Pak. J. Bot., 48(2): 519-526, 2016.

EFFECT OF DIFFERENT IRRIGATED CONDITIONS ON SOME MORPHOLOGICAL TRAITS OF WHEAT GENOTYPES GROWN IN SAUDI ARABIA

MAJED M.A. ALBOKARI*, ABDULMAJEED J. KHASHOGGI AND MOHAMMED A. ALMUWALID

Nuclear Science Research Institute (NSRI), King Abdulaziz City for Science & Technology KACST, Riyadh 11442, Saudi Arabia

**Corresponding author's email: mbokari@kacst.edu.sa*

Abstract

The Kingdom of Saudi Arabia being one of the driest countries globally needs drought tolerant wheat varieties. Breeding studies were conducted to determine the effects of different irrigation levels on some morphological traits of 4 wheat varieties. A pot-house experiment was conducted in split plot design using two different irrigations (well-watered and partial moisture stress) levels. Presently, the study was laid on different traits viz. plant height (cm), tiller number/plant, number of leaves/plant, leaf length (cm), flowering time (days), maturity time (days), 1000-grain weight (g) and grain yield/plant (g). The mean square from pooled analysis of variance revealed that the genotypes, treatments and genotype x treatment interaction were highly significant (p>0.05) for the traits leaf length, plant height, maturity time,1000-grain weight, grain yield per plot; however, number of leaves, number of tillers/plant, flowering time and 1000-grain weight showed non-significant difference. Similarly, genotype x reading interaction was also highly significant (p>0.05) leaf length, number of tillers per plant and plant height. The varieties Nukrat Zahran, Samrra Najran and Halba Najran and showed better performance for grain yield and maximum 1000-grain weight under both environments. Plant height showed highly significant positive correlation with number of leaves per plant and number of tillers per plant. At partial stress, 1000-grain weight showed highly significant (p>0.01) correlation (r=0.8608***) with grain yield and maturity time (r=0.9948***). The knowledge obtained through this research will be helpful while selection of best varieties with better tolerance to environmental stresses.

Key words: Irrigation levels, Morphological traits, *Triticum aestivum* L.

Introduction

Bread wheat (*Triticum aestivum* L.) is one of the most important cereal food crops of the world. The final grain yield is a complex polygenic economic trait governed by various associated yield components and environmental conditions. Recently, wheat crop productivity in the world is highly affected due to environmental stresses like drought, salinity and terminal heat stress and diseases (Blum, 1998, Rebetzke and Richards, 1999; Reynolds *et al*., 1999; Bux *et al.,* 2013). In Saudi Arabia, water scarcity has become an alarming situation in recent years and reflected serious threat to wheat and other crops and also water resources (Rogers & Lydon, 1994). Accordingly, drought affects plant growth and yield by modifying the essential mechanisms of plant like morphology, phenology, physiology, anatomy and biochemistry (Reynolds *et al*., 1997; Rebetzke and Richards, 1999; Sial *et al.,* 2009). Hence, the knowledge of interrelationship of morpho-agronomic and physiological characters among each other and with final yield provides a valid interpretation of wheat breeding material. Morphological traits like plant height, number of fertile tillers per plant, spike length, number of seeds per spike, seed index (1000-grain weight), main spike yield, leaf area and many other traits are directly or indirectly correlated with the final yield (Ceccarelli *et al.,* 1991; Reynolds *et al.,* 2000; Cuthbert *et al.,* 2008; Gelalcha and Hanchinal, 2013; Li *et al.*, 2013; Allahverdiyev *et al.,* 2015). Various researchers have observed positive correlation between yield and its associated traits such as plant height, biological yield, number of fertile tillers, seeds per spike (Mohammadi *et al*., 2012; Abderrahmane *et al*., 2013; Noureldin *et al*., 2013). The yield of crops can be enhanced through breeding strategies under water-deficit conditions by identifying the drought stress associated traits of plants (Sayre *et al.,* 1995; Strauss and Agenbag, 2000). Therefore, evaluation and selection of wheat germplasm under water stress condition is the main breeding objective (Rajaram *et al.,* 1996). There are several morphological traits like early growth vigour, early ground cover, stem thickness, stay green, high tiller survival, leaf area, waxiness, leaf rolling, plant height are known as drought adaptive traits in wheat (Sayre *et al.,* 1995; Reynolds *et al.,* 1999; Sial *et al.,* 2013). Previous studies on correlation coefficient have shown the determination among various yield traits under water stress conditions which could provide a better understanding of potential breeding material for drought tolerance. The present research studies were therefore conducted to determine the effects of different irrigation levels on some yield associated morphological and phenological traits of wheat varieties grown in Saudi Arabia. The main objectives of this study were to evaluate the performance of the wheat landraces and to select more potential genotypes which possess some tolerance to water scarce conditions. The studies on yield components will provide the basic specific knowledge regarding their genetic control and correlation with final yield in order to obtain sustainable yield from wheat. The information generated through this research will be useful in breeding program while selection process of the suitable variety for this region.

