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VARIABILITY AND HERITABILITY UNDER NORMAL AND RAINFED CONDITIONS IN *ASTIVUM* WHEAT (*TRITICUM ASTIVUM* L.)

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ABSTRACT

A set of 22 experimental wheat lines along with four check cultivars were evaluated in irrigated and unirrigated environments with objectives to determine genetic and phenotypic variation and heritability estimates for yield and its traits. The two environments were statistically at par for grains spike^{-1}, spike weight, biological yield, and grain yield except days to heading. Highly significant genetic variability existed among wheat lines ($P \leq 0.01$) in the combined analysis across two test environments for traits except spike weight. Genotypes x environment interactions were non-significant for traits indicating consistent performance of lines in two test environments. However lines and check cultivars were two to five days early in heading under unirrigated environment compared to the irrigated. Spike weight and grains spike^{-1} also reduced under unirrigated environments. Genetic variances were greater than environmental variances for most of traits. Heritability estimates were of higher magnitude (0.74 to 0.96) for days to heading, spike length, biological yield and grain yield, and low for spike weight in both the environments. The differential heritability for yield and yield related traits suggests simultaneous evaluation of wheat lines under the two environments.

Key-words: Genotype, phenotype, variability, wheat.

INTRODUCTION

Wheat (*Triticum aestivum L.*) is the most cultivated cereal crop of the world including Pakistan and ranks first among all the cereals. In Pakistan, it occupies around 8.5 million hectares with annual production of 21.0 million tones (Anon., 2005). Wheat yields of the country are much lower as compared to many other countries of the world due to abiotic (environmental stresses particularly high temperatures, drought and salinity) and biotic (diseases etc.) factors (Arain *et al.*, 1999; Reynolds *et al.*, 2001). Among the wheat growing countries of the world, Pakistan ranks 9th in average annual production. About 1.033 million hectares of wheat area in Pakistan entirely depends on natural precipitation. During 2002 grain yield averaged 2566 and 1178 kg ha^{-1} under irrigated and unirrigated regions of the country, indicating a yield gap of 1388 kg ha^{-1} between the two production environments. During 2002-03, total wheat area in NWFP was 732.1 thousand hectares of which 316.1 thousand hectares was irrigated and 416.0 thousand hectares unirrigated (rainfed). The average yield was 2018 kg ha^{-1} under irrigated vs 1025 kg ha^{-1} under unirrigated regions, indicating a decrease of 993 kg ha^{-1} under unirrigated, respectively (Minfal, 2003).

To overcome the consumption pressure of ever increasing population, the wheat breeders are concentrating their efforts to improve the yield potential of wheat by developing new varieties with desirable genetic make up. The high heritability associated with high genetic advance for main quantitative traits in wheat offer better scope of selection of genotypes in early segregating generations. Wheat breeders are utilizing available genetic resources to reconstruct the ideotype of plant to meet the ever increasing requirements of the population. In this regard heritability estimates plays an important role for planning the breeding strategy. The heritability of the character determines the extent to which it is transmitted from one generation to the next and it is most valuable tool when used in conjunction with other parameters in predicting genetic gain that follows in the selection for that characters (Afiah *et al*, 2000; Baloch *et al*, 2003; Ansari *et al*, 2004, 2005). The heritability values become a measure of the genetic relationship between parents and progeny; hence considerable research work has been carried out to incorporate the desirable genes in present wheat varieties to increase the productivity of the crop.

This shows that genetic improvement in grain yields of the currently grown wheat cultivars are not expressed to full potentials under the unirrigated environment due to lack of inherent ability to resist moisture stress (Collaku, 2006; Mladenor *et al.*, 2001). The crop under unirrigated area suffers a serious moisture stress through out its life cycle beginning from seedling stage to maturity. Even in areas where wheat is grown under the late stages of plant growth, showing considerable reduction in yield (Riaz and Chaudhary, 2003). Therefore, wheat yield improvement in the rainfed regions would provide the basis for eliminating hunger and instituting socio-economic development in the province.

