

## Yield and quality of multi-cut forage sorghum (*Sorghum sudanense*) as influenced by integrated nitrogen management

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### ABSTRACT

An experiment was conducted at Anand during rainy (*kharif*) season of 2004 and 2005 to study the effect of integrated N management on yield and quality of multi-cut forage sorghum (*Sorghum sudanense* L.). Application of 75 kg N through urea + 25 kg N/ha through farmyard manure (FYM) recorded significantly higher green-forage, dry-matter and crude-protein yields than other treatments, except application of 75 kg N through urea + 25 kg N/ha through castor cake. The increase was 11.1 - 18.6% in dry-matter yield and 19.4 - 20.0% in crude-protein yield over application of 100 kg N/ha through urea. Application of 50 kg N through FYM + 50 kg N/ha through castor cake was significantly inferior in forage production and was poor in quality as evident from low crude-protein yield and higher neutral detergent fibre (NDF) content. The maximum green-forage, dry-matter and crude-protein yields of forage sorghum were recorded under *Azotobacter* + *Azospirillum* inoculation compared with their individual inoculation or no inoculation of biofertilizer, but the effect on green-forage yield was non-significant. The maximum NDF content was recorded under no biofertilizer treatment, which was significantly higher than other treatments except *Azospirillum* inoculation. The application of 75 kg N through urea + 25 kg N/ha through castor cake along with *Azospirillum* inoculation was found superior in forage quality and recorded maximum crude-protein yield.

**Key words:** Crude-protein, Forage yield, Integrated N management, Multi-cut forage sorghum

The ill-effects of chemical fertilizers on soil health, energy crisis, prohibitive cost of chemical fertilizers and poor purchasing power of small and marginal farmers restrict the use of this vital input. Most of the nitrogen supply to the plants is given through chemical fertilizers in India, where the N is released rapidly and may not be taken up by the crop plants at the same rate and it also becomes unavailable, perhaps due to volatilization and leaching losses (Dahima *et al.*, 1999). The organic manures are natural sources of nutrients and their inclusion, such as that of farmyard manure (FYM) and non-edible cake, and use of biofertilizers in fertilizer management has become a necessity to improve the soil fertility and to sustain crop productivity. Non-symbiotic bacteria like *Azotobacter* and *Azospirillum* are potential biofertilizers capable of contributing N to a number of non-legume crops by trapping aerial reservoir. Activity of these micro-organisms may be influenced by the supply of nutrient like N through organic and inorganic sources. The continuous use of high level of chemical fertilizer is adversely affecting the sustainability of agricultural production and may cause environmental pollution (Virmani, 1994). Therefore, the

present study was undertaken to find out the efficient combination of organic and inorganic fertilizers for multi-cut forage sorghum under middle Gujarat condition.

### MATERIALS AND METHODS

A field experiment was conducted at Main Forage Research Station, Anand Agricultural University, Anand during rainy (*kharif*) season of 2004 and 2005 on loamy-sand soil. The experiment was conducted at different sites during both the years, having neutral pH (7.67) and electrical conductivity (0.25 dS/m). The soil was low in organic C (0.28%), available N (145 kg/ha), high in available P (43.6 kg/ha) and medium in available K (279.3 kg/ha).

A split-plot design was followed with three replications. There were six treatments of N management in main plots, viz. 100 kg N/ha through urea; 75 kg N through urea + 25 kg N/ha through farmyard manure (FYM); 75 kg N through urea + 25 kg N/ha through castor cake; 50 kg N through urea + 50 kg N/ha through FYM; 50 kg N through urea + 50 kg N/ha through castor cake; and 50 kg N through FYM + 50 kg N/ha through castor cake; and in the subplots were four levels of biofertilizer treatments, viz. no biofertilizer inoculation; *Azotobacter chroococcum*

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(ABA-1) inoculation; *Azospirillum lipoferum* (ASA-1) inoculation; and *Azotobacter chroococcum* (ABA-1) + *Azospirillum lipoferum* (ASA-1) inoculation. The plot size was 5.0 x 4.0 m.

