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Effect of Nitrogen Levels and Cutting Treatments on Forage and Grain Yields of Dual Purpose Barley (*Hordeum vulgare* L.) in Egypt

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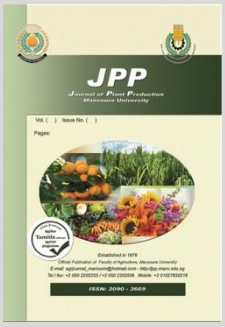

ABSTRACT

In order to determine the effects of three nitrogen fertilizer levels (60, 90, and 120 kg N/fad) and three cutting strategies (uncut, once at 35 DAS, and twice at 35 DAS and 55 DAS) on forage and grain yields of dual-purpose barley, two field experiments were performed at the sandy soil experimental farm of the faculty of Agriculture, Zagazig University, Egypt, during the winter seasons of 2022/23 and 2023/24, using split plot arrangement in Randomized Complete Block Design (RCBD) with three replicates. Results showed that raising N fertilizer level from 60 to 120 kg/fad resulted in significant increments in barley yield attributes and components, in favor of 120 kg N/fad which recorded the highest fresh forage yield, while 90 kg produced the highest significant dry forage one. N variation had no effect on harvest index. Cutting treatments significantly influenced barley yield components, where once-cut plants yielded the highest grain yield through maximized number of spikes/m^2, grains/spike and seed index. Cutting barley plants once promotes rapid regrowth and maximizes the role of vegetative material in grain yield assimilation. The effect of interactions between nitrogen levels and cutting treatments on barley plants was significant in favor of uncut plants aligned with 90 kg N/fad. The lowest fresh and dry forage yields were found in once and twice cutting treatments. The highest grain yield was achieved through uncut strategy and the combination 90 kg N/fad × once cut, while the lowest yield obtained from twice cut plants treated with 60 kg N/fad.

Keywords: Barley; nitrogen; cutting; forage yield; grain yield.

INTRODUCTION

Egypt is a developing country with a dense population exceeding one hundred million people undoubtedly suffers from a shortage of some pivotal agricultural products, for which, the demand exceeds their production. The shortage of green forage for animals feed is more demonstrated in the summer season, while in the winter, Egyptian clover (*Trifolium alexandrinum* L.) is considered the most widespread green forage crop and is considered a competitor to the rest of the winter crops for which the need increases, such as wheat (*Triticum aestivum* L.) and faba bean (*Vicia faba* L.) in particular, and barley (*Hordium vulgare* L.) as a primarily grain crop in Egypt (Rabie, 2020; Goma and Phillips, 2021; Badawy *et al*., 2023).

Barley is considered a great agricultural wealth as the 2nd ranked winter grain crop in Egypt, because it is a dual-purpose crop that has the ability to regrow after cutting. Therefore, it can be grown and harvested to serve as green forage with high nutritional value for livestock, and then left to regrow and produce grains during the same season. This increases the economic feasibility of its cultivation (Ali *et al*. 2023).

Given that most of Egypt's area barren desert and the majority of it are cultivable, and knowing that barley is an adaptable crop rather than wheat and can endure the changing climatic conditions, and taking into account the Egyptian people's need for bread loaf and expensive red meats, barley is considered an important sustainable solution (El-Khalifa *et al*., 2022). The management practices for dual-purpose crops need to balance the trade-offs between forage yield and grain yield. Optimizing nitrogen application and cutting treatments are crucial agronomic interventions that can significantly influence these outcomes (El Mouttaqi *et al*. 2023).

Nitrogen is one of the essential nutrients required for such a cereal plant growth and development. Several studies have investigated the efficacy of different nitrogen levels on the yield of dual-purpose barley in Egypt. According to Anas *et al*. (2020), increasing nitrogen application rates led to a significant improvement in both forage and grain yields of dual-purpose barley. Conversely, excessive nitrogen levels can result in lodging and reduced grain quality. Therefore, finding the optimal nitrogen level is crucial to maximizing the yield potential of dual-purpose barley (Reinprecht *et al*., 2020). Globally, about 10^{11} kg of nitrogen are supplied annually in the agricultural system (Hammad *et al*., 2017). Over and above, agricultural crops are only able to use 30:40% of the supplied nitrogenous fertilizer (Govindasamy *et al*., 2023).

Nitrogen, as the row protein, is considered the most important macro element must be available for plants in poor nutritive sandy soils, in order to ensure reasonable growth and yield of barley. Nitrogen is the nucleus of rapid regrowth after cutting to catch up with the flowering and grain filling stages at proper climatic conditions as possible (Thai *et al*., 2020; Naghdyzadegan *et al*., 2023). The cutting treatments of dual-purpose barley also plays a vital role in determining its productivity. Conyers *et al*. (2020) quoted that frequent cutting intervals resulted in higher forage yields but lower grain yields due to resource allocation

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trade-offs. In contrast, less frequent cutting may enhance grain yield at the expense of forage production (Salama *et al*., 2019). Balancing the cutting treatments is essential to achieve both satisfactory forage and grain yields from dual-purpose barley crops.

