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ASSESSMENT OF AGRONOMIC AND QUALITY PARAMETERS OF WHEAT (*TRITICUM AESTIVUM* L.) IN SOUTH PUNJAB, PAKISTAN

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Abstract

Enhancing wheat productivity and quality is essential for ensuring food security in Pakistan, where wheat serves as the primary staple crop. Identifying high-performing genotypes adapted to specific agro-ecological zones is critical for sustaining yield under changing climatic conditions. Therefore, systematic evaluation of wheat genetic resources is required to support targeted genotype recommendations and improved crop management strategies. This study assessed the agronomic and quality performance of thirty wheat genotypes under the environmental conditions of South Punjab (Dera Ghazi Khan). The experiment was conducted during the 2018 Rabi season at the Research Field of the Faculty of Agricultural Sciences, Ghazi University, using a randomized complete block design (RCBD) with three replications. Data was recorded for days to 50% anthesis, tillers per plant, plant height (cm), spikelets per spike, 1000-grain weight (g), grain yield per spike (g), grain moisture content (%), crude protein content(%), and total ash content (%). ANOVA revealed highly significant differences among genotypes for all traits except spike length. Mean comparison indicated that genotype GU-9 exhibited the longest duration to anthesis (121 days) and the highest 1000-grain weight (76.8 g), while genotype KASUK produced the most tillers per plant. The tallest plants (140.2 cm) were recorded for genotype SUP152/BA, and the longest spikes (13.56 cm) were observed in GU-8. The highest total ash content (11.31%) was found in GU-5, whereas GU-6 exhibited the highest crude protein content (14.87%). Maximum moisture content (22.94%) occurred in genotype TACUPETO. Grain yield showed a significant positive genotypic correlation with plant height, spike length, 1000-grain weight, and spikelets per spike. At the phenotypic level, days to 50% anthesis, tillers per plant, spikelets per spike, moisture content, protein content, and ash content were all significantly and positively correlated with grain yield. These findings highlight substantial genetic variability among wheat genotypes and identify several promising candidates for cultivation under the agro-climatic conditions of South Punjab.

Keywords: *Agronomic, Analysis of variance, Correlation, Genetic variability, Quality, Wheat*

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most widely cultivated cereal crops globally and serves as a staple food for a major proportion of the world's population (1). Wheat provides essential nutrients including carbohydrates, proteins, minerals, dietary fiber and amino acids, making it essential to human nutrition. It is also used in a wide range of food products such as bread, pasta, cereals, confectionery, and bakery products (2). Global demand for wheat is expected to rise by 60% by 2030 and to nearly double by 2050, particularly in developing countries (3). However, climate change poses serious threats to wheat production. Several studies have reported that rising temperatures, irregular rainfall patterns, and frequent drought episodes negatively affect wheat yield and productivity (4). These challenges highlight the urgent need for resilient, high-yielding wheat cultivars capable of performing well under diverse and stressed environments.

Pakistan, the second largest country in South Asia by population, relies heavily on wheat as the primary staple food. The country ranks among the top wheat-producing nations, cultivating approximately 9 million hectares annually and contributing nearly 2% to the national GDP (5). Punjab remains the leading wheat-producing province, followed by Sindh, Khyber Pakhtunkhwa, and Balochistan. Despite substantial production, the increasing population continues to exert pressure on national food supplies, emphasizing the need to improve wheat productivity and grain quality. Pakistan not only meets domestic consumption needs but also exports significant quantities of wheat, primarily to neighboring countries, specially Afghanistan (6).

Despite wheat's global importance, grain yield on farmers' fields often remains much lower than the genetic yield potential of improved cultivars. This yield gap is largely attributed to genotype × environment interactions, which significantly influence the expression of yield-related traits (7). The development and deployment of high-yielding, well-adapted cultivars therefore require systematic evaluation of genotypes across diverse agro-ecological conditions. Grain yield is a complex polygenic trait influenced by several morphological and physiological components. Grain yield improvement through genetic enhancement relies on understanding trait associations and their contribution to final yield (8).

Environmental variation plays a major role in determining varietal performance, with some genotypes yielding well under irrigated conditions but poorly in rain-fed environments (9). Therefore, region-specific evaluation is essential for recommending appropriate genotypes. Knowledge of genetic variability, yield components, and quality parameters helps breeders identify promising lines for future breeding interventions (10).

