The Bioscan 10(2): 763-767, 2015 (Supplement on Genetics and Plant Breeding)
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

GENOTYPIC VARIABILITY, PARTIAL REGRESSION ANALYSIS AND IDENTIFICATION OF EARLY MATURING WHEAT SUITABLE FOR KASHMIR VALLEY

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KEYWORDS
Bread wheat
Variability
Heritability
Correlation
Path coefficient

Received on :
24.04.2015

Accepted on :
18.06.2015

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ABSTRACT

Rice wheat cropping system is considered to be a key to food security in India. However, under temperate parts of north-west Himalayas like Kashmir, none of the wheat varieties have been found suitable for cultivation after rice is harvested. The initiative was taken to identify early maturity and high yielding genotype that could fit in Rice-Wheat cropping system. Twenty five wheat genotypes including two checks viz. SKW-355 and HS-240 were evaluated for early maturity, yield and its contributing traits. The analysis of variance revealed presence of significant variability among the genotypes for all the traits studied. Genotypic correlation coefficients revealed significant and positive association of grain yield with number of effective tillers m^{-1} (0.91), number of spikelets $spike^{-1}$ (0.70), grains $spike^{-1}$ (0.92) and 1000-grain (0.97) and negative significant correlation with plant height (-0.37), suggesting that selection of such traits may be rewarding in improving yield. Path coefficient analysis was carried out with grain yield $plot^{-1}$as response trait. Days to heading showed highest positive direct effect (2.71) on grain yield $plot^{1}$ followed by grain filling period (2.23) and 1000-grain weight (0.66). Four genotypes viz., SKW-355, HPW-366, UP-2831 and HPW-367 matured in 221.33, 225.00, 225.33 and 226.66 days, respectively and recorded the grain yield of 31.11, 22.22, 31.77 and 23.03 q ha^{-1} respectively thus were found suitable for cultivation under rice-wheat cropping system in Kashmir.

INTRODUCTION

India is a second largest wheat producing country, contributing about one-tenth of the global wheat production (93.90 million mt) spread across 29.90 m ha with a productivity of 3.14t ha^{-1}(Anonymous, 2012a). In Jammu and Kashmir, wheat occupies relatively lesser area than rice and maize, primarily because early and high yielding varieties, which fit in rice wheat system are lacking. Wheat occupies an area of 0.29 million hectares with a productivity of 1.4t ha^{-1} (Anonymous, 2012b). Jammu and Kashmir has been recognised as a food deficit state, necessitating large import of food grains exceeding more than 5 lac tonnes per annum. To promote rice-wheat based cropping system in the valley has been recognised as one of the important strategies to make agriculture more remunerative and sustainable. At the same time to promote full season winter wheat for high altitude areas would be an appropriate choice.

The study of genetic variability reveals about the presence of variation in their genetic constitution and it is utmost important as it provides the basis of effective selection (Kumar *et al.*, 2013). The progress of breeding in such a population is primarily conditioned by the magnitude, nature and inter-relationship of genetic variation for various plant characters. The genotypic correlation coefficients provide a measure of association between various characters and help to identify the traits that may be useful in selection Johnson *et al.* (1955) and has been used in wheat breeding in Kashmir Vaishnavi *et al.* (2000). Path coefficient analysis developed and described by Wright (1921) and used by Dewey and Lu (1959) measures the direct and indirect effects of various characters. The measures of trait association would help us to devise a selection index in order to select promising genotypes for promotion as varieties or their involvement as parents in the crossing programme. Therefore, the present study was aimed to study the genetic variability, character associations on the basis of correlation and regression analysis and identification of high yielding early maturity genotypes of wheat suitable for temperate climate of North-West Himalayas.

MATERIALS AND METHODS

The experimental materials comprised of 25 wheat (*Triticum aestivum* L.) genotypes including two checks SKW-355 and HS-240 and were grown in randomized block design with three replications. The experiment was laid out at experimental farm of Division of Plant Breeding and Genetics, SKUAST-Kashmir, during *Rabi* 2010-2011. The site is situated at an altitude of 1587 m above mean sea level, at 34º02 N latitude and 74º832 E longitude. Each entry was sown in five rows of 3 m length with inter-row spacing of 25 cm. Standard package of practices were adopted to raise a healthy crop. Observations were recorded on ten randomly selected competitive plants for eleven agro-morphological traits viz., days to heading, days to maturity, grain filling period, plant height, number of effective tillers m^{-1}, number of spikelets $spike^{-1}$, spike length, grains spike^{-1}, 1000-grain weight, grain yield plot^{-1} and harvest index. GCV and PCV were calculated by the formula given by Burton (1952), heritability (bs) as per Burton and Devane and genetic advance *i.e.* expected genetic gain as per procedure given by Johnson *et al.,* 1955. Correlation coefficients were computed according to the method suggested by Singh and Choudhary (1985). Data on days to maturity was recorded on whole plot basis.

