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Effect of nitrogen fertilization and number of cuttings on the green and dry forage yield of Triticale (*Triticosecale wittmack* X) crop

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Abstract
A field experiment was conducted at the Agricultural Research Station affiliated with the College of Agriculture, University of Basrah, located in Karma Ali, Basrah Governorate, during the winter season of 2023/2024. The soil at the site was of loamy texture. The objective of the study was to investigate the effect of nitrogen fertilization and cutting frequency on the green and dry forage yield of triticale (X *Triticosecale* spp.). The experiment was applied using a factorial experiment approach within a Randomized Complete Block Design (RCBD) with three replications. The factorial treatments were randomly distributed within each block, resulting in a total of 18 experimental units (3 nitrogen levels × 2 cutting frequencies × 3 replications).The experiment included two factors: The first factor was nitrogen fertilizer at three levels: 100, 150, and 200 kg N ha^{-1}, denoted as N1, N2, and N3 respectively. The second factor was cutting frequency: one cut and two cuts, denoted as C1 and C2 respectively. Key findings: The highest nitrogen level (N3) showed a significant superiority in all studied traits, achieving the highest averages for plant height (104.50 cm), number of tillers (563.20 tillers m^{-2}), green and dry forage yields (20.25 and 6.67 tons ha^{-1} respectively), and nitrogen use efficiency (80.70%).Regarding cutting frequency, the single cut treatment (C1) was significantly superior in plant height and number of tillers, with averages of 102.44 cm and 546.90 tillers m^{-2}, respectively. However, the two-cut treatment (C2) showed superiority in the remaining studied traits.

Keywords: Nitrogen, dry forage yield, of triticale, *Triticosecale wittmack* X

Introduction
Triticale (*Triticosecale wittmack x*), a cereal crop belonging to the Poaceae family, represents a successful effort by plant breeders to combine the desirable traits of wheat (*Triticum aestivum*) and rye (*Secale cereale*). It inherited the high yield potential and disease resistance from wheat, and the vigor and adaptability to poor soil and harsh environmental conditions from rye (Glamoclija *et al*., 2018) [11].Triticale is cultivated in many countries around the world as both a grain and forage crop. However, its cultivation in Iraq remains very limited due to farmers' lack of awareness regarding its economic and physiological importance. Expanding its cultivation requires improving its productivity as both a grain and forage crop. The productive capacity of any plant depends on the agricultural practices applied in the field, based on precise scientific principles and consideration of the suitable environmental conditions for growth. One of the most critical agronomic practices is fertilization, which plays a key role in supplying essential nutrients to plants, increasing agricultural yield, and improving crop quality. Among the major nutrients, nitrogen is particularly important due to its role in enhancing cell division and expansion, which positively affects plant height, leaf and tiller production, and consequently increases both root and shoot biomass and forage yield (Shati *et al*., 2001) [6]. Nitrogen is recommended to be applied in split doses, particularly after each cut, to stimulate tillering and regrowth (Plaza *et al*., 2017) [13]. Another important agricultural practice influencing the growth of forage crops is cutting (harvesting), which ensures plant vigor and the ability to regrow. Cutting also affects tiller development, crown and bud exposure, and the plant's ability to withstand post-harvest stress such as drought and heat, all of which can influence forage yield either positively or negatively (Khribit & Hashim, 2017) [3]. Due to the scarcity of studies on triticale in southern Iraq, this study aims to evaluate the performance of triticale under the region's conditions and to determine the optimal nitrogen fertilization level and cutting frequency that result in the best green and dry forage yields, as well as to identify the most effective combination of the two factors.

Materials and Methods

A field experiment was carried out during the winter season of 2023/2024 at the Agricultural Research Station of the College of Agriculture, University of Basrah (Karma Ali site), located in Basrah Governorate. The soil at the experimental site was of loamy texture. The objective was to evaluate the effect of nitrogen fertilization and number of cuts on the green and dry forage yield of triticale. The experiment followed a factorial arrangement within a Randomized Complete Block Design (RCBD) with three replications. The factorial treatments were randomly assigned within each block, resulting in a total of 18 experimental units (3 nitrogen levels × 2 cutting frequencies × 3 replications).The experiment involved two factors: Nitrogen fertilization at three levels: 100, 150, and 200 kg N ha^{-1}, designated as N1, N2, and N3.Cutting frequency with two levels: one cut and two cuts, designated as C1 and C2.Land preparation involved plowing the field twice using a moldboard plow to a depth of 30 cm in perpendicular directions. The soil was then leveled using disk harrows. The field was divided according to the experimental design into three blocks, each containing six plots. Each plot measured 2 × 2 meters (4 m^2), with a distance of 1.5 meters between blocks to prevent fertilizer movement. Phosphorus fertilizer was applied before planting in the form of triple superphosphate (46% P_2O_5) at a rate of 60 kg P_2O_5 ha^{-1} (Mahdi *et al*., 2011). The plots were irrigated immediately after sowing, and subsequent irrigations were applied as needed. Nitrogen fertilizer was applied in two equal splits as urea (46% N): the first dose after crop emergence and the second after the first cut. Data were statistically analyzed using analysis of variance (ANOVA), and treatment means were compared using the Least Significant Difference (LSD) test at the 0.05 probability level, as described by Al-Rawi and Khalaf-Allah (1980) [4].

