

## Original Research Article

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## Genetic Parameters of Variability and Path Analysis in Wheat under Timely and Late Sown Conditions

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### ABSTRACT

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An experiment was conducted to determine the genetic variability, heritability, genetic advance and character association for yield and its component traits in 60 wheat genotypes under timely and late sown conditions. Significant genotypic differences were observed for all the traits in both environments. The moderate magnitude of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) was recorded for grain yield per meter and effective tillers per meter and grain filling duration under timely and for grain yield per meter and effective tillers per meter under late sown condition. Above mentioned traits also showed high heritability coupled with high genetic advance in both the environments. Grain yield showed positive and significant correlation with effective tillers per meter, canopy temperature, but correlated negatively and significantly with plant height under timely sown condition. Under late sown condition grain yield showed positive and significant correlation with days to anthesis, plant height, effective tillers per meter, canopy temperature and grain weight. Path analysis showed that effective tillers per meter had highest positive direct on seed yield followed by days to anthesis, grain weight under both the environments, indicating that these were main contributors to grain yield.

### Introduction

Wheat (*Triticum aestivum* L. em. Thell) is a self-pollinated crop of the member of Poaceae family and one of the most leading cereals of many countries of the world including India. It has been described as “King of cereals” because of the acreage it occupies, high productivity and the prominent position it holds in the international food grain trade. Wheat is consumed in a variety of way such as bread, chapatti, porridge, flour, juice etc. wheat has relatively high content of niacin and thiamin which are principally concerned in providing the special protein called ‘Gluten’ (Bhushan *et al.*, 2013). India is the third largest wheat producer in the world

(FAO, 2015). Its total area is 30.23mha, production 93.50 mt and productivity 30.93 q/ha. Haryana with 11.36 mt production, 2.57 mha area and 4.40 t/ha productivity ranks third in the country (Anonymous, 2016). It contributes food to 36% of the global population and 20% of the calories. The growing pace of population is declining the cultivated land which is a great concern for world’s food security. With the passage of time this problem will be intensified further demanding increased cereal production to 1.7 fold to meet future challenges of food security (Mba *et al.*, 2012). Developing countries produce and utilize 81% of wheat they

consume. In the period leading up to 2020, demand for wheat for human consumption in developing countries is expected to grow at 1.6% each year. The global average wheat yield must be increase during the coming 25 years from 2.6 to 3.5 tones ha<sup>-1</sup> (Amirjani, 2012). Hence, there is a need to raise the wheat productivity.

Wheat production is affected by several environmental factors responsible for yield losses over world including India. Environmental stresses affect negatively plant growth, productivity, reproductive capacity, and survival. Environmental stress may result from abiotic factors and biotic factors.

Among abiotic factors heat stress is a major production constraint for bread wheat grown in non-temperate environments (Mason *et al.*, 2010; Pinto *et al.*, 2010). High temperature is affecting about 65 to 70 mha in the World (Reynolds *et al.*, 1994), around 13.5 mha area in India (Joshi *et al.*, 2007).

The influence of high temperatures on growth and development of wheat and other crops is well documented (Wheeler, *et al.*, 2000). Heat decreases leaf photosynthetic rate, increase embryo abortion, lesser grain number, and decrease filling duration of grains resulting in lower grain yield (Prasad *et al.*, 2006). When experienced during the reproductive phase, high temperatures induce the loss of both grain weight and number (Hays *et al.*, 2007).

In order to raise the yield potential of the crop, genetic variability in the existing wheat germplasm needs to be utilized in the breeding programme. Thus, there is an urgent need to study the variability of the crop.

The assessment of genetic parameters like genotypic variability, phenotypic variability, genotypic coefficient of variation, phenotypic coefficient of variation, heritability and

genetic advance are significant for the effective selection and improvement of breeding population. The genetic tools such as correlation and path analysis are useful in resolving complex polygenetic control of yield trait. The present study therefore was conducted to estimate magnitude of phenotypic and genotypic variability, heritability, genetic advance, correlation coefficient and path analysis with the aim to utilize the genetic information gained in developing superior wheat genotypes and varieties.

