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EFFECT OF IRRIGATION INTERVALS AND NITROGEN RATES ON FORAGE SORGHUM UNDER NORTH SINAI CONDITIONS

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ABSTRACT: This experiment was carried out at the Experimental Farm of the Faculty of Environmental Agricultural Sciences, Suez Canal University in El-Arish, during 2006 and 2007 seasons. This work aimed to study the effect of irrigation intervals (3, 5 & 8 days) and nitrogen fertilizer rates (45, 60, 75 & 90 kg N fed^{-1}) on forage sorghum (*Sorghum bicolor*). Nitrogen fertilizer (Urea 46%) was applied in three equal doses (20 days after emergence, after the 1st and the 2nd cuts). The experimental design was randomized complete block (RCBD) in a split plot design with three replications. The main plots were chosen for irrigation intervals, the sub-plots were devoted for nitrogen rates. Drip irrigation system was used with saline ground water (ranged between 3500 to 4600 ppm) pumped from a local well. Three cuts were taken throughout the growth season at 60, 105 and 136 days after sowing. All studied growth criteria had the highest values with irrigation every 3 days at all cuts in both seasons and combined analysis. The same trend was found with fresh, dry and protein yield. However, the highest means of crude protein was recorded with irrigation every 8 days at all cut except the third one, which irrigation every 5 days gave the highest crude protein in both seasons and combined analysis. Increasing nitrogen fertilizer rate from 45 to 90 kg N fed^{-1} increased all studied growth characters at the three cuts and over them in both seasons and combined analysis. Also, the maximum forage fresh, dry and protein yield were achieved when 90 kg N fed^{-1} was applied. No significant effect of interactions was found on forage sorghum growth and forage yield except dry weight and yield at the third cut and fresh yield at the first cut in both seasons and combined analysis.

The interaction of irrigation every 3 days and applying of 90 kg N fed^{-1} gave the maximum means of the obvious weight and yield (25.22 g/plant, 25.639 and 2.061 ton fed^{-1}, respectively) in combined analysis.

Key words: Forage sorghum, irrigation intervals, N-fertilization, growth, forage yield, protein content and yield.

INTRODUCTION

In Egypt, there are many forage crops which can be successfully grown during the summer in old lands of Delta and Valley, but their area is still very small because of severe competition with other cash and food crops. Therefore, the newly reclaimed lands, such as North Sinai, are the main way for increasing the area of such crops besides the important role of these crops for soil building and improvement during the early period of new land cultivation. Forage sorghum is a very promising summer crop to be grown on such new reclaimed lands because of its wide adaptability to ecological conditions. Also, it has fast regrowth ability after cutting or grazing which make it very desirable to compensate the summer shortage in forage summer production. Low tissues content of hydrocyanic acid (HCN) makes feeding at early stages quite safe compared to grain sorghum (Chatterjee and Das, 1989).

It was considered that growing forages consume high annual quantities of water, especially the perennial crops such as alfalfa which requires 35000 - 45000 m^3 ha^{-1} and Rhodes grass that consume about 17000-24000 m^3 ha^{-1} (AL-Doss, 1997), while, growing annual forage crops such as forage sorghum with conservative irrigating policy seem to be one of the available options accepted by both Ministry of Agriculture and Agronomist. Baumhardt *et al.* (1985) in Texas, reported that grain sorghum could be grown under various irrigation systems from full irrigation to dry land. Taking a cut of two month old plants of forage sorghum results in very fresh and more palatable animal feed (Martin *et al.*, 1976). Sorghum forage yield and nutritional value could be maximized by improving the soil nutritional contents especially nitrogen and irrigation water (Khair, 1999). Al-Suhaibani (2006), in Saudi Arabia Kingdom, found that expanding irrigation interval from 3 to 7 and 11 days decreased the forage yield from

143.6 to 123 and 85.3 ton ha^{-1}, respectively. On the other hand, there were no significant differences between irrigation every 7 and 14 days on grain sorghum growth and yield, while, 21-days interval decreased the studied characters (Latif *et al.*, 2000).

Increasing N-fertilization levels of forage grasses had favorable effects on different growth characteristics, forage yield and forage quality. On this respect, many investigators studied the effect of applying different rates of nitrogen on forage sorghum, their results varied according to different conditions, for example; adding 90 kg N fed^{-1} resulted in the highest values of growth characters (EL-Khawaga and Geweifel, 1991) in clay soil, fresh and dry forage yields as well as forage protein content (Geweifel and EL-Khawaga, 1991). Also, applying N-fertilizer at the rates of 130 kg N fed^{-1} (Marei, 1992), 80 kg N fed^{-1} (Reiad *et al.*, 1995), 120 kg N fed^{-1} (Mikhiel, 1997), 90 kg N fed^{-1} (Yousef, 2002) gave the highest fresh and dry forage yields as well as forage protein content of forage sorghum as compared with the lowest or highest studied levels. Forage sorghum should be fertilized at the rates of 150 kg N ha^{-1} (Ketterings *et al.*, 2004) and 250 kg N ha^{-1} (Beyaert and Robert, 2005) before planting and after each cut in a multi-cut system to maximize forage yield. On the other hand, AL-Suhaibani (2006) reported that different nitrogen levels (200, 400 and 600 kg ha^{-1}) did not significantly affect the forage production of sudangrass for all cuts. He added that applying large quantities of nitrogen has no clear positive effect for sudangrass grown under water shortage.

Because of lack information of water and fertilizer requirements of forage sorghum under North Sinai conditions, this study was initiated to explore the forage sorghum productivity and quality under different irrigation intervals and nitrogen fertilizers levels.

