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Response of Wheat (*Triticum aestivum* L.) Genotypes to Different Nitrogen Fertilizer Levels under Desert Farming Conditions

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ABSTRACT

Background: Wheat production in desert environments is constrained by poor soil fertility, particularly limited nitrogen availability. Optimizing nitrogen fertilization and selecting well-adapted genotypes are therefore important for improving wheat productivity under desert farming conditions. This study aimed to evaluate the response of different wheat genotypes to nitrogen fertilization under sandy soil conditions in Basra, Iraq.

Methods: A field experiment was conducted during the 2024-2025 winter season in Al-Zubair District, Basra Governorate, Iraq, using a factorial arrangement within a randomized complete block design (RCBD) with three replicates. Four nitrogen fertilizer levels were tested: 0, 75, 150 and 225 kg N ha^{-1} (N0, N1, N2 and N3, respectively), combined with five wheat genotypes: Srank, Jamran, Mehrkan, Sirwan and Buhouth 22. Growth, yield and yield-component traits were evaluated.

Result: Increasing nitrogen application significantly improved flag leaf area and most yield components. The application of 150 kg N ha^{-1} produced the highest flag leaf area, number of spikes, number of grains $spike^{-1}$ and grain yield (5.013 Mg ha^{-1}), whereas the control treatment (0 kg N ha^{-1}) recorded the highest 1000-grain weight (39.593 g). The Mehrkan genotype significantly outperformed the other genotypes in flag leaf area, number of spikes, number of grains $spike^{-1}$, grain yield (5.458 Mg ha^{-1}) and harvest index. The interaction between nitrogen levels and genotypes significantly affected several traits, with Mehrkan combined with 150 kg N ha^{-1} achieving the highest values for most yield components, while the interaction had no significant effect on harvest index.

Key words: Desert farming, Genotypes, Nitrogen, *Triticum aestivum* L., Wheat.

INTRODUCTION

Wheat (*Triticum* spp.) is one of the most important annual winter cereal crops and plays a strategic role in global food security, ranking first among cereal crops in terms of cultivated area and production (Hindi *et al*., 2026a). In Iraq, wheat is a major food source, providing an important proportion of calories, carbohydrates, proteins and amino acids; however, domestic production remains below the required level compared with global production (Hindi *et al*., 2026b; USDA, 2025).

Climate change, rising temperatures, water scarcity and drought have created increasing challenges for wheat production, encouraging the expansion of cultivation into desert lands. The success of wheat production under these conditions requires appropriate agricultural practices, including modern irrigation systems, the use of heat- and drought-tolerant genotypes and improved fertilization management (Ali *et al*., 2026; Saleh *et al*., 2026). The introduction of high-yielding and well-adapted genotypes is also an important approach for improving wheat productivity under changing environmental conditions (Iskander *et al*., 2024; Hindi *et al*., 2026b).

Fertilization is an essential component of crop production, particularly the application of macronutrients required for normal plant growth and development (Sharif *et al*., 2026). Nitrogen fertilization is especially important because it promotes cell division, vegetative growth, leaf and tiller development, protein synthesis and flag leaf development, thereby contributing to improved grain yield and its components (Jamel and Al-Farjawi, 2025). However, nitrogen may be lost through leaching and volatilization, making the determination of the appropriate fertilizer rate, application method and timing essential for maximizing plant utilization (Yadav *et al*., 2025). Despite numerous studies on the impact of nitrogen fertilization on wheat growth and productivity, the response of different genotypes to nitrogen levels, particularly high

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levels, remains insufficiently understood under the conditions of the Basra desert and sandy soils. Therefore, this study aimed to evaluate the response of genotypes to progressively higher nitrogen levels and identify differences in growth characteristics, yield components and grain yield, thereby contributing to the identification of the most suitable genotypes and nitrogen levels for these conditions. Therefore, this study aimed to evaluate the response of different wheat genotypes to different nitrogen fertilizer levels, assess their physiological and yield performance and determine the interaction between genotypes and nitrogen levels under desert farming conditions.

MATERIALS AND METHODS

Field experiments were carried out in winter season of 2024-2025 in Al-Zubair District, Basra Governorate, Iraq (30.28°N, 47.05°E) on sandy soil with a pH of 7.60, EC of 12.04 ds m^{-2}, organic matter content of 0.12%, available N of 5.22, P of 4.47 and K of 112 mg kg^{-1}, respectively. Irrigation was done using groundwater from artesian wells, noting that the water salinity is 5 ds m^{-2}. In these experiments, the effect of five wheat genotypes (Srank, Jamran, Mehrkan, Sirwan and Buhouth 22) on four levels of nitrogen fertilization (0, 75, 150 and 225 kg N ha^{-1} = N0, N1, N2 and N3, respectively) was investigated. Factorial design was utilized based on randomized complete block design (RCBD) with three replications, which gave a total of 60 experimental units (5 × 4 × 3 = 60), each plot was 4 m^2.