## **Materials and Methods**

The experimental materials comprised of genetically diverse 60wheat genotypes which were raised under timely (E1) and late sown condition (E2) during Rabi season, 2016-17 in a randomized block design with three replications at research farm of Wheat Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar. The plot size was 3mx 0.40m with row to row spacing of 20 cm. Hisar is located in global geographical position between 29.09°N and 75.43°E in western Haryana. Observations for all the traits were recorded by taking five plants per plot. The data were recorded for days to heading, days to anthesis, days to maturity, plant height, effective tillers per meter, chlorophyll fluorescence, canopy temperature, grain yield per meter, grain weight, and grain filling duration. Analysis of variance for the observations recorded on different characters was carried out as per the standard procedure of Fisher (1930). Genotypic and phenotypic coefficients of variation were estimated according to Burton and Devane (1953). Heritability in broad sense and Genetic advance were worked out as per the procedures of Falconer (1981), Johnson *et al.*, (1955), respectively. Phenotypic and genotypic correlation and path coefficients of

variation were computed as per the method given by Dewey and Lu (1959).

## **Results and Discussion**

### **Analysis of variance**

The mean sum of squares for different traits under study has been presented in table 1. The results indicated that mean sum of squares due to genotype were significant for all the morphological and physiological characters studied under both timely and late sown conditions indicating thereby the prevalence of enough genetic variability in the materials under study for selection and improvement. Therefore, further analysis of data is appropriate for computation of correlation coefficient analysis. Similar results were also recorded by Kumar *et al.*, (2013) and Nukasani *et al.*, (2013).

### **Variability parameters**

The result of mean, range, genotypic coefficient of variation (GCV), Phenotypic Coefficient of Variation (PCV), heritability (broad sense), and expected genetic advance have been presented in table 2. This revealed sufficient range of variation among genotypes for each character.

### **GCV and PCV**

A perusal of table 3 revealed that phenotypic coefficients of variance (PCV) was higher than genotypic coefficients of variance (GCV) for all the characters under study but the difference was relatively small indicating that these characters were less influenced by the environment. Under timely sown condition Grain filling duration depicted moderate PCV and GCV, respectively followed by grain yield per meter and effective tiller per meter whereas, under late sown condition Grain yield per meter and effective tillers per meter showed moderate value of PCV and GCV.

Similar results were obtained by Bhushan *et al.*, (2013) for grain yield and productive tiller per plant. Contrary to these results Gowda *et al.*, (2011) reported high PCV and GCV for grain yield, canopy temperature depression (10 days after anthesis) and canopy temperature depression (at anthesis), by Veerasha and Naik (2016), Jan and Kashyap (2013) and by Nukasani *et al.*, (2013) for number of productive tillers per meter and grain yield.

Lowest PCV and GCV were obtained for plant height followed by days to maturity, chlorophyll fluorescence, days to anthesis, days to heading and 1000-grain weight under timely sown condition and for days to maturity, days to anthesis, days to heading, chlorophyll fluorescence, plant height, grain filling duration, canopy temperature and 1000-grain weight under late sown condition. Similar results were reported by Bhushan and Sarial (2016) for days to heading, days to anthesis, days to physiological maturity and grain filling duration, by Bhushan *et al.*, (2013) for days to heading, days to maturity and 1000-grain weight. Nukasani *et al.*, (2013) reported moderate PCV and GCV for plant height and 1000-grain weight.