The interaction between nitrogen levels and cutting treatments further complicates the management decisions related to dual-purpose barley cultivation. Bastidas *et al.* (2004) highlighted that an optimal combination of nitrogen application levels and cutting intervals could maximize both forage and grain yields simultaneously. However, improper synchronization between nitrogen supply and cutting schedule may lead to suboptimal performance of dual-purpose barley crops (Patel *et al*., 2024). Understanding the synergistic effects between nitrogen levels and cutting treatments is crucial for optimizing the productivity of dual-purpose barley (Hadi *et al*., 2012).

Managing nitrogen levels and cutting treatments appropriately is essential for enhancing the forage and grain yields of dual-purpose barley in Egypt. Finding the right balance between these two factors was the aim of the study to achieve sustainable production systems that meet both livestock feed requirements and human food demands.

The study aimed at investigating the influence of three nitrogen fertilizer level and three cutting frequencies on forage and grain yields of dual-purpose barley, through analyzing growth parameters as plant height and No. of tillers/plant; as well analyzing yield components (No. of spikes/m^2, No. of grains/spike and 1000 grain wt.).

MATERIALS AND METHODS

Two field experiments were laid out at the sandy soil experimental farm of the Faculty of Agriculture, Zagazig University, Egypt *i.e.* located in El-Khattara, Fakous district, Sharkia Governorate, Egypt (30°39'56.9"N 31°53'03.8"E) during the winter seasons of 2022/23 and 2023/24, to investigate the effect of three nitrogen fertilization levels (60, 90 and 120 kg N/fad) and three cutting strategies *q.i.* no cut, cut for once 35 DAS and twice cuts, first at 35 DAS and the second 55 DAS, on both forage and grain yields of dual-purpose barley (*Hordeum vulgare* L.).

While preparing the soil for planting, samples from the upper 30 cm of soil surface were collected from the experimental site. Chemical and physical assessments were performed according to the methodology described by Lindsay and Norvell (1978) and Jackson (1958). Experimental soil was sandy loam with 8.1 pH, and a moderate salinity (EC = 0.54 dSm^{-1}). Available N, P, and K were 47.14, 15.36, and 180 ppm (mg kg^{-1} soil) respectively. Hence it is decided that soil was fertile to some extent.

Statistically, the experiment trail was laid in split plot arrangement in Randomized Complete Block Design (RCBD) with three replications. Nitrogenous fertilizer levels were loaded to main plots and cutting strategies were assigned to sub-plots. Each plot was 3 × 3 m ($9m^2$) including 15 rows and 20 cm apart while 3 m long.

Barley grains cv. Giza 138 were kindly obtained from the Egyptian Agricultural Research Center (ARC) and were sown on 13rd November in both seasons at 60 kg seeding rate per fad. (fad.= faddan, 4200 m^2). Ammonium Nitrate (33.5%) was used as nitrogenous source and it was applied in four equal splits (15, 35, 55 and 75 DAS). Phosphoric fertilizer as mono super phosphate (15.5 P_2O_5) at 200 kg/fad and potassium sulfate (48%) at 24 kg K_2O/fad were applied; considering that potassium was split in two equal doses (pre-sowing and 35 DAS). All agricultural operations like sprinkler irrigation, weed management and pest control were kept constant for all experimental units. Cutting for forage was at 5 cm height from soil surface. Spikes were harvested at 170 DAS.

To achieve the aim of investigation, fresh and dry forage yields (kg fad^{-1}), No. of tillers/plant, plant height (cm), No. of spikes/m^2, No. of grains/spike, 1000-grain weight (g), grain and biological yields (kg fad^{-1}) and harvest index (%) were estimated.

Data recorded from each plot were subjected to the analysis of variance (ANOVA) of the split plot design according to Gomez and Gomez (1984) using COSTAT-Statistics Software 6.400 package as described by Cardinali and Nason (2013), (available at https://cran.r-project.org/web/packages/costat/citation.html). The error mean squared of split plot design were homogenous (Bartlett's test), so the combined analysis was calculated for all the studied characters in both seasons. Means were compared using LSD (Waller and Duncan, 1969).

RESULTS AND DISCUSSION

Tables from 1 to 9 present the influence of both cutting treatments and nitrogen fertilizer levels on barley plants growth as well as both forage and grain yields.