Materials and Methods

The effects of different irrigations on some yield associated traits of four bread wheat (*Triticum aestivum* L.) varieties/landraces viz., Missani, Halba Najran, Samrra Najran and Nukrat Zahran were investigated during wheat cropping season 2013-14. The experiments were conducted in Net-house using two different irrigation levels i.e., Treatment-1= 02-days interval or well-watered (the irrigation applied after each two days interval) and Treatmen-2=07-days or partial stress, (the irrigation applied after each 7 days) at Al-Mozamiah Research Station, King AbdulAziz City for Science and Technology (KACST), Riyadh, Saudi Arabia. The trial was laid out in split-plot-design using 3 replications. Each genotype was grown with 4 rows, 4m long and 30cm apart. The yield associated traits studied were plant height, tiller number/plant, number of leaves/plant, leaf length, flowering time, maturity time, 1000-grain weight and grain yield/plant. The data on four traits plant height, tiller number/plant, number of leaves/plant and leaf length were recorded during three crop growth stages as early, normal and late (Reading-1, Reading-2 and Reading-3 respectively). The data were analyzed statistically through statistical software Statistis-8.10 using analysis of variance (ANOVA) as suggested by Steel & Torrie 1980 and Gomez & Gomez, 1984 and the means were compared using least significant difference (LSD) test ($p>0.05$) as Duncan's multiple range test (D'MRt). The Pearson's correlation coefficient (r) among various observed traits were calculated according to procedure of Snedecor & Cochran (1980).

Results and Discussions

The statistical analysis of variance (ANOVA) was carried out to determine the differences among 4 wheat varieties for different yield and yield associated traits under two irrigation levels (Tables 1-3). The ANOVA was conducted for individual treatments and pooled over treatments. The mean square (MS) from ANOVA showed highly significant ($p\leq0.05$) difference among genotypes for the traits plant height (cm) and leaf length, maturity time, 1000-grain weight, grain yield/plot; while the genotypes were non-significant for the trait number of tillers/plant and number of leaves per plant (Tables 1 and 3). The mean square from pooled ANOVA for genotype x treatment interaction and genotype x reading interaction were also highly significant ($p\leq0.01$) for the traits leaf length and plant height (Table 1). Mean square for genotype x reading interaction was also showed highly significant difference leaf length, number of tillers per plant and plant height. ANOVA from Treatment-1 (02-days irrigations) and treatment-2 (07-days irrigations) individually showed highly significant difference ($p\leq0.01$) for genotypes for leaf length and plant height, whereas, number of tillers per plant, leaf length and plant height showed highly significant difference for genotypes, Readings and Reading x genotype interaction (Table 2).

Table 1. Mean square from pooled analysis of variance for four morphological traits of wheat genotypes under two irrigation levels.

Source of variation	Degree of freedom	Mean square (MS)			
		No. of leaves	Leaf length	No. of tillers per plant	Plant height
Replications	2	0.21875	0.032	3.088	50.08
Genotypes	3	11.8924	377.691***	28.8287	6975.38***
Error	6	1.92708	5.466	6.1933	26.91
Rep. x Genotypes					
Treatments	1	4.75347	3.337	20.0556	2101.68***
Genotype x Treatment interaction	3	0.42940	288.205***	0.8333	1512.39***
Error	8	0.41667	6.488	6.0139	11.49
Rep. x Genotype x Treatment					
Readings	2	7.05900	391.069***	8.3368***	5762.33***
Genotype x Reading interaction	6	0.13889	32.572***	2.7072**	593.49***
Treatment x Reading	2	0.2222	16.428	4.7535**	143.31***
Genotype x Treatment x Reading interaction	6	0.34259	12.397	10.9757***	44.30
Error	32	0.29167	4.002	0.4653	13.75
Rep. x Geno x Treat x Reading					
Error	216	0.46412	5.747	2.078	14.06
Total	287	--	--	--	--

*: $p<0.05$ and **: $p<0.01$

Table 2. Mean square from analysis of variance for four morphological traits of wheat genotypes under under two irrigation levels.