The crop was fertilized with N through FYM, castor cake and urea as per the respective treatments of recommended N dose (100 kg N/ha), whereas the common basal dose of 17.5 kg P/ha was applied in all the treatments in the form of single superphosphate. Well-decomposed farmyard manure (FYM) (0.5% N on dry-weight basis) and castor cake (4.1% N) were applied as per treatment before sowing and incorporated into the soil, whereas urea was applied in furrows at the time after sowing. Nitrogen from urea source was given 25% each as basal, 30 days of sowing (DAS), and after first and second cut. The seeds of forage sorghum variety 'SSG 59-3' were treated with biofertilizers as per treatment and sown at a distance of 25 cm between the rows, using the seed rate 30 kg/ha in first and third weeks of July during 2004 and 2005, respectively. The crop received total rainfall 790.2 mm in 2004 and 752.2 mm in 2005 during the crop-growth season, and 9 and 7 irrigations were given as per the requirement.

Three cuts were taken for green-forage during both the years. The first cut was taken at 60 days after sowing, the second at 50 days after first cut and the third at 50% flowering stage. The plant samples were analysed for N content and the crude-protein content was worked out by multiplying it with 6.25, whereas neutral detergent fibre (NDF) content was determined using standard analytical procedure.

## RESULTS AND DISCUSSION

### Green-forage yield

Application of 75 kg N through urea + 25 kg N/ha through FYM produced significantly higher total green-forage yield of 56.7 t/ha during 2005 compared with other treatments except 75 kg N through urea + 25 kg N/ha through castor cake. Application of 50% N each from FYM and castor cake registered the lowest total green-forage yield of 48.6 t/ha in 2005 but it was on a par with treatments of 100 kg N through urea, 50 kg N through urea + 50 kg N through FYM and 50 kg N through urea + 50 kg N/ha through castor cake. Similar trend of N management was also observed during 2004, but the differences in green-forage yield were non-significant (Table 1).

The increase in total green-forage yield due to application of 75 kg N through urea + 25 kg N/ha through FYM was 10.31% over 100 kg N/ha through urea during 2005. However, the full amount of N provided through organic sources resulted in low yield due to slow mineralization, and the deficiency of N at growing period may be due to increase in C : N ratio. The great increase in forage yield

with an application of 75 kg through urea + 25 kg N/ha through FYM might be due to availability of N from urea along with the mineralization of N from organic manure, which is a slow process that provides N during the crop requirement at later stage, increasing the photosynthetic activity ultimately and resulting in production of more photosynthates. These results support those of Patidar and Mali (2002), and Singh and Kang (2005).

The green-forage yield of forage sorghum was not affected significantly due to biofertilizer treatments during 2004 and 2005. However, treatment of *Azotobacter* + *Azospirillum* inoculation recorded the maximum green-forage yield except in first cut during 2004 and no biofertilizer inoculation treatment gave the minimum green-forage yield except in first cut during 2004 and 2005 (Table 1).

### Dry-matter yield

The dry-matter yield was significantly affected due to nitrogen management during both the years (Table 2). Application of 75 kg N through urea + 25 kg N/ha through FYM and 75 kg N through urea + 25 kg N/ha through castor cake, being at par, gave significantly higher total dry-matter yield than that of 100 kg N/ha through urea and 50 kg N through FYM + 50 kg N/ha through castor cake during 2004 and 2005 and the increase was 11.1 and 18.6%, respectively compared with that of 100 kg N/ha through urea. The treatment of 50 kg N through FYM + 50 kg N/ha through castor cake recorded significantly lower total dry-matter yield than that of 50 kg N through urea + 50 kg N/ha through FYM during 2005 and of 50 kg N through urea + 50 kg N/ha through castor cake during 2004. The increase in dry-matter yield with organic manure was due to continuous supply of essential plant nutrients caused by continuous mineralization of organic manures, enhanced inherent nutrient-supplying capacity of the soil and their favourable effect on biological properties of the soil, which increased the forage yield of sorghum. (Hati *et al.*, 2001), Ghosh *et al.* (2003) and Kumar *et al.* (2005) also reported similar results.

