Int.J.Curr.Microbiol.App.Sci (2019) *8*(8): 1408-1416

International Journal of Current Microbiology and Applied Sciences
***ISSN: 2319-7706* Volume 8 Number 08 (2019)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2019.808.164

Studies on Genetic Variability, Heritability, Genetic Advance, Correlation and Path Analysis for Grain Yield and its Contributing Traits in Indigenous Wheat (*Triticum aestivum* L.)

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Keywords

Wheat, (*Triticum aestivum* L), variability, h^2, Correlation and path analysis

Article Info

Accepted:
12 July 2019
Available Online:
10 August 2019

A B S T R A C T

The present investigation was carried out with twenty (with two checks) indigenous genotypes of wheat to study the variability, heritability and genetic advance. The field experiment was conducted under timely sown condition during *Rabi* 2017-18 in randomized block design with three replication at Nidhariya Agriculture farm S.M.M. TOWN P.G. College Ballia, U.P. The data were recorded on twelve characters *viz*. days to 50% flowering, tillers per plant, flag leaf area, plant height, ear length, days to maturity, biological yield, ear weight, number of grains per ear, harvest index, test weight and grain yield per plant. Analysis of variance revealed that the treatments differed significant for all the characters under study except tillers per plant, ear length per plant and ear weight per plant which indicated the material to be of different genetic constitution. The highest values for GCV & PCV were recorded for the character biological yield per plant and grain yield per plant. High heritability along with high genetic advance was obtained for plant height, flag leaf area, biological yield and test weight indicating that traits were under additive gene control and selection for genetic improvement for these traits would be effective. The data showed that the grain yield had significant and positive association with days to 50% flowering (0.423), tillers per plant (0.3039), flag leaf area (0.3252), plant height (0.3450), ear length (0.3891), biological yield per plant (0.6292), ear weight (0.6420), harvest index (0.40040 and test weight (0.5527). Path coefficient analysis revealed that biological yield per plant (0.5356) had the highest positive direct effect on grain yield per plant followed by harvest index (0.3289). The results revealed that these traits may serve as effective selection attribute during selection in breeding program for yield improvement in wheat.

Introduction

Wheat (*Triticum aestivum* L. 2n=42), a self-pollinated crop of the Gramineae family and genus *Triticum*, is the world's largest famous energy rich cereal crop. Wheat is the second most important cereal staple food crop consumed nearly 35% of world population and provides 20% food calories. India is the second largest wheat growing country of the world after the China. The world acreage under wheat crop during 2017 – 2018 was 229.67 million hectare with production of 759.75 million tones with an average yield of

33.08 quintal / hectare. In India, the total area for wheat crop during 2017 – 2018 was 31.68 million hectare with production of 97.11 million tones and average productivity was 30.66 quintal / hectare. Uttar Pradesh ranked first with an area of 9878 hectare with the production of 30 million tones with average productivity of 30.76 quintal / hectare. The productivity of wheat in other state is comparatively lower than that of Punjab and Haryana. In Ballia district during 2017 – 2018 total wheat cultivated area 137.665 thousand hectare and production 542.431 thousand metric ton and productivity 39.40 q/ha. Grain yield is a complex trait and highly influenced by the action and interactions of various component characters (Grafius, 1960). Correlation coefficient measures the degree of mutual association between two variables without employing any cause and effect relationship. All possible correlation coefficient among 12 characters were calculated at genotypic and phenotypic level following the procedure of Searle (1961) Path coefficient is simply a standardized partial regression coefficient and such measure the direct influence on variable upon another and permitted the correlation coefficient in to component of direct and indirect effects (Wright 1921). The concept of path analysis was later on elaborated by Dewey and Lu (1959).

Materials and Methods

The experiment of present investigation was conducted to evaluate the twenty wheat germplasm lines including two checks (namelyPBW-343 and PBW-502) in Randomized Block Design with three replication at Agricultural Research Farm, Nidharia, S.M.M. Town Post Graduate College, Ballia (U.P.). These genotypes exhibited wide spectrum of variation for various agronomical and morphological characters. Each genotype was sown in 3 meters length, row to row spaced 30cm and intra row spacing of 5cm all recommended cultural practices and plant protection measures were applied to raise to healthy crop.

The data were recorded on twelve quantitative traits namely days to 50% flowering, flag leaf area (cm^2), plant height (cm), ear length (cm), tillers per plant, days to maturity, ear weight per plant (g), number of grain per ear, biological yield (g), harvest index (%), test weight (g) and grain yield/plant (g). From five randomly selected plants and days to 50% flowering and days to maturity were recorded on plot basis and all data were analyzed by standard statistical method.