Given the agro-climatic diversity of Pakistan, especially in semi-arid regions such as Dera Ghazi Khan, performance evaluation of wheat germplasm is vital for ensuring stable production. The objectives of the present study were to evaluate the agronomic and grain quality performance of different wheat genotypes under the climatic conditions of South Punjab (Dera Ghazi Khan) and to determine the genotypic and phenotypic correlations among grain yield, yield-related traits, and quality parameters in wheat genotypes.

METHODOLOGY

The study was conducted during the 2018 Rabi season at the Research Area of the Faculty of Agricultural Sciences, Ghazi University, Dera Ghazi Khan, Pakistan. Thirty wheat (*Triticum aestivum* L.) genotypes were evaluated. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each plot consisted of two rows (3 m long) with a row spacing of 30 cm and plant spacing of 5 cm. Standard agronomic practices were followed, including recommended nitrogen and phosphorus application, irrigation, and weed control.

Data were recorded from three tagged plants in each plot for key agronomic traits, including days to 50% anthesis (when 50% of spikes had extruded anthers), number of tillers per plant (average of five fertile tillers), plant height (cm) measured from the soil surface to the spike tip (excluding awns), spike length (cm) measured from base to tip (excluding awns), number of spikelets per spike (excluding sterile spikelet), 1000-grain weight (g) determined using a digital balance, and grain yield (g) per spike obtained by manually threshing individual spikes. For grain quality assessment, samples were cleaned, dried to constant weight, ground into fine powder, and stored in airtight containers. Moisture content was calculated after oven-drying fresh samples at 105 °C to constant weight; crude protein was determined through the Kjeldahl method (AACC, 2000) and computed using a conversion factor of 5.71, while ash content was measured by incinerating approximately 5 g of dried sample in a muffle furnace at 550–650 °C. The following formulas were used for proximate analysis:

$$\text{Moisture (\%)} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times 100$$

$$\text{Crude Protein (\%)} = \text{N (\%)} \times 5.71$$

$$\text{Ash (\%)} = \frac{\text{Ash weight}}{\text{Dry sample weight}} \times 100$$

STATISTICAL ANALYSIS

Analysis of variance (ANOVA) was conducted using R software by using the packages readxl, writexl, ggplot2, ggcorrplot, corrplot, plotly, dplyr and tidyverse to test genotype differences. Mean separation was performed using the Least Significant Difference (LSD) test at 5% probability and all the figures made by R software.

Genotypic and phenotypic correlation coefficients were estimated as follows:

$$R_g = \frac{\text{Gcov}_{xy}}{\sqrt{\text{Gvar}_x \times \text{Gvar}_y}} R_p = \frac{\text{Pcov}_{xy}}{\sqrt{\text{Pvar}_x \times \text{Pvar}_y}}$$

RESULTS AND DISCUSSION

PHENOTYPIC VARIATION AND AGRONOMIC PERFORMANCE

The evaluation of thirty wheat genotypes under the agro-climatic conditions of South Punjab (Dera Ghazi Khan) revealed substantial phenotypic variability for phenological, morphological, yield, and quality-related traits. Analysis of variance indicated highly significant ($p \leq 0.01$) differences among genotypes for most traits, confirming the presence of exploitable genetic diversity suitable for selection and varietal improvement similar results were observed in previous studies (11, 12).

Table I. ANOVA table with trait variability and significance

Trait	Significance	Mean	CV (%)
Days to 50% anthesis	**	101.9	3.84
Tillers per plant	**	8.99	18.67
Plant height (cm)	**	108.1	3.98
Spike length (cm)	NS	10.02	20.82
Spikelets per spike	**	14.9	4.69
Thousand grain weight (g)	**	34.9	6.55
Grain yield	*	56.2	34.62
Protein content (%)	**	9.8	4.87
Ash content (%)	**	9.2	3.14
Moisture content (%)	**	19.9	3.94

