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Original article

Development of "Wafaa Halabja", a New Bread Wheat (*Triticum aestivum* L.) Cultivar Adapted to the Rainfed Areas of Northern Iraq – Kurdistan Region

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To improve wheat productivity under rainfed agriculture in the Kurdistan Region of northern Iraq, a long-term field evaluation was conducted to identify superior bread wheat (*Triticum aestivum* L.) genotypes adapted to local agroecological environments. A total of 28 genotypes introduced from the International Maize and Wheat Improvement Centre, Mexico, were grown and assessed over eight consecutive growing seasons in the Shahrizor plain, a representative rainfed area. The primary objective was to evaluate the productivity and adaptability of these genotypes and select the most promising ones based on yield potential and environmental suitability. In the final three seasons, nine superior genotypes were selected and evaluated alongside three widely grown local cultivars using a randomised complete block design with three replications. The analysis was based on data from two consecutive agricultural seasons (2022/2023 and 2023/2024). The results revealed that genotype no. 22 consistently outperformed all others in grain yield, yield components and stability under rainfed agriculture. Its superior agronomic performance and genetic stability prompted its nomination for official registration. This genotype showed superiority for traits: number of spikes per square meter, 1,000-grain weight and grain yield, as well as stability for grain yield and yield-associated traits over the past three seasons, despite variations in rainfall amounts during these seasons. Following further evaluation by a special committee at the Iraqi Ministry of Agriculture in Baghdad, genotype no. 22 was officially approved and released as a new cultivar under the name 'Wafaa-Halabja' and recognised for its high productivity and suitability for rainfed farming systems in Northern Iraq. This achievement marks a significant step towards sustainable wheat production and food security in semi-arid regions.

Wheat (*Triticum aestivum* L.) has played a central role in the development of human civilisations for over 10,000 years. Its domestication traces back to the Fertile Crescent, with Mesopotamia, modern-day Iraq, being one of the primary centres of origin (Chawsheen 2010; Shaheen *et al.* 2024). Archaeological evidence suggests that ancient Iraqis were pioneers in cultivating wheat, thus facilitating the rise of complex societies through stable food supplies (Abate *et al.* 2018). Wheat remains one of the most critical crops globally, supplying an essential source of calories and protein, especially in the Middle East and North Africa (Saini *et al.* 2025). In Iraq, wheat holds immense socio-economic impor-

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tance, contributing to food security and rural livelihoods. National wheat production, however, struggles to meet domestic demand, prompting heavy reliance on imports (Morgan & Attché 2023; Saini *et al.* 2025; Shaheen *et al.* 2024).

The rainfed areas of northern Iraq, particularly the Shahrizor plain in the Kurdistan Region, face significant challenges related to climatic variability, and recent years have seen increasing climate instability, including erratic rainfall patterns, prolonged droughts, and higher temperatures (Huang & Rozelle 1995). These changes have severely affected the productivity and stability of wheat crops (Gaznayee & Al-Quraishi 2019). Consequently, farmers in these regions have faced unpredictable harvests, with some areas experiencing yield reductions of up to 40% in recent years (Delman *et al.* 2022).

Furthermore, soil degradation in Iraq's rainfed areas exacerbates the situation. Monoculture farming practices, nutrient depletion, and salinity build-up have led to a decline in soil fertility and water retention capacity (Arif *et al.* 2025). This degradation, coupled with the increasing frequency of pests and diseases, such as rusts and Fusarium head blight, presents a major threat to wheat production in these regions (Kumar *et al.* 2016). These multiple stresses demand immediate attention, and there is a clear need for new wheat cultivars that can thrive under these changing environmental conditions (Borojevic & Williams 1982).

These challenges, developing new wheat cultivars that are drought-tolerant, disease-resistant, and high-yielding under rainfed agricultures, are crucial. Modern wheat breeding, especially the use of molecular markers such as those for drought resistance (DREB-1A), provides promising tools for developing wheat varieties adapted to the semi-arid regions of northern Iraq (Awtaq *et al.* 2021; Zahir *et al.* 2024). Furthermore, breeding for key agronomic traits, such as spike number, 1,000-grain weight, and harvest index, has proven effective in improving wheat performance under challenging environmental conditions (Muslu *et al.* 2025).

Moreover, genotype-by-environment interactions play a critical role in wheat performance, particularly in regions like the Shahrizor plain, where climatic conditions vary from year to year. Studies by Hui *et al.* (2025) emphasized the importance of selecting wheat varieties that can adapt to such variability. Therefore, understanding these interactions is key to identifying and developing wheat genotypes that can provide stable yields over time, despite the unpredictability of rainfed agriculture.