Results and Discussion

The analysis of variance revealed significant differences among the treatment for all the characters except tillers per plant, ear length and ear weight. Therefore these characters are not considerable for any further breeding programmes (Table 1).

The success of selection in improving plant characters depends mainly on presence of substantial genetic variability and nature of heritability and gene action. The genetic variability is the raw material of plant breeding programme on which selection acts to evolve superior genotypes. The phenotypic and genotypic coefficients of variation can be used for assessing and comparing the nature and magnitude of variability existing for different characters in the breeding materials. Heritability in broad sense quantifies the proportion of heritable genetic variance to total phenotypic variance. Estimates of heritability help in estimating expected progress through selection. The genetic advance in per cent of mean provides indication of expected selection response by taking into account the existing genetic variability and heritability of the character.

Table.1 Analysis of variance of randomized block design (RBD) for 11 characters in wheat genotypes

Sr. no.	Characters	Source of Variation		
		Replication d.f.2	**Treatments 19**	**Error 38**
1	Days to 50% Flowering	1.71	5.79*	0.82
2	Tillers/ Plant	0.71	1.88	0.36
3	Flag Leaf Area (cm)2	2.0	37.16*	0.89
4	Plants Height (cm)	1.32	95.32*	0.26
5	Ear of Length/Plant (cm)	1.40	1.95	0.16
6	Days to Maturity	0.60	4.78*	1.41
7	Biological Yield/Plant (g)	3.32	51.38*	1.37
8	Ear of Weight/ Plant (g	0.05	1.99	0.35
9	No of Grains/Ear	4.21	97.82	4.86
10	Harvest Index (%)	46.11	90.85*	13.79
11	Test Weight (g)	0.68	46.71*	1.23
	Grain Yield/ Plant (g)	1.76	5.13	0.47

*, ** = Significant at 5% and 1% probability level

Table.2 Mean, range and other genetic parameters in wheat

Sr. no	Characters	Mean	Range	GCV	PCV	ECV	h^2 Broad sense %	Genetic Advance	Genetic Advance as % of Mean
1	Days to 50% Flowering	68.43	65.66 - 71.0	1.88	2.3	1.32	0.67	2.17	3.17
2	Tillers/Plant	7.38	5.85 - 8.79	9.63	12.62	8.16	0.58	1.12	15.14
3	Flag Leaf Area (cm)2	23.11	17.75 – 32.53	15.04	15.59	4.09	0.93	6.91	29.9
4	Plants Height (cm)	68.82	62.68 – 84.40	8.18	8.21	0.75	0.99	11.55	16.78
5	Ear of Length/Plant (cm)	9.24	8.16 – 10.83	8.35	9.43	4.37	0.79	1.41	15.25
6	Days to Maturity	109.11	106.0 – 111.66	0.97	1.46	1.09	0.44	1.45	1.33
7	Biological Yield/Plant (g)	22.35	16.22 – 30.78	18.26	19.0	5.25	0.92	8.08	36.16
8	Ear of Weight/Plant (g)	6.92	5.20 – 8.59	10.69	13.71	8.59	0.61	1.19	17.16
9	No of Grains/Ear	41.86	33.41 – 56.6	13.3	14.3	5.27	0.86	10.66	25.47
10	Harvest Index (%)	36.13	27.66 – 51.03	14.03	17.39	10.28	0.65	8.42	23.31
11	Test Weight (g)	23.60	18.26 – 32.24	16.49	17.15	4.7	0.92	7.71	32.68
12	Grain Yield/Plant (g)	7.96	5.13 –9.86	15.65	17.87	8.62	0.77	2.25	28.25

Table.2.1 Mean value of various plant characters in wheat (*Triticum aestivum* L.)

