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Response of durum wheat genotypes to different levels of organic and mineral fertilizers

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Abstract

A field experiment was carried out in the winter season (2024-2025) at the Second Agricultural Research Station of the College of Agriculture, Al-Muthanna University. This study sought to investigate the impact of genetic components and varying quantities of organic and mineral fertilizers on some characteristics of wheat. The experiment examined two variables: varying applications of organic and mineral fertilizers, specifically: 100% of the recommended mineral fertilizer, half the recommended mineral fertilizer NPK combined with half the recommended organic fertilizer, ¾ of the recommended mineral fertilizer paired with ¼ of the recommended organic fertilizer, and ¾ of the recommended organic fertilizer alongside ¼ of the recommended mineral fertilizer which is symbolized by F1, F2, F3 and F4 . The second variable involved genotypes of durum wheat, including EXAD 1105, EXAD 65, EXAD 1229, and Bohoth 7 which is symbolized by G1, G2, G3 and G4. The experiment utilized a split-plot design within a randomized complete block design (R.C.B.D) with three replicates. The main plots were fertilizer quantities, whereas the subplots were genotypes. The findings indicated the The G3 genotype excelled in plant height at 110.31 cm, and leaf area at 43.16 cm², The G2 genotype exhibited superior performance in achieving the greatest average chlorophyll content at 48.30%, spike length at 13.02 cm, and grain count per spike at 60.11 grains.

The F1 fertilization level exhibited superior performance, achieving the maximum average plant height of 103.90 cm and a leaf area of 43.77 cm². The F3 fertilization level excelled in producing a total of 357.58 tillers, with 350.75 tillers m^{-2}, chlorophyll content of 49.61%, spike length of 12.83 cm, and a grain count per spike of 55.37.

The G3XF1 combination excelled in plant height at 117.83 cm, but the G2XF3 combination excelled in leaf area at 49.37 cm². The G1XF3 combination excelled in tiller count with 395.67 tillers m^{-2}, whereas the G3XF3 combination excelled in chlorophyll content at 54.92% and spike length at 14.07 cm.

Keywords: durum wheat, wheat genotypes, organic fertilizers, mineral fertilizers

Introduction

Durum wheat (*Triticum durum* Desf.) is one of the most important cereal crops belonging to the Poaceae family. It is one of the types of wheat grown in different parts of the world, as its global production reached (778.52) million megagrams per hectare, at a rate of 3.51% (USDA, 2022). Durum wheat is a distinct type with qualitative characteristics in terms of grain hardness and high protein content, which may reach 16%, making it suitable for the production of pasta and bulgur (El-Hendawy et al., 2017). In Iraq, despite the availability of a suitable environment for growing durum wheat, its cultivation remains limited. This is due to several factors, perhaps the most prominent of which are the heavy reliance on soft wheat, the weak local marketing of durum wheat, the lack of industrial and commercial awareness of its importance, and environmental challenges such as declining water resources and deteriorating soil fertility, which negatively impact production (Khan et al., 2016). Recent research indicates that some genetic combinations, such as ACSAD 65, 1105, and 1229, have demonstrated high productivity under local environmental conditions. However, the agricultural performance of these combinations is greatly affected by fertilizer management. Fertilization is one of the most important factors influencing wheat yield and quality, particularly NPK, which is nitrogen (N), an essential element in protein synthesis, stimulating vegetative growth, and increasing gluten content in grains; and phosphorus (P), which plays an important role in root growth and crop maturity. Potassium (K), which is essential for improving grain filling and increasing its resistance to environmental stresses (Hauggaard-Nielsen et al., 2019).

As for organic fertilizers, particularly well-composted buffalo dung, studies have shown that they improve soil aeration, increase its ability to retain moisture, and stimulate microbial activity, which contributes to the decomposition of organic compounds and the gradual and safe release of nutrients, leading to improved soil fertility and increased crop fertilization response (Karki et al., 2021).

Based on the above, this study aims to investigate the effect of genetic makeup and different levels of organic and mineral fertilizers on the vegetative growth characteristics of durum wheat.

