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# ASSESSMENT OF GENETIC AND PHENOTYPIC VARIABILITY FOR MORPHOLOGICAL AND YIELD TRAITS IN IMPROVED WHEAT VARIETIES AND LANDRACES.

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*Wheat, landraces, modern cultivars, genetic variability, heritability, GCV, PCV, grain yield, genetic gain, breeding.*

**Abstract**

*Wheat (*Triticum aestivum *L.) is an important cereal crop, and the identification and utilization of genetically diverse germplasm are essential for improving grain yield and associated agronomic traits. The present study was conducted to evaluate the performance and genetic variability of wheat landraces and modern cultivars for important morphological and yield-related traits. The genotypes exhibited significant variation for plant height, spike length, spike weight, flag leaf area, grains per spike, grain weight per spike, biological yield, and grain yield, indicating the presence of substantial genetic diversity among the studied material. Plant height ranged from 47.89 to 100.67 cm, while spike length varied from 8.04 to 15.04 cm. Spike weight ranged from 2.10 to 4.89 g, and flag leaf area varied from 28.39 to 53.65. Grain yield ranged from 1741 to 5321 kg ha $^{-1}$, with the modern cultivar Abaseen-21 recording the highest grain yield, whereas LND-72 showed the lowest. Grain weight per spike ranged from 1.11 to 2.77 g, with LND-110 exhibiting the highest value. Biological yield varied from 5545.08 to 15075.08 kg ha $^{-1}$, and LND-96 produced the highest biological yield. Genetic analysis revealed that genotypic variance was generally higher than environmental variance for the evaluated traits, while genotypic coefficient of variation (GCV) was generally close to phenotypic coefficient of variation (PCV), indicating a relatively limited influence of environmental factors on trait expression. Broad-sense heritability estimates were high for most traits, ranging from 0.73 for grains per spike to 0.99 for grain weight per spike and biological yield. These findings indicate*

*considerable genetic control of the studied traits and suggest good prospects for selection and genetic improvement. The observed variability among landraces and modern cultivars provides valuable genetic resources for wheat breeding. In particular, Abaseen-21 may be useful as a source for improving grain yield, whereas LND-110, LND-113, and LND-96 may serve as promising genetic resources for improving grain weight per spike, flag leaf area, and biological yield, respectively.*

**INTRODUCTION**

Wheat is a cereal grain and one of the most widely cultivated and important crops globally, as well as the crop with the largest area in Pakistan under cultivation. The crop constitutes 7.8% of value in agriculture and around 1.9% of the country's GDP. It has the pivotal role in the economic stability of the nation. On average (2022-23 to 2024-25), Wheat was cultivated on 9.26 million hectares with the production of about 28.33 million tones. Production of Wheat has been increased by 0.9 percent average annual growth over the last time due mainly the improvement in yield by 3.00 percent, while the area has been observed unchanged. For the year 2024-25, Wheat crop has been estimated at 31.80 million tons 2, an increase by 7.5 percent over the last year (TWS report, 2024-25). Wheat consumption per capita in Pakistan is amongst the highest in the world at around 124kg per annum. Population growth in conjunction with the consumer preference for Wheat-based products is expected to push domestic demand 2.3pc higher in 2024 25 to 30.9Mt (McMeekin, 2024). The majority of wheat is cultivated throughout the winter months of October to December and is then harvested in May and June. In 2021–2022, it produced 1.3 million tonnes on 0.779 million hectares, making it a key crop in Khyber Pakhtunkhwa (KP).

Genetic variability among wheat genotypes can be estimated based on quantitative traits. The presence of genetic variability in a population can be divided into heritable and non-heritable variation. Heritability in general term is the ratio of genetic variance to the total variance i.e. phenotypic variance is known as heritability. The concept of heritability is associated with the relative influence of the heredity and environment. Heritability is of two types i.e. broad sense and narrow sense heritability. Broad-sense heritability estimates the ratio of total genetic variance, including additive, dominance, and epistatic variance, to the phenotypic variance, while heritability in narrow sense estimates only the additive portion of the total phenotypic variance (Raiz and Chowdhry, 2003). Furthermore, knowledge of the naturally occurring diversity in tetraploid wheat landraces helps to identify diverse groups of genotypes to be incorporated in the breeding programme.

As it is in all over the world, erosion of genetic resources has been steadily increasing in our country as well and this condition forces researchers to establish gene banks by collecting material from these regions in order to provide genetic material (Eser *et al.*, 2024). Consequently, some region faces the same problem and like many plant species, wheat landraces face extinction mainly due to commercial cultivars. Therefore, it occupation is of great importance that regional types should be collected and agricultural characteristics should be recorded. (Aujla *et al.,* 2010). There are numerous limitations and difficulties affecting wheat production and yield in Pakistan and throughout the world. In order to fulfill the growing population's need for food, more food must be produced globally, which can only be done by increasing cereal crop production, as well as the protection of grain commodities in storage against insects losses (Ahmad *et al.*, 2019).

The use of wheat is growing, even in nations with unfavorable conditions for the cultivation of wheat. Nevertheless, wheat is also an integral component of nutrition for animals, especially in years when harvests are badly impacted by the rain. The manufacturing of adhesives, paper additives and various other items frequently uses grains of lower quality (Curtis, 2019. The low yield per hectare is caused by a number of problems, including a lack of high-yielding cultivars that can be acclimated to a variety of agro-ecologies around the nation. As a result, the first step producing varieties is to determine the genetic variability of the present genotypes for the desired traits (Rahman *et al.*, 2016). Numerous yield-related

characteristics of bread wheat exhibit genetic development, heritability and variability as described by (Rahman *et al.,* 2016; Negasa and Chauhan, 2016.)

