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Genetic Variability and Correlation Studies in Winter Wheat (*Triticum aestivum* L.) Germplasm for Morphological and Biochemical Characters

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ABSTRACT

The morphological characterization of the genotypes as per the DUS norms revealed that more than 50% of the genotypes had absence of coleoptile anthocyanin colouration, green foliage colour and awned, intermediate type of growth habit, absence of waxiness and medium pubescence. The genotypes were also evaluated for variability parameters and correlations for seven metric traits. Significant genotypic differences were observed for all the traits studied indicating considerable amount of variation among genotypes for each character. The estimates of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were high for proline content and number of grains per earhead, moderate for earhead length, peduncle length, number of effective tillers per plant and plant height. The heritability estimates were high for all the traits studied. The expected genetic advance as per cent means were high for proline content, number of grains per earhead, earhead length, peduncle length, number of effective tillers per plant and plant height and moderate for total phenols. Plant height exhibited highly significant and positive genotypic and phenotypic correlation with peduncle length, number of effective tillers per plant and non-significant and positive genotypic and phenotypic correlation with total phenols and earhead length.

Key words: *winter wheat, genetic variability, correlation*

INTRODUCTION

Rice-wheat cropping system plays a significant role in food security, contributing 76% to total food grain production of India[1]. Among cereals wheat is the second-most produced crop, occupying 17% (one sixth) of crop acreage worldwide, feeding about 40% of the world population and providing 20% (one fifth) of total food calories and protein to human nutrition[2].

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In India, wheat is second important crop next to rice, with a total production of 93.90 million tonnes, grown over an area of 29.90 million hectares and productivity of 3.14 t/ha [3], whereas, in Jammu and Kashmir it is grown over an area of 0.29 million hectares with productivity of 1.4 t/ha [4].

The study of genetic variability reveals about the presence of variation in their genetic constitution and provides the basis for effective selection[5]. Breeding programs depend on the knowledge of key traits, genetic systems controlling their inheritance and genetic and environmental factors that influence their expression[6,7]. Development of high yielding varieties requires a thorough knowledge of the existing genetic variation for yield and its components. The observed variability is a combined estimate of genetic and environmental causes, of which only the former is heritable. There is a direct relationship between heritability and response to selection, which is referred to as genetic progress. The expected response to selection is also called genetic advance (GA). High genetic advance coupled with high heritability estimates offers the most effective condition for selection[8]. The utility of heritability therefore increases when it is used to calculate genetic advance, which indicates the degree of gain in a character obtained under a particular selection pressure. Thus, genetic advance is yet another important selection parameter that aids breeder in a selection program[9]. Phenotypic and genotypic coefficients of variations, heritability and genetic advance have been used to assess the magnitude of variance in wheat breeding material. Therefore, the present study was carried out to study the genetic variability and character associations on the basis of correlations among the various morphological and biochemical parameters to identity the traits that may be useful in selection.

MATERIALS AND METHODS

The present investigation was carried out at the Research Farm, Division of Plant Breeding and Genetics, Sher-e-Kashmir University of Agricultural Sciences and Technology, Chatha, Jammu. The experimental site is located between $32^0 39'$ N latitude and $74^0 58'$ E longitude and has altitude of 332 m above mean sea level. The experimental material of the study comprised of twenty-five genotypes of wheat. The experiment for recording field observations was laid out in complete randomized block design with three replications. Genotype in each replication was grown in a plot of 3 rows of 2 meter length each with a spacing of 30 cm between rows. In each plot, five random plants were tagged to record the observations. Mean value for the treatment was computed by taking the average. The characters studied and techniques adopted to record the observations are 1) Coleoptile anthocyanin colouration 2) Plant growth habit 3) Foliage colour 4) Flag leaf attitude 5) Waxiness 6) Presence of awns 7) Pubescence 8) Plant height (cm) 9) Effective tillers per plant 10) Earhead length 11) Number of grains per earhead 12) Peduncle length and13) Grain colouration with phenol.

The analysis of variance (ANOVA) for all characters was carried out separately. The genotypic and phenotypic coefficients of variability were computed as per the method suggested by Burton and Devane[10]. GCV and PCV values were categorized as low, moderate and high as indicated by Sivasubramaniam and Menon[11]. The heritability was categorized as low, moderate and high as given by Robinson et al[12].

