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## INTERPRETING WHEAT GENOTYPES FOR GRAIN YIELD UNDER DIFFERENT REGIMES OF KHYBER PAKHTUNKHWA

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**ABSTRACT:-** Pakistan has been blessed with wide range of environmental conditions ranging from plains to mountains. Wheat is grown throughout the country to feed more than 200 million people. To get maximum yield, high yielding genotypes suitable to diverse agro-climatic conditions are needed. However, so far few varieties have been developed that can efficiently grow in different environments. This is one of the reasons for lower wheat production in the country. Current experiment was conducted to monitor stability of yield potential of 15 diverse wheat genotypes at Skardu-Gilgit-Baltistan (Northern and mountainous region of Pakistan) and Peshawar, Khyber Pakhtunkhwa, during wheat crop season 2011-2012 using RCB design with three replications. The genetic material was comprised of 9 nationally released cultivars, three advance line from Tajikistan, one from China and two locally grown cultivars. The analysis of variance revealed significant differences among genotypes, locations and genotype by environment interactions for days to heading, days to maturity, plant height (cm), spike length (cm), spikelets spike<sup>-1</sup>, 1000-grain weight and grain yield. Flag leaf area (cm<sup>2</sup>) displayed non-significant differences across environments and its interaction with genotypes. Mean values across the environments range between 147.17 to 174.00, 190.83 to 202.83, 23.32 to 54.13, 78.40 to 115.17, 9.72 to 13.08, 16.33 to 23.80 for days to heading, maturity, flag leaf area, plant height, spike length and spikelets spike<sup>-1</sup>, respectively. The estimates of broad sense heritability were high for all studied traits. Similarly, genetic advance was also high for all studied traits except days to heading and maturity where genetic advance was low. High heritability coupled with high genetic advance indicated the effectiveness of selection in early generation for the improvement of these traits. Genotypes Faisalabad-2008 and line from Tajikistan (2S-3094) performed better for most of yield and associated traits across both environments therefore could be an asset for plant breeders to breed genotypes suitable for diverse environments.

*Key Words: Genotypes x Environment; Heritability; Genetic Advance; Skardu; Bread Wheat; GEI*

### INTRODUCTION

Bread wheat (*Triticum aestivum* L.) is one of the most important and widely consuming cereals of world including Pakistan. It occupies a central position in making agricultural policies of the country and

contributes 14.4 % to the value added in agriculture and 3.1% to GDP. Pakistan has diverse agro-ecological regions such as areas from Baluchistan to Khyber Pakhtunkhwa, plains of Punjab and Sindh, mountains of Azad Jammu Kashmir and Gilgit-Baltistan. Gilgit-Baltistan comprises

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the districts which are located in Northern part of the country where it borders with China and Kashmir. This area is mostly encompasses high mountains and rivers. It is connected with rest of the country through Silk Road. Gilgit-Baltistan is a land of subsistence farming with small land holdings. Under irrigated conditions wheat can be grown in the valleys and terraces of high mountains. Wheat is the major cereal crop of the area, which is planted both in the double cropping zone (upto 1800 meters) and in the single cropping zone (generally above 1800 meters). Agro ecological features of Gilgit-Baltistan are totally different from rest of the country. Moreover, the agro-climatic conditions within the Skardu itself are so contrasting that imposes challenges for the plant breeders.

Wheat is grown throughout the country including Gilgit-Baltistan. Hardly any cultivar has been developed for different parts of this region. Therefore, local farmer within the region are compelled to cultivate low yielding varieties which have not been bred for different environments. Wheat growing areas in Pakistan contain both irrigated and rainfed which are located in diverse environmental conditions. Therefore this demands the development of such varieties which can withstand diverse environmental conditions that give reasonable yields from all type of areas. Crop plant is exposed to a range of environmental factors such as the amount of precipitation, humidity, day length, temperature, texture and potency of soil during its growth which greatly influence its performance or yield (Asif *et al.*, 2003). The assessment of a variety in a series of diverse environments to test the consistency in yield

is therefore, a part of majority of the breeding programs (Kaya *et al.* 2002). Plant breeders around the country are trying hard to identify wheat genotypes with steady performance over a variety of environments. Only few high yielding wheat genotypes have been evolved by the breeders and are being cultivated across the country (Khan *et al.*, 2011). The true yielding potential of a genotype is the product of its interaction with environment. The difference in performance of a genotype when subjected to varying environments is termed as genotype  $\times$  environment (GE) interaction (Basford and Cooper, 1998). Varieties having lower degree of fluctuation in their yield performance in diverse environments are considered stable and widely adaptable genotypes (Amin *et al.*, 2005).

Heritability is a study of forecasting the behaviour of crops in erratic environments (Songsri *et al.*, 2008). It guides the breeder to predict a required genetic advance from selection in multiple environments. If the heritability is high for a particular trait, it can make the selection simpler and easy for that trait (Khan, 2013). However, in advanced generations heritability alone cannot be adequate to bring the desired improvement. Therefore, stress has been given to use heritability with significant magnitude of genetic advance. The effectiveness of heritability is boosted when accompanied by genetic advance, which projects the amount of genetic advance when subjected to a specific selection pressure. Hence, the use of genetic advance in selection is a significant parameter as it directs the breeder in selection (Ikramullah, *et al.*, 2011).

