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Effect of nitrogen fertilization and number of cuts on the grain yield of Triticale *Triticosecale wittmack* X

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Abstract
A field experiment was conducted at the Agricultural Research Station, College of Agriculture, University of Basrah, at the Karma Ali site, in a soil of loamy texture during the winter growing season of 2023-2024. The objective of the study was to determine the effect of nitrogen fertilization and number of cuts on the grain yield of triticale (*Triticosecale Wittmack* X.). The study included two factors: the first factor consisted of three nitrogen fertilizer levels—100, 150, and 200 kg N ha^{-1}—while the second factor was the number of cuts (one cut and two cuts), denoted as C_1 and C_2, respectively. The experiment was arranged in a factorial layout using a randomized complete block design (R.C.B.D) with three replications. Yield components and spike efficiency traits were studied. The results indicated that increasing nitrogen fertilizer levels led to an improvement in yield components and total grain yield. The level of 200 kg N ha^{-1} (N_3) produced the highest mean values for spike length, number of spikes per square meter, number of grains per spike, and grain yield, reaching 11.113 cm, 530.7 spikes m^{-2}, 59.52 grains spike^{-1}, and 6.467 Mg ha^{-1}, respectively. On the other hand, the level of 100 kg N ha^{-1} (N_1) recorded the highest mean of 1000-grain weight (38.93 g). Likewise, one cutting (C_1) resulted in the highest mean values of spike length, number of spikes per square meter, number of grains per spike, and grain yield (10.910 cm, 518.9 spikes m^{-2}, 58.86 grains spike^{-1}, and 7.056 Mg ha^{-1}, respectively). A significant interaction was observed between nitrogen fertilizer levels and number of cuts for some traits. The combination of 200 kg N ha^{-1} with one cutting ($N_3 \times C_1$) gave the highest mean values of spike length and number of grains per spike, reaching 11.403 cm and 61.70 grains spike^{-1}, respectively.

Keywords: Triticale, nitrogen fertilization, cutting frequency, grain yield

Introduction
Triticale (× *Triticosecale Wittmack*) is a cereal crop belonging to the family *Poaceae*. It represents a successful outcome of plant breeding efforts through chromosome doubling of a hybrid, combining the favorable characteristics of both parent species. From wheat (*Triticum aestivum*), triticale inherits its high yield potential and disease resistance, while from rye (*Secale cereale*), it inherits vigor and the ability to withstand adverse environmental conditions. Morphologically, triticale resembles wheat but surpasses it in plant size, spike length, grain yield, and protein content. It contains a higher protein percentage, reaching up to 4% more than wheat, and is also rich in lysine (Glamoclija *et al.*, 2018) [18].
Triticale is used in human nutrition due to its essential amino acid composition, which is often deficient in other cereal crops. Its flour can be used to produce brown bread as an alternative to barley and is also utilized in pastry production (Hleel, 1983; Al-Othmahy, 1996) [8, 13]. Although triticale is cultivated in many parts of the world as both a grain and forage crop, its cultivation in Iraq remains very limited due to the lack of awareness among farmers regarding its economic and physiological importance.
Globally, triticale is cultivated on approximately 3,830,794 hectares, with an average yield of 3.8 Mg ha^{-1} (FAO, 2022). The productivity of any crop depends on proper management practices applied under suitable environmental conditions, among which fertilization plays a crucial role. Nitrogen is an essential macronutrient required in large quantities for plant growth. A deficiency in nitrogen availability limits plant growth, weakens physiological performance, and consequently reduces yield (Vicente *et al.*, 2018) [22].
Another important agronomic practice that significantly affects the growth of forage crops is cutting frequency. Cutting influences the ability of plants to maintain sufficient vigor for

regrowth, as well as the duration of sustained productivity. It also affects tiller development, crown and bud exposure, and the degree to which buds and tillers are subjected to desiccation or heat stress after cutting. These factors can positively or negatively influence both the quantity and quality of the produced forage (Khurbit and Hashim, 2017) [5].

