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Selection Parameters in Wheat Accessions Based on Various Morpho-Physiological Traits

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ABSTRACT

The experiment was carried out to assess the genetic variability, correlation and path coefficient analysis for 12 morphological and 6 physiological traits in 40 wheat accessions under normal sown irrigated conditions at CCS Haryana Agricultural University, Hisar during rabi 2018-19. The mean sum of squares due to genotypes were significant for all the morphological and physiological characters studied indicating thereby the prevalence of enough genetic variability in the materials under study. Phenotypic and genotypic coefficients of variation were highest for grain yield followed by biological yield, tillers per plant and plant height. High heritability coupled with high genetic advance reflected for grain yield, biological yield, plant height, peduncle length and tillers per plant, therefore, indicating the importance of these traits, which can be better utilized for crop improvement. Grain yield was significant and positively correlated with biological yield, harvest index, 1000 grain weight, grains per spike, tillers per plant, spike length, peduncle length, grain filling duration, NDVI1, NDVI2, SPAD1 and SPAD2; and significantly negative with days to heading, CT1 and CT2. Path coefficient analysis revealed highest positive direct effect of biological yield, harvest index, SPAD1 and SPAD2 on grain yield. Hence, due emphasis should be given to these attributes for genetic improvement of grain yield in wheat.

Key words: *Genetic variability, Correlation, Path analysis, Wheat.*

INTRODUCTION

Wheat (*Triticum aestivum* L.), a cereal grass of *Poaceae* family and of the genus *Triticum*, is the world’s largest cereal crop. It has been described as the ‘King of Cereals’ because of the acreage it occupies, high productivity and the prominent position it holds in the food grain trade. It occupies an inimitable position in human life as it is the major source of food and energy with a large number of end use products. Globally, India has the largest area under wheat cultivation and is the second largest producer after China.

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Nationally, wheat is the second most important food crop after rice. It is cultivated extensively in North-Western and Central zones. India has reported a record production of 101.20 million tonnes wheat from an area of 29.55 million hectare during the crop season 2018-19 with a productivity of 34.24 q/ha. In Haryana, 11.65 million tonnes wheat was produced on an area of 2.51 million hectare with average productivity of 46.43 q/ha (ICAR-IIWBR, 2019).

The extent of genetic variability has been considered as a key factor which is an essential pre-requisite for a successful hybridization aimed at developing promising strains. The selection of parents becomes more complicated if the improvement is to be achieved for a quantitative and/or polygenetically controlled complex character like grain yield. In this regard, information on nature and magnitude of genetic variability is of immense value for starting any systematic breeding programme in crops. The presence of considerable genetic variability in the base material ensures better chances of evolving desired plant types. The knowledge of genetic parameters *viz.,* heritability and genetic advance among characters under selection is very useful for predicting genetic progress in breeding programme and developing efficient breeding strategies. Correlation coefficients describe associations among independent characters and delineate the direction of varied relationship. In addition, path analysis further clarifies the relationship by separating direct and indirect effects by partitioning the correlation coefficient.

The present study is an attempt to evaluate genetic variability and to determine correlation coefficient and path analysis among different morphological and physiological traits in wheat accessions under normal sown irrigated conditions.