This study aims to evaluate and select superior wheat genotypes adapted to the rainfed agriculture s of northern Iraq, particularly in the Shahrizor plain. This region, characterized by its semi-arid climate, faces significant challenges related to water availability, soil quality, and climatic variability. Through a comprehensive evaluation of multiple wheat genotypes, this study aimed to identify the most promising cultivar based on yield performance, drought tolerance, disease resistance, and environmental adaptability.

The ultimate goal of this research was to propose a new, high-performing wheat cultivar that is well-suited for the semi-arid, rainfed farming systems of the Kurdistan Region, thereby contributing to national food security and enhancing sustainable agricultural practice by developing a cultivar that can withstand the environmental stresses of the region, this study aimed to help ensure the viability of wheat farming in Iraq's rainfed areas, reducing reliance on imports and improving food sovereignty.

This research also intended to explore genotype-by-environment interactions in the context of rainfed wheat farming in Iraq, providing a deeper understanding of how different genotypes perform under varying environmental conditions and ensuring the selection of varieties with consistently high yields.

MATERIAL AND METHODS

The field experiments were conducted over eight consecutive cropping seasons, from 2016 to 2024, at the experimental field of the Technical College of Halabja, affiliated with the Sulaimani Polytechnic University, located in Halabja City, Kurdistan Region, Iraq. The geographic coordinates of the experimental site are 35.1770° N latitude and 45.9860° E longitude, at an elevation of approximately 485 meters above sea level. The experiments were conducted under rainfed (dryland) agriculture, relying on natural precipitation for crop water requirements.

Throughout the study period, all field trials were conducted using a randomized complete block design (RCBD) with three replications to ensure the reliability and accuracy of the results. Each experimental plot measured either 1 m × 1 m during the preliminary evaluation stage or 2 m × 2 m during the advanced selection and comparative yield trials. Each experimental plot consisted of 10 rows, with a row spacing of 20 cm. The inter-plot spacing was 1.0 m, while the distance between replications was 1.60 m. The seed rate was 120 kg/ha.

The land preparation process included both primary and secondary tillage, beginning with mouldboard plowing and completed with disc harrowing. The field was divided into experimental plots according to the RCBD layout. Fertilisation, weed control, and pest management practices were performed according to the recommendations of the Iraqi Ministry of Agriculture. Nitrogen and phosphorus fertilisers were applied at recommended rates to ensure optimal crop growth (Jadou 1995).

Study Progression

First season (2016 – 2017):

Introduction of 28 wheat genotypes from International Maize and Wheat Improvement Center (CIMMYT) (Table 1) tested initially as observational plots (1 m × 1 m) at the Halabja field. Physiological traits, growth characteristics, and grain yield data were collected.

Second season:

Selection of 17 promising genotypes based on the previous year's performance. Evaluation in RCBD design with plots of 2 m × 2 m dimensions.

Third season:

Further selection, narrowing down to 14 genotypes. Continuation of evaluation under rainfed agriculture.

Fourth season:

Replanting the same 14 genotypes for further validation under similar environmental conditions.

Fifth to seventh seasons:

Final selection of 9 genotypes. Comparative evaluation against three local cultivars: 'Araz,' 'Sulaimani 2,' and 'Rizgary.'

Eighth season (2023 – 2024):

Genotype 22 was selected as the most promising line. Expanded multiplication trials at multiple sites within the rainfed areas of Shahrizor plain. Submission of genotype 22 (proposed as the variety 'Wafaa-Halabja') to the National Variety Registration and Certification Committee (Ministry of Agriculture, Baghdad).

Traits Studied

Grain yield per square meter [g/m²]

Grain yield [t/ha]

Grain yield components:

- Spikes per square meter
- Grains per spike
- 1,000-grain weight
- Spiklets per spike
- Leaf area (measured at peak vegetative growt
- Plant height (measured at physiological maturity)

Statistical Analysis

Statistical analyses were performed using SAS software (SAS Institute, Cary, NC, USA). Analysis of variance (ANOVA) was conducted according to the RCBD structure to determine the significance of differences among genotypes. Mean comparisons were made based on the Least Significant Difference (*LSD*) test at the $p \leq 0.05$ level. Meteorological data, particularly seasonal rainfall and temperature trends, were monitored during the study period to assess their potential impact on genotype performance.