The soil preparation included two tillages to a depth of 30 cm and leveling, after that, planting was done on 20 November 2024 in rows at 20 cm distance from each other at a rate of 120 kg ha^{-1}. Triple superphosphate fertilizer (46% P_2O_5) was applied prior to planting at 100 kg P_2O_5 ha^{-1}. Urea fertilizer (46% N) was applied at three times after planting (Emergence, elongation and flowering). Irrigation was done whenever necessary and harvesting started on 25 April 2025 after reaching the full maturity. The eight middle rows were harvested to calculate the yield's characteristics and components, while the guarded peripheral rows were left unharvested.

The investigated traits were flag leaf area (cm^2), number of spikes m^{-2} (spike m^{-2}), number of grains $spike^{-1}$ (grains $spike^{-1}$), 1000-grain weight (g), grain yield (Mg ha^{-1}) and harvest index (%). Flag leaf area was calculated as (leaf length × maximum width × 0.95) It was measured at the flowering stage (Robertson and Giunta, 1994). Harvest index was calculated as:

$$\frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

(Donald, 1962).

The data were statistically analyzed using a randomized complete block design (RCBD) with factorial ordering and three replicates. The effects of the main factors and their interactions were analyzed using analysis of variance (ANOVA) and the means were compared using the least significant difference (LSD) test at a probability level of 0.05. (Al-Zubaidi and Al-Jubouri, 2016).

RESULTS AND DISCUSSION

Table (1) shows that:

First factor (V): Varieties had a highly significant effect ($P \leq 0.05$) on all studied traits, indicating clear differences among the tested varieties.

Nitrogen (N): Nitrogen levels also showed a highly significant effect ($P \leq 0.05$) on all traits, demonstrating that nitrogen application strongly influenced crop growth and yield.

V × N interaction: The interaction between variety and nitrogen was highly significant ($P \leq 0.05$) for all traits, indicating that the response to nitrogen differed among varieties.

Block effect: Block differences were not significant for most traits, suggesting relatively uniform experimental conditions.

Coefficient of variation (CV): The CV values ranged from 0.8% to 4.4%, indicating high experimental precision and low variability.

Overall: The results demonstrate that both variety and nitrogen fertilization, as well as their interaction, significantly affected flag leaf area, spike number, grains per spike, 1000-seed weight, grain yield and harvest index.

Flag leaf area (cm^2)

The results in Table 2 showed a significant effect of nitrogen levels on flag leaf area. N2 level recorded the highest average (32.753 cm^2), with an increase of 26.72% compared with N0 (25.847 cm^2). This may be attributed to the role of nitrogen in increasing chlorophyll content, photosynthetic

Table 1: The studied traits (ANOVA) analysis of variance.

S.O.V.	d.f.	Flag leaf area (cm^2)	Number of spikes per m-($spike/m^2$)	Number of grains per spike (grains/spike)	Weight of 1000 seeds (g)	Grain yield (Mg/ha)	Harvest index (%)
Block	2	9.3522	12.02	3.9335	0.8180	0.13400	6.711
V	4	17.1940**	3562.11**	43.3993**	30.1748**	3.64933**	14.262
N	3	138.3539**	5543.66**	417.5444**	283.8922**	4.46356**	7.614
V×N	12	2.5476**	910.56**	5.1161**	2.9727**	0.51356**	7.470
Error	38	0.4144	11.42	0.2377	0.2243	0.03225	3.745
Mean	-	28.512	400.62	39.840	34.855	4.560	44.16

efficiency, root growth and nutrient and water uptake. This result agrees with AL-Hakam and Abdul-alwahid (2024).

Mehrkan genotype significantly outperformed the other genotypes, recording the highest flag leaf area (30.183 cm^2), whereas Buhouth22 recorded the lowest (27.283 cm^2) and did not differ significantly from Srank. This may be related to genetic and physiological differences among genotypes. Similar results were reported by Hassouni and Al-Freeh (2025b) and Dawood *et al*. (2026).

The interaction between genotypes and nitrogen levels was significant. Mehrkan × N2 recorded the highest value (34.833 cm^2), while Srank × N0 recorded the lowest (23.733 cm^2).