Source of variation	Degree of freedom	Mean square (MS)			
		No. of leaves	Leaf length	No. of tillers per plant	Plant height
		T1 (02 days irrigation)			
Replications	2	0.3402	0.063	5.8819	32.93
Genotypes	3	7.57407	399.079***	13.4699	6132.95***
Error rep. x Genotypes	6	0.803	10.377	3.7616	20.61
Readings	2	0.11111	135.224***	12.8403***	2215.53***
Genotype x Reading interaction	6	0.2407	5.969	3.4144	374.95***
Error	124	0.2688	6.523	1.2198	10.37
Total	143	--	--	--	--
		T2 (07 days irrigation)			
Replications	2	0.0694	0.241	11.5208	2.88
Genotypes	3	4.74769	266.817***	16.1921	2354.82***
Error Rep. x Genotypes	6	1.63657	3.649	5.6782	20.37
Readings	2	0.11111	272.273***	0.2500	3690.11***
Genotype x Reading interaction	6	0.24074	38.999***	10.2685	262.84***
Error	124	0.61492	4.520	2.4326	17.67
Total	143	--	--	--	--

*: $p<$ p0.05 and **: $p<0.01$

Table 3. Mean square from analysis of variance for flowering time, time to maturity, grain yield per plot and 1000-grain weight of wheat genotypes under two irrigation levels.

Source of variation	Degree of freedom	Mean square (MS)			
		Flowering time	Maturity time	1000-grain wt	Grain yield/plot
		T1 (02 days irrigation)			
Replications	2	19.083	0.583	9.75	118.8
Genotypes	3	117.194	418.77***	99.638***	20024.3***
Error	6	26.528	3.361	1.305	166.3
Total	11	--	--		--
		T2 (07 days irrigation)			
Replications	2	0.3402	0.063	5.8819	32.93
Genotypes	3	7.57407	399.079***	13.4699**	6132.95***
Error	6	0.2688	6.523	1.2198	10.37
Total	11	--	--	--	--

*: $p<0.05$ and **: $p<0.01$

Table 4. Overall comparison of mean difference in 3 data readings observed from various traits of for four wheat varieties two different irrigation treatments.

Traits	Reading-1	Reading-2	Reading-3	Lsd (0.05)
	Treatment-1 (2-irrigation)			
No. of leaves	3.583 A	3.666 A	3.66 A	0.2095
Leaf length (cm)	16.573 C	17.896 B	19.906 A	1.0319
No. of tillers per plant	2.104 B	3.000 A	3.000 A	0.4462
Plant height (cm)	58.78 C	64.375 B	72.302 A	1.3008
	Treatment-2 (7-irrigation)			
No. of leaves	3.437 A	3.354 A	3.354 A	0.316
Leaf length (cm)	15.833 C	18.615 B	20.573 A	0.858
No. of tillers per plant	3.145 A	3.270 A	3.270 A	0.603
Plant height (cm)	50.73 C	60.63 B	68.04 A	1.698
	Mean of both Treatments(2 &7 irrigations)			
No. of leaves	3.510 A	3.510 A	3.510 A	0.1588
Leaf length (cm)	16.203 C	18.255 B	20.240 A	0.582
No. of tillers per plant	2.625 B	3.135 A	3.135 A	0.2005
Plant height (cm)	54.67 C	62.50 B	70.17 A	1.0902

The comparison of mean difference in 3 readings observed from various traits of for four wheat varieties are presented in Table 4. At T1 (2-irrigations), significant differences ($p<0.05$) were recorded among different Readings for all the traits except number of leaves. At T2 (7-irrigations), significant difference among Readings was observed for leaf length and plant height, whereas, non significant difference was observed in two other traits. At overall mean comparison (2 & 7 irrigations), except number of leaves all other traits showed significant difference with change in data readings (Table 4). Traits showed increase at reading 2 and 3 as compared to first reading.

Number of leaves per plant: The highly significant ($p<0.05$) differences were observed among genotypes for the trait number of leaves per plant (Table 5). This trait was measured during 3 different plant growth stages during the season. The overall mean for number of leaves per plant was significantly ($p<0.05$) increased (3.63) at T1-(02-days irrigations) as compared to (3.28) T2-(07-days irrigation). The variety Nukrat Zahran produced significantly higher number of leaves (4.27) than other genotypes Missani, Halba and Samrra Najran (3.6, 3.2 and 3.4 respectively) at T11-(02-days irrigation). Similarly, Nukrat Zahran showed significant increase in number of leaves per plant (3.91) at T2-(07-days irrigation); however, it was non significantly different than varieties Samrra Najran (3.27) and Missani (3.22). The variety Nukrat Zahran produced significantly the highest number of leaves (4.09) than all other genotypes and ranked first for this trait, whereas the difference among other genotypes was non-significant (Table 5). Water stress tolerance is a complex polygenic trait governed by gene and influenced by environmental changes. The drought studies have shown that various plant characteristics such as leaf size, leaf shape, number of leaves, stay green, early growth vigour, early ground cover, waxiness, stem thickness, stem length etc. playing a vital role in understanding the drought mechanism in cereal crops (Mosaad *et al*., 1995; Rucker *et al*., 1995; Passioura, 1996; Yordanov *et al*., 2003; Shao *et al*., 2008 Hameed *et al*., 2008; Lonbani & Arzani, 2011; Riaz *et al*., 2013). The photosynthetic activity of plants depend upon leaves per plant.

