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HERITABILITY AND SELECTION RESPONSE FOR MORPHOLOGICAL AND YIELD TRAITS IN NORMAL AND LATE PLANTED WHEAT

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Abstract

Late planting seriously influenced wheat production in Pakistan due to terminal heat stress, especially during anthesis and grain filling stages. Analysis of variance across two environments revealed significant differences ($P \leq 0.05$) among wheat genotypes for spike length, grains spike^{-1} and grain yield. Genotype × environment interaction was significant for spikes m^{-2}, spike length, grains spike^{-1} and grain yield which indicated differential performance of wheat genotypes across the two environments for 15 genotypes including checks. Heritability for spikes m^{-2}, spike length, 1000-grain weight and grain yield were 0.41 vs. 0.61, 0.78 vs. 0.85, 0.78 vs. 0.25, and 0.82 vs. 0.63 under normal and late planting environment, respectively. Expected selection response for most of the traits was greater than observed selection response under both environments. Mean of the 3 top ranking genotypes was greater than the mean of two check cultivar's yield contributing traits. Selection differential for most of the yield contributing traits was greater under late than normal planting. None of the 3 top ranking genotypes for yield components were common under the two planting environments. Net reduction in grain yield due to late planting recorded as 33% indicated non-adaptation of wheat genotypes to stress encountered.

Key words: Advanced lines, certified seed, selection differential, stress and *Triticum aestivum* (L.)

INTRODUCTION

Wheat is a staple food for more than 36% of the world's population and also the most important cereal crop in Pakistan. On world basis, wheat ranks second after rice, providing protein and caloric requirements to one third of the world population. In Pakistan wheat is grown both in irrigated and rainfed regions. During 2011-12, total wheat area in Pakistan was 8666 thousand hectares, out of which 7984.9 thousand hectares was irrigated while the remaining 1056.8 thousand ha was rainfed and the total production was 23517 thousand tons with an average yield of 2714 kg ha^{-1} (FBS, 2012). The situation of wheat production in Pakistan is much better than the past but wheat yield is still behind other agricultural developed countries of the world. Late planting is among one of the major reason of low wheat yield in Pakistan. Late planting adversely affects the growth, yield and quality of wheat. A delay of each day in sowing of wheat after 15th November onward decreases grain yield by 1%. Late sowing of wheat can reduce yield by 30 to 40% (Hussain et al., 1998). Wheat cultivation at its proper time is thus of extreme importance to obtain high yield as proper sowing time accounts for 10% of grain variation.

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Broad-sense heritability is the ratio of genotypic and phenotypic variance. Therefore, heritability is the combined result of genetic architecture of population and environmental conditions. In general, heritability is low to medium for the characteristics related with yield, since these are mostly polygenic traits. Heritability is widely used in the establishment of breeding programs and formation of selection indexes. It provides an estimate of genetic advance a breeder can expect from selection applied to a population in a given experiment and is essential for an effective crop-breeding programme by predicting the behavior of succeeding generations by devising the appropriate selection criteria and assessing the level of genetic improvement. Higher estimates of heritability, simplify the selection procedure (Khan et al., 2008). However, estimates of heritability alone do not provide an idea about the expected gain in the next generation, unless considered in conjunction with estimates of selection response or genetic advance. The utility of heritability therefore increases when used to calculate selection response, which indicates the degree of gain in a character obtained under particular selection pressure (Shukla et al., 2004). This research was undertaken to investigate broad-sense heritability for various traits under normal and late planting and to estimate selection differential and selection response (observed and expected) under each environment.

MATERIALS AND METHODS

The proposed study was conducted at The University of Agriculture, Peshawar during wheat crop season of 2012 -2013. A set of 15 wheat genotypes (13 lines and 2 check cultivars) were evaluated for yield and yield contributing traits as independent experiments under normal and late planting conditions. Both experiments were conducted in Randomized Complete Block Design with three replications. To eliminate environmental biasness both experiments were planted in the same field. The normal experiment was planted on November 11, 2012 while late experiment was planted on December 11, 2012. Each genotype was planted in 3 rows per plot, with row length of 3 meter and row-to-row spacing of 30 cm under each environment. Both experiments were given with similar amount of fertilizer and other crop husbandry practices throughout the growing season. Data was recorded on yield contributing traits viz. spikes m^{-2}, spike length, spikelets $spike^{-1}$, grains $spike^{-1}$, 1000-grain weight and grain yield.

Data were analyzed across the two environments using mixed effect model to ascertain genotype × environment interaction effect for each trait (Annicchiarico, 2002). The mean squares pertaining to genotype × environment interaction was used as error term to test the significance of environments and genotype main effect, while significance of genotype × environment interaction was determined by using mean squares of pool error. Since genotype × environment interaction was significant for most of the traits, data was also analyzed independently for each environment to compute genetic and environmental variances required for estimation of broad-sense heritability and selection response of traits using following formulas (Singh and Chaudhery 1997).