Number of spikes per m^{-2} (spike/m)

Table 3 showed a significant increase in the number of spikes m^{-2} with increasing nitrogen levels. N2 treatment recorded the highest average (427.93 spikes/m), significantly exceeding the other levels, whereas N0 recorded the lowest (384.20 spikes/m). This may be attributed to the role of nitrogen in promoting vegetative growth and increasing the number of productive tillers, thereby enhancing photosynthetic production and spike formation. This result agrees with Hussein *et al*. (2026).

Genotypes also significantly affected the number of spikes/m. Mehrkan recorded the highest average (426.42 spikes/m), while Buhouth22 recorded the lowest (387.25 spikes/m) and did not differ significantly from srank. These differences may be related to genetic variation among genotypes and their ability to produce fertile tillers. Similar results were reported by Alshamary (2025) and Hassouni and Al-Freeh (2025a).

The interaction N2 × Mehrkan recorded the highest average (487.00 spikes/m), significantly exceeding most other combinations, whereas N0 × Buhouth22 recorded the lowest (373.67 spikes m^{-2}).

Number of grains per spike (grains/spike)

Table 4 showed a significant effect of nitrogen fertilization on the number of grains per spike. N2 recorded the highest average (45.747 grains/spike), significantly exceeding the other levels, while N0 recorded the lowest (33.433 grains/spike). This may be attributed to the positive role of nitrogen in promoting plant growth and improving spike fertility and grain formation. Similar results were reported by Al-Obaidi *et al*. (2025).

Among genotypes, Mehrkan recorded the highest average (42.542 grains/spike), whereas Buhouth22 recorded the lowest (37.858 grains/spike). These differences may be related to genetic variation and the interaction between genotypes and environmental conditions (Al-Shammari and Al-Ansari, 2022). This result agrees with Hassouni and Al-Freeh (2025a).

The interaction Mehrkan × N2 recorded the highest average (49.033 grains $spike^{-1}$), while Buhouth22 × N0

Table 2: Effect of genotypes, nitrogen levels and the interaction between them on flag leaf area (cm^2).

Genotypes	Nitrogen levels (kg ha^{-1})				Genotypes
	N0	N1	N2	N3	average
Srank	23.733	27.933	32.067	26.033	27.442
Jamran	25.600	28.600	33.567	28.367	29.033
Mehrkan	27.100	30.333	34.833	28.467	30.183
Sirwan	26.233	29.467	32.333	26.433	28.617
Buhouth22	26.567	26.367	30.967	25.233	27.283
Nitrogen average	25.847	28.540	32.753	26.907	
LSD (0.05)	Genotypes	Nitrogen	Interaction		
	0.5321	0.4759	1.0641		

Table 3: Effect of genotypes, nitrogen levels and the interaction between them on the number of spike/m^2.

Genotypes	Nitrogen levels (kg ha^{-1})				Genotypes
	N0	N1	N2	N3	average
Srank	376.33	377.00	401.33	398.33	388.25
Jamran	380.00	381.67	405.67	396.00	390.83
Mehrkan	399.00	404.33	487.00	415.33	426.42
Sirwan	392.00	395.33	456.67	397.33	410.33
Buhouth22	373.67	397.00	389.00	389.33	387.25
Nitrogen average	384.20	391.07	427.93	399.27	
LSD (0.05)	Genotypes	Nitrogen	Interaction		
	2.793	2.498	5.586		

recorded the lowest (31.367 grains/spike). The superiority of N2, individually and in combination, may be attributed to improved photosynthetic efficiency and reduced floret abortion and competition for assimilates.

Weight of 1000 grain (g)

The data in Table 5 showed a significant effect of nitrogen levels on 1000-grain weight. N0 recorded the highest average (39.593 g), with an increase of 33.6% compared with N2 (29.633 g). The reduction in grain weight with increasing nitrogen levels may be attributed to the higher number of spikes m^{-2} and grains $spike^{-1}$, which increased competition for assimilates during grain filling. This result agrees with Hassouni and Al-Freeh (2025a).

Among genotypes, Srank significantly outperformed the others, recording the highest 1000-grain weight (36.842 g), whereas Mehrkan recorded the lowest (32.933 g). These differences may be related to genetic variation among genotypes and compensation among yield components. Similar variation was reported by AL-Hakam and Abdul-alwahid (2024) and Madab *et al*. (2025).

The interaction was significant, with Srank × N0 recording the highest 1000-grain weight (42.833 g), while Mehrkan × N2 recorded the lowest (27.867 g).

Grain yield (Mg/ha)

Table 6 showed a significant effect of nitrogen levels on grain yield. N2 recorded the highest yield (5.013 Mg ha^{-1}), with an increase of 33.076% compared with N0 (3.767 Mg ha^{-1}). This increase may be attributed to the positive effect of nitrogen on yield components, particularly the number of spikes and grains $spike^{-1}$. Similar results were reported by Jaskiewicz (2021); Biberdzic *et al*. (2021) and Al-Obaidi *et al*. (2025).