### **Heritability and genetic advance**

The genetic parameter heritability determines the extent of genetic control of a given trait and its transmission to progeny and, hence has bearing on the selection efficiency of trait concerned. Johnson *et al.*, (1955) advocated that for selection to be effective, heritability and genetic advance should be considered together. Under timely sown condition High estimates of heritability coupled with high genetic advance were recorded for effective tiller per meter (98.19 and 29.57), grain yield per meter (97.92 and 30.79) and grain filling duration (91.83 and 32.49) whereas, under late sown condition High estimates of heritability and genetic advance have been

observed for effective tillers per meter (97.92 and 30.44) and grain yield per meter (97.11 and 39.43). The high heritability and genetic advance are attributed due to additive gene action with least environment influence which would result in effective selection for these traits. Similar results were also recorded by Nukasani *et al.*, (2013) for tillers per meter and grain yield per meter, by Singh *et al.*, (2012) for tillers per plot and grain yield and by Veerasha and Naik (2016) for number of productive tillers per meter and grain yield. Contrary to this Kumar *et al.*, (2014) observed moderate heritability for number of tillers per meter and grain yield.

High heritability with moderate genetic advance was observed for 1000-grain weight (83.86 and 15.43) and canopy temperature (81.79 and 15.35) under timely sown condition and for High heritability and moderate genetic advance was observed for grain filling duration (84.73 and 12.14), canopy temperature (74.26 and 11.35), and 1000-grain weight (73.85 and 13.88) under late sown condition.

Similar results were also obtained by Jan and Kashyap (2013), Bhushan *et al.*, (2013) and Kumar *et al.*, (2014) for 1000-grain weight.

High heritability and low genetic advance was reported for days to heading (90.17 and 8.51), chlorophyll fluorescence (88.47 and 6.21), days to anthesis (88.39 and 8.12), days to maturity (85.61 and 4.31) and plant height (76.63 and 5.08) showed low genetic advance under timely sown condition and for plant height (91.71 and 8.51), chlorophyll fluorescence (87.89 and 6.69), days to anthesis (87.38 and 5.68), days to heading (87.04 and 5.67) and days to maturity (85.80 and 4.02) under late sown condition, indicating the presence of non-additive gene action hence, ineffective selection for the trait. Similar findings were obtained by Jan and Kashyap (2013) and Kumar *et al.*, (2014)

for days to maturity, by Singh *et al.*, (2012) and Rehman *et al.*, (2016) for days to heading.

### **Correlation coefficient analysis**

Yield, a complex polygenic trait has a large number of other contributing component traits. Correlation analysis reveals the relationship of dependent variable yield with its independent variables, thus association of various traits would determine their relative significance to improve yield. The results of correlation coefficient at phenotypic and genotypic level among different traits were studied and have been presented in table 3 (Timely sown) and table 4 (Late sown). In almost all the characters the magnitude of genotypic correlation coefficients was found higher than phenotypic correlation coefficients, thus indicating a good extent of strong inherent association between different characters.

Grain yield showed positive and significant correlation with effective tillers per meter, canopy temperature, but correlated negatively and significantly with plant height under timely sown condition. Under late sown condition grain yield showed positive and significant correlation with days to anthesis, plant height, effective tillers per meter, canopy temperature and grain weight. Similar results were reported by Nukasani *et al.*, (2013) for tillers per meter and grain weight per spike, by Arya *et al.*, (2005) for effective tillers per plant and by Singh *et al.*, (2013) for test grain weight. Days to heading had positive and significant phenotypic correlation with days to anthesis, days to maturity, plant height under both the conditions. Effective tillers per meters showed positive and significant association with canopy temperature under timely sown condition but a negative and significant correlation under late sown condition.

**Table.1** Analysis of variance for various characters in 60 wheat genotypes under timely sown (E1) and late sown (E2) conditions

			Days to heading	Days to anthesis	Days to maturity	Plant height	Effective tillers per meter	Chlorophyll fluorescence	Canopy temperature	Grain yield per meter	1000-Grain weight	Grain filling duration
<b>Replication</b>	<b>2</b>	<b>E1</b>	0.02	4.02	2.92	33.42	6.44	0.00	0.53	62.74	0.91	2.71
		<b>E2</b>	2.84	10.34	2.10	38.79	10.34	0.00	1.19	226.10	0.6	5.49
<b>Treatment</b>	<b>59</b>	<b>E1</b>	48.02**	49.83**	31.87**	30.37**	864.06**	0.002**	15.05**	1,016.50**	40.24**	91.80**
		<b>E2</b>	17.98**	20.05**	20.50**	57.61**	333.92**	0.00**	10.84**	452.18**	32.58**	13.32**
<b>Error</b>	<b>118</b>	<b>E1</b>	1.68	2.09	1.69	2.80	5.28	0.00	1.04	7.85	2.43	2.64
		<b>E2</b>	0.85	0.92	1.07	1.68	2.35	0.00	1.12	4.43	3.44	0.75