Broad-sense heritability = $H^2_{BS} = V_g / V_e$

Expected selection response = $R_e = i \times \sqrt{V_p} \times h^2$

Where i = 1.40 using 20% selection intensity

V_p = Phenotypic variance of the trait

H^2 = Heritability of the trait.

Observed selection response (R_o) for important yield contributing traits was also computed by following formula, (Fehr, 1993).

$$R_o = S \times H^2$$

Where,

S = selection differential = $\overline{x_s} - \overline{x}$

$\overline{X}_S$ = mean of top 3 ranking lines

$\overline{X}$ = mean of all 13 lines used in study.

RESULTS AND DISCUSSIONS

***Spikes m^{-2}*:** Pool analysis of variance over two environments showed highly significant (P≤0.01) differences among environments and G × E interaction for spikes m^{-2}. However, genotypes showed non-significant differences for spikes m^{-2}. CV and R^2 value for spikes m^2 were 13.3% and 0.85, respectively (Table 1). Significant G × E interaction indicates inconsistent performance of wheat genotypes for spikes production at these two environments. Spikes m^{-2} of 15 wheat genotypes ranged from 270 to 409 under normal planting (Table 2). Maximum spikes m^{-2} were produced by Ghaznavi while minimum by genotype SRN-94 under normal planted environment. Mean value for spikes m^{-2} ranged from 148 to 320 for genotype ISWYN-48 and ISWYN-5 under late planting. Across the two planting environments spikes m^{-2} ranged from 231 to 349 for genotypes SRN-94 and check cultivar Pirsabak-05, respectively. Our results are in line with those of Ahmad et al. (2011) who reported significant differences between two planting environments for productive tillers m^{-2}. Similar results have also been shown by Gul et al. (2012). Khan and Naqvi (2011) reported highly significant differences among genotypes, environment and genotype × environment for spikes m^{-2} under irrigated and rainfed conditions. Genetic variance (1108) for spikes m^{-2} was lower than environmental variance (1578), which resulted in low heritability (0.41) and selection response under normal planting. Under late planting, genetic variance was high (2519) in magnitude than environmental variance (1607) with a resultant heritability of 0.61 and selection response of 55 spikes m^{-2}. Across the two environments, genetic variance (916) was greater than respective environmental (159) and genotype × environment variance (897). Heritability and selection response across the two planting environments were 0.46 and 1.23, respectively (Table 3). Khan and Naqvi (2011) have reported moderate heritability for this trait under two environments. Haq et al. (2008) have also reported moderate heritability for spikes m^{-2} under normal planting. Mohammadi et al. (2008) has reported low heritability for spikes m^{-2} in dry environments only. Similarly, Talebi and Fayyaz (2012) have reported low heritability for this trait under two different environments.

Mean spikes m^{-2} of 3 top ranking genotypes was 396 and 302 under normal and late planting, respectively. Mean spikes m^{-2} of two check cultivars was 397 under normal planting and 300 under late plating. Mean of the top 3 selected lines ($\overline{x}_s$) was greater than the mean of the checks ($\overline{x}_c$) under late planting but less than the mean of the checks under normal planting. Selection differential (S), obtained as the differences between mean of the selected genotypes and overall population of genotypes, was 40 and 61 spikes m^{-2} under normal and late planting, respectively (Table 4). None of the top 3 ranking genotypes was common within two planting environments which further confirmed the existence of G × E interaction for spikes m^{-2}. The observed selection response (R_o) for spikes m^{-2} was 16 and 37 under normal and late planting, respectively. Thus, expected selection response for spikes m^{-2} was greater than observed selection response under both environments.

Spike length: Highly significant differences ($P \leq 0.01$) were observed among environments and genotypes for spike length through pooled ANOVA. G × E interaction was also significant indicating that genotypes differed for spike length over two environments (Table 1). Spike length under normal planting ranged from 8.7 to 10.7 cm. Maximum spike length under normal planting was observed for ISWYN-16 followed by genotype ISWYN-48, ISWYN-37 and SRN-27 while minimum was recorded for SRN-49. Under late planting, spike length ranged from 7.8 to 9.9 cm for SRN-34 and ISWYN-49, respectively. Across the two environments, mean value of genotypes for spike length ranged from 8.3 to 10.1 cm (Table 2). Maximum spike length across the two planting environments was recorded for genotype ISWYN-49, while minimum for SRN-49. Mean spike length of 15 wheat genotypes was 9.3 cm under normal and 8.9 cm under late planting. Thus a net reduction of 0.4 cm was recorded for spike length due to late planting. Our results are supported by the findings of Inamullah *et al*. (2007) for significant genotype and G × E interaction for spike length. Similarly, the findings of Hamam et al. (2009), Tanveer et al. (2009) and Baloch et al. (2012) also supported the results of the present study. Genetic variance (0.42) for spike length was greater than environmental variance (0.12) under normal planting. Broad-sense heritability for spike length was 0.80 and expected selection response was 0.80cm under normal planting. Genetic variance was also greater (0.39) than environmental variance (0.07) under late planting with a resultant heritability of 0.85 and selection response of 0.81cm, respectively. Across the two environments, genetic variance was greater (0.36) than respective environmental (0.09) and G × E variance (0.04). Heritability and selection response across the two planting environments were 0.73 and