MATERIALS AND METHODS

This experiment was conducted at the Experimental Farm of Faculty of Environmental Agricultural Science, El-Arish, Suez Canal University, North Sinai Governorate during two summer seasons of 2006 and 2007. This work aimed to investigate the effect of three irrigation intervals (3, 5 and 8 days) and four nitrogen fertilizer rates (45, 60, 75 and 90 kg N fed^{-1}) on forage sorghum growth and

yield. Each experiment included 12 treatments. The randomized complete block design in a split plot design with three replications was used. Irrigation treatments were randomly devoted in the main plots, while, nitrogen rates were arranged in the sub-plots. Planting dates were May 15th & 30th in the two respective seasons. Drip irrigation system was used with saline ground water (ranged between 3500-4600 ppm) pumped from a local well. The mechanical and chemical analysis of the soil at the experimental site are presented in Table 1.

The experimental unit area was 15 m^2 which consisted of 5 rows with 50 cm width and 6 m length for each row. Organic manure at a rate of 20 m^3 fed^{-1} and calcium super phosphate (15% P_2O_5) at a rate of 150kg fed^{-1}, while potassium sulphate (48% K_2O) at a rate of 50 kg fed^{-1} were applied during land preparation. The four nitrogenous fertilizer rates (Urea 46% N) were divided into three equal doses; the first one was applied after 20 days from emergence, while the second and third doses were added after the first and second cuts. All other agricultural practices were carried out as recommended.

Three cuts were taken throughout the growth season at 60, 106 and 136 days after sowing (DAS) for the first, second and third cuts, respectively. At each cut, a random sample of ten plants was taken from each sub plot to determine plant height, stem diameter, plant fresh and dry weight (g/plant) and dry matter of plant (%). Also, fresh and dry forage yields per feddan of each cut were recorded based on the yield per each sub plot. Crude protein content (%) was determined by using the modified microkjeldahl apparatus according to the method mentioned in A.O.A.C. (1990). Accordingly, total protein yield (kg fed^{-1}) was calculated.

Data were combined across two seasons and subjected to the proper statistical analysis of variance according to Snedecor and Cochran (1990) using MSTAT – Computer Programme. Mean values were compared using Duncan's multiple range test (Duncan, 1990).

RESULTS AND DISCUSSION

Effect of Irrigation Intervals

There were significant effects of irrigation intervals on forage sorghum growth criteria namely,

Table 1. Mechanical and chemical analysis of the soil for the experimental site

(1) Mechanical analysis: (particle size distribution %)			
Sand		**71**	
Silt		**23**	
Clay		**6**	
Texture		**Sandy loam**	
(2) Chemical properties in (1:5) soil water extract:			
Organic matter %		**0.65**	
Ca CO3 %		**6.13**	
pH		**7.33**	
EC (m mhos/cm 1:5)		**6.57**	
Soluble ions (mg L^{-1})			
Cat ions		**Anions**	
Ca^{++}	**5.6**	**HCO_3^{-1}**	**6.3**
Mg^{++}	**3.6**	**CL^-**	**15.13**
K^+	**0.22**	**$SO4^-$**	**1.88**
Na^+	**15.1**		

plant height, stem diameter, fresh and dry weights per plant and dry matter at the three cuts and means over them in both seasons and combined analysis except the dry matter at the first cut in the 1st season Tables 2, 3 and 4. All the obvious growth criteria decreased as plant age increased, where the maximum values were obtained after 60 days from sowing (first cut). This was true in both seasons and combined analysis. Increasing irrigation intervals from 3 to 8 days decreased plant height from 212.1, 191.2 and 135.7 to 196.6, 174.3 and 113.9 cm at the 1st, 2nd and 3rd cuts, respectively, in combined analysis Table 2. Over the three cuts, these reductions were 10.4, 13.0 and 10.9 % in 2006, 2007 and combined analysis, respectively. Similar trend was found for stem diameter, as these reductions according to water stress were 18.05, 17.18, 21.14 and 20.49 % at the third respective cuts and over them in combined analysis.

Irrigation every 3 days gave superiority of fresh weight means (228.6, 176.4 and 84.4 g/plant) at

the 1st, 2nd and 3rd cuts, respectively, in the 1st season Table 3. This trend was true in the second season and combined analysis. Over the third cuts and the two seasons, irrigated plants with adequate water supply (3-days interval) gave increases of fresh weight per plant by 8.01 and 24.6 % as compared with stressed plants (5 and 8-days, respectively). The same trend was recorded for dry weight per plant, where, means over the three cuts decreased from 31.6, 36.5 and 35.1 to 22.4, 26.5 and 22.6 g/plant in 2006, 2007 seasons and combined analysis, respectively. The highest means of plant dry matter (18.65, 19.64 and 16.26 %) were obtained from irrigation every 3 days at the 2nd, 3rd cuts and over the three cuts, respectively, in the first season Table 4. The same trend was found in the second season and combined analysis. These superiorities for irrigation every 3 days were by 67.0, 48.9, 69.4 % at the three respective cuts in the 2nd season and by 56.4 % over them in combined analysis as compared with irrigation every 8 days. However, the highest level of water stress (8-days interval) resulted in the maximum forage crude protein percentage at all cuts and means over them except the third cut in both seasons and combined analysis Table 4. Moderate water stress level (5-days interval) at the 3rd cut had the highest means of CP (9.56, 9.79 and 9.66 %) in 2006, 2007 seasons and combined analysis, respectively. In this respect, Miseha (1983) pointed out that growth and development of plants depend on cell division and elongation but cell division appears less sensitive to water deficit than cell elongation. These results are in harmony with those obtained by Martin *et al.* (1976), Yousef *et al.* (1996), Latif (1999) and Latif *et al.* (2000) on grain sorghum and AL-Suhaibani (2006) on forage sorghum.

