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ESTIMATION OF GENETIC VARIABILITY OF SEED TRAITS IN BREAD WHEAT

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Article Info

Abstract:
Significant genetic variability was observed among the 42 wheat genotypes for seed length and seed width, indicating the presence of substantial exploitable diversity for grain quality improvement. Analysis of variance revealed highly significant differences among genotypes for both traits. Seed length ranged from 6.445 to 8.388 mm with a mean value of 7.188 mm. Genotype PYT-2516 recorded the maximum seed length (8.388 mm), followed by PYT-2515 and PYT-2501, whereas the check cultivar NIA-Zarkhaiz exhibited the minimum seed length (6.445 mm). Most advanced lines showed superior grain length compared to the check cultivar, and several genotypes surpassed the commercial check IV-3, highlighting their breeding potential. Frequency distribution indicated that the majority of genotypes were clustered within the 6.89–7.34 mm range, while PYT-2516 formed a distinct class with the longest grains. Similarly, grain width showed significant variation among genotypes, ranging from 2.985 to 3.900 mm with an overall mean of 3.49 mm. The genotype PYT-2530 exhibited the maximum grain width (3.900 mm), followed by PYT-2506 (3.700 mm), whereas PYT-2515 recorded the narrowest grains (2.985 mm). Most genotypes were concentrated within the 3.585–3.785 mm class, while PYT-2530 represented the boldest grain class. The wide variation in both grain length and width suggests strong genetic control and provides valuable opportunities for selection and hybridization aimed at improving grain size, grain weight, and overall wheat productivity.

Keywords: Bread Wheat, Estimation, Genetic Variability, Seed Traits.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops worldwide, ranking first in total production and second after maize in cultivated area (FAO, 2023). It serves as a staple food for more than one-third of the global population and provides about 20% of total caloric intake (Curtis et al., 2002). Due to its wide adaptability, wheat is grown in diverse agro-climatic regions, including Pakistan, where it is cultivated extensively during the rabi season (Government of Pakistan, 2024). Wheat grain is a major source of carbohydrates, proteins, vitamins, and minerals, contributing significantly to human nutrition (Shewry & Hey, 2015). In Pakistan, wheat occupies approximately 9 million hectares, accounting for nearly 40% of the total cultivated area and forming the backbone of national food security (GOP, 2024). It supports rural livelihoods and provides income to millions of smallholder farmers (Khan et al., 2020) and (Banbhan et al., 2024). Wheat flour is widely used in the production of bread, chapatis, biscuits, noodles, and other food products, making it essential in both traditional and industrial food systems (Hussain et al., 2021) and (Kaleri et al., 2024). Global wheat production has increased substantially following the introduction of semi-dwarf varieties during the Green Revolution (Borlaug, 1983) and (Manzoor et al., 2024). However, population growth, land degradation, and climate change continue to challenge sustainable wheat production (Shiferaw et al., 2013). Therefore, continuous development of high-yielding, climate-resilient varieties remains a priority. Wheat improvement programs focus on enhancing yield, grain quality, and resistance to biotic and abiotic stresses (Lopes et al., 2012). Seed traits such as grain weight, length, and width play a crucial role in determining wheat yield and quality (Ali et al., 2008) and (Kubar et al., 2025). Thousand-kernel weight (TKW) is an important indicator of seed size and density, reflecting genetic potential and environmental influence (Rahman et al., 2016). Larger and heavier seeds generally result in better germination, seedling vigor, and yield potential (Ayoub et al., 2002). Grain width and morphology also influence milling quality, planting efficiency, and end-use characteristics, making these traits key targets in modern wheat breeding programs (Saini & Syed, 2025; Kabir et al., 2024).