RESULTS AND DISCUSSION

Mean, range, phenotypic and genotypic coefficient of variation, heritability (broad-sense) and expected genetic gain (%)

Analysis of variance revealed highly significant mean squares across the genotypes for all the traits studied (Table 1). Days to heading ranged from 170-195 days with a mean of 182.04 days while days to maturity ranged from 221-245 with a mean of 232.98 days. The grain filling period ranged from 43.33-54.99 days with a mean of 50.55 days. Plant height varied between 101.37 and 129.67 cm with a mean of 116.29 cm, respectively. The number of effective tillers m^{-1} ranged from 147.5-161.73 with a mean of 157.76. The lowest and highest values for number of spikelets spike^{-1} were 16.43 and 19.77, respectively with an average of 18.53. The number of grains spike^{-1} varied between 49.23 and 57.10 with the mean value of 54.26. The trait 1000-grain weight ranged from 33.83-40.13g with a mean of 37.08 g. The range of variability for grain yield was recorded between 1.20- 1.63 kg plot^{-1} with a mean of 1.39 kg. Harvest index (%) recorded a mean and range of 31.20 and 26.96-36.96 per cent and per cent, respectively. The magnitude of phenotypic and genotypic coefficient of variation for days to heading, days to maturity, grain filling period, plant height, number of effective tillers m^{-1}, number of spikelets spike^{-1}, spike length, grains spike^{-1}, 1000-grain weight was low (<10%) where as it was moderate for harvest index (10-20%) and high (>20%) for yield plot^{-1} (Table 2).

The success of any breeding programme depends on the presence of sufficient genetic variability to pursue effective selection. It is important to assess the relative magnitude of variability in order to use such information together with other selection parameters for the improvement of plant type through adoption of effective breeding methods (Williams, 1964; Briggs and Knowls, 1967). Genetic coefficient of variability (GCV) helps to choose a particular genotype whereas heritability (h^2) along with the genetic advance (per cent of mean) is more useful in predicting the resultant effective selection of the best genotypes. Since an important objective in the present study was to identify early maturity and high yielding genotype, the considerably high GCV for grain yield helped to identify the best performing genotype. The relative variability for earliness was lower as compared to yield per se. High values of GCV and PCV for yield has been reported by Ali *et al.* (2008) and Kumar *et al.* (2014). Magnitude of GCV and PCV has been found to be moderate for days to heading (10.0-20.0%) and low for days to maturity, grains spike^{-1}, number of spikelets spike^{-1}, spike length, plant height, by Laghari *et al.* (2010).

High heritability (bs) was recorded for all the traits (83.0-97.0%) except for traits grain filling period, number of spikelets spike^{-1} and spike length which recorded moderate values (<80%) (Table 2). Low heritability was recorded for days to maturity with a value of 41.50 per cent. Expected genetic gain as per cent of mean was low (<10.0%) for days to heading, days to maturity, number of effective tillers m^{-1}, number of spikelets spike^{-1}, whereas it was moderate (10.0-20.0%) for grain filling period, plant height, spike length, grains spike^{-1}, 1000-grain weight and harvest index. It was high (>20%) for grain yield plot^{-1}. High heritability was recorded for plant height (97%) which is in accordance with the studies of Kashif and Khaliq (2004), Abinasa *et al.* (2011) and Arya *et al.* (2013). High heritability has also been reported for grain yield plant^{-1}, grains spike^{-1}, 1000 grain weight, days to heading and harvest index by Majumder *et al.* (2008) and Kashif and Khaliq (2004). Expected genetic gain has been reported to be high for grain yield plant^{-1}, low for days to 50% heading and days to maturity

Table 1: Analysis of variance for maturity, yield and yield contributing traits in wheat accessions (*Triticum aestivum* L.)

