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NITROGEN FERTILIZER EFFECT ON GROWTH AND YIELD TRAITS OF TRITICALE (X *TRITICOSECALE WITTMACK*)

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SUMMARY

A field experiment during the winter crop of 2022–2023 focused on silts soil of the Agricultural Research and Experiments Station, College of Agriculture, University of Basra, Basra, Iraq. The latest study aimed to determine the cumulative effects of triticale (X *Triticosecale* Wittmack) cultivars and nitrogen fertilization levels on triticale growth and yield-related traits. The study included three triticale cultivars (Farah, Amal, and Muhannad) and four levels of nitrogen fertilizer (0, 100, 120, and 140 N kg ha^{-1}). The presented experiment had a randomized complete block design (RCBD) with factorial arrangement and three replications. The results showed the cultivars had a significant impact on some yield components, and the cultivar Amal gave the highest number of grains per spike, biological and grain yields, and protein (56.74 grains per spike, 22.75 and 6.64 mg ha^{-1}, and 12.20%, respectively). Triticale cultivar Muhannad achieved the topmost spike efficiency and 1000-grain weight with means of 96.96% and 40.67 g, respectively. The results further revealed that increased level of nitrogen fertilizer raised the grain yield. The nitrogen fertilizer (140 kg ha^{-1}) attained the maximum mean for spikes appearance, number of spikes, grains per spike, biological and grain yields, and protein percentage (95.87%, 675.2 spikes m^{-2}, 62.56 grains per spike, 26.78 and 8.07 mg ha^{-1}, and 12.66%, respectively).

Keywords: Triticale (X *Triticosecale* Wittmack), cultivars, nitrogen fertilization levels, growth and yield-related traits, protein percentage

Key findings: Triticale cultivar Amal showed the best performance and the highest grain yield (6.64 mg ha^{-1}). The nitrogen fertilizer (140 kg ha^{-1}) achieved the highest mean for the grain yield (8.07 mg ha^{-1}).

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INTRODUCTION

Triticale (X *Triticosecale* Wittmack) is a cereal crop that belongs to the family *Poaceae* and represents the fruitful attempt of scientists' efforts to obtain a crop that combines the characteristics of wheat and rye by doubling the chromosomes of the hybrid. Triticale combines positive characteristics of two parents, inherited from wheat (*Triticum aestivum* L.) the high ability to yield and resistance to diseases. The other parent, rye (*Secale cereal*), provides durability and ability to survive through its tolerance of unsuitable conditions, such as poor and poorly drained soils. In appearance, it is similar to wheat; however, it is superior in plant and spike size, grain yield, and protein content. It contains the high percentage of protein that may reach 4%, in addition to the highest content of lysine acid (Glamočlija *et al.,* 2018).

The triticale cultivation needs expansion by increasing its productivity using modern production technologies, including the introduction of high-yielding new cultivars. Considered a genotypic composition, it is suitable for cultivation in different regions with diverse environmental factors that affect the modern agriculture through their direct influence on crop growth and yield characteristics and its quality. Triticale cultivars differed among themselves in for growth and yield components (Al-Dulaimi, 2020; Al-Morshedy, 2023; Al-Zubaidi, 2022).

The productive capacity of crop plants primarily depends on different operations carried out in the field regarding inputs and cultural practices based on precise scientific foundations. It considers environmental conditions suitable for growth. Among these field operations, attention should focus on fertilization levels, considerably one of the important production factors fulfilling plant needs for nutrient elements. These macro-micro-elements improve the crop production and its quality (Martínez-Dalmau *et al.,* 2021).

The macro-elements, such as nitrogen, b one of the vital elements crucial in increasing cell division and expansion. The application of nitrogen fertilizer manifested positively in increasing the plant height, the number of leaves, and tillers per plant, leading to an upsurge in the total vegetative and root growth, eventually enhancing the plant's yield in quantity and quality (Mittal *et al.,* 2023). Varied levels of nitrogen fertilizer led to a rise in yield components, grain yield, and protein content (Ziyara, 2023). The presented research sought to determine the cumulative effects of Triticale (X *Triticosecale* Wittmack) cultivars and nitrogen fertilization levels on the Triticale growth and yield-related traits.

