01.

Table 8. The mean values for coleoptil length (cm)

Varieties	Rainfed	10% PEG 4000	16% PEG 4000
Golia	2.2 a	1.5 b	0.6 c
Basribey	1.6 a	0.7 b	0.5 c
Cumhuriyet 75	1.5 b	0.8 c	1.9 a
Sagittario	1.9 a	0.7 b	0.5 c
Pamukova	2.0 a	0.7 b	0.5 c
Negev	1.8 a	0.6 b	0.4 c

LSD (AxB)=0.02

Table 9. The results of analysis of variance for radicle length.

Variation Source	df	Calculated means of square
Application (A)	2	5.3 **
Varieties (B)	5	1.1 **
AxB	10	0.5 **
Error	36	0.0
General	53	

** Significant p<0.01.

Table 10. The mean values for radicle length (cm)

Varieties	Rainfed	10% PEG 4000	16% PEG 4000
Golia	4.0 a	2.1 b	2.1 b
Basribey	1.9 a	1.6 b	1.5 c
Cumhuriyet 75	2.9 a	2.4 b	1.4 c
Sagittario	2.7 a	2.3 b	2.1 c
Pamukova	2.3 a	2.3 a	1.5 b
Negev	2.6 a	2.6 a	1.4 c

LSD (AxB)=0.03

rainfall.

The drought which was occured during especially grain filling in Aegean Region leads to significantly declied yield. The examined characters were evaluated, in terms of resistance ton on-irrigated conditions the plant height, spike number per square meter and coleoptile length in germination studies with PEG 4000 was concluded to be taken into consideration. When the varieties were compared Cumhuriyet 75, Negev and Sagittario may be more efficient in drought years and these varieties can be said to use succesfully the drought resistance breeding studies.

REFERENCES

Acevedo, E., S. Ceccarelli. 1989. Role of physiologist-breeder in a breeding program for drought resistance conditions. *In* F.W.G. Baker, ed. *Drought resistance in cereals*, p. 117-139. Wallingford, UK, CAB International.

Baric, M., S.Keresa, H. Sarcevic, I.H. Jercic, D. Horvat, G. Drezner 2006. Influence of drought during the grain filling period to the yield and quality of winter wheat (*T.aestivum* L.) Prooceedings of 3rd International Congress 'Flour-Bread 05' and 5 th Croatian Congress of Cereal Technologists.

Blum, A. 1988. Plant breeding for stress environments. Boca Raton, Fla. (USA): CRC Press. 208 p.

Cekic, C. 2007. Kurağa Dayanıklı Buğday (*Triticum aestivum* L.) Islahında Seleksiyon Kriteri Olabilecek Fizyolojik Parametrelerin Araştırılması. Ankara Üni., Fen Bilimleri Enst., Toprak Anabilim Dalı, Doktora Tezi, 114 s., Ankara.

Fischer, R.A., J.T. Wood. 1979. Drought resistance in spring wheat cultivars. III. Yield associations with morpho-physiological traits. Agric.Res. 30:801.

Garcia del Moral, L.F., Y. Rharratia, D. Villegasb, C. Royob. 2003. Evaluation of grain yield and its components in durum wheat under Mediterranean Conditions: An ontogenic approach. Agronomy Journal, 95:266-274.

Gupta, N.K., S. Gupta, A. Kumar. 2001. Effect of water stress on physiological attributes and their relationship with growth and yield in wheat cultivars at different growth stages. J. Agronomy, 86:1437-1439.

Guttieri, M.J., J.C. Stark, K. Brien, E. Souza. 2001. Relative Sensitivity of Spring Wheat Grain Yield and Quality Parameters to Moisture Deficit. Crop Science, 41:327-335.

Kalapos, T., R. van den Boogaard, H. Lambers. *1996. Effect of soil drying on growth, biomass allocation and leaf gas exchange of two annual grass species. Plant Soil. 185, 137149.*

Kalayci M., M. Aydin, V. Ozbek, C. Cekic, M. Keser, F. Altay, H. Ekiz, A. Yilmaz, E. Kinaci, İ. Cakmak. 1998. Orta Anadolu Kosullarında Kuraga Dayanıklı Bugday Genotiplerinin Belirlenmesi ve Morfolojik ve

Fizyolojik Parametrelerin Geliştirilmesi. TUBITAK PROJESI, Bahri Dagdas Uluslarası Tarımsal Arastırma Enstitüsü.
Kalefetoglu, T., Y. Ekmekci 2005. The effects of drought on plants and tolerance mechanisms. G.U. journal of Science, 18 (4):723-740.
Karahan, S. 1996. Buğdaylarda (*Triticum* spp.) Kurağa Dayanma Mekanizmasının Labaratuvar, Sera ve Tarla Şartlarında İncelenmesi ve Dayanıklı Genotiplerin Seçimi ve Sonuçların Islah Programlarında Kullanılması Üzerine Araştırmalar. Selçuk Üni. Fen Bilimleri Enstitüsü, Tarla bitkileri Anabilim Dalı, Doktora Tezi, 184 s., Konya.
Rajaram, S., Braun, H.J., M. van Ginkel. 1996. CIMMYT's approach to breed for drought tolerance. Euphytica 92:147153.
Rampino, P., G. Spano, S. Pataleo, G. Mita, J.A. Napier, N. Di Fonzo, P.R. Shewry, C. Perrotta. 2006. Molecular analysis of a durum wheat 'stay green' mutant: expression pattern of photosynthesis-related genes. Journal of Cereal Science, 43:160-168.
Shahryari, R. E. Gurbanov, A. Gadimov, D. Hassanpanah. 2008. Tolerance of 42 bread wheat genotypes to drought stress after anthesis. Pak. J. Biol. Sci., 11: 1330-1335.
Simova-Stoilova, L., V.Vassileva, T. Petrova, N. Tsenov, K. Demirevska, U. Feller. 2006. Proteolytic activity in wheat leaves after drought stress and recovery. Gen. Appl. Plant Physiol., Special Issue: 91100.
Ormaetxe, I.I. P.R. Escuredo, C.A. Igor, M. Becana. 1998. Oxidative Damage in Pea Plants Exposed to Water Deficit or Paraquat. 116:173-181.

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