Effect of nitrogen levels

No. of tillers/plant and plant height (cm)

It was observed that raising nitrogen fertilizer level from 60 to 90 to 120 kg/fad was combined conjoint with a significant increment in No. of tillers/plant and plant height in both seasons. However the odds for supply 90 kg N/fad (N_2) which was at par statistically with applying 120 kg N/fad. Under N_2 fertilizer level, tillers/plant outnumbered the other N levels and recorded 8.13 and 8.26 tiller/plant in the 1st and 2nd seasons in the same order. The fewest tiller number/plant was observed under the lowest level (N_1, 60 kg N/fad) recording 4.62 and 4.59 tiller/plant in the 1st and the 2nd seasons, orderly (Table 1).

Table 1. Number of tillers/plant of dual-purpose barley as affected by nitrogen fertilizer levels, cutting treatments and the interaction between them

1st season	**Cutting treatments**			
Nitrogen levels (kg/fad)	**Uncut (C_1)**	**Once cut (C_2)**	**Twice cut (C_3)**	**Mean**
60 kg/fad (N_1)	6.14	4.00	3.74	4.62 b
90 kg/fad (N_2)	9.50	7.68	7.20	8.13 a
120 kg N/ fad (N_3)	8.38	6.88	7.26	7.50 a
Mean	8.01 a	6.19 b	6.06 b	
2nd season	Cutting treatments			
Nitrogen levels (kg/fad)	Uncut (C_1)	Once cut (C_2)	Twice cut (C_3)	Mean
60 kg/fad (N_1)	5.71	4.08	4.00	4.59 b
90 kg/fad (N_2)	11.21	7.30	6.26	8.26 a
120 kg N/ fad (N_3)	7.12	7.84	7.91	7.62 a
Mean	8.01 a	6.41 b	6.06 b	

Symbols beside means denote significance order at 5%, Means values without symbols denote non significance

Allusion to the plant height (Table 2), the tallest plants was the resultant of supply either 90 kg N/fad (N_2) or 120kg

N/fad (N_3) in both seasons. The shortest barley plants were obtained under the lowest N level (N_1, 60 kg N/fad) recording 89.36 and 92.46 cm in the 1st and the 2nd seasons. Nitrogen is indispensable nutrient for amino acids synthesis including tryptophan, which is the raw material auxin synthesis, auxin enhance both cell division and enlargement, thence the higher the N level, the higher will be auxin and so, plant growth taller.

Table 2. Plant height (cm) of dual-purpose barley as affected by nitrogen fertilizer levels, cutting treatments and the interaction between them

1st season	**Cutting treatments**			
Nitrogen levels (kg/fad)	**Uncut (C_1)**	**Once cut (C_2)**	**Twice cut (C_3)**	**Mean**
60 kg/fad (N_1)	88.40	104.21	75.48	89.36 b
90 kg/fad (N_2)	122.01	101.26	91.97	105.08 a
120 kg N/ fad (N_3)	129.34	117.35	75.01	107.23 a
Mean	113.25 a	107.61 a	80.82 b	
2nd season	Cutting treatments			
Nitrogen levels (kg/fad)	Uncut (C_1)	Once cut (C_2)	Twice cut (C_3)	Mean
60 kg/fad (N_1)	83.98	107.33	86.05	92.46 c
90 kg/fad (N_2)	113.47	109.37	102.08	108.31 a
120 kg N/ fad (N_3)	112.53	99.74	86.26	99.51 b
Mean	103.33 a	105.48 a	91.47 b	

Symbols beside means denote significance order at 5%, Means values without symbols denote non significance

Fresh and dry forage yields (kg/fad)

Fresh forage yield (kg/fad) was the highest when applying 120 kg N/fad (N_3) in both seasons amounting to 5883.88 and 4941.10 kg/fad, in 1st and 2nd seasons, respectively. Supply of 90 kg N/fad (N_2) ranked 2nd producing 5153.41 and 4759.30 kg fresh forage yield/fad in the 1st and 2nd seasons, respectively. Adding 60 kg N/fad produced the lowest fresh forage yield in the 1st and 2nd seasons by about 16.14% and 8.66% less than N_2 (90 kg N/fad) and by 25.15 and 11.55% less than N_3 (120 kg N/fad) in the 1st and 2nd seasons, respectively (Table 3).

Dry forage yield followed a resemble trend with the fresh forage yield, resulting a significant difference due to nitrogen levels in favor of N_3 (120 kg N/fad) followed by N_2 (90 kg N/fad) by 1991.94 and 1687.62 as well as 1814.74and 1575.94, in the 1st and 2nd seasons, respectively; while N_1 (60 kg N/fad) recorded the lowest dry forage yield (1258.62 and 1246.18 kg/fad) in in the 1st and 2nd seasons, respectively. Since the fresh weight of the plants is the result of its height and tillers it bears, thence, excellency of both barley plants height and tillers number/plant due to nitrogen availability in N2 and N3 treatments caused an expectant elevation in barley biomass *i.e.* both fresh and dry yields under the same fertilizer levels.