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**Objectives**

1. To evaluate genetic variability among Pakistani wheat landraces and modern cultivars for morphological, physiological and yield-related traits.
2. To identify superior genotypes with high grain yield, biological yield and drought-adaptive traits like flag leaf area and spike weight as donor parents.
3. To estimate genetic parameters such as GCV, PCV, broad-sense heritability and genetic gain for effective selection of target traits.
4. To determine association of yield contributing traits like grains per spike, grain weight per spike and spike length with grain yield.

**Materials and Methods**

The research activities were carried out by sowing landraces of modern wheat cultivars for morpho-yield traits in (2025-26) at the Cereal Crop Research Institute (CCRI), Pirsabak, Nowshera during the Rabi season. Experimental material was consists of 36 diverse genotypes (27 local landraces and 9 modern wheat cultivars) which was sown in alpha lattice design using two replications. Every tested genotype was sown in an experimental plot with two rows, each row was two meters in length, and 25 cm apart. The evaluation of the morpho-physiological impact was analyzed for selected wheat lines.

**Table2.1: List of genotypes (1to 27 local landraces and 9 modern cultivars)**

| S.no | Genotypes | S.no | Genotypes |
|---|---|---|---|
| 1 | LND-7 | 19 | LND-94 |
| 2 | LND-13 | 20 | LND-95 |
| 3 | LND-9 | 21 | LND-96 |
| 4 | LND-16 | 22 | LND-100 |
| 5 | LND-17 | 23 | LND-104 |
| 6 | LND-22 | 24 | LND-109 |
| 7 | LND-23 | 25 | LND-110 |
| 7 | LND-25 | 26 | LND-112 |
| 9 | LND-26 | 27 | LND-113 |
| 10 | LND-28 | 28 | Khaista-17 |
| 11 | LND-33 | 29 | Pirsabak-15 |
| 12 | LND-35 | 30 | Pirsabak-19 |
| 13 | LND-37 | 31 | Pirsabak-21 |
| 14 | LND-56 | 32 | Abaseen-21 |
| 15 | LND-72 | 33 | Paseena-17 |
| 16 | LND-83 | 34 | Taskeen-22 |
| 17 | LND-85 | 35 | Khyber-23 |
| 18 | LND-91 | 36 | Gulzar-19 |

**Result**

**1. Plant height**

Analysis of variance showed highly significant ($p \leq 0.05$) differences in plant height among the genotypes. Results indicated that considerable genetic variations were present for the said trait.

Among the wheat genotypes, the tallest plant height was recorded for LND -22(100 days), Whereas the shortest plant height was observed in Abaseen 21 (47 days). The LSD value was (6.11 %) and coefficient of variance CV was (3.47%) indicating low variability in the experiment.

Similarly, the phenotypic variance (VG) of 38.50 was lower than the genotypic variance (VP) of 110.43, indicating that most of variation is due to genetic factors, with only minor environmental variance (VE) of 8.31. Additionally, the genotypic coefficient of variation (GCV) was 13.63 (Table 4), slightly lower than the phenotypic coefficient variation (PCV) of 14.14, indicating some environmental influence, but overall trait is genetically controlled.

The broad- sense heritability ($H^2$) was maximum (0.98), suggested the plant height is largely genetically controlled that selection for the trait would be highly effective in breeding programs. For plant height the phenotypic coefficient of variation value PCV (118.47) was comparatively greater in magnitude than the genotypic of variation GCV (110.43. Similarly, the GCV and PCV for this trait were (13.63) and (14.14) respectively, and the broad-sense heritability was also high (0.93).

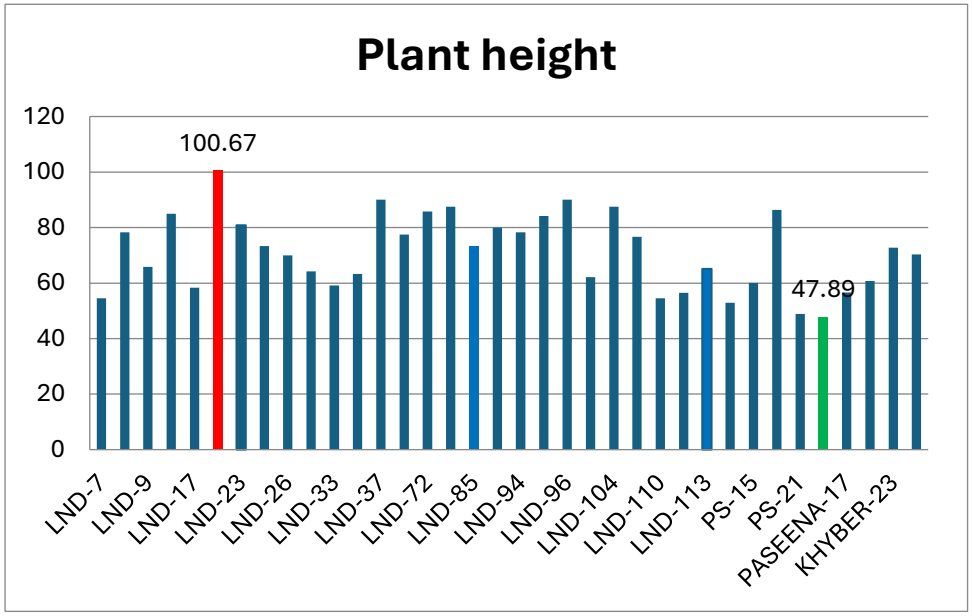





**Figure : Field view of wheat genotypes the grain filling stageplant heigh tmeasurement.**

**2: Spike Length (cm)**

Analysis of variance (ANOVA) showed highly significant ($P \leq 0.05$) differences among wheat landraces and modern cultivars for spike length (Table 2)The (LSD) value for spike length was 1.21 and coefficient of variation (CV) was 5.42 which showed the correctecness of the experiment. The mean values for spike length ranged from 8.04 to15.04 cm (table 2). The maximum spike length was reported for LND-104 (15.04cm), while the minimum of spike length was observed for LND-83 (8.04cm).

