Research Article

Study of genetic variability for morphological traits in bread wheat across sowing dates

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Abstract

The research was carried out with the objective to estimate genetic variability for morphological traits in wheat. Twenty wheat genotypes along with 2 checks were planted at Cereal Section Research Institute (CCRI) Pirsabak under two sowing dates. Analysis of variance revealed highly significant differences among genotypes for majority of the traits. Mean days to heading ranged from 106 to 113, days to maturity ranged from 145 to 151 days, plant height ranged from 92 to 108 cm, grain yield per hectare ranged from 2117 to 3984 kg ha⁻¹ and biological yield ranged from 8611 to 11250 kg ha⁻¹. Genetic and phenotypic variances were greater than environmental variances for all the traits however; genetic, phenotypic and environmental variances were almost minor (20.10, 24.03 and 2.19) for days to maturity and maximum (3354401.62, 5824977.32 and 908395.70) for biological yield, respectively. However, interaction between genotypes and sowing dates were almost negligible (1.74) for days to maturity and maximum (1562179.99) for biological yield. Regarding coefficients of variation (CV), values ranged from 0.85 to 9.28 for tested traits. According to mean performance, the genotypes viz., PS-23, PS-33, PS-34 and PS-28 showed high performance. However, the genotype Inq-91/FS(f8) was found to be the most stable in performance in both conditions and therefore, these genotypes could be used in future wheat breeding programs to enhance the grain yield in bread wheat.

Keywords: Genetic variability; Grain yield; Genetic and phenotypic variability; Bread wheat

Introduction

Wheat, a winter cereal commonly used as a staple food [1]. It provides food to 36% of the global population and contributes towards 20% food calories. It feeds 36% of the world population and contributes 20% of all food calories. Wheat is a major cereal crop farmed

on more than 240 million hectares (ha) around the world, more than any other crop. Wheat has more hectares in the world than all other crops combined [2]. Wheat is the most important source of vegetable protein in human food, with higher protein content than corn, rice, and other major cereals

worldwide. By 2020, the world's wheat demand is expected to be between 840 and 1000 million tonnes [3].

Wheat can be cultivated under both the irrigated as well as rainfed conditions [4]. Approximately, 8.74 million hectares of wheat crop were planted in Pakistan in 2018-2019. Wheat was planted on 0.74 million hectares in Khyber Pakhtunkhwa in 2018-2019, yielding 1.36 million tonnes with a total production of 1860 kg ha⁻¹ [5].

Climate change, a growing scarcity of water resources, and a deteriorating environment had a significant impact on wheat production [6]. One of the major causes of wheat yield decline is the cultivation of varieties of low genetic potential [7]. Wheat breeders are focussing their efforts to improve yield variability by producing new high yielding varieties with favourable genetic makeup in order to boost wheat output. The genetic potential of diverse genotypes of distinct morpho-yield traits is essential for a successful breeding program [8].

Variability refers to the occurrence of variances among individuals as a result of differences in their genetic makeup and upbringing. If the character expression of two people could be assessed in the same environment, the differences in expression would be due to genetic control, and this variation would be referred to as genetic variation [9]. Genetic variability, which arises from genetic variances among individuals in a population, is at the part of plant breeding because good variety management can result in long-term improvements in plant performance as well as seasonal changes [10]. To support and sustain a successful long-term wheat breeding program, genetic diversity, is necessary on a significant level within a population. The magnitude of genetic diversity in the population has been observed to be closely related to selection progress [11]. In the original accessions and races

across sampled populations representing various climatic and geographical locales, a significant level of genetic variability has been observed [12].

In light of the foregoing facts and figures, the current research was carried out with the following objectives: 1: to assess the extent of genetic variability in bread wheat genotypes. 2: Genotype $\times$ sow dates interaction in wheat cultivars. 3: for the estimation of coefficient of variation.

Materials and Methods

Experimental site, material and design

The study was conducted during 2015-2016 at the Cereal Crops Research Institute (CCRI) Pirsabak Nowshera, located at 340 North Latitude, 720 East Longitude, and 2880 Altitude. Twenty wheat genotypes, including two checks (Pakhtunkhwa-2015 and Pirsabak-13), were planted in a randomized complete block design (RCBD) with three replications on two different sowing dates: normal sowing November 24th and late sowing December 25th, 2015. A plot of 9 m² area was used having four rows of 1.5 meters length and 30 cm apart. The paternal genotypes are detailed in (Table 1). From sowing to harvesting, all agronomic practices were applied uniformly.