Source of variation	d.f.	DH	DM	GFP	PH	ET	SS	SL	GS	GW	GY	HI
Replications	2	0.16	0.48	0.17	1.40	2.62	0.28	0.69	0.26	0.26	0.01	8.12
Genotypes	24	38.03**	6.19**	26.95**	159.08**	30.43**	2.41**	2.58**	22.39**	15.81**	0.12**	65.98**
Error	48	1.03	1.98	2.18	1.22	1.48	0.22	0.28	0.31	0.32	0.01	0.65

*, ** significant at 5.0 and 1.0 per cent level, respectively; Abbreviations: DH: days taken to heading, DM: Days to maturity, GFP: Grain filling period, PH: Plant height (cm), ET: Number of effective tillers, SS: No. of spikelet spike^{-1}, SL: Spike length (cm), GS: Grains spike^{-1}, GY: Grain yield plot^{-1}, HI: Harvest index

Table 2: Variability parameters for agro-morphological traits

Traits	Mean	Range	PV ($\hat{\sigma}^2p$)	GV ($\hat{\sigma}^2g$)	PCV	GCV	h^2	GA (5%)
Days to heading	182.04 ± 0.83	170-195	13.36	12.33	1.93	1.85	0.92	3.67
Days to maturity	232.98 ± 1.15	221-245	3.38	1.40	0.82	0.52	0.41	0.70
Grain filling period	50.55 ± 1.21	43.33-54.99	10.44	8.25	9.12	8.11	0.79	14.85
Plant height	116.29 ± 0.90	101.37-129.67	53.84	52.61	6.31	6.23	0.97	12.70
No. of effective tillers m^{-1}	157.76 ± 0.99	147.5-161.73	11.13	9.64	2.11	1.96	0.86	3.77
No. of spikelets spike^{-1}	18.53 ± 0.38	16.43-19.77	0.95	0.73	5.26	4.61	0.76	8.32
Spike length	12.09 ± 0.43	10.26-13.00	1.05	0.76	8.48	7.24	0.73	12.75
Grains spike^{-1}	54.26 ± 0.46	49.23-57.10	7.67	7.35	5.10	5.00	0.95	10.08
1000-grain weight	37.08 ± 0.47	33.83-40.13	5.49	5.16	6.31	6.12	0.94	12.24
Grain yield plot^{-1}	1.39 ± 0.07	1.20-1.63	0.04	0.03	22.14	20.17	0.83	37.85
Harvest index	31.21 ± 0.95	26.96-36.96	10.07	8.71	10.86	10.10	0.86	19.35

Table 3: Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients among different plant traits

Parameters	Days to heading	Days to maturity	Grain filling period	Plant height	No. of effective tillers m^{-1}	No. of spikelet $spike^{-1}$	Spike length	Grains $spike^{-1}$	1000-grain weight	Harvest index	Grain yield $plot^{1}$
Days to heading	-	0.66**	-0.95**	0.16	-0.06	0.13	0.05	-0.21	-0.15	-0.26	-0.15
Days to maturity	0.47**	-	0.39**	0.18	0.16	0.06	-0.11	-0.15	-0.02	0.14	0.06
Grain filling period	-0.86**	0.33*	-	-0.12	0.16	-0.12	-0.10	0.21	0.18	0.45**	0.19
Plant height	0.14	0.11	-0.10	-	-0.23	-0.04	0.29*	-0.13	-0.18	0.04	-0.37**
No. of effective tillers m^{-1}	-0.04	0.08	0.11	-0.21	-	0.69**	0.38**	0.24	0.87**	0.15	0.91**
No. of spikelets $spike^{-1}$	0.11	0.01	-0.12	-0.04	0.57**	-	0.41**	0.64**	0.75**	0.28*	0.70**
Spike length	0.06	-0.04	-0.08	0.25	0.29*	0.34	-	0.20	0.21	0.39**	0.24
Grains $spike^{-1}$	-0.20	-0.11	0.17	-0.12	0.24	0.58**	0.16	-	0.95**	0.17	0.92**
1000-grain weight	-0.14	-0.03	0.15	-0.16	0.82**	0.68**	0.16	0.93**	-	0.14	0.97**
Harvest index	0.26	-0.15	0.38**	0.02	0.12	0.25	0.29*	0.18	0.14	-	0.21
Grain yield $plot^{1}$	-0.14	0.05	0.14	-0.31*	0.85**	0.60**	0.10	0.85**	0.93**	0.23	-

*,** indicates significance at 5.0 and 1.0 per cent level, respectively.