The genetic variance (GV=2.13) was greater than environmental variance (VE=0.34) which indicated that spike length were greatly influenced by genes than by environmental factor and slightly less than that of the phenotypic variance (VP=2.48). Similarly, it was observed that the estimates of genotypic coefficients of variation (GCV=13.48) were closer to phenotypic coefficient of variance (PCV=14.53), which showed that spike length had greatly influenced by genetic components as compared to environmental effect (table 4).

Furthermore, the estimated broad- sense heritability ($H^2$) for days to maturity was higher 0.86 which showed that environmental influence on spike length was minimum. Moreover, the genetic gain (GG) was 1.90, which ranged in low category suggested that improvement for spike length was limited.

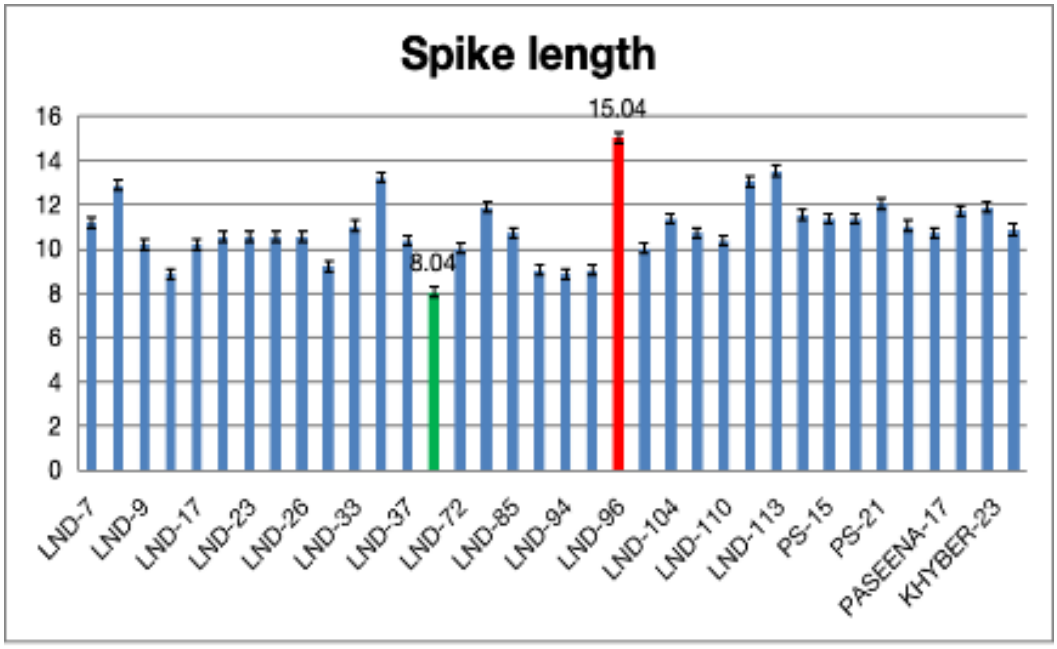



**Figure: Mean of spike length of different wheat genotypes under experimental conditions. Genotypes with highest yield are represented by red bars, whereas genotypes with the lowest yield are represented by green bars, error bars represent standard error of means.**



**Figure: Spike length measured using a metric scale to evaluate genotypic variation.**

**3. Spike weight**

The Analysis of variance displayed highly significant (P ≤0.01) difference for wheat land races and cultivars for spike weight (table 2).

The LSD value for spike weight was 0.45 and coefficient of variation (CV) was 6.58 which demonstrated the authenticity of the experiment. The mean values for spike weight ranged from 2.10 to 4.89 g. The maximum spike weight was observed for newly developed cultivars Abaseen-21 (4.89 g) followed by Pirsabak-15 took 4.75g.While minimum spike weight was recorded for LND-100 (2.10g) and LND-17 (2.12g).

Spike weight exhibited phenotypic variance (VP = 0.64) greater than genetic variance (GV=0.59), with a low environmental variance (VE=0.05).The genotypic coefficient of variation (GCV=23.27) was less than

the phenotypic coefficient of variation (PCV=24.18), indicating minimum environmental influence on spike weight (table 4).
Broad-sense heritability ($H^2$ = 0.93) was high, but the genetic gain was low (1.04), which suggested that breeders may need to wait for many cycles to improve spike weight effectively.