Table 3. Fresh and dry forage yield (kg/fad) of dual-purpose barley as affected by nitrogen fertilizer levels, cutting treatments and the interaction between them

	Fresh forage yield (kg/fad)			**Dry forage yield (kg/fad)**		
1st season	**Cutting treatments**			**Cutting treatments**		
Nitrogen levels (kg/fad)	**Once cut (C2)**	**Twice cut (C3)**	**Mean**	**Once cut (C2)**	**Twice cut (C3)**	**Mean**
60 kg/fad (N1)	3592.28	4754.45	4173.36 c	1131.35	1439.9	1285.62 c
90 kg/fad (N2)	4283.9	6022.93	5153.41 b	1596.97	2032.52	1814.74 b
120 kg N/ fad (N3)	4799.39	6968.38	5883.88 a	1752.91	2230.98	1991.94 a
Mean	4225.19 b	5915.25 a		1493.74 b	1901.13 a	
2nd season	Cutting treatments			Cutting treatments		
Nitrogen levels (kg/fad)	Once cut (C2)	Twice cut (C3)	Mean	Once cut (C2)	Twice cut (C3)	Mean
60 kg/fad (N1)	3871.12	4681.48	4276.30 c	1021.87	1470.5	1246.18 c
90 kg/fad (N2)	4238.34	5280.26	4759.30 b	1292.27	1859.62	1575.94 b
120 kg N/ fad (N3)	4376.57	5505.63	4941.10 a	1383.85	1991.4	1687.62 a
Mean	4162.01 b	5155.79 a		1232.66 b	1773.84 a	

Symbols beside means denote significance order at 5%, Means values without symbols denote non significance

Grain yield (kg/fad) and its components

Raisin nitrogen level from 60 to 90 kg N/fad then to 120 was conjoined with gradual and operative increments in No. of spikes/m^2 in both seasons, wherein the uppermost No. of spikes/m^2 in the 1st and 2nd seasons (473.33 and 480.33, respectively) was the resultant of supply the highest N level (120 Kg/fad), whilst, the fewest No. of spikes/m^2 in both seasons (423 and 421, in order) was along on supply the lowermost N level (60 kg/fad). No. of spikes/m^2 under the moderate N level of 90 kg/fad was betwixt and between (446.67 and 442.67) in both seasons orderly. These findings are in harmony with the results of tillering (Table 1).

No. of grains/spike (Table 5) ranged between 43.97, 43.11 under supply of 60 kg N/fad to 44.98, 44.99 under supply of 120 kg N/fad in the 1st and 2nd seasons, orderly. It is obvious from these results that raising N level up to 120 kg N/fad was result less in improving No. of grains/spike.

The thousand grain weight of barley was in co-ordinate under whichever N_1 or N_2 (60 or 90 kg N/fad) was supplied (Table 6), but both outclass 1000 grain weight under the fertilizer level of 120 kg/fad. 1000 grain weight of barley ranged from 38.70 to 42.30 g in the 1st season and from 39.34 to 41.28 g in the 2nd season.

Barley grain yield recorded at par values under the three N levels studied (60, 90 and 120 kg N/fad) in both seasons (Table 7). The grain yield ranged from 1069.67 to 1126 kg/fad in the 1st season; that range was from 1063 to 1126 kg/fad in the 2nd season. Excess supply of nitrogen was nonentity in improving barley yield productivity under our study conditions.

Biological yield (ton/fad) and harvest index

Biological yield (ton/fad) was significantly higher while supplying 120 kg N/fad amounting to 3.21 ton/fad in the 1st season and 3.31 ton/fad in the 2nd season, at the time that N_1 (60 kg N/fad) and N2 (90 kg N/fad) were at par ranking 2nd in significance amounting to 3.04 and 30.10 ton/fad in the 1st season and 2.99 and 3.05 ton/fad in the 2nd season, in order (Table 8). Considering results presented in Table (9), nitrogen levels did not affect significantly on harvest index.

Effect of cutting treatments

No. of tillers/plant and plant height (cm)

Results in Table (1) display the operative variation in No. of tillers per barley plant as affected by cutting treatments. Uncut plants has significantly more tillers/plant (8.01) compared with cut once (6.41) and cut twice (6.06). Plants cut once and those cut twice were in co-ordinate from the statistical view in the number of tillers/plant. It is obvious that whichever barley plants were cut once or twice, that was conjoined with operative decrease in No. of tillers/plant. These results matched well with those obtained by Ali *et al.*, 2023 in an Egyptian study.