Table 4: Effect of genotypes, nitrogen levels and the interaction between them on the Number of grains per spike (grains/spike).

Genotypes	Nitrogen levels (kg ha^{-1})				Genotypes
	N0	N1	N2	N3	average
Srank	33.100	36.867	44.567	38.600	38.283
Jamran	32.267	38.000	46.067	42.767	39.775
Mehrkan	36.233	39.033	49.033	45.867	42.542
Sirwan	34.200	39.967	47.167	41.633	40.742
Buhouth22	31.367	36.933	41.900	41.233	37.858
Nitrogen average	33.433	38.160	45.747	42.020	
LSD (0.05)	Genotypes	Nitrogen	Interaction		
	0.4029	0.3604	0.859		

Table 5: Effect of genotypes, nitrogen levels and the interaction between them on the weight of 1000 grain (g).

Genotypes	Nitrogen levels (kg ha^{-1})				Genotypes
	N0	N1	N2	N3	average
Srank	42.833	38.500	32.000	34.033	36.842
Jamran	41.033	37.033	30.200	35.733	36.000
Mehrkan	37.000	35.933	27.867	30.933	32.933
Sirwan	38.933	37.967	29.567	32.267	34.683
Buhouth22	38.167	35.367	28.533	33.200	33.817
Nitrogen average	39.593	36.960	29.633	33.233	
LSD (0.05)	Genotypes	Nitrogen	Interaction		
	0.3914	0.3501	0.7829		

Table 6: Effect of genotypes, nitrogen levels and the interaction between them on the grain yield (Mg/ha).

Genotypes	Nitrogen levels (kg ha^{-1})				Genotypes
	N0	N1	N2	N3	average
Srank	3.533	4.467	4.033	4.333	4.092
Jamran	3.767	4.567	4.433	4.400	4.292
Mehrkan	4.400	5.300	6.900	5.233	5.458
Sirwan	3.667	5.033	5.133	5.000	4.708
Buhouth22	3.467	4.300	4.567	4.667	4.250
Nitrogen average	3.767	4.733	5.013	4.727	
LSD (0.05)	Genotypes	Nitrogen	Interaction		
	0.1484	0.1327	0.2968		

Table 7: Effect of genotypes, nitrogen levels and the interaction between them on the harvest index (%).

Genotypes	Nitrogen levels (kg ha^{-1})				Genotypes
	N0	N1	N2	N3	average
Srank	43.83	46.19	45.42	41.52	44.24
Jamran	43.66	45.18	45.68	44.15	44.67
Mehrkan	45.03	45.95	46.25	45.45	45.67
Sirwan	41.14	44.28	41.73	45.09	43.06
Buhouth22	42.93	43.55	40.84	45.32	43.16
Nitrogen average	43.32	45.03	43.98	44.31	
LSD (0.05)	Genotypes	Nitrogen	Interaction		
	N.S	N.S	N.S		

Among genotypes, Mehrkan significantly outperformed the others, recording the highest grain yield (5.458 Mg ha^{-1}), while srank recorded the lowest (4.092 Mg ha^{-1}). This superiority may be related to genetic differences among genotypes and their higher number of spikes and grains/spike. Flag leaf area may also have contributed to the higher yield through its important role in photosynthesis and assimilate supply to the spike. These findings agree with Jassiml and Aziz (2021). Al-Obaidi and Al-Jubouri, (2023); Aziz and Sattar(2024); Hassouni and Al-Freeh (2025b) and Al-Obaidi *et al*. (2025).

The interaction between genotypes and nitrogen levels was significant. Mehrkan × N2 achieved the highest grain yield (6.900 Mg ha^{-1}), associated with its superiority in yield components, whereas Buhouth22 × N0 recorded the lowest (3.467 Mg ha^{-1}).

Harvest index (%)

The different levels of nitrogen fertilizer, genotype and the interaction between them had no significant effect on the harvest index trait (Table 7).

CONCLUSION

The results showed that adding nitrogen fertilizer at a rate of 150 kg N ha^{-1} resulted in the highest grain production response within the studied nitrogen levels in the desert environment. This contributed to an increase in flag leaf area, number of spikes and number of grains per spike, which was reflected in an increase in grain yield. Furthermore, the genotypes showed differences in their performance in terms of grain yield and its components. The Mehrkan variety achieved the highest productivity compared to the Sarank variety, with a 33.38% increase in grain yield for Mehrkan compared to Sarank.

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Conflict of interest

The authors declare that they have no conflicts of interest associated with this work.

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