Keeping in view the importance of

wheat and its widespread cultivation across the country an experiment was conducted with the objectives to i) study relative performance of wheat genotypes across contrasting environments, ii) estimate heritability and genetic advance for various traits across two environments, and iii) identify high yielding wheat genotype(s) for general cultivation.

## MATERIALS AND METHOD

A set of 15 wheat diverse wheat genotypes procured from Agricultural Research Station, Skardu (Gilgit-Baltistan) were evaluated at two locations *viz.*, The University of Agriculture Peshawar, Khyber Pakhtunkhwa and Agriculture Department Skardu, Gilgit-Baltistan during crop season 2011-12 using RCB design in three replications. The germplasm comprised of 9 approved varieties (Shafaq-2006, Faisalabad-2008, Chakwal-50, Bakhar-2002, Lasani-2008, Kohat-2010, Aas-2011, Meraj-200 and Sehar-2006); 3 advanced lines from Tajikistan, (2S-5066, 2S-3094 and 2S-4178); one line from PR China (China Selection) and two local cultivars (Mondu Tro and Bagrot). At each location, each genotype/line was sown in five rows of 5m length while rows were 0.3m apart. Approved cultural practices including hoeing, application of fertilizer and irrigation and all other practices necessary for crop management were followed throughout the growing season at each site. Data were recorded on ten randomly selected plants of each genotype at each location from central three rows at proper time on days to heading, days to maturity, plant height, flag leaf area, spike length, spikelet spike<sup>-1</sup>, 1000-grain weight and grain yield.

## Statistical Analysis

### A. Analysis of variance

Analysis of variance for individual trait was performed by Steel and Torrie (1984) using MSTATC computer program. The means were separated by Fisher's protected Least Significant Difference test (LSD).

### B. Variance, heritability and selection Response

Variance for the studied parameters were formulated from the analysis of variance under each environment to determine broad sense heritability ( $h^2_{BS}$ ) using the procedure followed by Singh et al. (1993)

$$h^2(BS) = \frac{\delta^2g}{\delta^2p} = \frac{\delta^2g}{\delta^2g + \delta^2ge + \delta^2e}$$

Where,

$V_G$  = Genetic variance;

$V_P$  = Phenotypic variance;

$V_{GE}$  = Genotype X Environment variance, and

$V_E$  = Error variance.

Selection response ( $Re$ ) for a trait at each location was predicted as:

$$Re = ix\sqrt{\rho}h^2x$$

Where,

$ix$  selection intensity for trait  $x$ ;  $h^2_x$  = heritability for trait  $x$ ;  $\sqrt{\rho}$  = square root of the phenotypic variance of trait  $x$ . selection intensity at 10% will be 1.76 was assumed in predicting direct selection responses at both environments (Falconer and Mackay, 1996).

## RESULTS AND DISCUSSION

### Climatic Data

This experiment was conducted at Peshawar-Khyber Pakhtunkhwa and Skardu (Gilgit-Baltistan). These two locations are totally different from

**Table 1. Description of experimental environments**

Location	Altitude	Latitude	Longitude	Annual rainfall	Temperature		Soil type	Average PH
					Min	Max		
Peshawar	331m	34.017° N	71.583° E	384mm	10.7 <sup>o</sup>	33.2 <sup>o</sup>	Alkaline	7.2-9.1
Skardu	2248m	35.300° N	75.617° E	202mm	4.7 <sup>o</sup>	23.4 <sup>o</sup>	Alkaline	7.6-7.9

one another and are located about 1000 km away having diverse agro-climatic conditions. Peshawar is located 331m above the sea level with 34.0167° N latitude whereas Skardu is located 2248m above sea level and at latitude of 35.3000°N. Annual precipitation varied from 202 to 384 mm for Skardu and Peshawar respectively. The annual temperatures ranged from to 10.7 °C to 32.02°C.at Peshawar, whereas, at Skardu temperature ranged from -4.7 to 23.4°C (Table 1). The crops at Skardu tolerated harsh cold stress (snow) during the months of December and January.

**Analysis of variance and Mean performance**

**Days to heading**

Early heading has a very crucial role in grain formation in majority of crops including wheat. Due to delay

