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GENETIC VARIABILITY, INTERRELATIONSHIP AND PATH ANALYSIS OF YIELD COMPONENTS IN WHEAT (*Triticum aestivum* L.)

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ABSTRACT

The present investigation was conducted with the objective to estimate genetic variability, character relationship between yield and yield contributing characters and their partitioning in to direct and indirect effect on grain yield in wheat. The experiment was carried out with 35 wheat genotypes and data were recorded for 12 characters. Analysis of variance showed highly significant differences among the genotype for all the characters.Characters with high estimates of variance like plant height, number of grains per spike, harvest index, biological yield and grain yield can be considered in selection for improvement of the crop varieties.Correlation analysis revealed that grain yield showed highly significant positive correlation with biological yield while significant positive correlation with tillers per plant and grains per spikelet. Path coefficient analysis revealed that highly positive direct effect on yield was recorded by biological yield followed by harvest index, grains per spikelet, spike length, plant height, 1000 grain weight and grains per spike.The path coefficient analysis helps to understand the casual factor better because it divided total effect of paired traits in to direct and indirect effect via other characters.The finding of present investigation might be use full to the future breeding programmes for developing improved genotype. On the basis of study, the desirable donors for each character were identified. The most promising donors for grain yield were WP710/17, TALL-2, WP708/17 TALL-1 and PBW590. These genotypes can be used for further breeding programme to improve the yield potential of the variety.

Key words: *Wheat, Triticum aestivum, variability, correlation, path analysis*

Wheat (*Triticum aestivum* L.) is the world's largest cereal crop which provides foods to 36% of the global population.India is one of the major producers of wheat and ranks second after China in area and production. In India the total production of wheat has increased from 12.6 m tones (1965-66) to about 98.61 m tones, area 29.72 m. hectare and productivity 33.18 during 2017-18. In Uttarakhand the total wheat area was 33 thousand-hectare, total production 880 thousand tonne and productivity was 26.43 qt. per hectare during Rabi 2017-18. (1). The development of high yielding wheat cultivars is the main objective of any wheat breeding programmes in the world.Analysis of variability among the traits and the association of a particular character in relation to other traits contributing to yield of a crop would be of great importance in planning a successful breeding program. Genetic variability is a sure thing which is required for any crop improvement programme to succeed. Yield is quantitative character and is governed by many genes having smaller effects i.e., polygenes. Thus, we can say that the yield is the final product of yield components. These components may affect the yield directly or indirectly. (2) gave the theory of path coefficient as an attempt to analyse statistically the cause and effect relationship in correlated variables, and provides critical examination of the specific forces acting to produce a given correlation. Therefore, yield can be maximized by improving the yield components provided there is no unfavourable association. The correlation study can show the magnitude of association between any two characters. thus, the knowledge of character association is essential for simultaneous improvement of yield and yield components.Path analysis differs from simple correlation in the sense that it points out the causes and their relative significance, whereas correlation simply measure the mutual association. The correlation coefficient simply indicates the degree of association among the characters contributing towards economic yield and its knowledge with regard to grain yield and yield components could be helpful in the selection. However, it does not provide measure of causal relationship exiting among variables. Therefore, it becomes essential to identify the component of yield and their relative contribution. The path coefficient analysis helps in understanding the causal factor better, because it divides total correlation of paired traits into direct and indirect effects via other characters.Therefore, the present investigation had been conducted to estimate the extent of variabilityforyield and its components and to assess the nature and magnitude of inter-character correlation and cause and effect analysis fordifferent characters in wheat germplasm lines.