Barley plants height was affected strongly by cutting treatments wherein the shortest plants were those cut twice (80.82, 91.47 cm), meanwhile the longest plants were those uncut (113.25, 103.33 cm) in the 1st and 2nd seasons, respectively. Plants cut once had betwixt and between heights (107.61, 105.48 cm) in the 1st and 2nd seasons, in the same order. Barley plants cut twice were shorter than those uncut by 28.66%, this could be ascribed to the short period for plants regrowth when cut twice (115 days) vs. 170 days for uncut plants, so plants under twice cut treatment could not repossess their normal height. Our results go along with those reported by Kaur *et al*. (2009), Jain and Nagar (2010) and Berkesia *et al*. (2022).

Fresh and dry forage yields (kg/fad)

Results in Table (3) illustrate the significance difference in fresh and dry forage yields (kg/fad) attributing to cutting treatments. Barley cut once (C_1) produced lower fresh forage yields amounted to 4225.19 kg/fad in the 1st season and 4162.01 kg in the 2nd season. Plants cut twice (C_3) produced higher fresh forage yield valued 5915.25 and 5155.79 kg/fad in the 1st and 2nd seasons, in the same order. Dry forage yields produced by barley plants cut once or twice kept up the same response as fresh forage yields. Thence the higher dry forage yield (1901.13, 1773.83 kg/fad) in the 1st and 2nd seasons was the outturn for barley plants cut twice. The lowermost dry forage yield (1493.74, 1232.66 kg/fad) in both seasons, in order, was obtained from the once cut treatment. These results are logically expected due to the chance of getting more green as well as dry forage yields by cutting more than once.

Grain yield and its components

From the results in Tables 4, 5, 6 and 8, it is found that uncut barley plants (C_1) recorded the highest yield components (No. of spikes/m^2, No. of grains/spike, 1000 grain wt.) in both sowing seasons. Once cut barley (C_1) produced more spikes (508 and 509.67 spikes/m^2) and more grains/spike (48.34 and 48.86) as well as heavier seed index of 43.37 and 42.71 g in the 1st and 2nd seasons, respectively; while grain yield/fad was 1224.33 kg in the 1st season and 1220.33 kg in the 2nd season. Cutting barley plants once (C_2) ranked 2nd in all yield components, reaching a final grain yield of 1106 kg/fad in the 1st season and 1091.66 kg in the 2nd season. Twice cut barley (C_3) produced the lowest yield components and overall grain yield amounted to 884.67 and 904.67 kg/fad in the1st and 2nd seasons, respectively.

Yield component results displayed the expected impacts of cutting barley plants once and twice, as when cutting once, No. of spikes/m^2 is affected because all grown tillers before cutting could not complete their growth and carry a complete spike; the same reason happened at cutting twice, as cutting plants once or twice suppressed the plant's ability to compensate all the cut tillers to complete their growth and carry a complete spike. The results also exposed that the No. of grains per spike as well as their weight were significantly influenced in a negative way, because cutting once or twice reduced the dry matter accumulation in the new regrown organs, which weakens its ability to perform the processes of dry matter transfer and grain filling during the stages of maturity.

Cutting barley plants once reduced the stored and the current assimilates, as well cutting barley plants twice caused severe reduction in the stored assimilates. Eke, the current assimilates from the main sources *q/e.* the flag leaf and the terminal internode were reduced, so the sink *i.e.* barley grains in spike were negatively affected presented either as No. of grains/spike or as 1000 grain weight. Thence the reduction in grain yield/fad under cutting treatments was expected, wherein barley plants endured during grain filling. It is worth to mention that the reduction in grain yields under cutting treatments was worthily compensated by the extra forage yields taken from cutting the growing barley plants once or twice as displayed before. These results are in harmony with the findings reported by Mansoor and Jeber, 2020.

Biological yield (ton/fad) and harvest index

It is noted from results showed in Tables (8) that the biological yield (ton/fad) of barley plants was significantly higher with no cut treatment (C_1) producing 3.52 and 3.63 ton/fad in the 1st and the 2nd seasons, respectively. Barley plants that were cut once ranked 2nd in biological yield amounted to 3.02 and 2.97 ton/fad in the1st and 2nd seasons, in the same order; while cut twice (C_3) produced 2.8 ton/fad in the 1st season and 2.74 ton/fad in the 2nd season, which were the lowest in both seasons. These results explain the reason of the significant variation of all yield components in favor of C_1 treatment (No cut), followed by C_2 (once cut) which ranked 2nd, and lately C_3 (cut twice) which recorded the lowest values of yield components, whereas the higher components resulted were from the higher biological yield, and *vice versa*.