The extent of genetic advance to be expected from selecting five per cent of the superior progeny was calculated by using the following formula:

Genetic Advance (GA) = $ih^2\sigma_p$

Where,

i = Intensity of selection

h^2 = Heritability in broad sense

σ_p= Phenotypic standard deviation

The value of i was taken as 2.06 assuming 5% selection intensity.

Genetic advance as per cent mean was categorized as low, moderate and high as given by Johnson et al[13].

The correlation at phenotypic and genotypic levels among all the characters was calculated by using the formula suggested by Miller et al[14]. The correlation coefficient (r) is expressed as follows.

$$r(x_1x_2) = \frac{Cov(x_1x_2)}{\sqrt{V(x_1)V(x_1)}} = \frac{\sigma(x_1x_2)}{\sqrt{\sigma(x_1)\sigma(x_2)}}$$

Where,

$r(x_1x_2)$ = correlation between x_1 and x_2

$Cov(x_1x_2)$ = covariance between x_1 and x_1

$V(x_1)$ = variance of one trait (x_1)

$V(x_1)$ = variance of other trait (x_2)

RESULTS AND DISCUSSION

Genetic Variability in morphological and biochemical characters

The analysis of variance for morphological and biochemical characters was carried out to partition the total variance due to genotypes and other sources. Analysis of variance revealed highly significant differences among entries in respect of all the characters studied. The data related to the mean sum of squares of all the characters studied are presented in Table 1, whereas, the data pertaining to mean performance of genotypes for various morphological and biochemical characters are presented in Table 2. Range, mean, phenotypic and genotypic coefficient of variation, heritability estimates and predicted genetic advance as per cent of mean for characters studied are presented in Table 3.

The mean plant height was 91.37 cm with a range of 68.49 cm (Alfrog) to 122.39 cm (WW-23). The PCV (14.77%) and GCV (14.72%) values were moderate. The trait had a high heritability of 99.35% and high expected GAM (30.23%). The peduncle length exhibited a wider variation, which ranged from 19.61 cm (Golden valley) to 40.32 cm (WW-23) with overall mean of 31.36 cm. The trait revealed moderate PCV (16.85%) and GCV (16.54%) values. The heritability recorded was high (96.40%) with high GAM (33.45%) for this trait. Number of estimated productive tillers per plant showed a wide variation, which ranged from 14.60 (WW-12) to 26.87 (Diana NS 720) and mean value for this trait was 21.72. The PCV (16.38%) and GCV (15.79%) were moderate for this trait. The heritability estimate was high (92.97%) with high GAM (31.37%). A range of 7.52 cm (WW-27) to 12.96 cm (Mega) was observed for earhead length with the mean value of 9.51 cm. The moderate PCV and GCV values of 16.84 per cent and 16.55 per cent, respectively, were exhibited for this trait. The heritability observed was 96.54 per cent with high genetic advance of 33.49 as per cent mean for this trait. Number of grains per earhead ranged from 18.13 (Diana NS 720) to 50.98 (WW 26) with a mean of 35.79. High PCV (23.89%) and GCV (23.46%) values were recorded for this trait with high heritability value of (96.39%). Genetic advance as per cent mean was also high (47.44%) for this trait. The proline content of the wheat genotypes ranged from 0.60 µmoles/g of leaf sample (PBW-343) to 2.83 µmoles/g of leaf sample (Mega) with a mean of 1.34 µmoles/g of leaf sample. High PCV (51.77%) and GCV (49.22%) were recorded for this trait. This trait exhibited high heritability value (90.39%) with the high value of genetic advance as per cent mean (96.40%).The total phenol content ranged from 205.58 mg/100g of leaf sample (PBW-343) to 308.14 mg/100g of leaf sample (Mega) with a mean of 249.76 mg/100g of leaf sample. The PCV (9.75%) and GCV (9.73%) were low for this trait. The heritability estimate was high (99.50%) with moderate GAM (19.98%).