**Table.2** Genetic parameters for yield and its component traits in wheat under timely (E1) and late sown (E2) condition

<b>Characters</b>	<b>Mean</b>		<b>GCV (%)</b>		<b>PCV (%)</b>		<b>h<sup>2</sup> (bs)</b>		<b>GA% of Mean</b>	
	<b>E1</b>	<b>E2</b>	<b>E1</b>	<b>E2</b>	<b>E1</b>	<b>E2</b>	<b>E1</b>	<b>E2</b>	<b>E1</b>	<b>E2</b>
<b>DH</b>	90.30	81.03	4.352	2.95	4.58	3.16	90.17	87.04	8.51	4.59
<b>DA</b>	95.12	85.66	4.19	2.95	4.46	3.15	88.39	87.38	8.12	4.86
<b>DM</b>	140.25	120.7	2.24	2.1	2.44	2.27	85.61	85.8	4.31	4.86
<b>PH</b>	107.53	100.1	2.82	4.32	3.22	4.5	76.63	91.71	5.08	8.52
<b>ET</b>	116.79	70.41	14.49	14.93	14.62	15.09	98.19	97.92	29.57	21.43
<b>CFL</b>	0.71	0.66	3.21	3.46	3.41	3.69	88.47	87.89	6.21	0.04
<b>CT</b>	26.23	28.15	8.24	6.39	9.11	7.42	81.79	74.26	15.35	3.19
<b>GY</b>	121.24	62.9	15.12	19.42	15.3	19.71	97.72	97.11	30.79	24.8
<b>GW</b>	43.41	39.76	8.18	7.84	8.93	9.12	83.86	73.85	15.43	5.52
<b>GFD</b>	33.12	31.96	16.46	6.4	17.17	6.95	91.83	84.73	32.49	3.88

**Table.3** Phenotypic (above Diagonal) and genotypic correlation coefficient (below diagonal) for Various characters in wheat genotypes under timely sown condition (E1)

Traits	DH	DA	DM	PH	ET	CFL	CT	GY	GW	GFD
DH	1.000	0.985**	0.363**	0.605**	0.084	0.162*	0.123	0.100	-0.239**	-0.018
DA	0.995**	1.000	0.354**	0.591**	0.072	0.163*	0.104	0.084	-0.264**	0.002
DM	0.401**	0.394**	1.000	0.502**	-0.124	0.066	-0.030	-0.080	0.160*	0.408**
PH	0.687**	0.673**	0.582**	1.000	-0.222**	0.182*	-0.064	-0.180*	0.022	0.125
ET	0.084	0.072	-0.139	-0.258**	1.000	0.088	0.274**	0.940**	0.048	0.031
CFL	0.165*	0.169*	0.081	0.239**	0.101	1.000	0.158*	0.093	-0.017	0.075
CT	0.162*	0.135	-0.050	-0.069**	0.308**	0.189*	1.000	0.295**	-0.052	-0.363**
GY	0.115	0.102	-0.092	-0.205**	0.960**	0.113	0.328**	1.000	0.099	-0.011
GW	-0.270**	-0.304**	0.195**	0.007	0.051	-0.020	-0.036	0.101	1.000	-0.044
GFD	-0.014	0.018	0.431**	0.175*	0.029	0.076	-0.419**	-0.011	-0.028	1.000

**Table.4** Phenotypic (above Diagonal) and genotypic correlation coefficient (below diagonal) for Various characters in wheat genotypes under late sown condition (E2)