The efficiency of barley plants in grain's production in relative to their biological yield which termed as "Harvest index, HI" recorded the uppermost values when barley plants were cut once (38.33% and 39.14%) in the 1st and 2nd seasons (Table 9). Harvest index of uncut treatment valued as much as 38.12% and 33.39% in the 1st and 2nd seasons and placed in the 2nd order. The minimum harvest indices values (32.66% and 33.55%) were the resultant of the twice cut treatment in the 1st and 2nd seasons. Harvest indices obtained by barley plants under uncut and twice cuts treatments were at par in the 2nd season. These results indicate that cutting barley plant once (C_2) was a promoter for plants to regrowth rapidly and maximize the role of the vegetative material (biological yield) in contributing in the final grain yield. These results go along with what was illustrated by Mansoor and Jeber, 2020 and Ali *et al.*, 2023.

Effect of interaction between nitrogen levels and cutting treatments

The interaction among nitrogen levels and cutting frequencies was significant in all studied traits in both experimenting seasons. The highest values of No. of tillers per plant were obtained through applying 90 kg N/fad (N_2) for uncut plants (C_1) producing 9.5 and 11.21 tillers/plant in the 1st and 2nd seasons, respectively; while the lowest No. of tillers (3.74 and 4 tillers/plant in the 1st and 2nd seasons, in order) was produced through applying 60 kg N/fad (N_1) for twice cut plants (C_3).

The tallest barley plants were those which uncut (C_1) and supplied by 120 kg N/fad (N_3) in the 1st season and 90 kg N/fad in the 2nd season (N_2) reaching to 129.34 cm and 113.47 cm in the 1st and 2nd seasons, respectively. However the shortest plants were those twice cut (C_3) combined with 60 kg N/fad (N_1) in the 1st season (75.48 cm) and 60 kg N/fad (N_1) in the 2nd season (86.05). These results indicate the negative effect of the low N level and cutting twice treatment on growth of barley plants.

Concerning Fresh and dry forage yields, it has been found that single cutting (C_1) combined with 60 kg N/fad (N_1) produced the lowest fresh and forage yields per fad amounting to 3592.28 kg and 1131.35 kg in the 1st season; as well, 3871.12 kg and 1021.87 kg in the 2nd season. The uppermost fresh and dry forage yields per fad were produced through combining twice cutting treatment (C_3) and 120 kg N/fad (N_3) producing 6968.38 kg and 2230.98 kg in the 1st season, and 5505.63 kg and 1991.4 kg in the 2nd one.

Yield components (No. of spikes/m2 and No. of grains/spike) were valued the highest in no cut barley (C1) combined with N3 (120 kg N/fad) and N2 (90 kg N/fad); while the lowest values of both yield components were recorded through double cut plants (C3) treated by the lower levels of nitrogen (N1 and N2). On the contrary, seed index (1000 grain weight) was recorded, where N1 × C1 and N2 × C1 recorded the highest seed index; as well, the lowest seed index was recorded through the combination N3 × C3.

Barley grain yield (kg/fad) was recorded the highest through no cutting strategy (C1) with supplying 60 and 90 kg N/fad, in the 1st season amounting to 1343 and 1230, and, the combination N1 × C1 which recorded 1303 kg/fad. Once cut strategy (C2) combined with 120 kg N/fad (N3) ranked 2nd, yielding 1165 and 1190 kg/fad. The lowest grain yield was obtained from double cut plants (C3) treated by 60 kg N/fad (N1) amounting to 845 and 896 kg/fad in the 1st and 2nd seasons, respectively.

The interaction among nitrogen levels and cutting frequencies was in favor of no cut plants (C1) in both seasons by 3.62 and 3.72 ton/fad while treating plants by 60 kg/fad (N1), respectively, followed by N3 (120 kg N/fad). The lowest biological yield in the 1st season was recorded by double cut plants (C3) treated by 120 kg N/fad (2.68 ton/fad), and in the 2nd season, once cut plants (C2) treated by 60 kg N/fad produced the lowest biological yield (2.54 ton/fad).

Harvest index as affected by the interaction between nitrogen levels and cutting treatments was decided in favor of the combination from once cut barley plants (C2) treated with 60 kg N/fad (N1) amounting to 0.39 in both seasons. Once cut plants (C2) accompanied with 90 kg N/fad (N2) ranked 2nd reaching 0.37 in the 1st season and 0.38 in the 2nd season. The lowest harvest index was reached through No cutting strategy (C1) in combination with N3 in the both seasons reaching to 0.31 and 0.32, respectively.