MATERIALS AND METHODS

Experimental site and procedure

The study ran a field experiment during the winter crop of 2022–2023 at the Agricultural Research and Experiments Station, College of Agriculture, University of Basra, Basra, Iraq (latitude 30.57 North and longitude 47.8). The latest research aimed to determine the cumulative effects of Triticale (X *Triticosecale* Wittmack) cultivars and nitrogen fertilization levels on triticale growth and yield-related traits. The experiment included two factors, with the first comprising three triticale cultivars (Farah, Muhannad, and Amal), while the second including four different levels of nitrogen fertilizer (0, 100, 120, and 140 kg ha^{-1}).

The experiment had a randomized complete block design (RCBD) with factorial arrangement, using three replications. The total experimental units were 36 (3 × 4 × 3), and each experimental unit has an area of 2 m^2 × 2 m^2. Planting the seeds of the triticale cultivars ensued on November 01, 2022, with a seeding rate of 120 kg ha^{-1} on the silty clay loam soil (Table 1). The sown seeds in rows had 15 cm distance between two rows (Al-Fahdawi, 2012). The study followed all the recommended inputs and cultural practices to the triticale crop to minimize field environmental effects.

Traits measured and analysis

The data recorded on traits consisted of heading (%), the number of spikes, grains per

Table 1. Chemical and physical characteristics of the experimental soil.

Traits		Values	Units
Degree of soil reaction (PH)		7.38	-
Electrical conductivity (E.C)		8.65	DC-Siemens M^{-1}
Organic matter		10.5	g kg^{-1}
Elements Ready made	Nitrogen	53.0	mg kg^{-1}
	Phosphorus	4.86	
	Potassium	125	
Soil components	Sand	369	g kg^{-1}
	Silt	536	
	Clay	95	

Table 2. Effect of triticale cultivars, nitrogen fertilization, and their interaction on the heading.

Cultivars	Nitrogen fertilization (kg ha^{-1})				Means (%)
	0	100	120	140	
Farah	92.38	91.54	95.17	96.70	93.62
Amal	93.30	88.31	91.89	93.11	91.65
Mohannad	95.19	97.65	97.22	97.79	96.96
Means (%)	93.62	92.50	94.76	95.87	
$LSD_{0.05}$ Cultivars: N.S., Fertilization: 4.44, Interaction: N.S.					

spike, 1000-grain weight (g), biological yield (mg ha^{-1}), grain yield (mg ha^{-1}), and protein content (%). The analysis by the study used the Genstat program. Employing the least significant difference ($LSD_{0.05}$) test also helped the comparison and separation of means (Al-Rawi and Khalaf-Allah, 2000).

RESULTS AND DISCUSSION

Heading (%)

The results indicated adding nitrogen fertilizer significantly affected the heading characteristic (Table 2). The nitrogen fertilizer level 140 kg ha^{-1} achieved the highest mean for heading percentage (95.87%), while the control treatment (with no fertilizer) emerged with the lowest mean for the said trait (93.62%). This may be due to the positive role of nitrogen fertilizer, which increased the efficiency of photosynthesis. Additionally, its vital role in flag leaf area, as the main source of photosynthesis products, reflected positively on this trait in the triticale crop (Ding *et al.,* 2023).

Spikes number

The increasing levels of nitrogen fertilizer showed a notable enhancement in the number of spikes per meter square (Table 3). The nitrogen fertilizer level of 140 kg ha^{-1} was significantly higher than the other levels and recorded with the topmost mean for spikes per meter square (675.2 spike m^{-2}), while the control treatment showed the lowest mean for the said trait (385.9 spike m^{-2}). The reason for increase in the number of spikes may refer to the fact that nitrogen fertilizer addition provided a continuous food supply of this nutrient, vital in improving the growth. It prolonged the vegetative growth period and boosted photosynthesis efficiency. This leads to an increase in metabolism products and the provision of nutrients necessary for the largest number of spikes to emerge. These results were consistent with the findings of Ziyara (2023), who also observed an upsurge in the number of spikes in triticale with increasing nitrogen fertilizer levels.

Table 3. Effect of triticale cultivars, nitrogen fertilization, and their interaction on the spike number.

Cultivars	Nitrogen fertilization (kg ha^{-1})				Means (#)
	0	100	120	140	
Farah	338.4	478.6	578.8	686.7	533.1
Amal	447.5	460.8	582.4	702.4	548.2
Mohannad	321.8	513.8	558.5	636.4	507.6
Means (#)	385.9	484.4	573.2	675.2	
$LSD_{0.05}$ Cultivars: N.S., Fertilization: 44.01, Interaction: 76.24					

Table 4. Effect of triticale cultivars, nitrogen fertilization, and their interaction on the grains per spike.

