Research Article

Genetic Variability and Heritability for Yield and Yield Associated Traits of Wheat Genotypes in Nowshera Valley, Pakistan

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Abstract | Variation of traits is the basic tool involved in the natural assessment and causes to produce sustainable crop under various environmental conditions. The aim of the present study was to assess twenty-four different wheat genotypes for morphological traits and yield components. The experiment was laid out in randomized complete block (RCB) design having three replications. Components of variation, broad sense heritability, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), range and genetic advance were estimated for yield and yield associated traits. Results revealed significant variation for all traits among the tested wheat genotypes. The results showed the existence of adequate genetic variability among the tested wheat genotypes. High PCV and GCV were found in grains spike^{-1}, while highest broad sense heritability with inferior genetic advance was recorded for plant height. Wheat genotype PR-110 out performed for grain yield, while PR-103 exhibited higher biological yield. Highest number of productive tillers m^{-2} was counted for PR-111, while intense leaf area index was displayed by PR-103. Hybrid-404 had relatively higher grain spike^{-1} while PR-114 was observed for highest 1000-grain weight. Among the genotypes Pirsabak-08 excelled for dwarf traits, while Hybrid-403 was found early maturing genotypes. Grain yield was positively correlated with productive tillers m^{-2}, and biological yield. Genotypes PR-110 and Hybrid-404 resulted in superior grain yield among the genotypes. The results should help plant breeders to utilise the most promising wheat genotypes of this study in future breeding programmes for enhancing wheat cultivars.

Received | May 03, 2018; **Accepted** | June 17, 2018; **Published** | August 19, 2018

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Citation | Din, I., F. Munsif, I.A. Shah, H. Khan, F. U. Khan, Ibrarullah, S. Uddin and T. Islam. 2018. Genetic Variability and Heritability for Yield and Yield Associated Traits of Wheat Genotypes in Nowshera Valley, Pakistan. *Pakistan Journal of Agricultural Research,* 31(3): 216-222.

DOI | http://dx.doi.org/10.17582/journal.pjar/2018/31.3.216.222

Keywords | Wheat genotypes, Genetic variability, Heritability, Correlation

Introduction

Wheat (*Triticum aestivum* L.) belongs to family Poaceae, and considered the major staple food crop among the cereals for majority of world populations including Pakistan. In Pakistan total area under wheat crop during 2014-15 was 9.18 million ha. Its total production in the country was 25.478 million tons with an average yield of 2775 kg ha^{-1}. Wheat put up 10.0% to the value added in agriculture and 2.1% to GDP (MINFA, 2014-15). The yield reducing diseases of wheat crop are loose smut, rust, and leaf blight that results 50% reduction in grains yield across the country (Noor et al., 2009).

Development of new varieties of wheat have been a prominent factor in increasing grains yield per unit area. Wheat breeders around the world are involve in development of new wheat varieties, in order to acquire better harvest index, and to cover the demand

of the growing population (Mangova and Rachovska, 2004). Morphological and genetic traits of wheat play crucial role in determining the significance of each trait in yield improvement, so advance wheat genotypes are assessed to improve grain yield by introducing new varieties that can endure environmental stresses (Mollasadeghi et al., 2011). The use of varieties which have vigorous potential for yield and varied range of adaptation play crucial role for improving wheat productivity. Therefore, developing of productive and resistant varieties had been played a prominent role in wheat breeding programs across the world. Acclimatization of different wheat verities under diverse environmental conditions has been constantly trailed for testing comparatively stable cultivars (Shafi et al., 2013). There is a great variation among the yield potential of modern wheat varieties, which shows that grain yield can be increased through improved crop management (Laghari et al., 2010). The extent and orientation of genetic variation could be important source for germplasm management and their use in breeding programs. (Tanya et al., 2011). The crossing of genetically distant genotypes may create higher genetic recombination, extant variation, and segregation in their progenies, and result in varieties with an extensive genetic makeup (Altintas et al., 2008).

