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ASSESSMENT OF GENETIC VARIABILITY FOR YIELD AND YIELD RELATED TRAITS IN WHEAT

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ABSTRACT

A field study was undertaken at Guru Kashi University, Talwandi Sabo in Bathinda (Punjab) throughout the Rabi season of 2023–2024 to evaluate the genetic variability of 43 wheat genotypes for yield and yield associated characteristics. The experiment used a Randomized Block Design with three replications. Analysis of variance showed considerable variation in all traits except flag leaf width, confirming significant genetic diversity among the genotypes. The maximum genotypic and phenotypic coefficient of variation (GCV and PCV) were noted for each plant's biological yield (GCV: 36.03%, PCV: 39.86%), grain weight per spike (GCV: 29.78%, PCV: 30.18%), and grains per spike (GCV: 22.01%, PCV: 22.23%), indicating their potential for selection. High heritability (>80%) combined with a high genetic advance (>30%)for grains per spike, expressed as a percentage of the mean (heritability: 98.01%, genetic advance: 44.88%), grain weight per spike (heritability: 97.38%, genetic advance: 60.54%), and biological yield per plant (heritability: 81.71%, genetic advance: 67.09%), suggesting these characteristics were mostly controlled by additive genetic effects and could be effectively improved through selection. Traits such as days to flowering (heritability: 87.37%, genetic advance: 8.14%), days to maturity (heritability: 90.97%, genetic advance: 3.58%), and plant height (heritability: 72.87%, genetic advance: 12.77%) displayed high heritability with moderate genetic advance, indicating the impact of both additive and non-additive gene effects.In contrast, traits like tillers per plant (heritability:17.57%) and flag leaf area(heritability: 21.27%) showed low heritability and genetic advance, implying strong environmental influence and limited potential for direct selection. This study found significant genetic variability within the wheat genotypes, with key yield-related traits showing strong potential for genetic improvement.

Keywords: Genetic advance, Heritability, Variance, Wheat Yield

INTRODUCTION

Wheat (*Triticum aestivum* L.) stands as a cornerstone of global agriculture, renowned as the "Staff of Life" for its vital role in sustaining over 4.5 billion people worldwide. Wheat is cultivated globally on approximately 222 million hectares, producing over 790 million tonnes with an average productivity of 3.56 tonnes per hectare (FAO, 2024). As the second-largest producer of wheat, India plays a crucial part in meeting global demand. In 2023, the country cultivated wheat in 31.76

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million hectares, with a production of 112.74 million tonnes. While the national average productivity is about 3.55 tonnes per hectare, the state of Punjab demonstrates exceptional output, achieving a productivity of 5.1 tonnes per hectare (DES, 2023). This development must occur while addressing both present and future obstacles, such as shrinking land and water supplies, in addition to rising temperatures brought by a climate shift and global warming (Bapela *et al.,* 2022). However, the path to sustainable wheat production faces challenges such as dwindling resources and climate change-induced stresses.

Development of improved genotypes that are capable of producing higher yield under various agro-climatic conditions and various stress condition is always the main objective of wheat breeding programme (Haydar *et al.,* 2020). The presence of genetic variety in the plant population is necessary for the creation of a successful plant breeding program. Hence, the level of significance of variability found in the gene pool of a crop species is of prime importance to a plant breeder for starting a judicious plant breeding program (Farshadfar *et al*., 2013). Estimating heritability helps plant breeders choose elite genotypes from various genetic groups. Hence, the current investigation was undertaken to estimate the genetic advancement, heritability and variability that can be applied to breeding and crop improvement programme.