Cultivars	Nitrogen fertilization (kg ha^{-1})				Means (#)
	0	100	120	140	
Farah	40.70	46.33	51.37	59.40	49.45
Amal	43.20	51.63	62.17	69.97	56.74
Mohannad	40.17	46.67	52.10	58.30	49.56
Means (#)	41.36	48.21	55.21	62.56	
$LSD_{0.05}$ Cultivars: 3.36, Fertilization: 3.89, Interaction: N.S.					

Grains per spike

The triticale cultivar Amal was remarkable by having the maximum mean for grains per spike (56.74), while the cultivar Farah recorded with the minimum grains spike^{-1} (49.45) (Table 4). It might be due to the association of this characteristic with the spike length, making the cultivar Amal superior. The spike traits are genetically controlled and cultivars always vary for such crucial trait. Based on the cultivars and the interaction of environmental and genetic factors, these may have an impact on differences among cultivars for the number of grains. These results also agreed with the conclusions of Ali and Hamza (2013) and Al-Dulaimi (2020), who indicated that the number of grains per spike sustained control from genotypic factors specific to the cultivated triticale cultivars.

The nitrogen fertilizer level (140 N kg ha^{-1}) significantly influenced and showed the ultimate number of grains per spike (62.56), while the control treatment provided the lowermost grain number (41.36 grain spike^{-1}) (Table 4). This was due to the positive role of nitrogen in improving plant growth and the fertility rate in spikes, ably forming more grains, eventually raising the grain yield. Al-Abdullah (2015) and Ullah *et al.* (2018) also noticed an increase in the number of grains per spike with an elevation in the added nitrogen fertilizer level; however, the interaction effect was nonsignificant for the said trait in triticale.

1000-grain weight

Triticale cultivar Muhannad achieved the significant superiority over the rest of the cultivars, as it achieved the highest mean for 1000-grain weight (40.67 g), while the cultivars Farah and Amal showed the lowest averages (39.31 and 39.33, respectively) (Table 5). The reason for the increase in 1000-grain weight may refer to the principle of compensation between the yield components because the cultivar Muhannad achieved the lowest number of tillers and spikes per unit area. It caused an increase in the products of photosynthesis during the grain-filling period. These results also aligned with past findings of Al-Zubaidi (2022) and Ziyara (2023) in wheat genotypes planted with different nitrogen fertilizer levels.

For 1000-grain weight, marked differences among the nitrogen fertilizer levels appeared (Table 5). In their effect on the weight of 1000 grains, the nitrogen fertilizer level at 100 N kg ha^{-1} outperformed the rest by showing the highest 1000-grain weight mean (41.80 g). Meanwhile, the fertilizer level at 140 N kg ha^{-1} signified the lowest mean for the said

Table 5. Effect of triticale cultivars, nitrogen fertilization, and their interaction on the 1000-grain weight.

Cultivars	Nitrogen fertilization (kg ha^{-1})				Means (g)
	0	100	120	140	
Farah	40.07	41.40	39.37	36.40	39.31
Amal	40.37	41.47	39.23	36.27	39.33
Mohannad	41.23	42.53	39.40	39.50	40.67
Means (g)	40.56	41.80	39.33	37.39	
$LSD_{0.05}$ Cultivars: 0.89, Fertilization: 1.03, Interaction: N.S.					

Table 6. Effect of triticale cultivars, nitrogen fertilization, and their interaction on the biological yield.

Cultivars	Nitrogen fertilization (kg ha^{-1})				Means (mg ha^{-1})
	0	100	120	140	
Farah	13.47	21.33	22.33	23.19	20.14
Amal	16.45	20.22	23.37	30.97	22.75
Mohannad	13.27	16.27	23.92	26.19	19.91
Means (mg ha^{-1})	14.40	19.27	23.20	26.78	
$LSD_{0.05}$ Cultivars: 2.03, Fertilization: 2.35, Interaction: 4.07					

trait (37.39 g). The reason for the decrease in the 1000-grain weight with an increasing nitrogen fertilizer level could be due to the increased number of spikes in square meter and the number of grains per ear. These led to competition within the plant for photosynthesis products. The resulting small-sized grains could be due to the lack of nutrients needed to fill the grains in the triticale crop (Hussain *et al.,* 2002).

Biological yield

The results revealed cultivar Amal attained the maximum mean for the biological yield (22.75 mg ha^{-1}), while the cultivar Muhannad with the minimum mean for the said trait (19.91 mg ha^{-1}) (Table 6). The reason for the differences among the cultivars for biological yield points to their differences in plant height. These results were analogous to the findings of Bijanzadeh *et al.* (2019), Al-Sulami (2021), and Al-Dulaimi (2022), who also mentioned significant differences among the triticale cultivars for biological yield.

