Yield Potential of $F_{4:7}$ Bread Wheat (*Triticum aestivum. L*) Lines under Normal and Late Plantings

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***Abstract*-- An experiment was conducted to evaluate advance wheat (*Triticum aestivum L*) breeding lines for yield and yield contributing traits. Fifteen $F_{4:7}$ bread wheat lines were assessed in randomized complete block design with three replications under normal and late planting conditions. Analysis of variance showed significant ($p \leq 0.01$) differences among wheat lines for all studied traits. Genotype × environment were significant for days to heading and grain fill duration. Generally, genotypes had varying response to late planting. Decline as result of delayed planting was recorded in days to heading (3.6%), days to maturity (1.8%), grain fill duration (2.7%), grain growth rate (16.3%), 1000 kernel weight (5.3%) and grain yield ha^{-1}(13.6%). Among wheat lines, maximum grain yield (3945 kg ha^{-1}) was produced by Margla/Ghaznavi-5 and Takbeer/Ghaznavi-3 under normal planting followed by Tatara/Takbeer-6 (3890 kg ha^{-1}). Broad-sense heritability estimates were 49, 38, 12, 60, 51, 55% for days to heading, days to maturity, grain filling duration, grain growth rate, 1000 grain weight, and grain yield ha^{-1}. Based on this study, the lines Takbeer/Ghaznavi-3, Takbeer/Ghaznavi-5 and Takbeer/khattakwal-4 were found superior for normal and late plantings.**

***Index Term*-- Heritability, G × E interaction, grain yield**

1. INTRODUCTION

Wheat (*Triticum aestivum* L) is an important crop worldwide. Unique chemical composition of wheat grain makes it prominent than any other cereals for bread making. In prehistoric age, the lake dwellers of Switzerland had grown wheat and there are indications of its cultivation in China about 3000 B.C. Wheat plant is believed to have originated in the region of north western India, Afghanistan and Abyssinia. Significant increase in population has increased the importance of wheat.

To feed the ever-increasing population, the need for more wheat will continue. There is scope to increase wheat yield in Pakistan through development of high yielding varieties and appropriate agronomic practices (Sial et al., 2000; Arain et al., 2002). Yield is the function of many components which when modified has direct influence on the productivity. Higher grain yields in wheat had been obtained by early planting (Darwinkel et al., 1977; Arain et al., 1999; 2001). Fluctuation in climatic conditions such as day length, temperature, humidity and precipitation may alter plant functions and productivity. Terminal heat stress ($\geq$ 35 C^{o}) in the post-anthesis period can significantly reduce grain weight in wheat and barley (Wardlaw and Wrigley, 1994), decrease grain quality (Randall and Moss, 1990).

Wheat yield is a result of many contributing factors, and among these the time of planting is an important one and can only be achieved by planting of wheat crop at its optimum time. Terminal heat stress due to late planting beyond certain limits lowers the grain yield significantly. Delay in wheat planting reduced grain yield considerably (Chio et al., 1992; Liszewski, 1999; Michiyama et al., 1998; Pecio and Wielgo, 1999).

Wheat is planted on an area of 9046 thousand hectares in Pakistan with an average yield of 2657 kg ha^{-1} (PBS, 2010) which is very low as compared to yield potential of the approved varieties in the country. Based on the previous research, wheat yield has been the lowest in Khyber Pakhtunkhwa among all four provinces of the country (PBS, 2004). One of the major reasons is that 60% of the area on which wheat is grown in Khyber Pakhtunkhwa is rainfed. Growers have to rely on rainfall for wheat plantation. In this case, the growers have to face huge yield losses. Normally, optimum plantation of wheat crop in Khyber Pakhtunkhwa is carried out from 25th October to 20th November (Shah, 1994). Delay in wheat plantation till December 5th, caused yield loss of 42% (Subhan et al., 2004). The present study was an attempt to ascertain performance of breeding lines over normal and late plantings. The objectives of the study were to determine significance of genotype by environment (GE) interaction for estimate broad-sense heritability for various yield and its contributing traits and to identify potential lines for future breeding programs.