Mean squares of plant height, peduncle length, number of effective tillers per plant, earhead length, number of grains per earhead, proline content and total phenols showed highly significant differences between genotypes. Such considerable range of variations provided a good opportunity for yield improvement. The estimates of GCV were high for proline content and number of grains per earhead, moderate for earhead length, peduncle length, number of effective tillers per plant and plant height and low GCV estimates were recorded for total phenols. The PCV values were higher than GCV values for all the traits which reflect the influence of environment on the expression of these traits. The estimates of PCV were high for proline content and number of grains per earhead, moderate for earhead length, peduncle length, number of effective tillers per plant and plant height and low PCV estimates were recorded for total phenols. Similar observations were also reported by Pathak and Nema[15], Pawar et al[16]., Jagashoran[17], Muhammed and Hussain[18], Ali et al[19]., Kahrizi et al[20]., and Abinasa et al[21]. Sharma et al[22]., Rama et al[23]., and Ali et al[19]., reported high GCV and PCV for number of grains per earhead. Pratibha[24] reported moderate GCV but high PCV for peduncle length. Whereas, Dixit and Patil[25] reported high PCV and Sharma et al[22]., reported low GCV and PCV for peduncle length. Kumar et al[26]., and Tsegaye et al[27]., reported moderate GCV and PCV values for number of effective tillers per plant and moderate GCV and PCV values for earhead length were reported by Ali et al[19]., which support the present findings.

High heritability estimates were recorded for all the traits studied. High heritability values for these traits indicated that the variation observed was mainly under genetic control and was less influenced by environment. Singh and Rai[28] and Pal and Garg[29] also noticed higher heritability value for plant height, number of productive tillers per meter length, and number of grains per earhead. Thakur et al[30]., also reported high heritability values for plant height, tillers per meter and spike length. Kamboj et al[31]., reported high heritability values for number of grains per spike. Sachan and Singh[32] (2003) also reported high heritability estimates for number of grains per earhead, plant height and number of tillers per plant which support the present findings.

Heritability and genetic advance are important selection parameters. High heritability accompanied with high genetic advance in case of plant height, number of productive tillers per plant, earhead length and number of grains per earhead, indicates that most likely the heritability is due to additive gene effects and selection may be effective in early generations for these traits. Similar findings have been reported by Sharma and Garg[33] and Dwivedi et al[34]. Kahrizi et al[20]., also reported high genetic advance as per cent of mean for peduncle length.

In the present study, high heritability coupled with moderate genetic advance was observed for total phenols suggesting further improvement of genotypes for the character for further selection and subsequent use in breeding programme.

Distinguishing morphological traits

The distinguishing traits in the winter wheat germplasm exhibited considerable variation (Table 4). Coleoptile anthocyanin colouration of seedlings was found to be present in eight (32%) wheat genotypes and absent in remaining seventeen (68%) genotypes. Three (12%) genotypes were found to have semi-erect type of growth habit, eight (32%) genotypes had semi-prostrate and the remaining fourteen (56%) genotypes had intermediate types of growth habit. The foliage colour of eighteen (72%) genotypes was found to be green, whereas, in the remaining seven (28%) genotypes, it was found to be dark green. None of the genotypes had pale green foliage. Flag leaf attitude varied from drooping (12 genotypes) to erect types (5 genotypes). Considerable variability was also found in terms of their waxiness, with strong waxiness found in two (8%) genotypes, medium in ten (40%) genotypes and absent in rest of the thirteen (52%) genotypes. Most of the genotypes were awned (21 genotypes), while four showed presence of scurs, none were awnless. Strong pubescence was found in four (16 %) genotypes, medium in thirteen (52%) and absent in eight (32%) genotypes. Grain colouration with phenol was found to be very dark in two (8%) genotypes, dark in eight (32%) genotypes, medium in nine (36%) genotypes and light in six (24%) genotypes.

Correlation studies

The genotypic and phenotypic correlation coefficients among different traits in the genotypes of winter wheat were measured in order to determine the extent of association among each component (Table 5). Generally, the genotypic correlation coefficients were higher than the respective phenotypic correlation coefficients indicating the involvement of genetic factors more than the environmental ones.