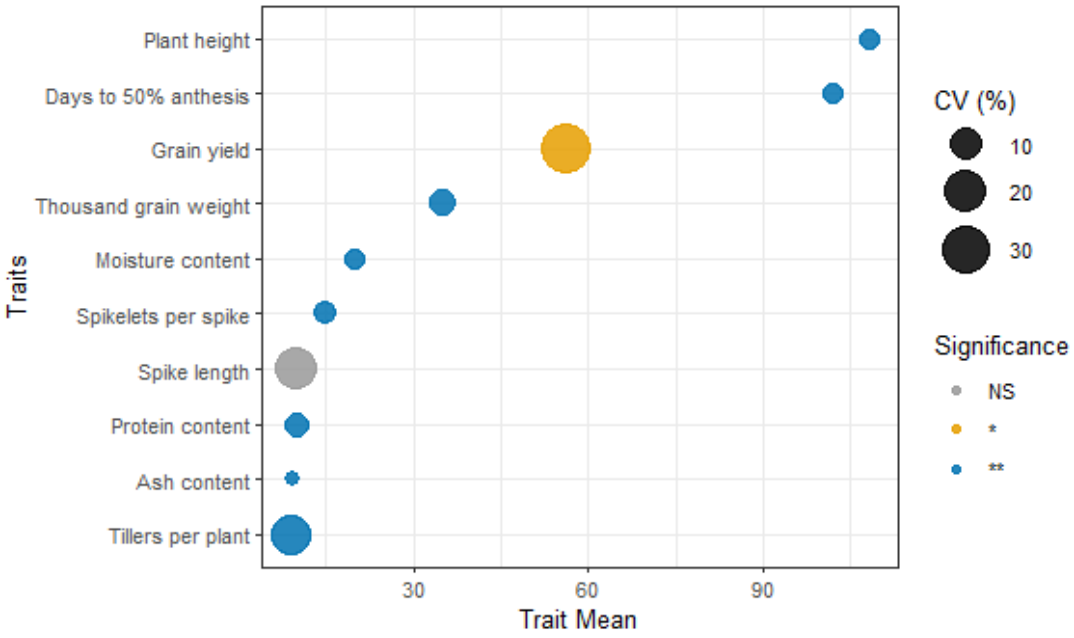

Fig. 1. ANOVA with trait variability and significance

All traits showed significant results except spike length (Table I), so these traits can be used for further studies. Plant height showed high significance (Fig. 1) which showed high effect of environment in expression of plant height.

GRAIN QUALITY ATTRIBUTES

Days to 50% anthesis reflecting wide variation in flowering behavior and adaptive responses. Early flowering genotypes such as WBLL1/FRE may be advantageous under terminal heat stress, while late flowering genotypes like GU-9 may exploit longer growing periods under favorable conditions. Tillers per plant varied markedly, highlighting differences in vegetative vigor, which is a key determinant of yield potential.

Plant height exhibited a broad range, indicating differential stem elongation and biomass accumulation among genotypes. Spike length showed comparatively lower variability and was non-significant, suggesting relative environmental stability of this trait under the tested conditions. In contrast, spikelets per spike and thousand-grain weight showed high and significant variability, demonstrating their strong genetic control and importance as yield-contributing traits.

Grain yield differed significantly among genotypes, with WBLL1*2/B, AARI-2011, and KACHU/SUP consistently outperforming others. These genotypes demonstrated superior agronomic performance and adaptability under local conditions.

Table II. Genotypes demonstrated superior agronomic performance

Trait	Range	Best genotype	Value
Days to 50% anthesis	96.7–121	GU-9	121
Tillers per plant	4.4–14.0	KASUKO	14
Plant height (cm)	77.5–140.2	SUP152/BA	140.2
Thousand grain weight (g)	19.5–76.8	GU-9	76.8
Protein content (%)	7.99–14.87	GU-6	14.87
Grain yield	30.0–81.7	WBLL1*2/B	81.67