No	Character	Days to 50% Flowering	Tillers/Plant	Flag Leaf Area (cm)2	Plants Height (cm)	Ear of Length/Plant (cm)	Days to Maturity	Biological Yield/Plant (g)	Ear of Weight/Plant (g)	No of Grains/Ear	Harvest Index (%)	Test Weight (g)	Grain Yield/Plant (g)
1	HD-2329	67.6667	6.8533	23.9300	67.0467	9.2333	109.6667	16.2333	6.1800	46.3333	42.5567	18.5600	6.9100
2	K-0307	67.0000	6.8867	26.0867	78.4733	10.5000	108.6667	30.7867	7.5367	43.6500	30.9567	26.1933	9.5067
3	HUW-234	65.6667	5.8533	17.7567	69.6233	8.1667	110.6666	19.5800	6.4400	40.4000	33.2400	21.1200	6.5100
4	HD-2733	70.3333	7.4067	21.6000	62.6867	8.4333	109.3333	22.7467	7.4067	33.4167	30.7800	22.4400	6.9133
5	DBW-14	67.3333	6.9333	19.0700	63.4433	8.7667	109.6666	18.1533	6.4600	39.0000	38.4100	23.6267	6.9333
6	HD-2643	68.3333	8.0067	24.5567	69.6367	8.5667	109.3334	23.8467	7.0133	38.8667	35.7400	28.5733	8.4633
7	KRL-213	70.3333	6.3333	24.3500	63.0567	9.1333	109.6667	25.7067	7.6833	56.6000	36.1367	19.4133	9.2900
8	ND-1014	68.6667	8.0667	24.0333	74.1767	8.6667	109.0000	22.5333	6.7100	36.0000	36.4667	23.2800	8.2300
9	UP-2338	68.0000	7.0667	23.3500	67.5000	9.4333	111.6666	19.3733	6.1200	50.1000	32.8467	19.5733	6.3633
10	K-9107	68.6667	7.7333	32.5333	84.4067	10.3000	109.6666	24.7000	7.9067	38.4000	35.9400	32.2400	8.8633
11	HP-2733	70.3333	8.6000	21.4167	67.5000	8.4000	109.0000	26.7733	6.7800	34.4667	31.9500	26.7200	8.5533
12	UP-262	68.6667	7.8000	20.0067	69.8100	10.8333	107.6666	23.1000	7.1633	37.6833	38.4300	27.0133	8.8200
13	MAHIK GOL	67.6667	7.1333	29.6333	68.2333	10.8333	108.0000	22.4000	8.5933	39.8333	40.7800	27.8933	9.0967
14	NW-5054	68.0000	8.5867	20.3767	73.7400	9.0333	110.0000	28.9400	7.4933	41.4500	30.8233	25.7533	8.9100
15	HD-2307	67.3333	7.8000	23.3867	65.4067	9.5667	107.6666	19.4733	5.2033	41.5333	30.6700	19.2800	5.9633
16	RAJ-3765	67.6667	6.2667	21.3133	64.7667	8.5000	109.6667	18.5133	5.4900	39.1667	27.6633	18.9067	5.1333
17	NW-2036	67.3333	8.7667	19.9567	73.0167	9.1667	106.0000	20.3867	7.4700	47.1333	40.0367	22.2400	8.1700
18	HP-1761	70.3333	7.0667	24.6933	63.6267	8.9333	107.6667	16.2200	6.9000	49.3500	51.0300	18.2667	8.3000
1	PBW-343	71.0000	7.4667	23.7500	66.9700	9.5667	110.3334	27.7667	7.3467	43.7333	35.5200	25.2800	9.8633
2	PBW-502	68.3333	7.1333	20.5467	63.3800	8.9000	109.0000	19.8667	6.5933	40.0867	42.6433	25.7867	8.4500

Table.3 Genotypic and penotyic correlation coefficient for 12 characters in wheat (*Triticum aestivum* L.)