MATERIALS AND METHODS

The present study was conducted at Research Area of Wheat and Barley Section of Department of Genetics & Plant Breeding, CCS Haryana Agricultural University, Hisar, which is located at latitude of 29º 10' N, longitude of 75º 46' E and at an altitude of 215.2 meters above mean sea. The experimental material consisted of 40 wheat accessions along with four check varieties namely WH 711, WH 542, WH 1124 and HD 3059 grown in randomized block design (RBD) with 3 replications during *rabi* 2018-19. The experiment was planted on 24th November and kept under normal agronomic care from sowing to maturity. Each accession was planted in paired rows of 2.5m length with inter-row and inter-plant distances of 20 and 10 cm, respectively. The experiment was conducted under optimum input conditions (150 kg N, 60 kg P_2O_5 and 25 kg $ZnSO_4$ per hectare based on soil testing reports). Observations were recorded at specific stage on five randomly selected plants per accession per replication for the 12 morphological traits *viz*., days to heading, days to maturity, grain filling duration, plant height (cm), peduncle length (cm), tillers per plant, spike length (cm), grains per spike, 1000 grain weight (g), grain yield per plant (g), biological yield per plant (g) and harvest index (%) and 6 physiological traits *viz.*, normalized difference vegetation index at anthesis (NDVI 1), normalized difference vegetation index at 15 days after anthesis (NDVI 2), canopy temperature at anthesis (CT 1), canopy temperature at 15 days after anthesis (CT 2), soil plant chlorophyll development at anthesis (SPAD 1), and soil plant chlorophyll development at 15 days after anthesis (SPAD 2).

The mean performance of each accession was recorded and employed for statistical analysis. Analysis of variance to test the significance for each character was carried out as per methodology advocated by Fisher (1925) and described by Panse and Sukhatme (1967). Phenotypic coefficient of variability (PCV) and Genotypic coefficient of variability (GCV) were calculated by the formula given by Burton (1952), heritability in broad sense (h^2) was calculated by using the formula suggested by Hanson et al. (1956) and genetic advance that is the expected genetic gain was calculated by using the procedure given by Johnson et al. (1955). Correlation and path coefficients were worked out as per method suggested by Al-Jibouri et al. (1958) and Dewey and Lu (1959), respectively.

RESULTS AND DISCUSSION

The pool of forty accessions and four check varieties was, assessed for genetic variability and association analysis. The mean sum of squares for different traits under study has been presented in Table 1. The results indicated hereby that mean sum of squares due to genotypes were highly significant for all the morphological and physiological characters studied indicating thereby the prevalence of enough genetic variability in the material for selection and improvement. The basic material, therefore, offers positive opportunities for investigation furtherance of the aforesaid objectives. The existence of significant variability has also been reported by Kumari et al. (2017) and Suresh et al. (2018) for morphological traits and by Sharma et al. (2018) and Sangwan et al. (2018) for physiological traits in wheat.

The estimates of genetic variability parameters for all the characters are presented in Table 2. In general, the results revealed wide range for all the traits under investigation. Phenotypic coefficients of variation (PCV) were greater than genotypic coefficients of variation (GCV) for all the characters which reflect the influence of environment on the expression of traits. GCV accounted for a major portion of PCV for all the characters studied, indicating that the genotypes were reflected by the phenotype and selection based on phenotypic performance could prove to be effective for these characters. The estimates of phenotypic and genotypic coefficients of variation varied from 3.36 to 20.70 % and 2.64 to 18.82 %, respectively. The perusal of data revealed highest phenotypic and genotypic coefficients of variation for grain yield followed by biological yield, tillers per plant and plant height, indicating availability of sufficient genetic variability and thus exhibited scope for genetic improvement through selection. However, days to heading and maturity exhibited least phenotypic and genotypic coefficients of variation. Similar findings were also reported by Nukasani et al. (2013), Parnaliya et al. (2015), Ali and Abdulla (2016), Arya et al. (2017), Meles et al. (2017), Neeru et al. (2017) and Rathwa et al. (2018) in wheat.

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. Heritability in broad sense was found to be maximum for plant height (86.37 %) and minimum for days to maturity (61.71%). The estimates of heritability are more advantageous when expressed in terms of genetic advance. Johnson et al. (1955) advocated that for selection to be effective, heritability and genetic advance should be considered together. High heritability coupled with high genetic advance reflected for grain yield, biological yield, plant height, peduncle length and tillers per plant, therefore, the variability present in these traits was of additive nature, which can be better utilized for crop improvement. These findings confirm with the results obtained by Kumari et al. (2017), Neeru et al. (2017), Rathwa et al. (2018) and Suresh et al. (2018).