Inoculation with *Azotobacter* + *Azospirillum* produced significantly higher total dry-matter yield (15.56 t/ha) during 2005 compared with no biofertilizer inoculation, but it was on a par with inoculation with *Azospirillum* alone. The lowest dry-matter yield was obtained under the treatment of no biofertilizer inoculation. Inoculation with *Azotobacter* + *Azospirillum* gave 7.01% higher dry-matter yield compared with no biofertilizer inoculation (Table 2). This increase could be attributed to the extra supply of N to the crop through their combined inoculation than no inoculation as well as individual inoculation. This finding closely supports the results of Singh *et al.* (2005).

The interaction effect was found significant for green-forage yield as well as total dry-matter yield during 2005 (Table 3). The treatment combination of 75 kg N through urea + 25 kg N/ha through FYM along with *Azotobacter* + *Azospirillum* inoculation recorded the highest total green-forage yield of three cuts (61.9 t/ha), and gave significantly higher total dry-matter yield (18.30 t/ha) over 100 kg N/ha through urea along with no biofertilizer inoculation, which was 37.2% more. Application of 100 kg N/ha through urea along with *Azotobacter* inoculation registered the lowest values of green-forage and dry-matter yields.

The increase in yield under treatment combination of 75 kg N through urea + 25 kg N/ha through FYM along with *Azotobacter* + *Azospirillum* inoculation was 15.9% compared with that under 100 kg N/ha through urea with out biofertilizer inoculation. This could be attributed to the decomposition of organic manure, which produced growth hormones and various organic acids, and increased the nitrogenase activity and carbon for the growth and activity of micro-organisms. These results are in agreement with the findings of Patidar and Mali (2004). The increase in total dry-matter yield with integrated N management might be due to increased N involved in increas-

**Table 1.** Green-fodder yield (t/ha) of forage sorghum as influenced by N management and biofertilizer inoculation

Treatment	2004				2005			
	I cut	II cut	III cut	Total	I cut	II cut	III cut	Total
<i>N management</i>								
100 kg N/ha through urea	19.8	17.7	13.1	50.7	28.9	12.4	10.2	51.4
75 kg N through urea + 25 kg N/ha through FYM	20.9	18.9	13.8	53.6	31.9	14.3	10.5	56.7
75 kg N through urea + 25 kg N/ha through castor cake	21.3	18.0	13.6	52.9	31.0	13.7	10.1	54.9
50 kg N through urea + 50 kg N/ha through FYM	19.4	17.1	13.0	49.5	28.6	13.3	9.2	51.1
50 kg N through urea + 50 kg N/ha through castor cake	20.5	18.0	13.3	51.8	28.0	12.7	10.2	50.9
50 kg N through FYM + 50 kg N/ha through castor cake	19.9	16.0	11.4	47.3	27.0	12.8	8.8	48.6
SEm±	0.8	0.6	0.7	1.5	0.8	0.5	0.5	1.0
CD (P=0.05)	NS	NS	NS	NS	2.5	NS	NS	3.1
<i>Biofertilizer inoculation</i>								
No inoculation	20.3	17.5	12.7	50.5	28.7	12.9	9.4	51.0
<i>Azotobacter</i>	20.8	17.6	13.1	51.4	28.5	13.3	9.9	51.8
<i>Azospirillum</i>	19.6	17.6	13.0	50.2	29.7	13.2	10.0	52.9
<i>Azotobacter</i> + <i>Azospirillum</i>	20.6	17.8	13.3	51.7	29.9	13.3	10.0	53.3
SEm±	0.5	0.4	0.3	0.7	0.5	0.4	0.2	0.8
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

**Table 2.** Dry-matter, crude-protein yield and NDF content of forage sorghum as influenced by N management and biofertilizer inoculation