Table 5. Mean performance of trait number of leaves for four wheat varieties under two irrigation levels.

Genotypes	Number of leaves		
	T1 (2-days irrigations)	**T2 (7-days irrigations)**	**Overall mean (T1 & T2)**
Missani	3.639 B	3.222 AB	3.43 B
Halba	3.222B	3.111 B	3.16 B
Samrra Najran	3.416 B	3.277 AB	3.35B
Nukrat Zahran	4.277 A	3.916 A	4.09 A
Mean	**3.638 A**	**3.382 B**	**---**
LSD (0.05)	0.5169	1.1017	0.5661

Means followed by the same letter not significantly different (p<0.05)

Table 6. Mean performance of trait leaf length (cm) for four wheat varieties under two irrigation levels.

Genotypes	Leaf length (cm)		
	T1 (2-days irrigations)	**T2 (7-days irrigations)**	**Overall mean (T1 & T2)**
Missani	17.694 B	17.944 C	17.8 B
Halba	16.389 BC	14.792 D	15.59 C
Samrra Najran	22.931 A	19.389 B	21.16 A
Nukrat Zahran	15.486 C	21.236 A	18.36 B
Mean	**18.125 A**	**18.340 A**	**---**
LSD (0.05)	1.8579	0.7378	0.9535

Means followed by the same letter not significantly different (p<0.05)

Table 7. Mean performance of trait number of tillers/plant for four wheat varieties under two irrigation levels.

Genotypes	Number of tillers/plant		
	T1 (2-days irrigations)	**T2 (7-days irrigations)**	**Overall mean (T1&T2)**
Missani	2.722 AB	3.555 AB	3.138 AB
Halba	2.194 B	2.527 B	2.361 B
Samrra Najran	2.333 B	2.833 AB	2.583B
Nukrat Zahran	3.555 A	4.000 A	3.777 A
Mean	**2.701 A**	**3.229 A**	**--**
LSD (0.05)	1.1186	1.3743	1.0149

Means followed by the same letter not significantly different (p<0.05)

Leaf length: The leaf length was measured during 3 different plant growth stages during the crop season. The highly significant ($p<0.05$) difference was recorded among genotypes for the trait leaf length (Table 6). The leaf length was measured during 3 different plant growth stages during the season. The variety Samrra Najran showed highly significant ($p<0.05$) increase in leaf length (21.16cm) overall both the treatments (T1 and T2) as compared to other genotypes. The other two varieties Missani and Nukrat Zahran also showed significant average increase (17.8 and 18.3cm respectively) over both the treatments. The difference for leaf length among genotypes was highly significant ($p>0.05$) while, the difference among both the treatments (T1 and T2) was non-significant for this trait. Samrra Najran produced significant increase in leaf length (22.93cm) at T1-(02 days irrigation) and Nukrat Zahran had the lowest leaf length (15.48cm). At T2, Nukrat Zahran had significant increase in leaf length (21.23cm) followed by Samrra Najran (19.38cm), whereas Missani variety showed decrease in leaf length at T2. On overall average of two treatments, the variety Halba had decrease in leaf length (15.59cm) as comparison to other varieties.

Number of tillers per plant: The trait number of tillers per plant is an important yield contributing character. Genotypes varied highly and significantly ($p<0.05$) for number of tillers per plant at T1-(02 days irrigation) and T2 (Table 7). The variety Nukrat Zahran produced significantly the highest number of tillers (3.55 and 4.00 respectively) under both the treatments (Table 5). In T1, two varieties Nukrat Zahran (3.55) and Missani (2.72) had the highest number of tillers. At T2, the highest number of tillers was recorded in three genotypes viz., Nukrat Zahran, Samrra Najran and Missani (4.0, 2.83, and 3.55 respectively). The variety Halba showed poor performance regarding its number of tillers as it could produce low number of tillers per plant under both the treatments.