To meet the growing demand of the livestock sector for concentrated feed and due to the limited studies available on the response of triticale to cutting frequency and nitrogen fertilization, the present study was conducted to evaluate the effect of nitrogen fertilization and number of cuts on the grain yield of triticale.

Materials and Methods

A field experiment was conducted at the Agricultural Research Station, Department of Field Crops, College of Agriculture, University of Basrah, during the 2023-2024 growing season. The soil of the experimental site was of loamy texture. The study aimed to investigate the effect of nitrogen fertilization and number of cuts on the grain yield of triticale (× *Triticosecale Wittmack*).

The experiment was carried out as a factorial experiment using a randomized complete block design (R.C.B.D) with three replications. The total number of treatments was (3 × 2) = 6, resulting in 18 experimental units. The first factor included three nitrogen fertilizer levels—100, 150, and 200 kg N ha^{-1}—designated as N_1, N_2, and N_3, respectively. The second factor was the number of cuts (one and two), represented by C_1 and C_2.

The field was prepared by plowing twice in perpendicular directions using a moldboard plow. The land was then divided according to the experimental units. Each plot measured 2 × 2 m (4 m²). The crop was sown on November 1, 2024, at a seeding rate of 120 kg ha^{-1}, using row planting with a 20 cm spacing between rows (Noaema, 2020) [20].

Urea fertilizer (46% N) was used as the nitrogen source and was applied according to the treatment levels in two splits, one after each cutting. Phosphorus fertilizer was applied at a rate of 100 kg P_2O_5 ha^{-1} in the form of triple superphosphate (20% P) (Al-Murshidi, 2022) [9].

Data were analyzed statistically according to the analysis of variance (ANOVA) procedure for each studied trait. Treatment means were compared using the Least Significant Difference (L.S.D.) test at the 0.05 probability level, as described by Al-Rawi and Khalaf-Allah (1980) [6].

The following traits were measured:

1. **Spike length (cm)**
   Ten spikes were randomly selected from each experimental unit within the harvested area (0.50 m²). Spike length was measured from the base to the tip, excluding the awns, at full maturity using a graduated ruler.
2. **Number of spikes m^{-2}**
   The number of spikes was determined at full maturity by counting all spikes harvested from three rows, each 1 m in length, from every experimental unit.
3. **Number of grains spike^{-1}**
   The number of grains per spike was determined by manually counting the grains of ten randomly selected spikes from each harvested area.
4. **1000-grain weight (g)**
   A random grain sample was taken from each experimental unit. A subsample of 1000 grains was counted and weighed using a precision balance.
5. **Grain yield (Mg ha^{-1})**
   Grain yield was estimated by weighing the harvested grains after threshing the crop from each experimental unit, and the weight was converted to megagrams per hectare (Mg ha^{-1}) using proportional calculation.
6. **Spike efficiency (%)**
   Spike efficiency was calculated from the harvested area (0.50 m²) according to the following formula:

$$\text{Spike efficiency (\%)} = \frac{\text{Number of spikes m}^{-2}}{\text{Number of tillers m}^{-2}} \times 100$$

Results and Discussion

1. Spike Length (cm)

The results presented in Figure 1 indicate that the nitrogen level of 200 kg N ha^{-1} (N_3) significantly exceeded the other treatments in spike length, recording the highest mean value of 11.113 cm, which represented an increase of 15.96% compared to the control treatment (N_1), which gave the lowest mean of 9.583 cm.

The increase in spike length may be attributed to the adequate supply of nitrogen necessary for photosynthesis, which reduces competition among growing tissues for assimilates and ensures sufficient nutrient availability to promote cell elongation and spike development. The increase in the flag leaf area, which plays a vital role in photosynthesis, may have also contributed to spike elongation. These findings are in agreement with those reported by Al-Hakim, who stated that increasing nitrogen levels leads to a significant increase in spike length.