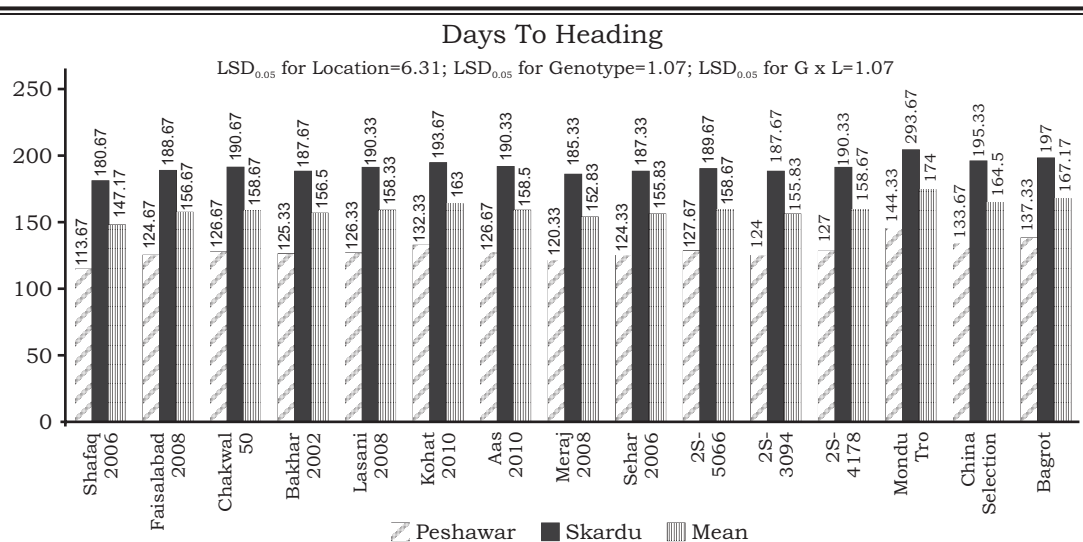
in heading, lesser time is available for grain filling which ultimately reflects in lower grain weight (Uddin et al. 2015). Significant ( $P \leq 0.01$ ) difference was observed for days to heading for locations, genotypes, and genotype by location interaction (Table 2). Mean values for genotypes across locations varied from 127.62 and 190.56 days, indicating large variation among genotypes. Overall, genotypes performed better at Peshawar than Skardu. Mean values for genotypes ranged from 147.17 to 174 days where genotype Shafaq-2006 took minimum day's genotype Mondu Tro took maximum days to heading (Fig. 1). Genotype by location interaction means ranged from 113.67 to 203.67days. Mean data revealed that earliest heading was observed for genotype Shafaq-2006 (113.67) at Peshawar, whereas, genotype Mondu Tro (203.67) took

**Table 2. Mean Squares value of location, genotypes and genotype by location interaction for various traits in wheat**

Parameters	Location (df=1)	Genotypes (df=14)	G×L (df=14)	Error (df=56)	CV %
Days to heading	89113.6**	235.14**	5.83**	0.37	0.38
Days to maturity	89113.6**	51.60**	5.83**	1.28	0.58
Flag leaf area	29.20ns	520.77**	0.50ns	27.01	14.2
Plant height	1070.53*	690.45**	3.16**	22.84	4.9
Spike length	73.98**	11.97**	1.40**	0.37	5.51
Spikelets spike-1	242.06**	23.56**	2.43*	1.28	6.08
1000-grain weight	275.97*	225.77**	93.77**	3097345.6	10.72
Grain yield	3622836.1*	3552773.8**	2325870.7**	3411448.4	14.4

\*\* , \* Significant at 0.01% and 0.05% probability level ns Non significant

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**Figure 1. Mean values for Days to heading across locations during 2011-12**

maximum days for heading at Skardu (Fig. 1). However, on overall basis the genotype Shafaq-2006 took lesser days for heading at both locations. Genotypic, genotype x environment and error variance for days to heading were 38.22, 1.82 and 0.38, respectively. Similar findings have been reported earlier in wheat for days to heading by Khan (2013), who observed significant differences among the genotypes, environments and their interaction. Our results are further supported by the findings of Ijaz et al. (2013), who reported significant difference between

genotypes and environments. Ikramullah et al. (2011) also reported significant difference among genotypes and environments in wheat for days to heading. Results of Litvinenko and Abakumenko (1989) are also in line with current findings. They observed significant differences for heading in wheat genotypes.

Days to heading exhibited high broad sense heritability (0.98) accompanied by low genetic advance (6.75) as percent of mean (Table 3), indicating the presence of non-additive type of gene actions which can be manipulated through

**Table 3. Variance components, broad-sense heritability (h<sup>2</sup>BS) and expected selection response (Re) for morphological parameters of wheat during 2011-12**