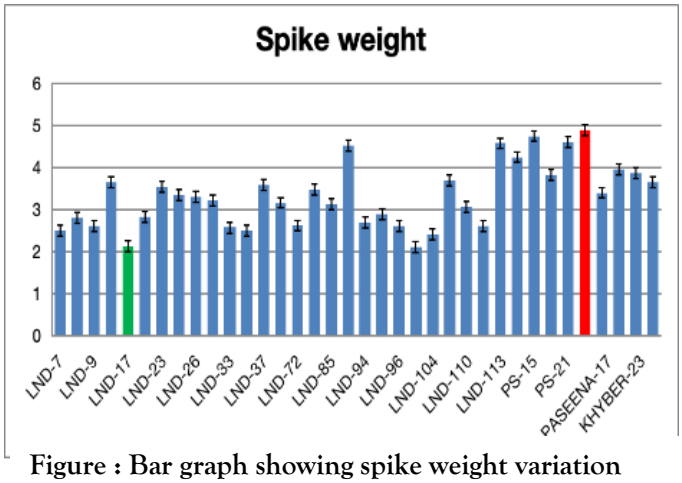



**Figure : Bar graph showing spike weight variation**




**Figure: Representative wheat spike weight used for counting.**

**5.Flage leaf Area**

Analysis of variance (ANOVA) showed highly significant (P ≤.0.05) difference for wheat land races and modern cultivars for flage leaf area (table 2).
The (LSD) value for flage leaf area was 6.28 and coefficient of variation (CV) was 7.62 which showed the validity of the experiment. The mean values for flage leaf area ranged from 28.39 to 53.65. The maximum number of flage leaf area were observed for LND-113(53.65) followed by LND-85 (52.47). While the minimum number of flage leaf area was recorded for modern wheat cultivar GULZAR-19 (28.39).
Flag leaf areas in wheat landraces and modern cultivars were tested and it was found differences in genotypes. In the study, the flag leaf area of local varieties was larger than modern varieties. The largest flag leaf area was measured in LND- (53.65).
Flage leaf area showed genotypic variance (GV=31.77) was greater than environmental variance (VE=9.29) through it was slightly less than that of the overall phenotypic variance (VP=41.06) for flage leaf area. Similarly, for genotypic coefficient of variation (GCV=14.10) was slightly lower than the phenotypic coefficient of variation (PCV=16.03) indicating predominant genetic influence with environmental effect

on the trait with heritability ($H^2$) 0.77, selection for flage leaf area were effective in breeding programmes (table 4).

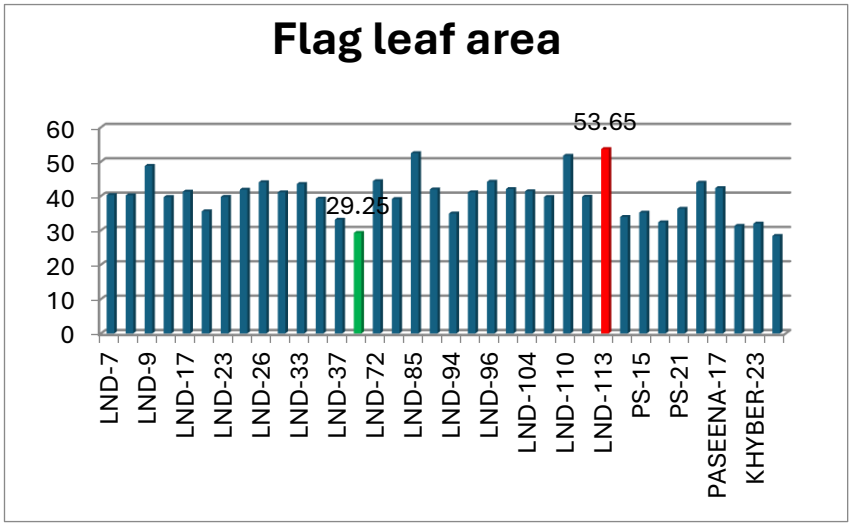



**Figure: Mean perforance of wheat genotypes for flag leaf area.**



**Figure : Flag leaf area of wheat genotypes showng variation in leaf length and width.**

**Table 2: Mean performance of plant height, spike length, spike weight, flage leaf area.**

| Enter name | Plant height | Spike length | Spike weight | Flag leaf area |
|---|---|---|---|---|
| LND-7 | 54.50 | 11.21 | 2.50 | 40.27 |
| LND-13 | 78.33 | 12.88 | 2.80 | 40.20 |
| LND-9 | 65.83 | 10.21 | 2.61 | 48.76 |
| LND-16 | 85.00 | 8.88 | 3.65 | 39.70 |
| LND-17 | 58.33 | 10.21 | 2.12 | 41.27 |
| LND-22 | 100.67 | 10.54 | 2.82 | 35.56 |
| LND-23 | 80.83 | 10.54 | 3.55 | 39.74 |
| LND-25 | 73.33 | 10.54 | 3.34 | 41.85 |
| LND-26 | 70.00 | 10.54 | 3.31 | 44.00 |
| LND-28 | 64.17 | 9.21 | 3.22 | 41.08 |
| LND-33 | 59.17 | 11.04 | 2.57 | 43.50 |
| LND-35 | 63.33 | 13.21 | 2.50 | 39.23 |
| LND-37 | 90.00 | 10.38 | 3.59 | 33.10 |

