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Evaluation of grain yield and its components in three bread wheat cultivars under drought stress

Shamsi . K[1], Petrosyan . M[2] , Noor - mohammadi . G [3]and Haghparast . R [4]

1 Islamic Azad University,Kermanshah Branch, Iran
2 Yerevan State University, Armenia
3 Islamic Azad University, Science and Research Branch ,Tehran, Iran
4 Dry land Agriculture Research sub - Institute Sararood , Kermanshah , Iran
Corresponding author email: keywan@iauksh.ac.ir

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1 SUMMARY

An experiment was carried out between 2007- 2008 in the Dryland Agriculture Research sub-Institute Sararood in order to study the effects of drought stress on yield and yield components of wheat cultivars under field conditions. The experiment was based on split plot in a randomized complete block design with three replications. The main plots included drought stress treatments at 4 levels: I_1-drought stress at the start of stem elongation stage (31 of the Zadoks); I_2-drought stress at the start of boot stage (43 of the Zadoks); I_3-drought stress at the start of grain filling stage (70 of the Zadoks) and I_4-full irrigation. The subplots included cultivars treatments at 3 levels: Chamran (C_1), Marvdasht(C_2) and Shahriar (C_3). Compared to the control treatment (I_4), treatments (I_1), (I_2), and (I_3) exhibited 85%, 57%, and 43% yield decrease, respectively. In response to moisture stress during different growth stages, Shahriar cv(C_3) was damaged more severely than Chamran cv (C_1) . Chamran cv (C_1) was one of cultivars with high yield potential in moisture stress conditions, especially in terminal season drought stress conditions

2 INTRODUCTION

Drought is the most common environmental stress affecting about 32% of the 99 million hectares under wheat cultivation in developing countries and at least 60 million hectares under wheat cultivation in developed countries (Rajaram, 2000). Iran is one of the countries where abiotic important stresses like drought, salinity, heat, and cold result in yield decrease, soil fertility destruction and also cessation of farming. In Iran, about 67% of the wheat cultured area is devoted to dry- farming lands, which are exposed to drought stress during the growth season (Galeshi & Oskuei, 2001).Flowering and grain- filling stages are identified as among the most critical stages of wheat growth and development to drought stress , during which wheat exhibits the highest sensitivity to water deficit. Also, it has been reported that wheat is sensitive to drought 2 week prior to anthesis (Machado et al, 1993; Rajaram et al, 1995). Royo et al, (2000) reported that flowering-to-maturing drought stress, especially accompanied by high temperature, shortened grain filling period for Triticale, reducing 1000 grain weight. The results of experiments by (Debake et al, 1996) demonstrated that imposing stress, especially after anthesis stage, entailed a significant decrease in harvest index. Gupta et al, (2001) declared there was a direct positive relation between biological yield and grain yield.

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The general objective of doing this experiment was to determine sensitivity of wheat growth stages to drought stress and specific objectives were to determine correlations between yield, yield components and the different traits related to yield under drought stress.

3 MATERIALS AND METHODS

This research was done, between 2007-2008 in the Dryland Agriculture Research sub- Institute Sararood (47°, 20/E;34°,20/ N), and 1361 meter elevated from sea level .Based on Dumarten's climate classification method, This area is part of the cold semiarid regions. Sararood test soil had clay – loamy texture with EC= 1.3 $ds.m^{-2}$ and PH=7.3;
Mahidasht test site had loamy – clay texture with EC=1.4 $ds.m^{-2}$ and PH=7.5. The main plots consisted of four drought stress treatments, i.e. imposition of drought stress at initiation of stem elongation stage (31 Zadoks) (I1), at booting stage (43 Zadoks) (I2), at initiation of grain filling stage (70 Zadoks) (I3) and full irrigation (I4).The subplots included three cultivars, i.e. Chamran (C_1), Marvdasht(C_2), and Shahriar (C_3). Seeding was carried out on November 23, 2007. Based on soil analysis, the required fertilizers were used as follows: 100 kg P_2O5/ha^{-1} and 60 kg N/ ha^{-1} prior to planting and 60kg N/ ha^{-1} were used as topdressing in the tillering stage. Each plot included 8 rows 20 cm apart, 4 meter long, 1 and 2 meter distances were taken between test plots and replicates, respectively. Density was taken at 400 seeds per square meter. At the end of growth period, plants from rows 4 and 5 of each plot, were harvested from each plot center and grain yield, biological yield, and harvest index were determined. MSTATC and SPSS software were used to analyze obtained data.