RESULTS

Plant Height (PH)

Plant height is an important agronomic trait linked to biomass accumulation and lodging resistance in wheat. In both growing seasons, significant differences ($p \leq 0.05$) were observed among the wheat genotypes for plant height (Figure 1). In 2022/2023, genotype 27 exhibited the greatest height (105.47 cm), followed by Sulaymaniyah 2 (98.47 cm) and genotype 18 (96.47 cm). The shortest plants were recorded for Aras (82.00 cm). In 2023/2024, genotype 13 attained the tallest plants (102.27 cm), while Rizgari had the lowest value (91.40 cm). The *LSD* values (8.55 and 5.31 cm) indicated statistically significant differences among genotypes.

Leaf Area (LA)

Leaf area is a critical component for light interception and photosynthetic capacity, directly influencing crop productivity. Significant variation was found in leaf area among genotypes in both seasons (Figure 2). In 2022/2023, genotype 22 had the highest leaf area (61.48 cm²), while genotype 21 recorded the smallest (38.31 cm²). A similar pattern was observed in 2023/2024, with genotype 22 again leading (49.76 cm²) and genotype 8 showing the lowest value (28.55 cm²). The observed differences were significant based on the *LSD* values (9.29 and 11.10 cm²).

T a b l e 1

Pedigree of the genotypes used in the study

1	SUP152*2/PFUNYE #1
2	CHIBIA//PRLII/CM65531/3/SKAUZ/BAV92/4/KINGBIRD #1/5/CHEN/AEGILOPS SQUARROSA (TAUS)//BCN/3/BAV92/4/INQALAB 91*2/KUKUNA
3	MELON//FILIN/MILAN/3/FILIN/4/PRINIA/PASTOR//HUITES/3/MILAN/OTUS//ATTILA/3*BCN/5/MELON//FILIN/MILAN/3/FILIN
4	MON/IMU//ALD/PVN/3/BORL95/4/OASIS/2*BORL95/5/SOKOLL/3/PASTOR//HXL7573/2*BAU
5	BAV92//IRENA/KAUZ/3/HUITES/4/DOLL/5/SERI.1B//KAUZ/HEVO/3/AMAD*2/4/KIRITATI
6	ZANDER-44/3/ATTILA/BAV92//PASTOR/4/NAVJ07
7	NAVJ07/SHORTENED SR26 TRANSLOCATION/3/ATTILA/BAV92//PASTOR
8	FRET2*2/KUKUNA*2/4/BOW/URES//2*WEAVER/3/CROC_1/AE.SQUARROSA (213)//PGO/5/TRCH/SRTU//KACHU
9	SERI.1B*2/3/KAUZ*2/BOW//KAUZ/4/CIRCUS/5/2*PRL/2*PASTOR//PBW343*2/KUKUNA/3/ROLF07
10	ZANDER-44/3/ATTILA/BAV92//PASTOR/4/NAVJ07
11	PRL/2*PASTOR
12	PICAFLOR #1/8/NG8201/KAUZ/4/SHA7//PRL/VEE#6/3/FASAN/5/MILAN/KAUZ/6/ACHYUTA/7/PBW343*2/KUKUNA
13	HUHWA1/3/2*PRL/2*PASTOR//SUNSTATE
14	MUNAL #1*2/4/HUW234+LR34/PRINIA//PBW343*2/KUKUNA/3/ROLF07
15	BAJ #1/6/WBLL1*2/4/YACO/PBW65/3/KAUZ*2/TRAP//KAUZ/5/KACHU #1
16	BAJ #1/6/WBLL1*2/4/YACO/PBW65/3/KAUZ*2/TRAP//KAUZ/5/KACHU #1
17	NS-732/HER/3/PRL/SARA//TSI/VEE#5/4/FRET2/5/WHEAR/SOKOLL
18	KS82W418/SPN/3/CHEN/AE.SQ//2*OPATA/4/FRET2/5/2*SOKOLL/3/PASTOR//HXL7573/2*BAU
19	WBLL1/KUKUNA//TACUPETO F2001/3/BAJ #1*2/4/PRL
20	KACHU//2*WHEAR/SOKOLL
21	SUP152*2/PFUNYE #1
22	SUPER152/BAJ #1
23	MUNAL #1/3/TRCH/SRTU//KACHU
24	SOKOLL/3/PASTOR//HXL7573/2*BAU*2/4/PASTOR//MILAN/KAUZ/3/BAV92
25	PFAU/WEAVER*2//TRANSFER#12,P88.272.2/7/TNMU/6/CEP80111/CEP81165/5/IAC5/4/YKT406/3/AG/ASN//ATR/8/BABAX/LR42//BABAX*2/3/PAVON 7S3, +LR47
26	Barcelona
27	Iraq
28	AL-Rasheed