Drought is one of the major environmental factors reducing grain production of rainfed wheat in arid and semi-arid regions. Drought may be described as period in which a scarcity of soil moisture is limiting the normal growth of plants. Drought has sometimes been referred to as “a period in which the soil contains little or no moisture”. Agricultural drought is defined as a climatic excursion involving a shortage of precipitation sufficient to adversely affect crop production (Collaku, 2006).

Drought resistance in field crops is a major factor for sTable crop production in drought prone environments and thus is considered by breeders as a genuine breeding target (Riaz and Chaudhary, 2003; Ayeicek and Yieldirin, 2006). Although genetic improvement in wheat is continuously been made for its better adaptability to a wider range of environments. The production targets from the rainfed cropped area are not fully realized. The reason is that the arid or rainfed areas, consisting a considerable proportion of the total cropped area, are not planted with the genotypes having a better adaptability to low and uncertain moisture supply and specifically breed for these areas. This situation has come under sharp focus and efforts are being made to plan and organize arid zone research in a proper manner.

Sufficient genetic information regarding important economic characters of wheat under drought stress is not available without which the breeding strategies for drought prone areas may not prove fruitful. Wheat improvement in the country has so far been focused for irrigated areas, however, low production of wheat and increasing demand of food supply for the ever increasing population has compelled agricultural scientists to plan and focus their research for higher production in drought prone areas of Pakistan.

Therefore the present study was undertaken with the objectives to determine magnitude of genetic and phenotypic variation and the heritability for yield and yield related traits in wheat under irrigated and unirrigated production environments.

MATERIALS AND METHODS

This study was conducted at the research area, Faculty of Agriculture, Gomal university, D.I.Khan during crop season 2005-06. A set of 22 experimental wheat lines along with four check cultivars, (Dera-98, Fakher-e-sarhad, Ghaznavi-98 and Tatara) was evaluated as independent experiments under irrigated as well as unirrigated environments. A randomized complete block design with three replications was used for both environments. To avoid environmental influence, both the environments were established adjacently in the same field. The irrigated experiment was regularly irrigated whenever required throughout the growing season. In contrast, the unirrigated experiment did not receive any canal irrigation except the one for bringing the field into “Vatter” for sowing. Each plot had three meter long 2 rows, spaced 0.30 meters apart. The experiment was held on October 28th, 2005 with hand hoe using seed rate of 100 kg ha^{-1}. Fertilizer was applied to both irrigated and unirrigated environments at the rate of 90 kg ha^{-1} N and 60 kg ha^{-1} P_2O_5 at the time of sowing. Weeds were controlled manually in the experiment. The plots were sickle harvested about 15 days after reaching to physiological maturity.
Data were recorded on the following parameters at appropriate time using protocol described for each.

Days to heading: Days to heading were recorded from the date of sowing to the date when 50% plants in a plot emerged spikes from the flag leaf.
Spike length: Ten random spikes were harvested from each plot and spike length was measured in centimeters. Spike length was measured from the base of the first spikelet attachment on the rachis to the tip of the spike excluding the awns.
Spike weight: The ten randomly selected spikes were manually threshed together and the total grain weight was divided by ten to determining the spike weight.
Number of grains spike^{-1}: Number of grains spike^{-1} was determined from the total grains obtained from threshing the ten spikes used for determining the number of grains spike^{-1}.
Biological yield: Each plot was harvested manually and the whole bundle was weighed after sun drying for one week before threshing to determine the biological yield.
Grain yield: Each bundle was threshed separately and then weighed to estimate grain yield ha^{-1}.

Statistical analysis: Data recorded on 22 wheat lines (including check cultivars) were statistically analyzed using PRG GLM option in SAS following linear model for a randomized complete block design as proposed by Steel and Torrie (1981). Genetic and environmental variance for all traits was estimated for the 22 experimental lines under each environment independently using PROG VARCOMP option in SAS. Broad-sence heritability (h^2_{BS})
$h^2_{BS} = V g / (Vg + Ve/r)$
Wherein
h^2_{BS} = broad sense heritability; Vg= genetic variance; Ve= environmental variance; r= number of replications.