Plant height exhibited highly significant and positive genotypic and phenotypic correlation with peduncle length (0.796^{**}, 0.783^{**}), number of effective tillers per plant (0.783^{**}, 0.397^{**}); significant and positive correlation with proline content (0.268^{*}, 0.246^{*}). Highly significant and negative genotypic and phenotypic correlation was observed with number of grains per earhead (-0.383^{**}, -0.374^{**}) while non-significant and positive genotypic and phenotypic correlation was observed with total phenols (0.220^{NS}, 0.218^{NS}) and earhead length (0.205^{NS}, 0.204^{NS}), respectively. Peduncle length exerted highly significant and positive correlation with number of effective tillers per plant (0.507^{**}, 0.471^{**}), proline content (0.492^{**}, 0.440^{**}) and total phenols (0.513^{**}, 0.501^{**}), highly significant and negative genotypic and phenotypic correlation with number of grains per earhead (-0.353^{**}, -0.336^{**}) and significant and positive genotypic correlation but non-significant and positive phenotypic correlation with earhead length (0.225^{*}, 0.218^{NS}). Number of effective tillers per plant showed significant and positive genotypic and phenotypic correlation, respectively, with proline content (0.265^{*}, 0.274^{*}), non-significant and positive correlation with earhead length (0.149^{NS}, 0.130^{NS}) and total phenols (0.143^{NS}, 0.139^{NS}) and non-significant and negative genotypic and phenotypic correlations with number of grains per earhead (-0.057^{NS}, -0.063^{NS}). There was a highly significant and positive genotypic and phenotypic correlation of earhead length with number of grains per earhead (0.430^{**}, 0.416^{**}) and non-significant and positive correlations with proline content (0.129^{NS}, 0.103^{NS}) and total phenols (0.048^{NS}, 0.047^{NS}). Number of grains per earhead showed significant and negative genotypic and phenotypic correlation with total phenols (-0.253^{*}, -0.246^{*}) and non-significant and negative correlation with proline content (-0.133^{NS}, -0.122^{NS}). The proline content exerted highly significant and positive genotypic and phenotypic correlation with total phenols (0.918^{**}, 0.870^{**}).

Genotypic correlation coefficient values were higher than the phenotypic values, indicating strong intrinsic associations were masked at phenotypic level to some extent due to environmental effects. Plant height exhibited highly significant positive correlations with peduncle length, number of effective tillers per plant. These results were in confirmation with the Aghaee et al[35]., and Maqbool et al[36]., who reported highly significant positive correlations of pant height with peduncle length and number of effective tillers per plant, respectively. Plant height exhibited non-significant positive correlations with earhead length. This was supported by work of Aghaee et al[35]., and Ali et al[19]., who found non-significant positive genotypic and phenotypic correlations of plant height with earhead length. Plant height exhibited highly significant negative genotypic and phenotypic correlations with number of grains per earhead. This was supported by work of Ali et al[19]. and Aghaee et al[35]., who found highly significant and significant negative genotypic and phenotypic correlations of plant height with number of grains per earhead, respectively. Number of effective tillers per plant showed non-significant and positive correlation with earhead length and non-significant and negative genotypic and phenotypic correlations with number of grains per earhead. Similar results were reported by Aghaee et al[35]. Earhead length exhibited highly significant positive correlations with number of grains per earhead. Ali et al[19]., Khaliq et al[37]., and Ahmad et al[38]., also found the similar results.

Table 1: Mean sum of squares for various characters in wheat genotypes

S. No.	Character	RMSS	GMSS	EMSS
1	Plant height (cm)	69.99	544.19**	1.18
2	Peduncle length (cm)	72.54	81.71**	1.01
3	Number of effective tillers per plant	52.50	36.18**	0.89
4	Earhead length (cm)	2.85	7.53**	0.09
5	Number of grains per earhead	47.28	214.11**	2.64
6	Proline content (µmoles/g of leaf sample)	1.24	1.35**	0.05
7	Total phenol content (mg/100g of leaf sample)	678.70	1773.01**	2.98

* and **Significant at 5% and 1% levels of significance, respectively.
RMSS = mean sum of squares due to replication,
GMSS = mean sum of squares due to genotypes and
EMSS = mean sum of squares due to error

Table 2: Mean performance for morphological and biochemical traits in wheat genotypes