MATERIALS AND METHODS

Thirty-fiveimproved genotype of bread wheat were evaluated at Research farm of R.M.P. P.G. College, GurukulNarsan, Haridwar (Uttrakhand) for different morphological traits. The GurukulNarsan is situated in the foothills of Shivalik range of Himalaya and falls in the humid sub-tropical climate Zone.The Material was planted in a randomized complete block design with three replications under timely sown Condition in the plot consists of 2 row of 2.5mlength spaced at 23 cm. the observations were recorded on a random sample of 10 plants from each plot for 12 quantitative characters viz., Plant height (cm), No of tillers/plant, Spike length(cm), Awn length(cm), No. of spikelet/spike, No. of grains/spikelet, No. of grains/spike, Grain weight/ear (gm), 100 grain weight (gm), Biological yield (gm), Harvest Index and Grain yield/plant (gm).

Genetic parameters viz., Mean, Range, Coefficients of variability (PCV and GCV),Correlation and Path coefficient were estimated for the character studied. Analysis of variance permits estimation of phenotypic, genotypic and environmental coefficients of variability. Estimation of different coefficients of variability was done following (3). Correlation coefficients between all possible pairs of characters were calculated at genotypic and phenotypic level. The analysis of variance and covariance was used for the estimation of correlation coefficient as suggested by (4). The phenotypic and genotypic correlation coefficients were further partitioned into direct and indirect effects with the help of path coefficient analysis as suggested by (5).

RESULTS AND DISCUSSION

Estimation of variability parameters : In populations genetic drift is a constant phenomenon due to which species gradually loose genetic Variation.Therefore, there’s a need for its conservation and determination as well. The results of ANOVA revealed that the mean sum of squares among the genotypes for all the characters were highly significant, which indicated that the genotypes were genetically divergent. This indicated that there is a great scope of selection of promising genotypes from the present gene pool. Information on the extent of genetic variability as well as heritability among the agronomically important traits is the requirement to design a suitable plant breeding method. Sometimes the trait of interest is influenced by the environmental conditions prevailing, especially in case of polygenic characters so it becomes important to partition the total variability components, to have information regarding the nature and extent of actual variability present.Range, General Mean (GM), Genotypic (GCV), Phenotypic (PCV) and Environmental (ECV) coefficients of variability estimates from present study are presented in Table-1.

A perusal of Table-1 indicated that theplant height ranged from 63.84 cm to 151.10 cm with general mean 88.94 cm and genotypic coefficient of variation 18.20 percent. The genotype TALL-2 attained maximum height and genotype HJ 507 had minimum height.In case of number of tillers per plant ranged from 4.33 to 8.66 with general mean 6.63 andgenotypic coefficient of variation 16.44 percent. The genotype TALL-2 and HD 2967 attained maximum number of tillers per plant and genotype PBW 530 attained minimum number of tillers. Mean spike length ranged from 7.83 cm. to 13.27cm with general mean 7.83 cm and genotypic coefficient of variation 12.21 percent. The genotype WP703/17 attained maximum spike length and genotype WHD 945 attained minimum spike length.Awn length exhibited mean range of variation from 4.70 cm to 15.00 cm with general mean 7.22 cm and genotypic coefficient of variation 28.40 percent.The genotype HAES 3949 attained maximum awn length and genotype DBW 17 attained minimum awn length.The general mean of number of spikelets per spike ranged from 17.33 to 22.67 with general mean 19.93 and genotypic coefficient of variation 7.03 percent. The genotype TALL-2 attained maximum spikelet per spike and genotype WP 708/17 attained minimum spikelet.The mean number of grains per spikelet ranged from 3.00 to 4.00 with general mean3.16 and genotypic coefficient of variation 7.90 percent. The genotype TALL-2 and HD 2967 attained maximum number of grains per spikelet.The mean number grains per spike ranged from 43.33 to 82.00 with general mean 59.75and genotypic coefficient of variation 15.61 percent. The genotype WHD 945 attained maximum number of grains per spike and genotype Golden attained minimum number of grains per spike.Grain weight per ear exhibited range of variation from 1.98 gm to 4.01gm with general mean2.75 gm and genotypic coefficient of variation 16.63 percent.The genotype WHD 945 attained maximum grain weight per ear and genotype Golden attained minimum grain weight.The mean 100 grain weight ranged from 3.48 gm to 5.67 gm with general mean 4.46 gm and genotypic coefficient of variation 10.26 percent.The genotype HAES 3949 attained maximum 100 grain weight and genotype WP 701/17 attained minimum grain weight.Biological yield showed mean performance ranged from 18.53 gm to 46.13 gm with general mean 30.23 gm and genotypic coefficient of variation 20.33 percent. The genotype TALL-2 attained maximum biological yield and genotype WHD 945 attained minimum biological yield.The mean harvest index per plant ranged from 26.50 gm to 82.29 gm with general mean 4.29 gm and genotypic coefficient of variation was 18.01 percent. The genotype WHD 945 attained maximum harvest index and genotype WP 701/17 attained minimum harvest index.The mean grain yield ranged from 9.00 gm to 21.26 gmwith general mean14.49 gm and genotypic coefficient of variation 19.70 percent. The genotype WP 710/17 attained maximum grain yield followed by TALL-2 and genotype WP 701/17 attained minimum grain yield.