Grain yield in wheat is the final product of systematic interaction of various biotic and abiotic factors, which are highly susceptible to these environmental fluctuations. (Hussain et al., 2011; Bibi et al., 2012). Grain yield is a complex trait and mostly dependent upon yield components, genotypic traits and various environmental conditions as well (Drezner et al., 2007; Atkinson et al., 2008). Each genotype has genetic ability to perform over varied range of ecological conditions and this ability is usually referred to as the sensitivity or adaptability of a genotype (Hancock, 2004). Keeping above facts in view, the current experiment was conducted to assess different wheat genotypes for yield and yield components.

Materials and Methods

The experiment on assessment of various wheat genotypes for improved morphological and yield associated traits was carried out at Cereal Crops Research Institute, Pirsabak, Nowshera, during Rabi season 2014-2015. CCRI Pirsabak, elevated at 288 m (945 ft.) and located on the intersection of 32° North latitude and 74° East longitude. The temperature was range of minimum 6 and maximum 35 C during crop growing period. The total rainfall recorded was 190.5 mm with relative humidity ranged from 48 to 67% (Figure 1). Twenty-four genotypes i.e. PR-103, PR-105, PR-106, PR-110, PR-111, PR-112, PR-113, PR-114, Pirsabak-13, Shahkar-13, Pirsabak-08, Pirsabak-05, Galaxi-13, Pakistan-13, NARC-13, Faisalabad-08, Lalma-13, AAS-11, Hybrid-400, Hybrid-401, Hybrid-402, Hybrid-403, Hybrid-404 and Hybrid-405 were compared. The experiment was conducted in randomized complete block (RCB) design having three replications. Each plot consisted of four rows with a row length of 5 meter and row to row distance of 30 cm thus making a plot size of 6 m^2. The seeds were sown at the recommended rate of 120 kg ha^{-1}. Irrigations and fertilizers application were applied equally to each experimental unit throughout the crop growing season.

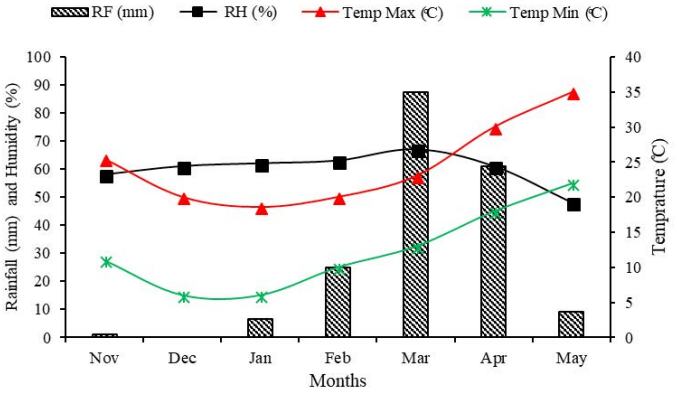

Figure 1: *Maximum, minimum temperature (℃), rainfall (mm) and relative humidity (%) during wheat growing season 2014-15.*

Statistical analysis

Data were recorded for variances in traits including days to maturity, leaf area index, plant height, productive tillers m^{-2}, grain $spike^{-1}$, biological yield, 1000-grain weight and grain yield. The collected data was statistically analyzed according to the appropriate method for randomized complete block design while using Statistical software Statistix 8.1. Means were compared using least significant differences test (LSD) at 0.05 percent level of probability where F-value was significant (Jan et al., 2009). Phenotypic and genotypic correlations were computed using method as suggested by (Kwon and Torrie, 1964).

Results and Discussion

Days to maturity

Analysis of variance revealed highly significant differ-

ences among the tested wheat genotypes for days to maturity (Table 1). Days to maturity ranged from 150 to 155. Early maturity was observed for genotypes Hybrid-402 and 403 among the tested genotypes followed by Hybrid-400, Hybrid-402 which was statistically at par with PR-105, while late maturity was observed for PR-110 and PR-114 (Table 3). 0.05% GCV achieved for days to maturity, while 1.48% increase was observed in PCV with broad sense heritability (34.04%) and 0.69 genetic advance (Table 2). Days to maturity showed non-significant negative correlation with grain spike^{-1} while showed positive non-significant correlation with rest of the traits (Table 4).