II. MATERIALS AND METHODS

This experiment was conducted at The University of Agriculture Peshawar during 2011-12. Fifteen $F_{4:7}$ bread wheat (*Triticum aestivum L*) lines along with two check cultivars Janbaz and Ghaznavi were planted in randomized complete block design with three replications. Each plot consisted of 4 rows of 5 m length with a row to row space of 30 cm. Normal date of planting was November 15, 2011 and late planting was December 02, 2011.

Collection of data: Days to heading were the number of days from date of planting to the date when 50 percent of the spikes emerged fully from flag leaf. Days to maturity were counted from the date of planting to the time when more than 80

percent of the spikes turned yellow. Grain fill duration was estimated as days between days to 50% heading and maturity (Sayre et al., 1997). Grain growth rate was estimated by dividing grain yield plot^{-1} by grain fill duration (Sayre et al., 1997). Thousand grains were counted with the seed counter and weighed to record thousand kernel weight. After threshing, grains were weighed to record grain yield per plot. Plot yield was converted to grain yield per hectare.

Broad-sense heritability was calculated for numerous traits according to the procedure of Singh and Chaudhery (1997).

- Heritability (BS)

$$h^2 = Vg/Vp$$

Data were analyzed using MS Excel: (Gomez and Gomez, 1985)

III. RESULTS & DISCUSSION

1. Days to heading

Analysis of variance for days to heading revealed significant ($p \leq 0.01$) differences among genotypes and GE interaction (Table 1). Mean value for days to heading was 130 days under normal planting and 120 days under late planting. Days to heading under normal planting ranged from 125 to 133 days while it ranged from 117 to 125 days under late planting. Maximum (133) days to heading were recorded for Margla/Ghaznavi-2 under normal. While minimum (117) days were observed for Margla/Khattakwal-2 under late planting (Table 2). Late planting caused 3.6% decline for days to heading (Table 4). Broad-sense heritability estimate was 49% for days to heading (Table 5).

The present results confirmed the earlier findings of Muhammad et al., (2007), who reported highly significant interaction for days to heading at different planting dates. The presence of GE interaction hinders application of technology in wider geographical area (Kang and Gorman, 1989). There had been reduction in days to heading as a result of late planting. Similar results were found by Hamam et al., (2009). The efficiency of selection for a particular trait largely depends on the genetic and non-genetic factors affecting the phenotypic differences among genotypes. Heritability, thus, is a significant factor for selecting efficient lines from a mix population (Khan and Naqvi, 2011). Heritability estimates varied environment to environment and material to material (Mahmood and chowdhry, 1999, Badole et al., 2010).

2. Days to maturity

Significant ($p \leq 0.01$) differences were observed among wheat lines for days to maturity while GE interaction was non-significant (Table 1). Mean values for days to maturity were 165 days under normal and 160 days under late planting with ranges of 162 to 168 days and 155 to 162 days respectively. Under normal planting, the line Margla/Ghaznavi-2 was late maturing by taking maximum number of days (168) to maturity while under late planting maximum (162) days to maturity were recorded for Margla/Ghaznavi-8. Minimum values of 162 and 155 days to maturity were recorded for line Takbeer/Ghaznavi-2 under both dates of planting (Table 2). Percent decline for days to maturity was 1.8% due to late planting (Table 4). Estimate of broad-sense heritability for days to maturity was 38% (Table 5).

Significant differences in wheat lines for days to maturity in this study endorsed the similar findings of Khan et al., (2007). Contrary to the GE interaction results in this study, Muhammad et al., (2007) reported highly significant interaction for days to maturity. The logic behind the non-significance GE interaction could be terminal drought and heat in Peshawar during wheat maturity. Contrary to lower broad-sense heritability estimate for days to maturity in this study, Riaz et al., (2010) reported high heritability. This could be the result of forced maturity as a result of drought and heat, leaving narrow genetic variability.