Genetic Variability in Seed Traits

Genetic variability represents the extent of genetic differences among individuals and provides the basis for selection in plant breeding (Falconer & Mackay, 1996). High variability enhances breeding progress, while limited variation restricts genetic improvement (Allard, 1999). In wheat, substantial variability has been reported for yield and seed-related traits, including TKW, grain length, and grain width (Kabir et al., 2024). Estimation of genetic parameters such as heritability and genetic advance is essential to assess selection efficiency. Traits with high heritability and high genetic advance are mainly governed by additive gene action and respond well to selection (Sewore & Abe, 2024). In contrast, low heritability indicates greater environmental influence, necessitating multi-environment testing (Firouzian et al., 2003). Seed traits are quantitative in nature and influenced by both genetic and environmental factors (Gupta et al., 2019). Parameters such as genotypic and phenotypic coefficients of variation (GCV and PCV) help evaluate the extent of variability and environmental effects (Burton & DeVane, 1953). Studies have reported moderate to high heritability and GCV for TKW and grain dimensions in bread wheat, indicating good prospects for genetic improvement (Kabir et al., 2024; Sewore & Abe, 2024). The present study aims to assess genetic variability, heritability,

and expected genetic gain for key seed traits in wheat genotypes. Understanding these parameters will aid in identifying superior genotypes with desirable seed characteristics for use in wheat breeding programs aimed at improving yield and grain quality.

Materials and Method

The present research work was conducted at the PBG Division, Nuclear Institute of Agriculture (NIA), Tando Jam, during the internship period from 15th October, 2025 to 15th November, 2025. The study focused on the estimation of genetic variability of seed traits in bread wheat planted under the Preliminary Yield Trial (PYT) during the previous rabi season 2024–25. The trial comprised a total of 42 genotypes, including 38 advanced lines and four commercial check varieties (IV-3, NIA-Shaheen, NIA-Zarkhaiz, and Akbar-19). The genotypes were sown in a plot size of 4.8 m² with a row length of 4 m using an alpha lattice experimental design. Harvested seed from all genotypes was used to record seed traits, including seed length and seed width. The list of germplasm evaluated for these parameters is presented in Table 1.

Table 1: List of wheat genotypes of preliminary yield trial used to assess seed traits

Sr. No.	Entry Name	Sr. No.	Entry Name
1.	PYT-2501	**22.**	PYT-2522
2.	PYT-2502	**23.**	PYT-2523
3.	PYT-2503	**24.**	PYT-2524
4.	PYT-2504	**25.**	PYT-2525
5.	PYT-2505	**26.**	PYT-2526
6.	PYT-2506	**27.**	PYT-2527
7.	PYT-2507	**28.**	PYT-2528
8.	PYT-2508	**29.**	PYT-2529
9.	PYT-2509	**30.**	PYT-2530
10.	PYT-2510	**31.**	PYT-2531
11.	PYT-2511	**32.**	PYT-2532
12.	PYT-2512	**33.**	PYT-2533
13.	PYT-2513	**34.**	PYT-2534
14.	PYT-2514	**35.**	PYT-2535
15.	PYT-2515	**36.**	PYT-2536
16.	PYT-2516	**37.**	PYT-2537
17.	PYT-2517	**38.**	SD-1060
18.	PYT-2518	**39.**	IV-3 (Check)
19.	PYT-2519	**40.**	NIA-Shaheen (Check)
20.	PYT-2520	**41.**	NIA-Zarkhaiz (Check)
21.	PYT-2520	**42.**	Akber-19 (Check)

To assess variation in grain dimensions, two main traits, namely seed length and seed width, were recorded for each genotype using a Vernier caliper. A total of ten seeds from each replication of every entry were used to measure seed length and seed width. The mean value of each data point for every entry was calculated and used for further analysis. The procedure for recording the data is illustrated in Figure 1.