The following traits were measured:

1. Plant height (cm)
2. Number of tillers (tillers m^{-2})
3. Green forage yield (tons ha^{-1})
4. Dry forage yield (tons ha^{-1})
5. Nitrogen use efficiency (%)

Results and Discussion

1. Plant Height (cm)

Table (1) shows that there were significant differences among nitrogen fertilization levels. The highest nitrogen level (N3) recorded a significantly greater mean plant height of 104.50 cm, compared to the lowest level (N1), which gave a mean of 92.33 cm. The increase in plant height with higher nitrogen levels may be attributed to nitrogen's vital role in enhancing cell division and elongation, particularly in the internodes. Nitrogen is essential for the synthesis of amino acids, including tryptophan, which is a precursor to auxin - a key plant hormone responsible for promoting cell division and elongation. Additionally, nitrogen improves root branching and efficiency in water and nutrient uptake, which ultimately supports greater plant growth. These findings are consistent with the results reported by Ziki *et al*. (2019) [14] and Ziyara (2023) [5], who noted that increasing nitrogen levels led to significant increases in plant height. From the same table, the results also indicate a significant difference between the two cutting frequencies. The single-cut treatment (C1) produced the highest average plant height (102.44 cm) compared to the two-cut treatment (C2). This may be due to the plants having more uninterrupted time to grow when only one cut is performed. In contrast, repeated cutting may deplete the reserves necessary for growth and reduce the elongation of lower internodes. These findings agree with the results of Al-Zirjawi *et al*. (2015), who observed similar trends under repeated harvesting.

Table 1: Effect of fertilizer levels on the number of cuttings

Fertilizer Levels Number of Cuttings	N1	N2	N3	Cutting Mean
C1	94.67	104.67	108.00	102.44
C2	90.00	95.67	101.00	95.56
	92.33	100.17	104.50	

$LSD_{0.05}$: Fertilizer = 2.407, Cutting = 1.965, Fertilizer × Cutting = N.S.

2. Number of Tillers (tillers m^{-2})

The results presented in Table (2) indicate significant differences among the nitrogen fertilization levels. The highest nitrogen level (N3) recorded the greatest mean number of tillers, reaching 563.20 tillers m^{-2}, with a significant difference compared to the other levels. In contrast, the lowest nitrogen level (N1) gave the lowest mean number of tillers, 459.70 tillers m^{-2}.The increase in the number of tillers can be attributed to the critical role of nitrogen in promoting root development, which in turn supports the formation of more tillers. Nitrogen may also enhance cytokinin synthesis, which reduces apical dominance by increasing the cytokinin-to-auxin ratio in the plant. This hormonal shift promotes lateral bud development and enhances tillering capacity. These findings are in agreement with Hassanein (2020) [2], who reported significant differences in tiller numbers under varying nitrogen levels. The data in Table (2) also show that the one-cut treatment (C1) resulted in a significantly higher number of tillers (546.90 tillers m^{-2}) compared to the two-cut treatment (C2), which recorded the lowest mean value of 481.20 tillers m^{-2}. This reduction may be due to repeated cutting, which leads to depletion of nutrient reserves and consequently weakens the plant's ability to regenerate new tillers in subsequent growth phases. These results are consistent with the findings of Al-Kinani (2019) [8] and Dubey *et al*. (2018) [10], who also observed a decline in tillering with increased cutting frequency.

Table 2: Effect of nitrogen fertilization levels, cutting frequency, and their interaction on number of tillers (tillers m^{-2}).

Fertilizer Levels Number of Cuttings	N1	N2	N3	Cutting Mean
C1	484.70	542.00	614.00	546.90
C2	434.70	496.70	512.30	481.20
	459.70	519.30	563.20	

$LSD_{0.05}$: Fertilizer = 46.54, Cutting = 38.00, Fertilizer × Cutting = N.S.