4 RESULTS AND DISCUSSION

Based on the results obtained, drought stress had highly significant effects (p=0.01) on yield and all yield components. The control treatments (I_4) with yield equal to 6632 kg/ha^{-1} had the highest yield and treatment (I_1) had the lowest yield, equal to 3576 kg/ha^{-1} . Comparison of yield and yield components means shows that the number of spikes per unit area (709.35 spikes) and number of grain per spike (17.7 grains) were reduced for treatment (I_1). Under drought stress condition (I_2), between grain yield and number of spikes per unit area ($r=0.80^{**}$), biological yield ($r=57^{**}$) number of grain per spike ($r=0.56^{**}$), and plant height ($r=0.47^{*}$) were correlated significantly. Richards et al, (2001) declared that during the flowering stage, drought stress disrupted flowing photosynthesis and transfer of stored substances into grains, which can be the cause of reduction of the number and weight of grains. Under drought stress condition (I_3), a high correlation was observed between harvest index ($r= 0.68^{**}$), number of grain per spike ($r= 0.74^{**}$) and grain yield .Mean comparison shows that this stress condition had no effects on number of spike per unit area because, in this treatment, drought stress was imposed after flowering and anthesis stages and reduced grains weight through shortening duration of reproductive period. Drought stress in stage (I_2), with yield equal to 4210 kg/ha^{-1} showed 57% yield reduction compared to control treatment (I_4).
Drought stress in stage (I_3) with yield equal to 4607 kg/ha^{-1} showed 43% reduction of yield compared to control treatment (I_4). Donaldson,(1996) reported that post anthesis drought stress reduced grain filling rate resulting in reduction of 1000 grain weight, which is in agreement with result of this experiment.

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Table 1: Effect of cultivar and irrigation on grain yield, yield components and some morphological traits.

Irrigation	PL(cm)	PH(cm)	SPSM	GPS	TGW(g)	GY(kg.h^{-1})	BY(kg.h^{-1})	HI(%)
I1	24.72C	58.44C	709.3B	17.79B	31.04B	3576D	10600C	32.90D
I2	27.02B	68.14B	705.3B	20.12C	32.19B	4210C	12440B	34.71C
I3	28.84B	82.54A	723.8A	24.32B	34.89AB	4607B	11780B	40.20B
I4	33.43A	89.46A	712.4B	28.89A	39.46A	6632A	13690A	49.41A
Cultivar								
C1	32.88A	83.62A	717.6A	23.72A	35.55A	4999A	12610A	40.87A
C2	26.86B	71.83B	715.3A	23.25B	35.06B	4849A	12230AB	39.68B
C3	25.77B	69.23B	705.2B	21.37C	32.57C	4428B	11520B	37.36C

Within treatment means followed by the same letter are not significantly at $p<0.05$ according to Duncan's multiple range test.

PL: peduncle length
PH: plant height:
SPSM.; spike per square meter;
GPS :grains per spike;
TGW: thousand grain weight ;
GY: grain yield ;
BY: biological yield ;
HI: harvest index: I1,I2,I3 and I4 ;
C1,C2 and C3: Chamran, Marvdasht and Shahriar cultivars.

Result of correlation of grain yield with yield components showed that under stress (I_1), a highly significant correlation is observed between 1000 grain weight($r=0.85^{**}$) and grain yield. Of the subsequent regression important degrees, are the number of spikes per unit area ($r=0.80^{**}$), number of grain per spike ($r=0.67^{**}$), harvest index ($r=0.59^{**}$), and biological yield($r=0.47^{**}$).Given that, for this treatment, drought stress was exercised at stem elongation stage, the number of fertile tillers were exposed to stress condition, resulting in decrease in grain yield.

The results of variance analysis for grain yield and all yield components between experimental cultivars showed a significant difference so that Chamran cv (C_1) with yield equal to 4992 kg/ha^{-1} produced the highest yield rate. Chamran cv (C_1) related with number of grain per spike, 1000 grain weight, number of spike per unit area, plant height and peduncle length. This cultivar had height and biological yield than any other cultivar. The number of grains per spike was higher in Chamran cv (C_1) that in Marvdasht (C_2) and in Shahriar cv (C_3).