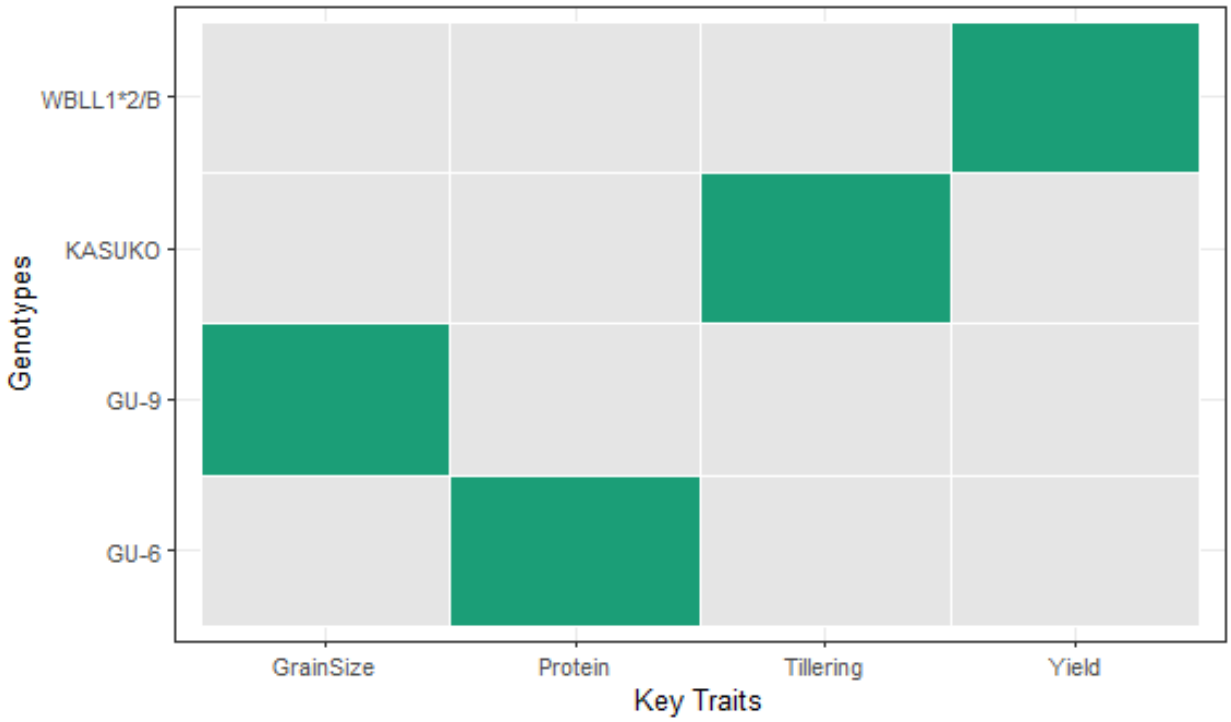

Fig. 2. Decision matrix for selection of superior wheat genotypes

Wide variability was observed among genotypes for all studied traits, indicating strong potential for selection and improvement. The highest values were recorded in GU-9 for days to 50% anthesis and thousand grain weight, KASUKO for tillers per plant, SUP152/BA for plant height, GU-6 for protein content, and WBLL1*2/B for grain yield, suggesting these genotypes as promising candidates for breeding programs as shown in Table II and Fig. 2 for explanation and easily understanding.

Significant differences were observed among genotypes for grain quality traits, including ash content, protein content, and moisture content. Ash content indicating variation in mineral accumulation efficiency. Protein content varied with GU-6 and GU-7 exhibiting superior protein levels, making them valuable candidates for quality-oriented breeding programs.

Moisture content reflects differences in grain maturity and post-harvest water retention characteristics. The observed diversity in quality traits suggests that simultaneous improvement of yield and grain quality is feasible through careful selection, as several high-yielding genotypes also expressed desirable quality profiles (Fig. 3).

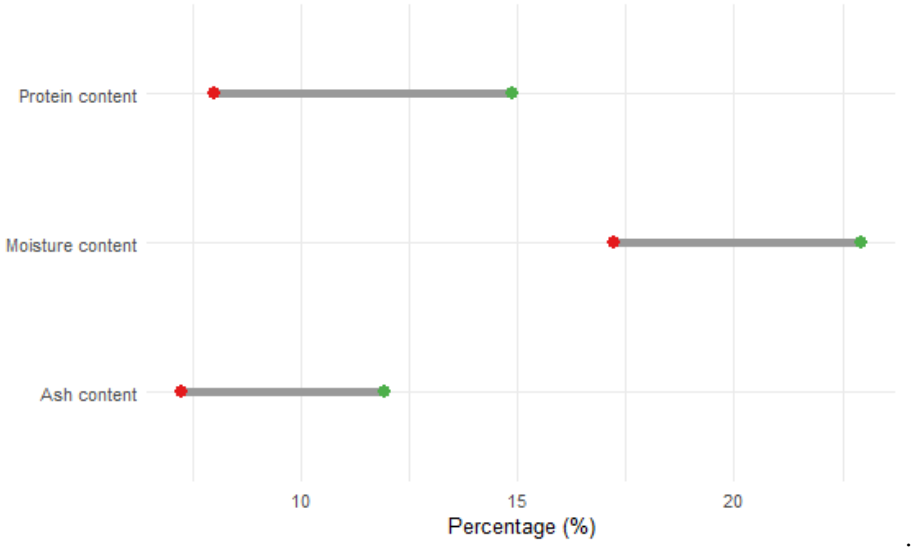

Fig. 3. Minimum and maximum values of grain quality traits

The evaluated genotypes exhibited distinct strengths valuable for breeding programs. WBLL1*2/B showed the highest grain yield, making it suitable for yield improvement, while GU-9 demonstrated high thousand grain weight and late maturity, useful for enhancing biomass and grain size. GU-6 is a promising candidate for quality breeding due to its high protein content, and KASUKO, with superior tillering ability, can contribute to yield stability (Table III).