Plant height: Genotypes indicated the highly significant difference ($p<0.05$) for plant height at both the treatments (Table 8). The significant increase in mean plant height was observed in T1 (65.15cm) than T2 (59.75cm). Genotype Samrra Najran produced significantly increased plant height (84.11 and 66.56cm respectively) than all other contesting varieties at T1 and T2. The other variety with taller plant height followed by Samrra Najran was Nukrat Zahran (64.20cm). Halba again showed significant decrease in plant height than other varieties at both the treatments.

Table 8. Mean performance of plant height (cm) for four wheat varieties under two irrigation levels.

Genotypes	Plant height (cm)		
	T1 (2-days irrigations)	**T2 (7-days irrigations)**	**Overall mean (T1&T2)**
Missani	62.181 B	59.89 B	61.03 B
Halba	54.417 C	48.35 C	51.38 C
Samrra Najran	84.111 A	66.56 A	75.33 A
Nukrat Zahran	59.903 B	64.208 A	62.05 B
Mean	**65.15 A**	**59.75 B**	--
LSD (0.05)	2.6186	2.6032	2.1154

Means followed by the same letter not significantly different (p<0.05)

Table 9. Mean performance of flowering time for four wheat varieties under two irrigation levels.

Genotypes	Flowering time		
	T1 (2-days irrigations)	**T2 (7-days irrigations)**	**Overall mean (T1&T2)**
Missani	92.00 A	94.33 AB	93.16
Halba	93.33 A	99.00 A	96.16
Samrra Najran	78.00 C	84.33 B	81.16
Nukrat Zahran	81.33 B	90.00 AB	85.66
Mean	**91.92 A**	**86.16 AB**	--
LSD (0.05)	2.7256	10.29	

Means followed by the same letter not significantly different (p<0.05)

Table 10. Mean performance of maturity time for four wheat varieties under two irrigation levels.

Genotypes	Maturity time		
	T1 (2-days irrigations)	**T2 (7-days irrigations)**	**Overall mean (T1 & T2)**
Missani	119.00 A	100.00 C	109.5
Halba	118.67 A	120.33 B	119.5
Samrra Najran	110.33 C	116.33 C	113.3
Nukrat Zahran	112.33 B	128.0 A	120.16
Mean	**116.17 A**	**115.08 A**	--
LSD (0.05)	1.4891	3.66	

Means followed by the same letter not significantly different (p<0.05)

Flowering time: The varieties Missani and Halba took significantly ($p<0.05$) highest number of days to flowering (92.0 and 93.3 days respectively), whereas, Samrra Najran took the lowest days (78.0) to flowering at T1 (Table 9). At T2, the variety Halba took significantly highest (99.0) days to flowering followed by Missani and Nukrat Zahran (94.33 and 90.0 days respectively) (Table 9). The mean days taken to flowering significantly reduced (86.16) at T2 as compared to T1 (91.92).

Maturity time: The maturity time of wheat varieties ranged from 110 days for SamrraNajran to 119 days for Missani and 118.6 days for Halba at T1 (Table 10). The highly significant ($p<0.05$) difference was observed for maturity period of wheat genotypes. The variety Samrra Najran took les days to maturity showed early maturity than other genotypes could be grown as short duration variety for late sowings. At T2, Nukrat Zahran took significantly more time to maturity (128.0 days) while Missani and Samrra Najran showed early maturity (100 and 116 days respectively).

1000-Grain weight: The 1000-grain weight of wheat genotypes was highly significant at T1 (Table 11). Two varieties Nukrat Zahran and Samrra Najran showed maximum 1000-grain weight (35.46 and 33.77g respectively), whereas Missani produced the lowest weight of 1000 grains (21.7g followed by Halba variety (30.06g). At, T2, again Nukrat Zahran and Samrra Najran produced bold grains with maximum weight (40.0 and 39.0g respectively). Significant increase in 1000-grain weight (35.24g) was observed at well-watered (T1) than T2 the partial stressed treatment (30.24g). Similar results were observed by (Ceccarelli *et al*., 1991; Mirbahar *et al.*, 2009)

Table 11. Mean performance of 1000-grain weight (g) for four wheat genotypes under two irrigation levels.

Genotypes	1000-grain weight (g)		
	T1 (2-days irrigations)	**T2 (7-days irrigations)**	**Overall mean (T1&T2)**
Missani	21.717 C	27.33 C	24.52
Halba	30.060 B	34.66 B	32.36
Samrra Najran	33.787 A	39.00 A	36.39
Nukrat Zahran	35.467 A	40.00 A	37.73
Mean	**35.24 A**	**30.25 B**	**--**
LSD (0.05)	2.3549	2.28	

Means followed by the same letter not significantly different ($p<0.05$)

Table 12. Mean performance of grain yield/plot (g) for four wheat varieties under two irrigation levels.