Increasing irrigation intervals decreased fresh, dry and protein yield at all cuts in both seasons and combined analysis Table 5. Irrigated forage sorghum every 3 days gave the highest means of fresh forage yield (21.231, 18.069 and 7.632 ton fed^{-1}) and dry yield (3.661, 3.861 and 1.982 ton fed^{-1}) at first, second and third cuts, respectively, in combined analysis. Also, as water stress increased (8-days interval), protein yield decreased at all studied cuts in both seasons and combined

Table 2. Plant height and stem diameter of forage sorghum as affected by irrigation intervals at the three cuts and over them in 2006, 2007 seasons and combined analysis

Irrigation intervals (day)	Plant height (cm)			Stem diameter (cm)		
	2006	2007	Combined	2006	2007	Combined
	The first cut (60 DAS)					
3	210.3 a	215.6 a	212.1 a	1.40 a	1.43 a	1.44 a
5	204.1 b	214.4 b	209.3 b	1.30 b	1.33 b	1.32 b
8	192.3 c	202.3 c	196.6 c	1.13 c	1.25 c	1.18 c
F-test	**	**	**	**	**	*
	The second cut (106 DAS)					
3	190.4 a	193.5 a	191.2 a	1.20 a	1.37 a	1.28 a
5	190.8 a	186.1 b	188.5 b	1.14 b	1.30 b	1.21 b
8	181.3 b	167.7 c	174.3 c	0.95 c	1.21 c	1.06 c
F-test	*	**	*	**	**	**
	The third cut (136 DAS)					
3	130.8 a	141.6 a	135.7 a	0.80 a	0.91 a	0.84 a
5	129.3 a	133.1 b	130.4 a	0.65 b	0.75 b	0.73 b
8	109.5 c	114.6 c	113.9 c	0.60 c	0.74 b	0.66 c
F-test	*	**	*	**	*	**
	Means over these cuts					
3	178.3 a	184.6 a	181.2 a	1.14 a	1.25 a	1.22 a
5	175.6 b	177.8 b	175.4 b	1.04 b	1.16 b	1.09 b
8	161.5 c	163.3 c	161.4 c	0.91 c	1.04 c	0.97 c
F-test	**	**	**			*

* = significant at P< 0.05 and ** = significant at P< 0.01. Means have the same letters in the same column are not significantly different at P < 0.05 level.

Table 3. Fresh and dry weight of forage sorghum as affected by irrigation intervals at the three cuts and over them in 2006, 2007 seasons and combined analysis

Irrigation intervals (day)	Fresh weight (g/plant)			Dry weight (g/plant)		
	2006	2007	Combined	2006	2007	Combined
			The first cut (60 DAS)			
3	228.6 a	243.7 a	235.6 a	40.1 a	44.7 ab	43.2 a
5	220.4 b	232.6 b	226.3 b	33.6 b	40.8 b	38.6 b
8	183.4 c	201.4 c	191.3 c	21.3 c	33.5 c	26.1 c
F-test	**	**	**	**	*	*
			The second cut (106 DAS)			
3	176.4 a	196.6 a	188.4 a	33.6 a	41.2 a	38.2 a
5	158.7 b	172.7 b	167.8 b	28.9 b	36.8 b	33.5 b
8	136.3 c	156.2 c	148.2 c	25.3 c	32.4 b	27.6 c
F-test	**	**	**	**	*	**
			The third cut (136 DAS)			
3	84.4 a	101.2 a	91.6 a	21.7 a	26.5 a	23.0 a
5	75.8 b	89.6 b	81.4 b	15.8 b	22.4 b	18.7 b
8	68.5 c	77.3 c	73.5 c	13.5 b	15.4 c	13.5 c
F-test	**	**	**	*	**	**
			Means over these cuts			
3	163.6 a	181.2 a	172.6 a	31.6 a	36.5 a	35.1 a
5	162.4 a	165.8 b	159.8 b	25.7 b	35.6 a	30.2 ab
8	130.6 b	145.6 c	138.5 c	22.4 c	26.5 b	22.6 c
F-test	*	**	**	**	*	**

* = significant at P< 0.05 and ** = significant at P< 0.01. Means have the same letters in the same column are not significantly different at P < 0.05 level.

Table 4. Dry matter and crude protein percentage of forage sorghum as affected by irrigation intervals at the three cuts and over them in 2006, 2007 seasons and combined analysis

Irrigation intervals (day)	Dry matter (%)			Crude protein (%)		
	2006	2007	Combined	2006	2007	Combined
The first cut (60 DAS)						
3	10.43	27.63 a	19.77 a	5.88 c	6.74 c	6.33 c
5	8.86	25.92 b	16.65 b	6.93 b	7.34 b	7.12 b
8	8.87	16.54 c	12.32 c	8.11 a	8.48 a	8.33 a
F-test	ns	**	**	**	**	**
The second cut (106 DAS)						
3	18.65 a	30.12 a	24.54 a	6.77 c	6.98 c	6.85 c
5	15.84 b	26.42 b	20.12 b	8.05 b	8.38 b	8.21 b
8	12.73 c	20.23 c	15.38 c	9.06 a	9.22 a	9.13 a
F-test	**	**	**	**	**	**
The third cut (136 DAS)						
3	19.64 a	30.25 a	24.56 a	8.74 c	8.96 c	8.89 c
5	18.55 a	22.76 b	20.26 b	9.56 a	9.79 a	9.66 a
8	14.12 b	17.86 c	15.41 c	9.03 b	9.25 b	9.12 b
F-test	*	**	**	**	**	**
Means over these cuts						
3	16.26 a	29.63 a	22.47 a	7.15 c	7.58 c	7.35 c
5	14.48 b	25.11 b	19.03 ab	8.21 b	8.53 b	8.33 b
8	11.83 c	18.25 c	14.37 c	8.75 a	9.01 a	8.87 a
F-test	**	**	*	**	**	**

* = significant at P< 0.05 and ** = significant at P< 0.01. Means have the same letters in the same column are not significantly different at P < 0.05 level.