3. Grain fill duration

Analysis of variance for grain fill duration exhibited significant ($p \leq 0.01$) differences among wheat lines. The GE interaction was also significant ($p \leq 0.01$) for grain fill duration (Table 1). Mean values for grain fill duration were 35 days and 38 days under normal and late plantings, respectively. The grain fill duration ranged from 30 to 40 days under normal planting while it ranged from 35 to 40 days under late plantation (Table 4). Maximum (40 days) grain fill duration was observed for the lines Takbeer/Khattakwal-4 and Margla/Khattakwal-2 in normal and late plantings, respectively. Minimum grain fill duration of 30 days and 35 days were observed for Margla/Ghaznavi-6 and Margla/Ghaznavi-2 under normal and late plantings, respectively (Table 3). Late planting produced 2.7% decline in grain fill duration (Table 4). Estimate of broad-sense heritability for grain fill duration was 12% (Table 5).

Grain fill duration is the period of transferring assimilates from source to sink. Over the range of 12 to 26°C increase in mean temperature during grain filling, grain weight was reduced at a rate of 4 to 8%/°C (Wardlaw et al., 1980). Acevedo et al., (1991b) reported a mean reduction of 4% in grain weight per °C increase in mean temperature during grain filling. Increased grain fill duration provided assimilates more time to partition into dry matter, resulting increased grain weight spike^{-1} and harvest index (Sayre et al. 1997). Low broad-sense heritability estimate for grain fill duration inferred lower chance of improvement in the current material.

4. Grain growth rate (g day^{-1})

Statistical analysis of the data for grain growth rate indicated significant ($p \leq 0.01$) differences among wheat lines while GE interaction was non-significant (Table 1). Under normal planting, grain growth rate ranged from 43 to 77 g

with a mean value of 57 g and under late planting, it ranged from 23 to 60 g with mean of 40 g day^{-1} (Table 4). Maximum (77 g day^{-1}) grain growth rate was noted for the line Margla/Ghaznavi-5 under normal planting, while under late planting mean growth rate reduced to 60 g day^{-1}. Under normal planting, minimum (43g) value was observed for the line Takbeer/Khattakwal-8, while under late planting, minimum (23g) grain growth rate was recorded for the line Margla/Ghaznavi-8 (Table 3). Late planting caused 16.3% decline for grain growth rate. Broad-sense heritability estimate for grain growth rate was 60% (Table 5).

Grain growth rate is one of the determinants for grain yield. In this study, there had been reduction in growth rate with delayed planting. However, non-significant GE interaction signifies that the reduction as a result of delayed planting was uniform.

5. 1000-grain weight (g)

Significant ($p \leq 0.01$) differences were observed among wheat lines for 1000 kernels weight while the GE interaction was non-significant (Table 1). Data for 1000 kernels weight ranged from 33 to 47 g with a mean value of 40 g under normal planting while under late planting the mean value was 35 g with the range of 25 to 45 g. On average, maximum (47 g) 1000 kernel weight was recorded for Janbaz under normal planting and under late planting, maximum (45 g) 1000 kernel weight was given by Takbeer/Khattakwal-8 Under normal planting, wheat line Takbeer/Khattakwal-4 realized maximum 1000 kernels weight of 45 g. Minimum 1000 kernels weight was 33 g and 25 g observed for Margla/Ghaznavi-2 under normal and late plantings, respectively (Table 3). Late planting caused 5.2% decline in 1000 kernels weight. Estimate of broad-sense heritability was 55% for 1000 kernels weight (Table 5).

The significant differences among wheat lines and non-significant GE interaction indicated stability in performance of the wheat lines. Inamullah et al., (2007) reported similar results for 1000 kernels weight. However, reduction in 1000 kernels weight over environments was noticed (Ansari et al. 1989). Chaturvedi and Gupta, (1995) reported moderate heritability for 1000 kernel weight, while Mehmet and Yildirim, (2006) reported low heritability for 1000 grain weight.