Genotypes	Grain yield/plot		
	T1 (2-days irrigations)	**T2 (7-days irrigations)**	**Overall mean (T1 & T2)**
Missani	282.33 D	305.00 C	293.66
Halba	433.33 B	468.33 A	450.83
SamrraNajran	380.00 C	415.00 B	397.5
NukratZahran	462.00 A	486.67 A	474.3
Mean	**418.75 A**	**389.41 B**	**--**
LSD (0.05)	2.4695	25.73	

Means followed by the same letter not significantly different ($p<0.05$)

Table 13. Correlation coefficient (r) between various morphological traits of wheat genotypes under two irrigation levels.

Traits	**No. of leaves**	**Leaf length (cm)**	**No. of tillers per plant**	**Plant height (cm)**
	Treatment-1 (2 days irrigations)			
No. of leaves	1.00			
Leaf length (cm)	-0.4436	1.00		
No. of tillers per plant	-0.5158	0.9965***	1.00	
Plant height (cm)	0.9579***	-0.1727	-0.2538	1.00
	Treatment-2 (07 days irrigations)			
No. of leaves	1.00			
Leaf length (cm)	0.8303	1.00		
No. of tillers per plant	0.7627	0.8095*	1.00	
Plant height (cm)	0.9151***	0.5374	0.5399*	1.00
Traits	**Flowering time**	**Maturity time**	**1000-grain weight**	**Grain yield/plot**
	T1 (02 days irrigation)			
Flowering time	1.00			
Maturity time	-0.1510	1.00		
1000-grain weight	-0.5628	0.8927*	1.00	
Grain yield/plot	-0.0164	0.9837***	0.8353*	1.00
	T2 (07 days irrigation)			
Flowering time	1.00			
Maturity time	0.9948***	1.00		
1000-grain weight	-0.7490	-0.8052	1.00	
Grain yield/plot	-0.3221	-0.3995	0.8608***	1.00

* and ***Correlation coefficient significant at the 0.05 and 0.01 levels of probability, respectively

Grain yield per plot: Wheat genotypes showed wide variation for the grain yield per plot at T1 (Table 12). Genotype Nukrat Zahran gave significantly (p>0.05) the highest plot yield (462g) than all other contesting genotypes at T1. Another two genotypes Halba and Missani also produced higher yield (433.3g and 282g respectively); where Samrra Najran could produce the lowest grain yield (380.0g) than all other genotypes at T1. Similarly, two genotypes Nukrat Zahran (486.87g) and Halba (468.3g) again gave maximum 1000-grain weight at T2. Overall reduction in grain yield was recorded at partial moisture stress (389.4g) than well-irrigated (418.75g) environment. The reduction in final yield and various other growth traits of wheat due to water stress have been reported by various researchers (Eitzinger *et al*., 2002; Sial *et al.,* 2009; Sial *et al*., 2010).

Correlation coefficient studies: To investigate the interrelationship between various morphological traits, the simple correlation coefficient was calculated (Table 13). The plant height (cm) showed highly significant (p>0.01) positive correlation (r=0.957***) with number of leaves per plant; while the number of tillers per plant showed highly significant (p>0.01) positive correlation (0.9965***) with leaf length trait at T1. However, other traits showed significant negative correlation among each other (Table 13). At T2 (07-days irrigation), the highly significant (p>0.01) positive correlation (r=0.9151***) between plant height and number of leaves per plant, plant height with number of tillers (0.5399*) at (P>0.05); whereas, number of tillers per plant showed significant (p>0.05) positive correlation coefficient (r=0.8095*) with leaf length. The other traits among each other indicated the negative correlation (Table 13). At T1, the highly significant (p>0.05) positive correlation (r=0.892***) was observed maturity time and 1000-grain weight, maturity time (p>0.01) to grain yield per plant (r=0.9837***) and grain yield with 1000-grain weight (r=0.8353***). At T2, 1000-garin weigh showed highly significant (p>0.01) correlation (r=0.8608***) with grain yield and flowering time to maturity (r=0.9948***). Similar finding have been reported by Mohammadi *et al.,* 2012; Gelalcha *et al.,* 2013; Chhibber and Jain, 2014.

