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(Original Article)

Optimizing Cutting Interval and Nitrogen Fertilizer Level for Enhanced Panicum (*Panicum maximum* L.) Forage Yield and Quality in Egypt

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Abstract

A filed experiment was conducted at a sandy soil experimental farm located in El Salhia El kadima, Fakous District, Sharqia Governorate, Egypt during 2020 and 2021 years. A randomized complete block design in split plot arrangement was used to study the effect of two cutting intervals (28 and 38 days) and three nitrogen fertilizer levels (40, 80, 120 kg N/fed.) as well as their interaction on the forage yield and quality of *Panicum maximum* plants. Cutting intervals were assigned to main plots while nitrogen fertilizer levels were allocated to sub plots. Results indicated that longer cutting interval (38 days) resulted in taller plants with significant higher number of tillers/m^2, leaf/stem ratio, total green, and dry forage yields. Meanwhile, nitrogen fertilization at 120 kg N/fed. contributed to the tallest plants, highest number of tillers/m^2, green forage yield, and crude protein content. The difference between 80 kg N/fed and 120 kg N/fed was insignificant in most studied traits. The interaction between cutting intervals and nitrogen fertilizer levels was not significant for most studied traits. Based on the study's results, it can be stated that panicum plants should be cut every 38 days and fertilized with 80 kg N/fed for increasing the potential forage yield and its quality.

Keywords: *Cutting interval, Forage crop, Forage yield, Panicum maximum, Nitrogen fertilizer.*

Introduction

Egypt faces a summer shortage of green forage due to competition, water scarcity, and harsh climate. This affects the quality and quantity of milk and meat production, posing a significant challenge for farmers. The changeable climate makes it difficult for crops to produce satisfying yield in sandy soils (Elshamy *et al.,* 2022*)*. The cultivation of *Panicum* plants, a drought-tolerant grass, could be a viable solution to Egypt's green forage scarcity which hinders agricultural sector development. Panicum is a warm-season perennial grass used in tropical and subtropical regions, widely adapted to several soil and environmental conditions with high yield potential. However, its productivity and quality can be affected by factors like cutting intervals and nitrogen fertilization. Therefore, finding new alternatives to traditional forage crops that thrive in such conditions is crucial (Atallah *et al.,* 2022*;* Soliman *et al.,* 2024).

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Cutting intervals affects the balance between vegetative and reproductive growth, as well as the quality of the forage. Olufajo *et al.* (2015) reported that the maximum dry forage yield and crude protein content were obtained with a cutting interval of 21 days. Cutting intervals of 28 or 42 days had a higher dry matter yield than cutting intervals of 24 or 56 days (Ribeiro *et al*., 2016). Kone *et al.* (2017) found that a cutting interval of 30 days and nitrogen fertilization at a rate of 400 kg/ha resulted in the highest dry matter yield and crude protein content. Gomide *et al.* (2019) illustrated that cutting intervals of 21 and 30 days resulted in higher crude protein content compared to cutting intervals of 14 and 35 days.

In addition to being necessary for plant development, nitrogen is also needed for the synthesis of proteins, which are crucial for animal nutrition. According to Santos *et al.* (2018), nitrogen fertilizer raised the forage's crude protein content and dry matter yield. The greatest dry matter yield and crude protein content were obtained by applying nitrogen fertilizer at 300 kg/ha and cutting every 30 days, as confirmed also by Almeida *et al.* (2017) and Gomide *et al.* (2019). According to the findings of Emizael *et al.* (2022) and Galindo *et al.* (2019), the maximum dry matter yield and crude protein content were obtained with a cutting interval of 21 days and nitrogen fertilizer at a rate of 400 kg/ha.

Therefore, optimizing cutting interval and nitrogen fertilization is essential for maximizing the yield and quality of *Panicum maximum* in Egypt, and that was the objective of study.

Materials and Methods

Experimental Site description

The experiment was conducted for two years (2020 and 2021) in an experimental field located in El Salhia El Kadima, Fakous District, Sharqia Governorate, Egypt (30°45'36.3"N 32°02'01.6"E). The physical and chemical properties of the soil of the experimental site are presented in (Table 1).

Table 1. Physical and chemical properties of the experimental site before sowing

Soil particles distribution	Values
Sand (%)	88.42
Silt (%)	4.25
Clay (%)	7.33
Soil texture	Sandy
Organic matter, (g kg^{-1})	5
pH*	7.5
EC, (dSm^{-1}) **	0.8
Chemical properties	
Soluble cations and anions, (mmol L^{-1}) **	
Total N, (g kg^{-1})	3.70
Total P, (g kg^{-1})	0.12
Total K, (g kg^{-1})	1.6
Available N, (mg kg^{-1}soil)	41.15
Available P, (mg kg^{-1}soil)	12.46
Available K, (mg kg^{-1}soil)	120.5

* Soil-water suspension 1: 2.5 ** Soil water extract 1: 5

Metrological data

The experimental site experienced a typical range of temperatures throughout two years, with an average temperature of around 25 °C. The highest temperatures were in the summer, with a temperature range of 30 to 34 °C. The site's proximity to water bodies from the Nile River provided relief from the heat. The autumn season temperature decreased to an average of 22 to 27 °C. Winter was slightly cooler, with temperatures averaging 12 to 16 °C. The spring season temperatures gradually increase, with warm, sunny days, and comfortable evenings.

Metrological data were obtained from "The Deutscher Wetterdienst and Environment, Canada (https://meteostat.net/en/place/eg/).

