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STUDIES ON GENETIC VARIABILITY AND INTER-RELATIONSHIP AMONG THE DIFFERENT TRAITS IN WHEAT *(Triticum aestivum* L.)

ISTRAŽIVANJE MEĐUSOBNE VARIJABILNOSTI I MEĐUSOBNIH ODNOSA RAZLIČITIH SVOJSTAVA PŠENICE *(Triticum aestivum* L.)

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SUMMARY

Correlation, path analysis, heritability and genetic advance were studied between grain yield and yield contributing traits in twenty genotypes. The positive and significant genotypic correlation of grain yield was found with spike length, plant height, flag leaf area and 1000-grain weight. Among these traits, spikelets per spike also showed the highest direct effect towards grain yield; while negative direct effect was exhibited by spike length. Heritability coupled with genetic advance was highest for plant height, flag leaf area, grain yield and 1000 -grain weight. So, these characters are more useful in wheat breeding program for high yield.

Key words: Genetic advance, heritability, path analysis, genetic correlation, quantitative traits, wheat

INTRODUCTION

Wheat is the most important human consumable product directly and indirectly in most areas of the world including Pakistan. In Pakistan the area under wheat cultivation was 9.06 million hectare with production of 23.42 million tones and productivity of 2585 kg per hectare during 2008-09 (Economic Survey of Pakistan, 2008-09) which is comparatively low to leading wheat producing countries where productivity is 2984.6 kg per hectare.

Correlation is a realistic technique to develop selection criteria, which is mostly based on phenotypic characters used for the improvement of yield through plant breeding program (Josi, 2005). Path coefficient analysis and heritability help in the picking of characters whose selection would be result in the improvement of crop yield (Akanda and Mundit, 1996). Therefore, this study would helpful for evaluating the importance of different agro-morpholgical characters in bread wheat that contribute to direct and indirect effects on crop yield and would be helpful in the selection of best traits for higher grain yield. Heritability and genetic advance are also used in crop improvement. It has been emphasized that heritability alone is not enough for selection unless accompanied by genetic advance. The utility of heritability increases when it is used to calculate genetic advance, which indicates the degree of gain in a character obtained under a particular selection

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pressure. Thus, genetic advance is yet another important selection parameter that helps breeder in a selection program (Shukla *et al*., 2004). Therefore, an attempt was made to identify variability, correlation and path coefficient estimates of economically important plant characteristics and to determine the characteristics contributing to seed yield in wheat.

MATERIAL AND METHOD

A research trial on wheat was conducted in Randomized Complete Design with three replications at the Research Farm of Wheat Research Institute, Faisalabad. Twenty bread wheat genotypes were selected as genetic material (Table 1). Three seeds per hill were sown by dippler which was later thinned to one seedling after germination. The plot size was kept 3 m in length of each repeat, maintaining P x P and R x R distances were 6cm and 30cm, respectively. The data was recorded by ten guarded plants selected from each genotype in every repeat at random for number of productive tillers (NPT), spike length (SL), spikelets per spike (SL/S), days to 50% heading (DH), days to 90% maturity (DM), plant height (PH), peduncle length (PL), flag leaf area (FLA), 1000-grain weight (1000-GW) and grain yield (GY).

Analysis of variance of the data for each attribute was computed using the method described by Steel and Torrie (1984).Genotypic and phenotypic correlations were computed according to the method developed by Kwon and Torrie (1964). Path coefficient analysis was done according to Dewey and Lu (1959). Heritability in broad sense was estimated from the result of variance analysis according to the formula given by Burton and DeVane (1953). Genetic advance was computed following the procedure elaborated by Singh and Chaudhary (2004) at 10% selection intensity.