The nitrogen fertilizer level of 140 kg ha^{-1} revealed with the premier mean of biological yield (26.78 mg ha^{-1}), while the control treatment gave the lowest for the said trait (14.40 mg ha^{-1}) (Table 6). An explanation is the role of nitrogen fertilization in increasing the percentage of shoots, reflecting a boost in the efficiency of photosynthesis, and thus, raising dry matter accumulation (Buhedma *et al.*, 2016; Hassanein *et al.*, 2018). According to interaction effects, the cultivar Amal with the fertilizer level of 140 N kg ha^{-1} showed the highest biological yield (30.97 mg ha^{-1}), with the least interaction recorded between the cultivar Muhannad and control treatment (13.27 mg ha^{-1}) (Hassanein *et al.,* 2018).

Grain yield

The outcomes revealed nitrogen fertilizer levels showed a significant effect on the grain yield of triticale cultivars (Table 7). The fertilizer level at 140 kg N ha^{-1} gave the maximum mean grain yield amounting to 8.07 mg ha^{-1}, which was almost double than the control treatment, with the lowest mean grain yield (4.25 mg ha^{-1}). The reason for the increase in grain yield was due to the considerable positive role of nitrogen in improving yield components like the number of spikes and grains in the spike, eventually boosting grain yield. These results were consistent with the findings of Yousaf *et al.* (2014), Jaśkiewicz (2021), and Biberdzic *et al.* (2021) who also obtained a significant increase in triticale grain yield with increasing levels of nitrogen fertilizer.

Table 7. Effect of triticale cultivars, fertilization, and their interaction on the grain yield.

Cultivars	Nitrogen fertilization (kg ha^{-1})				Means (mg ha^{-1})
	0	100	120	140	
Farah	4.48	5.44	5.97	7.91	5.95
Amal	4.27	6.50	7.11	8.68	6.64
Mohannad	3.99	5.09	7.64	7.61	6.08
Means (mg ha^{-1})	4.25	5.68	6.91	8.07	
$LSD_{0.05}$ Cultivars: N.S., Fertilization: 0.78, Interaction: N.S.					

Table 8. Effect of triticale cultivars, nitrogen fertilization, and their interaction on the protein in the grains.

Cultivars	Nitrogen fertilization (kg ha^{-1})				Means (%)
	0	100	120	140	
Farah	9.26	10.40	11.63	12.76	11.01
Amal	11.56	11.46	12.13	13.63	12.20
Mohannad	9.40	9.63	10.66	11.60	10.32
Means (%)	10.07	10.50	11.46	12.66	
$LSD_{0.05}$ Cultivars: 5.36, Fertilization: 6.19, Interaction: 10.72					

Grain protein (%)

The results enunciated that the cultivar Amal excelled other cultivars by recording with the highest mean of protein percentage (12.20%) compared with the cultivar Muhannad, recording with the lowest protein in grains (10.32%) (Table 8). The reason for the difference in the protein percentage among triticale cultivars may be due to the genotypes' varied genetic makeup. Past studies also exhibited that wheat cultivars differed in their composition and lead to significant differences in protein content (Siddiqi *et al.,* 2020; Alhabbar *et al*., 2023; Naas and Al-Majidi, 2024).

The supreme value of protein percentage in grains (12.66%) resulted with the nitrogen fertilizer level of 140 kg ha^{-1}, while the control treatment appeared with the lowest protein percentage (10.07%) (Table 8). An explanation for the increase in protein percentage in triticale grains refers to the positive role of nitrogen fertilizer in building the protein. The meaningful interaction between the triticale cultivars and nitrogen fertilization for percentage of protein in grains revealed that the interaction between the cultivar Amal with the nitrogen fertilizer (140 kg ha^{-1}) achieved the highest protein percentage (13.63%). Meanwhile, the interaction between the cultivars Muhannad and Farah with the control treatment showed the lowest protein percentage in grains (9.40% and 9.26%, respectively).

CONCLUSIONS

The results revealed that the genotypic makeup of triticale cultivars, as well as, the type and quantity of fertilizer added, were the basic factors influencing yield-contributing traits and grain yield. The cultivar Amal excelled in most of the characteristics under study, and its cultivation requires further expansion, which is essential in increasing productivity. The nitrogen fertilizer at the rate of 140 kg ha^{-1} needs adoption for getting good results in most of the triticale traits.

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