Table-1 : The general mean, range of variation, Genotypic (GCV), Phenotypic (PCV) and Environmental (ECV) coefficient of variation for different characters in wheat.

Characters	General mean	Range of variation	Coefficient of variation		
			GCV	PCV	ECV
Plant Height	88.94	63.84 - 151.10	18.20	20.37	9.15
Number of tillers per plant	6.63	4.33 - 8.67	16.44	20.55	12.33
Spike length (cm)	7.83	7.83 - 13.27	12.21	12.38	2.04
awn length (cm)	7.22	4.70 – 15.00	28.40	28.76	4.55
Number of spikelets per spike	19.93	17.33 - 22.67	7.03	8.00	3.83
Number of grains per spikelet	3.16	3.00 - 4.00	7.90	11.72	8.65
Number of grains per spike	59.75	43.33 - 82.00	15.61	17.11	7.02
Grain weight/ear	2.75	1.98 - 4.01	16.63	19.91	10.95
100 grain weight	4.46	3.48 - 5.67	10.26	10.42	1.87
Biological yield	30.23	18.53 - 46.13	20.33	22.05	8.53
Harvest Index	49.29	26.50 - 82.29	18.01	21.03	12.80
Grain yield/plant	14.49	9.00 - 21.26	19.70	23.50	10.87

From the results of analysis of variance, it is clear that variability existed in the experimental materials for the character studies. Plant height showed maximum variance followed by harvest Index, grains per spike, biological yield, grain yield per plant, awn length and number of spikelets per spike, spike length, tillers per plant, grain weight per ear days to emergence, 100 grain weight and no. of grains per spikelet. These results are also in agreement with the findings of (6,7,8,9,10,11 and 12). Characters with high estimates of variance like plant height, harvest index, biological yield and grain yield can be considered in selection for improvement of the crop. Hence the magnitude of variance for any trait in population is of big importance to a plant breeder for starting a breeding programme.

Revealing character associationsamong yield components : Grain yield is a complex character, which is the end product of multiplicative interaction between the various yield components, earlier workers had emphasized significance of components approach in forming a successful breeding programme. The correlation coefficient gives an idea about the various associations existing between yield and yield contributing components.The correlation coefficients among different characters had been estimated and presented in Table-2.

The experimental findings of the present investigation revealed that Grain yield showed highly significant positive correlation with biological yield whilesignificant positive correlation with harvest index, grains per spikelet and tillers per plant. Similar relationships were recorded by (13).Harvest index exhibited significant positive correlation with grain yield, however significant negative correlation was observed with biological yield, spike length and tiller per plant. Similar findings were reported(13).Biological yield showed highly significant positive correlation with plant height while it showed significant positive correlation with tillers per plant similar observations were recopied by (14). 100-grain weightshowed highly significant and positive correlation with awn length and significant positive correlation with grain weight per ear. Grains weight per ear exhibited highly significant and positive correlation with awn length, spikelet per spike and grains per spike, however Grains per spike showed highly significant and positive correlation with spikelet per spike for both genotypic and phenotypic level.Grains per spikelet showed highly significant and positive correlation with spikelet per spike while significant and positive correlation with tillers per plant.Spikelet per spike was associated with spike length in highly significant and positive direction while it exhibited significant and positive correlation with plant height.Spike length showed highly significant and positive correlation with plant height at both levels.Tillers per plant showed significant and positive correlation with plant height. Similar results were obtained earlier workers as reported by (15 and 16).