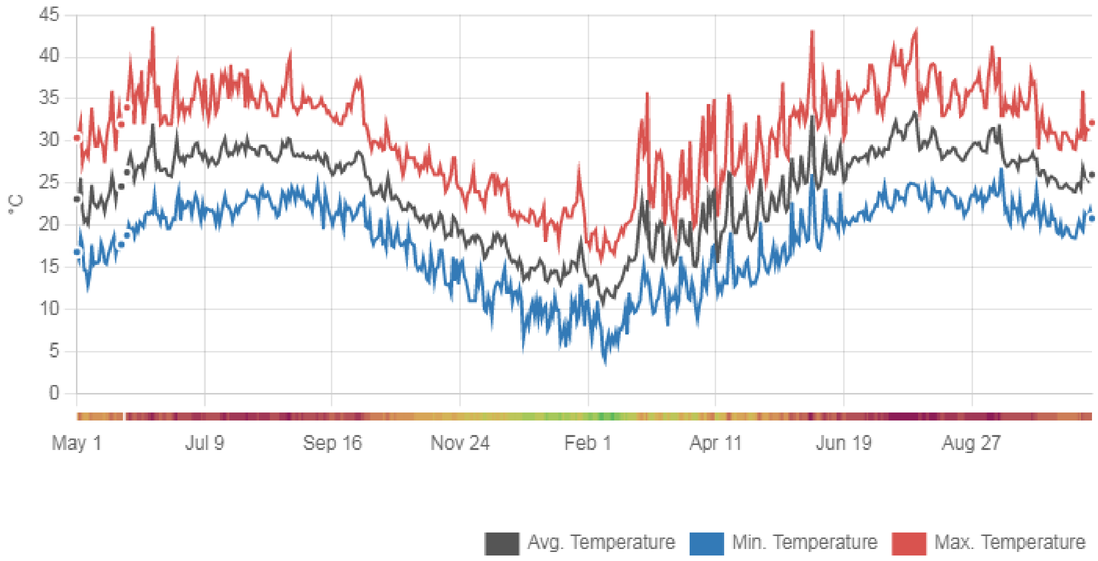

Fig 1. Average, minimum and maximum temperature over the experimental site during 2020 and 2021

Experimental Design and cultural practices

To study the influence of two cutting intervals (28 and 38 days) and three nitrogen fertilization levels (40, 80, and 120 kg N/fed) on *Panicum maximum* plants. The experiment was laid out in randomized complete block design in split plot arrangement using three replications, wherein cutting intervals were allocated to main plots and nitrogen levels were laid out in the sub plots.

Grains of *Panicum maximum* cv. *mombasa* were obtained kindly from Agricultural Research Centre (ARC), Egypt, and were planted on April 15th in a nursery for 40 days, then seedlings were transferred to the field and replanted on May 26th at 50 x 50 cm planting spaces. The experimental unit was a plot of 4 m x 7 m (the plot contained 112 seedlings).

The field was ploughed, compacted and levelled. Irrigation was flooding every 5 days as the irrigation traditions in the region. Phosphorus fertilizer as super phosphate (15.5% P_2O_5) was applied before planting at a level of 100 kg/fed. A dose of Potassium fertilizer as Potassium sulphate (48% K_2O) was supplied 10 days after cutting each time at level of 25 kg/fed. The 1st cut was taken 50 days after replanting seedlings under all treatments. Plants were cut to a height of 10 cm from soil surface. The nitrogen fertilizer was supplied as urea (46.5% N) according to treatments divided equally over 10 cuts. All other agricultural practices were conducted as recommended by the Ministry of Agriculture and Land Reclamation, Egypt, under the region conditions.

The cutting process was done using a diesel operated cutter in certain dates according to intervals treatments as follows: under 28 days interval, cuts from the 1st to the 10th one occurred on Jul. 16th, Aug. 14th, Sep. 12th, Oct. 10th, Nov. 8th, Mar. 28th, Apr. 26th, May 24th, Jun. 22nd and Jul.20th. Also, under 38 days interval, cuts from the 1st to the 10th one were performed on Jul.16th, Aug. 24th, Oct. 2nd, Nov. 8th, Dec. 16th, Apr. 6th, May 14th, Jun. 22nd, Jul. 30 and Sep. 8th.

It is worth mentioning that the vegetative growth of the panicum plants started to stop under the two treatments (28 days and 38 days) with the onset of the last quarter of November, which coincided with a sudden sharp drop in temperature starting from approximately Nov. 22nd until the end of February. Therefore, cutting was stopped after the 5th cut under both treatments. At the end of February, the stunted woody vegetative growth, formed during the cold period, were pruned, as they were not valid to be used as forage. Then, with the beginning of March, the vegetative growth of panicum plants began to be active again with the gradual rise in temperature. Accordingly, the remaining cuts were resumed from the 6th to the 10th cuts.

Studied characters and data collection

Plant height (cm), No. of tillers/plant, Leaves/stem ratio (%), single cuts green and dry forage yields, total green and dry forage yields were studied in all cuts. Protein and phosphorus contents in forage (%) were studied in the 1st, 3rd, 5th and 9th cuts only due to its high cost. After cutting plants, the green forage yield was recorded and dried in the open air, and then the dry forage yield was recorded. The forage samples were then analysed for crude protein according to Jackson (1967) through multiplying N uptake by 5.75. Phosphorus content (%) was assessed according to AOAC (1990).

Statistical analyses

Recorded data were analyzed using analysis of variance (ANOVA) of the randomized complete block design (RCBD) 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 means were separated using the least significant difference (LSD) test at a 5% level of significance.

Results and Discussion

1- Plant height

It is clear from Table 2 that there were significant effects of cutting intervals in the 1st, 5th, 6th, 7th, and 8thcuts, and nitrogen fertilization in all cuts, while the interaction between them was significant in the 5th cut only.

Results declared that the cutting at 38 days surpassed the shorter interval (28 days) and gave the tallest plants at the 1st, 5th, 6th and 8th cut, which reached 125.23, 141.33, 131.60 and 126.07 cm, respectively, which was significantly different from the shorter cutting interval (28 days) which gave the tallest plants only at the 7th cut (129.43 cm).

The reason for the superiority of the longer cutting interval (38 days) may be due to the sufficient period for more growth under the climatic conditions that provoked the regrowth, especially increased temperature over months (Fig. 1). This gave the plant sufficient opportunity during this period to continue growing and elongating, increasing the effectiveness and efficiency of the photosynthesis process, and increase the production of dry matter, which in turn led to an increase in growth rates, and this is greatly reflected in plant height.

From the results of the same table, the levels of nitrogen fertilizer differed in their influence on this trait. Fertilizer level of 120 kg N/fed gave the tallest plants at the 3rd, 4th, 5th, 6th, 7th, 8th, 9th and 10th cuts, with an average of 148.95, 146.50, 151.15, 141.40, 132.75, 130.65, 129.65 and 129.55 cm, respectively. This was significantly similar to the level of 80 kg N/fed, which gave 142.85 and 126.35 cm in the 5th, and 9th cuts. However, the treatment of 40 kg N/fed gave the lowest averages in all cuts. The reason for increasing plant height by increasing N levels is attributed to the role of the amino acid Tryptophan, which is the raw material needed to proteins, auxin synthesis, auxin control the cell elongation in addition to proteins in chlorophyll, amino acids, and cell nucleus. These compounds are considered the main component of the plant's protoplasm. Therefore, nitrogen deficiency may result in depression of cell division and thus reduced growth. Nitrogen has a significant role in increasing the branching of roots and increasing their efficiency in absorbing water and nutrients from the soil leading to increasing plant height. It also affects growth regulator indole acetic acid formation, which is necessary for cell elongation. This result is consistent with Fernandes *et al*. (2014) and Hare *et al*. (2015).