Materials and Methods

A field experiment was conducted during the winter extension (2024-2025) at the research station of the College of Agriculture, Al-Muthanna University, Iraq. The aim was to assess the performance of four newly created durum wheat genotypes and identify the most appropriate one for the region's attributes, considering the impacts of different mineral and organic fertilizer inputs.

The soil in the field was examined prior to planting at the soil laboratory of the College of Agriculture, Al-Muthanna University, by collecting random samples to a depth of 0-30 cm. The physical and chemical parameters of the soil are presented in Table 1.

Table (1) Physical and chemical properties of the soil

Characteristic	**Unit**	**Value**
Ph	-	7.6
EC	ds|m	3.4
Sand	mg kg^{-1} soil	76.9
Clay	mg kg^{-1} soil	5.7
Silt	mg kg^{-1} soil	17.3
Soil texture	Sandy Loam	
N	mg kg^{-1}	45.56
P	mg kg^{-1}	13.3
K	mg kg^{-1}	198.47

Experimental Design

The experiment was conducted using a split-plot design, using a randomized complete block design (R.C.B.D) with three replicates. The fertilizer quantities occupied the main plots, while the genotypes occupied the split plots.

Experimental Factors:

the main plots were additions of organic and mineral fertilizers, including:

1-mineral fertilizer (recommended %100) ,

2-Half the recommended NPK mineral fertilizer + half the recommended organic fertilizer.,

3- %75recommended mineral fertilizer + 25% recommended organic fertilizer.

4-%75recommended organic fertilizer + 25% recommended mineral fertilizer. which is symbolized by F1 ,F2 ,F3 ,F4)

while durum wheat genotypes : EXAD 1105, EXAD 65, EXAD 1229, and the comparison cultivar Bohoth 7 which is symbolized by G1 ,G2 ,G3 ,G4.

Traits studied:

Plant height (cm): Plant height was measured using a measuring tape from the soil surface level to the end of the spike without the ear for ten plants randomly taken from the median lines of each experimental unit during the flowering stage.

Flag leaf area (cm2): Measured using a graduated ruler for ten plants randomly selected from each experimental unit at the flowering stage, according to Thomus's law (1975). Flag leaf area = flag leaf length × width at the widest point × 0.95.

Chlorophyll content measurement: Relative chlorophyll content in plant leaves was estimated using a SPAD-Value device, a portable device that measures light absorption at two wavelengths (650 and 940 nm). The reading was taken from the third leaf from the apex of each plant, randomly selected for ten plants from the two medians in the early morning to avoid the effects of heat stress**.**

Spike length (cm): Spike length was measured using a measuring tape from the base of the spike (at its junction with the upper node of the stem) to its final apex, excluding the petiole, for ten plants randomly selected from the medians of each experimental unit at the physiological maturity stage**.**

Total number of tillers (m-2): The total number of tillers was calculated after Flowering was calculated from the area of the median lines during the vegetative growth stage of plants, with a length of 2 m^2 for each experimental unit, and converted to a square meter**.**

Number of grains per spike (1 grain per spike): Calculated from the average number of grains in ten spikes randomly selected after manually thinning each spike individually and counting the number of grains per spike.

Results and discussion

Plant Height (cm)

Table (2) indicates that the G3 genotype exhibited superior performance, achieving the highest average of 110.31 cm for this attribute, whereas the G1 genotype recorded the lowest average of 94.69 cm. This results could be due to variations in genetic composition.

The results of the table indicate that the F1 fertilization level, achieving the maximum average plant height of 103.90 cm, which did not significantly different from F2 and F3, which achieved 101.99 cm and 103.47 cm, respectively. The F4 fertilization level recorded the lowest average for this characteristic, measuring 97.12 cm. This result could be due to the application of the complete fertilizer advice, which contributes to the enhancement of this characteristic. Nitrogen is essential for cell division and expansion, potassium is crucial for growth and development, and phosphorus facilitates root growth and enhances water and nutrient absorption, hence promoting enhanced plant growth (Al-Alusi, 2009). Table (2) indicates that the G3XF1 combination outperformed others, recorded 117.83 cm of plant hieght, which was not substantially different from the G2XF3 combination, which measured 111.93 cm. Simultaneously, the G1XF4 combination exhibited the lowest average for this characteristic, attaining 88.02 cm.