| | | | | | |
|---|---|---|---|---|---|
| LND-56 | 77.50 | 8.04 | 3.16 | 29.25 | |
| LND-72 | 85.83 | 10.04 | 2.62 | 44.33 | |
| LND-83 | 87.50 | 11.88 | 3.48 | 39.13 | |
| LND-85 | 73.33 | 10.71 | 3.13 | 52.47 | |
| LND-91 | 80.00 | 9.04 | 4.52 | 41.92 | |
| LND-94 | 78.33 | 8.88 | 2.69 | 34.91 | |
| LND-95 | 84.17 | 9.04 | 2.89 | 41.09 | |
| LND-96 | 90.00 | 15.04 | 2.60 | 44.14 | |
| LND-100 | 62.17 | 10.04 | 2.10 | 42.03 | |
| LND-104 | 87.50 | 11.38 | 2.41 | 41.39 | |
| LND-109 | 76.67 | 10.71 | 3.69 | 39.72 | |
| LND-110 | 54.50 | 10.38 | 3.07 | 51.71 | |
| LND-112 | 56.47 | 13.04 | 2.60 | | 39.79 |
| LND-113 | 65.11 | 13.54 | 4.58 | 53.65 | |
| KHAISTA-17 | 52.89 | 11.54 | 4.25 | 33.90 | |
| PIRSABAK-15 | 60.06 | 11.38 | 4.75 | 35.17 | |
| PIRSABAK-19 | 86.39 | 11.38 | 3.82 | 32.34 | |
| PIRSABAK-21 | 48.89 | 12.04 | 4.61 | 36.28 | |
| ABASEEN-21 | 47.89 | 11.04 | 4.89 | 43.87 | |
| PASEENA-17 | 56.56 | 10.71 | 3.40 | 42.30 | |
| TASKEEN-22 | 60.73 | 11.71 | 3.96 | 31.31 | |
| KHYBER-23 | 72.73 | 11.88 | 3.87 | 31.97 | |
| GULZAR-19 | 70.3 | 10.87 | 3.65 | 28.39 | |
| CV | 3.47 | 5.42 | 6.58 | 7.62 | |
| LSD 5% | 6.11 | 1.21 | 0.45 | 6.28 | |

**5. Grain yield (kg/ha)**

Analysis of variance (ANOVA) showed highly significant ($P \leq 0.05$) differences among wheat landraces and modern cultivars for grain yield (Table 3).

The LSD value for grain yield was 293.29 kg/ha and coefficient of variation (CV) was 4.17%, which showed the correctness of the experiment. The mean values for grain yield ranged from 1741 to 5321 kg/ha. The maximum grain yield was reported for Abaseen-21 (5321 kg/ha), while the minimum grain yield was recorded for LND-72 (1741 kg/ha).

Variation in grain yield among landraces was mainly due to genetic differences and their yield potential. Cultivars like Abaseen-21 with 5321 kg/ha grain yield performed best because they possess genetic potential for higher tillering, more grains per spike, and better grain filling, which are important traits for breeding high-yielding wheat varieties. High-yielding genotypes are valuable for food security and farmer income. Conversely, landraces like LND-72 with 1741 kg/ha grain yield may be adapted to marginal environments with low input conditions where stability is more important than maximum yield. Thus, both high and low yielding genotypes provide useful genetic diversity for future wheat improvement programs.

The genetic variance (GV = 927846.41) was much greater than environmental variance (EV = 20278.72), which indicated that grain yield was greatly influenced by genetic factors. Phenotypic variance (VP = 948125.14) was slightly higher than genotypic variance (Table 4). Moreover, genotypic coefficient of variation (GCV = 28.21%) was closer to phenotypic coefficient of variation (PCV = 28.52%), which demonstrated that grain yield was largely influenced by genetic components compared to environmental factors.

Furthermore, broad-sense heritability ($H^2$) for grain yield was high (0.98), which indicated that grain yield was mainly influenced by genetic factors with minimal environmental impact. Moreover, genetic advance (GA) was computed as 13.34%, which suggested that genetic components could play an important role in the inheritance and improvement of grain yield.

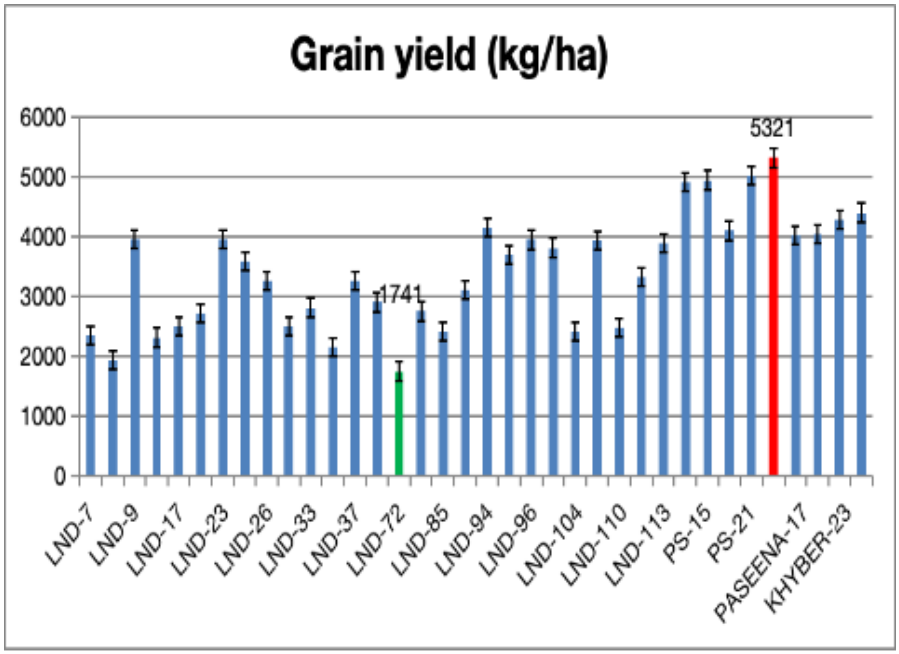






**Figure : Bar graph showing grain yield (kg/ha) across wheat lines, with PS-21 recording the highest yield (5821 kg/ha). Bottom: Representative wheat grain sample from harvested plots. Error bars indicate standard deviation.**

**6. Grain weight per spike (g)**

Analysis of variance (ANOVA) showed highly significant ($P \leq 0.05$) variation among wheat landraces and modern cultivars for grain weight per spike (Table 3).