Path analysis for understanding interrelationships : In present investigation path coefficient analysis was carried out taking grain yield as the dependent variable and remaining 11 traits as independent variables. The positive direct effect on grain yield (dependent variable) was the function of (independent variable) biological yield followed by harvest index, grains per spikelet, spike length, plant high, 100 grain weight and grains per spike. However genotypic direct negative effect on yield was via spikelet per spike, tillers per plant, grain weight per ear and awn length.The direct and indirect effect of yield contributing character on yield have been elaborated with the help of Path coefficient analysis using genotypic correlation coefficients among yield and its components and presented in Table-3.

Higher positive direct effect on yield was recorded for biological yield (1.305) followed by harvest index (0.948), grains per spikelet (0.186), spike length (0.122), plant high (0.097), 1000 grain weight (0.070), and grains per spike (0.068). Direct negative effect on yield was recorded for number of spikelet per spike (–0.276)

Table-2 : Genotypic (G), Phenotypic (P) and Environmental (E) Correlation coefficients exhibiting interrelationship among yield and different yield components in wheat.

Characters		Plant high	Tillers per Plant	Spike length	Awn length	Spikelet per Spike	Grain per spikelet	Grain per spike	Grain weight per ear	100Grain weight	biologic al yield	Harvest Index	Grain yield per plant
Plant height	G	1.000	0.400*	0.442**	-0.055	0.411*	0.124	0.194	0.160	-0.157	0.468**	-0.251	0.304
	P		0.272	0.382*	-0.049	0.307	0.141	0.198	0.183	-0.137	0.398*	-0.204	0.227
	E		-0.049	-0.091	-0.000	-0.070	0.200	0.213	0.259	0.010	0.069	-0.065	0.024
Tillers per Plant	G		1.000	0.096	-0.019	-0.012	0.388*	-0.231	-0.241	-0.307	0.690*	-0.406*	0.403*
	P			0.074	-0.030	-0.045	0.202	-0.157	-0.160	-0.237	0.580*	-0.206	0.360*
	E			-0.023	-0.154	-0.129	-0.016	0.045	-0.004	0.041	0.307	0.037	0.272
Spike length	G				-0.244	0.478**	0.028	0.184	0.284	0.077	0.210	-0.382*	-0.098
	P				-0.234	0.424**	0.016	0.175	0.237	0.073	0.189	-0.326*	-0.095
	E				0.145	0.130	-0.022	0.138	0.034	-0.077	-0.023	-0.112	-0.149
Awn length	G				1.000	-0.008	0.189	0.190	0.488**	0.484**	-0.028	0.190	0.114
	P					-0.018	0.136	0.171	0.404*	0.468**	-0.039	0.163	0.088
	E					-0.138	0.092	-0.008	0.020	-0.059	-0.225	0.071	-0.110
Spikelet per Spike	G					1.000	0.541**	0.574**	0.515**	0.153	0.257	-0.182	0.080
	P						0.269	0.488**	0.451**	0.139	0.204	-0.075	0.107
	E						0.005	0.256	0.279	0.075	-0.020	0.226	0.189
Grains per spikelet	G						1.000	0.126	0.084	-0.035	0.299	0.012	0.338*
	P							0.139	0.121	-0.018	0.168	0.042	0.197
	E							0.202	0.180	0.043	-0.063	0.089	0.005
Grains per spike	G							1.000	0.858**	-0.088	-0.059	0.216	0.069
	P								0.779*	-0.067	-0.068	0.163	0.033
	E								0.556	0.152	-0.118	-0.009	-0.099
Grain weight per ear	G								1.000	0.395*	-0.037	0.224	0.104
	P									0.348*	-0.067	0.207	0.091
	E									0.242	-0.181	0.167	0.062
100 Grain weight	G									1.000	-0.030	0.078	0.056
	P										-0.030	0.069	0.049
	E										-0.044	0.045	0.019
Biological yield	G										1.000	-0586**	0.618**
	P											-0.543**	0.544**
	E											-0.426	0.282
Harvest Index	G											1.000	0.253
	P												0.382*
	E												0.714
Grain yield per plant	G												1.000
	P												
	E												