MATERIAL AND METHODS

The field test was carried out at Guru Kashi University's farm in Talwandi Sabo, Bathinda (Punjab), located at 29°57'37.5" N latitude, 75°07'16.6" E longitude, and an altitude of 201 m above the average sea level using 43 wheat genotypes in the Rabi season of 2023–2024. The details of genotypes studied is provided in Table-01. The genotypes were seeded in a randomized block design (RBD) with three replications each, with each row consisting of two-meter-long plots and a line-to-line distance of 25 cm. Observations for all attributes were recorded on five randomly selected individuals per genotype in each replication. The traits recorded were days to 50% flowering (DF), days to maturity (DM), plant height (PH), peduncle length (PL), spike length (SP), number of grains per spike (NGPS), grain weight per spike (GWPS), biological yield per plant (BY), biological yield per plot (BYPP), grain yield per plant (GY), grain yield per plot (GYPP), test weight (TW), flag leaf length (FLL), flag leaf width (FLW), and flag leaf area (FLA) (Fouad, 2020). The mean data of the traits were analysed statistically for variability parameters, using opstat. Wheat plant growth is divided into three stages:vegetative (from seed germination to tillering); reproductive (from stem elongation to flowering) and ripening (from flowering to grain maturity) (Koshraj, 2020;Rao *et al*., 2021). Vegetative growth lasts around 45-60 days. The optimal temperature for vegetative growth is 15^{o}c to 20^{o}c (Gautam *et al*., 2018). The temperatures in the months of November and December are suitable for vegetative growth. The rainfall should be around 30-40mm during seedling initiation to ensure adequate moisture content in the soil, which is crucial for seedling emergence. The temperature for the reproductive stage ranges from 20^{o}c to 25^{o}c, making it suitable for stem elongation to flowering. The ripening stage (from flowering to grain maturity) requires temperatures between 25^{0}c to 30^{0}c (Guarin and Asseng, 2022). During the ripening stage,reduced water is needed and the temperature should be higher during the harvesting stage to ensure proper grain drying.

RESULTS AND DISCUSSION

Analysis of Variance

Analysis of variance (ANOVA) of grain yield and yield related traits in wheat genotypes

Table 1. List of wheat genotypes

Sr.No.	Genotypes	Pedigree	Sr. No.	Genotypes	Pedigree
1	WH 1124	MUNIA/CHTO//AMSEL	23	WH 1184	HD2850/WH147
2	WH 1100	PBW 65/2*PASTOR	24	HD 2307	HD-2160/116-1-3
3	WH 1136	NI 5663RAJ 3765	25	HD 2687	CPAN 2009/HD 2329
4	WH 1140	WBLLI*2/VIVITSI	26	HD 3043	PJN/BOW//OPATA*2/3 CROC_
					1/A.SQUARROSA (224)//OPATA
5	WH 1126	WBLL1*2/VIVITSII	27	HD 3386	N/A
6	WH 1202	D67.2/PARANA66.270//AE.SQ. (320)/3/CUNNINGHAM	28	HD 3219	PBW343/HD2879
7	WH 1160	WAXWING*2/VIVITSI	29	HD 3182	N/A
8	WH 715	30/PBW 761	30	PBW 761	PBW 550//Yrl5/6* Avocet/3/2* PBW 550
9	WH 542	JUP/BJY"S"//URES	31	PBW 163	N/A
10	WH 522	N/A	32	PBW 706	MINO / 898.97
11	WH 1132	PBW 65/2*PASTOR	33	PBW 769	ATTILA/3*BCN/3/CROC_1/AE.SQUAR ROSA (224)//OPATA/4/CHIBIA//PRLII/ CM65531/3/ SKAUZ/BAV92/4/MUNAL#1
12	WH 1063	BARBET 1 Selection	34	PBW 826	WBLL1*2/KKTS//PASTOR/KUKUNA/3/ KINGBIRD#1//INQALAB 91*2/TUKURU/5/ KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ /4/SAUAL
13	WH 1185	SONALIKA / RAJ 3777	35	PBW 677	PFAU/MILAN/5/CHEN/A.Squa//BCN/3/ VEE#7/BOW/4/PAST