Table 1. Twenty Genotypes along with their parentage
Tablica 1. Dvadeset genotipova sa svojim podrijetlom

Sr No	Genotypes	Parentage
1	Lasani.08	LUAN/KOH97
2	Faisalabad.08	PBW65/2*PASTOR
3	Seher.06	CHIL/2*STAR/4/BOW/CROW//BUC/PVN/3/…
4	Shafaq.06	LU26/HD2179/2*INQ91
5	Miraj	SPARROW/INIA//V.7394/WL.711/3/BAU'S'
6	Fareed	CROW'S'NAC//BOW'S'
7	04022	INQ.91/3/CROW'S'/NAC//BOW'S'
8	04178	SH.88/90A204//MH.97
9	05066	AMSEL/ATTILA//INQ.91/PEW'S'
10	BT006	MAYA/MONS//HORK/FSD85
11	05082	CHENAB2000/INQ.91
12	06068	AMSEL/ATTILA//INQ.91/PEW'S'
13	06096	UQAB.2000/3/LU26/HD2179//INQ.91
14	06056	BABAX*2/3/MANGO/VEE#10//PRL/4/BABAX/5/KAUZ*2YACO//KAUZ
15	06103	ATTILA/PASTOR
16	06018	LU26/HD2179//CHIL'S'
17	06016	BOW'S'/CROW'S'//UQAB.2000
18	07178	PASTOR//TODY/BAU/3/PASTOR
19	07189	BL2064//SW89-5124*2/FASAN/3/TILHI
20	05003	KARWAN-2/4/BURGUS/SORT-12-13//KAL/BB/3/PAK81

RESULTS AND DISCUSSION

The analysis of variance (Table 2) revealed significant differences among the treatments for all the traits indicating that there exists a good amount of genetic variability and all the genotypes differ from each other in respect of characters, which open a way to go ahead for improvement of the material through selection.

Table 2. Analysis of variance for various quantitative traits in wheat genotypes
Tablica 2. Analiza varijacije za razna kvantitativna svojstva u genotipovima pšenice

SOV	DF	NPT	SL	SL/S	DH (5%)	DM (90%)	PH (cm)	PL (cm)	FLA (cm)	1000-GW (g)	GY (g)
Reps	02	1.289	0.219	0.542	4.550	0.217	0.572	0.645	0.517	0.813	1.303
Genotypes	19	5.211*	2.262*	2.427*	47.715**	11.561*	93.355**	10.114*	47.463**	30.140**	53.788**
Error	38	0.178	0.197	0.422	2.041	0.866	2.284	2.021	0.694	0.914	1.051

Table 3. Mean value of various traits of twenty wheat genotypes
Tablica 3. Srednja vrijednost raznih svojstava dvadeset genotipova pšenice

Genotype	NPT	SL (cm)	SL/S	DH (50%)	DM (90%)	PH (cm)	PL (cm)	FLA (cm)	1000-GW(g)	GY (g)
Lasani.08	13.11a	10.23jkl	18.73fg	88.33fgh	135.3cdef	89.69cde	32.00ef	31.37j	47.37def	20.86d
Faisalabad.08	8.66cdef	10.53ghijkl	18.13g	87.00h	133.3ghij	96.99def	31.53f	39.46c	48.93cd	19.91de
Seher.06	9.33bcde	10.73fghijk	19.33defg	87.67gh	133.0ghj	99.62cd	34.17bcdef	32.94hi	48.23de	24.25bc
Shafaq.06	9.55bcde	12.20abc	18.93fg	98.00efgh	133.3ghij	104.10b	34.43bcdef	43.87a	46.90efgh	29.25a
Mirag.08	8.33defg	11.07fghij	19.93fg	87.00h	131.7j	91.15jkl	36.53ab	38.96c	46.20fghi	18.76ef
Fareed.06	10.66b	11.30defg	19.70bcdef	88.00gh	132.0ij	89.22l	33.67cdef	41.48b	45.00ij	19.22def
04022	8.55def	12.03bcd	20.33abcd	90.00efg	135.7bcde	92.22ijk	34.23bcdef	36.43ef	45.07hij	23.00c
04178	8.77cdef	10.33ijkl	20.40abcd	90.67def	133.7fghi	92.32ijk	32.00ef	29.28k	46.20fghi	23.27c
05066	7.12g	12.70ab	20.27abcde	91.33de	134.3efgh	89.77kl	38.77a	41.38b	47.03efg	17.94fg
BT006	8.44defg	13.93a	20.53abcd	90.67def	136.3abcd	103.70b	36.70ab	32.01ij	50.70b	15.82hi
05082	7.66fg	11.13efgii	19.73bcdef	95.67b	137.7a	93.89ghi	34.20bcdef	35.18fg	43.67j	13.63j
06068	9.88bcd	11.57cdef	21.07a	95.67b	136.3abcd	104.50b	35.30bcd	31.80ij	50.10bc	17.49fgh
06096	8.10efg	12.03bcd	20.93ab	91.00de	134.7defg	96.03efg	34.00bcdef	33.81gh	56.10a	25.34b
06056	9.44bcde	11.18efgh	19.65cdef	92.67d	133.0ghij	100.40c	35.87bcd	38.70cd	50.10bc	16.49gh
06103	9.77bcd	10.43hijkl	18.57fg	98.67a	137.3ab	104.5b	36.20abc	33.85gh	45.13hij	14.40ij
06018	8.66cdefg	10.80fghijk	19.07efg	93.00cd	132.7hij	95.20fgh	36.43abc	39.13c	45.20hij	16.12ghi
06016	8.11efg	11.93bcde	20.80abc	95.33bc	134.3efgh	98.20cde	33.17def	36.19ef	45.93fghi	17.55fgh
07178	8.81cdef	11.57cdef	21.33a	98.33a	137.3ab	109.00a	35.13bcd	37.34df	46.33fghi	22.96c
07189	10.22bc	10.20kl	19.77bcdef	96.33ab	131.7j	98.37cde	33.40def	33.16hi	45.30ghij	17.98fg
05003	10.55b	9.867 l	19.80bcdef	98.67a	136.7abc	93.09hij	33.13def	32.53hij	4080.k	13.09j