Table-3 : Genotypic Path coefficient analysis showing direct (bold) and indirect effect of the characters on grain yield in wheat.

Characters	Plant Height	Number of tillers per plant	Spike length	Awn length	Number of spikelets per spike	Number of Grains per Spikelet	Number of Grain per Spike	Grain weight per ear	100 Grain weight	Biological Yield	Harvest Index	Corr. with yield
Plant Height	**0.097**	-0.101	0.054	0.000	-0.113	0.023	0.013	-0.016	-0.011	0.611	-0.238	-0.251
Number of tillers per plant	0.039	**-0.253**	0.012	0.000	0.003	0.072	-0.016	0.024	-0.021	0.900	-0.385	-0.406
Spike length	0.043	-0.024	**0.122**	0.002	-0.132	0.005	0.013	-0.028	0.005	0.274	-0.362	-0.382
Awn length	-0.005	0.005	-0.030	**-0.007**	0.002	0.035	0.013	-0.048	0.034	-0.037	0.180	0.190
Number of spikelets per spike	0.040	0.003	0.058	0.000	**-0.276**	0.101	0.037	-0.051	0.011	0.335	-0.173	-0.182
Number of Grains per Spikelet	0.012	-0.098	0.003	-0.001	-0.149	**0.186**	0.009	-0.008	-0.002	0.390	0.011	0.012
Number of Grain per Spike	0.019	0.058	0.022	-0.001	-0.151	0.023	**0.068**	-0.084	-0.006	-0.077	0.205	0.216
Grain weight per ear	0.016	0.061	0.035	-0.004	-0.141	0.016	0.058	**-0.098**	0.028	-0.048	0.212	0.224
100 Grain weight	-0.015	0.078	0.009	-0.004	-0.042	-0.007	-0.006	-0.039	**0.070**	-0.039	0.074	0.078
Biological Yield	0.046	-0.174	0.026	0.000	-0.071	0.056	-0.004	0.004	-0.002	**1.305**	-0.553	-0.586
Harvest Index	-0.024	0.103	-0.047	-0.001	0.050	0.002	0.015	-0.022	0.005	-0.765	**0.948**	0.253

followed by tillers per plant (–0.253), grain weight per ear (–0.098) and awn length(–0.007). High positive indirect effects of plant height on yield were recorded via biological yield (0.611) followed by spike length (0.054), grains per spikelet (0.023) and grains per spike (0.013), however, negative indirect effects of plant hight on yield were recorded via harvest index (0.238) followed by spikelet per spike (–0.113) tillers per plant (–0.101) grain weight per ear (–0.016) and 100 grain weight (–0.011). Highest positive indirect effect of tiller plant on yield was recorded for biological yield (0.900) followed by grains per spikelet (0.072), plant high (0.039), grain weight per ear (0.024), spike length (0.012) and spikelet per spike (0.003), however, negative indirect effect of tillers per plant was recorded via harvest index(–0.385) followed by 100 grain weight (–0.021), grains per spike(–0.016). Spike length exerted high indirect positive effect on yield via biological yield (0.274) followed by plant hight (0.043), grains per spike (0.013), grains perspikelet (0.005), 100 grain weight (0.005) and awn length (0.002),while the highest indirect negative effect on grain yield was recorded for harvest index (–0.362) followed by spikelet per spike (0.132), grain weight per ear (–0.028) and tillers per plant (–0.024).