The results also revealed that one cutting (C_1) significantly surpassed two cuttings (C_2), recording the highest mean spike length of 10.910 cm, whereas the two-cutting treatment gave the lowest mean of 9.519 cm. The reduction in spike length under repeated cutting could be due to the depletion of stored nutrients, which weakens the plant’s ability to regrow normally, thereby reducing the assimilate supply available for spike elongation. This result is consistent with the findings of Al-Jayashi (2020) [2], who reported that repeated cutting negatively affects spike length.

A significant interaction was observed between nitrogen levels and cutting frequency. The combination (N_3 × C_1) recorded the highest mean spike length (11.403 cm), significantly surpassing all other combinations, while (N_1 × C_2) gave the lowest mean value (8.600 cm). This interaction trend was consistent with the behavior of the individual factors, indicating that the same underlying causes described for the main effects were responsible for shaping the relationship between the two factors when combined.

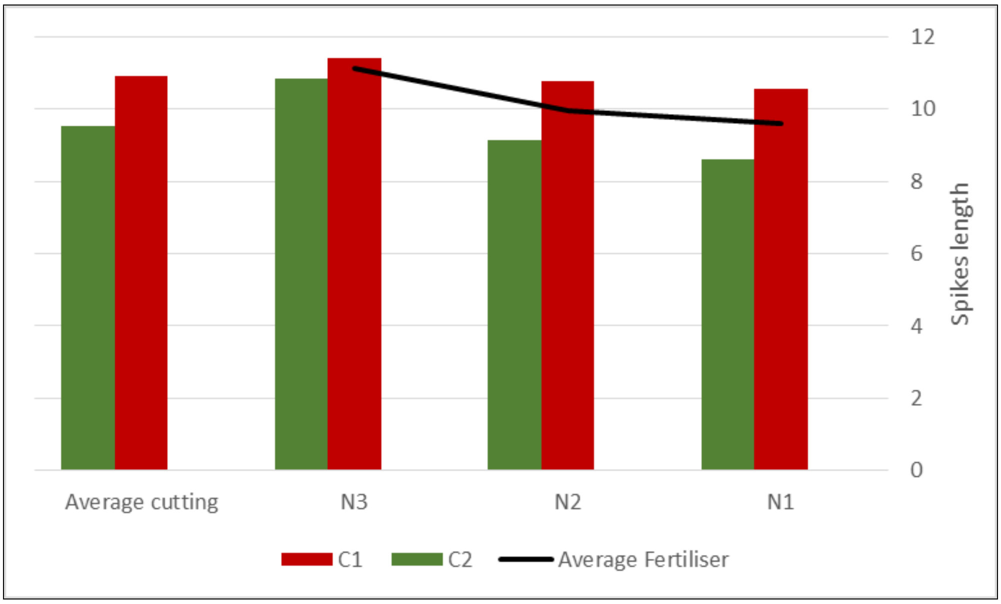

Fig 1: The effect of nitrogen fertilization, number of cuttings, and their interaction on spike length (cm).

2. Number of Spikes m⁻²

As shown in Figure 2, there was a significant increase in the number of spikes with the increasing levels of nitrogen fertilizer. The nitrogen level of 200 kg N ha^{-1} (N_3) significantly surpassed the other levels, recording the highest mean of 530.7 spikes m^{-2}, which represented an increase of 21.44% compared with the treatment N_1, which gave the lowest mean of 437.0 spikes m^{-2}.

The increase in spike number may be attributed to the enhanced nutrient availability resulting from nitrogen addition, which plays a crucial role in improving vegetative growth by extending the vegetative period and increasing tiller production. Moreover, nitrogen promotes flag leaf expansion, enhancing the interception of light and the efficiency of photosynthesis. Consequently, more assimilates become available for the formation of productive tillers. In addition, improved root development under adequate nitrogen supply enhances water and nutrient uptake, reduces inter-plant competition, and supports the growth of fertile tillers capable of producing more spikes.