Data collection

Data was collected on the following parameters using a standard approach specified by several writers and researchers. Days to heading were counted from the time of seeding to the time when 50% of the plants had finished heading. Days to maturity were calculated as the number of days when 90 percent of the plants in a plot reach physiological maturity. Plant height was measured in cm from the soil surface to the top of the spike, excluding awns, at physiological maturity. Grain yield was recorded in each subplot by harvesting the material, sun dried and threshed separately and was converted to kg ha⁻¹. At maturity, each plant was harvested separately and

weighed with an electronic scale before threshing to determine biological yield.

Statistical analysis

Micro Soft excel was used to statistically evaluate the data relevant to the aforesaid characters. In addition, the analysis of variances package is given below (Table 2).

Estimation of genetic variability

The genotypic, phenotypic and environmental variances were calculated by the following formulas:

$$\text{Genetic variance (Vg)} = \frac{M1-M2}{RSD}$$

$$VG \times SD = \frac{M2-M3}{R}$$

While, environmental Variance (Ve) is M_3 and $VP = VG + VG \times SD + VE$

Results

Days to heading

Combined analysis of variance stated that mean square depicts significant differences among different genotypes and sowing dates, while genotype $\times$ sowing dates interaction was found non-significant for days to heading (Table 3). Minimum days to heading (106) were recorded for CDRI-SA-12 and DN-123 followed by SRN-13121 and PS-23 (107). Similarly, Maximum days (113 days) to heading were observed for CDRI-PV-1, followed by PS-34 and DN-120 with 112 and 112 days to heading, respectively (Table 4). Similarly, phenotypic variance (31.66) and genetic variance (25.97) were greater than environmental variance (3.22) and genotype $\times$ sowing dates interaction (2.48) for days to heading and coefficients of variance (1.40) which indicated of genotypic variability for days to heading (Table 5).

Days to maturity

Combine analysis of variance for days to maturity stated that mean square showed significant differences between different genotypes and sowing dates, while genotype $\times$ sowing dates interaction was found non-significant (Table 3). Therefore, the minimum days to maturity (145) was reported for DN-123 followed by Pirsabak-13, CDRI-PV-2 and CDRI-SA-12. Similarly,

maximum days (151) to maturity were observed for PS-28, followed by CT-13169 and PS-34 with the same 150 days to maturity, as respectively (Table 4). Likewise, phenotypic variance (24.03) and genetic variance (20.10) was greater than environmental variance (2.19) and genotype $\times$ sowing dates interaction (1.74) for days to maturity and coefficients of variance (0.85) showed narrow range of genotypic variability along with less influence of environment for the expression of days to maturity (Table 5).

Plant height

Mean square showed significant differences among different genotype and sowing dates ($p \leq 0.001$) for plant height while the interaction for genotype $\times$ sowing dates was also found highly significant as evident from the analysis of variance in mean square (Table 3). Mean data for plant height varied from 91.50 to 108.00. Maximum plant height (108 cm) was observed in genotype PS-28, while genotype Pirsabak-13 was recorded minimum for plant height (91.50) (Table 4). Furthermore, Phenotypic variance (165.16cm) and genetic variance (131.45cm) was greater than environmental variance (10.41cm) and genotype $\times$ sowing dates interaction was (23.30) for plant height and coefficients of variance for the said attribute was (2.74) (Table 5).

Biological yield

The (Table 3) showed that biological yield was significantly affected by sowing dates, genotypes and the interaction between G $\times$ SD. The mean range for biological yield was ranging between 8611.11 to 11250.00 kg ha⁻¹. Among the genotypes maximum biological yield was observed for PS-23 (11250.00 kg ha⁻¹) followed by SRN-13121 (10972.22 kg ha⁻¹), while minimum was recorded for AUP-07014 (8611.11) followed by CDRI-SA-12 (8750.00). However, the remaining genotypes showed medium performance for the said attribute (Table 4). Moreover, phenotypic variance (5824977.32) and

genetic variance (3354401.62) was greater than environmental variance (908395.70) and genotype $\times$ sowing dates interaction (1562179.99) for plant height and coefficients of variance (8.00) showed the genotypic variability along with less influence of environment for the expression of the said trait (Table 5).