S. No.	Germplasm	Plant height (cm)	Peduncle length (cm)	No. of effective tillers/plant	Earhead length (cm)	No. of grains/ earhead	Proline content (µmoles/g of leaf sample)	Total phenols (mg/100g of leaf sample)
1	Alfrog	68.49	27.03	24.07	10.17	43.87	0.67	232.18
2	Arkan	96.27	33.89	23.33	9.48	29.73	0.75	229.08
3	Beserka	81.85	30.04	16.87	7.74	36.00	1.17	249.38
4	Blue boy	103.91	37.40	25.47	11.81	38.40	1.85	258.86
5	Bolal	78.49	31.60	18.93	9.72	37.60	2.39	298.24
6	Centruck	108.53	37.33	26.40	11.03	32.73	0.82	243.04
7	China 84-40022	106.05	35.32	24.93	7.60	26.07	2.05	264.32
8	Drina	96.43	34.67	20.93	7.93	26.27	2.10	291.34
9	Drina NS 720	89.06	32.22	26.87	7.61	18.13	2.06	272.42
10	Golden valley	79.81	19.61	16.27	8.37	26.60	0.81	238.68
11	Joss Cambier	83.33	32.78	22.87	8.07	40.73	1.99	261.06
12	Mega	98.84	36.64	21.87	12.96	36.20	2.83	308.14
13	Nord Desprez	102.42	31.23	14.80	9.73	35.05	0.96	243.42
14	Saptadhara	100.42	32.89	23.60	12.62	47.07	2.31	252.76
15	Vir-45347	95.40	35.90	22.13	9.40	29.60	0.75	236.96
16	WW- 7	91.44	31.28	22.00	7.54	29.33	0.88	238.32
17	WW-12	76.54	30.53	14.60	10.57	34.82	0.71	234.80
18	WW-21	109.99	37.35	26.33	9.87	37.80	1.30	250.96
19	WW-23	122.39	40.32	23.47	8.89	22.20	1.55	254.24
20	WW-24	92.98	30.15	22.80	11.39	45.33	0.88	238.92
21	WW-25	75.17	26.40	21.87	9.28	45.28	1.11	249.66
22	WW-26	92.69	27.20	20.87	9.65	50.98	0.69	220.98
23	WW-27	76.83	27.25	21.40	7.52	47.00	1.61	257.18
24	Agra local	82.73	22.90	17.70	8.73	35.05	0.65	213.52
25	PBW-343	74.20	22.01	22.57	10.22	42.86	0.60	205.58
	CD	1.786	1.646	1.548	0.489	2.669	0.353	2.833
	S.E(m)	0.628	0.579	0.544	0.172	0.939	0.124	0.996

CD= Critical difference, S.E(m)= Standard error of mean

Table 3: Genetic variability parameters in winter wheat genotypes

S. No.	Characters	Mean±S.E(m)	Range		GCV	PCV	h^2 (%)	GAM (%)
			Min.	Max.				
1	Plant height (cm)	91.37±0.628	68.49	122.39	14.72	14.77	99.35	30.23
2	Peduncle length (cm)	31.36±0.579	19.61	40.32	16.54	16.85	96.40	33.45
3	Number of effective tillers per plant	21.72±0.544	14.60	26.87	15.79	16.38	92.97	31.37
4	Earhead length (cm)	9.51±0.172	7.52	12.96	16.55	16.84	96.54	33.49
5	Number of grains per earhead	35.79±0.939	18.13	50.98	23.46	23.89	96.39	47.44
6	Proline content (µmoles/g of leaf sample)	1.34±0.124	0.60	2.83	49.22	51.77	90.39	96.40
7	Total phenol (mg/100g of leaf sample)	249.76±0.996	205.58	308.14	9.73	9.75	99.50	19.98

h^2= heritability in broad sense, GCV = Genotypic Coefficient of Variation, PCV= Phenotypic Coefficient of Variation, GAM = Genetic Advance over mean, Min.= minimum, Max.= maximum, S.E(m)= Standard error of mean.