These findings are consistent with those reported by Bielski (2015) [15] and Ali *et al.* (2015) [12], who found a significant increase in spike number with higher nitrogen application levels.

The results also indicate that the number of spikes decreased with repeated cutting. The two-cut treatment (C_2) recorded the lowest mean value of 452.4 spikes m^{-2}, compared with the one-cut treatment (C_1), which gave the highest mean of 518.9 spikes m^{-2}. This reduction may be due to the depletion of nutrient reserves resulting from repeated cutting, which limits regrowth and subsequently decreases the number of tillers that develop into fertile shoots and spikes. These results are in agreement with the findings of Al-Kinani (2019) [8], Agegnehu *et al.* (2016) [11], and Dubey *et al.* (2018) [16], who also reported a reduction in spike number with increased cutting frequency.

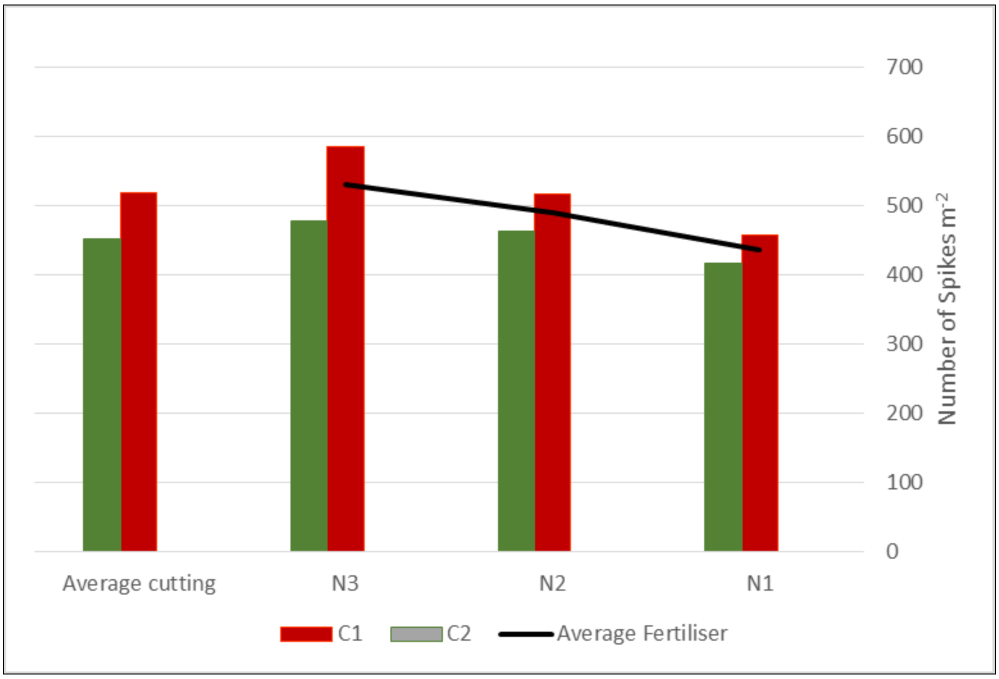

Fig 2: The effect of nitrogen fertilization, number of cuttings, and their interaction on the number of spikes per m².

3. Number of Grains per Spike (grains spike^{-1})

The nitrogen level N_3 (200 kg N ha $^{-1}$) presented the highest average number of grains per spike (59.52 grain spike^{-1}), and it was significantly different when compared to the accessions that received nitrogen in rate N_1, which exhibited diplayed lowest number of grains per spike (50.50 grain spike^{-1}) (Figure 3).