Concerning the interaction, it was significant in the 5th and 6th cuts. The results in Table 2 show that the combination of the shorter cutting interval (28 days) and 120 kg N/fed outperformed the remined interactions, giving the tallest plants amounting to 153.3 cm and 143.3 cm. The longer cutting interval (38 days) with the fertilizer level 40 kg N/fed in the 5th and 6th cuts recorded the shortest plants (111.6 and 116.1 cm). This can be attributed to the matching of ambient conditions with and the higher fertilization level (120 kg N/fed). It provided the plant with ideal conditions for growth and dry matter accumulation, which had a positive effect in increasing plant height.

It is worth noting, from field observation of the crop that *Panicum* plants grow quickly after cutting, especially on days when temperatures are high, as plant height increases at a rate of 4-6 cm per day after cut.

Table 2. Effect of cutting intervals, nitrogen fertilizer levels and their interaction on plant height (cm)

Cut	Interval	N level			Average	Interaction
		40 kg/fed	80 kg/fed	120 kg/fed		
1st	28 days	100.6	116.6	136.6	**117.93 b**	
	38 days	105.1	126.1	144.5	**125.23 a**	
	Average	**102.85 c**	**121.35 b**	**140.55 a**		
F. test	*		*			NS
2nd	28 days	116.5	125.4	144.9	**128.93**	
	38 days	118.5	131.6	149.3	**133.13**	
	Average	**117.5 c**	**128.5 b**	**147.1 a**		
F. test	NS		*			NS
3rd	28 days	118.8	134.5	148.5	**133.93**	
	38 days	119.8	146.1	149.4	**138.43**	
	Average	**119.3 c**	**140.3 b**	**148.95 a**		
F. test	NS		*			NS
4th	28 days	121.3	139.2	135.2	**131.90**	
	38 days	125.8	132.8	157.8	**138.80**	
	Average	**123.55 c**	**136 b**	**146.5 a**		
F. test	NS		*			NS
5th	28 days	111.6 d	142.7 b	149.0 a	**134.43 b**	
	38 days	127.7 c	143.0 b	153.3 a	**141.33 a**	
	Average	**119.65 b**	**142.85 ab**	**151.15 a**		
F. test	*		*			*
6th	28 days	116.1 d	126.2 c	143.3 a	**128.53 b**	
	38 days	121.1 c	133.2 b	140.5 a	**131.60 a**	
	Average	**118.1 c**	**129.2 b**	**141.4 a**		
F. test	*		*			*
7th	28 days	114.3	129.3	144.7	**129.43 a**	
	38 days	109.4	129.8	120.8	**120.00 b**	
	Average	**111.85 c**	**129.55 b**	**132.75 a**		
F. test	*		*			NS
8th	28 days	110.7	113.5	128.5	**117.57 b**	
	38 days	114.7	130.7	132.8	**126.07 a**	
	Average	**112.7 c**	**122.10 b**	**130.65 a**		
F. test	*		*			NS
9th	28 days	116.1	125.7	123.8	**121.87**	
	38 days	118.2	127.0	135.5	**126.90**	
	Average	**117.15 b**	**126.35 ab**	**129.65 a**		
F. test	NS		*			NS
10th	28 days	111.1	118.0	130.5	**119.87**	
	38 days	114.3	118.9	128.6	**120.60**	
	Average	**112.7 c**	**118.45 b**	**129.55 a**		
F. test	NS		*			NS

At the 5% probability level, * denotes significance; NS denotes not significant. Means followed by the same symbol non-significant.

2- Number of tillers/m^2

Results in Table 3 reveal that there were significant effects of the two cutting intervals at the 2nd, 3rd, 4th, 5th, 6th, and 7th cuts and of nitrogen fertilizer levels at the 1st, 2nd, 5th, 6th, 7th, 9th, and 10th cuts on No. of tillers/ m^2. In addition, the shorter cutting interval (28 days) at the 2nd, 4th, and 7th cuts gave the highest average number of tillers/ m^2 reaching 418.33, 431.67 and 603 tillers/ m^2, respectively. The longer cutting interval (38 days) at the 3rd 5th and 7th cuts recorded the highest number of tillers with an average of 365.33, 663.33 and 603 tillers/m^2, respectively. Superiority of the longer cutting interval in this trait may be due to the longer period in warmer temperatures which was appropriate and encourages vegetative growth. This is consistent with what has been reported by Silveira *et al.* (2010).

Nitrogen fertilizer levels varied significantly in their impact on No. of tillers/m^2, as 120 kg N/fed at the 1st, 2nd, 5th, 6th, 7th, 9th, and 10th cuts gave the highest average number of tillers amounting to 419, 397.5, 635.5, 641.5, 624, 591.5, and 239 tillers/m^2, respectively, which did not differ significantly from the fertilizer level of 80 kg N/fed at the 7th, 9th and 10th cuts. The later produced an average of 538, 514, and 218.5 tillers/m^2, which in turn gave the highest average of 361 tillers in the 2nd cut.

The fertilizer level of 80 kg N/fed tillering at the 5th cut, amounting to 356.5 tillers/m^2. The lowest averages were with the treatment 40 kg N/fed and at all cuts. Perhaps the reason for this is due to the effective and major role of N element through in increasing root growth, in addition to the formation of cytokinin, which is responsible for reducing apical dominance by increasing its quantity at the expense of auxin in plants, which leads to an increase in the plant's ability to grow more shoots (Escarela *et al.,* 2016*;* El Mouttaqi *et al.,* 2023). This is consistent with what was found by Nascimento (2018).

It is also noted that the No. of tillers increases in the successive cuts and as the plants age, as a result of the formation of secondary tillers from the buds located in the axils of the basal leaves of the primary tillers. The effect of interaction among cutting intervals and nitrogen levels was significant in favor of the combination (28 days interval × 120 kg N/fed) the 1st, 2nd, 4th, 7th, 10th cuts, and also was significant in 5th, 6th, 9th cuts in favor of the combination (38 days interval × 120 kg N/fed). However, in the 3rd cut it was significant while cutting at 38 days interval and supply 80 kg N/fad. It is observed that cutting panicum plants every 28 days during the low temperature conditions accompanied with 120 kg N/fad promoted tillering, while cutting every 38 days was positively promoted under raised temperatures, which indicate that the temperature interacts significantly with panicum plants growth.