Table 4: Estimates of direct and indirect effects of different plant traits

	Predictor variables										Response variable
Parameters	Days to heading	Days to maturity	Grain filling period	Plant height	No. of effective tillers m^{-1}	No. of spikelet $spike^{-1}$	Spike length	Grains $spike^{-1}$	1000-grain weight	Harvest index	Grain yield $plot^{-1}$
Days to heading	2.71	-0.67	-2.12	0.01	-0.03	-0.03	-0.01	0.12	-0.19	0.05	-0.15
Days to maturity	1.79	-1.01	-0.88	0.01	0.06	-0.02	0.07	0.08	-0.03	-0.03	0.06
Grain filling period	-2.57	0.40	2.23	-0.01	0.06	0.03	0.01	-0.12	0.24	-0.08	0.19
Plant height	0.43	-0.19	-0.28	0.08	-0.10	0.01	-0.14	0.07	-0.25	0.01	-0.37**
Effective tillers m^{-1}	-0.18	-0.16	0.37	-0.02	0.39	-0.14	-0.05	-0.46	1.14	0.03	0.91**
No. of spikelets $spike^{-1}$	0.35	-0.06	-0.27	-0.01	0.27	-0.21	-0.05	-0.35	0.98	0.05	0.71**
Spike length	0.16	0.12	-0.24	0.02	0.15	-0.08	-0.12	-0.11	0.28	0.07	0.24
Grains $spike^{-1}$	-0.59	0.15	0.47	-0.01	0.33	-0.13	-0.03	-0.54	1.24	0.03	0.92**
1000-grain weight	-0.41	0.02	0.41	-0.12	0.34	-0.25	-0.23	0.52	0.66	0.03	0.98**
Harvest index	0.86	0.15	-1.01	0.01	0.06	-0.06	-0.05	-0.1	0.19	0.18	0.23

*,** indicates significance at 5.0 and 1.0 per cent level, respectively.

by Dharmendra and Singh (2010). High GCV along with high heritability estimates and expected genetic gain are more useful than either of these parameters taken alone in predicting the resultant effect of selecting the best genotype (Johnson *et al.*, 1955). Low expected genetic advance results from low genetic variance and genotypic coefficient of variation rather than due to moderate or low heritability estimate (Singh *et al.*, 1983).

Estimates of phenotypic and genotypic correlation coefficients

Correlation coefficients at genotypic level were generally higher in magnitude than coefficients at phenotypic level (Table 3). Days to heading exhibited positive and significant genotypic and phenotypic correlations with days to maturity but negative and significant correlations with grain filling period. This indicates that earliest to flower genotypes had extended grain filling period and therefore to score total maturity days becomes an important feature for selection of early types. Since flowering and maturity days are positively correlated (as also reported by Singh *et al.*, 2010, Kumar *et al.*, 2013), thus can't be explained by grain filling days. That means the three traits contributing to crop maturity interact and are partly contributed by some other traits as can be better understood by path coefficients. Days to maturity revealed positive significant phenotypic and genotypic correlation with days to heading and grain filling period. Grain filling period showed positive and significant association with harvest index. Plant height was positively and significantly correlated with spike length and showed significant negative association with grain yield $plot^{-1}$ at genotypic and phenotypic level. Number of effective tillers m^{-1} exhibited positive and significant genotypic and phenotypic correlations with number of spikelets $spike^{-1}$, spike length, 1000-grain weight, and grain yield $plot^{-1}$. Number of spikelets $spike^{-1}$ exhibited positive and significant genotypic correlations with spike length, grains $spike^{-1}$, 1000-grain weight, grain yield $plot^{-1}$ and harvest index. Spike length showed positive and significant genotypic correlation with harvest index. Grains $spike^{-1}$ exhibited positive and significant correlation with 1000-grain weight and grain yield $plot^{-1}$ at both genotypic and phenotypic levels. 1000-grain weight was positively and significantly associated with number of effective tillers m^{-1}, number of spikelets $spike^{-1}$, grains $spike^{-1}$ and grain yield $plot^{-1}$ at genotypic and phenotypic levels. Harvest index exhibited a positive and significant association with grain filling period and spike length and spikelets $spike^{-1}$. Grain yield $plot^{-1}$ was positively and significantly correlated with number of effective tillers m^{-1}, number of spikelets $spike^{-1}$, grains $spike^{-1}$ and 1000-grain weight however, showed significant negative with plant height. Significant genotypic correlation between grain yield and number of effective tillers m^{-1} has also been reported by Usman *et al.* (2006), Lad *et al.* (2003). Yield is a complex polygenic character and is shaped by its correlation with the contributing and causation factors. It has been