Figure 1: Data recording for grain length and grain width with the help of Vernier caliper

Results and Discussion

Genetic Variability of Genotypes Based on Seed Length

The results of the analysis of variance (ANOVA) revealed that all genotypes differed significantly from one another with respect to seed length (Table 2). The overall mean seed length of the trial was 7.188 mm, ranging from a minimum of 6.445 mm to a maximum of 8.388 mm (Table 3). Among the 42 genotypes, PYT-2516 recorded the highest seed length with an average of 8.388 mm, indicating its potential contribution to larger grain size. This was followed by PYT-2501, which showed a seed length of 7.900 mm and also fell within a desirable range (Table 3). In contrast, the minimum seed length was observed in NIA-Zarkhaiz (6.445 mm), indicating relatively smaller seeds. Among the check cultivars, NIA-Zarkhaiz recorded the minimum grain length (6.445 mm), whereas IV-3 exhibited the maximum grain length (7.753 mm). The results further indicated that all advanced lines had greater grain length compared to the check cultivar NIA-Zarkhaiz. Moreover, three genotypes, namely PYT-2501, PYT-2515, and PYT-2516, possessed larger grain length than the check cultivar IV-3 (Table 3). This variability in seed length highlights the presence of genetically diverse material that can be exploited for improving grain size in future wheat breeding efforts. The histogram based on grain length

showed that most genotypes were distributed within the range of 6.89–7.34 mm. This class represented the largest group, containing 14 genotypes. The second most frequent class ranged from 7.345–7.795 mm and included 12 genotypes. Only one genotype, PYT-2516, was found in the class ranging from 8.245–8.695 mm, representing the genotype with the longest grain length among all evaluated entries.

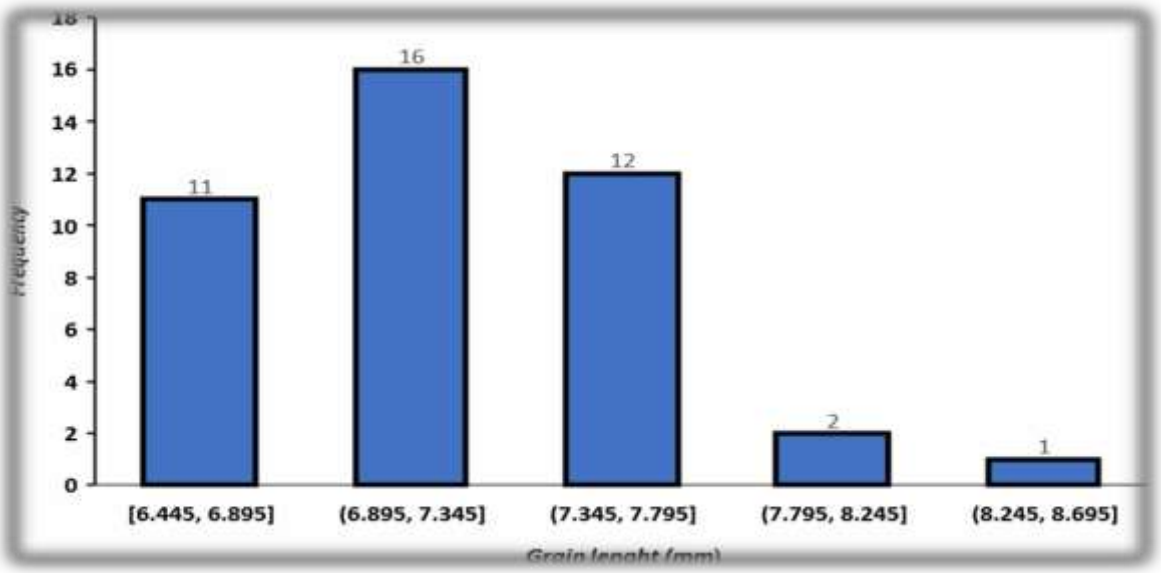
Table 2: Analysis of Variance (ANOVA) of 42 genotype of PYT for grain length

Source	df	SS	MSS	*F-value*	*p-value*
Replication	1	0.0338	0.03380		
Block	2	0.0689	0.03443		
Entry	41	16.2817	0.3971	7.7626	0.0000
Error	40	2.4506	0.06127		
Total	83				
CV3.44					

