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Full Length Research Paper

Heat and drought resistances criteria in spring bread wheat: Drought resistance parameters

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Some spring bread wheat genotypes were evaluated for drought resistance using drought tolerance efficiency (DTE) and drought susceptibility index (DSI) under rainfed conditions in this study. Field trials were conducted in the Research Area of Field Crops Department, Agricultural Faculty, Cukurova University during 2002 - 2003 with high rainfall and 2003 - 2004 with low rainfall growth seasons. High variations were observed for drought resistance parameters both DTE and DSI in this study. While DTE values ranged from 65 - 98%, DSI values changed 0.077 - 1.761. The genotypes with high DTE and low DSI were evaluated as drought resistant; meanwhile, genotypes with low DTE and high DSI were considered as drought susceptible. Thus, genotypes Croc 1/*Aegilops squarrosa*, Genc 99, Weawer/WL 3926, Oasis/Kauz//*4 Bcn, and Punjab 96 with the lowest DSI and the highest DTE values were accepted drought resistant genotypes which may be used as the genetic sources for drought resistance.

Key words: Drought tolerance efficiency, drought susceptibility index.

INTRODUCTION

Drought is a potential major constraint to plant production, but it is a major problem for the developing countries, and in a bad climatic condition can be the major constraint on yield in developed countries as well. Although drought can strike at any time, the plants are most prone to damage due to limited water during flowering time. Plants can resist to the high temperatures by the lose of water as a result of transpiration where the stoma is disclosuring (Mujdeci et al., 2007). Some indices to determine drought tolerance are drought susceptibility index – DSI (Fischer and Maurer, 1978) and drought tolerance efficiency – DTE (Fischer and Wood, 1981). These indices are yield stability parameters which are based on how much reduction is realized under drought stress. Parameshwarappa et al. (2008) reported that the minimum yield reduction in chickpea genotypes was shown in a line which had the highest DTE and the lowest DSI. Some researchers announced that the cultivars which had the lowest DSI values were drought resistant than the cultivars with the highest DSI values (Ozkan et al., 1998; Ozturk, 1999; Zarea-Fizabady and Ghodsi, 2004; Golabadi et al., 2006; Sio-Se Mandeh et al., 2006). Indeed, DSI can be used for identification of genotypes with yield stability in moisture stressed environments (Bansal and Sinha, 1991; Ahmad et al., 2003). However, DSI could partially be determinative indice among the genotypes as resistant or susceptible to drought (Amiri and Assad, 2005).

If heat stress occurs during the post-anthesis (grain filling period), it negatively influences the movement of photosynyhetic products to the developing kernels and inhibits the starch synthesis; thus, it causes in lower grain weight also lower yield and alters grain quality (Bhullar and Jenner, 1985). The range of optimum temperatures in wheat growth are 18 - 24°C. Over these range (28 -32°C)

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even 5 - 6 days short periods cause 20% or more yield losses in wheat (Stone and Nicolas, 1994).

This study was conducted to screen drought resistant spring bread wheat genotypes with high DTE and low DSI values under drought stress in Cukurova Region of the Mediterranean.

MATERIALS AND METHODS

Field trials were conducted at Field Crops Department Research Area (Latitude: 41°04´N, Longitude: 36°71´E, and Altitude: 36 m), Agricultural Faculty, University of Cukurova, during the 2002 - 2003and 2003 - 2004 growth seasons. Trial design was a completely randomized block with three replications. Twenty four bread wheat genotypes were used as material. Seeds were sown with a plot drill (Hege-80) at first week of December in both seasons. Trial plots were 6 m^2 (5 × 1.2 m sizes), and sowing density was 450 seeds m^{-2}. All of phosphorus (80 kg ha^{-1}, P_2O_5) and half of total nitrogen (80 kg ha^{-1}, N) was applied at sowing time. The other half of N was split and given at tillering (as urea) and booting (as ammonium nitrate) stages, respectively. Weeds were controlled by hand and no-irrigation was applied during growth seasons. The trial was harvested at the first week of June in both growth seasons with a Hege-125.