Table 5: Grouping of genotypes based on days to maturity

Genotype	Days to maturity	Maturity group	Yield (q ha^{-1})
SKW-355	221.33^{f}	Early	31.11^{b}
HPW-366	225.00^{e}		22.22^{d}
UP-2831	225.33^{e}		31.77^{b}
HPW-367	226.66^{e}		23.03^{d}
VL-949	233.66^{d}	Medium	22.22^{d}
HS-240	233.66^{d}		29.84^{bc}
HPW-363	234.00^{cd}		22.95^{d}
HS-536	234.66^{cd}		22.22^{d}
VL-951	234.66^{cd}		22.22^{d}
HPW-368	234.66^{cd}		36.22^{a}
HD-3101	236.33^{cd}		22.22^{d}
HS-535	236.33^{cd}		24.44^{d}
UP-2830	236.66^{c}		32.88^{ab}
HPW-364	240.33^{b}	Late	29.76^{bc}
VL-953	242.33^{ab}		28.15^{c}
VL-952	242.66^{ab}		22.22^{d}
HS-539	242.66^{ab}		22.95^{d}
HPW-365	243.33^{a}		22.44^{d}
HS-537	243.66^{a}		33.55^{ab}
VL-804	243.66^{a}		31.10^{bc}
HS-538	244.33^{a}		22.22^{d}
VL-954	244.66^{a}		29.17^{bc}
HPW-362	244.66^{a}		25.92^{cd}
VL-950	245.00^{a}		24.48^{d}
HD-3102	245.00^{a}		22.96^{d}
CD (5%)	2.84		3.53

suggested that the number of spikes plot^{-1}, number of grains spike^{-1} and 1000- seed weight are the dimensions of a box whose volume is considered to be grain yield. An increase in one component would result in an increase in the grain yield if there is no reduction in the other components. This might not be true in practice because of the competition for available assimilates which causes the phenomenon of yield component compensation. The genetic principle underlying the correlation among traits is primarily because of genes occupying common linkage group or manifestation of pleiotropic effect of gene in some cases. In the present study it was found that the estimates of genotypic correlation coefficient were higher in magnitude than their corresponding correlation coefficients at phenotypic level and were similar in direction. Higher magnitude of genotypic correlation assures that selection for grain yield improvement may be rewarding and has been previously reported by Singh *et al.* (2002) and Munir *et al.* (2007).