Table 3: Grain length of 42 wheat genotypes

Sr. No.	Entry	Grain Length (mm)	Sr. No.	Entry	Grain Length (mm)
1.	**PYT-2501**	**7.900**	**22.**	PYT-2522	7.568
2.	PYT-2502	7.560	**23.**	PYT-2523	6.615
3.	PYT-2503	7.185	**24.**	PYT-2524	7.018
4.	PYT-2504	7.720	**25.**	PYT-2525	7.123
5.	PYT-2505	7.100	**26.**	PYT-2526	7.348
6.	PYT-2506	6.840	**27.**	PYT-2527	6.915
7.	PYT-2507	6.688	**28.**	PYT-2528	7.428
8.	PYT-2508	6.613	**29.**	PYT-2529	6.980
9.	PYT-2509	7.295	**30.**	PYT-2530	7.545
10.	PYT-2510	7.048	**31.**	PYT-2531	7.363
11.	PYT-2511	7.485	**32.**	PYT-2532	7.308
12.	PYT-2512	7.715	**33.**	PYT-2533	7.383
13.	PYT-2513	7.475	**34.**	PYT-2534	6.830
14.	PYT-2514	6.770	**35.**	PYT-2535	7.240
15.	PYT-2515	8.163	**36.**	PYT-2536	7.278
16.	**PYT-2516**	**8.388**	**37.**	PYT-2537	6.478
17.	PYT-2517	6.543	**38.**	IV-3	7.753
18.	PYT-2518	7.228	**39.**	NIA-Shaheen	7.013
19.	PYT-2519	6.698	**40.**	**NIA-Zarkhaiz**	**6.445**
20.	PYT-2520	7.328	**41.**	SD-1060	6.665
21.	PYT-2521	7.005	**42.**	Akber-19	7.320

Figure 1: Histogram depicting different classes of genotypes based on seed length



Genetic variability of genotypes based on seed width

The ANOVA analysis revealed highly significant differences among the 42 wheat genotypes for grain width which suggests that the genotype selection can play a crucial role in this trait. The result shows that the overall average for grain width for genotype was recorded as 3.49 mm which ranged from 2.985 mm to 3.900 mm (Table 5). The genotype PYT-2530 exhibited the maximum seed width (3.900 mm), making it one of the most promising genotypes for producing bold seeds. This was followed closely by PYT-2506, which recorded a seed width of 3.700 mm, indicating that it also possesses desirable seed characteristics. On the other hand, the minimum seed width was recorded in PYT-2515, with a value of 2.985 mm, reflecting narrower seeds as compared to the others. The presence of such wide variability in both seed length and seed width suggests that the studied genotypes contain a rich pool of genetic resources. This diversity can be utilized not only for direct selection of superior lines but also for hybridization programs aimed at combining favorable traits. Larger and wider seeds often correlate positively with grain weight, milling quality, and overall yield, which are critical objectives in wheat improvement. Therefore, the genotypes that showed higher values for these traits could be considered for further evaluation and possible recommendation in wheat breeding programs.

The histogram based on grain width shows that the most genotypes have grain width ranging from 3.585–3.785mm. This histogram class represents the biggest class in terms of number of genotypes which counts as 17.Thesecondclass having more number of genotypes is 3.385–3.585 mm,

containing 15 genotypes. The only one genotype i.e. PYT-2530 is found in class ranging from 3.785–3.985 mm. This genotype also represents the boldest grain width among all the contesting genotypes.