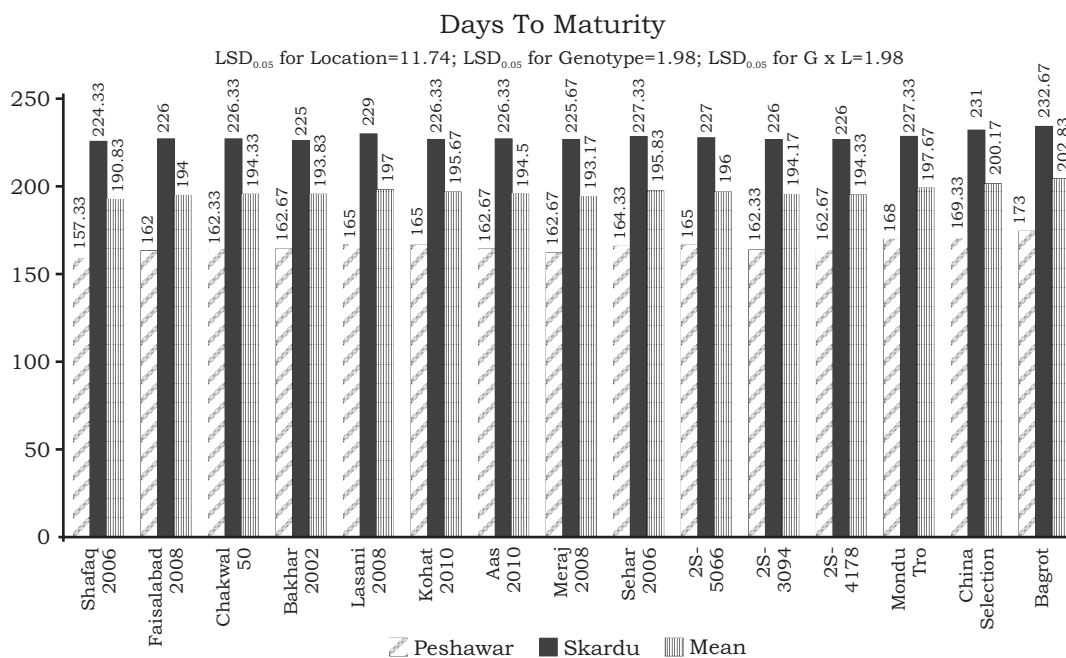
Traits	V <sup>g</sup>	V <sup>gy</sup>	V <sup>e</sup>	h <sup>2</sup> (BS)	GA	GA (%)
Days to heading	38.22	1.82	0.38	0.98	10.74	6.75
Days to maturity	7.63	1.52	1.28	0.89	4.58	2.34
Flag leaf area	86.71	8.84	27.02	1.00	16.38	49.43
Plant height	103.02	16.49	22.84	0.90	16.90	16.80
Spike length	1.76	0.34	0.38	0.88	2.19	19.75
Spikelet spike	3.52	0.39	1.28	0.90	3.13	16.81
1000-grain weight	204483.9	672045.4	309734.6	0.35	467.70	1333.23
Grain yield	4016544	1047832	3411448	0.99	3507.82	199.94

heterosis breeding. Sardana et al. (2007) proposed that high heritability may not always leads to increased genetic advance, unless adequate amount of variability present in the germplasm. . High heritability accompanied with low genetic advance for days of 50% heading was also reported by Eid (2009). Similarly, Rafiullah et al. (2007) and Ikramullah et al. (2011) also reported high heritability in wheat genotypes.

**Days to Maturity**

Analysis of variance for days to maturity revealed highly significant ( $P \leq 0.01$ ) variations among genotypes, location and their interaction (Table 2). Mean values for genotypes ranged from 190.83 to 202.83 days (Fig. 2). Among locations, at Peshawar genotypes took 164.17 days for maturity, whereas, at Skardu genotypes matured in 227.09 days where earliest maturity was recorded for Shafaq-2006, whereas, maximum

days for maturity were taken by genotype Bagrot (Fig. 2). Mean data for genotypes and its interaction with the environment revealed that genotype Shafaq-2006 took minimum days (157.33) at Peshawar whereas, genotype Bagrot (232.67) took maximum days to mature at Skardu (Fig. 2). On overall basis, genotype Shafaq-2006 took minimum days to maturity at both environments. Current findings are supported by the earlier reports of Inamullah et al. (2011) who reported significant variations among wheat genotypes for maturity. As per Worland et al. (1994) photosensitivity and vernalisation-sensitive genes determine the differences in maturity in different crop varieties because genes responsible for earliness are responsive to temperature. Salfer (1996) also reported that early maturing varieties/lines respond to high



**Figure 2. Mean values for days to maturity across locations during 2011-12**

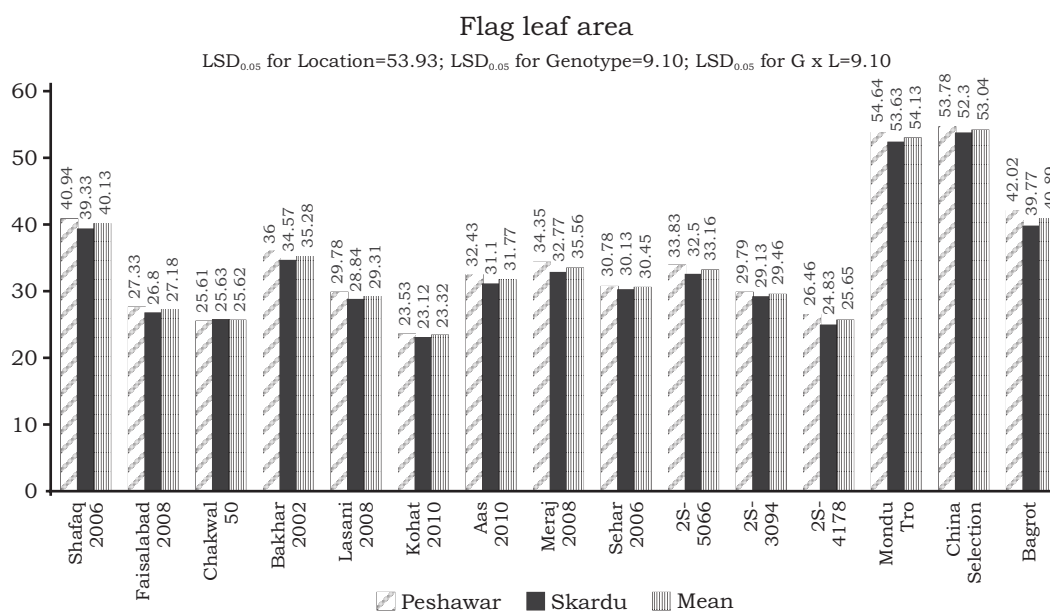
temperature at time of maturity in case of occurrence of intrinsic earliness genes.