Table 4. Number of spikes/m^2 of dual-purpose barley as affected by nitrogen fertilizer levels, cutting treatments and the interaction between them

1st season	**Cutting treatments**			
Nitrogen levels (kg/fad)	**Uncut (C_1)**	**Once cut (C_2)**	**Twice cut (C_3)**	**Mean**
60 kg/fad (N_1)	485.00	413.00	371.00	423.00 c
90 kg/fad (N_2)	501.00	457.00	382.00	446.67 b
120 kg N/ fad (N_3)	538.00	481.00	401.00	473.33 a
Mean	508.00 a	450.33 b	384,67 c	
2nd season	Cutting treatments			
Nitrogen levels (kg/fad)	Uncut (C_1)	Once cut (C_2)	Twice cut (C_3)	Mean
60 kg/fad (N_1)	465.00	419.00	379.00	421.00 c
90 kg/fad (N_2)	512.00	446.00	370.00	442.67 b
120 kg N/ fad (N_3)	552.00	472.00	417.00	480.33 a
Mean	509.67 a	445.67 b	388.67 c	

Symbols beside means denote significance order at 5%, Means values without symbols denote non significance

Table 5. Number of grains/spike of dual-purpose barley as affected by nitrogen fertilizer levels, cutting treatments and the interaction between them

1st season	**Cutting treatments**			
Nitrogen levels (kg/fad)	**Uncut (C_1)**	**Once cut (C_2)**	**Twice cut (C_3)**	**Mean**
60 kg/fad (N_1)	46.24	46.01	39.66	43.97
90 kg/fad (N_2)	49.65	41.14	38.62	43.14
120 kg N/ fad (N_3)	49.13	43.88	41.94	44.98
Mean	48.34 a	43.68 b	40.07 c	
2nd season	Cutting treatments			
Nitrogen levels (kg/fad)	Uncut (C_1)	Once cut (C_2)	Twice cut (C_3)	Mean
60 kg/fad (N_1)	45.32	45.55	38.47	43.11
90 kg/fad (N_2)	51.63	42.37	37.07	43.69
120 kg N/ fad (N_3)	49.62	43	42.36	44.99
Mean	48.86 a	43.64 b	39.3 c	

Symbols beside means denote significance order at 5%, Means values without symbols denote non significance

Table 6. 1000 grain wt. of dual-purpose barley as affected by nitrogen fertilizer levels, cutting treatments and the interaction between them

1st season	**Cutting treatments**			
Nitrogen levels (kg/fad)	**Uncut (C_1)**	**Once cut (C_2)**	**Twice cut (C_3)**	**Mean**
60 kg/fad (N_1)	45.50	40.4	41.01	42.30 a
90 kg/fad (N_2)	44.17	40.67	40.70	41.85 a
120 kg N/ fad (N_3)	40.43	40.09	35.59	38.70 b
Mean	43.37 a	40.39 b	39.10 c	
2nd season	Cutting treatments			
Nitrogen levels (kg/fad)	Uncut (C_1)	Once cut (C_2)	Twice cut (C_3)	Mean
60 kg/fad (N_1)	43.22	38.78	41.83	41.28 a
90 kg/fad (N_2)	43.28	38.64	41.11	41.01 a
120 kg N/ fad (N_3)	41.64	40.09	36.3	39.34 b
Mean	42.71 a	39.17 b	39.75 b	

Symbols beside means denote significance order at 5%, Means values without symbols denote non significance

Table 7. Grain yield (kg/fad) of dual-purpose barley as affected by nitrogen fertilizer levels, cutting treatments and the interaction between them

1st season	**Cutting treatments**			
Nitrogen levels (kg/fad)	**Uncut (C_1)**	**Once cut (C_2)**	**Twice cut (C_3)**	**Mean**
60 kg/fad (N_1)	1343	1021	845	1069.67
90 kg/fad (N_2)	1230	1132	889	1117.00
120 kg N/ fad (N_3)	1100	1165	920	1095.00
Mean	1224.33 a	1106.67 b	884.67 c	
2nd season	Cutting treatments			
Nitrogen levels (kg/fad)	Uncut (C_1)	Once cut (C_2)	Twice cut (C_3)	Mean
60 kg/fad (N_1)	1303	990	896	1063.00
90 kg/fad (N_2)	1181	1095	907	1094.33
120 kg N/ fad (N_3)	1177	1190	911	1126.00
Mean	1220.33 a	1091.66 b	904.67 c	

Symbols beside means denote significance order at 5%, Means values without symbols denote non significance

Table 8. Biological yield (ton/fad) of dual-purpose barley as affected by nitrogen fertilizer levels, cutting treatments and the interaction between them