Table 2: Correlation coefficients of grain yield with yield components and some morphological traits in wheat.

Character		PL(cm)	PH(cm)	GPS	SPSM	TGW(g)	BY(kg.h^{-1})	HI (%)
	Irrigation							
	I1	0.45 ^{ns}	0.473 *	0.677 **	0.804 **	0.859 **	0.474 *	0.594 **
Grain yield	I2	0.013 ^{ns}	0.472*	0.565 *	0.804 **	0.429 ^{ns}	0.579 *	0.030 ^{ns}
	I3	0.248 ^{ns}	0.310 ^{ns}	0.186 ^{ns}	0.724 **	-0.380 ^{ns}	0.341 ^{ns}	0.689 **
	I4	0.125 ^{ns}	0.279 ^{ns}	0.281 ^{ns}	-0.62 ^{ns}	0.436 ^{ns}	0.223 ^{ns}	0.697 **
	Cultivars							
Grain yield	C1	0.609 **	0.708 **	0.884 **	-0.236 ^{ns}	0.505 **	0.65 **	0.862 **
	C2	0.527 **	0.700 **	0.879 **	0.537 ^{ns}	0.716 **	0.780 **	0.929 **
	C3	0.630 **	0.724 **	0.920 **	-0.189 ^{ns}	0.588 **	0.570 **	0.980 **

$P^{*}<0.05$; ** $p<0.01$; ns : Non – significant.

PL: peduncle length
PH: plant height:
SPSM.; spike per square meter;
GPS :grains per spike;
TGW: thousand grain weight ;
GY: grain yield ;
BY: biological yield ;
HI: harvest index: I1,I2,I3 and I4 ;
C1,C2 and C3: Chamran, Marvdasht and Shahriar cultivar

The results of grain yield and yield components correlations showed that, for all experimental cultivars, the number of grains per spike had the highest correlation with grain yield, indicating the importance of number of grains per spike in determining grain yield of the experimental cultivars. Also, plant height and peduncle length had significant effects on grain yield, having high correlation.

The results of the experiments showed that, under moisture stress conditions, the number of spikes per square meter, number of grains per spike , number of days prior to flowering had significant positive correlations with grain yield of plants (Garcia et al, 2003) .

Generally, the difference between grain yields of cultivars can be attributed to difference between these traits, among which the number of grains per spike is the highest of all. Leilah et al, (2005) demonstrated that five traits of grain weight per spike, harvest index, biological yield, number of spike per square meter, and spike length were introduced into stepwise regression model, accounting for 98.1% of grain yield variance. In the present experiment, results of variance analysis showed that cultivar and drought stress interaction effects on traits of harvest index, 1000 grain weight, number of grain per spike, and number of spike per unit area are significant. The highest and lowest 1000 grain weights related to Marvdasht cv (C_2) and control treatment (I_4), and Shahriar cv (C_3) and treatment (I_1), respectively. Also, the highest and lowest number of grain per spike related to Marvdasht cultivar (C_2) and treatment (I_4) and Shahriar cv (C_3) and treatment (I_1), respectively. And the highest number of grains per unit area related to Chamran cv (C_1) and treatment (I_3), and after it, related with treatment (I_4) and Marvdasht cv (C_2). Marvdasht cv (C_2) had the highest grain yield under full irrigation condition (I_4) and the lowest grain yield under stress treatment (I_1) related with Shahriar cv (C_3).

Review of results shows that, under moisture stress conditions, Chamran (C_1) and Shahriar cv (C_3) had the highest and lowest yield, respectively. Fischer,(1979) believes that there was genotypic variance between wheat cultivars in terms of drought tolerance and, usually, cultivars having high yields under normal conditions better tolerate stress conditions and produce acceptable yields (Table 1, and 2) .

5 CONCLUSION

The results showed that, given direct and indirect effects of yield components on grain yield, number of grains per spike had the highest effect on grain yield of all. In general, these results confirm that Chamran cv (C_1) is one of cultivars with high yield potential in moisture stress conditions, especially in terminal season drought stress conditions, and enjoys high stability of yield. It is one of cultivars with high yield in full irrigation condition.

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