Table 4: Mean value of different distinguishing morphological traits in wheat genotypes

S. No.	Germplasm	Anthocyanin colouration	Plant growth habit	Foliage colour	Flagleaf attitude	Waxiness	Presence of awns/scurs	Pubescence	Grain colouration with phenol
1	Alfrog	absent	semi-erect	green	semi-erect	medium	awned	medium	medium
2	Arkan	present	intermediate	dark green	drooping	absent	awned	absent	medium
3	Beserka	absent	intermediate	dark green	erect	absent	awned	absent	light
4	Blue boy	absent	intermediate	green	semi-erect	medium	awned	medium	medium
5	Bolal	present	intermediate	green	drooping	absent	scurs	absent	dark
6	Centruck	absent	intermediate	green	semi-erect	medium	scurs	medium	dark
7	China 84-40022	absent	intermediate	green	drooping	medium	awned	absent	very dark
8	Drina	present	semi-prostrate	green	semi-erect	medium	scurs	strong	medium
9	Drina NS 720	absent	intermediate	green	drooping	medium	scurs	medium	medium
10	Golden valley	absent	semi-prostrate	dark green	erect	absent	awned	medium	dark
11	Joss Cambier	absent	intermediate	green	erect	absent	scurs	strong	light
12	Mega	absent	intermediate	green	drooping	absent	awned	absent	light
13	Nord Desprez	present	semi-prostrate	green	semi-erect	absent	awned	strong	dark
14	Saptadhara	absent	intermediate	green	drooping	absent	awned	medium	light
15	Vir-45347	present	semi-prostrate	dark green	drooping	medium	awned	medium	medium
16	WW- 7	absent	semi-prostrate	green	semi-erect	strong	awned	medium	medium
17	WW-12	absent	intermediate	dark green	semi-erect	absent	awned	absent	medium
18	WW-21	absent	intermediate	green	drooping	medium	awned	medium	very dark
19	WW-23	present	semi-erect	green	drooping	medium	awned	medium	dark
20	WW-24	absent	semi-prostrate	green	drooping	medium	awned	strong	dark
21	WW-25	absent	intermediate	green	semi-erect	strong	awned	medium	medium
22	WW-26	present	semi-prostrate	green	drooping	absent	awned	medium	light
23	WW-27	absent	semi-prostrate	dark green	erect	absent	awned	absent	light
24	Agra local	present	intermediate	green	drooping	absent	awned	medium	dark
25	PBW-343	absent	semi-erect	dark green	erect	absent	awned	absent	dark

Table 5 Genotypic (r_g) and phenotypic (r_p) correlation coefficients among different traits in wheat genotypes

Character		Plant height (cm)	Peduncle length (cm)	No. of effective tillers/plant	Earhead length (cm)	No. of grains per earhead	Proline content (µmoles/g of leaf sample)	Total phenols (mg/100g of leaf sample)
Plant height (cm)	r_g	1						
	r_p	1						
Peduncle length (cm)	r_g	0.796**	1					
	r_p	0.783**	1					
No. of effective tillers per plant	r_g	0.417**	0.507**	1				
	r_p	0.397**	0.471**	1				
Earhead length (cm)	r_g	0.205NS	0.225*	0.149NS	1			
	r_p	0.204NS	0.218NS	0.130NS	1			
No. of grains per earhead	r_g	-0.383**	-0.353**	-0.057NS	0.430**	1		
	r_p	-0.374**	-0.336**	-0.063NS	0.416**	1		
Proline content (µmoles/g of leaf sample)	r_g	0.268*	0.492**	0.265*	0.129NS	-0.133NS	1	
	r_p	0.246*	0.440**	0.274*	0.103NS	-0.122NS	1	
Total phenols (mg/100g of leaf sample)	r_g	0.220NS	0.513**	0.143NS	0.048NS	-0.253*	0.918**	1
	r_p	0.218NS	0.501**	0.139NS	0.047NS	-0.246*	0.870**	1

NS= non-significant, *and **Significant at 5% and 1% levels of significance, respectively, r_g=genotypic correlation coefficient and r_p=phenotypic correlation coefficient

CONCLUSION

Correlation studies provide information on the nature and extent of association between any two pairs of metric traits. Thus, it could be possible to bring about genetic upgradation in one trait by selection of the other trait. High heritability accompanied with high genetic advance as per cent means were observed in all the characters, indicating that most likely the heritability is due to additive gene effects and selection may be effective in early generations for these traits. The genotypes showed diversity at phenotypic level and some of them also showed suitable agronomic performance and can be used to broaden the genetic base of breeding programmes.