The estimates of broad sense heritability were high (0.89) for days to maturity indicating the presence of less environmental effect on this trait among tested genotypes further suggesting the existence of non-additive type of gene action. Low genetic advance (2.34) as percent of mean (Table 3) also indicates the effect of non-additive gene action for this trait. High heritability coupled with low genetic advance suggested the effectiveness of specific selection procedure for the improvement of this trait. High heritability for days to maturity in bread wheat was also observed by Ijaz *et al.* (2013) and Singh *et al.* (2009).

### Flag leaf area

Flag leaf area is considered as the main contributor in grain formation in wheat therefore larger flag leaf

areas is preferred by the breeders in wheat. Analysis of variance displayed significant differences for flag leaf area among genotypes, whereas, non-significant differences were exhibited between locations and its interaction with genotypes (Table 2), suggesting the existence of sufficient genetic variability among tested genotypes. Mean value for flag leaf area across locations showed maximum value at Peshawar (34.76cm) and minimum at Skardu (33.63cm). Mean values for genotypes ranged from 23.32 to 54.13 cm where genotype Kohat-2010 attained minimum and genotype China Selection displayed maximum flag leaf area. As per interaction, minimum flag leaf area was recorded for genotype Kohat-2010 (23.12cm) at Skardu, whereas, maximum mean value (54.64cm) was recorded for genotype China Selection at Peshawar (Fig. 3). Rahim *et al.* (2006) also found significant differences among wheat genotypes. However,



**Figure 3. Mean values for flag leaf area across locations during 2011-12**

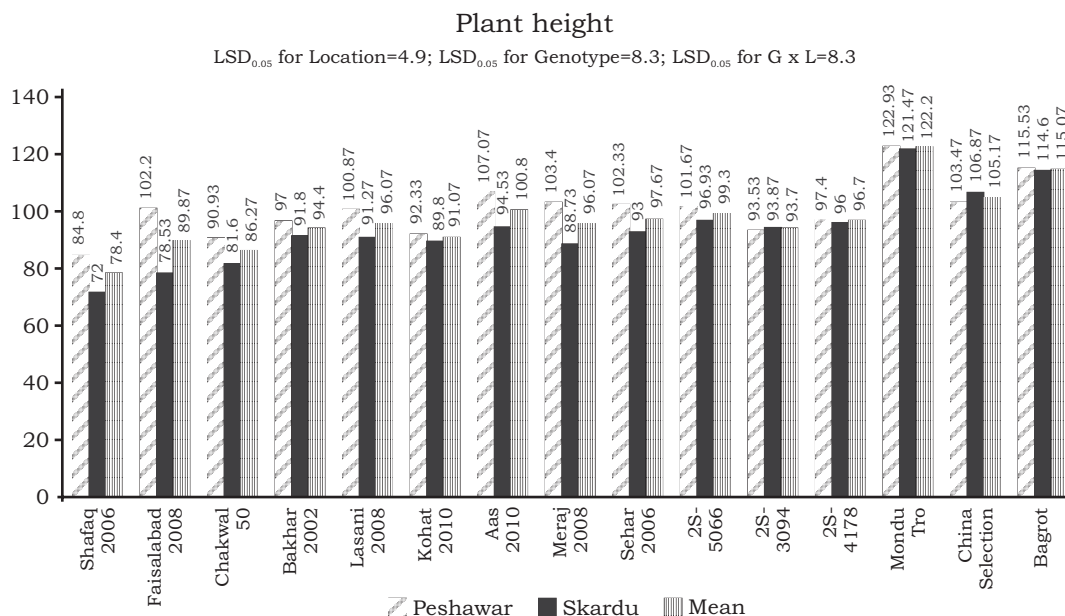
Mcneal and Berg (1977) observed non-significant differences for flag leaf area in wheat. The contrasting results could be attributed to differences in the germplasm or severity in environments.

In the present investigation, high heritability (16.38) estimates coupled with high genetic advance (49.43) were recorded for flag leaf area (Table 3) suggesting the presence of additive type of gene action, hence selection in early generation would be more effective. Current results are in line with the earlier findings of Ali *et al.* (2008), Haq *et al.* (2008) and Chowdhry *et al.* (1997) who reported high heritability and genetic advance in wheat.