Conclusion

The present research study concluded that the wheat variety Nukrat Zahran and Halba Najran have some genetic potential to produce higher grain yield than other contesting varieties under partial water stress conditions. The variety Nukrat Zahran along with Samrra Najran could produce maximum 1000-grain weight under both (well-watered and partial moisture stress) environments. The various yield components showed positive interrelationship among each other like plant height with number of leaves per plant, number of tillers per plant, seed index (1000-garin weight) and plant maturity with final grain yield. The traits recorded during three different timings (growth stages) showed significant differences in all 3 data readings. Our results showed highly significant differences among all traits at various timings (readings), except number of leaves. Traits showed increase at reading 2 and 3 as compared to first reading. This knowledge about plant architecture provided the basic and specific information regarding selection and validation of suitable varieties for water stress conditions. It is expected that these selected varieties will produce higher yields under some harsh environments.

References

Abderrahmane, H., F. Abidine, B. Hamenna and B. Ammar. 2013. Correlation, path analysis and stepwise regression in durum wheat (*Triticum durum* Desf.) under rainfed conditions. *J. Agric. Sustain*., 3(2): 122-131.

Allahverdiyev, T.I., J.M. Talai, I.M. Huseynova and J.A. Aliyev. 2015. Effect of drought stress on some physiological parameters, yield, yield components of durum (*Triticum durum* Desf.) and bread (*Triticum aestivum* L.) wheat genotypes. *Ekin. J. Crop Breed. and Gen*., 1(1): 50-62.

Blum, A. 1998. Improving wheat grain filling under stress by stem reserve mobilisation. *Euphytica,* 100: 77-83.

Bux, H., A. Rasheed, M.A. Sial, A.G. Kazi, A.Z. Napir and A.M. Kazi. 2013. An overview of stripe rust of wheat (*Pucciniastriiformis* f. sp. *tritici*) in Pakistan. *Archives of Phyto pathology and Plant Protection (UK).* 45(19): 2278-2289.

Ceccarelli, S., E. Acevedo and S. Grando. 1991. Breeding for yield stability in unpredictable environments: Single traits, interaction between traits, and architecture of genotypes. *Euphytica*., 56: 169-185.

Chhibber, S. and D. Jain. 2014. Inter correlation studies among yield and its contributing traits in bread wheat genotypes grown in Haryana, India (*Triticum aestivum* L.). *Int. J. Current Res. and Review*, 6(12): 12-18.

Cuthbert, J.L., D.J. Somers, A.L. Brule-Babel, P.D. Brown and G.H. Crow. 2008. Molecular mapping of quantitative trait loci for yield and yield components in spring wheat (*Triticum aestivum* L.). *Theor. Appl. Genet*., 117: 595-608.

Eitzinger, J., M. Stastna, Z. Zalud and M. Dubrovsky. 2002. Simulation study of the effect of soil water balance and water stress on winter wheat production under different climate change scenarios. *Agri. Water Manag*., 61: 195-217.

Gelalcha, S. and R.R. Hanchinal. 2013. Correlation and path analysis in yield and yield components in spring bread wheat (*Triticum aestivum* L.) genotypes under irrigated condition in Southern India. *Afr. J. Agri. Res.,* 8(24):3186-3192.

Gomez, K.A. and A.A. Gomez. 1984. Statistical procedures for agricultural research (2 ed.). John wiley and sons, NewYork, 680p.

Hameed, M., N. Naz, M.S. Aqeel, A. Islam-ud-din and A. Riaz. 2008. Morphological adaptations of some grasses from the salt range, Pakistan. *Pak. J. Bot*., 40(4): 1571-1578.

Li, Y.F., Y. Wu, N.H. Espinosa and R.J. Peña. 2013. Heat and drought stress on durum wheat: Responses of genotypes, yield, and quality parameters. *J. Cereal Sci*., 57(3): 398.404.

Lonbani, M. and A. Arzani. 2011. Morpho-physiological traits associated with terminal droughtstress tolerance in triticale and wheat. *Agron. Res.,* 9(1-2): 315-329.

Mirbahar, A.A., G.S. Markhand, A.R. Mahar, S.A. Abro and N.A. Kanhar. 2009. Effect of water on yield and yield components of wheat (*Triticum aestivum* L.) varieties. *Pak. J. Bot*., 41(3): 1303-1310.

Mohammadi, M., P. Sharifi, R. Karimizadeh, M. Kazem and M.K. Shefazadeh. 2012. Relationships between grain yield and yield components in bread wheat under different water availability (dryland and supplemental irrigation conditions). *Not. Bot. Hortic. Agrobo.,* 40(1): 195-200.