Productive tillers m^{-2}

Productive tillers m^{-2} was found significantly different (Table 1) among the tested wheat genotypes. Productive tillers m^{-2} ranged from 362 to 429. Comparison of the mean showed that genotypes PR-111 showed highest performance for productive tillers m^{-2}among the genotypes, followed by PR-113, while least number of tillers m^{-2} was noted for Hybrid-402 (Table 2). 58.54% GCV was observed for productive tillers m^{-2}, while maximum magnitude of PCV observed was 69.08 percent. Broad sense heritability observed was 84.74% with a genetic advance of 7.22 (Table 3). Productive tillers m^{-2} showed positive significant correlation with grain yield and it had negative significant correlation with grain spike^{-1} while positive non-significant correlation with rest of the traits (Table 4).

Table 1: *Analysis of variance for the traits of different wheat genotypes.*

Traits	Means Square			
	Replication	Genotypes	Error	P value
Days to maturity	4.05556	3.7965	1.49034	0.0034
Productive tillers m^{-2}	92.264	752.280	42.583	0.0000
Leaf area index	0.10811	0.23244	0.10325	0.0095
Plant Height	31.291	124.42	6.112	0.0000
Number of grain spike^{-1}	418.584	137.136	37.318	0.0001
1000-grains weight	4.00931	9.15173	4.57235	0.0225
Biological yield	15.0219	12.3708	3.7245	0.0005
Grains Yield	0.65914	0.56506	0.31992	0.0494

Leaf area index (LAI)

Leaf area index was found significantly different among the tested wheat genotypes (Table 1). Leaf area index ranged from 4.1 to 2.0. Means comparison showed that genotype PR-103 displayed superior LAI, followed by Pirsabak-05, PR-110 and Hybrid-405, while reduce LAI was noted for Hybrid-402, and Pirsabak-08 (Table 2). GCV and PCV for LAI ranged from 2.31 to 7.35% respectively. Heritability for LAI was 31.51% with GA of 9.28 (Table 3). Correlation studies showed that LAI had positive significant correlation with grains spike^{-1}, and negative significant correlation with grains yield and biological yield, while positive non-significant correlation with 1000-grains weight (Table 4).

1000-grains weight (g)

Data concerning 1000-grains weight as displayed in Table 1 manifested significant differences for 1000-grains weight among the tested wheat genotypes. 1000-grains weight ranged from 34.3 to 41.7g. Highest 1000-grains weight was noted for wheat genotype PR-114, followed by Hybrid-403 and Pirsabak-05, while lowest 1000-grain weight was displayed by PR-105 (Table 2). GCV and PCV recorded for this traits were 4.09% and 16.08% respectively. Broad sense heritability observed for 1000-grains weight was 25.03% with genetic advance of 3.36 percent (Table 3). 1000-grains weight had positive non-significant correlation with grain yield and plant height, while it had negative non-significant correlation with rest of the traits (Table 4).

Plant height (cm)

The data displayed in Table 1 indicated highly significant differences for plant height among the tested wheat genotypes. Among the genotypes plant height was ranged from 87 to 115 cm. Maximum plant height was expressed by PR-111, followed by PR-103, PR-112 and AAS-11, whereas genotype Pirsabak-08 was found dwarf among the tested genotypes (Table 2). GCV and PCV of plant height ranged from 38.49% and 44.25%, respectively. Broad sense heritability for plant height was 87% with genetic advance of 11.81 (Table 3). Plant height revealed positive significant correlation with productive tillers m^{-2} and LAI, while showed negative non-significant correlation with grains spike^{-1}, while non-significant positive correlation with rest of the traits.