1.93 cm, respectively (Table 3). Previously, Nabi *et al*. (1998), Memon et al. (2007), Haq et al. (2008) and Ajmal et al. (2009) have also reported high heritability estimate for spike length in wheat.

Under normal planting, mean spike length of 3 top genotypes was 10.58 cm, while mean spike length of top 3 ranking genotypes under late planting was 9.71 cm. Mean spike length of two check cultivars was 9.28 and 8.45 cm under normal and late planting, respectively (Table 4). Thus, mean spike length of 3 top selected genotypes was greater than checks mean under both environments. Selection differential (S) was 0.71 and 0.81 cm under normal and late planting, respectively. The observed selection response (R_o) for spike length was 0.55 and 0.69 cm under normal and late planting, respectively. Thus, expected selection response was greater than observed selection response under both environments for spike length.

Spikelets spike^{-1}: Highly significant differences (P≤0.01) were observed between the two planting environments for spikelets spike^{-1}. However, genotypes and G × E interaction was not non-significant for spikelets spike^{-1} (Table 1). Mean value of spikelets spike^{-1} ranged from 16 to 19 under normal planting. Maximum mean value for spikelets spike^{-1} was recorded for ISWYN-48, ISWYN-6, ISWYN-37, ISWYN-6, SRN-27, SRN-95 and SRN-94, while minimum for ISWYN-13. Under late planting, spikelets spike^{-1} ranged from 13 to 16 (Table 2). Minimum spikelets spike^{-1} under late planting was recorded for SRN-95, while maximum for two check cultivars and ISWYN-48, ISWYN-37, ISWYN-5, SRN-27 and SRN-94. Across the two planting environments, spikelets spike^{-1} ranged from 15 to 18 for genotype SRN-34 and SRN-27. Mean spikelets spike^{-1} of 15 wheat genotypes was 18 and 15 under normal and late planting, respectively. Thus, the genotypes showed a net reduction of 3 spikelets spike^{-1} due to late planting. Our results are supported by the findings of Khan (2013) who reported non-significant differences among wheat genotypes for spikelets spike^{-1}. In contrast, Inamullah et al. (2007) have reported significant G × E interaction for this trait. Similarly, Mohsin *et al*. (2009) and Kashif and Khaliq (2004) have also reported significant differences among wheat genotypes for spikelets spike^{-1}. Genetic variance was lower (0.53) than environmental variance for spikelets spike^{-1} under normal planting with resultant low broad-sense heritability (0.28) and expected selection response of 0.54. Under late planting, genetic variance (0.85) was also lower than environmental variance (1.01) with a moderate heritability and selection response of 0.46 and 0.88, respectively. Across the two environments genetic variance was lower (0.46) than respective environmental variance (1.19) but greater than G × E variance (0.23). Low heritability (0.24) and selection response (0.65) was recorded for this trait across the two planting environments (Table 3). Moderate to low heritability for spikelets spike^{-1} has also reported by Kashif and Khaliq (2004) and Khan (2013) whereas high heritability by Mohsin et al. (2009).

Mean of the 3 top ranking genotypes was 19.4 and 16.4 for spikelets spike^{-1} under normal and late planting, respectively. Mean of the two check cultivars was 16.5 and 16.4 under normal and late planting, respectively (Table 4). Thus, mean of the 3 top selected lines ($\overline{x}_s$) was greater than mean of mean of the checks ($\overline{x}_c$) under both environments. Selection differential (S) was 1.2 under normal and 1.1 under late planting. Two top ranking genotypes was common among the production environments which explains presence of non- significant G × E interaction for this trait. The observed selection response (R_o) for spikelet spike^{-1} was 0.34 and 0.52 under normal and late planting which was lower than expected selection under both environments.