Treatment	Dry-matter yield (t/ha)		Crude-protein yield (t/ha)		NDF content (%)	
	(total of 3 cuts)		(total of 3 cuts)			
	2004	2005	2004	2005	2004	2005
<i>N management</i>						
100 kg N/ha through urea	13.43	14.07	1.24	1.40	75.08	76.29
75 kg N through urea + 25 kg N/ha through FYM	14.92	16.68	1.45	1.68	73.11	74.37
75 kg N through urea + 25 kg N/ha through castor cake	14.86	16.50	1.48	1.59	73.06	75.46
50 kg N through urea + 50 kg N/ha through FYM	13.27	15.33	1.16	1.39	75.28	76.32
50 kg N through urea + 50 kg N/ha through castor cake	14.18	14.24	1.32	1.37	74.44	75.96
50 kg N through FYM + 50 kg N/ha through castor cake	12.36	13.20	1.11	1.21	75.94	77.09
SEm±	0.45	0.38	0.04	0.04	0.46	0.64
CD (P=0.05)	1.41	1.19	0.13	0.14	1.44	NS
<i>Biofertilizer inoculation</i>						
No inoculation	13.51	14.54	1.21	1.34	75.76	76.83
<i>Azotobacter</i>	14.17	14.66	1.32	1.39	74.06	75.46
<i>Azospirillum</i>	13.60	15.26	1.26	1.51	74.65	76.29
<i>Azotobacter</i> + <i>Azospirillum</i>	14.07	15.56	1.39	1.53	73.48	75.09
SEm±	0.21	0.27	0.03	0.03	0.47	0.4
CD (P=0.05)	NS	0.77	0.08	0.09	1.33	NS

ing the protoplasmic constituents and accelerating the process of cell division and elongation, which in turn gives luxuriant vegetative growth for higher dry-matter.

### Crude-protein yield

Nitrogen management had significant influence on crude-protein yield (Table 2). Significantly higher crude-protein yield was recorded under application of 75 kg N through urea + 25 kg N/ha through FYM (1.68 t/ha) during 2005, and under treatment of 75 kg N through urea + 25 kg N/ha through castor cake (1.48 t/ha) during 2004 compared with 100 kg N/ha through urea. Both the treatments having 75 kg N through urea + 25 kg N/ha through FYM and 75 kg N through urea + 25 kg N/ha through castor cake were found at par, giving 20.0 and 19.4% higher yield respectively compared with 100 kg N/ha through urea. These results confirm the findings of Sadhu *et al.* (1990). The treatment of *Azotobacter* + *Azospirillum* inoculation registered significantly higher total crude-protein yield during 2004 and 2005 compared with no biofertilizer inoculation (Table 2). This increase could be ascribed to increased dry-matter yield. The results are in line with the findings of Kumar and Sharma (2002).

The interaction effect of N management and

biofertilizer treatments on crude-protein yield was found significant during 2004 and 2005 (Table 4). The treatment combination 75 kg N through urea + 25 kg N/ha through castor cake along with *Azospirillum* inoculation gave the maximum crude-protein yield (1.67 t/ha) during 2004, and that 75 kg N through urea + 25 kg N/ha through FYM along with *Azospirillum* inoculation gave maximum crude-protein yield (1.85 t/ha) during 2005 compared with 100 kg N/ha through urea along with no biofertilizer inoculation, which produced the lowest crude-protein yield.

The appreciable increase in total crude-protein yield recorded with combined effect of nitrogen management and bio-fertilizer inoculation under treatment combinations 75 kg N through urea + 25 kg N/ha through castor cake along with *Azospirillum* inoculation and 75 kg N through urea + 25 kg N/ha through FYM along with *Azospirillum* inoculation as compared with the control during 2004 and 2005 was 38.2 and 54.2%, respectively.