3. Green Forage Yield (tons ha⁻¹)

Table (3) clearly shows that nitrogen fertilization had a significant effect on green forage yield. The highest nitrogen level (N3) produced the highest mean green forage yield of 20.25 tons ha⁻¹, significantly surpassing the other levels. In contrast, the lowest nitrogen level (N1) recorded the lowest mean yield of 15.77 tons ha⁻¹.The increase in green forage yield can be attributed to the positive effect of nitrogen on enhancing photosynthesis and the production of carbohydrates and other assimilates, which contributes to increased vegetative growth. This includes taller plants, more tillers (as shown in Tables 1 and 2), and an extended vegetative growth period—ultimately leading to higher green biomass. These findings are consistent with those of Al-Kinani (2019) [8] and Jamil (2024) [1], who reported similar increases in green forage yield with increasing nitrogen levels. Regarding the cutting frequency, the two-cut treatment (C2) gave a significantly higher mean green forage yield (19.45 tons ha⁻¹) compared to the one-cut treatment (C1), which recorded 17.03 tons ha⁻¹. This result may be explained by the cumulative effect of regrowth after each cutting, which leads to an overall increase in total forage yield.

Table 3: Effect of nitrogen fertilization levels, cutting frequency, and their interaction on green forage yield (tons ha⁻¹)

Fertilizer Levels Number of Cuttings	N1	N2	N3	Cutting Mean
C1	15.50	17.32	18.27	17.03
C2	16.05	20.06	22.23	19.45
	15.77	18.69	20.25	

$LSD_{0.05}$: Fertilizer = 1.357, Cutting = 1.108, Fertilizer × Cutting = N.S.

4. Dry Forage Yield (tons ha⁻¹)

As shown in Table (4), nitrogen fertilization levels had a significant effect on dry forage yield. The highest nitrogen level (N3) recorded the highest mean dry yield of 6.760 tons ha⁻¹, while the lowest level (N1) gave the lowest yield (value not explicitly stated, but lower than the others). The increase in dry matter yield can be attributed to the higher nitrogen input, which led to increased green forage yield—ultimately resulting in greater dry biomass accumulation. These results are consistent with those reported by Ziyara (2013) [5] and Al-Shuwaili (2014) [7], who found that higher nitrogen rates enhanced both green and dry forage yields. The data also indicate that the two-cut treatment (C2) significantly outperformed the one-cut treatment (C1) in dry forage yield, with mean values of 6.573 tons ha⁻¹ and 5.711 tons ha⁻¹, respectively. This reflects the benefit of repeated regrowth contributing to cumulative dry matter accumulation.

Table 4: Effect of nitrogen fertilization levels, cutting frequency, and their interaction on dry forage yield (tons ha⁻¹

Fertilizer Levels Number of Cuttings	N1	N2	N3	Cutting Mean
C1	5.27	5.77	6.10	5.71
C2	5.60	6.70	7.42	6.57
	5.43	6.23	6.76	

Fertilizer = 0.545 Cuttings = 0.445 Fertilizer × Cuttings = N.S.

5. Nitrogen Use Efficiency (NUE) (%)

The results in Table (5) indicate a significant effect of nitrogen fertilization levels on nitrogen use efficiency (NUE). The highest nitrogen level (N3) recorded the highest NUE, reaching 80.70%, while the lowest level (N1) recorded 0%, the lowest mean value for this trait. These results confirm the crop's positive response to increasing nitrogen fertilization, highlighting the nutrient-deficient nature of the experimental soil. This observation aligns with the findings of Jamel *et al.* (2020), who reported similar responses in nutrient-poor soils. Regarding the effect of cutting frequency, the data reveal a significant influence as well. The two-cut treatment (C2) showed the highest NUE with a mean of 90.80%, while the one-cut treatment (C1) recorded the lowest mean value at 46.65%. This may be due to the repeated regrowth and nutrient uptake in the second cut, which enhanced the overall utilization efficiency of the applied nitrogen.

Table 5: Effect of nitrogen fertilization levels, cutting frequency, and their interaction on nitrogen use efficiency (%)

Fertilizer Levels Number of Cuttings	N1	N2	N3	Cutting Mean
C1	0.00	36.80	56.50	46.65
C2	0.00	76.70	104.90	90.8
	0.00	56.75	80.70	

LSD at 0.05: Fertilizer = 17.6 ,Number of cuttings = 26.28, Fertilizer × cuttings = N.S

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