Traits	DH	DA	DM	PH	ET	CFL	CT	GY	GW	GFD
DH	1.000	0.955**	0.584**	0.563**	0.189*	0.028	0.038	0.245**	-0.149*	0.042
DA	0.980**	1.000	0.593**	0.581**	0.181*	0.030	0.050	0.237**	-0.153*	0.027
DM	0.615**	0.626**	1.000	0.373**	-0.059	0.107	0.083	-0.042	-0.233**	-0.045
PH	0.611**	0.622**	0.404**	1.000	0.144	0.149*	0.095	0.155*	-0.101	-0.069
ET	0.209	0.203	-0.069	0.163*	1.000	-0.005	-0.223**	0.935**	0.256**	-0.009
CFL	0.043	0.047	0.124	0.169*	-0.016	1.000	0.110	0.025	-0.045	0.011
CT	0.021	0.042	0.112	0.106*	-0.265**	0.126	1.000	0.210**	-0.231**	0.057
GY	0.266**	0.255**	-0.049	0.155*	0.959**	0.030	0.274**	1.000	0.237**	0.070
GW	-0.214**	-0.232**	-0.311**	-0.131	0.298**	-0.039	-0.310**	0.280**	1.000	0.024
GFD	0.036	0.033	-0.086	-0.068	-0.015	0.028	0.102	0.082	0.016	1.000

DH-Days to Heading, DA-Days to anthesis, DM-Days to maturity, PH-Plant height, ET-Effective tillers per meter, CFL-Chlorophyll fluorescence, CT-Canopy temperature, GY- Grain yield per meter, GW-Grain weight, GFD-Grain filling duration.

**Table.5** Direct (diagonal) and indirect path effects of different characters on grain yield per meter in timely sown condition (E1)

Trait	DH	DA	DM	PH	ET	CFL	CT	GW	GFD
<b>DH</b>	<b>-0.49006</b>	-0.4878	-0.1964	-0.33663	-0.04138	-0.08101	-0.07958	0.13234	0.00682
<b>DA</b>	0.48813	<b>0.49039</b>	0.19315	0.33009	0.0354	0.08281	0.06634	-0.14923	0.00865
<b>DM</b>	0.0169	0.01661	<b>0.04218</b>	0.02457	-0.00587	0.0034	-0.00212	0.00822	0.0182
<b>PH</b>	0.02904	0.02845	0.02462	<b>0.04227</b>	-0.01092	0.01009	-0.00292	0.00031	0.0074
<b>ET</b>	0.08239	0.07044	-0.13573	-0.25217	<b>0.97586</b>	0.09836	0.30028	0.04976	0.02812
<b>CFL</b>	0.00039	0.0004	0.00019	0.00056	0.00024	<b>0.00235</b>	0.00044	-0.00005	0.00018
<b>CT</b>	0.00292	0.00243	-0.00091	-0.00124	0.00554	0.0034	<b>0.01799</b>	-0.00065	-0.00754
<b>GW</b>	-0.01584	-0.01785	0.01143	0.00043	0.00299	-0.00119	-0.00211	<b>0.05865</b>	-0.00166
<b>GFD</b>	0.00099	-0.00125	-0.03056	-0.0124	-0.00204	-0.00537	0.02967	0.002	<b>-0.07082</b>
<b>GY (rg)</b>	<b>0.115</b>	<b>0.102</b>	<b>-0.092</b>	<b>-0.205</b> <sup>**</sup>	<b>0.960</b> <sup>**</sup>	<b>0.113</b>	<b>0.328</b> <sup>**</sup>	<b>0.101</b>	<b>-0.011</b>

Residual - 0.06937

**Table.6** Direct (diagonal) and indirect path effects of different characters on grain yield per meter in late sown condition (E2)