Table (2) Effect of genotypes and different levels of organic and mineral fertilizer on plant height.

average	genotype				fertilizers
	G4	G3	G2	G1	
103.90	97.39	117.83	105.17	95.22	**F1**
101.99	99.57	108.08	103.15	97.15	**F2**
103.47	94.01	109.58	111.93	98.35	**F3**
97.12	95.20	105.76	99.49	88.02	**F4**
	96.54	110.31	104.94	94.69	**average**
Interference	**genotype**		**fertilizers**		**L.S.D**

7.375	3.308	5.509	**(0.05)**

Leaf Area

Table 3 indicates that the G3 genotype exhibited superior performance, achieving the greatest average leaf powder trait at 43.16 cm², which was not significantly different from the G2 genotype's which recorded of 42.19 cm². Simultaneously, the G1 genotype produced the lowest mean for this characteristic, attaining 35.35 cm². This may result from variations in genetic composition.

The data from the table indicate that the F1 fertilization level excelled, achieving the maximum average leaf area of 43.77 cm², the F4 fertilization level gave the lowest average for this characteristic at 37.54 cm². This results could be due to the use of the complete fertilizer advice, which contributes to the enhancement of leaf area. Nitrogen is essential for cell division and expansion, potassium is crucial for growth and development, and phosphorus facilitates root growth and enhances water and nutrient absorption, leading to greater plant growth (Al-Alusi, 2009). The data in Table 3 indicate that the G2XF3 combination recorded the highest leaf area compere the other combinations, achieving a measurement of 49.37 cm², which was not statistically different from the averages of the combinations (G1XF1, G2XF1, G3XF1, G3XF2, G1XF3, G3XF4), which were 43.86, 47.01, 44.48, 44.46, 44.30, and 46.13 cm², respectively. Simultaneously, the G4XF4 combination exhibited the lowest average for this characteristic, attaining 29.98 cm².

Table 3: Effect of genotypes and different levels of organic and mineral fertilizer on leaf area (cm2)

average	**genotype**				**fertilizers**
	G4	**G3**	**G2**	**G1**	
43.77	39.72	44.48	47.01	43.86	**F1**
40.42	40.50	44.46	39.27	37.46	**F2**
39.64	31.21	33.67	49.37	44.30	**F3**
37.54	29.98	46.13	37.01	37.02	**F4**
	40.66	43.16	42.19	35.35	**average**
Interference	genotype		fertilizers		**L.S.D**
6.196	3.060		3.929		**(0.05)**

Total number of tillers

Table (4) indicates that the G4 genotype exhibited superiority, recorded the highest average total of 357.58 tillers m^{-2}, whereas the G2 genotype recorded the lowest average at 304.08 tillers m^{-2}. This results could be due the plant's capacity to branch, determined by its genetic composition (Evans,1993).

The results of the table indicate that the F3 fertilization level was superior, recorded the greatest average total of 350.75 tillers m^{-2}, which did not substantially different from the F2 fertilization level, providing an average of 339.33 tillers m^{-2}. Whereas, the F1 fertilization level recorded the lowest average for this characteristic, reaching 315.75 tillers per square meter. This could be from the accelerated cell division caused by the elevated nitrogen content in the fertilizer mixture. The results in Table (4) indicate that the G1F3 combination excelled, achieving an average of 395.67 tillers m-2, which was not significantly different from the G4F2 and G4F4 combinations, which recorded averages of 366.00 and 378.33 tillers m-2, respectively. Simultaneously, the G2F4 combination exhibited the lowest average for this characteristic, attaining 287.67 tillers m^{-2}.

Table (4) Effect of genotypes and different levels of organic and mineral fertilizer on the number of shoots (tillers m^{-2})

average	genotype				fertilizers
	G4	G3	G2	G1	
315.75	339.00	333.33	296.67	294.00	**F1**
339.33	378.33	326.00	306.33	346.67	**F2**
350.75	347.00	334.67	325.67	395.67	**F3**
318.50	366.00	293.33	287.67	327.00	**F4**
	357.58	321.83	304.08	340.83	**average**
Interference	genotype		fertilizers		**L.S.D**
40.338	21.881		17.648		**(0.05)**

Chlorophyll percentage

Table (5) indicates that the G2 genotype exhibited superior performance, achieving the greatest average chlorophyll percentage at 48.30%, which was not significantly different from the G3 genotype's 47.57%. whereas, the G4 genotype recorded the lowest mean for this characteristic, attaining 42.48%. This results due to from the plant's genetic composition.