Sr.No.	Genotypes	Pedigree	Sr. No.	Genotypes	Pedigree
14	WH 1270	SHA7//PRL/VEE#6/3/FASAN/	36	PBW 681	UP2338/KALYANSONA
		4/HAAS8446/2*FASAN/5/CBRD /KAUZ/6/MILAN/AMSE L/7/FRET2*2/ KUKUNA/8/2*WHEAR/5OKOLL			
15	WH 1105	MILAN/S87230//BABAX	37	PBW 644	PBW-175/HD-2643
16	WH 1182	KLDR/PEWIT1//MILAN/DUCULA	38	PBW 750	TOB/ERA//TOB/CNO67/3/PLO/4/VEE#5/ 5/KAUZ/6/FRET2/7/PASTOR//MILAN/ KAUZ/3/BAV92
17	WH 283	1981/RAJ-821	39	PBW 165	N/A
18	WH 1127	RL6043/4/NAC//PASTOR/3/BABAX	40	PBW 475	W4671/PBW54
19	WH 1164	RL 604/4*NAC//2*PASTOR	41	DBW 222	KACHU/SAUAL/8/ATTILA*2/PBW 65/6/ PVN//CAR422/ANA/5/BOW/CROW//BUC/ PVN/3/YR/4/TRAP#1/7/ATTILA/2*PASTOR
20	WH 1134	PRL/2*PASTER	42	DBW 303	WBLL1*2/BRAMBLING/4/BABAX/ LR42//BABAX#2/3/SHAMA*2/5/ PBW343*2/KUKUNA*2//FRTL/PIFED
21	WH 1152	PBW 65/2*PASTOR	43	DBW 187	NAC/TH.AC//3*PVN/3/MIRLO/BUC/ 4/2*PASTOR/5/KACHU/6/KACHU
22	WH 1135	HD29/2* WEAVER	-		

Fig. 1. Meteorological data of temperature and rainfall during rabi season (2023-2024)

showed substantial differences across treatments for the majority of the traits, indicating sufficient variability for effective selection (Table 2). The mean sum of squares for days to flowering (DF), days to maturity (DM), plant height (PH), peduncle length (PL), number of tillers per plant (TPP), grain per spike (GS), grain weight per spike (GWPS), biological yield per plant (BY), grain yield per plant (GY), grain yield per plot (GYPP), biological yield per plot (BYPP), test weight (TW), and flag leaf length (FLL) were highly significant ($p < 0.01$) among treatments, indicating significant genetic variability. Spike length (SL) and flag leaf area (FLA) showed significant differences at $p < 0.05$. This variability suggested potential for selection and improvement of these attributes in wheat breeding programs.

The mean performance of the 43 wheat genotypes across 16 morphological traits, along with estimates of genetic parameters are displayed in Table 3. The average grain yield per plant was 9.02 g, while grain yield per plot ranged from 295.61 to 384.87 g. On average, genotypes took 91.56 days to reach 50 percent flowering and 132.01 days to mature. The average plant height was 98.49 cm. Among yield components, the mean number of grains per spike was 53.72.Additionally, each spike's average grain weight was 2.01 g. The average biological yield per plant was 19.42 g. These mean values provide a baseline understanding of the overall performance of the genotypes under the specific experimental conditions.

Table 3 shows that all attributes had a higher phenotypic coefficient of variation (PCV) than genotypic coefficient of variation (GCV),showing that environmental influences play a role. High heritability and high genetic advance were observed for grain weight per spike (h^2 = 97.38%, GA = 1.21, GAM = 60.54%), biological yield per plant (h^2 = 81.71%, GA = 13.026, GAM = 67.08%), and grains per spike (h^2 = 98.00%, GA = 24.11,

Table 2. Analysis of variance for grain yield and related traits

Source of		Mean Sum of Square															
variation	df	DF	DM	PH	PL	TPP	SL	GS	GWS	BY	GY	GYPP	BYPP	TW	FLL	FLW	FLA
Replication	**2**	20.67	6.8	361.66	37.16	2.38	33.59	144.93	0.27	37.52	2.59	740 51.59	372 807.9	3.56	7.19	2.49	693. 69
Treatments	**42**	47. 11**	17. 99**	172. 61**	11. 81**	0.65*	26.68	422. 25**	1.08**	157 .	13.1 75**	318 07**	11602 1.75**	33. 6.01**	131. 56**	0.87 52**	555. 41*
Error	**84**	2.17	0.58	19.06	3.2	0.4	17.81	2.84	0.01	10.95	2.85	597 2.64	1922 5.14	1.48	26.16	0.71	30 6.81

**= Significant at 1% and *= Significant at 5% level of significance

Table 3. Genetic components of variance, heritability and genetic advance of different traits