R	Character	Days to 50% Flowering	Tillers /Plant		Flag Leaf Area (cm)2	Plants Height (cm)		Ear of Length/Plant (cm)		Days to Maturity		Biological Yield/Plant (g)		Ear of Weight/Plant (g)		No of Grains/Ear		Harvest Index (%)		Test Weight (g)		Grain Yield/Plant (g)	
	Days to 50% Flowering	**r(g)**	0.2765		0.2209	-0.3001		-0.0578		0.0894		0.3019		0.3210		0.0655		0.1419		0.0883		0.4349	
		r(p)	**0.1717**		**0.1441**	**-0.2529**	*	**-0.1149**		**-0.0560**		**0.2383**		**0.2394**		**0.0722**		**0.2110**		**0.0176**		**0.423**	**
	Tillers/Plant		r(g)		-0.0006	0.3879		0.0488		-0.6629		0.3862		0.2755		-0.3759		-0.0551		0.5110		0.3826	
			r(p)		**0.0569**	**0.3068**	*	**0.1067**		**-0.1947**		**0.2897**	*	**0.1571**		**-0.2424**		**0.0111**		**0.3495**	**	**0.3039**	*
	Flag Leaf Area (cm)2				r(g)	0.4794		0.5803		-0.0652		0.2350		0.5155		0.0947		0.1743		0.4063		0.4179	
					r(p)	**0.4665**	**	**0.5510**	**	**0.0058**		**0.2255**		**0.3867**	**	**0.1091**		**0.1055**		**0.3872**	**	**0.3252**	*
	Plants Height (cm)					r(g)		0.4443		-0.0783		0.4881		0.4334		-0.1775		-0.1880		0.6083		0.4012	
						r(p)		**0.4084**	**	**-0.0277**		**0.4687**	**	**0.3474**	**	**-0.1473**		**-0.1587**		**0.5838**	**	**0.3450**	**
	Ear of Length/Plant (cm)							r(g)		-0.4112		0.3093		0.4831		0.1195		0.1509		0.4277		0.4971	
								r(p)		**-0.1606**		**0.2615**	*	**0.4308**	**	**0.1211**		**0.1274**		**0.4057**	**	**0.3891**	**
	Days to Maturity									r(g)		0.1054		-0.3009		0.0077		-0.4316		-0.0773		-0.2127	
										r(p)		**0.1052**		**-0.0776**		**0.0939**		**-0.3551**	**	**-0.0354**		**-0.1962**	
	Biological Yield/Plant (g)											r(g)		0.6491		-0.1341		-0.4745		0.6100		0.7480	
												r(p)		**0.4586**	**	**-0.1165**		**-0.4450**	**	**0.5692**	**	**0.6292**	**
	Ear of Weight/Plant (g)													r(g)		-0.0008		0.2478		0.6685		0.9309	
														r(p)		**0.0798**		**0.1900**		**0.5308**	**	**0.6420**	**
	No of Grains/Ear															r(g)		0.3567		-0.5397		0.1202	
																r(p)		**0.2767**	*	**-0.4877**	**	**0.1034**	
	Harvest Index (%)																	r(g)		-0.0719		0.2187	
																		r(p)		**-0.0608**		**0.4004**	**
	Test Weight (g)																			r(g)		0.6634	
																				r(p)		**0.5527**	**

*** Significance at 5% level** ** Significance at 1% level

Table.4 Direct and indirect effect at genotypic level of different quantitative characters on yield in wheat (*Triticum aestivum* L.)

No	Character	Days to 50% Flowering	Tillers/ Plant	Flag Leaf Area (cm)2	Plants Height (cm)	Ear of Length/Plant (cm)	Days to Maturity	Biological Yield/Plant (g)	Ear of Weight/ Plant (g)	No of Grains/Ear	Harvest Index (%)	Test Weight (g)	Grain Yield/ Plant (g)	
1	Days to 50% Flowering	**0.1154**	0.0319	0.0255	-0.0346	-0.0067	0.0103	0.0349	0.0371	0.0076	0.0164	0.0102	0.4349	*
2	Tillers/Plant	0.0026	**0.0093**	0.0000	0.0036	0.0005	-0.0062	0.0036	0.0026	-0.0035	-0.0005	0.0048	0.3826	*
3	Flag Leaf Area (cm)2	-0.0261	0.0001	**-0.1182**	-0.0567	-0.0686	0.0077	-0.0278	-0.0609	-0.0112	-0.0206	-0.0480	0.4179	*
4	Plants Height (cm)	0.0021	-0.0028	-0.0034	**-0.0071**	-0.0032	0.0006	-0.0035	-0.0031	0.0013	0.0013	-0.0043	0.4012	*
5	Ear of Length/Plant (cm)	-0.0032	0.0027	0.0319	0.0244	**0.0550**	-0.0226	0.0170	0.0266	0.0066	0.0083	0.0235	0.4971	*
6	Days to Maturity	-0.0007	0.0050	0.0005	0.0006	0.0031	**-0.0076**	-0.0008	0.0023	-0.0001	0.0033	0.0006	-0.2127	
7	Biological Yield/Plant (g)	0.1617	0.2069	0.1259	0.2614	0.1657	0.0565	**0.5356**	0.3477	-0.0718	-0.2541	0.3267	0.7480	*
8	Ear of Weight/Plant (g)	0.0931	0.0800	0.1496	0.1257	0.1402	-0.0873	0.1884	**0.2902**	-0.0002	0.0719	0.1940	0.9309	*
9	No of Grains/Ear	0.0158	-0.0908	0.0229	-0.0429	0.0289	0.0019	-0.0324	-0.0002	**0.2416**	0.0862	-0.1304	0.1202	
10	Harvest Index (%)	0.0467	-0.0181	0.0573	-0.0618	0.0496	-0.1420	-0.1561	0.0815	0.1173	**0.3289**	-0.0236	0.2187	
11	Test 1000 Grain Weight/Plants (g)	0.0274	0.1585	0.1260	0.1886	0.1326	-0.0240	0.1892	0.2073	-0.1673	-0.0223	**0.3101**	0.6634	*
RESIDUAL EFFECT =SQRT(1- 1.0078)														
Bold figures indicate direct effects.														