RESULTS

GENETIC VARIABILITY

Mean square pertaining to heading, spike and grain characteristics and yield traits are given in Table 1. The two test environments did not differ for grains spike^{-1}, ($P \leq 0.43$), spike weight ($P \leq 0.13$), biological yield ($P \leq 0.14$) and grain yield ($P \leq 0.32$) but the differences were significant for days to heading ($P \leq 0.26$) and spike length ($P \leq 0.05$). Highly significant genetic variation among the experimental lines ($P \leq 0.01$) in the combined analysis over the two environments was detected for days to days to heading, grains spike^{-1}, spike length, biological yield, and grain yield except spike weight ($P \leq 0.44$). Genotype x environment interaction was non significant for these traits indicating consistent performance of experimental lines across the two test environments (Table 1). However, means and genetic parameters about all the traits of the wheat experimental lines are being presented independently for each environment for comparison.

Table 1. Mean squares for days to heading, spike length , spike weight, grains spike^{-1}, biological yield and grain yield of 22 spring wheat lines evaluated under irrigated and unirrigated environments at Faculty of agriculture during crop season 2005-06.

Source	Df	Days to heading	Spike length	Spike weight	Grains spike^{-1}	Biological yield	Grain yield
Environment (E)	1	593.93**	2.01*	5.58 NS	103.70 NS	60007575NS	4547348.48 NS
Reps w/n E	4	26.15	0.29	1.56	136.13	1872537.80	3543560.60
Genotype (G)	21	233.07**	6.91**	3.34 NS	108.26**	20294372.30 **	2858315.29**
Gx E	21	9.55 NS	0.40 NS	3.44 NS	61.52 NS	3527417.03 NS	436237.37 NS
Error	84	6.25	0.44	3.27	65.11	3271013.71	652687.59
CV(%)	…..	1.98	5.98	72.44	14.43	15.75	20.25

NS= non-significant

*, **= significant at 5 and 1 % level of probability, respectively.

DAYS TO HEADING

A perusal through the means (Table 2) indicated that the wheat genotypes significantly differ in the days to heading. Days to days to heading among the genotypes ranged from 108.2 to 138.3. The highest (138.3) days taken to heading were observed in line IR2. Means given in Table 2 revealed that environments significantly differ for days to heading. The maximum number of 129.4 days was observed in irrigated environment. The minimum number of 125.5 days was exhibited in unirrigated environment.

There were non significant differences in the mean values of days to heading between genotypes and environment interaction. However, line RF9 took maximum number of 139.7 days under irrigated environment, while IR2 needed minimum number of 105.7 days in unirrigated environment.

Genetic, environmental and phenotypic variances and heritability estimates for days to heading under irrigated and unirrigated environments are given in Table 8. Genetic variances for heading were 5-8 times greater than the environmental variances under irrigated and unirrigated environments respectively. However heritability estimates for days to heading were identical and of higher magnitude (0.94 in irrigated vs 0.96 in unirrigated environments) indicating equal opportunity of selecting genotypes with desirable heading in both environments.

Table 2. Means for days to heading of 22 experimental lines and four check cultivars under irrigated and unirrigated environments during crop season 2005-06.

	Days to heading		
	Irrigated	Unirrigated	Mean
IR10	130.7	128.3	129.5
IR11	131.3	125.3	128.3
IR14	137.0	134.7	135.8
IR15	135.0	129.7	132.3
IR17	131.7	129.7	130.7
IR18	126.0	130.7	128.3

IR2	110.3	105.7	108.2
IR20	125.3	120.3	122.8
IR21	130.7	126.0	128.3
IR5	133.0	127.7	130.3
IR7	126.0	123.3	124.6
RF10	123.0	117.3	120.1
RF2	128.3	123.3	125.8
RF21	123.7	119.3	121.5
RF29	126.7	122.0	124.3
RF3	126.0	119.7	122.8
RF33	133.7	127.0	130.3
RF35	130.7	123.3	127.0
RF36	123.7	121.0	122.3
RF37	125.0	118.3	121.6
RF5	126.3	121.0	123.6
RF9	139.7	137.0	138.3
Dera-98*	136.0	131.3	133.6
F.Sarhad*	134.7	129.7	132.3
Ghaznavi-98*	139.3	135.0	137.1
Tatara*	130.3	124.7	127.5
Mean	129.4	125.05	