The LSD value for grain weight per spike was 0.08 g and coefficient of variation (CV) was 1.85%, which showed the correctness of the research work. The mean values for grain weight per spike ranged from 1.11 to 2.77 g. The maximum grain weight per spike was recorded for LND-110 (2.77 g) followed by LND-23 (2.75 g), while the minimum grain weight per spike was recorded for cultivar Abaseen-21 (1.11 g) followed by Taskeen-22 and Khyber-23 (1.47 g).

Variation in grain weight per spike among landraces was mainly due to genetic differences in grain size and grain filling capacity. Landraces like LND-110 with 2.77 g grain weight per spike had heavier spikes because they possess genetic potential for more grains per spike and better grain filling, which is important

for breeding high-yielding wheat varieties. Higher grain weight per spike contributes directly to grain yield. Conversely, cultivars like Abaseen-21 with 1.11 g grain weight per spike may be adapted to environments where more spikes per unit area compensate for lower grain weight per spike. Thus, both high and low grain weight per spike genotypes provide useful genetic diversity for future wheat improvement programs. The genetic variance (GV = 0.21) was greater than environmental variance (EV = 0.00), which indicated that grain weight per spike was greatly influenced by genetic factors. Phenotypic variance (VP = 0.21) was slightly higher than genotypic variance (Table 4). Furthermore, genotypic coefficient of variation (GCV = 21.79%) and phenotypic coefficient of variation (PCV = 21.79%) were identical, which showed minimal environmental influence.

Moreover, the estimates of broad-sense heritability ($H^2$) for grain weight per spike was high (0.99), which confirmed the minimal influence of environmental factors.

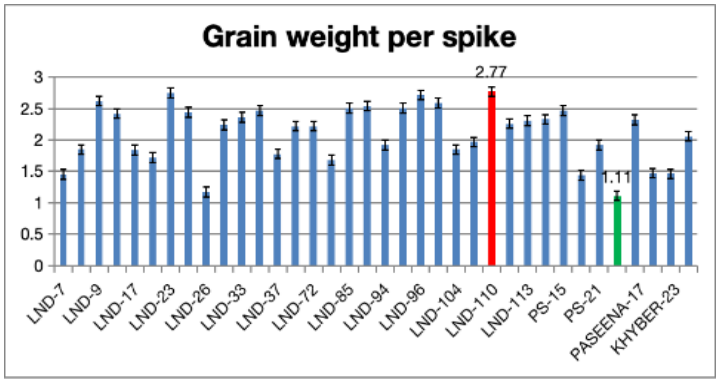





**Figure : Variation in grain weight per spike among wheat lines, ranging from 1.11 g to 2.77 g.**

**8: Biological yield (kg/ha)**

Analysis of variance (ANOVA) showed highly significant ($P \leq 0.05$) differences among wheat landraces and modern cultivars for biological yield (Table 3).

The LSD value for biological yield was 325.47 kg/ha and coefficient of variation (CV) was 1.50%, which showed the correctness of the experiment. The mean values for biological yield ranged from 5545.08 to 15075.08 kg/ha. The maximum biological yield was reported for LND-96 (15075.08 kg/ha) followed by LND-109 (13375.08 kg/ha), while the minimum biological yield was recorded for LND-13 (5545.08 kg/ha) followed by LND-100 (6045.08 kg/ha).

Variation in biological yield among landraces was mainly due to genetic differences in total biomass production. Landraces like LND-96 with 15075.08 kg/ha biological yield produced more biomass because they possess genetic potential for higher plant height, more tillers, and better vegetative growth, which is

important for breeding dual-purpose wheat for grain and fodder. High biological yield genotypes are valuable for livestock feed. Conversely, landraces like LND-13 with 5545.08 kg/ha biological yield may have higher harvest index and partition more assimilates to grain rather than vegetative parts. Thus, both high and low biomass genotypes provide useful genetic diversity for future wheat improvement programs. The genetic variance (GV = 4168238.31) was much greater than environmental variance (EV = 24973.33), which indicated that biological yield was greatly influenced by genetic factors. Phenotypic variance (VP = 4193211.64) was slightly higher than genotypic variance (Table 4). Moreover, genotypic coefficient of variation (GCV = 19.33%) was closer to phenotypic coefficient of variation (PCV = 19.38%), which confirmed that biological yield was largely influenced by genetic components compared to environmental factors.

Furthermore, the estimates of broad-sense heritability ($H^2$) for biological yield was high (0.99), which showed that it was largely influenced by genetic factors with minimal environmental impact. Moreover, genetic advance (GA) was computed as 2849.75 kg/ha, which suggested that genetic variance could play an important role in the inheritance and improvement of biological yield.