6. Grain yield (kg ha^{-1})

Significant ($p \leq 0.01$) differences were observed for grain yield while the GE interaction was non-significant (Table 1). Data for grain yield ranged from 2667 to 3945 kg ha^{-1} with mean value 3363 kg ha^{-1} under normal planting. Grain yield under late planting ranged from 1167 to 3722 kg ha^{-1} with mean of 2560 kg ha^{-1}. Under normal planting, maximum (3945 kg ha^{-1}) grain yield ha^{-1} was recorded for Margla/Ghaznavi-5 while under late planting the line Tatara/Takbeer-6 produced maximum (3722 kg) grain yield ha^{-1}. Minimum (2667 kg) grain yield was observed for Margla/Ghaznavi-2 under normal while the same line exhibited minimum (1167 kg) grain yield under late planting (Table 3). Late planting caused 13.6% decline in grain yield ha^{-1} (Table 4). Broad-sense heritability estimate for grain yield was 51% (Table 5).

Genetic variability in wheat lines with no GE interaction for grain yield in the current study are supported by javed et al. (2011). However, Inamullah et al., (2007) found significant effect of planting dates on genotypes for grain yield. In the current study, wheat lines showed higher mean grain yield when planted at normal time. Therefore for producing higher grain yield normal planting is recommended. Grain yield of wheat crop is the combined effect of various yield contributing components (Araus et al., 2001). Lower grain yield under late planting was mainly due to lower 1000 kernels weight, reduced grain growth rate day^{-1} and days to maturity. Delay planting exposed the crop to the heat shock of late summer, resulting in forced maturity. Reduction in grain yield at late planting was due to the effect of heat on the grain filling duration. Rahman et al., (2009) pointed out that terminal heat had more shocking effects on grain filling duration rather than anthesis period or total number of days to maturity. Musich and Dusek, (1980) reported that increasing temperatures resulted in earlier termination of grain filling. Moderate broad-sense heritability for grain yield in the current material indicated selection of high yielding lines.

Table I

Mean squares for days to heading (DH), days to maturity (DM), grain fill duration (GFD), grain growth rate (GGR), 1000-grain weight (TGW) and grain yield ha[1] (GY), Peshawar, 2011-12.

Sov	Environments	Reps.within E	Genotype	G x E	Error	CV %
DH	1754.206**	10.471	28.311**	9.164**	2.679	1.31
DM	936.088**	17.167	14.838**	3.838ns	2.406	1.0
GFD	125.186*	12.922	19.833**	13.061**	5.765	6.5
GGR (g day^{-1})	97060.019**	129.250	546.766**	59.705ns	51.393	14.8
TGW (g)	546.039ns	140.392	148.510**	20.873ns	16.059	10.6
GY (kg ha^{-1})	16475568.930**	505835.069	1708483.203**	226411.314ns	233385.964	16.3

**- highly significant, *- significant, ns- non-significant

Table II

Mean values for days to heading, days to maturity, grain fill duration, grain growth rate, 1000-grains weight and grain yield ha^{-1} under normal and late plantings, Peshawar, 2011-12.