Such an increase may be attributed to the promotion effect of nitrogen on plant growth (Lassaletta *et al*) and fertilization efficiency of spikelets which is more effective in grain filling. And thus it encourages a higher final grain yield. Our findings are consistent with Al-Abdullah (2015) [7] and Ullah *et al*. (2018) [21] observed that the number of grains per spike was markedly improved at increased nitrogen fertilization.

There was also a clear effect of frequency cuts, C_1 treatment (a cut) with a mean number of grains per spike 58.86 more than the average increase opposed to that observed in low amount C_2 treatment (two cuts) that obtained only three days between gashing gates in which the average 50.61 grains spike^{-1}. ReadToEndDOCX. These results are in accordance with those of Al-Badri (2025) [1], who reported that the spike length was reduced and the number of grains per spike was also decreased with multiple cutting.

The N levels and cutting frequency interaction was also significant. The average highest mean over ($N_3 \times C_1$) of 61.70 grains spike $^{-1}$ was significantly better than all the combinations.

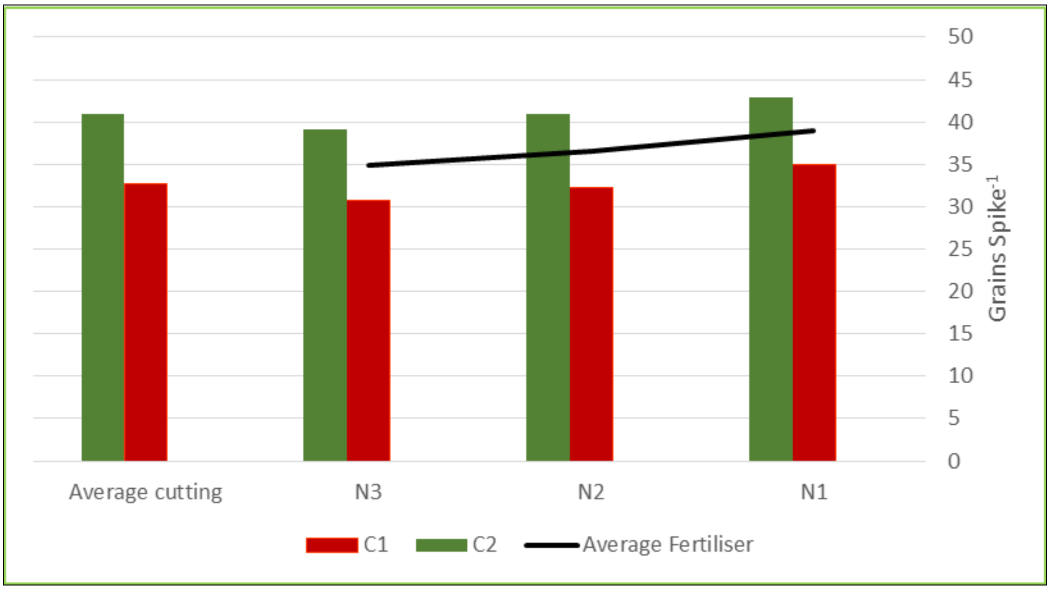

Fig 3: The effect of nitrogen fertilization, number of cuttings, and their interaction on the number of grains per spike (grain spike^{-1}).

4. 1000-Grain Weight (g)

As can be seen in Figure 4, there is a distinct variance between nitrogen levels on TN1000 /(t. ha^{-1}.\). The 100 kg N ha^{-1} (N_1) had the highest mean of 38.93 g, and was significantly higher by 11.45% than the lowest mean following the treatment of 200 kg N ha^{-1} (N_3), at 34.93 g.

The reduction of 1000-grain weight with the high N rates could be associated with increase in the number of spikes m-2 and grains spike-1, which increased competition between filling grains for assimilates. This competition probably decreased the available nutrients for grain filling and led to a decrease in grain size. It implies that an increment in one component of yield can cause a decrease in the other components due to compensatory effect among the yield components. The results are in accordance with the findings of Hassan and Ali (2014) [4] in their report on 1000-grain weight being significantly influenced by nitrogen levels.