Table 3. Effect of cutting intervals, nitrogen fertilizer levels and their interactions on the average number of tillers/m^2

Cut	Interval	N level				Interaction
		40 kg/fed	80 kg/fed	120 kg/fed	Average	
1st	28 days	194 c	350 b	426 a	**323.33**	
	38 days	152 c	320 b	412 a	**294.67**	
	Average	**173 c**	**335 b**	**419 a**		
F. test	**NS**		*			*
2nd	28 days	227 c	478 b	550 a	**418.33 a**	
	38 days	171 d	244 c	245 c	**220.00 b**	
	Average	**199 c**	**361 b**	**397.5 a**		
F. test	*		*			*
3rd	28 days	267 d	294 cd	259 d	**273.33 b**	
	38 days	318 c	419 a	359 b	**365.33 a**	
	Average	**292.5**	**356.5**	**309**		
F. test	*		**NS**			*
4th	28 days	375 c	407 b	513 a	**431.67 a**	
	38 days	373 c	380 c	363 c	**372.00 b**	
	Average	**374**	**393.5**	**438**		
F. test	*		**NS**			*
5th	28 days	284 b	485 b	481 b	**416.67 b**	
	38 days	461 b	739 b	790 a	**663.33 a**	
	Average	**372.5 b**	**612 a**	**635.5 a**		
F. test	*		*			*
6th	28 days	308 e	399 d	554 b	**420.33 b**	
	38 days	449 c	709 a	729 a	**629.00 a**	
	Average	**378.5 c**	**554 b**	**641.5 a**		
F. test	*		*			*
7th	28 days	427 c	628 ab	754 a	**603.00 a**	
	38 days	256 d	448 c	494 b	**399.33 b**	
	Average	**341.5 c**	**538 b**	**624 a**		
F. test	*		*			*
8th	28 days	433	288	409	**376.67**	
	38 days	348	443	485	**425.33**	
	Average	**390.5**	**365.5**	**447**		
F. test	**NS**		**NS**			**NS**
9th	28 days	440 d	449 d	507 c	**465.33**	
	38 days	353 e	579 b	676 a	**536.00**	
	Average	**396.5 b**	**514 ab**	**591.5 a**		
F. test	**NS**		*			*
10th	28 days	228 c	164 d	328 a	**240.00**	
	38 days	226 c	273 b	258 b	**252.33**	
	Average	**227 b**	**218.5 b**	**293 a**		
F. test	**NS**		*			*

At the 5% probability level, * denotes significance; NS denotes not significant. Means followed by the same symbol non-significant.

3- Leaf/stem ratio (%)

Table 4 indicates that cutting intervals in the 2nd, 3rd and 4th cuts and the interaction between intervals and nitrogen fertilizer levels in the 5th cut only had a significant effect on leaf/stem ratio trait. However, the effect of N- fertilizer levels on this trait was not significant in all cuts.

Table 4. Effect of cutting intervals, nitrogen fertilizer levels and their interactions on leaves to stem ratio (%)

Cut	N level					Interaction
	Interval	40 kg/fed	80 kg/fed	120 kg/fed	**Average**	
1st	28 days	107	116.8	118.5	**114.10**	
	38 days	114.7	102.4	114.1	**110.40**	
	Average	**110.85**	**109.6**	**116.3**		
F. test	**NS**		**NS**			**NS**
2nd	38 days	116.9 c	112.8 c	114.5 c	**114.73 b**	
	38 days	150.3 a	133.6 b	150.9 a	**144.93 a**	
	Average	**133.6**	**123.2**	**132.7**		
F. test	*		**NS**			*
3rd	28 days	131.9	140	132.5	**134.80 a**	
	38 days	124.3	95.3	115.5	**111.70 b**	
	Average	**128.1**	**117.65**	**124**		
F. test	*		**NS**			**NS**
4th	28 days	129.5	128.12	126.9	**128.20 a**	
	38 days	98.3	111.3	84.9	**98.17 b**	
	Average	**113.9**	**119.75**	**105.9**		
F. test	*		**NS**			**NS**
5th	28 days	99.2 b	102.6 b	88.0 d	**96.60**	
	38 days	89.9 d	113.6 a	101.8 b	**101.77**	
	Average	**94.5 e**	**108.1 b**	**94.9 e**		
F. test	**NS**		**NS**			*
6th	28 days	113.6	110.9	98.8	**107.77**	
	38 days	108.1	97.6	139.2	**114.97**	
	Average	**110.85**	**104.25**	**119**		
F. test	**NS**		**NS**			**NS**
7th	28 days	115.4	119.9	107.6	**114.30**	
	38 days	107.8	104.5	98.3	**103.53**	
	Average	**100.3**	**112.2**	**102.95**		
F. test	**NS**		**NS**			**NS**
8th	28 days	120.8	100.8	124.3	**115.30**	
	38 days	100.4	119.8	108.0	**109.40**	
	Average	**110.6**	**110.3**	**116.15**		
F. test	**NS**		**NS**			**NS**
9th	28 days	106.5	97.5	120.1	**108.03**	
	38 days	98.3	101.4	102.5	**100.73**	
	Average	**102.4**	**99.45**	**110.5**		
F. test	**NS**		**NS**			**NS**
10th	28 days	120.6	95.4	103.7	**106.57**	
	38 days	88.9	104.1.1	108.8	**100.6.60**	
	Average	**104.75**	**99.75**	**106.25**		
F. test	**NS**		**NS**			**NS**

At the 5% probability level, * denotes significance; NS denotes not significant. Means followed by the same symbol non-significant.

The longer cutting interval (38 days) recorded the highest leaf/stem ratio (%) at the 2nd cut reaching 144.93 %, which differed significantly from the shorter cutting interval (28 days). The shorter cutting interval gave the highest average for this trait amounting to 134.80 % and 128.2 % at the 3rd and 4th cuts, respectively. The reason for the varying effects of cutting intervals on this trait may be due to the varying effect of staying period synchronized with high temperature in July and August on plant growth, which led to decreased No. of tillers (Table 4), and therefore the competition between them decreased. This led to an increase in leaf area, and weight of leaves compared to the weight of stems.

Regarding the interaction between cutting intervals and nitrogen fertilizer levels at the 2nd and the 5th cuts, the results in Table 4 show the superiority of the combination (38 days cutting interval and 80 kg N/fed amounting to 113.6 %. The shorter cutting interval (28 days) with the fertilizer level 120 kg N/fed in the same cut recorded the lowest average for this trait by 88 %. In the 2nd cut, cutting panicum plants every 38 days accompanied with both 40 and 120 kg N/fad the highest leaves/stem ratio (150.3% and 150.9%), respectively; while the lowest ratio was obtained through the combination (28 days interval and 80 kg N/fad).