Spike Length (SL)

Spike length is associated with the potential number of spikelets and grains, thus contributing to yield components. Genotype 27 showed the longest spikes in both seasons (12.71 and 10.67 cm), followed by genotype 22 (9.59 and 8.93 cm) (Figure 3). The shortest spike lengths were observed in genotype 21 (7.90 and 6.79 cm). These values exceeded the *LSD* limits (1.97 and 2.53 cm), indicating significant genetic variability for this trait.

Spikes per m²

The number of spikes per m² is a critical factor influencing grain yield in rainfed environments. In 2022/2023, genotype 22 recorded the highest spike density (925.23 spikes/m²), followed by genotype 11 (893.18) (Figure 4). In the 2023/2024 season, genotype 22 maintained superiority (852.35), whereas Aras had the lowest spike number (404.06). The *LSD* values (209.09 and 287.10) confirmed the statistical significance of these differences.

Grains per Spike (GS)

This trait reflects the fertility and efficiency of spike development, directly influencing yield potential. Genotype 22 produced the highest grain number per spike in both seasons (60.60 and 58.61), followed by genotype 27 (58.53 and 53.75) (Figure 5). The lowest grain number was found in genotype 8 (37.23 and 32.75). These differences were statistically significant, exceeding the *LSD* values (11.98 and 6.90).

Spikelets per Spike (SP)

Spikelet number per spike affects grain arrangement and filling, serving as a yield-determining

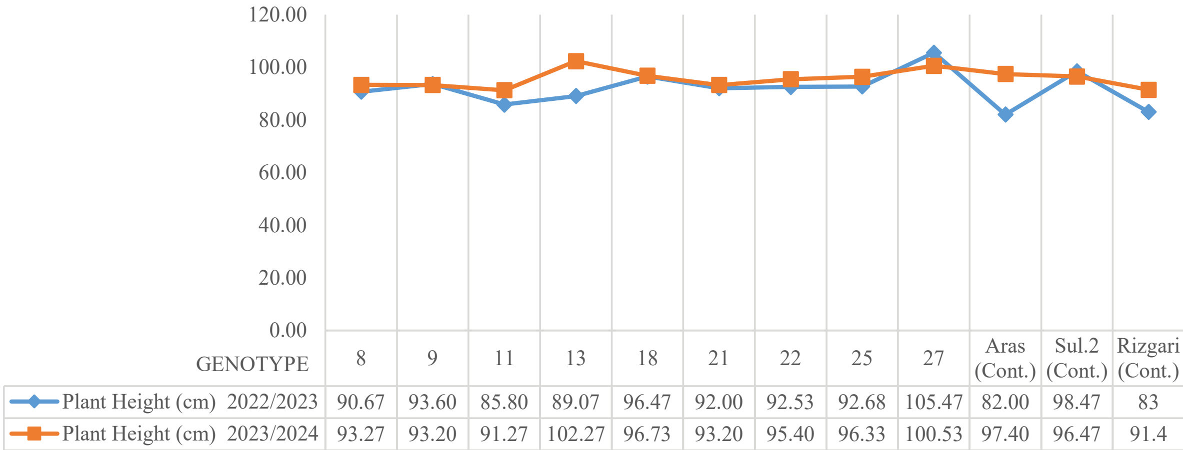


Figure 1. Plant heights of 9 genotypes and 3 check varieties during the two crop seasons.