CORRELATION

The results (Table 4) revealed that number of productive tiller had positive association with grain yield per plant both at genotypic and phenotypic level. The selection of this trait would be effective to enhance grain yield. Similar findings were reported by Subhani and Chowdhry (2000)

Spike length exhibited positive and significant association with spikelets per spike, peduncle length, flag leaf area, 1000-grain weight and grain yield at genotypic level, while at phenotypic level, it showed highly significant association with spikelet per spike, peduncle length, flag leaf area and 1000-grain weight (Table 4). The selection of these traits would be effective to enhance the grain yield and development of bread wheat variety. Singh and Singh (1999) and Khaliq *et al.* (2004) also observed positive and significant results between spike length and grain yield.

Table 4. Genotypic and phenotypic correlation coefficient among certain quantitative traits in wheat
Tablica 4. Genotipski i fenotipski koeficijent korelacije među nekim kvantitativnim svojstvima pšenice

Traits		NPT	SL (cm)	SL/S	DH (50%)	DM (90%)	PH (cm)	PL (cm)	FLA (cm)	1000-GW (g)	GY (rg)
	G	1	-0.5850	-0.3808	-0.0045	-0.0358	0.1950*	-0.5385	-0.3030	-0.2035	0.0063
	P	1	-	-	-0.0166	-0.0360	0.1830	-	-0.2765*	-0.1739	0.0139
NPT			0.5526**	0.3329**				0.4448**			
SL	G		1	0.5154*	-0.1935	0.1169	0.1207	0.6107*	0.3818*	0.4655*	0.2544*
	P		1	0.5038**	-0.1757	0.1325	0.1171	0.5357**	0.3678**	0.4418**	0.2403
	G			1	0.4085*	0.3537*	0.1454*	0.1355	-0.3283	0.2732*	0.0821
SL/S	P			1	0.3750**	0.3430**	0.1320	0.1444	-0.2800*	0.2511	0.0782
	G				1	0.6160*	0.3855*	0.1394*	-0.3034	-0.3519	-0.5346
DH	P				1	0.5854**	0.3752**	0.1357	-0.2962*	-	-
(50%)										0.3446**	0.5156**
DM	G					1	0.4003*	0.0752	-0.4135	-0.1107	-0.3080
(90%)	P					1	0.3934**	0.0757	-	-0.0977	-0.2853*
									0.3973**		
	G						1	0.1012*	-0.1691	0.2951*	0.1402*
PH	P						1	0.0853	-0.1643	0.2905*	0.1356
	G							1	0.3881*	0.1021	-0.2866
PL	P							1	0.3366**	0.1051	-0.2706*
	G								1	-0.0950	0.1872*
	P								1	-0.0885	0.1858
FLA											
	G									1	0.3916*
1000-	P									1	0.3873**
GW											

The results in Table 4 revealed that spikelet per spike had positive and significant correlation at genotypic level with days to 50% heading, days to 90% maturity, plant height and 1000-grain weight but positive and highly significant correlation at phenotypic level with days to 50% heading and days to 90% maturity which suggested that selection of plants having more spikelets per spike increased the grain yield and thereby, could be used in breeding program. Akhtar (1991); Mohy-ud-Din (1995) and Khaliq *et al.* (2004) also detected a significant correlation between spikelet per spike with grain yield at genotypic level.