***Grains spike^{-1}*:** Analysis of data for grains spike^{-1} over the two environments showed highly significant differences among environments. Significant differences were also recorded among genotypes for grains spike^{-1}. However, G × E interaction was non-significant for grains spike^{-1} (Table 1). Coefficient of variations (CV) and R^2 for grains spike^{-1} were 6.9% and 0.67, respectively. Grains spike^{-1} is an important yield-contributing trait and has a direct effect towards grain yield (Ajmal et al., 2009). Significant differences among wheat genotypes and environments for grains spike^{-1} are previously reported (Memom et al., 2007; Ajmal et al., 2009; Khan and Naqvi 2011; Punia et al., 2011). In contrast, Khan and Naqvi (2011) have also reported significant G × E interaction for this trait. Grains spike^{-1} of 15 wheat genotypes ranged from 47 to 59 for genotypes ISWYN-6 and SRN-71 under normal planting, 39 to 51 for check cultivar Pirsabak-05 and ISWYN-37, ISWYN-49 under late planting (Table 2). Across the two planting environments, grains spike^{-1} ranged from 44 to 54. Maximum grains spike^{-1} across the two planting environments was recorded for SRN-34, while minimum for check cultivar Pirsabak-05. Mean grains spike^{-1} of 15 wheat genotypes was 53 and 48 under normal and late planting, respectively. Thus a net reduction of 5 grains spike^{-1} was observed due to late planting. Genetic variance (9.33) for grains spike^{-1} was greater than environmental variance (3.37) with a moderate heritability of 0.73 and selection response of 3.67 under normal planting. Under late and across planting genetic variances (1.88 and 4.46) was lower than respective environmental variances (21.84 and 12.60) resulting in low heritabilities and selection response for grains spike^{-1} under these two environments (Table 3). Khan and Naqvi (2011) and Taleebi and Fayyaz (2012) have also reported moderate to low heritability for grains spike^{-1} in wheat. Similarly, Ansari *et al*. (2004) and Eid (2009) have reported low heritability for this trait.

Mean grains spike^{-1} of 2 check cultivars was 54.0 and 43.8 under normal and late plating, respectively (Table 4). Similarly mean grains spike^{-1} of 3 top selected genotypes was 58 and 50 under normal and late plating, respectively. Thus mean grains spike^{-1} of 3 top selected genotypes was greater mean of the checks under both environments. Selection differential (S) was 4.7 and 2.03 for grains spike^{-1} under normal and late planting, respectively. The observed selection response (R_o) for grains spike^{-1} was 3.43 and 0.16 under normal and late planting, respectively which shows that observed selection response (R_o) was lower than expected selection response (R_e) under both environments.

***1000-grain weight*:** The combined analysis for 1000-grain weight of 15 wheat genotypes across location showed highly significant differences among environments and G × E interaction (Table 1). However, genotypes showed non-significant differences across the two planting environments. Thousand-grain weight is considered to be one of the most important yield-contributing traits and is considered as potential selection criteria for yield under different environments. Thousand-grain weight is controlled by genetic as well as environmental factors (Hamam et al., 2009). Previously Khan and Naqvi (2011) reported significant differences among environments, genotypes and G × E interaction for grain weight. Ullah *et al*. (2011) also reported significant genotype and G × E interaction but non-significant differences in 1000-grain weight due to different environments. Ilyas et al. (2013) has reported significant differences due to genotypes but non-significant G × E interaction. Similarly, Punai et al. (2011) has concluded non-significant differences among testers and lines × testers under two different environments. Mean value for 1000-grain weight ranged from 42 to 51 g under normal planting, and 38 to 42 g under late planting conditions. All the genotypes showed more 1000-grain weight under normal planting. Net reduction of 5 g in 1000-grain weight was observed due to late planting. Genetic variance (7.0) for 1000-grain weight was greater in magnitude than respective environmental variance (1.9) under normal sown condition (Table 3). The resultant broad sense heritability and expected selection response for this trait under normal planting was recorded as 0.78 and 3.27 g, respectively. The amount of genetic variances was lower (1.06, 1.85) than environmental variances (3.19, 2.85) under late and across two planting environments. This resulted in low heritabilities (0.25 and 0.28) and low selection responses (0.72 and 0.74 g per 1000-grain) under late and across planting condition, respectively (Table 2). Moderate to low heritability for 1000-grain weight is previously reported by Ilyas et al. (2013) and Talebi and Fayyaz (2012). In contrast, Ali and Shakoor (2012), Haq et al. (2008) and Ahmad et al. (2007) have reported high heritability for this trait in wheat.

Mean of the 3 top selected genotypes for 1000-grain weight was 48.9 and 42.3 g under normal and late planting, respectively (Table 4). Mean of the two check cultivars for this trait was 39.6 and 39.9 g under normal and late planting, respectively. Thus, the mean of the 3 top selected genotypes was greater than mean of the checks under both environments. Selection differential was 3.3 and 1.8 g under normal and late planting, respectively. Observed selection response (R_o) for 1000-grain weight was 2.57 and

0.46 g under normal and late planting, respectively. Thus, expected selection response (R_e) was greater than observed selection response for both planting environments.