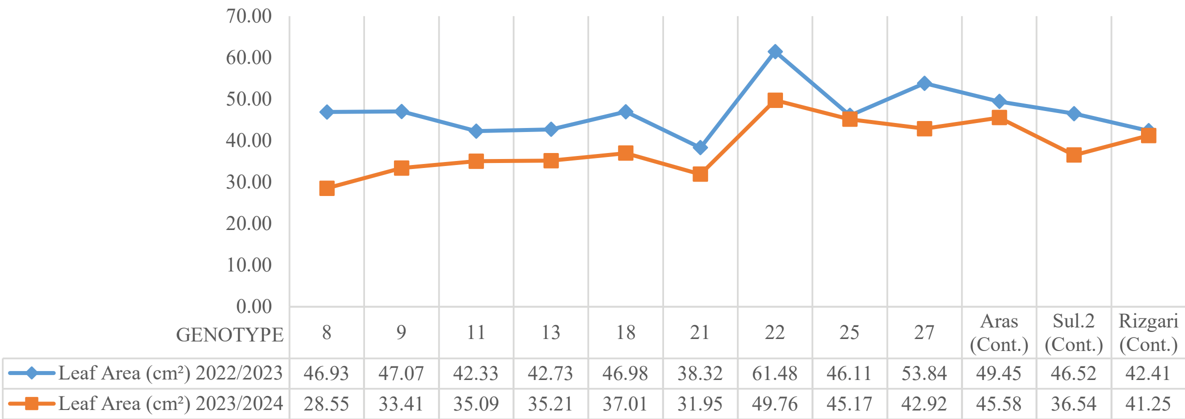
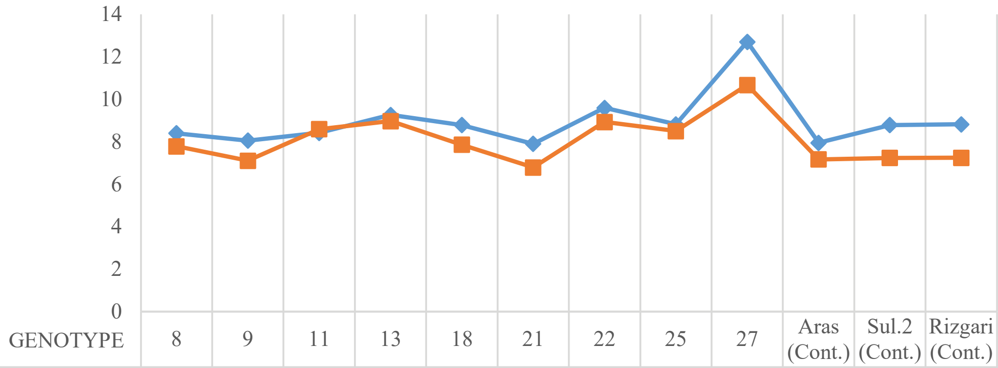
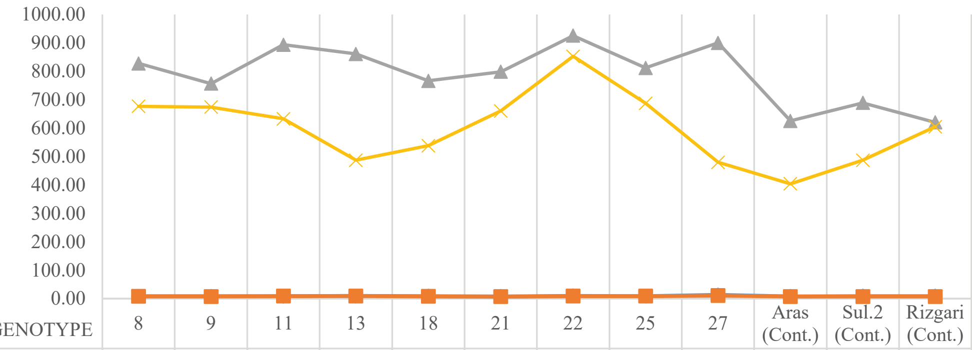


Figure 2. Leaf areas of 9 genotypes and 3 check varieties during the two crop seasons



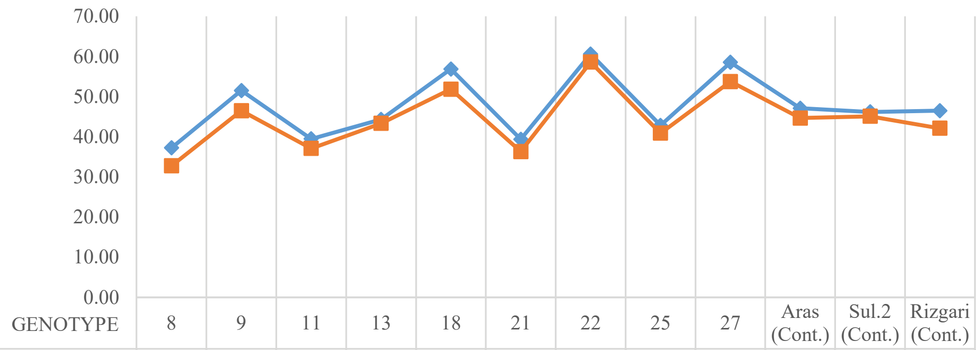
GENOTYPE	8	9	11	13	18	21	22	25	27	Aras (Cont.)	Sul.2 (Cont.)	Rizgari (Cont.)
Spike length (cm) 2022/2023	8.4	8.05	8.42	9.258	8.783	7.9	9.593	8.816	12.706	7.95	8.781	8.816
Spike length (cm) 2023/2024	7.78	7.107	8.59	8.968	7.856	6.789	8.93	8.5	10.674	7.167	7.237	7.24

Figure 3. Spike length of 9 genotypes and 3 check varieties during the two crop seasons.