Growing for longer time in field under appropriate nitrogen fertilization had an effective role in providing favorable growth conditions for such a grass plant. This led to reduced competition between the tillers and thus increased leaf area and weight, and thus an increase in vegetative growth including distribution of roots (El Mouttaqi *et al*., 2023).

4-Green forage yield (ton/cut)

The significant effect of cutting intervals is evident in all cuts except the 5th, 9th and 10th cuts, and the significant effect of nitrogen fertilizer levels is evident in all cuts except the 10th cut, while the significant effect of the interaction was limited to the 3rd, 4th, 5th, 6thand 7th cuts only (Table 5).

Results in Table 5 clarify that the longer cutting interval (38 days) recorded the highest average for green forage yield at the 1st, 2nd, 3rd, 4th, 5th, 6th, and 7th cuts, amounting to 7.42, 6.13, 10.66, 16.04, 22.86, 24.87, and 22.48 ton/fed, respectively. The shorter cutting interval (28 days) at the 8th cut recorded the highest green forage yield (19.29 ton/fed). The reason for the superiority of longer cutting interval in green fodder yield may be attributed to the ideal growth of plants during this period in which the climatic factors (temperature and photosynthesis active period), which in turn was suitable for increasing plant height (Table 2) and the formation of tillers (Table 3). This had a positive impact on plant growth and thus an increase in green forage yield. This result is consistent with what was found by Silveira *et al*. (2010).

Nitrogen fertilizer treatment at the level of 120 kg N/ fed gave the highest green forage yield at the 1st, 2nd, 4th, 5th, 6th, 7th, 8th, and 9th cuts with averages of 8.15, 7.47, 15.04, 24.14, 26.13, 26.03, 20.04, and 25.21 ton/fed, respectively, which did not differ significantly from the fertilizer level 80 kg N/fed at the 1st, 6th, 7th, cuts, giving 7.75, 18.38, and 24.26 ton/fed, respectively. As for the fertilizer level of 80 kg N/fed, it gave the highest value for green forage yield at the 3rd cut, with an average of 12.54 ton/fed.

Table 5. The effect of cutting intervals, nitrogen fertilizer levels and their interactions on the average green forage yield/cut (ton/cut)

Cut	N level					Interaction
	Interval	40 kg/fed	80 kg/fed	120 kg/fed	**Average**	
1st	28 days	5.69	7.56	7.01	**6.75 b**	
	38 days	5.06	7.94	9.28	**7.42 a**	
	Average	**5.38 b**	**7.75 a**	**8.15 a**		
F. test	*		*			NS
2nd	38 days	4.95	5.09	7.61	**5.88 b**	
	38 days	4.03	7.03	7.33	**6.13 a**	
	Average	**4.49 c**	**6.56 b**	**7.47 a**		
F. test	*		*			NS
3rd	28 days	6.31 c	9.53 b	9.58 b	**8.81 b**	
	38 days	5.84 c	15.54 a	9.58 b	**10.66 a**	
	Average	6.07 b	12.54 a	9.58 b		
F. test	*		*			*
4th	28 days	6.43 d	8.36 d	11.47 c	**8.75 b**	
	38 days	13.91 b	15.58 b	18.61 a	**16.04 a**	
	Average	**10.17 b**	**11.97 b**	**15.04 a**		
F. test	*		*			*
5th	28 days	20.29	20.63	24.12	**21.68**	
	38 days	22.98	21.47	24.15	**22.86**	
	Average	**21.64 b**	**21.55 b**	**24.14 a**		
F. test	NS		*			NS
6th	28 days	11.60 c	13.40 d	18.78 c	**14.59 b**	
	38 days	17.77 c	23.36 b	33.49 a	**24.87 a**	
	Average	**14.68 b**	**18.38 a**	**26.13 a**		
F. test	*		*			*
7th	28 days	12.69 c	27.06 b	23.15 a	**20.97 b**	
	38 days	17.06 d	21.47 a	28.91 b	**22.48 a**	
	Average	**14.87 b**	**24.26 a**	**26.03 a**		
F. test	*		*			*
8th	28 days	20.00	17.39	20.50	**19.29 a**	
	38 days	16.18	16.60	19.58	**17.45 b**	
	Average	**18.09 b**	**16.99 b**	**20.04 a**		
F. test	*		*			NS
9th	28 days	18.24	20.67	20.04	**19.65**	
	38 days	14.03	15.55	30.38	**19.99**	
	Average	**16.13 b**	**18.11 b**	**25.21 a**		
F. test	NS		*			NS
10th	28 days	9.16	7.94	11.68	**9.59**	
	38 days	9.58	9.71	10.55	**9.94**	
	Average	**9.37**	**8.82**	**11.11**		
F. test	NS		NS			NS

At the 5% probability level, * denotes significance; NS denotes not significant. Means followed by the same symbol non-significant.

The reason for the increase in green forage yield at these levels may be due to the significant role of nitrogen in increasing leaf growth and sustaining leaf area, thus increasing the rate of photosynthesis per unit leaf area to control the production of carbohydrates and other substances. It also affects the size of green canopy and thus increases the production and accumulation of dry matter and increases plant heights (Table 2) and the number of tillers (Table 3).

Nitrogen encourages reproductive buds, which are responsible for increasing the number of tillers and the formation of shoots after cutting, and this is a characteristic that distinguishes this plant, and for which it is shown as a forage crop. In addition, it is one of the perennial crops with a large vegetative mass that requires large quantities of nitrogen fertilizer for the best vegetative growth, which reflects positively on increasing the green forage yield (Silveira *et al*., 2010 and El Mouttaqi *et al*., 2023).

Concerning the effect of the interaction between cutting intervals and nitrogen fertilizer levels, it was significant at the 4th, 6th and 7th cuts. The combination of the longer cutting interval (38 days) and the fertilizer level of 120 kg N/fed gave the highest average yield of green forage, reaching 18.61 and 33.49 tons in the 4th and 6th cuts, respectively; while the combination of the shorter cutting interval (28 days) and the fertilizer level of 120 kg N/fed gave the highest average yield of green forage, reaching 23.15 ton/fad in the 7th cut. However, the combination of cutting every 38 days accompanied by supplying 80 kg N/fed recorded the highest value of green forage at the 3rd cut. The reason for this superiority could be attributed to the No. of tillers increased due to the suitability and sufficiency of growing period as well as the role of nitrogen fertilization at this level.