Grain yield per plant

The mean square for grain yield depicts highly significant variation due to genotypes in two sowing dates and genotype $\times$ sowing dates interaction was also found highly significant (Table 3). This suggested that the magnitude of differences in genotypes was sufficient to provide some scope for selecting genotypes with improved heat stress tolerance. The main effect of sowing dates regimes and the interaction between genotypes $\times$ sowings dates regimes were highly significant for the measured traits. Grain yield of genotypes varied, particularly under stress conditions, the average grain yield was recorded in all wheat genotypes which ranged between 2116.67 to 3983.89. Among all the genotypes, maximum grain yield was observed for PS-34 (3983.89), followed by PS-23 (3786.67). Similarly, minimum was reported for CDRI-SA-12 (2116.67). However, the remaining genotypes showed medium performance for the said attribute (Table 4). Moreover, phenotypic variance (1603499.81) and genetic variance (1117393.60) was greater than environmental variance (125365.31) and genotype $\times$ sowing dates interaction (360740.90) for plant height and coefficients of variance (9.28) showed the high of genotypic variability along with less influence of environment for the expression of the said trait (Table 5).

Discussion

Plant breeders are interested in developing novel wheat genotypes with early maturity since it is desirable. As a result of the delayed heading, there is less time for grain filling,

resulting in lesser grain weight. Early-heading genotypes can have a longer grain filling period, allowing them to finish a higher portion of the grain filling earlier in the season when air temperatures are cooler and more suitable for wheat [13]. Our results are in line with [14] who reported genotypic (27.01) and phenotypic variance (29.58) for days to heading. Further our results are also in conformity with those reported by [15].

Physiological maturity in grains crops refers to the attainment of maximum seed dry weight. Because the crop is prone to several sources of stress such as lodging, pre-harvest sprouting, hail, and biological challenges, knowing when the crop reaches physiological maturity is critical in particular situations [16]. Our result of days to maturity was not in line with [17] who reported genotypic and phenotypic variance respectively. Our results were different and high genotypic, phenotypic and environment variation found because our genotypes evaluated at two sowing dates. Our results are contradictory to [18] who reported environmental, phenotypic, and genotypic and (CV) coefficient of variances for days to maturity, respectively.

Wheat breeding programs use plant height as a crucial criterion. Short stature genotypes are chosen by plant breeders because they help increase lodging resistance and respond well to nutrients and irrigation in wheat [19]. Because taller plants are more likely to lodge and require more energy to transmit photosynthates to the grains in wheat [20], shorter plants are necessary. According to genotypic variance (V_g) and phenotypic variation (V_p) our calculated variation was not matching to [21] who reported the genotypic, phenotypic and environmental variance, respectively. Likewise, our finding was not similar to [22]. Results further revealed that plant height might be an effective trait to select higher yielding genotypes. Our result was different from [23]

who reported a high level of genotypic and environmental variance.

In our results of biological yield genetic, phenotypic, environmental and (CV) coefficient of variance is not similar to [24]. Similarly, our results were different from [25] who reported phenotypic, genotypic, environment and coefficient of variance for biological yield. Grain yield is a complicated feature, and plant breeders are primarily concerned in developing high-yielding genotypes to meet the countries food requirement. In wheat plant breeding projects, differences in genotypes for grain yield and yield-related traits are the most important concern [26]. The magnitude of difference between VG, VP, VG×SD, VE and CV was relatively high for grain yield. This implies greater influence of environmental factors for the phenotypic

expression of these characters that make difficult or practically impossible to exercise selection based on phenotypic performance of the genotypes to improve the characters. In our results genetic variance and phenotypic variance for grain yield was greater than environmental variance. My result was opposite to [27] who reported environmental, genotypic and phenotypic variance for grain yield.

Wheat genotypes yielded dramatically different amounts of grain in both conditions. As a result, the overall scenario revealed that genetic variability plays a substantial role, implying the use of integrated heat stress breeding strategies that might possibly harness additive and non-additive genetic variability under normal and heat stress conditions.

Table 1. List of wheat genotypes along with station and parentage used in study during 2015-16 at CCRI, Pirsabak Nowshera

S. No.	Genotypes	Breeding Station	S. No.	Genotypes	Breeding Station
1.	Inq-91/FS(f8)	NIFA Pesh.	11.	PS-33	CCRI Pirsabak
2.	SRN-13121	NIFA Pesh.	12.	PS-34	CCRI Pirsabak
3.	CT-13052	NIFA Pesh.	13.	PS-35	CCRI Pirsabak
4.	CT-13169	NIFA Pesh.	14.	AUP-05814	PBG (UAP)
5.	DN-120	ARI D.I. Khan	15.	AUP-07014	PBG (UAP)
6.	DN-122	ARI D.I. Khan	16.	CDRI-PV-1	NARC Islamabad
7.	DN-123	ARI D.I. Khan	17.	CDRI-PV-2	NARC Islamabad
8.	PS-22	CCRI Pirsabak	18.	CDRI-SA-12	NARC Islamabad
9.	PS-23	CCRI Pirsabak	19.	Pakhtunkhwa-2015	CCRI Pirsabak
10.	PS-28	CCRI Pirsabak	20.	Pirsabak-13	CCRI Pirsabak