$LSD_{0.01}$ Environment (E) = 4.0
$LSD_{0.01}$ genotype (G) = 3.6
* = check cultivar

SPIKE LENGTH

A perusal through the means (Table 3) indicated that the wheat genotypes significantly differ for spike length. Spike length among the genotypes ranged from 9.3 to 13.8 cm. The highest (13.8 cm) spike length was recorded in line RF36. the lowest (9.3 cm) spike length were recorded in line RF21 (Table 3).

Means given in Table 3 revealed that environments significantly differ for spike length. The maximum number of 11.4 cm spike length was noted in irrigated conditions. The minimum number of 11.2 cm spike length was exhibited in unirrigated environment.

There were non significant differences in the mean values of spike length between the genotypes and environment interaction. However, line RF36 gives maximum spike length of 14.0 cm under unirrigated environment, while line RF2 gives minimum number of 8.8 cm spike length in unirrigated environment.

Plant height of 91.9 cm was observed under irrigated environment, which was at par with unirrigated environment.

The interacting effects of genotypes x environments on plant height were non-significant. However, the maximum plant height of 109.7 cm was recorded by genotype RF36 under unirrigated environment.

Genetic variances for spike length were greater in magnitude than the environmental variance in both the environments indicating less environmental influence (Table 8). The heritability estimates for spike length in both the environments were of higher magnitude (0.80 in irrigated and 0.91 in unirrigated).

Table 3. Means for spike length of 22 experimental lines and four check cultivars under irrigated and unirrigated environments during crop season 2005-06.

	Spike length		
	Irrigated	Unirrigated	Mean
IR10	11.3	12.0	11.6
IR11	10.0	10.3	10.6
IR14	12.0	13.0	12.5
IR15	12.3	12.3	12.3
IR17	12.3	12.3	12.3
IR18	10.3	9.6	10.0
IR2	10.6	10.0	10.3

IR20	11.3	11.0	11.1
IR21	11.6	11.3	11.4
IR5	11.3	10.6	11.0
IR7	11.6	11.0	10.8
RF10	10.6	9.7	10.1
RF2	9.8	8.8	9.3
RF21	12.6	12.3	12.4
RF29	11.3	11.3	11.3
RF3	12.1	12.0	12.1
RF33	12.0	12.1	12.0
RF35	13.0	13.3	13.1
RF36	13.6	14.0	13.8
RF37	11.3	11.0	11.1
RF5	11.1	10.3	10.7
RF9	11.3	11.0	11.1
Dera-98*	10.6	11.0	10.8
F.Sarhad*	11.0	10.3	10.6
Ghaznavi-98*	11.0	10.6	10.8
Tatara*	11.3	11.0	10.7
Mean	11.4	11.2	

LSD $_{0.01}$ Environment (E) = 1.1
LSD $_{0.01}$ genotype = 1.0
* = check cultivar

SPIKES WEIGHT

Significant differences were observed among the genotypes for spike weight. The highest (2.5 gm) spike weight was recorded in line RF21, RF7 and RF29. The lowest (1.9 gm) spikes weight was recorded in line IR21 (Table 4). The effect of environment on spike weight was non significant. However, the maximum spikes weight of 2.3 gm was observed under irrigated environment, which was at par with unirrigated environment.

The interacting effects of genotypes x environments on spikes weight were non-significant. However, line RF29 gives maximum spikes weight of 2.8 gm under irrigated environment, while Dera-98 (check) gives minimum number of 1.8 gm spike weight in unirrigated environment.

Genetic variances for spike weight were smaller in magnitude than environmental variance in both environments.The heritability estimates for spike weight were 0.05 and -0.23 in irrigated and unirrigated environments (Table 8).

Table 4. Means for spikes weight of 22 experimental lines and four check cultivars under irrigated and unirrigated environments during crop season 2005-06.