Table 5. Fresh, dry and protein yield of forage sorghum as affected by irrigation intervals at the three cuts and over them in 2006, 2007 seasons and combined analysis

Irrigation intervals (day)	Fresh yield (ton fed^{-1})			Dry yield (ton fed^{-1})			Protein yield (ton fed^{-1})		
	2006	2007	Combined	2006	2007	Combined	2006	2007	Combined
The first cut (60 DAS)									
3	20.876 a	22.634 a	21.231 a	3.023 a	4.283 a	3.661a	1.221 a	1.559 a	1.376 a
5	15.211 b	17.156 b	16.365 b	2.110 b	2.833 bc	2.451b	1.049 b	1.252 b	1.154 b
8	10.005 c	10.123 c	10.066 c	1.654 c	2.584 c	2.018 c	0.819 c	0.865 c	0.838 c
F-test	**	**	**	*	*	*	**	**	*
The second cut (106 DAS)									
3	16.014 a	20.110 a	18.069 a	3.696 a	3.816 a	3.861 a	1.081 a	1.434 a	1.259 a
5	13.234 b	15.664 b	14.361 b	2.846 b	3.168 b	3.017 b	1.055 a	1.306 b	1.185 b
8	7.287 c	10.066 c	8.636 c	2.087 c	2.325 c	2.213 c	0.658 b	0.936 c	0.795 c
F-test	**	**	**	**	**	**	*	**	**
The third cut (136 DAS)									
3	6.923a	7.866 a	7.632 a	1.033 a	2.915 a	1.982 a	0.603 a	0.718a	0.664 a
5	5.543b	6.904 b	6.112 b	1.211 b	1.841bc	1.533b	0.524 b	0.655a	0.592 b
8	4.002c	5.117 c	4.651 c	0.968 c	1.443 c	1.211c	0.374c	0.461b	0.415 c
F-test	**	*	**	**	**	**	**	*	**
Total of these cuts									
3	43.814 a	50.622 a	47.221 a	7.752 a	11.616a	9.680 a	2.905 a	3.606 a	3.297 a
5	33.989 b	39.726 b	36.876 b	6.166 b	7.843 b	7.003 b	2.634 b	3.220 b	2.925 b
8	21.296 c	25.308 c	23.306 c	4.711 c	6.355 c	5.531 c	1.842 c	2.253 c	2.046 c
F-test	**	**	**	**	**	**	**	**	**

* = significant at P< 0.05 and ** = significant at P< 0.01. Means have the same letters in the same column are not significantly different at P < 0.05 level.

analysis. These reductions were 57.71, 60.05 and 61.14 % for irrigation every 3 day at the total protein yield as compared with 8 day interval in the 1st, 2nd seasons and combined analysis, respectively. These results may refer to that water stressed plants not suffered from low water supply only, but also reduction in nutrient supply andphotosynthetic area which reflected on decreasing light interception and in turn decreased dry matter (DM) accumulation. This stressed reduction in DM affected negatively forage and protein yields. These results are in accordance with those obtained by Khair (1999) and AL-Suhaibani (2006).

Effect of Nitrogen Fertilizer Rates

There were significant effects of N-rates on all growth criteria in both seasons and combined analysis Tables 6, 7 and 8. Increasing nitrogen fertilizer rate from 45 to 90 kg N fed^{-1} increased plant height from (201.5 and 214.6 cm) to (229.6 and 242.4 cm) at the 1st cut and from (172.3 and 184.7 cm) to (191.3 and 204.1 cm) at the 2nd cut in both seasons (2006 and 2007, respectively, Table 6).

These increases were by 12.21 and 10.32 % at the third cut in both respective seasons. That was true for stem diameter at each cut and over them in both seasons and combined analysis, where, these increases were by 19.47, 16.53 and 16.24 % at the means over these cuts in 1st, 2nd seasons and combined analysis, respectively.

Increasing nitrogen fertilizer rate increased fresh and dry weight per plant at all cuts in both seasons and combined analysis except dry weight at the third cut in the first season and combined analysis Table 7. Applying 90 kg N fed^{-1} gave the highest means of fresh weight (175.4 and 186.5 g/plant) over the three cuts in 2006 and 2007 seasons, respectively. That was true for dry weight, where, these superiorities were 25.78, 23.08 and 22.47 % over the three cuts in the 1st, 2nd seasons and combined analysis, respectively. Nitrogen fertilizer rates had a significant effect on dry matter and forage protein content at all cuts and over them in both seasons and combined analysis except the 2nd and 3rd in 1st season and at the 3rd cut in

Table 6. Plant height and stem diameter of forage sorghum as affected by nitrogen fertilizer rates at the three cuts and over them in 2006, 2007 seasons and combined analysis

N-rates ($kgNfed^{-1}$)	Plant height (cm)			Stem diameter (cm)		
	2006	2007	Combined	2006	2007	Combined
The first cut (60 DAS)						
45	201.5 d	214.6 d	210.1 d	1.11 d	1.21 d	1.18 d
60	211.3 c	224.5 c	218.5 c	1.23 c	1.29 c	1.28 c
75	224.5 b	238.7 b	233.9 ab	1.35 b	1.46 b	1.45 b
90	229.6 a	242.4 a	236.2 a	1.44 a	1.60 a	1.55 a
F-test	**	**	*	**	**	**
The second cut (106 DAS)						
45	172.3 d	184.7 d	180.2 cd	1.04 d	1.16 c	1.12 d
60	176.8 c	189.4 c	184.6 c	1.13 c	1.21 b	1.19 c
75	182.6 b	201.2 b	195.8 b	1.22 b	1.27 a	1.26 a
90	191.3 a	204.1 a	199.4 a	1.25 a	1.27 a	1.28 a
F-test	*	*	*	**	*	*
The third cut (136 DAS)						
45	113.6 d	123.4 c	120.3 d	0.63 c	0.69 c	0.68 c
60	121.4 c	131.6 b	128.6 c	0.68 b	0.79 b	0.78 b
75	126.9 b	135.5 a	132.4 b	0.74 a	0.82 a	0.80 a
90	129.4 a	137.6 a	135.3 a	0.76 a	0.84 a	0.81 a
F-test	**	*	*	*	*	*
Means over the third cuts						
45	161.8 d	172.6 d	167.8 d	0.91 d	1.01 d	0.98 c
60	168.7 c	181.9 c	176.2 c	0.98 c	1.08 c	1.05 b
75	177.1 b	190.8 b	185.1 b	1.09 b	1.17 b	1.16 ab
90	182.6 a	193.7 a	190.6 a	1.13 a	1.21 a	1.17 a
F-test	**	**	**	**	**	*

* = significant at P< 0.05 and ** = significant at P< 0.01. Means have the same letters in the same column are not significantly different at P < 0.05 level.

