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Evaluation of Yield and Yield Components of Facultative and Winter Bread Wheat Genotypes (*Triticum aestivum* L.). under Different Irrigation Regimes in Khorasam Province in Iran

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Abstract: To evaluate drought tolerance of 20 genotypes of bread wheat under different irrigation regimes, a strip plot experiment based on a complete randomized block design with 3 replications was conducted for 2 growing seasons (1998-2000). Main plots were allocated to 3 levels of irrigation namely 10 days (A_1), 20 days (A_2) and 30 day (A_3) intervals. Sub plots were allocated to 20 genotypes of winter and facultative bread wheat. Grain yield, total biomass, number of spike m^{-2}, harvest index and 1000 kernel weight significantly affected by irrigation treatments and therefore negative responses were more pronounced by increasing irrigation intervals. Water use efficiency was higher for 2o days irrigation interval compared with other treatments. Grain yield, biological yield and number of spikes m^{-2} were higher for C-75-6, C-75-10 and C-75-16 genotypes for all treatments. However when a 20 and 30 days irrigation interval were applied, grain yield, number of spike m^{-2}, harvest index and water use efficiency for C-75-14 and C-75-9 genotypes were higher. These genotypes were more flexible under drought condition. They were relatively early maturing and had relatively higher number of spike m^{-2} and also higher harvest index and water use efficiency.

Key words: Bread wheat, drought tolerance, irrigation interval

INTRODUCTION

A large area of the arid and semi arid arable lands of the world is under wheat production systems. Water deficit and other environmental stresses associated with harsh conditions of these regions is the main cause of low productivity. On the other hand, most of the experimental findings are on the basis of works conducted under optimal conditions[1-3] and therefore may not be relevant to the stress environment of arid regions.

It has been widely evidenced[1,4] that different genotypes respond differently to water shortage and hence based on this concept and genetic make of the plant varieties, variability in response to drought could be an appropriate criteria for plant selection under drought conditions[2,5-7]. Therefore proper investigation on the recognition of yield criteria associated with drought tolerance is a priority issue in experiments under water shortage.

There have been numerous literatures dealing with plant criteria suitable under water shortage such as rooting depth, osmotic relationships, leaf pubescent and so on[5,7], however none has been shown to be an exclusive indicator of drought tolerance. Also, there are a wide range of evidence regarding the response of plants to drought at different stages of growth and development[8-10], of which grain filling stage has been reported to be the most critical stage in this respect[3-5,11-13]. Dastfal and Ramazanpoor[14], Zarea and Ghodsi[10] and Ghodsi *et al.*[11] have concluded that water deficit reduced almost all yield components of wheat including 1000 kernel weight, number of seeds/spike, number of spike m^{-2} and harvest index.

The main purpose of this trial was to investigate the drought tolerance of some Iranian wheat genotypes from the elite germplasm of the cold region of Iran.

MATERIALS AND METHODS

This experiment was conducted as a strip plots with a randomized block design and 3 replications for two years (1998-2000) in a nationwide wheat trial for the cold regions.

Main plots were allocated to three irrigation intervals of 10 days (A_1), 20 days (A_2) and 30 days (A_3) and sub plots were 20 winter and facultative bread wheat genotypes (Table 1). Seeds were sown in sub plots of 6 by 2.4 m on 12 rows with 20 cm apart, on the basis of 400 seeds m^{-2}.

Planting and other field management were practiced based on the normal recommendation of seed and plant improvement institute (SPII). Water was applied through

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Table 1: Pedigree of facultative and winter bread wheat genotypes

Genotypes	Pedigree
C-75-1	Alamoot
C-75-2	Gds/4/Anza/3/Pi/Nar/Hys/5/Ve "S" IAS 58-10-42-48.
C-75-3	Alvand//Aldan "S" IAS58-10-42-48
C-75-4	BOW "S" Crow "S"/4/Omid//Hy 9-73-37
C-75-5	OWL 85256* 30H-*-* EOH
C-75-6	OWL 85254*-3H-* O * HOH
C-75-7	WRS 8702732*-HR-*-* H4
C-75-8	90-Zhong. 165
C-75-9	Gaspard
C-75-10	Gascogne
C-75-11	Siossons
C-75-12	Pyn/Bay SWM 15182-12 WOM-OWM-OSE-OYC
C-75-13	Mirtos
C-75-14	87 Zhong 291
C-75-15	Bez-2B/Cgn//Vratza
C-75-16	1-63-48/Seri 82
C-75-17	C 75489
C-75-18	88 Zhong 218
C-75-19	Spb "S"//K 134 (60)/Vee "S"
C-75-20	90 Zhong 87

a centrally controlled system and the required amount was calculated on the basis of differences between moisture content before irrigation and at FC (Equation 1):

$$F_{n=(\theta 2-\theta 1)} * r * D \quad (1)$$

where, Fn is the net irrigation depth (mm), θ2 and θ1 soil moisture content at FC and before each irrigation, respectively, r, soil bulk density and D, rooting depth (mm).