The positive genotypic correlation between plant height and grain yield was observed. The selection of moderate plant height increased grain yield per plant. Subhani & Khaliq (1994); Chaturvedi and Gupta (1995) and Khan *et al.* (1999) also reported positive and significant correlations between yield and plant height.

Flag leaf area had positive and significant genotypic correlation with grain yield (Table 4). This trait is very useful for breeder to enhance the grain yield per plant. Subhani and Chowdhry (2000) also observed positive and significant correlation between flag leaf area and grain yield per plant.

The correlation between 1000-grain weight and grain yield was also positive and significant at genotypic but highly significant at phenotypic level. The contribution of 1000-grain weight will be more effective to enhance the grain yield. Baser *et al.* (2000); Aycecik & Yildirim (2006) and Inamullah *et al.* (2006) also observed positive association of 1000 grain weight with grain yield.

PATH ANALYSIS

Path coefficient analysis is an effective way of assessing the influence of each variable upon the resultant variable directly as well as indirectly by partitioning the genetic correlation. It helps in choosing the plant traits that influence the breeding program for high yield. The highest positive direct contribution was noted by spikelet per spike to grain yield (Table 5) followed by flag leaf area, days to 90% maturity, plant height, number of productive tiller and 1000-grain weight. These findings indicate that a slight increase in any one of the above traits may directly contribute towards seed yield. Subhani and Chowdhary (2000) also observed similar findings. Thus, selection of these traits could be effective for high grain yield. The highest positive indirect effect on grain yield was observed by number of productive tillers followed by 1000-grain weight and spike length.

Table 5. Direct (bold values) and indirect effects of quantitative traits on grain yield in wheat; the last column shows the genotypic correlation of grain yield.

Tablica 5. Izravno (masna slova) i neizravno djelovanje kvantitativnih svojstava na prinos zrna u pšenici: zadnji stupac pokazuje genotipsku korelaciju prinosa zrna

Traits	NPT	SL	SL/S	DH (50%)	DM (90%)	PH (cm)	PL (cm)	FLA (cm)	1000 G W (g)	GY (rg)
NPT	0.527	7.957	-4.099	4.6888	-0.187	0.511	-2.748	-1.976	-0.020	0.006
SL	-0.308	-13.595	5.548	2.029	0.611	0.316	3.116	2.490	4.674	0.254
SL/S	-0.200	-7.006	10.765	4.284	1.849	0.381	0.691	2.141	2.743	0.082
DH (50%)	-2.356	2.630	4.397	-10.488	3.220	1.010	0.711	-1.978	-3.533	-0.534
DM (90%)	-1.887	-1.589	3.808	-6.460	5.227	1.049	0.383	-2.696	-1.112	-0.308
PH (cm)	0.102	-1.640	1.565	-4.043	2.092	2.621	0.516	-1.103	2.963	0.140
PL (cm)	-0.283	-8.302	1.458	-1.462	0.393	0.265	5.102	2.531	1.025	-0.286
FLA (cm)	-0.159	-5.190	-3.534	3.182	-2.161	-0.443	1.980	6.522	-9.541	0.187
1000-GW (g)	-0.107	-6.328	2.941	6.690	-0.578	0.773	0.520	-0.619	0.100	0.391

HERITABILITY AND GENETIC ADVANCE

All the traits under study revealed high value of heritability in broad sense. Highest heritability value was exhibited (Table 6) by flag leaf area (0.985) followed by grain yield (0.980) and plant height (0.976), which suggested that these characters are least influenced by the environmental factors and also indicates the dependency of phenotypic expression which reflects the genotypic ability of cultivars to transmit the genes to their off-springs. Jedynski (2001) and Ajmal *et al.* (2009) also reported highest heritability in wheat for plant height and grain yield, respectively.