Grain yield: The cumulative efforts of plant breeders for improvement of different characters are concentrated for the improvement of grain yield. The pool analysis over environment exhibited highly significant differences between the two planting environments for grain yield (Table 1). Though genetic variation among wheat genotypes across environment was non-significant but genotype × environment interaction for grain yield was highly significant ($P \leq 0.01$). Thus the rating of wheat genotypes was not consistent across the two environments for grain yield. The coefficient of variations and R^2 for grain yield were 7.3% and 0.94, respectively. Differences among environments and genotype × environment for grain yield have been previously reported by Taleebi et al. (2009), Aycicek and Yildirim (2006). Ullah et al. (2011) has reported non-significant differences in yield of wheat genotypes due to environment and genotype × environment interaction but significant differences among genotypes. Similarly, Ahmad et al. (2007) has reported significant differences due to genotypes and genotype × environment interaction but non-significant due to environments in yield of wheat. Grain yield of wheat genotypes ranged from 4029 to 5873 kg ha^{-1} under normal and 2123 to 3621 kg ha^{-1} under late planted experiment (Table 2). Thus, all genotypes had higher yield under normal than late planting condition. Grain yield of wheat genotypes ranged from 4029 to 5873 kg ha^{-1} under normal planting. Wheat genotype ISWYN-5 produced the highest grain yield (5873 kg ha^{-1}) followed by genotype ISWYN-6 (5708 kg ha^{-1}) and ISWYN-49 (5370 kg ha^{-1}) under normal planting. Under late planting, grain yield ranged from 2123 (kg ha^{-1}) to 4128 (kg ha^{-1}). Highest grain yield was recorded for check cultivar Pirsabak-05 (4128 kg ha^{-1}) followed by SRN-49 (3621 kg ha^{-1}) and ISWYN-16 (3617 kg ha^{-1}) under late planting (Table 2). Reduction in grain yield of wheat genotypes due to late planting ranged from 408 to 3585 kg ha^{-1} (10 to 63%). Average across two planting condition, maximum grain yield was observed for check cultivar Pirsabak-05 (4739 kg ha^{-1}) followed by ISWYN-5 (4646 kg ha^{-1}) and ISWYN-16 (4240 kg ha^{-1}). Mean grain yield of 15 wheat genotypes was 4838 and 3244 kg ha^{-1} under normal and late planting, respectively. Thus, the net grain yield reduction was 1593 kg ha^{-1} (33 %) due to late planting. Similar reduction in grain yield of wheat genotypes due to late planting has been reported by several researchers like Ali et al. (2004), Wajid et al. (2004), Sial et al. (2005), Inamullah et al. (2007), Hamam et al. (2009), Tanveer et al. (2009), Sial et al. (2010), Sattar et al. (2010), Baloch et al. (2012) and Ali and Shakoor (2012). Most researchers have concluded that yield reduction in wheat is mostly due to reduced production of spikes m^{-2}, spike length and grain weight evaluated in variable environments (Ikramullah et al., 2011; Jadoon et al., 2013; Ullah et al., 2014; Ullah et al., 2016).

Genetic variance for grain yield was greater in magnitude than respective environmental variance under both environments (Table 3). Broad-sense heritability for grain yield was 0.82 under normal vs. 0.62 under late planting. The resultant selection response for grain yield was 735 kg ha^{-1} under normal and 463 kg ha^{-1} under late planting condition. However, genetic variances across environments were smaller in magnitude than environmental and G × E variances. The resultant heritability and selection response for grain yield across environment were zero. Previously Khan et al. (2003) and Ilyas et al. (2013) have reported moderate to high heritability for grain yield in wheat. Similarly, Khan et al. (2008) has reported moderate heritability for grain yield under irrigated and low heritability under rainfed condition in wheat.

Mean yield of 3 top ranking genotypes was 5650 kg ha^{-1} under normal and 3594 kg ha^{-1} under late planting condition (Table 4). Mean yield of 2 check cultivars was 5429 and 3800 kg ha^{-1} under normal and late planting, respectively. Thus, mean yield of 3 top selected genotypes was greater than checks mean under both environments. Selection differential was 812 and 350 kg ha^{-1} under normal and late planting condition, respectively. Mean yield of selected genotypes was greater than mean of two check cultivars under normal planting, but not under late planting environment. None of the top 3 ranking genotypes was common among the two test locations which further confirmed the existence of genotype × environment interaction for grain yield. The observed selection response (R_o) for grain yield was 665.8 and 220.2 kg ha^{-1} under normal and late planting, respectively. Thus, expected selection response (R_e) for grain yield was greater than observed selection response (R_o) under both environments.

Table 1. Mean squares for spikes m^{-2}, spike length, spikelets spike^{-1}, grains spike^{-1}, 1000- grain weight and grain yield of 15 wheat genotypes across two environments (normal and late) at The University of Agriculture, Peshawar during 2012-13.