As for the effect of cutting frequency, a significant difference was also noticed. The treatment with two-cuts (C_2) registered the highest mean 1000-kernel weight value of 40.98 g and one-cut (C_1), the lowest 32.66 g. The interaction nitrogen and frequencies not were significant for this characteristic.

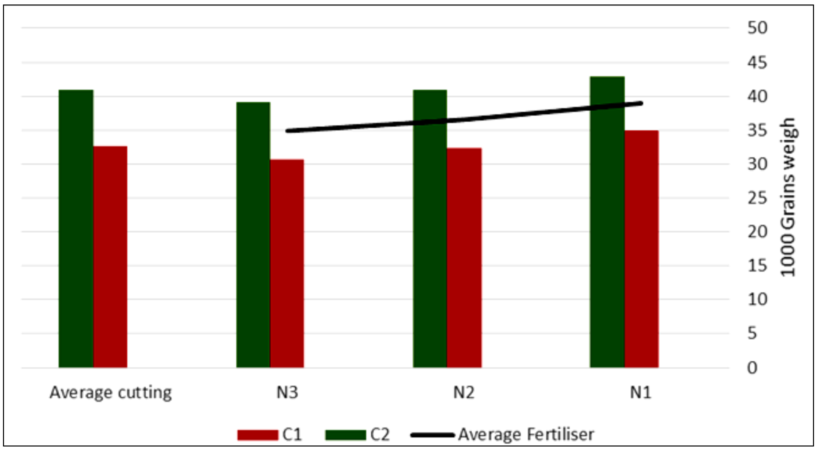

Fig 4: The effect of nitrogen fertilization, number of cuttings, and their interaction on the 1000-grain weight (g).

5. Grain Yield (Mg ha⁻¹)

As per the data (Table 5), nitrogen fertilizer levels had a significant impact on grain yield. Highest averaged grain yield of 6.467 Mg ha^{-1} was obtained from treatment with 200 kg N ha^{-1} (N_3), an increase of 32.87% over the lowest mean yield of 4.867 Mg ha^{-1} recorded under the application of100 kg N ha^{-1} (N_1).

The improvement in grain yield could be due to the favorable impact of N on yield components including spike number and grains per spike (Figures 2 and 3). These attributes are the result of all the physiological mechanisms that have operated in the plant during its whole cycle, and contributed to a higher grain yield. This finding is in agreement with that of Yousaf *et al*. (2014), Jaskiewicz (2021) and Biberdzic *et al*. (2021) [23, 19, 14] who found a similar effect in the Triticale grain yield as well, under the influence of higher nitrogen levels.

As to the mowing frequency, difference among treatments were significant. The single-cut (C_1) had the highest mean grain yield of 7.056 Mg ha^{-1}, while two-cut (C_2) had the least with value of 4.278 Mg ha^{-1}. This discrepancy could because the single-cut management led to tillers differentiation, and then increased fertile spikes number compared with non-cut treatment and to increase yield per unit area. Interaction between levels of nitrogen and cutting frequency was not significant for Grain yield.