1st season	**Cutting treatments**			
Nitrogen levels (kg/fad)	**Uncut (C_1)**	**Once cut (C_2)**	**Twice cut (C_3)**	**Mean**
60 kg/fad (N_1)	3.62	2.61	2.89	3.04 b
90 kg/fad (N_2)	3.37	3.06	2.83	3.10 b
120 kg N/ fad (N_3)	3.57	3.40	2.68	3.21 a
Mean	3.52 a	3.02 b	2.80 c	
2nd season	Cutting treatments			
Nitrogen levels (kg/fad)	Uncut (C_1)	Once cut (C_2)	Twice cut (C_3)	Mean
60 kg/fad (N_1)	3.72	2.54	2.72	2.99 b
90 kg/fad (N_2)	3.47	2.92	2.75	3.05 b
120 kg N/ fad (N_3)	3.68	3.49	2.76	3.31 a
Mean	3.63 a	2.97 b	2.74 c	

Symbols beside means denote significance order at 5%, Means values without symbols denote non significance

Table 9. Harvest index (%) of dual-purpose barley as affected by nitrogen fertilizer levels, cutting treatments and the interaction between them

1st season	**Cutting treatments**			
Nitrogen levels (kg/fad)	**Uncut (C_1)**	**Once cut (C_2)**	**Twice cuts (C_3)**	**Mean**
60 kg/fad (N_1)	36.00	38.38	31.31	35.23
90 kg/fad (N_2)	35.70	38.61	32.32	35.54
120 kg N/ fad (N_3)	33.66	38.00	34.34	35.33
Mean	35.12 b	38.33 a	32.66 c	
2nd season	Cutting treatments			
Nitrogen levels (kg/fad)	Uncut (C_1)	Once cut (C_2)	Twice cuts (C_3)	Mean
60 kg/fad (N_1)	35.00	38.61	33.33	35.65
90 kg/fad (N_2)	34.34	41.82	33.66	36.61
120 kg N/ fad (N_3)	32.64	37.00	33.66	34.43
Mean	33.99 b	39.14 a	33.55 b	

Symbols beside means denote significance order at 5%, Means values without symbols denote non significance

CONCLUSION

It is concluded from the study results discussed that barley plants fertilized by 90 kg N/fad and once cut at 35 days after sowing recorded the highest grain yield/fad (about 1100 kg/fad), and producing about or more than 4 tons of green forage yield for animal feeding.

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تأثير مستويات النيتروجين ومعاملات الحش على محصول العلف والحبوب فى الشعير ثنائى الغرض

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الملخص

لدراسة تأثير ثلاثة مستويات من السماد النيتروجينى (٦٠ و٩٠ و١٢٠ كجم نيتروجين/فدان) وثلاث نظم للحش (بدون حش، الحش مرة واحده عند عمر ٣٥ يومًا بعد الزراعة، والحش مرتين عند عمر ٣٥ يومًا بعد الزراعة و٥٥ يومًا بعد الزراعة) على محصول العلف والحبوب فى الشعير ثنائي الغرض، أجريت تجربتان حقليتان في المزرعة التجريبية بالأرض الرملية الخاصة بكلية الزراعة، جامعة الزقازيق، مصر، خلال فصلي الشتاء ٢٣/٢٠٢٢ و٢٤/٢٠٢٣، باستخدام تصميم القطاعات الكاملة العشوائيه فى ثلاث مكررات. أظهرت النتائج أن رفع مستوى السماد النيتروجينى من ٦٠ إلى ١٢٠ كجم/فدان أدى إلى زيادات معنويه في كلٍ من مساهمات ومكونات محصول الشعير لصالح ١٢٠ كجم نيتروجين/فدان الذى سجل أعلى محصول علف أخضر، بينما حقق المستوى ٩٠ كجم نيتروجين/ فدان أعلى محصول علف جاف، فى حين لم يكن لاختلاف مستويات النيتروجين تأثير معنوى على مؤشر الحصاد. أثرت معاملات الحش معنوياً على مكونات محصول الشعير، حيث أعطت النباتات المحشوشه مرة واحدة أعلى محصول حبوب من خلال زيادة عدد السنابل فى المتر المربع، وعدد الحبوب/سنبلة و وزن الألف حبة. يعزز حش نباتات الشعير مرة واحدة إعادة النمو السريع ويعظم دور المجموع الخضرى في المساهمه فى محصول الحبوب. كان تأثير التفاعلات بين مستويات النيتروجين ومعاملات الحش معنوياً لصالح التوليفة (عدم الحش مع التسميد النيتروجينى بمعدل ٩٠ كجم /فدان). أدى الحش مرة واحده إلى إنتاج أقل إنتاجية من العلف الأخضر والجاف. أعلى محصول حبوب كان نتاج عدم الحش مع التسميد النيتروجينى بمعدل ٩٠ كجم /فدان، في حين أن أقل محصول حبوب كان نتاج حش نباتات الشعير مرتين والتسميد بمعدل ٦٠ كجم نيتروجين/فدان.

الكلمات الداله: الشعير؛ النيتروجين؛ الحش؛ محصول العلف؛ محصول الحبوب.