

Effect of Time of Nitrogen Application on Growth, Yield and Quality of Four Forage Sorghum Cultivars

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Abstract: This study was conducted to determine the effect of time of nitrogen application on the growth, yield and quality of four forage sorghum cultivars included Abusabien (*Sorghum bicolor* L. Moench), Sudangrass (*Sorghum sudanense*) and two sorghum-Sudangrass hybrids (Panar and Speedfeed). Nitrogen was applied at the rate of 80 Kg N/ha with four application regimes: (N1) Control, (N2) application of the whole dose two weeks after sowing, (N3) application of the whole dose five weeks after sowing, (N4) application of 40 Kg N ha⁻¹ two weeks after sowing + application of 40 Kg N ha⁻¹ five weeks after sowing. Parameters studied included: Plant density, plant height, number of leaves per plant, stem diameter and leaf area (LA). In addition Dry matter yield, crude protein and crude fiber contents were studied. The results showed significant differences among the cultivars for most of the studied characters while no significant differences were detected among the fertilizer treatments. In most of the counts Abusabien was superior to other cultivars in plant height, stem diameter and LA of the first crop while other cultivars were superior to Abusabien in the dry matter yield of the ratoon crop. No significant differences were detected among the cultivars in the crude protein content. The effect of time of nitrogen application was not significant on most of the growth attributes and forage yield, but early application of the whole dose seemed to increase most of the growth parameters and forage yield. Nitrogen timing significantly affected the crude protein and crude fiber contents.

Key words: Nitrogen timing, dry matter yield, crude protein, crude fiber, forage sorghum

INTRODUCTION

Forage sorghum locally known as Abusabien and the hybrids of Sudangrass with sorghum are the most common forage grasses grown in the majority of the production area in Sudan. They are primarily summer crops but are also grown during winter to bridge the forage deficit during early summer due to the lack of other suitable winter forages^[1]. The hybrids are crosses between forage type sorghum and Sudangrass, they are taller compared with Sudangrass^[2]. The hybrids response to frequent cutting is better compared to Abusabien. Khair *et al.*^[3] classified Speedfeed and Pioneer 877F as a multiple cutting genotypes due to relatively higher dry matter in the second cut compared to Abusabien.

Investigations on the essential factors that determined forage sorghum yield showed favorable responses to nitrogen fertilization^[4,5]. Lourenco *et al.*^[6] reported that the application of nitrogen fertilizer up to 100 Kg N/ha increased plant height and shoot numbers of Sudangrass. Several workers found that nitrogen application increases the forage yield^[7,8]. Han and Kim^[9] noticed that different nitrogen rates applied to the hybrid

Pioneer 988 had no effect on the second cut dry matter yield. Nitrogen alters plant composition much more than any other mineral nutrients^[10]. The dry matter yield and crude protein content of sorghum varieties have shown favorable responses to nitrogen fertilization in several experiments^[4,11-13]. Nitrogen application timing is influenced by many factors including cultivar, extended use and soil conditions^[14]. Iptas and Brohi^[15] reported that time of nitrogen application had no significant effect on the dry matter yield of sorghum-Sudangrass hybrids; however the highest crude protein was obtained with application of the whole dose at sowing. Malhi *et al.*^[16] found that single application of nitrogen gave the higher dry matter yield of smooth Broomegrass compared to split application. Oral and Acikgos^[17] reported that the total clipping weights of Turfgrass mixture from single nitrogen application was greater compared with splitting the fertilizer.

There is a considerable interest in the time of nitrogen fertilization required to maximize the total forage yield and at the same time enhance the quality of the forage, however no evidence for optimum time of nitrogen application at which higher forage yield and quality

can be obtained. Thus the main objective of this study is to evaluate the response of different cultivars of forage sorghum to the time of nitrogen application.

MATERIALS AND METHODS

This study was carried out in 2003; at Shambat, Sudan (Latitude 15° 40'-N, Longitude 32° 32'-E). The soil of the experimental site was cracking clay with about 50% clay with a pH of 8.0. It contains 0.065% N, 0.230 Meq/L K and 0.193 Meq/L P. The growing period of the cultivars was four months from June to October. The average temperature for the study period was 31.4°C and the average relative humidity was 54.2%. A total precipitation of 288.1 mm was recorded during the growing period.

The soil was disc ploughed, disc harrowed, leveled and ridged. Ridges spacing was 70 cm. Four forage sorghum cultivars were used included Abusabien (*Sorghum bicolor* L. Moench), Sudangrass (*Sorghum sudanense*) and two Sorghum X Sudangrass hybrids, which were Panar and Speedfeed. Treatments were arranged in a split plot design with four replications. The plot size was 4 X 3 m each composed of four ridges. The seeding rate was 48 Kg/ha in case of Abusabien, Panar and Speedfeed while 24 Kg/ha were used in case of Sudangrass. Seeds were sown in rows in the eastern side of the ridge on 24th of June 2003. Then the crops were irrigated immediately after sowing and then at intervals of 10-12 days.