Table III. Genotypes and their key strength with breeding relevance

Genotype	Key strengths	Breeding relevance
WBLL1*2/B	Highest grain yield	Yield improvement
GU-9	High TGW, late maturity	Biomass and grain size
GU-6	Highest protein content	Quality breeding
KASUKO	High tillering ability	Yield stability

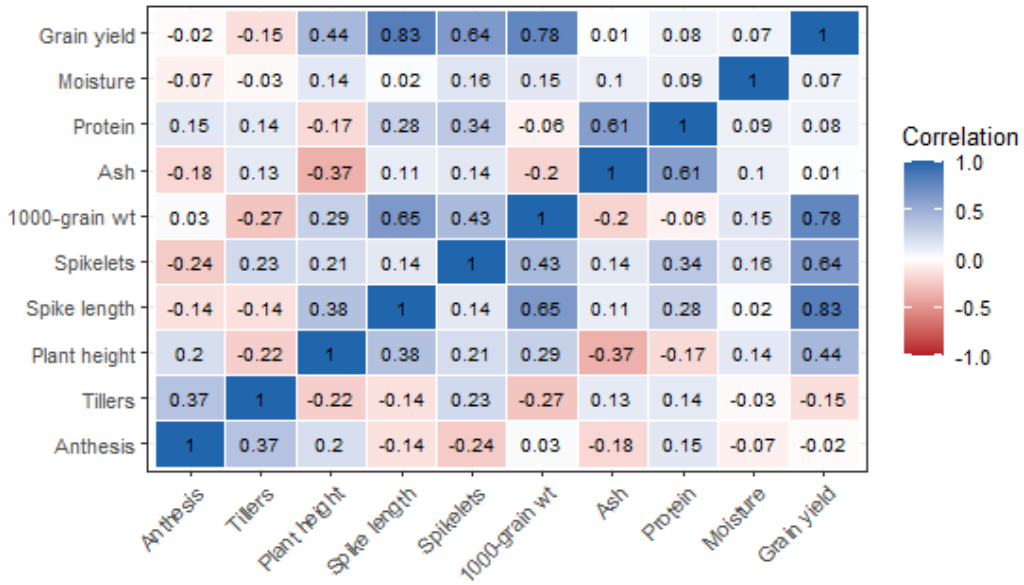

Fig. 4. Genotypic correlation matrix among agronomic and quality traits

Phenotypically, grain yield showed significant positive associations with spikelets per spike, protein content, ash content, and moisture content, highlighting the interdependence between yield and grain quality traits (Fig. 5) similar findings were also observed in previous studies (15, 16). Thousand-grain weight and spikelets per spike emerged as the most influential yield components, exhibiting consistent positive associations with grain yield across both correlation levels similar results found previously (17, 18).