Grains spike^{-1}

Analysis of variance of grains spike^{-1} showed highly significant differences among the tested wheat genotypes (Table 1). Grains spike^{-1} ranged from 47.7 to 73.6. Maximum grains spike^{-1}was recorded for wheat genotype Hybrid-404, followed by PR-103, Hybrid-403 and Hybrid-401, while genotypes Pirsabak-

Table 2: *Means for the agronomic characters of 24 different wheat genotypes evaluated under the agroecological conditions of Nowshera valley Khyber Pakhtunkhwa Pakistan.*

Genotypes	Parameters							
	Day to maturity	Productive Tiller m^{-2}	Plant height (cm)	LAI	Grain $spike^{-1}$	1000 grain weight	Biological yield (tons ha^{-1})	Grain yield (tons ha^{-1})
PR-103	153.0 ad	482.67 ac	110.87 b	2.72 a	69.93 a	36.23 df	16.96 a	3.80 be
PR-105	151.0 de	410.33 df	95.67 i	1.92 df	55.87 bd	34.27 f	13.98 ac	3.71 be
PR-106	152.7 bd	440.00 af	107.47 bc	2.05 cf	48.20 cf	37.90 be	15.69 ab	4.20 ae
PR-110	155.0 a	473.33 ad	102.67 de	2.48 ac	55.40 be	38.07 be	14.38 ac	4.97 a
PR-111	152.0 be	499.00 a	115.13 a	2.18 bf	46.87 df	39.87 ac	13.37 be	4.39 ac
PR-112	153.3 ac	483.67 ac	109.80 b	1.93 df	50.07 cf	37.37 bf	13.75 ad	4.62 ab
PR-113	152.0 be	464.67 ab	102.87 de	2.06 bf	56.67 bd	38.60 ad	14.33 ac	4.10 ae
PR-114	153.3 ac	420.67 bf	104.60 cd	2.05 cf	54.87 bf	41.67 a	13.37 be	4.40 ac
Pirsabak-13	153.0 ad	442.67 af	88.53 j	1.68 f	49.00 cf	37.03 bf	9.27 fh	3.49 ce
Shahkar-13	152.3 be	453.33 ad	96.53 gi	2.00 cf	51.33 cf	37.27 bf	10.24 eh	3.46 de
Pirsabak-08	151.3 be	410.67 df	87.27 j	1.66 f	50.07 cf	36.40 cf	12.37 cf	4.34 ad
Pirsabak-05	153.3 ac	446.33 ae	104.80 cd	2.58 ab	44.93 f	40.10 ab	12.02 ch	3.76 be
Galaxi-13	154.0 ab	463.33 ad	104.80 cd	2.24 ae	55.07 be	38.23 ae	13.90 ac	3.81 be
Pakistan-13	152.3 be	467.00 ad	105.13 cd	2.05 cf	50.13 cf	38.83 ad	11.49 ch	3.84 be
NARC-13	152.0 be	446.33 ae	100.53 eg	1.84 df	48.73 cf	36.83 bf	11.62 ch	4.39 ac
Faisalabad-08	152.3 be	454.33 ad	100.40 eh	1.87 df	54.13 bf	34.87 ef	11.48 ch	4.09 ae
Lalma-13	151.7 ce	416.00 cf	101.93 df	1.93 df	49.47 cf	37.03 bf	12.41 bf	3.71 be
ASS-11	152.3 be	414.67 cf	108.33 bc	2.15 bf	57.60 bc	39.03 ad	12.12 cg	4.38 ad
Hybrid-400	151.0 de	438.67 af	105.27 cd	1.74 ef	45.67 ef	38.60 ad	12.46 bf	4.22 ae
Hybrid-401	152.0 be	379.67 ef	102.00 df	1.86 df	61.47 ab	35.97 df	8.94 gh	3.34 e
Hybrid-402	150.3e	375.67 f	102.53 de	1.66 f	55.80 bd	39.87 ac	8.81 h	3.32 e
Hybrid-403	150.3 e	430.33 af	96.47 hi	1.86 df	62.87 ab	40.27 ab	10.56 dh	3.91 be
Hybrid-404	151.0 de	413.00 df	98.00 fi	2.00 cf	70.27 a	37.93 be	12.77 be	3.51 ce
Hybrid-405	152.7 bd	487.00 ab	100.03 cd	2.34 ad	56.53 bd	38.13 be	14.38 ac	4.40 ac
LSD value	2.0064	69.144	4.0632	0.528	10.04	3.5144	3.1718	0.9286