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REFERENCES

1. Gangola, P., Singh, R., Bhardwaj, A. K. and Gautam, P., Effect of moong straw on soil properties under INM in long-term rice-wheat cropping system in a Mollisol., *Int Journal of Agric, Environ and Biotechnol.*, **5(3):** 281-286 (2012).
2. Sharma, P., Imran, Sharma, P., Chugh, V., Dhaliwal, H. S. and Singh, D., Morphological, Cytological and Biochemical Characterization of wheat *Aegilops Longissima* Derivatives BC_1F_6 and BC_2F_4 with High Grain Micronutrient., *Int Journal of Agric, Environ and Biotechnol.*, **7(2):** 191-204 (2014).
3. Anonymous., Directorate of Economics and Statistics, Department of Agriculture and Cooperation., (2012).
4. Anonymous., Wheat profile, Government of India, Department of Agriculture and Cooperation., (2012).

5. Kumar, B., Singh, C. M. and Jaiswal, K. K., Genetic variability, association and diversity studies in bread wheat (*Triticum aestivum* L.)., *The Bioscan.*, **8(1):** 143-147 (2013).
6. Kahrizi, D. and Mohammadi, R., Study of Androgenesis and Spontaneous Chromosome Doubling in Barley (*Hordeum vulgare* L.) genotypes using Isolated Microspore Culture. *Acta Agron*., **57(2):** 155-164 (2009).
7. Mohammadi, R., Armion, M., Kahrizi, D. and Amri, A., Efficiency of screening techniques for evaluating durum wheat genotypes under mild drought conditions. *Int. Journal of Plant Prod*., **4(1):** 11-24 (2010).
8. Larik, A. S., Malik, S. I., Kakar, A. A. and Naz, M. A., Assessment of heritability and genetic advance for yield and yield components in *Gossypium hirsutum* L., *Sci. Khyber*, **13:** 39-44 (2000).
9. Shukla, S., Bhargava, A., Chatterjee, A. and Singh, S. P., Estimates of genetic parameters to determine variability for foliage yield and its different quantitative and qualitative traits in vegetable amaranth (*A. tricolor*). *Journal of Genet. and Breed*., **58:** 169-176 (2004).
10. Burton, G. W. and Dewane, E. H., Estimating heritability in tall Fescues (*Festuca allamidiaceae*) from replicated clonal material. *Agron. Journal*., **45:** 1476-1481 (1953).
11. Sivasubramaniam, S. and Menon, M., Heterosis and inbreeding depression in rice., *Madras Agric. Journal*., **60:** 1139 (1973).
12. Robinson, H. F., Comstock, R. E. and Harvey, P. H., Genotypic and phenotypic correlation's in corn and their implications in selection., *Agron. Journal*., **43:** 282-287 (1949).
13. Johnson, H. W., Robinson, H. F. and Comstock, R. E., Estimates of genetic and environmental variability in soybean., *Agron. Journal*., **47:** 314-318 (1955).
14. Miller, P. A., Williams, J. C., Robinson, H. F. and Comstock, R. I., Estimates of genotypic and environmental variance and co-variance in upland cotton and their implication in selection., *Agron. Journal*. **50:** 126-131 (1958).
15. Pathak, N. N. and Nema, D. P., Genetic advance in land races of wheat. *Indian Journal of Agric. Sci*., **55:** 478-479 (1985).
16. Pawar, S. D., Thete, R. Y. and Dumbre, A. D., Estimates of genetic variability parameters in F_2 population of wheat., *Journal of Maharashtra Agric. Univer*., **13:** 210-211 (1988).
17. Jagshoran., Estimation of variability parameters and path coefficient for some quantitative characters in hill wheat., *Madras Agric. Journal*., **82:** 441-444 (1995).
18. Muhammed, B. and Hussain, S., Genetic variability and correlation studies in foxtail millet (*Setaria italica*)., *Crop Resea*., **28(1, 2 & 3):** 94-97 (2004).
19. Ali, Y., Atta, B. M., Akhter, J., Monneveux, P. and Lateef, Z., Genetic variability, association and diversity studies in wheat (*Triticum aestivum* L.) germplasm., *Pak. Journal of Bot*., **40(5):** 2087-2097 (2008).
20. Kahrizi, D., Cheghamirza, K., Kakaei, M., Mohammadi, R. and Ebadi, A., Heritability and genetic gain of some morpho-physiological variables of durum wheat (*Triticum turgidum* var. *durum*)., *Afric. Journal of Biotechnol*., **9(30):** 4687-4691 (2010).
21. Abinasa, M., Ayana, A. and Bultosa, G., Genetic variability, heritability and trait associations in durum wheat (*Triticum turgidum* L. var. *durum*) genotypes., *Afric. Journal of Agric. Resea*., **6(17):** 3972-3979 (2011).
22. Sharma, P. K., Gupta, P. K. and Balyan, M. S., Genetic diversity in a large collection of wheats (*Triticum* spp.)., *Indian Journal of Genet. Plant Breed*., **58(3):** 271-278 (1998).
23. Rama, U., Sharma, S. C. and Sethi, G. S., Comparative estimates of genetic variation in wheat under normal and drought stress