The results of the table indicate that the F3 fertilization level is superior, achieving the greatest average for this feature at 49.61%, which did not significantly differ from the F2 and F4 levels, gave averages of 46.33% and 44.49%, respectively. The F1 fertilization level recorded the lowest average for this characteristic, attaining 43.54%. The results in Table (5) indicate that the G3XF3 combination surpassed the

other combinations, achieving an average of 54.92%, which did not significantly different from the G2XF3 combination, which had an average of 51.47% for the Chlorophyll percentage. whereas, the G1XF1 combination exhibited the lowest average for this trait, at 40.30%.

Table (5) Effect of genotypes and different levels of organic and mineral fertilizers on the chlorophyll percentage trait.

average	genotype				fertilizers
	G4	G3	G2	G1	
43.54	41.85	43.41	48.59	40.30	**F1**
46.33	41.97	46.95	48.12	48.25	**F2**
49.61	44.63	54.92	51.47	47.40	**F3**
44.49	41.46	44.99	45.01	46.51	**F4**
	42.48	47.57	48.30	45.61	**average**
Interference	**genotype**		**fertilizers**		**L.S.D**
6.149	2.361		5.244		**(0.05)**

Spike Length

Table (6) indicates that the G2 genotype exhibits superiority, achieving the highest average for this feature at 13.02 cm, whereas the G1 genotype presents the lowest average at 11.22 cm. This may be attributable to the characteristics of the genotype.
The results of the table indicate that the F3 fertilization level is superior, achieving the maximum average spike length of 12.83 cm, which did not significantly different from F1 and F2, which recorded averages of 11.96 cm and 11.97 cm, respectively. The F4 fertilization level recorded the lowest average for this characteristic, achieved 10.98 cm.
Table (6) demonstrates the superiority of the G3F3 genotype, which gave 14.07 cm, showing no significant difference from the genotypes G2F1, G3F1, G1F2, G2F2, G2F3, G4F3, and G2F4, which achieved 11.96 and 11.97 cm. The measurements were (13.40, 11.97, 13.07, 13.07, 13.30, 13.30, 12.30) cm, respectively, but the G3F2 combination exhibited the lowest average for this characteristic, at 10.07 cm.

Table (6) Effect of genotypes and different levels of organic and mineral fertilizers on spike length.

average	genotype				fertilizers
	G4	G3	G2	G1	
11.97	11.53	11.97	13.40	10.97	**F1**
11.96	11.63	10.07	13.07	13.07	**F2**

12.83	13.30	14.07	13.30	10.63	**F3**
10.98	10.53	10.87	12.30	10.20	**F4**
	11.75	11.74	13.02	11.22	**average**
Interference	**genotype**		**fertilizers**		**L.S.D**
2.383	1.145		1.601		**(0.05)**

Number of grains per spike (grain per spike-1)

Table (7) indicates that the G2 genotype exceeded the other genotypes, achieving the greatest average of 60.11 grains per spike, whereas the G3 genotype recorded the lowest average at 49.52 grains per spike. This outcome with the conclusions of Al-Maamouri (2015). The data indicate that the F3 fertilization level surpassed the F2 level, achieving the highest average of 55.37 grains per spike, which was not significantly different from the F2 level's average of 54.85 grains per spike. Conversely, the F4 fertilization level produced the lowest average, at 52.21 grains per spike.

Table (7) Effect of genotypes and different levels of organic and mineral fertilizers on the number of grains per spike^{-1}

average	**genotype**				**fertilizers**
	G4	**G3**	**G2**	**G1**	
50.52	48.90	44.97	58.53	49.67	**F1**
54.85	50.00	52.33	62.83	54.23	**F2**
55.37	53.33	49.17	61.63	57.33	**F3**
52.21	48.73	51.63	57.43	51.03	**F4**
	50.24	49.52	60.11	53.07	**average**
Interference	genotype		fertilizers		**L.S.D**
N.S	2.245		2.749		**(0.05)**

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