	Spikes weight		
	Irrigated	Unirrigated	Mean
IR10	2.3	2.2	2.2
IR11	2.0	2.0	2.0
IR14	2.1	2.2	2.1
IR15	2.5	2.1	2.3
IR17	2.5	2.2	2.3
IR18	2.3	2.3	2.3
IR2	2.3	2.2	2.2
IR20	2.6	2.3	2.4
IR21	2.0	1.9	1.9
IR5	2.2	2.1	2.1
IR7	2.6	2.5	2.5
RF10	2.3	1.9	2.1
RF2	2.3	2.2	2.2

RF21	2.7	2.3	2.5
RF29	2.8	2.3	2.5
RF3	2.4	2.2	2.3
RF33	2.5	2.2	2.3
RF35	2.7	2.2	2.3
RF36	2.5	2.3	2.5
RF37	2.2	2.2	2.2
RF5	2.0	1.9	1.9
RF9	2.2	2.0	2.1
Dera-98*	2.2	1.8	2.0
F.Sarhad*	2.6	2.3	2.4
Ghaznavi-98*	2.4	2.1	2.3
Tatara*	2.2	2.1	2.3
Mean	2.3	2.1	

* = check cultivar

GRAINS SPIKE^{-1}

Significant differences were observed among the genotypes for grains spike^{-1}. The maximum grains spike^{-1} of 61.9 was recorded in line IR14, while the minimum grains spike-1 of 46.3 was recorded in RF10 (Table 5).
The effect of environment on grains spike^{-1} was non significant. However, the maximum grains spike^{-1} of 56.9 was observed under irrigated environment, which was at par with unirrigated environment.
The interacting effects of genotypes x environments on grains spike^{-1} were non significant. However, the maximum grains spike-1 of 68.6 was recorded by genotype RF5 under irrigated environment.
Environmental variances for grains spike^{-1} in irrigated and unirrigated environments were 8 and 11 times greater than the respective genetic variance. The heritability for grains spike^{-1} was 0.33 under irrigated and 0.21 under unirrigated environment.

Table 5. Means for grains spike^{-1} of 22 experimental lines and four check cultivars under irrigated and unirrigated environments during crop season 2005-06.

	GRAINS SPIKE^{-1}		
	Irrigated	Unirrigated	Mean
IR10	59.0	57.3	58.1
IR11	54.0	49.3	51.6
IR14	59.6	64.3	61.9
IR15	59.6	48.6	54.1
IR17	57.3	61.3	59.3
IR18	54.3	59.6	56.9
IR2	53.0	52.3	52.6
IR20	52.3	47.0	49.6
IR21	56.6	49.3	52.9
IR5	53.0	59.0	56.0
IR7	59.3	63.3	56.3
RF10	47.3	45.3	46.3
RF2	49.3	49.6	49.4
RF21	58.0	60.6	59.3
RF29	57.3	60.6	58.9
RF3	58.6	53.6	56.1
RF33	62.3	60.3	61.3
RF35	62.0	55.6	53.8
RF36	59.3	54.0	56.6
RF37	48.6	55.6	52.1
RF5	68.6	49.0	58.5
RF9	59.0	53.6	56.3

Dera-98*	57.3	49.0	53.1
F.Sarhad*	60.0	61.0	60.5
Ghaznavi-98*	58.3	51.6	54.9
Tatara*	57.0	55.0	56.0
Mean	56.9	55.2	

* = check cultivar

BIOLOGICAL YIELD

The data in Table 6 indicated that the biological yield of wheat was significantly affected by genotypes wih highest biological yield of 15333 kg ha^{-1} produced by genotype RF29. Dera-98 (check) gave the lowest biological yield of 7333 kg ha^{-1}.

Analysis of variance revealed non significant differences between environment for biological yield, however, highest biological yield (11762 kg ha^{-1}) was recorded under unirrigated environmet, while lowest biological yield (10756 kg ha^{-1}) was noted under irrigated environment.

Results (Table 6) showed that interaction between genotype x environment was also non significant for biological yield. The biological yield was maximum (16833 kg ha^{-1}) for genotype RF29 under unirrigated environement. The minimum biological yield of 7166 kg ha^{-1} was found in check variety Dera-98 under unirrigated environment.