Correlation analysis was done separately for morphological and physiological traits, whose results have been presented in Table 3 and 4, respectively. The grain yield was significant and positively correlated with biological yield, harvest index, 1000 grain weight, grains per spike, tillers per plant, spike length, peduncle length and grain filling duration; and significantly negative with days to heading. Significant positive correlation was also observed for days to heading with days to maturity; days to maturity with grain filling duration; grain filling duration with plant height, peduncle length, spike length, tillers per plant, grains per spike, 1000 grain weight and biological yield; plant height with peduncle length, tillers per plant, 1000 grain weight and biological yield; peduncle length with tillers per plant, 1000 grain weight and biological yield; spike length with grains per spike and harvest index; tillers per plant with 1000 grain weight and biological yield; grains per spike with 1000 grain weight, biological yield and harvest index; 1000 grain weight with biological yield. Ayer et al. (2017) also recorded positive correlation of grain yield with biological yield, harvest index, 1000 grain weight, number of grains per spike and peduncle length. Similar results of correlation were also imitated in the findings of Mohanty et al. (2016), Islam et al. (2017), Suresh et al. (2018), Baye et al. (2020) and Sareen et al. (2020).

Significant negative correlation was recorded for days to heading with grain filling duration, plant height, peduncle length, spike length, tillers per plant and biological yield; days to maturity with tillers per plant; plant height with harvest index; peduncle length with number of grains per spike and harvest index; tillers per plant with harvest index, and biological yield with harvest index.

The estimates of genotypic correlation coefficients among different physiological traits and with grain yield are depicted in Table 4. The results revealed significant positive correlation of grain yield with physiological traits *viz.,* NDVI 1, NDVI 2, SPAD 1 and SPAD 2, however canopy temperature (CT 1 & 2) exhibited significant negative correlation with grain yield. Islam et al. (2017) and Mansouri et al. (2018) also observed negative correlation between grain yield and canopy temperature. Significant positive correlation was observed for NDVI 1 with NDVI 2 and SPAD 2; NDVI 2 with SPAD 2; CT 1 with CT 2; and SPAD 1 with SPAD 2. Likewise, significant negative correlation was recorded for NDVI 1 with CT 1 and CT 2; NDVI 2 with CT 1; CT 1 with SPAD 2; and CT 2 with SPAD 2. These findings were further validated by the results of Del Pozo et al. (2016), Sultana et al. (2014) and Kumar et al. (2018).

The results of path coefficient analysis for morphological traits are presented in Table 5 and for physiological traits in Table 6. Biological yield (0.900) exerted the highest positive direct effect on grain yield followed by harvest index (0.761) and plant height (0.081). These results are in line with the findings of Ali and Abdulla (2016), Islam et al. (2017), Suresh et al. (2018) and Baye et al. (2020). The highest negative direct effect on grain yield was recorded for days to maturity (-0.066). Parnaliya et al. (2015) and Baye et al. (2020) also reported the negative direct effect of days to maturity on grain yield, which support our finding. The results also showed maximum positive indirect effect of tillers per plant on grain yield through biological yield, whereas, plant height exhibited highest negative indirect effect *via* harvest index. The low residual effect (0.0079) indicated that most of the variability in grain yield for the genotypes under study has been explained by the independent variables included in the analysis.

Among physiological characters, SPAD 1 had highest direct effect on grain yield, followed by SPAD 2, NDVI 2, NDVI 1, CT 1 and CT 2. Similar findings were also reported by Mądry et al. (2015), Neeru et al. (2017) and Khanal et al. (2020). The trait NDVI 1 had highest positive, while CT 1 recorded with highest negative indirect effect on grain yield through CT 2. A residual factor of 0.544 depicted that six physiological parameters used in the study were unable to account for a major portion of the variability present in grain yield. It also denotes that other possible independent variables which were not included in the study had a significant effect on grain yield.