Characters	Genetic components of variance							
	Mean	SE (±)*	Range (Mean ± SE)*	h^2 bs (%)	GCV (%)	PCV (%)	GA	GAM (%)
Grain yield per plant	9.02	0.89	8.13-9.91	54.487	20.462	27.721	2.807	31.114
Days to flowering	91.56	0.81	90.75-92.37	87.365	4.227	4.523	7.452	8.139
Days to maturity	132.01	0.43	131.58-132.44	90.971	1.824	1.912	4.734	3.584
Plant Height	98.49	2.42	96.07-100.91	72.865	7.264	8.509	12.580	12.773
Peduncle length	18.73	1.03	17.70-19.76	47.261	9.046	13.158	2.399	12.810
Tillers per plant	4.69	0.37	4.32-5.06	17.567	6.196	14.784	0.251	5.350
Spike length	12.29	2.45	9.84-14.74	14.238	13.992	37.081	1.337	10.876
Grains per spike	53.72	0.97	52.75-54.69	98.008	22.009	22.231	24.113	44.884
Grain weight per spike	2.01	0.07	1.94-2.08	97.379	29.783	30.181	1.215	60.543
Biological yield per plant	19.42	1.92	17.50-21.34	81.710	36.026	39.855	13.026	67.085
Grain yield per plot	340.24	44.63	295.61-384.87	28.691	14.409	26.900	54.090	15.899
Biological yield per plot	868.89	80.05	788.84-948.94	62.664	20.673	26.115	292.924	33.711
Test weight	26.75	0.70	26.05-27.45	87.830	12.222	13.042	6.313	23.596
Flag leaf length	28.11	2.95	25.16-31.06	57.313	21.078	27.842	9.242	32.871
Flag leaf weight	1.73	0.49	1.24-2.22	6.987	13.404	50.711	0.126	7.299
Flag leaf area	35.86	10.11	25.75-45.97	21.266	25.386	55.050	8.648	24.116

GAM = 44.88%), suggesting that these attributes were regulated by additive gene activity and could be effectively improved through selection (Table 3).

Significant genetic variability, high heritability and considerable genetic advancements for improving productivity and quality attributes in wheat genotypes provided a strong basis for selection and breeding programs designed to improve these traits. These findings were consistent with prior investigations by Arya *et al.,* (2017), Kumari *et al.,* (2022), Rani *et al.,* (2018), and Ahmed *et al.,* (2019), which also reported significant genetic variability and potential for improvement in various agronomic traits in wheat.

Grains per spike, grain weight per spike, and biological yield per plant, all showed substantial heritability and genetic advance as a percentage of the mean across environments. Characteristics such as days to flowering (h^2 = 87.37%, GA = 7.452, GAM = 8.14%), days to maturity (h^2 = 90.97%, GA = 4.734, GAM = 3.58%), plant height (h^2 = 72.87%, GA = 12.58, GAM = 12.77%), test weight (h^2 = 87.83%, GA = 6.313, GAM = 23.60%), and flag leaf length (h^2 = 57.31%, GA = 9.242, GAM = 32.87%) also demonstrated strong heritability but with moderate to high level of genetic advance, demonstrating gene effects that are both additive and non-additive. These findings align with previous studies by Koshraj (2020), Kumar *et al.,* (2018), Rani *et al.,* (2018), Dhaliwal *et al.,* (2023), and Raviteja *et al.,* (2023).

CONCLUSION

The analysis of morphological and quality traits in 43 wheat genotypes revealed significant genetic variability, establishing a strong foundation for targeted breeding programs. The ANOVA findings showed significant differences among genotypes for key traits, confirming the existence of enough genetic variety for selection. Yield-related traits, including biological yield per plant (BY), grains per spike (GS), and grain weight per spike (GWPS), exhibited high heritability (98.01%, 97.38%, and 81.710%, respectively) and genetic advance (44.88%, 60.54%, and 67.08%), suggesting these attributes are predominantly controlled by additive genetic effects and may be effectively improved through selection. Similarly, test weight (TW) and biological yield per plant (BY) showed strong heritability (87.83% and 81.710%) with considerable genetic advance(23.60% and 67.09%, respectively), reinforcing their potential for enhancement through breeding.

Hence, the present study affirmed that wheat genotypes selected for the study possessed considerable genetic variability, providing valuable insights for breeders in selecting superior varieties. Identifying attributes with high heritability and genetic advance led to reliable selection efficiency, resulting in the high-yielding wheat cultivars.

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