**Plant height**

Plant height is vital character in wheat improvement programs. Plant breeders usually focus on short or medium height that helps in lodging resistance. It also utilizes chemical

fertilizers, irrigation and other inputs efficiently. Current data revealed significant differences across locations whereas, highly significant differences were observed among wheat genotype and its interaction with environment (Table 2). Locations means showed that genotypes grown at Peshawar attained maximum plant height (100.96cm) while minimum plant height (94.07cm) was recorded at Skardu. Mean values for plant height among wheat genotypes ranged from 78.40 (Shafaq-2006) to 122.20cm (Mondu Tro) (Fig. 4). In Genotype x Location interaction, genotype Shafaq-2006 (72cm) produced short plants at Skardu whereas tall plants were produced by genotype Mondu Tro (122.93cm) at Peshawar (Fig.4). However, on overall basis, genotype Mondu Tro attained maximum plant height at both locations. Current findings confirm the earlier results of Khan *et al.* (2013) who reported significant



**Figure 4. Mean values for plant height across locations during 2011-12**



differences among wheat genotypes, environments and their interaction.

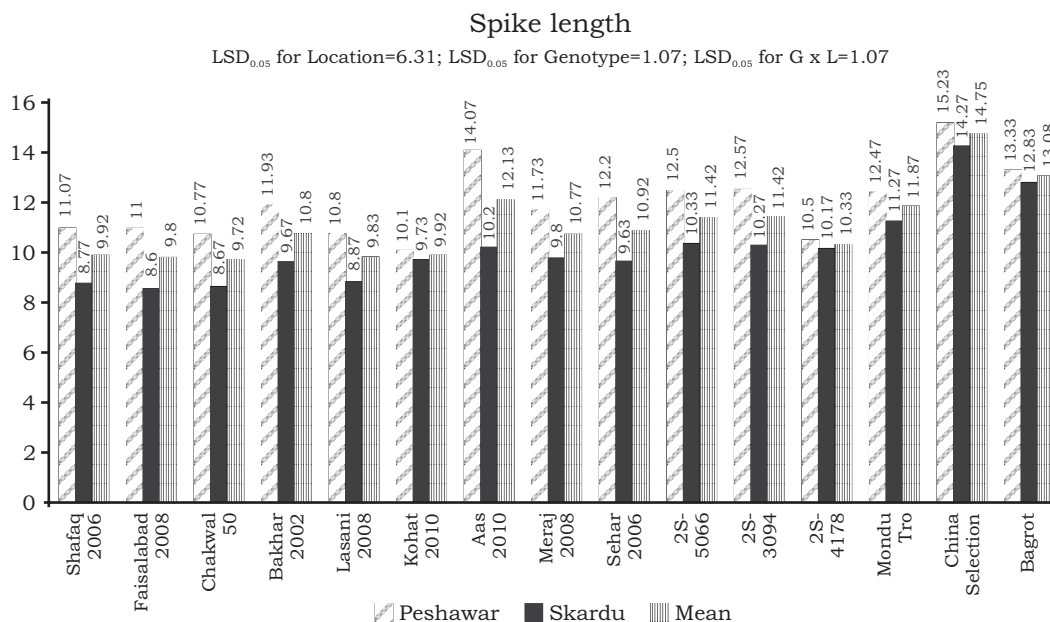
Plant height exhibited high heritability (0.90) associated with high genetic advance (16.80) (Table 3), pointing towards the effectiveness of selection in early generation. Current results are in line of earlier reports of Kalimullah *et al.* (2012) who reported high heritability for plant height in wheat. Ikramullah *et al.* (2011) also reported high heritability for plant height in wheat genotypes across different locations.

### Spike length

Highly significant ( $p < 0.001$ ) differences were observed for spike length among genotypes, environments and GE interaction (Table 2) indicating the presence of sufficient genetic variability among tested genotypes. Mean value for location ranged from 10.20 to 12.02cm where minimum spike lengths were noted at Skardu and

maximum spike lengths were recorded at Peshawar. Among genotypes, spike length ranged from 9.72 to 14.75cm for genotype Chakwal-50 and China Selection respectively. Mean values for interaction ranged from 8.60cm (for genotype Faisalabad-2008) at Skardu to 15.23cm ( for genotype China Selection) at Peshawar (Fig.5). Current results are in conformity with earlier results of Khan (2013) who observed significant difference among genotype, location and genotype by environment interaction in wheat genotypes. Khalil *et al.* (2006) also found highly significant difference for spike length among wheat genotypes.

The estimates of broad sense heritability and genetic advance for spike length were high (0.88 and 19.75, respectively) (Table 3) indicating the involvement of additive type of gene action. This type of results helps plant breeders to exploit



**Figure 5. Mean values for spike length across locations during 2011-12**

such traits through selection in early generations. Our results are in agreement to the earlier findings of Laghari *et al.* (2010) who found high heritability for wheat genotypes. High heritability estimates were also reported by and Kashif and Khaliq (2004) in wheat.