All nitrogen treatments were applied at the rate of 80 Kg N/ha in the form of urea with four applications regimes: Control [N1, no nitrogen], 80 Kg N/ha two weeks after sowing [N2], 80 Kg N/ha five weeks after sowing [N3] and (40 Kg N/ha two weeks after sowing + 40 Kg N/ha five weeks after sowing) [N4].

Ten plants were randomly selected from the middle ridges of each individual plot for determining plant height, number of leaves per plant, stem diameter and leaf area. A vernier was used to determine the stem diameter.

One meter length from each of the two middle ridges was harvested and then air dried to estimate the dry matter yield. Crude protein was determined by the Kjeldahl method while the crude fiber was determined according to the AOAC^[18]. After the first cut the crops were allowed to regrow for ratoon crop. Irrigation intervals were 10-12 days. Harvesting was carried out six weeks after the first cut and the dry yield was obtained.

Data were analyzed using ANOVA and means were separated using Least Significant Difference (LSD) at the $p = (0.05)$ level.

RESULTS AND DISCUSSION

Effect of nitrogen and nitrogen timing on the growth parameters: The study showed that the effect of nitrogen and time of nitrogen application on the plant population was not significant (Table 1). This indicates that the fertilizer had no significant effect on the germination percentage. This result is in line with the finding of^[19], who observed that application of nitrogen did not influence the plant population of Abusabien and Pioneer 988. Iptas and Brohi^[15] confirmed the formal result. The plant height was not affected by time of nitrogen application (Table 2). Similar result was reported by^[20]. On the other hand plant height was significantly affected by the application of nitrogen compared to control at the age of ten weeks (Table 2). Lourenco *et al.*^[6] reported similar result. This result may be due to the fact that nitrogen promotes plant growth and increases the number and length of the internodes which result in progressive increase in plant height.

Nitrogen and time of nitrogen application did not significantly affect the number of leaves per plant (Table 2). This was probably attributable to the genetic factor which controls the number of leaves per plant. As shown in (Table 2), stem diameter did not significantly affected by the time of nitrogen application. This may be due to the high plant density of the forage which leads to more tillers per plant that act as more sinks rather than increasing the stem diameter. The results also showed that all nitrogen treatments were significantly increased the leaf area over the control (Table 2). The result could be due to the fact that nitrogen enhances growth and consequently leaf expansion and development or may be explained by the confirmed evidence that nitrogen increases the leaf duration and so consequently increases the leaf area. Supporting evidence of the positive effect of nitrogen application on the leaf area was reported by^[21], however nitrogen timing effect on the leaf area was not significant.

Varietal differences: The results showed significant differences among the cultivars in number of plants per unit area. The cultivars Panar and Speedfeed were significantly outnumbered Abusabien which recorded the least number of plants per unit area (Table 1). The high plant population of the hybrids probably due to the small size of their seeds which reflected in greater number of seeds sown per unit area compared to Abusabien. Abusabien gave the tallest plants, largest stem diameters and largest leaf areas compared to other cultivars (Table 2). The decrease in the plant height of the hybrids compared to Abusabien which was observed in this study was associated with the increase in the plant population

Table 1: Effect of time of nitrogen application and cultivars on plant population

Time of N application	No. of plants/m ²	Cultivars	No. of plants/m ²
N1	87.38 a	Abusabien	62.25 c
N2	97.75 a	Sudangrass	99.88 a
N3	78.56 a	Panar	105.56 a
N4	85.44 a	Speedfeed	81.44 b
LSD (0.05)	NS	LSD (0.05)	14.35

* Means within columns followed by the same letters are not significantly different at 5% level using LSD test. * LSD (0.05) = Least significant difference at 5% level. * NS= Not significant

Table 2: Effect of time of nitrogen application and cultivars on the growth parameters at the age of ten weeks

Treatments	Plant height (cm)	No. of leaves per plant	Stem diameter (mm)	Leaf area (cm ²)
Time of Nitrogen application				
N1	161.10 b	13.11 a	8.63 a	161.01 b
N2	182.34 a	15.51 a	9.56 a	188.87 a
N3	165.94 ab	17.55 a	10.34 a	209.86 a
N4	184.63 a	15.48 a	9.26 a	191.01 a
LSD (0.05)	18.82	NS	NS	22.16
Cultivars				
Abusabien	182.66 a	13.21 b	14.38 a	286.34 a
Sudangrass	168.14 b	19.88 a	6.67 d	124.36 d
Panar	170.28 b	14.35 b	7.77 c	152.94 c
Speedfeed	172.93 ab	14.21 b	8.98 b	187.10 b
LSD (0.05)	10.32	2.39	1.05	18.80