5-Total green forage yield (ton/fed)

Fig. 2 indicates that there was a significant effect of cutting interval and nitrogen fertilization levels on the total green forage yield. The longer cutting interval (38 days) was superior in producing the highest total green forage yield of 157.51 ton/fed, compared to the shorter interval (28 days) which produced total forage yield of 135.64 ton/fed. It is noted that 38 days interval appear to be superior under different fertilization levels, and the reason for this is attributed to the suitability of number of days for photosynthetic activity which reflected on the formation of a green surface capable of making maximum use of light to produce more dry matter.

Regarding the effect of nitrogen fertilization, it is noted that the average green forage yield increases with increasing fertilization levels. The high fertilizer level of 120 kg N/fed produced the highest total green forage yield (172.9 ton/fed.), while 80 kg N/fad ranked 2nd producing 145.94 ton/fed. Otherwise, the lowest yield as achieved in the lower N treatment (40 kg N/fed) which was amounted to 120.9 ton/fad. This may be due to the role of nitrogen in increasing plant height, No. of tillers and the green forage yield per cut.

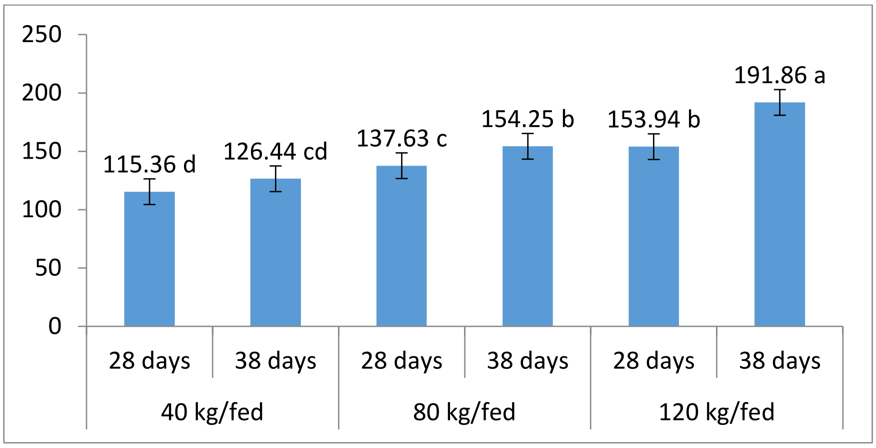

Fig 2. Total green forage yield (ton/fed) as affected by nitrogen fertilizer levels and cutting intervals.

6-Dry forage yield (ton/cut)

Table 3 shows a significant effect of cutting intervals in the first nine cuts (1-9) and nitrogen fertilization levels in all cuts except the 2nd and 4th cuts. The interaction had a significant effect only in the 9th cut of the dry forage yield.

The longer cutting interval (38 days) produced the highest dry forage yield at the 1st, 3rd, 4th, 5th, 6th, 9th, and 10th cuts, with an average of 1.62, 3.02, 5.14, 8.17, 8.82, 6.37, and 3.13 ton/fed, respectively. However, the shorter cutting interval (28 days) gave an average dry yield of 1.77, 7.71, and 7.39 ton/fed at the 2nd, 7th, and 8th cuts, respectively. The reason for the increase in the dry yield with the 2nd interval after 38 days of growth is due to the increase in the green forage yield (Table 5).

Nitrogenous fertilization treatment of 120 kg N/fed gave the highest dry forage yield in the 2nd, 4th, 6th, 7th, 8th, 9th, and 10th cuts, reaching 2.09, 4.73, 8.90, 9.45, 6.57, 6.84, and 3.31 ton/fed, respectively. 80 kg N/fed did not differ significantly from the level of 120 kg N/fed at the 5th and 7th cuts, which produced average dry yield of 1.94 and 8.32 ton/fed, respectively, and differed significantly from the treatment 40 kg N/fed, which produced the lowest average dry forage yield. These results could be due to the role of nitrogen in increasing the yield of green fodder yield (Table 5).

Concerning the interaction between cutting intervals and nitrogen fertilization at the 6th, 8th and 9th cuts, the results in Table 6 show that the combination of the longer cutting interval (38 days) and the fertilizer level of 120 kg N/fed yielded the highest average for this trait, amounting to 12.48 and 10.07 ton/fed at the 6th and 9th cuts. Meanwhile, the combination 28 days and 120 kg N/fad yielded the highest dry forage yield (8.81 ton/fad) in the 8th cut. The combination of 28 days interval and 40 kg N/fed in the 6th and 9th cuts recorded the lowest average for this trait by 3.75 and 2.87 ton/fed, while the longest interval accompanied with 40 kg N/fad recorded the lowest dry forage yield/fad (2.77 ton) in the 8th cut. The trend of dry matter results is parallel to that of the green forage results.

Table 6. The effect of cutting intervals, nitrogen fertilizer levels and their interactions on dry forage yield (ton/cut)

Cut	N level					Interaction
	Interval	40 kg/fed	80 kg/fed	120 kg/fed	**Average**	
1st	28 days	0.73	1.75	2.05	**1.52 b**	
	38 days	0.92	2.14	1.78	**1.62 a**	
	Average	**0.82 b**	**1.94 a**	**1.92 a**		
F. test	*		*			**NS**
2nd	38 days	1.10	1.98	2.21	**1.77 a**	
	38 days	1.315	1.68	1.97	**1.66 b**	
	Average	**1.20**	**1.83**	**2.09**		
F. test	*		**NS**			**NS**
3rd	28 days	1.764	2.15	2.33	**2.09 b**	
	38 days	2.07	4.19	2.78	**3.02 a**	
	Average	**1.91 c**	**3.17 a**	**2.56 b**		
F. test	*		*			**NS**
4th	28 days	2.03	2.23	3.50	**2.59 b**	
	38 days	4.65	4.79	5.97	**5.14 a**	
	Average	**3.34**	**3.51**	**4.73**		
F. test	*		**NS**			**NS**
5th	28 days	3.65	8.10	7.47	**6.41 b**	
	38 days	7.07	8.54	8.89	**8.17 a**	
	Average	**5.36 b**	**8.32 a**	**8.18 a**		
F. test	*		*			**NS**
6th	28 days	3.75 d	4.03 d	5.32 c	**4.37 b**	
	38 days	5.27 c	8.68 b	12.48 a	**8.82 a**	
	Average	**4.51 c**	**6.36 b**	**8.90 a**		
F. test	*		*			*
7th	28 days	5.14	7.52	10.45	**7.71 a**	
	38 days	4.08	10.19	8.45	**7.58 b**	
	Average	**4.61 b**	**8.85 a**	**9.45 a**		
F. test	*		*			**NS**
8th	28 days	6.95 b	6.42 b	8.81 a	**7.39 a**	
	38 days	2.77 d	2.85 d	4.33 c	**3.32 b**	
	Average	**4.86 b**	**4.63 b**	**6.57 a**		
F. test	*		*			*
9th	28 days	2.87 b	3.5 b	3.60 b	**3.33 b**	
	38 days	4.14 b	4.88 b	10.07 a	**6.37 a**	
	Average	**3.50 c**	**4.19 b**	**6.84 a**		
F. test	*		*			*
10th	28 days	2.50	2.43	3.46	**2.80**	
	38 days	3.26	2.97	3.16	**3.13**	
	Average	**2.88 b**	**2.70 b**	**3.31 a**		
F. test	**NS**		*			**NS**

At the 5% and 1% probability levels, * and ** denote significance; NS denotes not significant. Means followed by the same symbol non-significant.