For evaluation of drought tolerance, SSI or Stress susceptibility index was calculated as fallows:

$$SSI = [1-(Ydi/Ypi)/SI], \; SI = YD/YP \quad (2)$$

SSI = Stress susceptibility index
SI = Stress intensity
YD = Yield average under stress
YP = Yield average under normal condition
Ydi = Yield of each genotype under stress
Ypi = Yield of each genotype under normal condition.

RESULTS AND DISCUSSION

Compound statistical analysis for the grain and total dry matter yield showed that there was a difference between years and genotypes in response to irrigation levels. As expected, with increasing irrigation intervals, this two criteria were decreased significantly (Fig. 1).

Grain yield was more than twice as much for the 10 days irrigation interval compared with that of 30 days interval.

This is not strange and has been evidenced in the literature[5,10-12,14,15]. Yield for the irrigation interval of 20 days was much higher than that for 30 days interval. This implies that one more irrigation particularly at critical stages such as grain filling could be crucial.

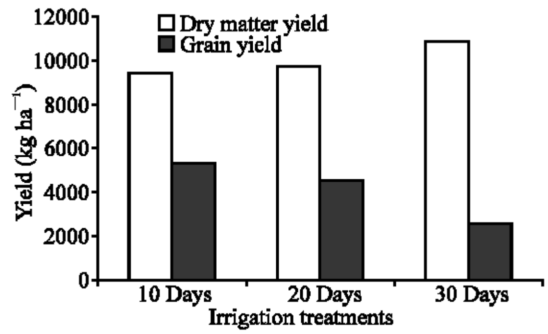

Fig. 1: Grain yield and total dry matter of bread wheat genotypes

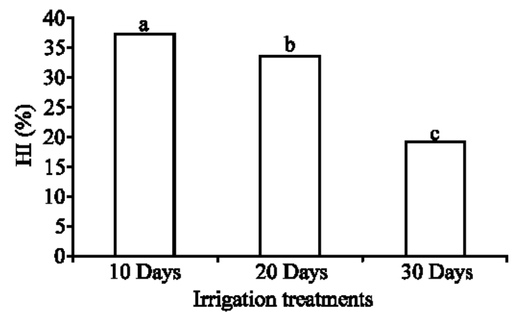

Fig. 2: Harvest index of bread wheat genotypes

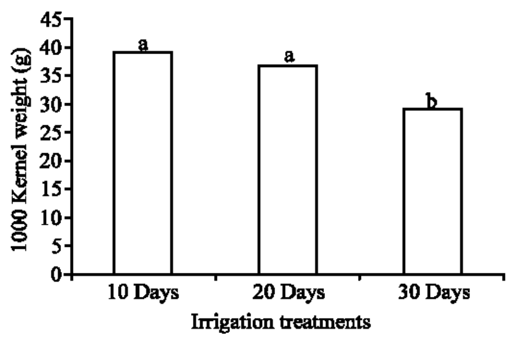

Fig. 3: 1000 kernel weight of bread wheat genotypes

Such situation is the real case in wheat production system of khorasan and could be argued that, in such system where overlapping of date of planting of summer crops and critical time of water needs for wheat coincides a compromise should be made for allocation of water for these two types of crops. In other word reducing the irrigation requirement of wheat to the level of A_2 (20 days interval) seems to compensate for the loss of yield by providing this amount of water for summer crops with not much loss of yield. Reports in the literature indicate a pronounced negative effect of water shortage on wheat at time of grain filling[3,11,12,16,17] and this period has been regarded as the most critical time of water shortage.

Table 2 shows a significant variability in response of genotypes to irrigation intervals and hence to water

Table 2: Grain yield and stress susceptibility index (SSI) of bread wheat genotypes

Genotypes	10 days irrigation interval (kg h^{-2})	20 days arrogation interval (kg h^{-2})	30 days irrigation interval (kg h^{-2})	SSI (A_2)	SSI (A_3)	Mean H.I.
C-75-1	4750	4210	1720	0.81	1.19	23.83
C-75-2	5750	4950	2260	0.99	1.13	30.44
C-75-3	5140	4460	1900	0.94	1.18	29.56
C-75-4	3910	3830	2340	0.15	0.75	26.73
C-75-5	4520	3590	1510	1.46	1.25	25.68
C-75-6	6150	4520	2470	1.88	1.12	29.98
C-75-7	5530	4360	1960	1.51	1.21	28.83
C-75-8	5660	5240	2870	0.53	0.92	35.70
C-75-9	5470	5260	3310	0.27	0.74	33.63
C-75-10	6110	4680	2710	1.66	1.04	32.82
C-75-11	5930	4540	2580	1.64	1.16	27.92
C-75-12	4740	4270	2.05	0.70	1.06	25.23
C-75-13	5030	4020	2540	1.42	0.92	30.95
C-75-14	5230	5210	3150	0.03	0.74	34.57
C-75-15	5420	4290	2690	1.48	0.94	31.37
C-75-16	6130	4810	2700	1.53	1.05	30.71
C-75-17	4500	3470	2430	1.63	0.86	27.43
C-75-18	4080	4450	2600	0.65	0.68	27.20
C-75-19	5130	5190	2260	0.08	1.05	28.91
C-75-20	5510	4670	3080	1.07	0.83	31.10
Mean	5240	4500	2450	*SI_1=0.14	D_2=0.53	29.63