Path coefficient analysis

Association of various plant traits with the trait of major and economic importance like grain yield is the consequence of their direct and indirect effects. Therefore, it becomes imperative to partition such associations into measures of direct and indirect effects of component traits through path coefficient analysis. Cause and effect relationship for various traits was worked out (Table 4). Days to heading showed highest positive direct effect (2.71) towards grain yield plot^{-1} followed by grain filling period (2.23) and 1000-grain weight (0.66). Similarly positive direct values were obtained from plant height (0.08), number of effective tillers m^{-1} (0.39) and harvest index (0.18). The negative direct effect (-1.01) on grain yield was effected by days to maturity. Similarly, a negative direct effect was contributed by number of spikelets spike^{-1} (-0.21), spike length (-0.12) and grains spike^{-1} (-0.54) towards grain yield. Days to heading showed highest positive direct effect (2.71) on grain yield plot^{-1}. The indirect effects of days to heading via plant height, grains spike^{-1} and harvest index were positive with path coefficient values of 0.01, 0.12 and 0.05, respectively while indirect effects via days to maturity, grain filling period, number of effective tillers m^{-1}, number of spikelets spike^{-1}, spike length and 1000-grain weight were negative with a value -0.67, -2.12, -0.03, -0.03, -0.01 and -0.19, respectively. The trait days to maturity had negative direct effect on grain yield plot^{-1} (-1.01) while similar negative values were obtained from indirect effects via grain filling period (-0.88), number of spikelets spike^{-1} (-0.02), 1000-grain weight (-0.03) and harvest index (-0.03); whereas days to heading, plant height, number of effective tillers m^{-1}, spike length, grains spike^{-1} had positive indirect effects on grain yield plot^{-1} with path coefficient values of 1.79, 0.01, 0.06, 0.07 and 0.08, respectively. However, the contribution via days to maturity towards grain yield plot^{-1} was non-significant. Grain filling period exhibited positive direct effect (2.23) towards grain yield plot^{-1}and positive indirect effects through days to maturity, number of effective tillers m^{-1}, number of spikelets spike^{-1}, spike length and 1000-grain weight with the values of 0.40, 0.06, 0.03, 0.01 and 0.24, respectively. Direct effects from plant height towards grain yield was found to be 0.08 with positive indirect effects via days to heading (0.43), number of spikelets spike^{-1} (0.01), grains spike^{-1} (0.07) and harvest index (0.01) while as negative indirect effects were recorded via days to maturity (-0.19), grain filling period (-0.28), number of effective tillers m^{-1} (-0.10), spike length (-0.14) and 1000-grain weight (-0.25) and total contribution towards grain yield plot^{-1} was found to be significant and negative. The number of effective tillers m^{-1} had a positive direct effect (0.39) on grain yield plot^{-1}. Number of spikelets spike^{-1} had negative direct effect on grain yield plot^{-1} with a value of -0.21 and contributed indirectly via days to heading (0.35), number of effective tillers m^{-1} (0.27) and 1000-grain weight (0.98). Spike length also showed negative direct effect on grain yield plot^{-1}(-0.12) and promoted the positive indirect effects through days to heading (0.16), days to maturity (0.12), plant height (0.02), number of effective tillers m^{-1} (0.15), 1000-grain weight (0.28) and harvest index (0.07). Grains spike^{-1} showed negative direct effect (-0.54) towards grain yield plot^{-1}, whereas extended the positive indirect effect via days to maturity (0.15), grain filling period (0.47), number of effective tillers m^{-1} (0.33), 1000-grain weight (1.24) and harvest index (0.03).1000-grain weight had positive direct effect (0.66) towards grain yield plot^{-1}. Harvest index showed positive direct effect on grain yield plot^{-1}(0.18)and promoted the positive indirect effects via days to heading (0.86), days to maturity (0.15), plant height (0.01), number of effective tillers m^{-1} (0.06), 1000-grain weight (0.19). Significant genotypic correlation between grain yield and 1000-grain weight has been reported by and Singh *et al.* (1983). Besides this, the direct effect of 1000-seed weight on grain yield has been observed by Pathak *et al.* (1986). Therefore, because of their high direct effects, the selection criteria for improvement of yield in the present study should be based on the traits effective tillers per plant and 1000-seed weight.

Evaluation of genotypes for earliness

Three genotypes viz. HPW-366, UP-2831 and HPW-367 were early maturing and were recognized as candidates to fit in rice-wheat based cropping system in the valley. Among these UP-2831 yielded significantly higher than both checks SKW-355 and HS-240. The genotype UP-2831 recorded shorter plant height, greater spike length and higher number of spikelets spike^{-1} than the two checks. Late maturing genotypeHS-537 and medium maturing genotypes viz.,HPW-368,UP-2830showed high yield compared to the two checks and therefore, are suitable to be grown as full season varieties in high altitude regions.

REFERENCES

Abinasa, M., Ayana, A. and Bultosa, G. 2011. Genetic variability, heritability and trait associations in durum wheat (*Triticum turgidum* L. var. *durum*) genotypes. *African J. Agricultural Research.* **6(17):** 3972-3979.

Ali, Y., Babar, M. A., Javed, A., Philippe, M. and Zahid, L. 2008. Genetic variability, Association and diversity studies in wheat (*Triticum aestivum* L.) germplasm. *Pakistan J. Botany.* **40(5):** 2087-2097.

Anonymous 2012a. Directorate of Economics and statistics, Department of Agriculture and Cooperation.

Anonymous 2012b. Wheat Profile, Government of India, Department of Agriculture and Cooperation.

Arya, S., Mishra, D. K. and Bornare, S. S. 2013. Screening genetic variability in advance lines for drought tolerance of bread wheat (*Triticum aestivum*) . *The Bioscan.* **8(4):** 1193-1196.