Genetic and environmental variances were 2.03 x 10^6 and 2.7 x 10^6 under irrigated vs 3.7 x 10^6 and 3.8 x 10^6 under unirrigated environments. similarly heritability estimates (0.74)for biological yield were obtained under each environment (Table 8).

Table 6. Means for biological yield of 22 experimental lines and four check cultivars under irrigated and unirrigated environments during crop season 2005-06.

	Biological yield (Kg ha^{-1})		
	Irrigated	Unirrigated	Mean
IR10	10333	11667	11000
IR11	11000	10833	10916.5
IR14	12333	13833	13083
IR15	14333	14166	14244.5
IR17	9833	10000	9916.5
IR18	9166	8333	8749.5
IR2	8333	8500	8416.5
IR20	10166	10333	10249.5
IR21	10333	9166	9749.5
IR5	10333	12333	11333
IR7	11500	11500	11500
RF10	8333	11166	9749.5
RF2	8333	11166	9749.5
RF21	12166	13666	12916
RF29	13833	16833	15333
RF3	11000	13166	12083
RF33	11166	14666	12916
RF35	12666	15666	14166
RF36	11000	14000	12500
RF37	9000	11333	10166.5
RF5	9666	13166	11416
RF9	12833	12166	12499.5
Dera-98*	7500	7166	7333
F.Sarhad*	11333	12833	12083
Ghaznavi-98*	13666	8333	10999.5
Tatara*	9500	9833	9666.5
Mean	10756.5	11762.3	

LSD $_{0.01}$ genotype (G) = 3456.4
* = check cultivar

GRAIN YIELD

The data in Table 7 indicated that grain yield of wheat was significantly (0.01) affected by genotypes with highest grain yield of 5166 kg ha^{-1} produced by genotypes RF29. line IR2 gave the lowest grain yield of 2167 kg ha^{-1}.

Analysis of variance revealed non significant differences between environment for grain yield, however, highest grain yield (4192 kg ha^{-1}) was recorded under irrigated environment, while lowest grain yield (3597 kg ha^{-1}) was noted under unirrigated environment.

There were non significant differences in the mean values of 1000-grain weight between genotypes and environment interaction. The grain yield was maximum (5500 kg ha^{-1}) for genotype tatara (check) under irrigated environment, while check cultivar Fakher-e-sarhad gives minimum grain yield of 1700 kg ha^{-1} under unirrigated environment.

Genetic and environmental variances were 3.3 x 10^5 and 2.7 x 10^6 under irrigated vs 3.3 x 10^5 and 3.4 x 10^5 under unirrigated environment. Heritability estimates for grain yield were 0.75 in irrigated vs 0.50 under unirrigated environment, respectively (Table 8).

Table 7. Means for grain yield of 22 experimental lines and four check cultivars under irrigated and unirrigated environments during crop season 2005-06.

	GRAIN YIELD (kg ha^{-1})		
	Irrigated	Unirrigated	Mean
IR10	4167	4000	4083.5
IR11	4500	3833	4166.5
IR14	4833	4000	4416.5
IR15	4333	4333	4333
IR17	3666	2833	3249.5
IR18	3333	3166	3249.5
IR2	2500	1833	2166.5
IR20	4166	4000	4083
IR21	4166	2833	3499.5
IR5	4333	3833	3583
IR7	3666	3000	3333
RF10	3333	3333	3333
RF2	3666	3333	3499.5
RF21	4666	4000	4333
RF29	5000	5333	5166.5
RF3	4833	4666	4749.5
RF33	5000	3666	4333
RF35	4166	5000	4583
RF36	4500	3833	4166.5
RF37	3333	3833	3583
RF5	4666	4000	4333
RF9	5000	5000	5000
Dera-98*	3000	2333	2666.5
F.Sarhad*	4666	1700	3183
Ghaznavi-98*	4000	3000	3500
Tatara*	5500	2833	4166.5
Mean	4192	3597.1	
LSD	5.9	6.1	

* = check cultivar

Table 8. genetic variance (Vg), environmental variance (Ve), phenotypic variance (Vp) and heritability estimates (h^2) for various traits of 22 experimental wheat lines evaluated under irrigated and unirrigated environment during crop season 2005-06.