On the calculation of drought susceptibility index (DSI) the formula of Fischer and Maurer (1978) was used:

DSI = (1 - Yd/Yp)/D

Yd = Grain yield of the genotype under moisture stress
Yp = Grain yield of the genotype under non-stress
D = 1- (Mean yield of all genotypes under stress / Mean yield of all genotypes under non-stress)
Drought tolerance efficiency (DTE) was estimated by the equation of Fischer and Wood (1981). According to this equation: DTE (%) = (Yield under stress /Yield under non-stress) * 100
Variance analysis and multiple comparisons of data were analyzed with Duncan Multiple Range Test, and correlations among characters were made by JMP (2007).

RESULTS AND DISCUSSION

Drought tolerance efficiency (DTE) value which was one of the drought resistance parameters were ranged from 65 - 98% (Table 1). Thus, Saar (65%), SW 89 - 5124*2/Fasan (65%), Thb//Maya/Nac/3/Rabe/4/Milan (67%), Inqalab 91 (72%), and Trap 1/Bow//Milan/3/ Bau (72%) showed the lowest DTE. Another parameter of drought resistance is drought susceptibility index (DSI), and the values of this parameter were ranged 0.077 - 1.761. DSI values of above mentioned genotypes were 1.755, 1.761, 1.696, 1.427, and 1.397, respectively. On the other hand, Genc 99 (98%), Croc 1/*Aegilops squarrosa* (98%), Weawer/WL 3926 (96%), Oasis/Kauz//*4 Bcn (94%), and Punjab 96 (91%) had the highest DTE. So, these genotypes had the lowest DSI values which were 0.077, 0.123, 0.205, 0.319, and 0.438, respectively. Results of this study have showed a parallelism with Parameshwarappa et al. (2008)'s findings. They reported that minimum yield reduction was realized in the genotypes which had the highest DTE and the lowest DSI. Actually, while Croc 1/*Aegilops squarrosa*, Genc 99, Weawer/WL 3926, Oasis/Kauz//*4 Bcn, and Punjab 96 were the most drought resistant genotypes with the minimum yield reduction and also the highest DTE and the lowest DSI; Saar, SW 89-5124*2/Fasan, Thb//Maya/Nac/3/Rabe/4/Milan, Inqalab 91, and Trap 1/Bow//Milan/3/ Bau were the most drought susceptible genotypes with maximum yield losses and the lowest DTE, also the highest DSI. In parallel, most of findings (Ozkan et al., 1998; Ozturk, 1999; Golabadi et al., 2006; Sio-Se Mandeh et al., 2006) showed that genotypes with the lowest DSI values were more tolerant than with the highest DSI. In the same way, Ahmad et al. (2003) have reported that drought susceptible varieties had higher values (DSI >1) while resistant varieties had lower values (DSI<1). Furthermore, avarage of DSI values of drought resistant genotypes (Croc 1/*Aegilops squarrosa*, Genc 99, Weawer/WL 3926, Oasis/Kauz//*4 Bcn, and Punjab 96) in this study was 0.232 while drought susceptible genotypes (Saar, SW 89-5124*2/Fasan, Thb//Maya/Nac/3/Rabe/4/Milan, Inqalab 91, and Trap 1/Bow//Milan/3/ Bau) had 1.607 as mean. Stone and Nicolas (1994) reported that temperatures over 18 - 24°C during five to six days causes 20% or more losses in the yield of wheat. Indeed, in our study, yield losses were ranged 2% (genotype Croc 1/*Aegilops squarrosa*) to 35% (genotype SW 89-5124*2/Fasan). In the growth season of 2003 - 2004, decreased rainfall caused yield losses. Indeed, total precipitation of this growth season was higher (587 mm) than the previous growth season (2002 - 2003, with 442 mm); however, 2003 - 2004 growth season had lower rainfall (65 mm) than the previous growth season (168 mm) for generative period of the growth season (anthesis to ripening). Furthermore, the day numbers over 30°C during grain filling period were 22 and 5 for first season (2002 - 2003) and second season (2003 - 2004), respectively. Grain filling period had even hot temperatures in the growth season of the 2002 - 2003, the favorable precipitations inhibited the effects of the hot temperatures. On the other hand, lower precipitation in the ripening period on the next season (2003 - 2004) caused the yield losses.