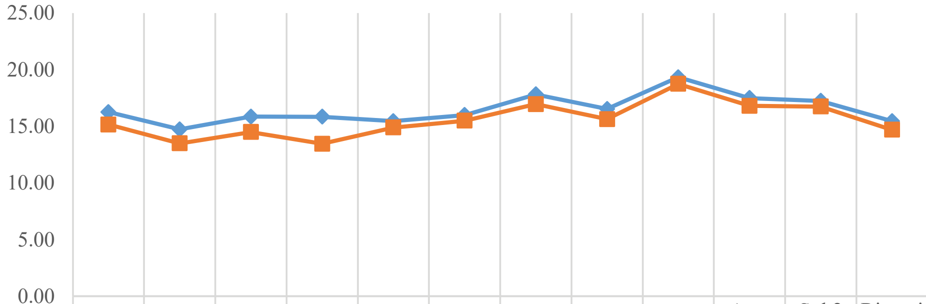
GENOTYPE	8	9	11	13	18	21	22	25	27	Aras (Cont.)	Sul.2 (Cont.)	Rizgari (Cont.)
Number of spikes/m² 2022/2023	827.17	756.61	893.18	860.55	766.19	798.28	925.23	811.47	899.68	625.02	688.88	619.98
Number of spikes/m² 2023/2024	676.71	674.05	632.37	486.79	537.79	660.31	852.35	687.09	479.35	404.06	486.76	604.72
Spike length (cm) 2022/2023	8.4	8.05	8.42	9.258	8.783	7.9	9.593	8.816	12.706	7.95	8.781	8.816
Spike length (cm) 2023/2024	7.78	7.107	8.59	8.968	7.856	6.789	8.93	8.5	10.674	7.167	7.237	7.24

Figure 4. Spikes per m² of 9 genotypes and 3 check varieties during the two crop seasons.



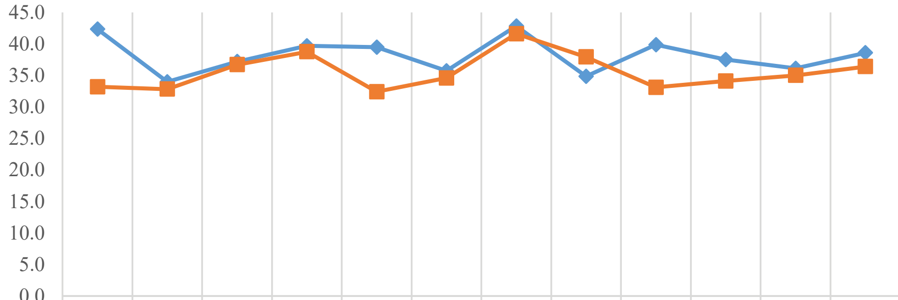
GENOTYPE	8	9	11	13	18	21	22	25	27	Aras (Cont.)	Sul.2 (Cont.)	Rizgari (Cont.)
Number of Grain/Spike 2022/2023	37.23	51.53	39.47	44.33	56.87	39.37	60.60	42.83	58.53	47.10	46.20	46.50
Number of Grain/Spike 2023/2024	32.75	46.51	37.12	43.33	51.87	36.32	58.61	40.91	53.75	44.67	45.12	42.11

Figure 5. Grains/spike of 9 genotypes and 3 check varieties during the two crop seasons.