Source of variation	DF	Spikes m^{-2}	Spike length	Spikelets spike^{-1}	Grains spike^{-1}	1000-Grain weight	Grain yield
Environment (E)	1	296872**	21.4**	199.5**	603.2**	608.4**	57135340**
Rep within (E)	4	10725	0.08	2.84	4.2	7.7	77752
Genotypes (G)	14	9783 ^{NS}	2.4**	4.65 ^{NS}	42.8*	20.2 ^{NS}	728610*
G × E	14	4285**	0.2*	1.9^{NS}	16 ^{NS}	9.1**	971590**
Error	56	1593	0.09	1.18	12.6	2.6	86432
CV (%)	-	13.3	3.2	6.5	6.9	3.7	7.3
R^2	-	0.85	0.91	0.81	0.67	0.8	0.94

Table 2. Means and ranges for spikes m^{-2}, spike length, spikelets spike^{-1}, grain spike^{-1}, 1000- grain weight and grain yield of 15 wheat genotypes across two environments (normal and late) at The University of Agriculture, Peshawar during 2012-13.

Trait	Environment	Range	Mean
Spikes m^{-2} (no.)	Normal	270 - 409	355
	Late	231 - 349	241
Spike length (cm)	Normal	8.7 - 10.7	9.3
	Late	7.8 - 9.9	8.9
Spikelets spike^{-1} (no.)	Normal	16 -19	18
	Late	13 - 16	15
Grains spike^{-1} (no.)	Normal	47 - 59	53
	Late	39 - 51	48
1000 Grain weight (g)	Normal	42 - 51	45
	Late	38 - 42	40
Grain yield (kg ha^{-1})	Normal	4029 - 5873	4838
	Late	2123 - 4128	3244

Table 3. Variance components, Heritability (H^2), and Selection response (R_e) for spikes m^{-2}, spike length, spikelet $spike^{-1}$, grains $spike^{-1}$, 1000-grain weight and grain yield of 15 wheat genotypes under each planting and across planting at University of Agriculture, Peshawar during 2012-13.

Trait	Environment	V_g	V_{ge}	V_e	H^2	R_e
Spikes m^{-2}	Normal	1108.60	--	1578.60	0.41	29.94
	Late	2519	--	1607.10	0.61	54.90
	Across	916.20	897.64	159.82	0.46	1.23
Spike length (cm)	Normal	0.42	_	0.12	0.78	0.80
	Late	0.39	_	0.07	0.85	0.81
	Across	0.36	0.04	0.09	0.73	1.93
Spikelet $spike^{-1}$ (no.)	Normal	0.53	_	1.37	0.28	0.54
	Late	0.85	_	1.01	0.46	0.88
	Across	0.46	0.23	1.19	0.24	0.65
Grains $spike^{-1}$ (no.)	Normal	9.33	_	3.37	0.73	3.67
	Late	1.88	_	21.84	0.08	0.54
	Across	4.46	1.15	12.60	0.24	0.65
1000-Grain weight (g)	Normal	7.00	_	1.99	0.78	3.27
	Late	1.06	_	3.19	0.25	0.72
	Across	1.85	2.18	2.59	0.28	0.74
Grain yield (kg ha^{-1})	Normal	336524	_	73512	0.82	735.76
	Late	172587	_	99353	0.63	463.34
	Across	4097	295052	86432	0.01	0.03

Table 4. Mean of top 3 lines ($\bar{x}_s$), all lines ($\bar{x}$), checks ($\bar{x}_c$) and selection differential (S), and observed selection response (R_o) under each environment.

Trait	Environment	$\bar{x}_s$	$\bar{x}$	$\bar{x}_c$	S	Top 3 ranking genotypes	R_O
Spikes m^{-2}	Normal	396	355	397	40	ISWYN-37, SRN-34,ISWYN-16	16.46
	Late	302	241	300	61	ISWYN-5, SRN-49, ISWYN-6	37.21
Spike length	Normal	10	9	9	1	ISWYN-16, ISWYN-37,SRN-95	0.55
	Late	9	8	8	1	ISWYN-49, SRN-95,ISWYN-37	0.69
Spikelet $spike^{-1}$	Normal	19	18	16	1	SRN-27, ISWYN-37,ISWYN-48	0.34
	Late	16	15	16	1	SRN-27, SRN-94, ISWYN-37	0.52
Grains $spike^{-1}$	Normal	58	53	54	4	SRN-71, SRN-34, SRN-95	3.43
	Late	50.	48	43	2	ISWYN-49, ISWYN-5, SRN-27	0.16
1000-grain weight	Normal	48	45	39	3	ISWYN-49, SRN-94, SRN-71	2.57
	Late	42	40	39	1	ISWYN-48, ISWYN-49,SRN-94	0.46
Grain yield	Normal	5650	4838	5429	812	ISWYN-5,ISWYN-6,ISWYN-49	665.84
	Late	3593	3244	3800	349	SRN-71, SRN-34, ISWYN-16	220.25

CONCLUSIONS

Heritability, selection differential and selection response were different under both environments. Therefore, selection for various traits should be conducted independently under both environments. Yield and yield contributing traits showed reduction due to late planting for all genotypes. Genotype SRN-71, SRN-34 and ISWYN-16 performed better under late, while ISWYN-5, ISWYN-6 and ISWYN-49 performed better under normal planting. Therefore, these lines should be further evaluated.