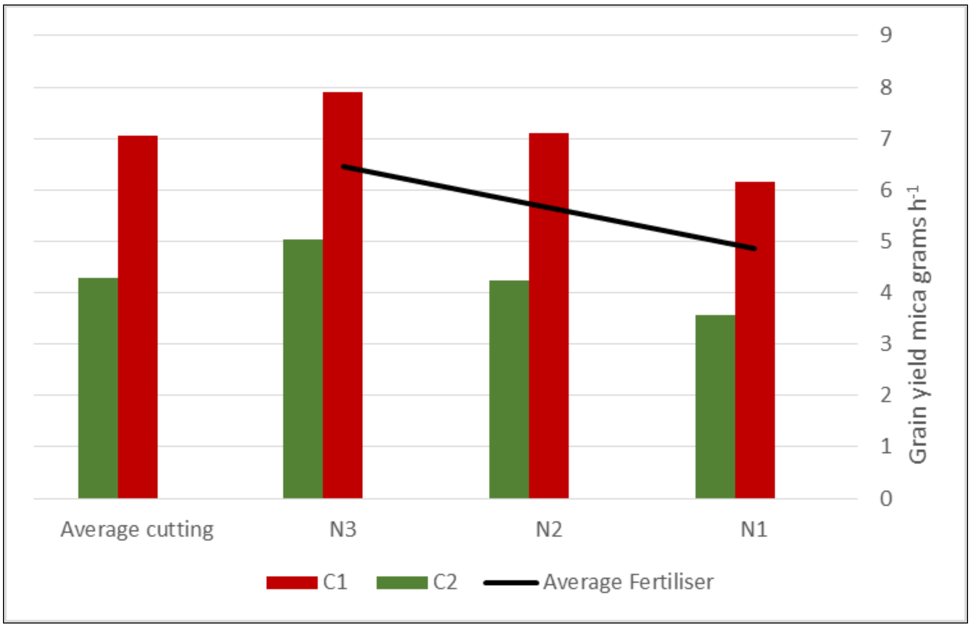

Fig 5: The effect of nitrogen fertilization, number of cuttings, and their interaction on total grain yield (Mg ha^{-1}).

6. Spike Fertility Efficiency (%)

The results presented in Figure 6 indicated that there were no significant differences among the nitrogen fertilizer levels, cutting frequencies, or their interaction for this trait.

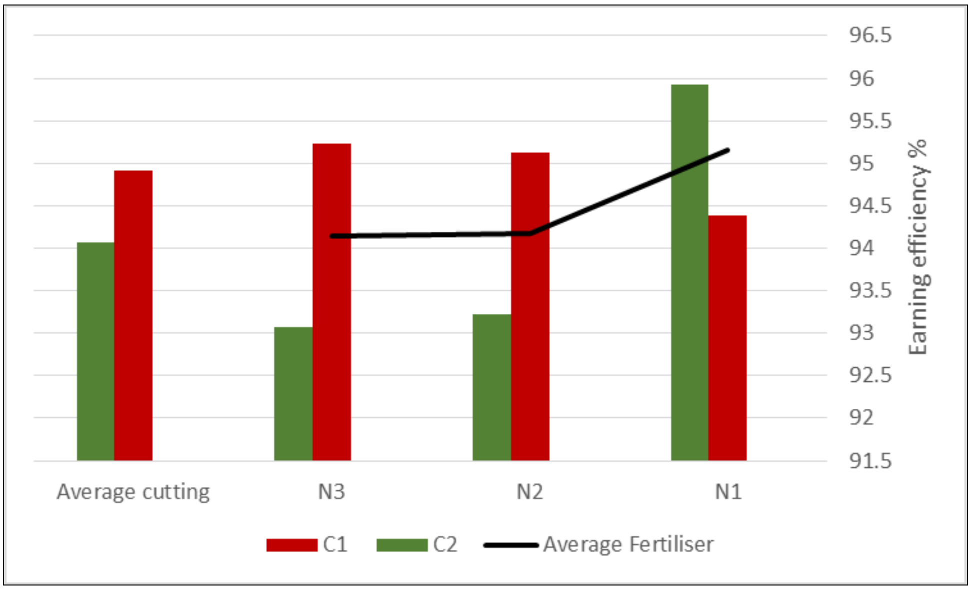

Fig 6: The effect of nitrogen fertilization, number of cuttings, and their interaction on the spike efficiency (%).

Conclusion

It can be concluded that applying nitrogen fertilizer at 200 kg ha^{-1} is the optimal level for increasing grain yield, as it enhances spike length, spike number, grains per spike, and overall grain yield. Moreover, the cutting frequency has a direct effect on crop growth, while repeated cuttings reduce grain production.

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