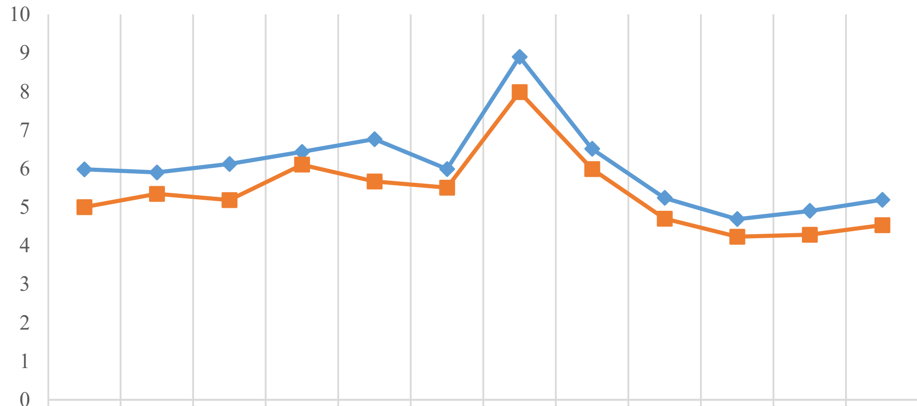
GENOTYPE	8	9	11	13	18	21	22	25	27	Aras (Cont.)	Sul.2 (Cont.)	Rizgari (Cont.)
Number of Spiklets 2022/2023	16.27	14.73	15.87	15.85	15.47	16.00	17.82	16.54	19.34	17.50	17.26	15.47
Number of Spiklets 2023/2024	15.17	13.50	14.50	13.47	14.90	15.50	16.97	15.63	18.76	16.82	16.75	14.70

Figure 6. Spikelets/spike of 9 genotypes and 3 check varieties during the two crop seasons.



GENOTYPE	8	9	11	13	18	21	22	25	27	Aras (Cont.)	Sul.2 (Cont.)	Rizgari (Cont.)
1000-Grain Weight (g) 2022/2023	42.4	34.0	37.2	39.7	39.5	35.7	42.8	34.9	39.9	37.5	36.1	38.6
1000-Grain Weight (g) 2023/2024	33.2	32.8	36.7	38.8	32.4	34.6	41.6	37.9	33.1	34.1	35.0	36.4

Figure 7. The thousand-grain weight of 9 genotypes and 3 check varieties was observed during the two crop seasons.



GENOTYPE	8	9	11	13	18	21	22	25	27	Aras (Cont.)	Sul.2 (Cont.)	Rizgari (Cont.)
Grain Yield (t/ha) 2022/2023	5.982	5.898	6.121	6.433	6.763	5.987	8.899	6.511	5.236	4.689	4.9	5.191
Grain Yield (t/ha) 2023/2024	5	5.342	5.183	6.101	5.667	5.505	7.987	5.989	4.7	4.233	4.281	4.533

Figure 8. Grain yields of 9 genotypes and 3 check varieties were observed during the two crop seasons.

component. In both seasons, genotype 27 outperformed all other genotypes (19.34 and 18.76), while genotype 9 recorded the fewest spikelets (14.73 and 13.50). The *LSD* thresholds (1.80 and 1.7) confirmed the significance of differences among genotypes (Figure 6).

1,000-Grain Weight (GW)

The weight of 1,000 grains is a key trait for assessing grain quality and yield stability. Genotype 22 showed the highest values in both seasons (42.83 and 41.62 g), followed by genotype 8 (42.36 and 33.20 g) (Figure 7). Genotype 9 had the lowest grain weight (33.97 and 32.83 g). The *LSD* values (4.38 and 2.95 g) confirmed these differences as statistically significant.

Grain Yield (GY)

Grain yield is the most integrative and economically significant trait for evaluating genotype performance. Genotype 22 exhibited the highest grain yield in both seasons (8.90 and 7.99 t/ha), outperforming all other genotypes. Genotypes 18 and 13 also produced high yields in 2022/2023 (6.76 and 6.43 t/ha), while genotype 13 maintained a good performance in 2023/2024 (6.10 t/ha). The lowest yields were recorded for Aras (4.69 and 4.23 t/ha). The *LSD* values (1.58 and 1.26 t/ha) confirmed the significance of the yield differences among genotypes (Figure 8).

Summary of Results

The consistent and significant differences observed across genotypes for all studied traits underscore the importance of evaluating wheat genotypes under rainfed agriculture s, such as those prevailing in the Shahrizor plain. Such environments pose specific challenges related to water availability, making the identification of stable and high-performing genotypes a critical goal for breeding programs in semi-arid regions. Among all tested entries, genotype 22 demonstrated outstanding performance across most yield-related attributes, including leaf area, spike length, number of grains per spike, 1,000-grain weight, and grain yield. Its superiority was particularly evident in grain yield, where it significantly outperformed both local and improved controls in both seasons. This reflects the cumulative effect of favourable expression in key agronomic traits, ultimately resulting in higher productivity under rainfed agriculture s. These findings highlight genotype 22 as a promising candidate for future cultivar development and recommend its advancement to further multilocation trials in similar agroecological zones.