REFERENCES

Ahmad, F., S. Khan, S.Q. Ahmad, H. Khan, A. Khan and F. Muhammad. 2011. Genetic analysis of some quantitative traits in bread wheat across environments. Afric. J. Agric. Res., 6(3): 686-692.

Ahmad, F., F. Mohammad, M. Bashir, Saifullah and H. Khan. 2007. Inheritance of important traits in bread wheat over different planting dates using diallel analysis. Sarhad J. Agric., 23(4): 360-365.

Ajmal, S.U., N. Zakir and M.Y. Mujahid. 2009. Estimation of genetic parameters and character association in wheat. J. Agric. Biol. Sci., 1(1): 15-18.

Ali, I.H. and E.F. Shakor. 2012. Heritability, variability, genetic correlation and path analysis for quantitative traits in durum and bread wheat under dry farming conditions. Mesoptamia J. Agric., 40(4): 456-463.

Ali, M.A., M. Ali, and Q. Uddin. 2004. Determination of grain yield of different wheat varieties as influenced by planting dates in agro-ecological conditions of Vehari. Pak. J. Life Soc. Sci., 2(1): 5-8.

Annicchiarico, P. 2002. Genotype × environment interaction: challenges and opportunities for plant breeding and cultivar recommendations. FAO, Rome. Plant Production and Protection Paper 174.

Ansari, K.A., B.A. Ansari and A. Akhund. 2004. Extent of heterosis and heritability in some quantitative characters of bread wheat. Indus J. Plant Sci., 3: 189-192.

Aycicek, M and T. Yildirim. 2006. Heritability of yield and some yield components in bread wheat genotypes. Bangladesh J. Bot., 35(1): 17-22.

Baloch, M.S., M.A. Nadimi, M. Zubair, I. Awan, E.A. Khan and S. Ali. 2012. Evaluation of wheat under normal and late sowing conditions. Pak. J. Bot., 44(5): 1727-1732.

Eid, M.H. 2009. Estimation of heritability and genetic advance of yield traits in wheat under drought condition. Int. L. Genet. Molecul. Biol., 1(7): 115-120.

Federal Bureau of Statistics (FBS). 2012. Agricultural statistics of Pakistan. Govt of Pakistan. Islamabad.

Fehr, W.R. 1993. Principles of cultivar development Vol. I. Theory and techniques. McMillon Pub Co. The New York, USA.

Gul, H., B. Saeed, A.Z. Khan, U. Latif, K. Ali, J.U. Rehman and S.U. Rehman. 2012. Yield and yield contributing traits of wheat cultivars relation with planting dates and nitrogen fertilization. J. Agric. Bio. Sci., 7(6): 1990-6145.

Hamam, K.A., A. Saboor and G.A. Khalid. 2009. Stability of wheat genotypes under different environments and their evaluation under sowing dates and nitrogen fertilizer levels. Aust. J. Basic Appl. Sci., 3(1): 206-217.

Haq, W.U., M.F. Malik, M. Rashid, M. Munir and Z. Akram. 2008. Evaluation and estimation of heritability and genetic advancement for yield related Attributes in wheat lines. Pak. J. Bot., 40(4): 1699-1702.

Hussain, A., M. Maqsood, A. Ahmad, S. Aftab and Z. Ahmad. 1998. Effect of irrigation during various development stages on yield, component of yield and harvest index of different wheat cultivars. Pak. J. Agric. Sci., 34: 104-107.

Ikramullah, I.H. Khalil, H. Rahman, F. Mohammad, H. Ullah and S.K. Khalil. 2011. Magnitude of heritability and selection response for yield traits in wheat under two selection environments. Pak. J. Bot., 43(5): 2359-2363.

Ilyas, M., F. Mohammad, I.H. Khalil, M. Arif, W. Khan, Saifullah and S.M. Azam. 2013. Yield potential of $F_{4:7}$ bread wheat lines under normal and late plantings. Intl. J. Bot. Appl. Sci., 13(4): 582-585.

Inamullah, A., H. Shah, Z. Haq and F.U. Khan. 2007. An analysis of the planting dates effect on yield and yield attributes of spring wheat. Sarhad J. Agric., 23(2): 1530-1535.

Jadoon, S.A., H. Ullah, F. Mohammad, I.H. Khalil, M. Alam, D. Shahwar, M.F.A. Malik and Y. Jamal. 2013. Impact of forage clipping treatments on performance of winter wheat. Gene. and Mole. Res., 12(4): 5283-5288.