Table 7. Fresh and dry weight of forage sorghum as affected by nitrogen fertilizer rates at the three cuts and over them in 2006, 2007 seasons and combined analysis

N-rates ($kgNfed^{-1}$)	Fresh weight (g/plant)			Dry weight (g/plant)		
	2006	2007	Combined	2006	2007	Combined
			The first cut (60 DAS)			
45	189.6 d	199.5 d	196.1 d	23.62 d	29.41 d	28.33 d
60	201.5 c	221.7 c	213.4 c	27.53 c	38.72 c	33.62 c
75	258.9 b	262.6 b	262.6 b	36.84 a	43.46 a	42.11 a
90	261.3 a	269.5 a	266.2 a	36.17 b	42.69 b	40.55 b
F-test	**	**	**	*	*	*
			The second cut (106 DAS)			
45	128.6 d	137.7 d	134.6 d	25.63 d	31.69 d	29.18 d
60	144.3 c	159.2 c	153.7 c	29.87 c	37.43 c	35.22 c
75	171.5 b	197.5 b	186.2 b	33.37 b	43.53 a	39.25 a
90	186.5 a	190.3 a	189.3 a	34.26 a	40.39 b	38.62 b
F-test	**	**	**	**	**	**
			The third cut (136 DAS)			
45	67.8 c	75.2 d	73.4 d	14.25	19.11 d	17.36
60	69.3 c	88.7 c	80.6 c	15.67	20.29 c	18.12
75	74.5 b	97.6 b	88.2 b	15.88	20.34 bc	18.62
90	79.6 a	101.4 a	91.4 a	14.64	20.66 a	19.88
F-test	*	**	**	NS	*	NS
			Means over these cuts			
45	127.7 d	137.5 d	133.7 d	20.87 d	26.33 d	25.60 c
60	138.4 c	155.4 c	147.2 c	23.65 c	31.55 c	29.31 b
75	168.1 b	185.6 a	178.4 b	27.36 a	35.65 a	32.62 a
90	175.4 a	186.5 a	182.4 a	28.12 a	34.23 a	33.02 a
F-test	**	**	**	*	*	**

*** = significant at P< 0.05 and ** = significant at P< 0.01. Means have the same letters in the same column are not significantly different at P < 0.05 level.**

combined analysis for dry matter and at the third cut in 2006 season and combined analysis for protein percentage Table 8. Increasing nitrogen fertilizer rates from 45, 60 and 75 up to 90 kg N fed^{-1} increased dry matter percentage, where, the highest rate (90 kg N fed^{-1}) gave the highest means (21.48, 24.63 and 24.12%) at the 1^{st} , 2^{nd} and over the three cuts in combined analysis. The same positive effect of nitrogen fertilizer rates was observed on forage protein content, where, applying 90 kg N fed^{-1} gave the highest protein content (9.66 and 9.82 %) at the 1^{st} and 2^{nd} cut in combined analysis, meanwhile, adding 75 and/or 90 kg N fed^{-1} had no significant difference at the third cut in the second season (10.19 and 10.04 %, respectively). Over the third cuts, applying 90 kg N fed^{-1} overcame 45, 60 and 75 kg N fed^{-1} by 26.1, 14.3 and 6.8%, respectively in combined analysis.

Concerning to forage yield, there were highly significant effect of different nitrogen fertilizer rates on fresh, dry and protein yield at the first, second cuts and the total of the three cuts in both seasons and combined analysis Table 9. However, the effect of N-rates was not significant at the third cut in the first season for fresh, dry and protein yields and in combined analysis for fresh and dry yields. Increasing nitrogen fertilizer rate from 45 up to 90kg Nfed^{-1} increased fresh forage yield from 12.453 and 13.789 ton fed^{-1} up to 18.334 and 21.244 ton fed^{-1} at the 1^{st} cut in the 1^{st} and 2^{nd} seasons, respectively. These increases were by 58.14 % at the 2^{nd} cut in 2006 season and by 46.65 and 30.36 % at the 2^{nd} and 3^{rd} cut, respectively, in 2007 season for applying 90 kg N fed^{-1} as compared with 45 kg N fed^{-1}. That was true for dry yield, where, the highest means (1.986, 2.015 and 1.086 ton fed^{-1} in 2006 season and 3.714, 4.150 and 2.125 ton fed^{-1} in 2007 season at the 1^{st}, 2^{nd} and 3^{rd} cuts, respectively) were achieved with the highest nitrogen rate (90 kg N fed^{-1}). These superiorities for dry yield of the three cuts were by 61.61, 56.36 and 57.50 % due to applying 90 kg N fed^{-1} as compared with 45 kg N fed^{-1} in 1^{st}, 2^{nd} seasons and combined analysis, respectively. Also, protein yield increased from 0.803, 0.702 and 0.523 ton fed^{-1} up to 1.907, 1.425 and 0.763 ton fed^{-1} as nitrogen fertilizer rate increased from 45 up to 90 kg N fed^{-1} at the three respective cuts in combined analysis.