A thorough study of correlation and path analysis concluded that the traits biological yield, harvest index, SPAD 1, CT 1 and CT 2 depicted a true association with grain yield, as the magnitude of their correlation coefficients and direct path effects were comparable. Consequently, it is suggested that these parameters can be considered as key component traits for adequate selection in wheat improvement.

Table 1: Mean sum of squares for different traits in wheat accessions

Source of Variation	d. f.	Mean sum of squares								
		DH	DM	GFD	PH	PL	SL	TIL	GPS	TGW
Replication	2	4.099	1.909	2.599	43.080	1.812	0.240	0.022	11.949	4.244
Genotypes	43	81.137**	50.765**	33.108**	939.691**	127.044**	3.475**	5.989**	138.27**	80.274**
Error	86	13.874	8.700	4.560	47.002	6.690	0.343	0.430	10.312	5.099

Continued….

Source of Variation	d. f.	Mean sum of squares								
		BY	GY	HI	NDVI 1	NDVI 2	CT 1	CT 2	SPAD1	SPAD2
Replication	2	17.970	3.232	3.046	0.005	0.002	4.772	3.750	0.895	1.877
Genotypes	43	149.428**	18.349**	68.679**	0.017**	0.012**	17.555**	22.257**	35.283**	127.372**
Error	86	9.082	1.200	6.102	0.002	0.001	2.791	1.923	5.874	13.793

****Significant at 1 % level**

(**DH**: Days to heading, **DM**: Days to maturity, **GFD**: Grain filling duration, **PH**: Plant height, **PL**: Peduncle length, **SL**: Spike length, **TIL**: Tillers per plant, **GPS**: Grains per spike, **TGW**: 1000-grain weight, **BY**: Biological yield per plant, **GY**: Grain yield per plant, **HI**: Harvest index, **NDVI1**: Normalized difference vegetation index at anthesis, **NDVI 2**: Normalized difference vegetation index at 15 days after anthesis, **CT 1**: Canopy temperature at anthesis, **CT 2**: Canopy temperature at 15 days after anthesis, **SPAD 1**: Soil plant chlorophyll development at anthesis, **SPAD 2**: Soil plant chlorophyll development at 15 days after anthesis)

Table 2: Genetic variability parameters for different traits in wheat accessions

Trait	Mean ± SE	Range	GCV (%)	PCV (%)	Heritability (bs) (%)	Genetic Advance (% of mean)
DH	99.58 ± 2.15	88.67 - 109.67	4.76	6.05	61.78	7.70
DM	142.09 ± 1.70	132.67 - 149.00	2.64	3.36	61.71	4.27
GFD	36.99 ± 1.23	28.33 - 42.33	8.34	10.14	67.61	14.13
PH	107.71 ± 3.96	77.90 - 146.3	16.02	17.23	86.37	30.66
PL	39.74 ± 1.49	27.40 - 51.80	15.94	17.22	85.71	30.40
SL	11.79 ± 0.34	9.47 - 14.07	8.66	9.99	75.27	15.49
TIL	8.49 ± 0.38	5.60 - 12.33	16.03	17.79	81.18	29.76
GPS	60.2 ± 1.85	47.07 - 70.20	10.85	12.09	80.53	20.06
TGW	36.79 ± 1.30	26.03 - 50.36	13.61	14.93	83.09	25.55
BY	36.77 ± 1.74	23.04 - 52.08	18.60	20.33	83.74	35.06
GY	12.71 ± 0.63	6.57 - 17.97	18.82	20.70	82.65	35.24
HI	34.87 ± 1.43	24.41 - 44.22	13.10	14.89	77.36	23.73
NDVI 1	0.79 ± 0.02	0.67 - 0.86	8.99	10.30	76.12	16.16
NDVI 2	0.72 ± 0.02	0.60 - 0.81	8.37	9.81	72.72	14.70
CT 1	20.29 ± 0.97	17.50 - 25.13	10.93	13.69	63.81	17.99
CT 2	26.93 ± 0.80	21.93 - 30.33	9.67	10.95	77.90	17.58
SPAD 1	50.41 ± 1.40	43.93 - 57.03	6.21	7.86	62.53	10.12
SPAD 2	45.49 ± 2.14	31.80 - 55.83	13.53	15.80	73.30	23.85