*SI: Stress intensity

Table 3: Water use efficiency (For two years)

Irrigation treatment	Arrogation interval	First year (1998-1999) Number of irrigation	Water used (m^3 h^{-1})	WUE (kg m^{-3})	Second year (1999-2000) Number of irrigation	Water used (m^3 h^{-1})	WUE (kg m^{-3})
A_1	10	5	3901.8	1.32	5	5362.4	0.97
A_2	20	3	2505.7	1.70	3	3407.1	1.39
A_3	30	2	2037.4	1.49	2	2588.9	0.72

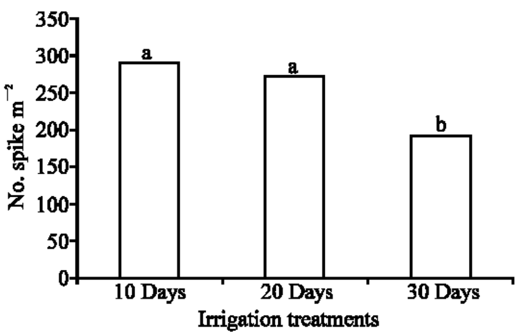

Fig. 4: Number of spike m^{-2} of bread wheat genotypes

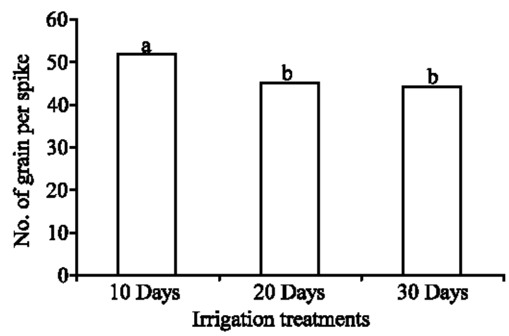

Fig. 5: Number of grain/spike of bread wheat genotypes

shortage and the most promising genotypes in terms of water shortage were C-75-9, C-75-14, C-75-20, C-75-8, C-75-10 and C-75-16.

Water deficit reduced harvest index and yield components such as harvest index, number of spikes per m^2, number of kernels per spike and 1000 kernel weight (Fig. 2-5). Whereas plant criteria such as plant height, peduncle length, number of days to spike emergence and plant maturity were not affected significantly. Yield decrease due to water deficit was attributed to reduction in number of spikes per m^2, number of kernels per spike and 1000 kernel weight. This results were also confirmed elsewhere[14,16].

Harvest index was also affected by degree of moisture availability and it appears that genotypes with higher yield under water deficiency also had higher harvest index (Table 2).

Drought tolerance for genotypes was calculated by method proposed by Fisher and Maurer[18], the result of which is presented in Table 2. Stress intensity for A_2 treatment (20 days interval) was 0.141 and for A_3 (30 days) was 0.534. In other words average yield of genotypes was reduced by 14% in A_2 and 53% in A_3 compared with A_1 treatment.

Water use efficiency for different irrigation intervals (Table 3) indicated higher values for A_2 (20 days) treatment. This figure was 1.52 kg grain m^{-3} water compared to 1.13 for A_1 and 1.06 for A_3 though some genotypes such as C-75-16 and C-75-10 seems to show a multidivertional trend and responded favorably under both water shortage (30 days) and water availability conditions (10 days). Variability of wheat genotype in response to water has been well documented[1,4,6,7].

The overall results of present investigation showed that of the total of 20 genotypes from the selected research centers on yield comparison trial in cold regions of the country, 8 genotypes showed promise under both stress and optimal conditions.

Genotypes such as C-75-6, C-75-10 and C-75-16 recorded the highest yield, number of spikes m^{-2} with A_1 (10 days) treatment and average water use efficiency for these genotypes were 1.88, 1.66 and 1.64, respectively. However as stated before C-75-14, C-75-9 and C-75-8 with higher yield under stress condition performed an stable use efficiency with water deficit and hence, matured earlier, had a longer peduncle length and higher number of spike m^{-2} and also higher harvest index and water use efficiency.

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