Kashif, M and I. Khaliq. 2004. Heritability, correlation and path coefficient analysis for some metric traits in wheat. Intl. J. Agric. Bio., 6 (1): 138-142.

Khan, A.S. 2013. Genetic variability and heritability estimates in F_2 wheat genotypes. Intl. J. Agric. Crop Sci. 5(9): 983-986.

Khan, A.S., I. Salim and Z. Ali. 2003. Heritability of various morphological traits in wheat. Intl. J. Agric. Bio., 5(2): 138–140.

Khan, H., H. Rahman, H. Ahmed and H. Ali. 2008. Magnitude of heterosis and heritability in sunflower over environments. Pak. J. Bot., 40(1): 301-308.

Khan, N and F.N. Naqvi. 2011. Heritability of Morphological Traits in Bread Wheat Advanced Lines Under Irrigated and Non-Irrigated Conditions. Asian J. Agric. Sci., 3(3): 215-222.

Memon, S., M.U. Qureshi, B.A. Ansari and M.A. Sial. 2007. Heritability for grain yield and its related characters in spring wheat. Pak. J. Bot., 39(5): 1503-1509.

Mohammadi, T., M. Amin, F. Subhan, M.I. Khan, and A.J. Khan. 2008. Identification of traits in bread wheat genotypes contributing to grain yield through correlation and path coefficient analysis. Pak. J. Bot., 40(6): 2393-2402.

Mohsin, T., N. Khan and F.N. Naqvi. 2009. Heritability, phenotypic correlation and path coefficient studies for some agronomic characters in synthetic elite lines of wheat. J. Food Agric. Env., 7(3): 278-282.

Nabi, T.G., M.A. Chowdhry, K. Aziz, and W.M. Bhutta. 1998. Interrelationship among some polygenic traits in hexaploid spring wheat. Pak. J. Biol. Sci., 1: 299-302.

Punia, S.S., A.M. Shah and B.R. Ranwha. 2011. Genetic analysis for high temperature tolerance in bread wheat. Afr. Crop Sci. J., 19(3): 149-163.

Sattar, A., M.A. Cheema, M. Farooq, M.A. Wahid, A. Wahid and B.H. Babar. 2010. Evaluating the performance of wheat varieties under late sown conditions. Int. J. Agric. Biol., 12: 561–565.

Shukla, S., A. Bhargava, A. Chatterjee and S. Singh. 2004. Estimates of genetic parameters to determine variability for foliage yield and its different quantitative and qualitative traits in vegetable amaranth (*A. tricolor*). J. Genet. Breed., 58: 169-176.

Sial, M.A., M.A. Arian, M.U. Dahot, G. Sarwar, M. Khalil, A. Laghari, S.M. Mangri, A. Mirbahar, and M. 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., M.A. Arian, S. Khanzada, M.H. Naqvi, M.U. Dahot, and N.A. Nizamani. 2005. Yield and quality parameters of wheat genotypes as affected by sowing dates and high temperature stress. Pak. J. Bot., 37(3): 575-584.

Singh, R.K. and B.D. Chaudhery. 1997. Biometrical methods in quantitative genetic analysis. Kalyani Pub New Delhi, India.

Talebi, R and F. Fayyaz 2012. Estimation of heritability and genetic parameters associated with agronomic traits of bread wheat under two constructing water regimes. J. Appl. Bio. Sci., 6(3): 35-39.

Tanveer, S.K., I. Hussain, M. Asif, M.Y. Mujahid, S. Muhammad, M. Qamar and M. Asim. 2009. Performance of different wheat varieties/lines as affected by different planting dates and seeding rates under high rainfall area of potohar. Pak. J. Agri. Sci., 46(2): 102.

Ullah H., H. Subthain, I.H. Khalil, W.U. Khan, Y. Jamal and M. Alam. 2014. Stress selection indices an acceptable tool to screen superior wheat genotypes under irrigated and rain-fed conditions. Pak. J. Bot., 46(2): 627-638.

Ullah, H., W.U. Khan, M. Alam, I.H. Khalil, K.N. Adhikari, D. Shahwar, Y. Jamal, I. Jan and M. Adnan. 2016. Assessment of G×E interaction and heritability for simplification of selection in spring wheat genotypes. Canad. J. Plant Sci., 96(6): 1021-1025.

Ullah, I., I.H. Khalil, H. Rahman, F. Mohammad, H. Ullah and S.K. Khalil. 2011. Magnitude of heritability and selection response for yield traits in wheat under two different environments. Pak. J. Bot., 43(5): 2359-2363.

Wajid, A., A. Hussain, A. Ahmad, A.R. Goheer, M. Ibrahim and M. Mussaddique. 2004. Effect of sowing date and plant population on biomass, grain yield and yield components of wheat. Int. J. Agric. Bio., 6(6): 1003-1005.