Variability with respect to the characters measured in terms of range, mean, PCV, GCV, heritability in broad sense and genetic advance in terms of per cent of mean have been presented in Table 2. The values for range among different genotypes varied highly for the characters like harvest index, no. of grain per ear, plant height, flag leaf area and biological yield per plant. These results are similar to those of Khan *et al.,* (2011) and Maurya *et al.,* (2014). The highest values for GCV and PCV were recorded for the character Biological yield per plant, test weight, grain yield per plant and harvest index. A close proximity between GCV and PCV values for almost all the characters revealed less influence of the environment on expression of the characters (Kumar *et al.,* 2003). In the present experiment high heritability along with high genetic advance was obtained for plant height, flag leaf area, biological yield per plant, test weight, no. of grains per ear, ear length per plant and grain yield per plant. It can be concluded that since these characters are highly responsible for selection. Superior genotype can be evolved through selection on express of these characters. A heritability estimate alone is meaningless and along with genetic advance is more meaningful in predicting the ultimate effect of selection. It should be noted that non-additive genetic effects lowers the genetic gain while additive gene action is responsible for high genetic gain. The results are in conformity with the findings of Kumar (1985) and Kumar *et al.,* (2014).

In the present investigation, simple correlation coefficients were computed among 12 characters (Table 3). Seed yield per plant was positively and significantly correlated at phenotypic level with days to 50% flowering (0.423), tillers per plant (0.3039), flag leaf area (0.3252), plant height (0.3450), ear length (0.3891), biological yield (0.6292), ear weight (0.6420) and test weight (0.5527). It implies that by increasing the value of these component traits, seed yield can be drastically increased. These results are similar to those of Verma *et al.,* 2019, Jee *et al.,* 2019 and Garg *et al.,* 2014. On the other hand, few quantitative traits were inter correlated with each other *viz.*,Tillers per plant was positive significant correlation with plant height (0.3068), biological yield per plant (0.2897) and test weight (0.3495).Ear length showed highly significant and positive association with ear weight (0.4308) and test weight (0.4057). Biological yield per plant showed highly significant positive correlation with ear weight (0.4586) and test weight (0.5692). Ear weight showed highly significant and positive association with test weight (0.5308). This suggests that selection would be quit efficient in improving yield and these nine yield components in wheat. Similar results have been reported by Kumar *et al.,* (2014).

Path coefficient analysis is a tool to partition the observed correlation coefficient into direct and indirect effects of yield components on grain yield. Path analysis provides clearer picture of character associations for formulating efficient selection strategy. The results of path coefficient analysis carried out using simple correlation coefficients among 11 characters are given in Table 4.

Results revealed that biological yield per plant (0.5356) had positive and significant association with grain yield which exerted maximum direct effect on grain yield followed by harvest index (0.3289). Thus, biological yield per plant and harvest index emerged as major direct yield components. These traits could be considered as important traits for selection in a breeding program for higher grain yield of the bread wheat. These results are similar to those of Singh *et al.,* 2012; Phougat *et al.,* 2017. The highest positive indirect effect on grain yield was exerted by Days to 50% flowering (0.0319) via tillers per plant followed by days to 50% flowering (0.0255) via flag leaf area. These characters emerged as most important indirect yield contributing characters because they showed substantial positive indirect effect towards grain yield. The remaining estimates of indirect effects in this analysis were very low indicating their importance indirect contribution towards grain yield.

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How to cite this article:

Suryabhushan Kumar, Brijesh Singh, S.P. Verma, V.N. Pathak, Chaman Jee and Singh, J.P. 2019. Studies on Genetic Variability, Heritability, Genetic Advance, Correlation and Path Analysis for Grain Yield and Its Contributing Traits in Indigenous Wheat (*Triticum aestivum* L.). *Int.J.Curr.Microbiol.App.Sci.* 8(08): 1408-1416. doi: https://doi.org/10.20546/ijcmas.2019.808.164