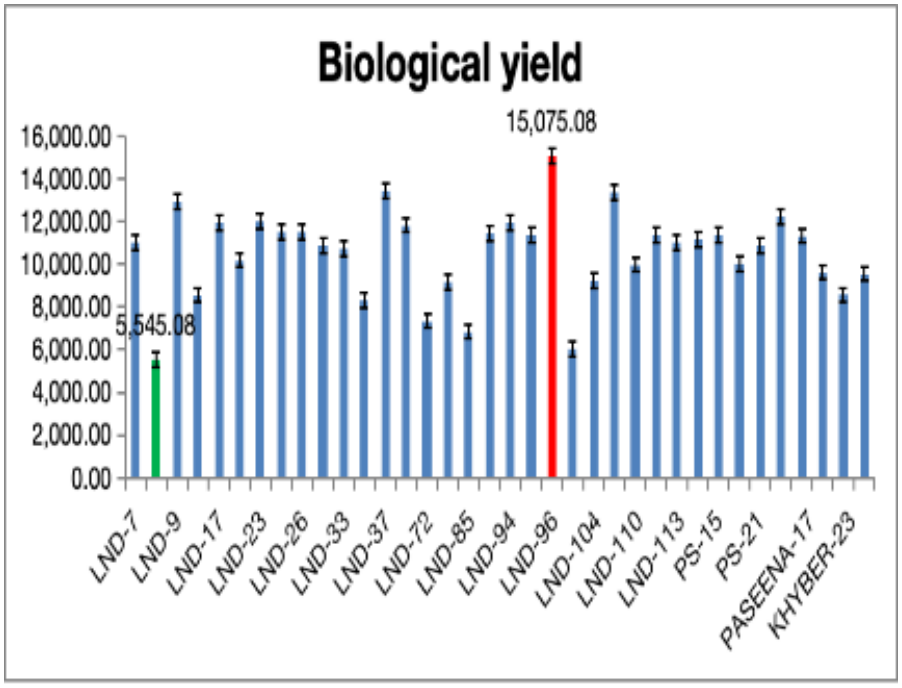



**Figure 8: Field view of mature wheat crop showing phenotypic variation among wheat landraces of modern cultivars.**



**Figure :** Mean of biological yield of different wheat genotypes under experimental conditions. Genotypes with highest yield are represented by red bars, whereas genotypes with the lowest yield are represented by green bars error bars represent standard error of means.

**Table 3: Mean performance of Grain yield, Grain weight per spike, Grain per spike, Biological yield.**

| Enter name | Grain yield kg/h | Grain weight per spike | Biological yield |
|---|---|---|---|
| LND-7 | 2341 | 1.45 | 11,035.08 |
| LND-13 | 1931 | 1.85 | 5,545.08 |
| LND-9 | 3961 | 2.62 | 12,955.08 |
| LND-16 | 2311 | 2.42 | 8,555.08 |
| LND-17 | 2501 | 1.84 | 11,975.08 |
| LND-22 | 2711 | 1.72 | 10,205.08 |
| LND-23 | 3961 | 2.75 | 12,045.08 |
| LND-25 | 3591 | 2.44 | 11,505.08 |
| LND-26 | 3261 | 1.17 | 11,505.08 |
| LND-28 | 2501 | 2.24 | 10,875.08 |
| LND-33 | 2811 | 2.36 | 10,735.08 |
| LND-35 | 2151 | 2.47 | 8,335.08 |
| LND-37 | 3261 | 1.78 | 13,465.08 |
| LND-56 | 2901 | 2.22 | 11,845.08 |
| LND-72 | 1741 | 2.22 | 7,345.08 |
| LND-83 | 2751 | 1.68 | 9,165.08 |
| LND-85 | 2411 | 2.51 | 6,845.08 |
| LND-91 | 3111 | 2.54 | 11,445.08 |
| LND-94 | 4151 | 1.92 | 11,975.08 |
| LND-95 | 3701 | 2.51 | 11,385.08 |
| LND-96 | 3951 | 2.72 | 15,075.08 |
| LND-100 | 3811 | 2.59 | 6,045.08 |
| LND-104 | 2411 | 1.85 | 9,265.08 |
| LND-109 | 3941 | 1.97 | 13,375.08 |
| LND-110 | 2471 | 2.77 | 9,985.08 |
| LND-112 | 3331 | 2.26 | 11,395.08 |
| LND-113 | 3891 | 2.31 | 11,035.08 |
| KHAISTA-17 | 4921 | 2.33 | 11,165.08 |
| PIRSABAK-15 | 4946 | 2.47 | 11,375.08 |

| | | | |
|---|---|---|---|
| PIRSABAK-19 | 4101 | 1.44 | 10,045.08 |
| PIRSABAK-21 | 5031 | 1.92 | 10,895.08 |
| ABASEEN-21 | 5321 | 1.11 | 12,255.08 |
| PASEENA-17 | 4026 | 2.32 | 11,345.08 |
| TASKEEN-22 | 4046 | 1.47 | 9,635.08 |
| KHYBER-23 | 4281 | 1.46 | 8,575.08 |
| GULZAR-19 | 4401 | 2.06 | 9,555.08 |
| CV | 4.17 | 1.85 | 1.50 |
| LSD 5% | 293.29 | 0.08 | 325.47 |

**Table 4: Genetic components of different studied traits.**

| Traits | GV | VE | VP | $H^2$ | GG | GCV | PCV |
|---|---|---|---|---|---|---|---|
| Plant height | 110.3 | 8.31 | 118.4 | 0.93 | 14.19 | 13.63 | 14.14 |
| Spike length | 2.13 | 0.34 | 2.48 | 0.86 | 1.90 | 13.48 | 14.53 |
| Spike weight | 0.59 | 0.05 | 0.64 | 0.93 | 1.04 | 23.27 | 24.18 |
| Grain weight per spike | 0.21 | 0.00 | 0.21 | 0.99 | 0.64 | 21.79 | 21.79 |
| Flage leaf area | 31.77 | 9.29 | 41.06 | 0.77 | 6.94 | 14.10 | 16.03 |
| Grain yield | 660,263 | 16,793.39 | 677,056.47 | 0.98 | 1,123.40 | 27.66 | 28.01 |
| Biological yield | 4,168,238.31 | 24,973.33 | 4,193,212 | 0.99 | 2,849.75 | 19.33 | 19.38 |

GV=Genotypic variance, VE= Environmental variance, VP= Phenotypic variance, $H^2$= Heritability, GG= Genetic gain, GCV= Genotypic coefficient of variance, PCV= Phenotypic coefficient of variance.