Briggs, F. N. and Knowels, P. F. 1967. Introduction to plant breeding. Reinhold Publishing Corporation New York/ London. pp. 53-61.

Burton, G. W. 1952. Quantitative inheritance of grasses. Proc 6th Int, Grassland Congress. **1:** 277-283.

Burton, G. W. and De Vane, E. H. 1953. Estimating heritability in tall fescue (*Festuca arundinacea*) from replicated clonal material. *Agronomy J.* **45:** 478-481.

Dewey, D. R. and Lu, K. M. 1959. A correlation and path co-efficient analysis of crested wheat grass seed production. *Agronomy J.* **51:** 515-518.

Dharmendra, S. and Singh, K. N. 2010. Variability analysis for yield and yield attributes of bread wheat under salt affected condition. *Wheat Information Service.* **110:** 35-39.

Johnson, H. W., Robinson, H. F. and Comstock, R. E. 1955. Estimates of genetic and environmental variability in soyabean. *Agronomy J.* **47:** 314-318.

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

Kumar, B., Singh, C. M. and Jaiswal, K. K. 2013. Genetic variability, association and diversity studies in bread wheat (*Triticum aestivum L.*).*The Bioscan.* **8(1):** 143-147

Kumar, N., Markar, S. and Kumar, V. 2014. Studies on heritability and genetic advance estimates in timely sown bread wheat (Triticum aestivum L.) *Bioscience Discovery.* **5(1):** 64-69,

Lad, D. B., Bangar N., Bhor, T. J., Mukherkar, G. D. and Biradar, A.B. 2003. Correlation and path coefficient analysis in wheat. *J. Maharashtra Agricultural University.* **28(1):** 23-25.

Laghari, K. A., Sial, M. S., Arain, M. A., Dahot, M. U., Mangrio, M. S. and Pirzada, A. J. 2010. Comparative Performance of Wheat Advance Lines for Yield and its Associated Traits.*World Applied Sciences J.* **8 (Special Issue of Biotechnology and Genetic Engineering):** 34-37.

Majumder, D. A. N., Shamsuddin, A. K. M., Kabir, M. A. and Hassan, L. 2008. Genetic variability, correlated response and path analysis of yield and yield contributing traits of spring wheat. *J. Bangladesh Agriculture University.* **6(2):** 227-234.

Munir, M., Chowdhry, M. A. and Malik, T. A. 2007. Correlation studies among yield and its components in bread wheat under drought conditions. *International J. Agriculture and Biology.* **9(2):** 287-290.

Pathak, N. N., Dema, D. P. and Pillai, P. V. A. 1986. Correlation and path analysis in wheat under high temperature and moisture stress conditions. *Wheat Information Service.* **61/62:** 68-72.

Singh, B. N., Vishwakarma, S. R. and Kumar, S. V. 2010. Character association and path analysis in elite lines of wheat (*Triticum aestivum* L.) *Plant Archives.* **10(2):** 845-847.

Singh, H., Ram Mohan, D. S., Sharma, H. C. and Singh, T. 1983. Correlation and path coefficient analysis among flag leaf area, yield and yield attributes in wheat (*Triticum aestivum* L.). *Cereal Research Communication.* **7(2):** 145-152.

Singh, R. K. and Chaudhary, B. D. 1985. Biometrical methods in quantitative genetic analysis. *Kalyani Publ.*,New Delhi

Singh, S. P. and Dwivedi, V. K. 2002. Genetic divergence in wheat (*Triticum aestivum* L). *New Agriculturist* **13:** 5-7.

Uddin, M. J., Mitra, B., Chowdhry, M. A. Z. and Mitra, B. 1997. Genetic parameters, correlation, path-coefficient and selection indices in wheat. *Bangladesh J. Science and Industrial Research.* **32:** 528-538.

Usman, S., Iihsan, K., Mehmood, T. and Rafique, M. 2006. Phenotypic and genotypic correlation coefficients between yield and yield components in wheat. *J. Agricultural Research.* **44(1):** 1-6.

Vaishnavi, R. 2000. Association among grain yield traits in bread wheat (*Triticum aestivum* L. em. Thell). *SKUAST J. Research.* **2:** 167-170.

Williams, W. 1964. Genetical principles and Plant breeding. *Blackwell Scientific Publication.* Oxford, London.

Wright, S. 1921. Correlation and causation. *J. Agriculture Research.* **20:** 557-85.