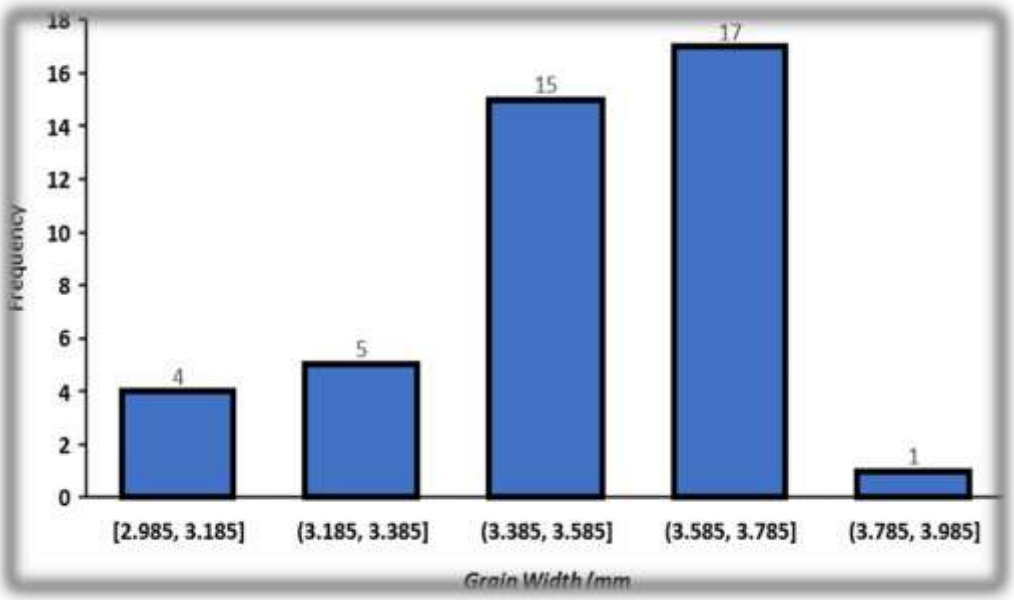
Table 4: Analysis of Variance (ANOVA) of 42 genotypes of PYT for grain width

Source	df	SS	MSS	*F-value*	*p-value*
Replication	1	0.04366	0.04366		
Block	2	0.03364	0.01682		
Entry	41	3.0806	0.0751	9.7632	0.0000
Error	40	0.36070	0.00902		
Total	83				
CV = 2.71					

Table 5: Grain width of wheat seed of 42 genotypes

Sr. No.	Entry	Grain Width (mm)	Sr. No.	Entry	Grain Width (mm)
1.	PYT-2501	3.630	**22.**	PYT-2522	3.555
2.	PYT-2502	3.460	**23.**	PYT-2523	3.635
3.	PYT-2503	3.625	**24.**	PYT-2524	3.685
4.	PYT-2504	3.370	**25.**	PYT-2525	3.500
5.	PYT-2505	3.622	**26.**	PYT-2526	3.700
6.	**PYT-2506**	**3.700**	**27.**	PYT-2527	3.410
7.	PYT-2507	3.670	**28.**	PYT-2528	3.685
8.	PYT-2508	3.660	**29.**	PYT-2529	3.622
9.	PYT-2509	3.180	**30.**	**PYT-2530**	**3.900**
10.	PYT-2510	3.428	**31.**	PYT-2531	3.402
11.	PYT-2511	3.605	**32.**	PYT-2532	3.612
12.	PYT-2512	3.335	**33.**	PYT-2533	3.557
13.	PYT-2513	3.455	**34.**	PYT-2534	3.622
14.	PYT-2514	3.027	**35.**	PYT-2535	3.550
15.	PYT-2515	2.985	**36.**	PYT-2536	3.655
16.	PYT-2516	3.092	**37.**	PYT-2537	3.507
17.	PYT-2517	3.293	**38.**	IV-3	3.580
18.	PYT-2518	3.637	**39.**	NIA-Shaheen	3.533
19.	PYT-2519	3.557	**40.**	NIA-Zarkhaiz	3.445
20.	PYT-2520	3.515	**41.**	SD-1060	3.250
21.	PYT-2521	3.670	**42.**	Akber-19	3.323

Figure 2: Histogram depicting different classes of genotypes based on seed width



Conclusion

The present study evaluated 42 genotypes of bread wheat based on two critical grain morphology traits: seed length and seed width. The results revealed significant variation among genotypes, highlighting the genetic diversity present within the evaluated entries. Notably, the genotype PYT-2516 exhibited the largest seed length, while PYT-2530 showed the widest seed width, indicating their potential as promising parents for breeding program aimed at improving seed size and yield and can be effectively utilized in future breeding program to develop high yielding and better quality wheat varieties suited to local environmental conditions.

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