**Spikelets spike<sup>-1</sup>**

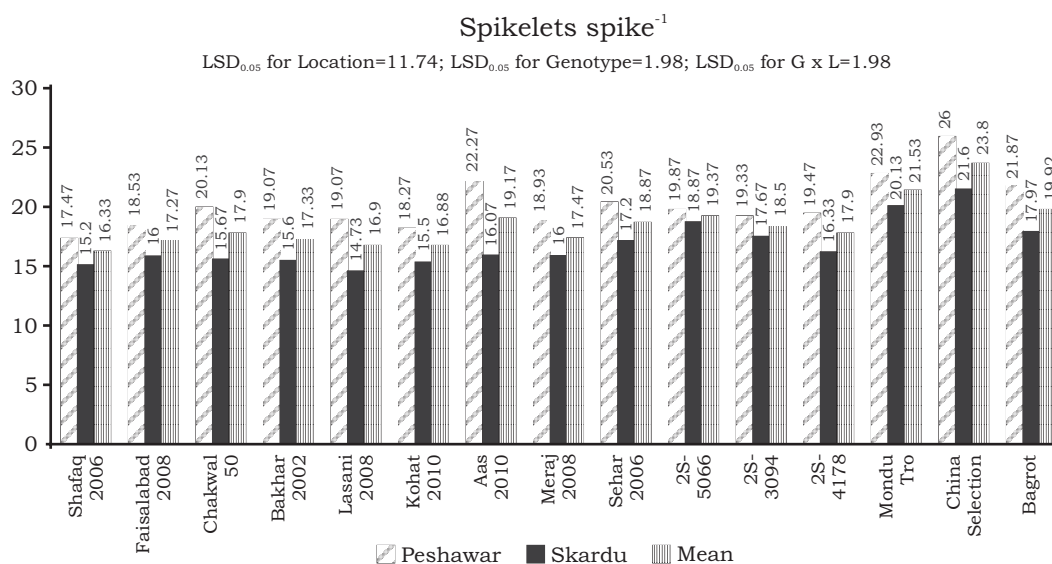
Number of spikelets spike<sup>-1</sup> is one of the important yield contributing trait in wheat. Mean square values for spikelets spike<sup>-1</sup> showed significant (p<0.001) differences for locations, genotypes and their interaction (Table 2) suggesting the presence of reasonable variability among the tested genotypes and locations. Genotype mean values for spikelet spike<sup>-1</sup> ranged from 16.33 (Shafaq-2006) to 23.80cm (China Selection). Mean value across location showed maximum spikelets spike<sup>-1</sup> at Peshawar (20.25cm) and minimum spikelets spike<sup>-1</sup> at Skardu (16.97). Interaction means were minimum for

genotype Lasani-2008 (14.73cm) at Skardu while maximum for genotype China Selection (26cm) at Peshawar (Fig. 6). Genotype Mondu Tro and China Selection revealed more spikelet spike<sup>-1</sup> in genotype and genotypes × location interaction. Highly significant differences for spikelets spike<sup>-1</sup> were also reported by Khan (2013).

Spikelets spik<sup>-1</sup> showed high heritability (0.90) coupled with high genetic advance (16.81) (Table 3), indicating the presence of additive genes in controlling this trait. Hence, selection in early generation for the improvement of spikelets spike<sup>-1</sup> would be effective. Current findings are in conformity with the earlier reports of Gupta, *et al.* (2004) and Deswal, *et al.* (1996).

**1000-grain weight**

Thousand grains weight is very important yield contributing character and is given more emphasis during cultivar development process.



**Figure 6. Mean values for spikelets spike-1 across locations during 2011-12**

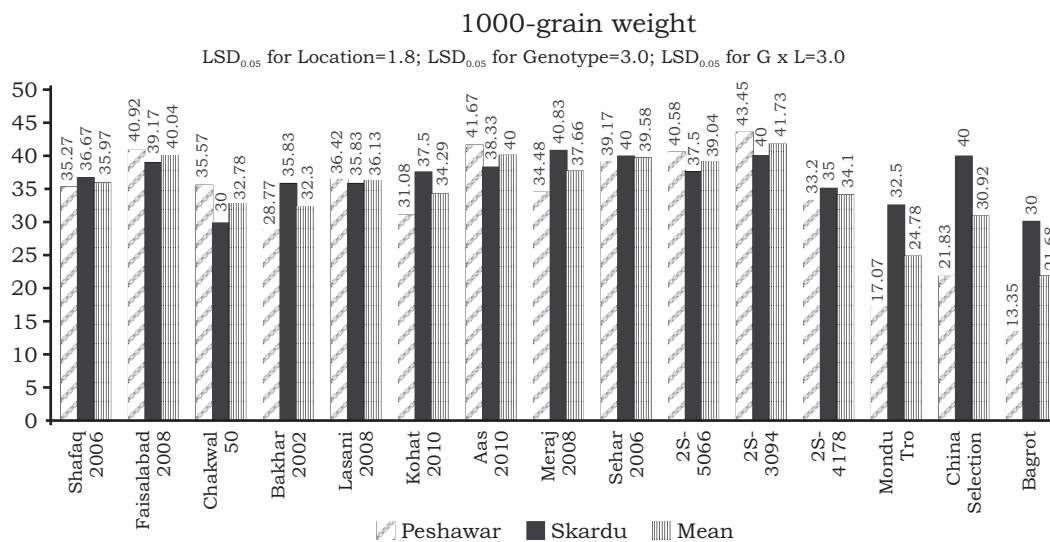
Analysis of variance revealed significant differences among the genotypes, locations and its interaction with genotypes for 1000-grain weight (Table 2). Genotype mean values for 1000-grain weight ranged from 30.92g to 44.49g. Minimum mean values for 1000-grain weight were recorded for the genotype China Selection 30.92g while; maximum mean values were recorded for genotype Sehar 2006 (44.94g) for 1000-grain weight. Mean value for 1000 grain weight for the genotype grown at Skardu were minimum (33.33g) while 1000 grain weight at Peshawar were recorded maximum 36.83g. The interaction mean data for 1000 grain weight revealed minimum for the genotype Bagrot 13.35g at Peshawar while maximum 1000-grain weight were recorded for genotype 2S-3094 (43.45g) at Peshawar (Fig. 7). Overall genotype 2S-3094 and Faisalabad 2008 showed maximum values for 1000-grain weight in genotypes and genotypes × location interaction.