conditions., *Journal of Hill Resea*., **12:** 92-94 (1999).
24. Pratibha, K., Genetic studies on variability, free threshability and cluster association in the advanced breeding lines of dicoccum wheat (*Triticum dicoccum* Schrank)., *M. Sc. (Agri.) Thesis*, University of Agricultural Sciences, Dharwad., (2005).
25. Dixit, R. N. and Patil, V. P., Variability and heritability studies in wheat., *J of Maharashtra Agric Univers*., **8:** 170-172 (1983).
26. Kumar, S., Singh, D. and Dhivedi, V. K., Analysis of yield components and their association in wheat for architecturing the desirable plant type., Indian Journal of Agric. Resea., **44(4):** 267-273 (2010).
27. Tsegaye, D., Dessalegn, T., Dessalegn, Y. and Share, G. Genetic variability, correlation and path analysis in durum wheat germplasm (*Triticum durum* Desf)., *Agric. Resea. Review*., **1(4):** 107-112 (2012).
28. Singh, R. P. and Rai, A. K., Genetics of quantitative traits in bread wheat., *Madras Agric. Journal*., **74:** 11-14 (1987).
29. Pal, B. and Garg, D. K., Estimation of genetic parameters in three wheat crosses., Crop Improvement., **19:** 149-151 (1992).
30. Thakur, S. K., Pandey, R. L. and Kandarlkar, U. S., Genetic association and variability of grain yield and other quantitative characters in F_2 population of wheat crosses., *Advances in Plant Sci*., **12:** 237-239 (1999).
31. Kamboj, M. C., Naveen, C., Subhandra, Yadav, R. K. and Chaundra, N., Genetic analysis of yield and its components in bread wheat (*Triticum aestivum* L.)., *Atlas Agri-Bio-Res*. **5(1):** 41-43 (2000).
32. Sachan, M. S. and Singh, S. P., Genetics of yield and its components in durum wheat (*Triticum durum* Desf.)., *Journal Interacademicia*., **7(2):** 140-143 (2003).
33. Sharma, A. K. and Garg, D. K., Genetic variability in wheat (*Triticum aestivum* L.) crosses under different normal and saline environments., *Annals of Agric. Resea*., **23(3):** 497-499 (2002).
34. Dwivedi, A. N., Pawar, I. S., Shashi, M. and Madan, S., Studies on variability parameters and character association among yield and quality attributing traits in wheat., *Haryana Agric Uni Journal of Resea*., **32(2):** 77-80 (2002).
35. Aghaee, M., Mohammadi, R. and Nabovati, S., Agro-morphological characterization of durum wheat accessions using pattern analysis., *Australian Journal of Crop Sci*., **4(7):** 505-514 (2010).
36. Maqbool, R., Sajjad, M., Khaliq, I., Rehman, A. U., Khan, A. S. and Khan, S. H., *American-European Journal of Agric., Environ. and Sci*., **8(2):** 216-224 (2010).
37. Khaliq, I., Parveen, N. and Chowdhry, M. A., Correlation and path coefficient analysis in bread wheat., *Int. Journal of Agric and Biol*., **6(4):** 633-635 (2004).
38. Ahmad, B., Khalil, I. H., Iqbal, M. and Rahman, H. U., Genotypic and phenotypic correlation among yield components in bread wheat under normal and late plantings., *Sarhad Journal of Agric.*, **26(2):** 259-265 (2010).