### Neutral detergent fibre content

Nitrogen management significantly influenced the neutral detergent fibre (NDF) content during 2004 (Table 2). Application of 50 kg N through FYM + 50 kg N/ha through castor cake recorded the maximum NDF content

**Table 3.** Interaction effect of N management and biofertilizer inoculation on total green-fodder yield (t/ha) of forage sorghum during 2005

N management	Biofertilizer inoculation			
	No inoculation	<i>Azotobacter</i>	<i>Azospirillum</i>	<i>Azotobacter</i> + <i>Azospirillum</i>
100 kg N/ha through urea	53.4 (13.33)	46.8 (12.38)	52.4 (14.28)	53.0 (16.28)
75 kg N through urea + 25 kg N/ha through FYM	53.8 (15.70)	52.8 (15.30)	58.1 (17.43)	61.9 (18.30)
75 kg N through urea + 25 kg N/ha through castor cake	52.8 (15.62)	55.4 (16.00)	59.2 (18.16)	52.1 (15.33)
50 kg N through urea + 50 kg N/ha through FYM	49.4 (15.92)	54.3 (15.02)	48.1 (14.57)	52.6 (15.80)
50 kg N through urea + 50 kg N/ha through castor cake	49.3 (13.67)	51.3 (15.08)	51.4 (14.13)	51.6 (14.08)
50 kg N through FYM + 50 kg N/ha through castor cake	47.5 (12.98)	50.2 (13.28)	48.2 (12.96)	48.6 (13.59)
CD (P=0.05)			5.33 (1.89)	

Figures in parentheses indicate total dry matter yield (t/ha) of forage sorghum

**Table 4.** Interaction effect of N management and biofertilizer inoculation on total crude protein yield (t/ha) of forage sorghum

N management	2004				2005			
	No inoculation	<i>Azotobacter</i>	<i>Azospirillum</i>	<i>Azotobacter</i> + <i>Azospirillum</i>	No inoculation	<i>Azotobacter</i>	<i>Azospirillum</i>	<i>Azotobacter</i> + <i>Azospirillum</i>
100 kg N/ha through urea	1.20	1.15	1.11	1.47	1.20	1.13	1.47	1.78
75 kg N through urea + 25 kg N/ha through FYM	1.36	1.40	1.49	1.56	1.51	1.55	1.85	1.80
75 kg N through urea + 25 kg N/ha through castor cake	1.37	1.46	1.67	1.41	1.43	1.62	1.84	1.46
50 kg N through urea + 50 kg N/ha through FYM	1.10	1.34	0.91	1.29	1.36	1.30	1.33	1.53
50 kg N through urea + 50 kg N/ha through castor cake	1.30	1.47	1.24	1.25	1.30	1.49	1.31	1.36
50 kg N through FYM + 50 kg N/ha through castor cake	0.92	1.07	1.10	1.35	1.19	1.21	1.19	1.22
CD (P=0.05)		0.20				0.21		

(75.9%), but it was on a par with that of 100 kg N/ha through urea and 50 kg N through urea + 50 kg N/ha through FYM treatments during 2004. The lowest NDF content was observed under 75 kg N through urea + 25 kg N/ha through castor cake during 2004 and under 75 kg N through urea + 25 kg N/ha through FYM during 2005, indicating improvement in fodder quality by these treatments.

The NDF content was significantly influenced due to biofertilizer treatments during 2004 only. Maximum NDF content (75.8%) was recorded under no bio-fertilizer inoculation treatment and the lowest NDF content (73.5%) was recorded under *Azotobacter* + *Azospirillum* inoculation, the later being on a par with *Azotobacter* inoculation treatment, indicating better quality of fodder. The reduction in NDF content and thereby improvement in fodder quality under optimum organic and inorganic nitrogen sources might be due to the increase in succulence. The increased content of NDF in the plant under 50 kg N through FYM + 50 kg N/ha through castor cake and no bio-fertilizer inoculation treatment reduced the palatability.

The present study clearly indicates that the application of 75 kg N through chemical fertilizer + 25 kg N/ha through FYM or castor cake along with seed inoculation with *Azotobacter chroococcum* (ABA-1) + *Azospirillum lipoferum* (ASA-1) improved the fodder quality and gave maximum forage production of multi-cut forage sorghum in sandy-loam soils under middle Gujarat conditions.

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