(**DH**: Days to heading, **DM**: Days to maturity, **GFD**: Grain filling duration, **PH**: Plant height, **PL**: Peduncle length, **SL**: Spike length, **TIL**: Tillers per plant, **GPS**: Grains per spike, **TGW**: 1000-grain weight, **BY**: Biological yield per plant, **GY**: Grain yield per plant, **HI**: Harvest index, **NDVI1**: Normalized difference vegetation index at anthesis, **NDVI 2**: Normalized difference vegetation index at 15 days after anthesis, **CT 1**: Canopy temperature at anthesis, **CT 2**: Canopy temperature at 15 days after anthesis, **SPAD 1**: Soil plant chlorophyll development at anthesis, **SPAD 2**: Soil plant chlorophyll development at 15 days after anthesis)

Table 3: Genotypic correlation coefficients among different morphological traits in wheat accessions

Traits	DH	DM	GFD	PH	PL	SL	TIL	GPS	TGW	BY	HI	GY
DH	1.000	0.573**	-0.630**	-0.382**	-0.475**	-0.181*	-0.271**	-0.096	-0.154	-0.312**	0.015	**-0.311****
DM		1.000	0.457**	-0.163	-0.124	0.053	-0.219*	-0.013	-0.137	-0.100	0.044	**-0.126**
GFD			1.000	0.249**	0.411**	0.201*	0.186*	0.185*	0.204*	0.362**	0.042	**0.326****
PH				1.000	0.841**	-0.157	0.289**	-0.079	0.284**	0.538**	-0.567**	**0.139**
PL					1.000	-0.049	0.250**	-0.245**	0.283**	0.551**	-0.493**	**0.186***
SL						1.000	-0.159	0.293**	-0.026	0.031	0.208*	**0.178***
TIL							1.000	0.024	0.440**	0.588**	-0.212*	**0.399****
GPS								1.000	0.385**	0.175*	0.331**	**0.417****
TGW									1.000	0.507**	0.092	**0.546****
BY										1.000	-0.300**	**0.718****
HI											1.000	**0.437****
GY												**1.000**

***, **Significant at 5 % and 1% level, respectively**

(**DH**: Days to heading, **DM**: Days to maturity, **GFD**: Grain filling duration, **PH**: Plant height, **PL**: Peduncle length, **SL**: Spike length, **TIL**: Tillers per plant, **GPS**: Grains per spike, **TGW**: 1000-grain weight, **BY**: Biological yield per plant, **GY**: Grain yield per plant, **HI**: Harvest index)

Table 4: Genotypic correlation coefficients among different physiological traits and grain yield in wheat accessions

Physiological Traits	NDVI 1	NDVI 2	CT 1	CT 2	SPAD 1	SPAD 2	GY
NDVI 1	1.000	0.382**	-0.314**	-0.472**	0.101	0.213*	**0.359****
NDVI 2		1.000	-0.206*	-0.141	0.052	0.692**	**0.249****
CT 1			1.000	0.272**	-0.041	-0.265**	**-0.398****
CT 2				1.000	-0.147	-0.295**	**-0.543****
SPAD 1					1.000	0.529**	**0.353****
SPAD 2						1.000	**0.439****
GY							**1.000**

***, **Significant at 5 % and 1% level, respectively**

(**NDVI 1**: Normalized difference vegetation index at anthesis, **NDVI 2**: Normalized difference vegetation index at 15 days after anthesis, **CT 1**: Canopy temperature at anthesis, **CT 2**: Canopy temperature at 15 days after anthesis, **SPAD 1**: Soil plant chlorophyll development at anthesis, **SPAD 2**: Soil plant chlorophyll development at 15 days after anthesis, **GY**: Grain yield per plant)