**Discussion**

The present study investigated the performance of different wheat genotypes for important agronomic and yield-related traits under varying environmental conditions. Significant variations were observed among the genotypes for plant height, spike length, spike weight, grains per spike, grain weight per spike, biological yield, grain yield, and harvest index. These variations indicate the presence of substantial genetic diversity among the tested genotypes, which can be effectively utilized in wheat improvement programs aimed at developing high-yielding and widely adapted cultivars.

Yield in wheat is a complex trait governed by the interaction of several morphological and physiological characteristics. Traits such as plant height, spike length, grains per spike, and spike weight directly contribute to grain yield potential. Biological yield and harvest index reflect the efficiency of biomass production and assimilate partitioning toward economic yield. Therefore, understanding the variability and relationships among these traits is essential for the identification of superior genotypes with enhanced productivity and stability.

The discussion presented in this chapter compares the findings of the current study with previous reports to explain the observed variations among wheat genotypes. Furthermore, it highlights the potential of promising genotypes for their utilization in future breeding programs aimed at improving wheat productivity, adaptability, and resilience under changing environmental conditions.

**1: Spike length**

Yadav et al., (2021) and Singh et al., (2020) reported slightly greater value for PCV than GCV and heritability for spike length which was similar to the results of current study and showed the greater role of genetic factor for wheat.

**2: Spike Weight**

Khan *et* al. (2018) reported high heritability for spike weight of wheat which was similar to the present investigation, indicating the greater genetic influence on spike weight rather than environmental effects.

**3.Flage leaf area**

Kumar et al., (2014) and Kyosev and Desheva (2015) were similar to the result of present studies among wheat varieties for flage leaf area with Genetic advance as percent over means varied from 43% with high genetic gain as percent over mean reached calculations for flag leaf area (43%), High heritability along with genetic advance percent over means better explains the gene action involved and scope for phenotype selection.

**4: Grain Yield**

Fikir Desalew (2024)) recorded greater Vg than Ve and lesser value than Vp with high heritability and genetic gain for grain yield which supported the results of present study that indicated the favorable conditions for effective selection and genetic improvement. However, Dagnaw *et* al., (2022) demonstrated moderate broad-sense heritability (0.42) and Genetic gain for wheat grain yield.

**5: Grain Weight per Spike**

Khan *et* al., (2018) demonstrated high heritability and greater Vg than Ve and slightly less from VP for grain weight per spike. However, the present research work showed high heritability with similar Vg and VP values which showed the major role of genes in controlling grain weight per spike in wheat genotypes.

**6: Biological Yield**

Ahmad and Gupta (2023) and Rauf *et* al., (2023) observed high Vg than Ve and slightly less than Vp values and high heritability for biological yield of wheat, which was matching with results of this study. However, Parkash *et* al., (2020) reported greater Ve than Vg and low heritability which showed the greater environmental influence on biological yield of wheat.

**Conclusion**

The present study demonstrated substantial phenotypic and genetic variability among wheat landraces and modern cultivars for important morphological, yield-contributing, and yield-related traits. The significant differences observed among genotypes indicate the presence of adequate genetic diversity that can be exploited in wheat improvement programs. Considerable variation was observed for plant height, spike length, spike weight, flag leaf area, grains per spike, grain weight per spike, biological yield, and grain yield.

The genetic parameter estimates further demonstrated that genotypic variance was generally greater than environmental variance, while the relatively narrow differences between GCV and PCV for most traits indicated limited environmental influence on their expression. High broad-sense heritability estimates were observed for most traits, particularly grain weight per spike (0.99), biological yield (0.99), grain yield (0.98), plant height and spike weight (0.93), indicating that a substantial proportion of the observed variation was genetically controlled. Therefore, selection based on phenotypic performance is expected to be effective for several of the studied traits.

The genotypes differed considerably in their performance for individual traits. The modern cultivar **Abaseen-21** exhibited the highest grain yield (5321 kg $ha^{-1}$) and spike weight (4.89 g), making it a promising parent for improving yield potential. **LND-110** recorded the highest grain weight per spike (2.77 g), whereas **LND-113** showed superior flag leaf area (53.65) and high spike length. **LND-96** produced the highest biological yield (15075.08 kg $ha^{-1}$), indicating its potential as a source of high biomass production. The contrasting performance of landraces and modern cultivars highlights the importance of conserving and utilizing landrace diversity in wheat breeding.

Overall, the results suggest that the evaluated wheat germplasm contains valuable genetic resources for the improvement of yield and associated traits. Genotypes exhibiting superior performance and favorable heritability estimates can be incorporated into hybridization and selection programs to develop improved wheat cultivars. However, because genotype × environment interactions can influence the

expression of quantitative traits, the most promising genotypes should be further evaluated across multiple environments and seasons before their recommendation for commercial cultivation or use as parental material.

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