Trait	DH	DA	DM	PH	ET	CFL	CT	GW	GFD
<b>DH</b>	<b>-0.19964</b>	-0.20118	-0.12288	-0.12188	-0.04174	-0.00866	-0.0041	0.04268	-0.00719
<b>DA</b>	0.32652	<b>0.32403</b>	0.20283	0.20145	0.06564	0.01523	0.01351	-0.07533	0.01079
<b>DM</b>	-0.02043	-0.02078	<b>-0.03319</b>	-0.0134	0.00228	-0.00411	-0.00372	0.01033	0.00286
<b>PH</b>	-0.03912	-0.03984	-0.02588	<b>-0.06408</b>	-0.01046	-0.01083	-0.00682	0.00842	0.00434
<b>ET</b>	0.19618	0.1901	-0.06439	0.15311	<b>0.93837</b>	-0.0149	0.24839	0.27929	-0.01445
<b>CFL</b>	0.00231	0.0025	0.00659	0.009	-0.00085	<b>0.05324</b>	0.00669	-0.00208	0.00148
<b>CT</b>	-0.00032	-0.00064	-0.00172	-0.00163	0.00406	-0.00193	<b>0.01534</b>	0.00476	-0.00157
<b>GW</b>	-0.0023	-0.00251	-0.00335	-0.00142	0.00321	-0.00042	-0.00334	<b>0.01078</b>	0.00017
<b>GFD</b>	0.00307	0.00284	-0.00735	-0.00576	-0.00131	0.00237	0.00871	0.00138	<b>0.08519</b>
<b>GY (rg)</b>	0.266 <sup>**</sup>	0.255 <sup>**</sup>	-0.049 <sup>NS</sup>	0.155 <sup>*</sup>	0.959 <sup>**</sup>	0.030 <sup>NS</sup>	0.274 <sup>**</sup>	0.280 <sup>**</sup>	0.082 <sup>NS</sup>

Residual - 0.06346

DH-Days to Heading, DA-Days to anthesis, DM-Days to maturity, PH-Plant height, ET-Effective tillers per meter, CFL-Chlorophyll fluorescence, CT-Canopy temperature, GY-Grain yield per meter, GW-Grain weight, GFD-Grain filling duration.

Canopy temperature showed positive and significant association with chlorophyll fluorescence under timely sown condition but under late sown condition the correlation was non-significant.

### **Path coefficient analysis**

Since correlation studies alone are not sufficient to make picture of association analysis very clear, hence the assessment of real contribution of an individual character towards seed yield per plant becomes essential. Path coefficient provides a clear and more realistic picture of a complex situation that exists at correlation level. It measures the direct as well as indirect effect of one variable on the dependent variable through the other traits. The path coefficient analysis was done on genotypic correlations and results have been presented in table 5 (Timely sown) and table 6 (Late sown).

A critical perusal of path coefficient analysis in which diagonal values is direct effects revealed that effective tillers per meter had highest positive direct effect on seed yield followed by days to anthesis, grain weight, plant height, days to maturity, canopy temperature and chlorophyll fluorescence under timely sown condition. Under late sown condition effective tillers per meter had a highest positive direct effect on seed yield followed by days to anthesis, grain filling duration, chlorophyll fluorescence, canopy temperature and grain weight. Similar finding were also reported by Nukasani *et al.*, (2013) for tillers per meter and grain weight per spike, by Bhushan *et al.*, (2013) for productive tillers per plant and test weight. The negative direct effect was recorded for days to heading and grain filling duration under timely sown condition and for days to heading, plant height and days to maturity under late sown condition. Similar results were also obtained by Bhushan *et al.*, (2013)

for days to heading, days to maturity and grain filling period. Contrary to these results Nukasani *et al.*, (2013) reported negative direct effect on grain yield although the magnitudes are very small. Residual factor value was found 0.06937 and 0.06346 under timely and late sown condition respectively indicated that there are some other factors influencing the grain yield, which were not being included in the study. From the results obtained in the present study, it can be concluded that effective tillers per meter and canopy temperature, in order, were the most important traits supporting grain yield in wheat. Therefore, more emphasis should be given on these traits while making selection for high yielding genotypes in wheat.

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