Lines	Days to heading			Days to maturity			Grain fill duration			Grain growth rate			1000-grain weight			Grain yield ha^{-1}		
	1st	2nd	Mean	1st	2nd	Mean	1st	2nd	Mean	1st	2nd	Mean	1st	2nd	Mean	1st	2nd	Mean
Tatara/Takbeer-6	125	120	123	165	157	162	40	35	38	60	55	58	37	37	37	3890	3722	3805
Takbeer/Ghaznavi-2	125	120	123	162	155	160	35	37	36	65	50	58	37	33	35	3833	3000	3417
Takbeer/Ghaznavi-3	128	120	125	163	158	160	35	39	37	67	50	59	35	35	35	3945	3167	3555
Takbeer/Ghaznavi-5	130	120	125	163	158	160	33	40	37	68	43	56	43	40	40	3722	3500	3610
Margla/Ghaznavi-1	130	120	125	167	160	163	35	38	37	60	40	50	35	32	35	3610	2445	3028
Margla/Ghaznavi-2	133	125	130	168	160	165	35	35	35	45	25	35	33	25	30	2667	1167	1917
Margla/Ghaznavi-5	130	120	125	162	157	160	30	37	34	77	60	69	38	30	35	3945	3055	3500
Margla/Ghaznavi-6	130	118	125	163	157	160	30	40	35	60	42	52	40	37	40	3167	3055	3112
Tatara/Takbeer-3	128	120	125	162	158	160	34	40	37	54	35	45	45	40	43	3000	2555	2778
Margla/Ghaznavi-7	130	125	128	165	160	163	35	37	37	50	27	38	40	30	35	2945	1890	2417
Margla/Ghaznavi-8	130	125	128	167	162	165	35	37	36	55	23	40	37	27	32	3222	2055	2640
Margla/Khattakwal-1	127	123	125	165	160	163	38	37	38	43	30	37	43	35	40	2722	1610	2167
Margla/Khattakwal-2	125	117	120	165	158	160	40	42	40	50	37	45	45	43	45	3390	2333	2860
Takbeer/Khattakwal-4	125	118	122	165	158	162	40	40	40	50	45	48	45	43	45	3333	2333	2833
Takbeer/Khattakwal-8	125	120	123	165	160	163	40	40	40	43	35	40	45	45	45	2833	2000	2417
Ghaznavi	130	120	125	165	160	163	36	40	38	60	42	50	33	33	33	3500	2778	3140
Janbaz	130	120	125	165	160	163	37	40	38	60	50	55	47	40	43	3445	2833	3140
Mean	130	120		165	160		35	38		57	40		40	35		3363	2560	

Ist (Normal sowing), 2nd (late sowing)

Table III

Means, ranges, % decline, Lsd and best populations for days to heading (DH), days to maturity (DM), grain fill duration (GFD), grain growth rate (GGR), 1000-grain weight (TGW) and grain yield ha[1] (GY), Peshawar, 2011-12.

	Normal Planting		**Late Planting**			
Character	**Range**	**Lsd (5%)**	**Range**	**Lsd (5%)**	**% decline**	**Best population**
DH	125-133	7.5	117-125	4.6	3.6	Takbeer/khattakwal-4
DM	162-168	6.5	155-162	4.7	1.8	Takbeer/khattakwal-4
GFD	30-40	16.8	35-40	9.7	2.7	Takbeer/khattakwal-4
GGR (g day^{-1})	43-77	12.2	23-60	11.1	16.3	Margla/Ghaznavi-5
TGW (g)	33-47	6.8	25-45	6.2	5.2	Takbeer/khattakwal-4
GY (kg ha^{-1})	2667-3945	840.8	1167-3722	73.3	13.6	Takbeer/Ghaznavi-3

Table IV

Heritability estimates for days to heading, days to maturity, grain fill duration, grain growth rate, 1000-grain weight and grain yield ha^{-1}, Peshawar, 2011-12.

Parameters	**Vg**	**V p**	**Heritability (%)**
Days to heading	4.7	9.6	49
Days to maturity	1.8	4.7	38
Grain fill duration	1.1	9.3	12
Grain growth rate (g day^{-1})	81.1	135.3	60
1000-grain weight (g)	21.3	38.9	55
Grain yield (kg ha^{-1})	247012	478073	51

High ≥ 60%, Moderate ≥ 30%, low < 30%

IV. CONCLUSION AND RECOMMENDATIONS

Analysis of variance showed highly significant differences among the wheat lines for all the parameters, indicating sufficient variability to have an effective selection. GE interactions were significant for days to heading and grain fill duration while non-significant for days to maturity, grain growth rate, 1000-grains weight and grain yield.

Broad-sense heritability estimates were >47% for days to heading, grain growth rate, 1000-grains weight and grain yield ha^{-1}. However, broad-sense heritability estimates for days to maturity and grain fill duration were <40%.

Based on the results of this study, wheat lines Takbeer/Ghaznavi-3, Takbeer/Ghaznavi-5 and Takbeer /khattakwal-4 were found superior for grain yield, days to heading, days to maturity, grain fill duration and 1000-grains weight, respectively. Hence these lines could be used in future breeding programs for developing high yielding wheat varieties.

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