Highest positive indirect effect on grain yield via awn length was recorded for harvest index (0.180) followed by grains per spikelet (0.035), 100 grain weight (0.034), grains per spike (0.013), tillers per plant (0.005) and spikelet per spike (0.002), however, the highest indirect negative effect on grain yield via awn length was recorded for grains weight per ear (0.048) followed by biological yield (–0.037), spike length (–0.030) and plant height (–0.005).The highest indirect positive effect on yield via spikelet per spike was recorded for biological yield (0.335) followed by grains per spikelet (0.101), spike length (0.058), Plant high (0.040) grains per spike (0.037) and 100 grain weight (0.011), while highest indirect negative effect on yield via spikelet per spike was recorded for harvest index (–0.173) and grain weight per ear (–0.051).The indirect positive effect on yield via grain per spikelet was recorded for biological yield (0.390) followed by plant high(0.012), harvest index (0.011), grains per spike (0.009) and spike length (0.003),however indirect highest negative effect on yield via grains per spikelet was recorded for spikelet per spike (–0.149) followed by tiller per plant (–0.098), grain weight per ear (–0.008), 100 grain weight(–0.002) and awn length (–0.001).

The highest indirect positive effect on yield via grains per spike was recorded for harvest index (0.205) followed by tiller per plant (0.058), grains per spikelet (0.023), spike length (0.022) and plant height (0.019). While highest indirect negative effect on yield via grains per spike was recorded for spikelet per spike (–0.151) followed by grain weight per ear (–0.084), biological yield (–0.077), 100 grain weight (–0.006) and all length (–0.001).The highest indirect positive effect on grain yield via grain weight per ear was recorded for harvest index (0.212) followed by tiller per plant (0.061) grains per spike (0.058) spike length (0.035) 100 grain weight (0.028) grains per spikelet (0.016) and plant high (0.016). Highest indirect negative effect on yield via grain weight per ear was recorded for spikelet per spike (–0.141) followed by biological yield (–0.048) and awn length (–0.004).The indirect positive effect on yield via 100 grain weight was recorded for tiller per plant (0.078) followed by harvest index (0.074) and spike length (0.009). The indirect negatives effect on yield via 100 grain weight was recorded for spikelet per spike (–0.042) followed by grain weight per ear (–0.039), plant high (–0.015), grains per spikelet (–0.007), grains per spike (–0.006) and awn length (–0.004).

The highest indirect positive effect on yield via biological yield was recorded for grain per spikelet (0.056) followed by plant high (0.046) spike length (0.026) and grain weight per ear (0.004), however, indirect negative effect on grain yield via biological yield was recorded for harvest index (–0.556) followed by tillers per plant (–0.174), spikelet per spike (–0.071), grains per spike (–0.004) and 100 grain weight(–0.002). The indirect positive effect on yield via harvest index was recorded for tiller per plant (0.103) followed by spikelet per spike (0.050), grains per spike (0.015) and 100 grain weight (0.005). Indirect negative effect on yield via harvest index was recorded for biological yield (–0.765) followed by spike length (–0.047), plant high (–0.024), grain weight per ear (–0.022) and awn length (–0.001). Similar results were also observed by (11 and 13) for grain yield and its various component characters.

The knowledge of such relationships has direct bearing on the selection, and if this knowledge is applied appropriately to the selection, the gain per selection cycle may be much higher as compared to selection of new genotypes randomly. It may not only help in picking up new desirable genotype but it may also reduce the selection pressure. However, totally dependence on such relationship for selection may mislead and end up with the poor selection with change in material and environment. Hence, selection should not be entirely based on such knowledge until and unless the relationship is confirmed.

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