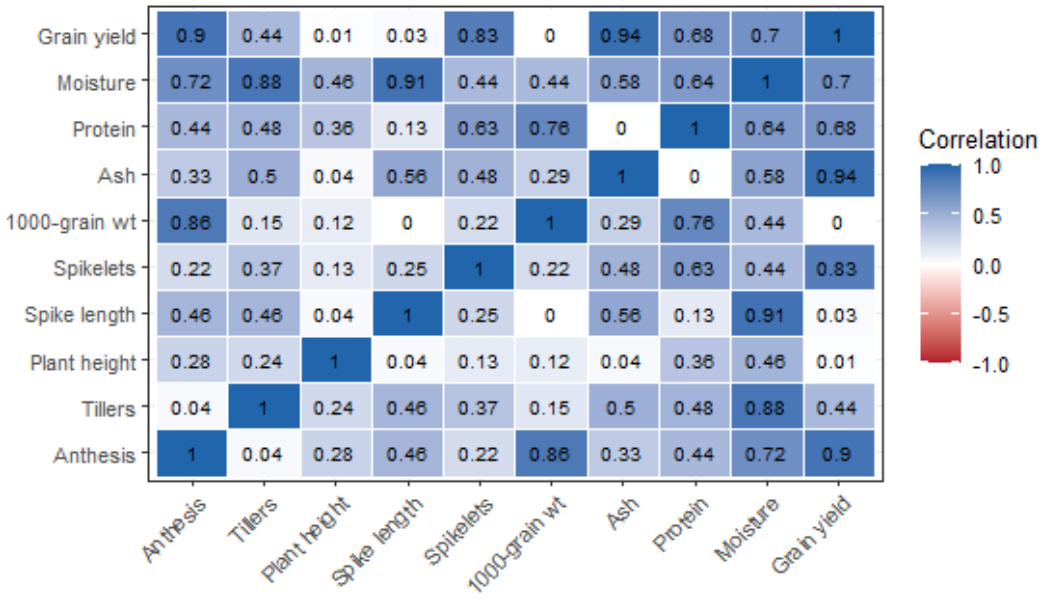

Fig. 5. Phenotypic correlation matrix among agronomic and quality traits

Overall, the strong and favorable associations among key yield and quality traits suggest that integrated selection strategies can effectively enhance wheat productivity and grain quality under the agro-climatic conditions of Dera Ghazi Khan.

The substantial phenotypic variability observed in the present study for traits such as days to 50% anthesis, tillers per plant, plant height, thousand grain weight, and grain yield is consistent with earlier findings reported by Mohammadi *et al.* (2012) and Ali *et al.* (2015) in wheat germplasm under diverse agro-ecological conditions (19, 20). However, unlike previous studies conducted in northern Punjab (e.g., Faisalabad and Lahore), where spike length often showed significant genotypic variation, our results recorded non-significant differences for spike length. This discrepancy may be attributed to the unique thermal and moisture stress patterns in South Punjab (Dera Ghazi Khan), which could have masked genetic expression of spike length. Similar suppression of spike-related traits under terminal heat stress has also been documented by Poudel *et al.* (2019) in late-sown wheat environments (21).

Regarding grain quality, the protein content range (7.99–14.87%) observed in our study aligns well with the findings of Peña *et al.* (2002) and Oury *et al.* (2010), who reported that wheat genotypes grown under warmer conditions tend to exhibit moderate to variable protein levels depending on nitrogen uptake efficiency (22, 23). Interestingly, genotypes GU-6 and GU-7 showed superior protein content despite not being the highest yielders, which supports the well-known inverse relationship between grain yield and protein concentration reported by Simmonds (1995) (24). However, our correlation analysis revealed a positive genotypic association between grain yield and protein content for certain high-performing genotypes like WBLL1*2/B, contradicting the classical yield-protein trade-off. This suggests that under the specific agro-climatic conditions of South Punjab, simultaneous improvement of yield and protein quality may be possible, a finding also recently reported by Guttieri *et al.* (2017) in heat-tolerant wheat lines (25).

The strong positive associations we observed between grain yield and spikelets per spike, thousand grain weight, and moisture content are in close agreement with the work of Kumar *et al.* (2014) in Indian wheat germplasm and Reynolds *et al.* (2009) in CIMMYT-derived lines (26, 27). However, unlike studies from temperate wheat-growing regions (e.g., Europe and Canada), where plant height often shows a negative correlation with grain yield due to lodging risks, our study recorded no such negative association. This divergence is likely due to the predominantly dry and high-temperature conditions in Dera Ghazi Khan, where taller genotypes (e.g., SUP152/BA) may have better competitive ability for light and soil

moisture, as previously suggested by Trethowan *et al.* (2001) in similar semi-arid environments (28). Therefore, our findings emphasize the need for region-specific breeding strategies rather than adopting selection indices developed for temperate or high-rainfall zones.

CONCLUSION

Thirty wheat genotypes were evaluated for yield and quality traits under RCBD at Ghazi University (2018 Rabi season). Significant variation was observed for most traits, except spike length. Genotypes GU-9, KASUK, and SUP152/BA exhibited superior performance in grain yield, tillering, and plant height. Grain yield showed strong positive genotypic correlations with 1000-grain weight, spike length, and plant height, while phenotypic correlations highlighted associations with anthesis duration, tillering, protein, ash, and moisture content.

These results indicate substantial genetic variation among genotypes, suggesting that high-performing lines such as GU-9 and KASUK are promising candidates for breeding programs aimed at improving yield and grain quality especially for Dera Ghazi Khan Farmers.

Conflict of interests:

The authors don't share any competing interests in this manuscript

Authors' contribution:

HKZ Research work and collected data; MU Data analysis; MTM Supervised the research; AB & MSS Interpreted results; TR & FU Statistical analysis; MR, MA & AZ Critical analysis

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