7-Total dry forage yield (ton/fed)

Results displayed in Fig. 3 show the significant effect of cutting intervals and nitrogen fertilizer levels on the total dry forage yield. The longer cutting interval (38 days) was significantly superior in recording the highest average total dry forage yield (48.82 ton/fed) over the shorter cutting interval (28 days); which recorded 39.98 ton/fed. The reason for the superiority of the longer cutting interval in this trait may be due to its superiority in the total green forage yield (Fig. 2) in addition to the superiority of each cut separately on green and dry forage yields, as shown in Tables (5 and 6).

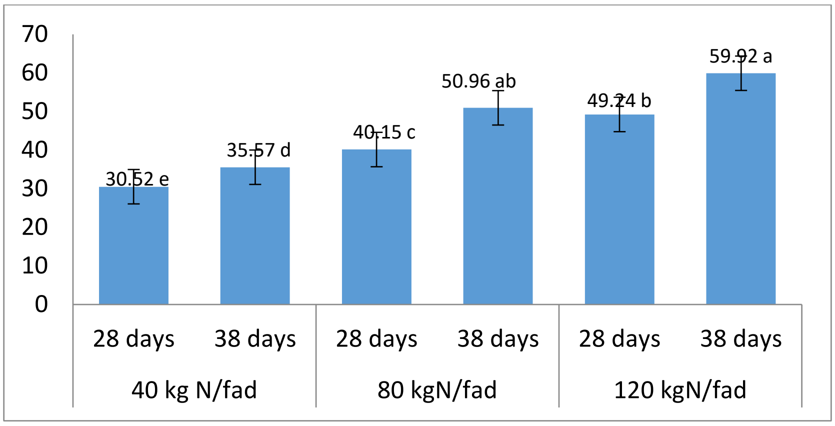

Fig 3. Total dry forage yield (ton/fed) as affected by nitrogen fertilizer levels and cutting intervals

It is noted that there is a proportional increase in the averages total dry forage yield of *Panicum maximum* with the gradual increase in the levels of nitrogen fertilization, where the highest average reached the level of 120 kg N/fed by 54.58 ton/fed while 80 and 40 kg N/fed produced 45.56 and 33.05 ton/fed, respectively. This reflects the importance of nitrogen after each cut. This high yield is linked to the reasons mentioned in the dry forage yield per cut (Fig. 3). Furthermore, it is clear that the results of this trait are the direct outcome of the dry forage yield in individual cuts.

8-Crude protein content (%)

Results presented in Table 7 indicate a significant effect of cutting intervals at the 1st, 3rd, and 7th cuts. Nitrogen fertilizer levels differences were significant in all cuts except the 1st cut. Significant effects of the interaction were shown in the 3rd and 9th cuts.

The longer cutting interval (38 days) recorded the highest protein content amounting to 10.52 % and 10.47 % in the 1st and 3rd cuts, respectively. The shorter cutting interval (28 days) recorded the highest percentage of protein at the 1st, 7th and 9th cuts, amounting to 10.52, 10.80 and 10.76 %. The reason for these results is due to the increase in the concentration of nitrogen inside the plant.

Concerning the effect of nitrogen fertilizer levels, 120 kg N/fed recorded the highest average for this trait, amounting to 10.97 % at the 3rd and 9th cuts. The treatment of 40 kg N/fed gave the lowest average for this trait in all cuts.

Likewise, 120 kg N/fed at the 5th cut recorded the highest protein content amounting to 10.76%. This did not differ significantly from 80 kg N/fed, which recorded 10.5 % and was superior with an increase of 2.3 % over the 40 kg N/fed treatment which recorded 10.26 %. Also, at the 9th cut, 40 kg N/fed recorded the highest protein content of 10.5 %, and was not significantly different from 80 kg N/fed), which recorded 10.63 %.

Table 7. The effect of cutting intervals, nitrogen fertilizer levels and their interactions on the average percentage of protein (%)

Cut	N level					Interaction
	Interval	40 kg/fed	80 kg/fed	120 kg/fed	**Average**	
1st	28 days	10.13	10.76	10.65	**10.52**	
	38 days	8.505	10.5	10.50	**9.84**	
	Average	**9.31**	**10.63**	**10.57**		
F. test	**NS**		**NS**			**NS**
3rd	28 days	10.23	10.29	10.86	**10.47**	
	38 days	10.39	10.65	11.07	**10.71**	
	Average	**10.31 b**	**10.47 b**	**10.97 a**		
F. test	*		*			*
5th	28 days	10.18	10.29	10.76		**10.41**
	38 days	10.34	10.71	10.76		**10.61**
	Average	**10.26 c**	**10.5 b**	**10.76 a**		
F. test	**NS**		*			**NS**
7th	28 days	10.34	11.13	10.92	**10.80**	
	38 days	10.13	9.76	10.50	**10.13**	
	Average	**10.23 c**	**10.44 b**	**10.71 a**		
F. test	*		*			*
9th	28 days	10.55	10.65	11.07	**10.76**	
	38 days	10.44	10.60	10.86	**10.64**	
	Average	**10.50 b**	**10.63 ab**	**10.97 a**		
F. test	**NS**		*			*

At the 5% and 1% probability levels, * and ** denote significance; NS denotes not significant. Means followed by the same symbol non-significant.

The reason for that increase is the efficiency of using Nitrogen during enough time to use nitrogen under suitable weather conditions for the activity of the nitrate reductase enzyme during the cut operations (Chen and Huang, 2020). They observed a linear correlation between the time after nitrogen fertilizer addition and the percentage of protein content.

Concerning the effect of the interaction, the combination of 120 kg N/fed and 38 days interval at the 3rd cut as well as 120 kg N/fed and 28 at the 9th cut recorded the highest protein content, amounting to 11.07 % in both cuts. The lowest average was in the 1st cut and reached 8.5 % at the combination of 38 days cutting interval and 40 kg N/fed.