* Means within columns followed by the same letters are not significantly different at 5% level using LSD test. * LSD (0.05) = Least significant difference at 5% level. * NS= Not significant

Table 3: Effect of time of nitrogen application and cultivars on the dry matter yield (tons/ha) of the first crop and the ratoon

Treatments	First crop dry matter yield (tons/ha)	Ratoon dry matter yield (tons/ha)
Time of Nitrogen application		
N1	5.80 b	5.54 a
N2	8.29 a	6.05 a
N3	7.67 a	6.74 a
N4	7.37 b	5.94 a
LSD (0.05)	1.65	NS
Cultivars		
Abusabien	8.32 a	5.07 c
Sudangrass	6.47 a	7.16 a
Panar	7.57 a	6.02 b
Speedfeed	6.77 a	6.00 b
LSD (0.05)	NS	0.48

* Means within columns followed by the same letters are not significantly different at 5% level using LSD test. * LSD (0.05) = Least significant difference at 5% level. * NS= Not significant

of the hybrids. This could be attributed to the competition among the plants at high density for moisture and nutrients. On the other hand the hybrids were taller than Sudangrass; this result is in conformity with^[2]. Significant differences in the number of leaves per plant were recorded among different cultivars (Table 2). The ranking order regarding the number of leaves per plant were Sudangrass followed by Speedfeed, Panar and Abusabien.

Dry matter yield: The results revealed that nitrogen treatments increased the forage dry matter yield significantly over the control by 30% for (N2), 24.4% for (N3) (Table 3). This is probably attributed to the fact that nitrogen increases the photosynthetic capacity of the plants which enhances growth. This result is in conformity with the finding of^[5,11]. On the other hand nitrogen application did not affect the dry matter yield of the ratoon crop (Table 3). Such result might be

attributable to the fact that nitrogen is rapidly hydrolyzed and taken up by the roots so the residual effect of nitrogen in the ratoon crop was not expected. The dry matter yield was not affected by nitrogen timing. A similar response was observed by^[22] in Rice and^[23] in Wheat.

No significant differences were detected among the cultivars for the dry matter yield of the first crop, while highly significant differences were detected among the cultivars for the ratoon dry matter yield (Table 3). Sudangrass exhibited the highest dry matter yield of the ratoon crop, it produced 7.16 tons/ha. The least production in the ratoon crop was obtained by Abusabien which produced 5.07 tons/ha. This conclusion was also reached by^[24] and^[2] who found that ratooning of forage sorghum throughout the whole year is very poor.

Forage quality: The forage quality was determined in terms of crude protein and crude fiber contents. The effect of time of nitrogen application was highly significant on

Table 4: Effect of time of nitrogen application and cultivars on crude protein and crude fiber contents

Treatments	Crude protein %	Crude fiber %
Time of Nitrogen application		
N1	4.04 c	24.14 a
N2	6.14 a	23.35 b
N3	5.12 b	24.17 a
N4	3.80 c	20.60 c
LSD (0.05)	0.62	0.25
Cultivars		
Abusabien	4.80 a	22.70 b
Sudangrass	4.82 a	23.66 a
Panar	4.81 a	23.99 a
Speedfeed	4.61 a	22.31 b
LSD (0.05)	NS	0.79

* Means within columns followed by the same letters are not significantly different at 5% level using LSD test. * LSD (0.05) = Least significant difference at 5% level. * NS= Not significant

both crude protein and crude fiber contents (Table 4). Application of the whole dose two weeks from sowing resulted in the highest crude protein content, while the late application 35 days from sowing showed the highest crude fiber content. The increase in the crude protein content due to nitrogen application compared to control was attributed to the role played by nitrogen in protein synthesis. The positive response of nitrogen on the crude protein content has been obtained by many investigators^[5,25,26].

The crude protein content of the four cultivars was not significantly different (Table 4). This result is in line with the finding of^[24], who found non significant differences among the cultivars Abusabien, Pioneer 988 and Pioneer 877F in the crude protein content.

CONCLUSION

From the results obtained in this study it can be concluded that, generally time of nitrogen application does not affect the growth attributes and the forage yield of forage sorghum. However nitrogen is very essential for forage sorghum production. For the cultivars the data indicate that Sudangrass and (Sorghum X Sudangrass) hybrids are much suitable for multiple cutting systems. Abusabien in contrast is better suited for single cutting system.

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