Means followed by different letters was significantly different at 5% level of probability.

Table 3: *Mean values, range, genotypic and phenotypic coefficients of variation, heritability, genetic advance and correlation of grain yield with the some agronomic traits of 24 wheat genotypes.*

Traits	Mean	Range		GCV (%)	PCV (%)	Heritability (%)	GA	Correlation with Grain yield
		Min	Max					
Days to Maturity	152	150	155	0.50	1.48	34.03	0.69	1.00
Productive Tillers m^{-2}	404	362	429	58.54	69.08	84.74	7.22	0.44
Plant Height	102	87	115	38.49	44.25	87.00	11.81	0.31
Leaf Area index	3.6	2.2	4.1	2.31	7.35	31.51	9.28	0.18
Grain $Spike^{-1}$	56.8	47.7	73.6	73.76	93.62	78.78	20.80	-0.21
1000-grain weight	37.93	34.3	41.7	4.09	16.08	25.03	3.36	0.17
Biological yield t ha^{-1}	12.5	8.8	17.0	2.04	10.01	41.47	17.92	0.52
Grain Yield t ha^{-1}	4.0	3.32	4.97	22.80	54.99	20.43	6.66	1.00

05 had minimum number of grain $spike^{-1}$ (Table 2). GCV and PCV recorded for grains $spike^{-1}$ was 73.76% and 93.63%, respectively. The estimate of broad sense heritability was found as 78.78% with genetic advance of 20.80 (Table 3). Grains $spike^{-1}$ showed positive significant correlation with LAI, while showed

negative significant correlation with productive tillers m^{-2} while it had negative non-significant correlation with days to maturity and plant height (Table 4).

Biological yield (tons ha^{-1})

Biological yield ha^{-1}(Table 1) exhibited substantial significant differences among the tested wheat gen otypes. Biological yield ranged from 8.8 to 17 tons' ha^{-1}. Mean value of comparison showed that Hybrid-405 produce highest biological yield, followed by PR-110, PR-106 and PR-113, while minimum biological yield was observed for genotype Hybrid-402 (Table 2). GCV and PCV of biological yield tons' ha^{-1} was ranged from 2.04 to 10.01%, while the estimate of heritability was observed 41.7% with the genetic advance of 17.92 (Table 3). Biological yield had positive significant correlation with productive tillers m^{-2}, grains yield, while it had negative significant correlation with grains $spike^{-1}$ and LAI, while showed positive non-significant correlation with plant height and negative non-significant with days to maturity and 1000-grains weight (Table 4).

Table 4: *Simple correlation among the yield and yield associated traits of different wheat genotypes.*

Traits	DM	PH	Tillers m^{-2}	LAI	GPS	GY	TGW	BY
DM	-	0.221	0.148	0.225	-0.090	0.071	-0.143	-0.290
PH	-	-	0.312**	0.048**	-0.083	0.175	0.222	0.203
Tillers m^{-2}	-	-	-	-0.150	-0.243*	0.489**	-0.120	0.530**
LAI	-	-	-	-	0.321**	-0.827**	-0.044	-0.818**
GPS	-	-	-	-	-	-0.347**	-0.082	-0.298*
GY	-	-	-	-	-	-	0.012	0.961**
TGW	-	-	-	-	-	-	-	-0.066
BY	-	-	-	-	-	-	-	-