In this study, statistically significant correlations between non-stressed yield (Yp), stressed yield (Yd), and drought stress parameters (DTE and DSI) were obtained. Thus, negative correlation ($r = -0.620^{**}$, $p < 0.01$) was shown between Yp and DTE while positive correlation ($r = 0.416^{*}$, $p < 0.05$) between Yd and DTE. Also, there was a positive correlation ($r = 0.625^{**}$, $p < 0.01$) between Yp and DSI; and negative correlation ($r = - 0.412^{*}$, $p < 0.05$) between Yd and DSI. These results is similar with that of Talebi et al. (2009). They found a positive correlation ($r = 0.680^{**}$, $p < 0.01$) between Yp and DSI, and a negative correlation ($r = - 0.710^{**}$, $p < 0.01$) between Yd and DSI. In addition, a great negative correlation ($r = - 0.999^{***}$, $P < 0.001$) was found between DTE and DSI.

Table 1. Means of the grain yield (Yp-under non-stress, Yd-under drought stress) and drought resistance parameters (DTE-drought tolerance efficiency, DSI-drought susceptibility index) of the spring bread wheat genotypes.

Genotypes	Grain yield ($kgha^{-1}$)		Drought resistance parameters	
	2002 - 2003 (Yp)	2003 - 2004 (Yd)	DTE (%)	DSI
ADANA 99	7372 abc*	5631	76	1.199
BALATTILA	7217 abc	5495	76	1.211
CAZO/KAUZ//KAUZ	6870 bc	5528	80	0.992
CHEN/AEGILOPS SQUARROSA	6839 bc	5629	82	0.898
CHUM 80 A.542/CNO 79	6643 bc	5461	82	0.903
CROC 1/AE.SQUARROSA	5005 b	4884	98	0.123
F6 0314.76/MRL	7121 abc	5722	80	0.997
GENC 99	5082 d	5005	98	0.077
INQALAB 91	7420 abc	5334	72	1.427
KAUZ/ALTAR 84//ADS	7137 abc	5967	84	0.832
KAUZ/WEAVER	6567 bc	4976	76	1.230
MILAN	6766 bc	5341	79	1.069
MON 'S' /ALD 'S'//BOW'S'	7647 ab	5799	76	1.227
OASIS/KAUZ//*4 BCN	6659 bc	6241	94	0.319
PFAU/MILAN	7562 ab	6283	83	0.859
PUNJAB 96	7356 abc	6721	91	0.438
SAAR	7218 abc	4723	65	1.755
SW 89-5124*2/FASAN	6571 bc	4292	65	1.761
THB//MAYA/NAC/3/RABE/4/MILAN	8118 a	5405	67	1.696
TRAP 1/BOW//MILAN/3/BAU	7668 ab	5558	72	1.397
URES-BOW 'S'	7619 ab	6151	81	0.978
VARONA CNO 79	7659 ab	6507	85	0.764
WEAWER/WL 3926	6191 cd	5941	96	0.205
WL 6718	7086 abc	5848	83	0.887
Mean	6975	5602		
$LSD_{0.05}$	1240	NS		
CV (%)	10.8	17.0		

*Within the columns, means with the same letter(s) are not significantly different at p = 0.05

Conclusively, DSI and DTE are the most important resistance parameters to evaluate the genotypes under drought stress. Also, these indices can be easily used to find drought tolerant or resistant genotypes in the wheat breeding programs.

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