At the total of these cuts, as nitrogen rate duplicated (from 45 to 90 kg Nfed-1), protein yield duplicated (from 2.025 to 4.049 but with more nitrogen

Table 8. Dry matter and crude protein percentage of forage sorghum as affected by nitrogen fertilizer rates at the three cuts and over them in 2006, 2007 seasons and combined analysis

N-rates ($kgNfed^{-1}$)	Dry matter (%)			Crude protein (%)		
	2006	2007	Combined	2006	2007	Combined
The first cut (60 DAS)						
45	11.55 d	15.65 d	14.33 d	5.66 d	6.63 d	6.42 d
60	12.26 cd	16.85 cd	15.67 c	6.54 c	8.75 c	7.60 c
75	15.33 a	20.77 b	19.23 b	7.18 b	8.88 bc	8.21 b
90	16.87 a	23.79 a	21.48 a	8.65 a	10.49 a	9.66 a
F-test	*	**	**	**	**	**
The second cut (106 DAS)						
45	18.75	22.45 d	20.42 d	6.36 d	7.98 d	7.38 d
60	18.80	22.96 cd	21.15 cd	7.16 c	8.62 c	8.19 c
75	20.63	24.69 b	23.65 b	7.88 bc	9.77 b	9.01 a
90	22.15	26.16 a	24.63 a	8.16 a	11.33 a	9.82 a
F-test	NS	*	*	*	**	*
The third cut (136 DAS)						
45	19.11	20.19 d	20.88	8.26	9.53 c	9.03
60	21.68	21.05 cd	22.23	8.36	9.88 bc	9.62
75	23.66	22.87 bc	24.56	9.13	10.19 a	9.86
90	23.86	26.64 a	26.88	9.46	10.04 a	9.80
F-test	NS	*	NS	NS	*	NS
Means over the third cuts						
45	16.36 c	18.87 d	18.55 c	6.57 d	7.92 d	7.74 d
60	17.31 bc	19.84 cd	19.68 c	7.24 c	8.96 c	8.54 c
75	19.49 a	22.35 b	22.48 b	7.94 bc	9.47 b	9.14 b
90	20.66 a	25.23 a	24.12 a	8.54 a	10.38 a	9.76 a
F-test	*	**	*	*	**	*

* = significant at P< 0.05 and ** = significant at P< 0.01. Means have the same letters in the same column are not significantly different at P < 0.05 level.

Table 9. Fresh, dry and protein yield of forage sorghum as affected by nitrogen fertilizer rates at the three cuts and over them in 2006, 2007 seasons and combined analysis

N-rates (kgNfed^{-1})	Fresh yield (ton fed^{-1})			Dry yield (ton fed^{-1})			Protein yield (ton fed^{-1})		
	2006	2007	Combined	2006	2007	Combined	2006	2007	Combined
The first cut (60 DAS)									
45	12.453 d	13.789 d	13.119 d	1.986 d	2.388 d	2.202 d	0.706 d	0.911 d	0.803 d
60	15.664 c	15.704 c	15.678 c	2.154 c	2.724 c	2.461 c	1.021 c	1.369 c	1.188 c
75	17.776 b	19.958 b	18.861 b	3.009 b	3.102 b	3.082 b	1.273 b	1.768 b	1.546 b
90	18.334 a	21.244 a	19.778 a	3.542 a	3.714 a	3.663 a	1.581 a	2.224 a	1.907a
F-test	**	**	**	**	**	**	**	**	**
The second cut (106 DAS)									
45	8.860 d	10.314 d	9.583 d	2.015 d	2.615 d	2.319 d	0.561 d	0.819 d	0.702 d
60	10.050 c	12.175 c	11.109 c	2.325 c	3.649 c	3.036 c	0.714 c	1.041 c	0.906 c
75	13.065 b	14.379 b	13.715 b	2.797 bc	3.869 bc	3.416 b	1.024 b	1.402 b	1.228 b
90	14.011 a	15.125 a	14.561 a	3.471 a	4.150 a	3.812 a	1.141 a	1.712 a	1.425 a
F-test	**	**	*	**	**	**	**	**	**
The third cut (136 DAS)									
45	5.118	6.802 d	6.011	1.086	1.386 d	1.331	0.418	0.641 d	0.523 d
60	6.264	6.668 c	6.851	1.254	1.476 c	1.491	0.521	0.656 c	0.568 c
75	7.113	8.133 b	7.682	1.332	1.956 b	1.692	0.644	0.827 b	0.716 b
90	7.017	8.867 a	7.992	1.205	2.125 a	1.743	0.661	0.889 a	0.763 a
F-test	NS	*	NS	NS	**	NS	NS	**	**
Total of these cuts									
45	26.428 d	30.903 d	28.711 d	5.085 d	6.388 d	5.850 d	1.683 d	2.370 d	2.025 d
60	31.366 c	34.535 c	33.632 c	5.729 cd	7.846 c	6.984 c	2.254 c	3.063 c	2.661 c
75	37.946 b	42.467 b	40.255 b	7.139 b	8.896 b	8.185 b	2.93d7 b	3.992 b	3.486 b
90	39.357 a	45.233 a	42.330 a	8.218 a	9.988 a	9.214 a	3.380 a	4.816 a	4.094 a
F-test	**	**	**	*	**	**	*	**	*

* = significant at P< 0.05 and ** = significant at P< 0.01. Means have the same letters in the same column are not significantly different at P < 0.05 level.

application of 60 and 75 kg Nfed^{-1}, the increases were by 53.85 and 17.44%, respectively. These results could be due to the prominent role of nitrogen in encouraging the vegetative growth of sorghum plants through accelerating cell division and enlargement as well as increasing the photosynthetic apparatus efficiency resultant of which is more conversion of light energy to chemical energy expressed as dry matter accumulation. The encouraging role of nitrogen on vegetative growth of sorghum plants as expressed in this study by plant height, stem diameter, fresh and dry weights per plant and forage protein content resulted in increasing forage fresh, dry and protein yields per feddan at each cut. These results are in harmony with those obtained by EL-Khawaga and Geweifel (1991); Geweifel and EL-Khawaga (1991); Marei (1992); Reiad *et al.* (1995); Yousef (2002) and Al-Suhaibani (2006).