Present results are supported by the findings of Khan (2013) and Ahmad et al. (2009) who reported significant difference for 1000-grains weight.

Thousand grains weight exhibits low heritability (0.35) coupled with high genetic advance (1333.23) (Table 3), indicating the selection in later generation for the improvement of 1000-grain weight would be effective. Current findings are contradictory with the earlier reports of Gupta, *et al.* (2004).

**Grain yield**

Analysis of variance showed significant differences ( $p < 0.01$ ) for genotypes, locations and their interaction for the grain yield (Table 2). Grain yield for all genotypes ranged between 1719 kg ha<sup>-1</sup> and 4775 kg ha<sup>-1</sup>. Maximum mean values for grain yield was recorded from the genotype 2S-3094 (4775 kg ha<sup>-1</sup>) whereas, minimum mean value for grain yield was obtained from the genotype Bagrot (1719 kg ha<sup>-1</sup>) (Fig. 8). Mean value for grain yield



**Figure 7. Mean values for 1000-grain weight across locations during 2011-12**

recorded minimum (3665 kg ha<sup>-1</sup>) at Peshawar location, while maximum (3850 kg ha<sup>-1</sup>) was recorded at Skardu. Interaction means for grain yield revealed minimum value for genotype Bagrot (1719 kg ha<sup>-1</sup>) while maximum were recorded by genotype Faisalabad 2008 (4904 kg ha<sup>-1</sup>) at Peshawar (Fig. 8). Overall genotype 2S-3094 and Faisalabad 2008 showed maximum grain yield ha<sup>-1</sup>. Present results are in line with the earlier findings of Khan (2013) who found significant differences among genotypes, environments and genotype × environment. Khalil et al. (2008) also reported highly significant differences among wheat genotypes for grain yield across environments.

Grain yield exhibited high heritability coupled with high genetic advance of 0.99 and 199.94 %, respectively (Table 3). Which directs the presence of Additive genes in controlling this trait and selection would be efficient in early generation. Present results are in conformity with the Ikramullah et al. (2011) and

Kashif and Khaliq (2004), who observed high heritability and genetic advance in wheat population.

### CONCLUSION

All the studied traits were under environmental influence except flag leaf area. Genotype Faisalabad-2008 and line from Tajikistan (2S-3094) performed superior for yield and associated traits than the rest of the studied genotypes across both environments and hence are indicative of their potential to adapt to fluctuating environments. The high magnitude of heritability and genetic advance provide evidence that the traits were predominantly controlled by additive type of gene actions. Therefore, it is recommended that selection will be effective in early generations.

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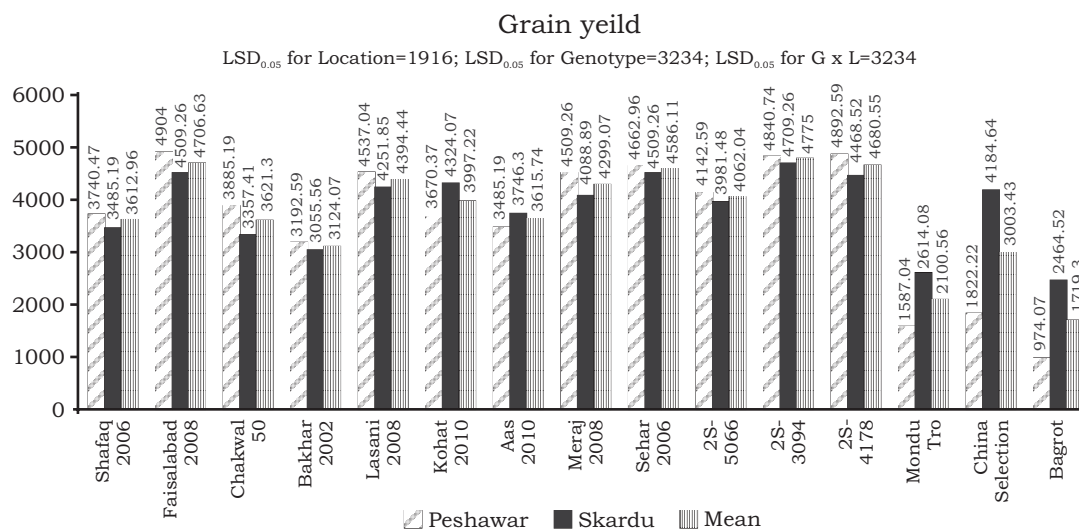


Figure 8. Mean values for grain yield across locations during 2011-12

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