****:** *Correlation is significant at the 0.01 level;* ***:** *Correlation is significant at the 0.05 level;* **DM:** *Days to maturity,* **PH:** *Plant height,* **LAI:** *Leaf area index,* **GPS:** *Grain $spike^{-1}$,* **TGW:** *1000-grain weight,* **GY:** *Grain yield and* **BY:** *Biological yield.*

Grain yield (tons ha^{-1})

Grain yield exhibited significant (Table 1) differences among the tested wheat genotypes. Grain yield ranged from 3.32 to 4.97 tons' ha^{-1}. Comparison of mean revealed that genotypes PR-110 performed best in term of grain yield, followed by genotypes PR-112, Hybrid-405 and PR-114. Lowest grain yield was recorded for genotype Hybrid-402 (Table 2). Genotypic and phenotypic variation noted for grain yield was 22.80% and 54.99%, respectively. Broad sense heritability found to be 20.43% with genetic advance 6.66% (Table 3). Correlation studies showed that grain yield had positive significant correlation with productive tillers m^{-2} and negative but significant correlation with LAI and grains $spike^{-1}$, while it had positive non-significant correlation with days to maturity and plant height (Table 4).

Developing of improved crop varieties are basically dependent on genetic makeup of the parent material. Twenty-four wheat genotypes were assessed for agromorphalogical and genetic variability traits, while observing morphological, yield and yield associated traits. Highly significant differences were noted in all traits, which indicated vast genetic variation in the area of study. Higher broad sense heritability was present among the genotypes for days to maturity which in line with the finding of Zheng et al. (2011) that early maturing varieties have a great impact on the harvest index of given crop. Our results for plant height are supported by the finding of Ewert et al. (2005) that breeding approaches of wheat make it possible to improve the yield and yield potential by the introduction of semi dwarf varieties of wheat. Similar result was observed for productive tillers m^{-2} which might be the result of the genetic makeup of parent material (Piepho et al., 2004). Intense leaf area index is the product of dense tiller m^{-2}. An increased in tillers density will show trends for concentrated leaf area index (Bavec et al., 2007). Variation among the traits play an important role that will ultimately result in the evaluation and selection of genotypes. A great variation was found among the tested genotypes for grains $spike^{-1}$ which is desirable trait in wheat variety improvement. Spikes with higher number of grains $spike^{-1}$ become the result of improved grain yield. The number of grains $spike^{-1}$ were in confirmation with (Hammad et al., 2013). Production of biomass depend on the genotypic traits of parent's plant material. Differences in biological yield are in line with the findings of Khan et al. (2007) who reported different biological yield for various genotypes. Yield of the crop can be enhanced by cultivation of productive varieties and productive varieties can be selected from genotypes having higher number of grains $spike^{-1}$. Grain yield is the result of productive tillers per unit area and grains $spike^{-1}$ also dependent on environmental conditions prevailing (Ahmad et al., 2006).

Conclusions

It is apparent that genetic makeup and variability is the major factor for grain yield in wheat. The results showed significant variation for morphological and yield components among the tested wheat genotypes. The high yielding genotypes may be released as commercial variety based on the superiority of spikelet's per spike, grains spike-^{1}, 1000-grains weight, and grains yield. Genotypes PR-110, PR-112 and Hybrid-405 showed better performance for grain yield as compared to other's genotypes and thus recommended for cultivation under agro-ecological conditions of Khyber Pakhtunkhwa, Pakistan.

Acknowledgement

Financial support for this study was provided by the Cereal Crops Research Institute, Pirsabak, Nowshera, Khyber Pakhtunkhwa.

Author's Contribution

Fazal Munsif: Help in write-up and statistical analysis.
Irfan Ahamd Shah: Planned and supervised the experiment at CCRI.
Hamayoon Khan: Overall management.
Fahad Ullah Khan: Technical input at every step.
Ibrarullah, Shahab Uddin and Tauqir Islam: helped in data collection.

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