Regardless the effect of the studied factors; i.e. irrigation intervals and nitrogen fertilizer rate, forage fresh yield at the first cut surpassed evidently that of the second cut (by 39.68 and 44.32 % in 2006 and 2007 seasons, respectively) which in turn over-yielded the third cut. On the other hand, the dry forage yield of the second cut differed slightly than the first one and was nearly double that of the third cut. In combined analysis, the first cut yielded 46.53, 37.73 and 44.40 % of fresh, dry and protein yields as compared with the total fresh, dry and protein yields of the three cuts, respectively.

Effect of Interaction

The effect of irrigation intervals and nitrogen fertilizer rates interaction on growth criteria and forage yields of forage sorghum were not significant at all cuts except the forage dry weight and yield at the third cut and fresh yield at the first cut in both seasons and combined analysis Table 10. The highest means of dry weight (25.22 g/plant), fresh yield (25.639 ton fed^{-1}) and dry yield (2.061 ton fed^{-1}) were obtained when sorghum plants irrigated every 3 days and fertilized with 90 kg N fed^{-1}, while, the lowest means were 12.03 g/plant, 8.296 and 1.055 ton fed^{-1}, respectively, which were achieved by the interaction of 8-day interval and 45 kg N fed^{-1}.

Conclusion

According to the aforementioned results of this investigation, it could be recommended to irrigate forage sorghum every 3 days and applying 90 kg N fed^{-1} to gain higher forage yield under North Sinai conditions and similar areas.

Table 10. Effect of interaction between irrigation intervals and nitrogen fertilizer rate on forage dry weight and yield at the third cut and fresh forage yield at the first cut in 2006, 2007 seasons and combined analysis

Irrigation intervals (day)	N-rates (kgN/fed^{-1})	Dry weight (g/plant, at 3rd cut)			Fresh yield (ton fed^{-1}, at 1st cut)			Dry yield (ton fed^{-1}, at 3rd cut)		
		2006	2007	combined	2006	2007	combined	2006	2007	combined
3	45	19.66 d	21.86 de	20.81 d	17.451f	19.299 f	18.383 f	1.426 e	1.832 e	1.631 f
	60	20.17 c	22.05 c	21.23 c	19.643de	21.929 d	20.791 d	1.573 d	1.949 cd	1.764 cd
	75	22.84 b	24.32 b	23.61 b	22.845 b	25.608 b	24.326 b	1.987 b	2.021 b	2.011b
	90	25.06 a	25.21 a	25.22 a	24.654 a	26.612 a	25.639 a	2.037 a	2.045 a	2.061 a
5	45	14.65 ij	14.89 hi	14.81 h	12.657hi	13.889 h	13.276hi	1.116 ij	1.522 h	1.321 hi
	60	15.87 gh	17.09 fg	16.52 g	15.898 g	16.584 g	16.245 g	1.165 hi	1.731 g	1.453 g
	75	17.66 f	18.92 f	18.32 f	19.116 e	20.462 ef	19.802 e	1.576 d	1.806 f	1.695 ef
	90	17.98 ef	20.48 e	19.25 ef	20.895cd	22.115 cd	21.511 c	1.611 c	1.905 d	1.761 d
8	45	11.86 l	12.14 k	12.03 k	6.887 l	9.695 l	8.296 k	0.986 k	1.118 l	1.055 l
	60	13.34 k	13.28 jk	13.62 j	8.664 k	12.772 k	10.721 j	1.112 j	1.254 j	1.186 k
	75	13.66 jk	14.55 hi	13.84 ij	11.231 j	13.595 j	12.416 f	1.325 g	1.293 ij	1.312 i
	90	14.86 hi	16.42 g	15.68 h	12.468 ij	13.836 ij	13.157 i	1.397 f	1.175 k	1.288 j
F-test		*	*	**	**	**	**	*	**	**

* = significant at P< 0.05 and ** = significant at P< 0.01. Means have the same letters in the same column are not significantly different at P < 0.05 level.

REFERENCES

Al-Doss, A.A. 1997. Forage production in Saudi Arabia between expansion and water use conservation. First Saudi Meeting for Agric. Sciences, Proceeding, Vol. 2: 1-10.

Al-Suhaibani, N.A. 2006. Effect of irrigation intervals and nitrogen fertilizer rates on fresh forage yield of Sudangrass [*Sorghum sudanense* (Piper) Stapf.]. Res. Bult., Food Sci. & Agric. Res. Center, King Saud Univ., 142: 1-14.

A.O.A.C. 1990. Official methods of analysis. 5th ed. A.O.A.C., Washington, 25, D.C., U.S.A.

Baumhardt, R.L., R.E. Zartman and P.W. Unger. 1985. Grain sorghum response to tillage used during fallow and limited irrigation. Agron. J. 77: 643-646.

Beyaert, R.P. and C.R. Robert. 2005. Influence of Nitrogen Fertilization on Multi-Cut Forage Sorghum–Sudangrass Yield and Nitrogen Use. Agron. J. 97: 1493-1501.

Chatterjee, B.N. and P.K. Das. 1989. Forage crop production principles and practices. New Delhi: Oxford & I B H Publishing Co.

Duncan, D.B. 1990. Multiple rang and multiple F test, Biometrics, 11: 1-24.

EL-Khawaga, A.A.H. and H.G.M. Geweifel. 1991. Effect of seeding rate and nitrogen fertilization on forage sorghum 1. Growth analysis. Zagazig J. Agric. Res., 18 (6): 1805-1816.

Geweifel, H.G.M. and A.A.H. EL-Khawaga. 1991. Effect of seeding rate and nitrogen fertilization on forage sorghum 2. Forage yield and quality. Zagazig J. Agric. Res., 18 (6): 1817-1827.