	Irrigated				unirrigated			
	Vg	Ve	Vp	h^2	Vg	Ve	Vp	h^2
Days to heading	345	6.7	36.8	0.94	42.2	5.6	44.3	0.96
Spike length	0.6	0.5	0.8	0.80	1.5	0.04	1.6	0.91
Spikes weight	-0.1	5.9	2.1	0.05	-0.04	0.6	0.2	-0.23
Grains spike^{-1}	6.4	54.7	24.6	0.33	6.8	75.5	31.9	0.21
Biological yield	2.03×10^6	2.7×10^6	2.9×10^6	0.74	3.7×10^6	38×10^6	5×10^6	0.74
Grain yield	3.3×10^5	3.4×10^5	4.4×10^5	0.75	3×10^5	9×10^5	6×10^5	0.50

DISCUSSION

The experimental lines as well as check cultivars were 2 to 5 days early in heading under unirrigated environment. Thus rainfed conditions accelerated the heading because of less availability of water. Check cultivars Ghaznavi-98 and experimental line RF9 took more days to heading under both the environments. Significantly less number of days to heading was taken by IR2 in both the environments. Significant differences for heading in wheat genotypes have also been reported by Litvinenko and Abakumenlio (1989) mainly due to existence of drought. Greater magnitude of heritability (0.94 and 0.96) were observed for days to heading under both the environments indicating effctiveness of selection among the current pool of genotypes. However, medium to low heritability for days to heading have been reported by Gupta and Verma (2001) in durum wheat under irrigater and rainfed conditions. Similarly significant variation with low heritability of 40% has been reported by Muhammad *et al.* (2001) in a study involving 24 wheat breeding lines.

Highly significant differences among genotypes were obtained for spike length in unirrigated environment. Maximum numbers of spike length (14 and 13.6) were recorded for genotype RF36 under both the environments. High (0.80 and 0.91) heritability was estimated for spike length in irrigated and unirrigated environments.

Maximum spikes weight leads to an increase in total biological and grain yield. Biological yield is considered important for fodder purposes in developing countries like Pakistan. More spikes weight was observed in irrigated environments than unirrigated. Maximum spikes weight (2.8 gm) was produced by experimental line RF29 followed by line RF21 (2.7 gm) under irrigated environment. Lowest magnitudes of heritability (0.05 and -0.23) were observed under both the irrigated and unirrigated environments. Reduced number of spikes weight under unirrigated water stressed environment were also reported by Ahamd *et al.* (1991) who studied the effect of moisture stress in two varieties of wheat in a pot experiment for morphological characters like plant height, productive tillers plant^{-1} and 1000-grain weight.

Highly significant differences among genotypes were obtained for grains spike^{-1} in unirrigated environment. Maximum numbers of grains spike^{-1} (68.6) were recorded for genotype RF5 under irrigated environments. Low medium (0.33 and 0.21) heritability was estimated for grains spike^{-1} in irrigated and unirrigated environments.

Highly significant differences were observed among wheat lines for biological yield in both environments. Maximum biological yield of 14333 and 14166 kg ha^{-1} was recorded for IR15 under irrigated and unirrigated environments, respectively. Several of the wheat lines evaluated produced more biological yield under unirrigated environment due to more and timely rain in the growing season of 2005-06. greater heritability of 0.74 was estimated under each environment. Gupta and Verma (2001) showed high heritability estimates coupled with high genetic advance for biological yield under normal and rainfed conditions. Wheat lines, whether selected or not, had on the average more biological yield in unirrigated environment. However,check cultivars produced more biological yield under irrigated than unirrigated.

Grain yield was also significantly different among wheat genotypes under both the environments. Water stress under unirrigated environment generally reduced the grain yield. In contrast, wheat lines RF29, RF35 and RF47 produced more grain yield under unirrigated than irrigated environment. Heritability estimates was high to moderate (0.75 to 0.50) under irrigated and unirrigated environment.

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