High heritability does not mean a high genetic advance for a particular quantitative character. Johnson *et al* (1955) reported that heritability estimates along with genetic gain would be more rewarding than heritability alone in predicting the consequential effect of selection to choose the best individual. The expected genetic advance (Table 6) was high for plant height (9.582) followed by grain yield (7.303) and flag leaf area (6.895). High heritability coupled with high genetic advance was observed for plant height followed by grain yield, flag leaf area and days to 50% heading which suggested that these characters can be considered as favorable attributes for the improvement through selection and this may be due to additive gene action (Panse, 1957) and thus, could be improved upon by adapting selection without progeny testing. Similar results have also been reported by Ajmal *et. al* (2009). High heritability coupled with low genetic advance were noticed for spikelet per spike (1.306), spike length (1.394) and number of productive tillers (1.998). It may be inferred that these characters were regulated by non-additive gene action and presence of high genotype x environment inter-action. The heritability if being exhibited due to the favourable influence of environment rather than the genotype and simple selection will not be rewarding. As, such, progeny or family testing should be practiced for amelioration of these traits. However, they can be improved by development of hybrid varieties by utilization of transgressive segregants in heterosis breeding programme. This implies that the breeder can go for selection over several successive generations following hybridization to isolate desirable transgressive segregants.

CONCLUSION

It is concluded from the present study that the traits like plant height, flag leaf area and 1000- grain weight showed strong association with grain yield as

Table 6. Estimation of heritability and genetic advance of different yield attributes of wheat genotypes
Tablica 6. Procjena hereditarnosti i genotipskog razvoja raznih svojstava prinosa genotipova pšenice

Traits	VARP (G)	VARP (P)	VAR (E)	GCV	PCV	ECV	H2(b.s)	G.A at 10% S.E
NPT	1.497	1.736	0.239	13.32	14.34	5.32	0.862	1.998
SL	0.688	0.753	0.0655	7.38	7.73	2.28	0.913	1.394
SL/S	0.668	0.808	0.140	4.13	4.54	1.89	0.826	1.306
DH (50%)	15.224	15.904	0.680	4.23	4.32	0.89	0.957	6.717
DM (90%)	3.564	3.853	0.288	1.40	1.46	0.40	0.925	3.195
PH (cm)	30.356	31.118	0.761	5.65	5.72	0.89	0.976	9.582
PL (cm)	2.697	3.371	0.673	4.75	5.32	2.38	0.800	2.585
FLA (cm)	15.589	15.821	0.231	10.99	11.07	1.34	0.985	6.895
1000 GW (g)	9.742	10.046	0.304	6.64	6.74	1.17	0.970	5.411
GY(g)	17.578	17.929	0.350	21.65	21.86	3.06	0.980	7.303

(VARP G) Genotypic variance, (VARP P) Phenotypic variance, (VAR E) Environmental variance, (GCV) Genotypic coefficient of variance, (PCV) phenotypic coefficient of variance, (ECV) environmental coefficient of variance, (H2b.s) Broad sense heritability and (G.A) Genetic advance at 10% selection intensi

well as high direct effects. The values of heritability and genetic advance for these traits were also high as compared to other traits studied in the present study. Hence, it is suggested that utmost importance is given to these characters in selection criteria for improving the wheat grain yield.

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SAŽETAK

U dvadeset genotipova istraživani su korelacija, analiza putanje, hereditarnost i genetski napredak između prinosa zrna i svojstava koja pridonose prinosu. Nađena je pozitivna i značajna genotipska korelacija prinosa zrna s duljinom klasa, visinom biljke, područjem snijeti i težinom 1000 zrna. Među ovim svojstvima klasići po klasu također su pokazali najveći izravan učinak prema prinosu zrna, dok je negativan izravan učinak očitovala duljina klasa. Hereditarnost zajedno s genetskim napretkom bila je najviša za visinu biljke, područje snijeti, prinos zrna i težinu 1000 zrna. Prema tome, ova su svojstva korisnija u programu uzgoja pšenice za visoki prinos.

Ključne riječi: genetski napredak, hereditarnost, analiza putanje, genetska korelacija kvantitativna svojstva pšenice