Ketterings, Q.M., G. Godwin, J.H. Cherney, S. Beer and T.F. Kilcer. 2004. Nitrogen management for brown mid rib sorghum sudangrass: Results of two years of studies at the Mt. Pleasant Research Farm. What's cropping up? 14(2):5–6.

Khair, M.A. 1999. Principles Production of Forage Crops. Training and Publishing Department, Agricultural Research Committee, Sudan.

Latif, S.J. 1999. Performance of some tolerant and susceptible restorer lines of grain sorghum for drought tolerance. Egypt. J. Appl. Sci., 14 (10): 156-164.

Latif, S.J., A.E.A.A. Mourad and A.M. El-Kady. 2000. Effect of different irrigation intervals and nitrogen fertilizer rates on growth and yield of the new grain sorghum hybrid (Shandaweel-2). Egypt. J. Appl. Sci., 15 (2): 105-116.

Marei, Z.M. 1992. Effect of irrigation and nitrogen on the productivity of sorghum forage crop. Ph.D. Thesis, Fac. Agric., Minufiya Univ., Egypt.

Martin, J.H., W.H. Leonard and D.L. Stamp. 1976. Principles of Field Crop Production. Macmillan Publishing Co., Inc., New York.

Mikhiel, G.S. 1997. Productivity and quality of some forage crops as affected by nitrogen fertilization at Nubaria area: 1- Hybrid sorghum, 2- Fodder maize. J. Agric. Sci., Mansoura Univ., 22 (12): 4095-4104.

Miseha, W.I. 1983. Physiological studies on water requirements of wheat plant. Ph. D. Thesis Zagazig Univ. Fac. Agric., Moshtohor, A.R.E.

Reiad, M. Sh., M.S. EL-Hakeem, M.A. Hammada and O.M. Saida Abd Alla. 1995. Chemical content of fodder sorghum plants as infleunced by nitrogen and organic manure fertilizers under Siwa Oasis conditions. Annals Agric. Sci., Moshtohor, 33 (2): 623-635.

Snedecor, G.W. and W.G. Cochran. 1990. Statistical Methods. 8th Ed. Iowa State Univ. Iowa, USA.

Yousef, K.M.R., A.H. Ali and S.J. Latif. 1996. Response of grain sorghum to preceding crop, irrigation and nitrogen fertilization in calcareous soils. Egypt. J. Appl. Sci., 11 (12): 350-364.

Yousef, M.S.H.A. 2002. Effect of nitrogen fertilization and plant spacing on forage sorghum under new reclaimed land conditions. Agric. Res. J., Suez Canal Univ.,1: 15-22

تأثير فترات الرى ومستويات التسميد النيتروجينى على محصول الذرة الرفيعة العلفية تحت ظروف شمال سيناء

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أقيمت تجربتان حقليتان فى المزرعة التجريبية لكلية العلوم الزراعية البيئية بالعريش، جامعة قناة السويس، خلال موسمى ٢٠٠٦ و ٢٠٠٧م بهدف دراسة تأثير ثلاث فترات رى (الرى كل ٣، ٥ و ٨ يوم)، و أربعة معدلات تسميد نيتروجينى (٤٥، ٦٠، ٧٥، و ٩٠ كجم ن /ف) على محصول الذرة الرفيعة العلفية. تم إضافة السماد الآزوتى (يوريا ٤٦ % نيتروجين) على ثلاث دفعات (بعد ٢٠ يوم من الإنبات، بعد الحشة الأولى ، والحشة الثانية). استخدم تصميم القطاعات العشوائية الكاملة بنظام المنشقة مرة واحدة فى ثلاث مكررات، حيث وضعت معاملات الرى فى الوحدات التجريبية الرئيسية بينما وزعت معدلات التسميد عشوائيا فى القطع الشقية. استخدم نظام الرى بالتنقيط. تم الحصول على ثلاث حشات خلال موسم النمو بعد ٦٠، ١٠٥، و١٣٦ يوم من الزراعة. أوضحت النتائج أن أعلى القيم لجميع صفات النمو المدروسة (ارتفاع النبات، قطر الساق، الوزن الطازج والجاف للنبات، ونسبة المادة الجافة) تحققت عند الرى كل ٣ أيام فى جميع الحشات فى موسمى الزراعة ومتوسطهما، وتحقق نفس الاتجاه فى النتائج مع المحصول الأخضر والجاف ومحصول البروتين، إلا أن اكبر متوسطات لمحتوى البروتين الخام تحقق عند الرى كل ٨ أيام فى جميع الحشات، ما عدا الحشة الثالثة، حيث أدى الرى كل ٥ أيام إلى إعطاء أعلى محتوى من البروتين الخام فى موسمى الزراعة ومتوسطهما. أدت زيادة معدلات التسميد النيتروجينى من ٤٥ الى ٩٠ كجم ن/ف الى زيادة معنوية لكل الصفات الخضرية المدروسة فى جميع الحشات ومتوسطاتها فى موسمى الزراعة ومتوسطهما. أمكن الحصول على أفضل محصول علف أخضر، وجاف وبروتين عند التسميد بمعدل ٩٠ كجم ن/ف. لا يوجد تأثير معنوى للتفاعل بين فترات الرى ومعدلات التسميد النيتروجينى على كل صفات النمو والمحصول المدروسة فى كل الحشات وفى موسمى الزراعة ومتوسطهما، فيما عدا الوزن الجاف للنبات والمحصول الجاف فى الحشة الثالثة، والمحصول الغض فى الحشة الأولى فى موسمى الزراعة ومتوسطهما. ادى الرى كل ٣ أيام، والتسميد النيتروجينى بمعدل ٩٠ كجم ن/ف الى الحصول على أعلى متوسطات للصفات السابقة (٢٥,٦٣ جم/نبات، ٢٥,٦٣٩ و ٢,٠٦١ طن/ف ، على التوالى) فى متوسط الموسمين.