9-Phosphorus concentration (%)

Results illustrated in Table 8 reveal the significant effect of cutting intervals in the 1st, 3rd, and 9th cuts, as well, nitrogen fertilization levels in the 1st, 3rd, 5th, and 7th cuts, and the interaction between them in the percentage of phosphorus, which was significant in the 5th and 9th cuts.

Table 8. The effect of cutting intervals, nitrogen fertilizer levels and their interactions on the average percentage of Phosphorus (%)

Cut	N level					Interaction
	Interval	40 kg/fed	80 kg/fed	120 kg/fed	**Average**	
1st	28 days	0.36	0.35	0.37	**0.36**	
	38 days	0.38	0.37	0.33	**0.36**	
	Average	**0.37 a**	**0.36 b**	**0.35 c**		
F. test	**NS**		*			*
3rd	28 days	0.33	0.36	0.35	**0.35 b**	
	38 days	0.39	0.33	0.36	**0.36 a**	
Average	**Average**	**0.36 a**	**0.34 c**	**0.35 b**		
F. test	*		*			**NS**
5th	28 days	0.37	0.43	0.34	**0.38**	
	38 days	0.36	0.39	0.39	**0.38**	
	Average	**0.36 b**	**0.41 a**	**0.36 b**		
F. test	NS		*			**NS**
7th	28 days	0.34	0.35	0.43	**0.37**	
	38 days	0.38	0.39	0.40	**0.39**	
	Average	**0.36 b**	**0.37 b**	**0.41 a**		
F. test	**NS**		*			**NS**
9th	28 days	0.34	0.38	0.39	**0.37**	
	38 days	0.36	0.32	0.42	**0.37**	
	Average	**0.35 b**	**0.35 b**	**0.40 a**		
F. test	*		**NS**			*

At the 5% and 1% probability levels, * and ** denote significance; NS denotes not significant. Means followed by the same symbol non-significant.

The shorter cutting interval recorded the same average of P at the 1st, 5th and 9th cuts reaching 0.36, 0.38 and 0.37 %, respectively. The longer cutting interval (38 days) was superior at the 3rd and 7th cuts and recorded the highest P content by 0.36 and 0.39 %**,** which significantly differed from the shorter interval (28 days) which gave 0.35 % at the 3rd cut. The reason for this may be due to the ability of the roots to secrete organic acids that reduce the degree of soil interaction and thus increase the availability of phosphorus, which helps in its absorption (Hocking, 2001).

Concerning the levels of nitrogen fertilizer levels, they differed in their effect on this trait, where 120 kg N/fed achieved the highest average of P content by 0.41 and 0.40 % at the 7th and 9th cuts, respectively. This did not differ significantly from 80 kg/ha, which gave 0.37 and 0.35 %, respectively in both cuts. 80 kg N/fed recorded the highest P content amounting to 0.41 % at the 5th cut, and it differed significantly from the rest of levels, with an increase over 40 kg N/fed which recorded the lowest P content (0.36) amounting to 12.3 %.

In the 7th cut, 120 kg N/fed had the highest average of P (0.41 %) and differed significantly from the rest of levels. The reason for those results is attributed to that nitrogen fertilizer increased cell division and increased their number, and then this had a positive effect on expanding the root system of the plant and absorbing the largest amount of elements, including Phosphorus. Additionally, nitrogen fertilizers increase the concentrations of nutrients by reducing soil PH and in favor of high concentrations of nitrogen, and this is consistent with the findings of El Mouttaqi *et al.,* 2023

Concerning the interaction effect between cutting intervals and N levels, the combination of the longer interval and 80 kg N/fed recorded the highest averages of phosphorus percentage by 0.40 and 0.42 % at the 7^{th} and 9^{th} cuts, respectively. The shorter interval interaction with 80 kg N/fed recorded the lowest P content by 0.32 % at the 9^{th} cut.

Conclusion

The current study's results suggest that cutting panicum plants every 38 days and fertilizing with 80 kg N/fed will maximize their capacity for forage production with higher quality.

Conflicts of interest

There are no conflicts of interest.

Further recommendation

It is advisable to focus more studies on how to maximize the efficiency of Nitrogen use in new sandy soils, supporting its role by potassium fertilization management.

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ضبط فترة الحش ومستوى السماد النيتروجيني لتحسين محصول علف البانيكام وجودته في مصر

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قسم المحاصيل، كلية الزراعة، جامعة الزقازيق، الشرقية، مصر.

الملخص

أجريت تجربه حقليه خلال العامين 2020، 2021 في مزرعة تجريبية ذات تربة رملية، تقع في الصالحية القديمة، مركز فاقوس، محافظة الشرقية، مصر؛ باستخدام تصميم القطاعات الكاملة العشوائية (RCBD) لدراسة تأثير فترتي حش (28 ،38 يومًا) وثلاثة مستويات من السماد النيتروجيني (40، 80، 120 كجم نيتروجين/فدان) والتفاعل بينها على محصول العلف وجودته في البانيكم. أشارت النتائج إلى أن فترة الحش الأطول (38 يومًا) أدت إلى زيادة ارتفاع النباتات، مع عدد أكبر بكثير من السيقان/م2، ومعنوية في نسبة وزن الأوراق/السيقان، وإنتاجية العلف الأخضر والكلي، وإنتاجية العلف الجاف الكلي. في الوقت نفسه، ساهم التسميد النيتروجيني عند مستوى 120 كجم نيتروجين/فدان في الحصول على أعلى ارتفاع للنبات، وأعلى عدد سيقان للمتر المربع، وكذلك أعلى إنتاجية علف أخضر، ومحتوى بروتين خام. وقد حققت كمية السماد النيتروجيني 80 كجم نيتروجين/فدان نفس درجة التأثير الناتج عن إضافة 120 كجم نيتروجين/فدان في معظم الصفات المدروسة، ولم يكن التفاعل بين فترات الحش ومستويات التسميد النيتروجيني معنوياً في معظم الصفات المدروسة، بيَّنت النتائج ارتباطاً موجباً بين مستويات السماد النيتروجيني وتركيز الفسفور في العلف. أوصت الدراسة بناءً على النتائج بحش نباتات البانيكم كل 38 يوماً وإضافة السماد النيتروجين بكمية 80 كجم نيتروجين/فدان لزيادة إنتاج العلف الأخضر وجودته المتحصل عليه من زراعة فدان البانيكم.

الكلمات المفتاحية: *البانيكم، النيتروجين، جودة العلف، فترة الحش، محصول العلف.*