Table 5: Direct (diagonal values) and indirect effects of different morphological traits on grain yield in wheat accessions

Traits	DH	DM	GFD	PH	PL	SL	TIL	GPS	TGW	BY	HI	Correlation with GY
DH	**0.033**	-0.038	0.010	-0.031	-0.012	-0.002	-0.003	-0.003	0.005	-0.281	0.011	**-0.311****
DM	0.019	**-0.066**	-0.007	-0.013	-0.003	0.001	-0.003	-0.001	0.004	-0.090	0.033	**-0.126**
GFD	-0.021	-0.030	**-0.015**	0.020	0.010	0.002	0.002	0.006	-0.006	0.326	0.032	**0.326****
PH	-0.013	0.011	-0.004	**0.081**	0.021	-0.002	0.004	-0.003	-0.008	0.484	-0.432	**0.139**
PL	-0.016	0.008	-0.006	0.068	**0.025**	-0.001	0.003	-0.008	-0.008	0.496	-0.375	**0.186***
SL	-0.006	-0.004	-0.003	-0.013	-0.001	**0.009**	-0.002	0.010	0.001	0.028	0.158	**0.178***
TIL	-0.009	0.015	-0.003	0.023	0.006	-0.002	**0.012**	0.001	-0.013	0.530	-0.161	**0.399****
GPS	-0.003	0.001	-0.003	-0.006	-0.006	0.003	0.000	**0.034**	-0.011	0.157	0.252	**0.417****
TGW	-0.005	0.009	-0.003	0.023	0.007	0.000	0.005	0.013	**-0.029**	0.456	0.070	**0.546****
BY	-0.010	0.007	-0.006	0.043	0.014	0.000	0.007	0.006	-0.015	**0.900**	-0.229	**0.718****
HI	0.001	-0.003	-0.001	-0.046	-0.012	0.002	-0.003	0.011	-0.003	-0.271	**0.761**	**0.437****

Residual factor = 0.0079

(**DH**: Days to heading, **DM**: Days to maturity, **GFD**: Grain filling duration, **PH**: Plant height, **PL**: Peduncle length, **SL**: Spike length, **TIL**: Tillers per plant, **GPS**: Grains per spike, **TGW**: 1000-grain weight, **BY**: Biological yield per plant, **GY**: Grain yield per plant, **HI**: Harvest index)

Table 6: Direct (diagonal values) and indirect effects of different physiological traits on grain yield in wheat accessions

Physiological Traits	NDVI 1	NDVI 2	CT 1	CT 2	SPAD 1	SPAD 2	Correlation with GY
NDVI 1	**0.034**	0.022	0.074	0.186	0.023	0.019	**0.363****
NDVI 2	0.013	**0.058**	0.048	0.056	0.012	0.063	**0.233****
CT 1	-0.011	-0.012	**-0.235**	-0.107	-0.009	-0.024	**-0.398****
CT 2	-0.016	-0.008	-0.064	**-0.394**	-0.034	-0.027	**-0.543****
SPAD 1	0.003	0.003	0.010	0.058	**0.231**	0.048	**0.353****
SPAD 2	0.007	0.040	0.062	0.116	0.122	**0.091**	**0.439****

Residual factor = 0.5441

(**NDVI 1**: Normalized difference vegetation index at anthesis, **NDVI 2**: Normalized difference vegetation index at 15 days after anthesis, **CT 1**: Canopy temperature at anthesis, **CT 2**: Canopy temperature at 15 days after anthesis, **SPAD 1**: Soil plant chlorophyll development at anthesis, **SPAD 2**: Soil plant chlorophyll development at 15 days after anthesis, **GY**: Grain yield per plant)

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