Mosaad, M.G., G.O. Ferranru and V. Mahalakshmi. 1995. Tiller development and contribution to yield under different moisture regimes in two Triticum species. *J. Agri. Crop Sci*., 36(6): 982-986.

Noureldin, N.A., H.S. Saudy, F. Ashmawy and H.M. Saed. 2013. Grain yield response index of bread wheat cultivars as influenced by nitrogen levels. *Ann. Agri. Sci.*, 58(2): 147-152.

Passioura, J.B. 1996. Drought and drought tolerance. In: *Drought Tolerance in Higher Plants: Genetical, Physiological and Molecular Biological Analysis*. (Ed.): E. Belhassen, Dordrecht, The Netherlands: Kluwer Academic. pp. 3-12.

Rajaram, S., H.J. Braun and M.V. Ginkel. 1996: CIMMYT's approach to breed for drought tolerance. *Euph*., 92: 147-153.

Rebetzke, G.J. and R.A. Richards. 1999. Genetic improvement of early vigour in wheat. *Aust. J. Agric. Res.,* 50: 291-301.

Reynolds, M.P., S. Nagrajan, M.A. Razzaque and O.A.A. Ageeb. 1997. Using canopy temperature depression to select for yield potential of wheat in heat-stressed environments. In: *Wheat Program Special Report*. (Ed.): D. F. Cimmyt. 42. Mexico.

Reynolds, M.P., B. Skovmand, R.M. Trethowan and W.H. Pfeiffer. 1999. Evaluating a concept model for drought tolerance. In: *Using Molecular Markers to Improve Drought Tolerance*. (Ed.): J.M. Ribaut, Mexico,

Reynolds, M.P., M.I.B Delgado, M.G. Rodriguez and A.L. Saavedra. 2000. Photosynthesis of wheat in a warm, irrigated environment. I: Genetic diversity and crop productivity. *Field Crops. Res*., 66: 37-50.

Riaz, A., A. Younis, A.R. Taj, A. Karim, U. Tariq, S. Munir and S. Riaz. 2013. Effect of drought stress on growth and flowering of marigold (*Tagetes erecta* L.). *Pak. J. Bot*., 45(S1): 123-131.

Rogers, P. and P. Lydon. 1994.Water in the Arab World: Perspectives and Prognoses, The Division of Applied Sciences. Harvard University, Cambridge, pp. 267-316.

Rucker, K.S., C.K. Kevin, C.C. Holbrook, J.E. Hook. 1995. Identification of peanut genotypes with improved drought avoidance traits. *Peanut Sci.,* 22: 14-18.

Sayre, K.D., E. Acevedo and R.B Austin. 1995. Carbon isotope discrimination and grain yield for three bread wheat germplasm groups grown at different levels of water stress. *Field Crops Res*., 41: 45-54.

Shao, H.B., L.Y. Chu, C.A. Jaleel and C.X. Zhao. 2008. Water-deficit stress-induced anatomical changes in higher plants. *Comptes Rendus*., 331(3): 215-225.

Sial, M.A., M.U. Dahot, M.A. Arain, G.S. Markhand, S.M. Mangrio, M.H. Naqvi, K.A. Laghari and A.A. Mirbahar. 2009. Effect of water stress on yield and yield components of semi-dwarf bread wheat (*Triticum aestivum* L.). *Pak. J. Bot.,* 41(4): 1715-1728.

Sial, M.A., M.A. Arain, M.U. Dahot, G.S. Markhand, K.A. Laghari, S.M. Mangrio, A.A. Mirbahar and M.H. Naqvi. 2010. Effect of sowing dates on yield and yield components on mutant-cum-hybrid lines of bread wheat. *Pak. J. Bot*., 42(1): 269-277.

Sial, M.A., J. Akhter, A.A. Mirbahar, K.D. Jamali, N. Ahmed and H. Bux. 2013. Genetic studies of some yield contributing traits of F_2 segregating generation of bread wheat. *Pak. J. Bot.*, 45(5): 1841-1846.

Snedecor, W.G. and W.G. Cochran. 1980. Statistical methods. 7th ed. The Iowa State Univ. Press Ames IOWA, USA.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and procedures of statistics: A biological approach. Second Edition, McGraw Hill, Book Co., New York, Toronto, London.

Strauss, J.A. and G.A. Agenbag. 2000. The use of physiological parameters to identify drought tolerance in spring wheat cultivars. *S. Afr. J. Plant and Soil,* 17(1): 20-29.

Yordanov, I., V. Velikova and T. Tsonev. 2003. Plant responses to drought and stress tolerance. *Bulg. J. Plant Physiol*., (Special issue), 187-206.

(Received for publication 17 March 2015)