DISCUSSION

This study assessed the effects of different seasons on wheat yield components, such as plant height, leaf area, spike length, number of spikes per square meter, number of grains per spike, number of spiklets per spike, 1,000-grain weight, and grain yield during the 2022/2023 and 2023/2024 growing seasons. The results presented here will be compared, analysed, and interpreted in light of existing research.

1. Plant Height and Leaf Area

The data shows that genotype 27 recorded the highest plant height (105.47 cm) in the 2022/2023 season, while genotype 22 had the largest leaf area (61.48 m²) in the same year. These results are consistent with previous studies, such as (Awtaq *et al.* 2021), who found that an increase in leaf area is directly related to higher photosynthetic efficiency, leading to higher yields. The larger leaf area genotype 22 suggests a higher capacity for photosynthesis, which likely contributed to its improved performance in grain production.

2. Spike Length and Spikes per Square Meter

Genotype 27 also exhibited the longest spike length (12.71 cm) in the 2022/2023 season and the highest number of spikes per square meter (899.68). These results are consistent with (Zahir *et al.* 2024), who emphasized that longer spikes and higher spike density are important contributors to higher yields. Longer spikes provide more space for grain filling, which is beneficial for grain production. However, there was a noticeable decrease in the number of spikes per square meter in 2023/2024 for genotype 27 (479.35). This decline may be due to adverse environmental conditions such as temperature fluctuations or water stress during the reproductive phase, as indicated by Muslu *et al.* (2025) including biotic and abiotic factors, directly affect its production.

Among these stressors, Fusarium infection poses a significant risk, leading to severe yield losses, and compromising the overall quality of the crop. To understand the regulatory mechanisms modulating wheat's response against *Fusarium* head blight (FHB).

3. Spikelet Number per Spike, Gains per Spike, and Grain Yield

For grains per spike, genotype 22 performed well in both seasons (60.60 grains in 2022/2023 and 58.61 grains in 2023/2024), indicating its potential to produce a large number of grains per spike. This finding is consistent with (Hossain *et al.* 2021), who found that increasing the number of grains per spike is strongly associated with higher yield potential in wheat. Spikelet number per spike significantly affects grain yield by influencing grain arrangement and filling. Genotype 27 showed the highest spikelet count, while genotype 9 had the lowest, with differences being statistically significant. This trait is important for selecting high-yielding genotypes in wheat breeding programs. A higher spikelet number generally leads to increased grain number per spike, which contributes directly to yield improvement. Therefore, improving this trait can enhance overall productivity, especially under rainfed agriculture.

Genotype 22 also recorded the highest grain yield in the 2022/2023 season (8.90 t/ha), which further supports its potential as a high-yielding genotype. On the other hand, genotype 27 showed a low grain yield in 2023/2024 (4.70 t/ha), despite performing well in 2022/2023. This decrease could be attributed to factors such as nutrient depletion or climatic stress, which can negatively impact grain filling (Sharma *et al.* 2003; Gaju *et al.* 2009).

4. 1,000-Grain Weight

Regarding the 1,000-grain weight, genotype 22 had the highest weight (42.83 g in 2022/2023 and 41.62 g in 2023/2024), a key trait associated with good grain quality and higher yield potential (Hadjichristodoulou 1990; Liu *et al.* 2025). This characteristic is important not only for yield but also for the marketability of wheat, as larger grains are often preferred for their quality.

5. Statistical Significance (LSD)

The least significant difference (*LSD*) values shown statistically significant differences between genotypes for most of the yield components, such as plant height (*LSD* = 8.55 cm) and number of spikes (*LSD* = 11.9). These values highlight the reliability of the results and confirm that the observed differences are meaningful. Statistical significance further supports the importance of genotype selection in optimizing wheat yield.

CONCLUSIONS

The results obtained from this study indicate that genotype 22 consistently outperformed other genotypes across multiple yield components in both growing seasons. It exhibited high grain yield, large 1,000-grain weight, and an excellent number of grains per spike, making it an ideal candidate for a new wheat variety. The superior performance of genotype 22 in both seasons, along with its robustness in yield components, suggests that it is genetically stable and adaptable to varying environmental conditions. These characteristics, especially the high yield and good grain quality, make genotype 22 a promising variety for commercial cultivation. Thus, based on the genetic stability and yield performance of genotype 22, it was recommended for registration as a new wheat variety 'Wafaa-Halabja'. This variety shows strong potential for increasing wheat production and contributing to food security. Further evaluations and trials in diverse environmental conditions should be conducted to confirm its performance across broader regions.

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