Table 2. Analysis of variance model used for 20 bread wheat genotypes, evaluated during the year 2015-16 at CCRI, Pirsabak Nowshera

Source of variation	Mean square	Expected mean square
Sowing Date (SD)	M1	-----
Replication (SD)	M2	-----
Genotype (G)	M3	Ve + Vgsd + rsd Vg
G × SD	M4	Ve + rVgsd
Error	M5	Ve
Total		-----

Table 3. Mean sum of square for days to heading (DH), days to maturity (DM), plant height (PH), biological yield (BY) and grain yield (GY) of 20 wheat genotypes including two checks cultivars evaluated two sowing dates during the year 2015-16 at CCRI, Pirsabak Nowshera

SOV	DF	DH	DM	PH	BY	GY
SD	1	11880.30	28152.03	2557.63	442368000.00	43882675.93
Rep/SD	4	4.54	2.88	14.69	988444.44	392794.26
Gen	19	26.75	20.96	133.27	3354403.51	1117394.62
G x SD	19	3.55	2.47	26.77	1864978.56	402529.34
Error	76	3.22	2.19	10.41	908395.71	125365.31

Table 4. Pooled mean performance of twenty wheat genotypes evaluated in two different sowing dates with two checks for various characters, and at CCRI Pirsabak Nowshera during 2015-16

Genotypes	Days to heading	Days to maturity	Plant height	Biological yield	Grain yield
Inq-91/FS(f8)	109	149	93.67	9427.78	3388.89
SRN-13121	107	148	99.83	10972.22	3231.67
CT-13052	108	147	102.00	10138.89	3401.67
CT-13169	112	151	92.83	9722.22	3186.67
DN-120	112	149	100.67	8972.22	2824.44
DN-122	108	148	95.83	9722.22	3067.78
DN-123	107	145	100.00	10694.44	3457.78
PS-22	110	151	100.67	10555.56	3577.78
PS-23	107	147	107.33	11250.00	3786.67
PS-28	109	151	108.00	10833.33	3653.33
PS-33	108	147	107.83	10416.67	3335.00
PS-34	112	151	99.00	10555.56	3983.89
PS-35	106	148	101.83	10555.56	3372.22
AUP-05814	110	148	99.67	10000.00	2846.67
AUP-07014	111	150	96.50	8611.11	2636.11
CDRI-PV-1	113	150	99.83	10277.78	2842.78
CDRI-PV-2	108	146	99.17	10694.44	3440.56
CDRI-SA-12	106	146	103.50	8750.00	2116.67
Pakhtunkhwa-2015	108.00	147.33	105.33	10694.44	3541.67
Pirsabak-13	107.67	145.67	91.50	9722.22	3178.89
LSD at 5%	2.26	1.86	4.08	1200.65	446

Table 5. Genetic variability, genotypic, phenotypic and environmental variance and genotype × sowing dates interaction for days to heading (DH), day to maturity (DM), plant height (PHT), biological yield (BY) and grain yield (GY) of 20 genotypes including two checks cultivars evaluated during the year 2015-16 at CCRI, Pirsabak Nowshera

Traits	DH	DM	PHT	BY	GY
VG	25.97	20.10	131.45	3354401.62	1117393.60
VGSD	2.48	1.74	23.30	1562179.99	360740.90
VP	31.66	24.03	165.16	5824977.32	1603499.81
VE	3.22	2.19	10.41	908395.70	125365.31
CV	1.40	0.85	2.74	8.00	9.28

Conclusion

Analysis of variance showed highly significant differences for majority of the traits, and showed greater genetic variability and hence can be used for upgrading of obtainable cultivars or releasing as new variety. Almost all the traits were found highly genetic variance and genotype $\times$ sowing dates interaction suggested that improvement for most of the yielding traits is possible in early generation of selection. The tested genotypes in stress and non-stress conditions Inq-91/FS(f8), AUP-05814, PS-34 and PS-28 were identified as superior lines for future wheat breeding programs and could be released as new tolerant and resistant variety to biotic and abiotic stress after multi-location trials.

Authors' contributions

Conceived and designed the experiments: M Uzair & H Khan, Performed the experiments: M Ali & G Subhan, Analyzed the data: F Akbar & J Ali, Contributed materials/analysis/ tools: S Ali, Wrote the paper: M Babar.

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