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Varietal Response to Graded Levels of Nitrogen and Bio-fertilizers on Forage Yield of Sorghum (*Sorghum bicolor* L. Moench) during the Summer Season

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A field experiment was conducted at the Main Forage Research Station, Anand Agricultural University, Anand, to find out the "Varietal Response to Graded levels of Nitrogen and Bio-fertilizers on forage yield of Sorghum (*Sorghum bicolor* L. Moench) during summer season" of 2011. It was laid out in split-plot design with four replications, two varieties of sorghum (S-1049 and GFS-5), were relegated in the main plots and combinations of nitrogen levels 25, 50 and 75 kg N ha^{-1}) and two levels of bio-fertilizers (inoculation and uninoculated) treatments were assigned to the sub-plots. Based on the research investigation, it was found that the application of nitrogen at 75 kg ha^{-1} produced significantly higher green forage, dry matter and crude protein yields. The higher NDF content recorded in 25 kg N ha^{-1}**.** HCN content in forage sorghum was significantly higher with 75 kg N ha^{-1} (N_1). Application of bio-fertilizers (B_1) recorded significantly higher green forage, dry matter and crude protein yields than no bio-fertilizer treatment (B_2), while bio-fertilizers inoculation failed to exhibit their significant influence on NDF content and HCN content of forage sorghum. The interaction effect between varieties, nitrogen levels and bio-fertilizers was found not significant concerning growth and yield attributes. The variety GFS-5 recorded a higher net realization of 33978 Rs. ha^{-1} and higher B.C.R. values of 2.31. Application of 75 kg N ha^{-1} resulted in higher net realization (Rs. 26605 ha^{-1}) with B.C.R. of 1.77. Inoculation of *Azotobacter* and *Azospirillum* resulted in maximum net realization (Rs.25852 ha^{-1}) with B.C.R. of 1.75. The maximum net realization of Rs. 36877 ha^{-1} with B.C.R. of 2.44 was obtained in treatment combination $V_2N_3B_1$.

Introduction

Livestock is becoming agriculture's most economically important sub-sector. "It contributes 25 percent to the total agricultural income. Milk production has shown an average compound annual growth rate of almost 4.5 percent (Ravishankar, 2008). The low productivity is mainly due to inadequate supplies of quality feeds and fodders.

The livestock population of India is around 500 million and is expected to grow at the rate of 1.23 percent in the coming years. To meet this challenge, concentrated efforts are to be made for reducing the large gap between the demand and supply of fodder in the country. In animal feed supply, cereals have a major role and four major kinds of cereal viz. maize, barley, sorghum and pearl millet account for about 44 percent of the total cereals fodder production.

"At present, the country faces a net deficit of 61.1 percent green fodder and 21.9 percent dry fodder. This situation indicates green forage supply has to grow at 3.2 percent to meet the deficit" (Kumar and Faruqui, 2010). Gujarat state has a total animal population of 18.44 million heads and their total fodder requirement worked out is 42.2 million tonnes, whereas only 20.0 million tonnes of fodder is made available in a normal year. Thus, the state is not only short of quantity but quality fodder also.

As a result, livestock suffers continuously from malnutrition year-round in general, resulting in their production capacity at a sub-optimum level. It is, therefore, very essential to maximize quality and forage production per unit area and time. Cereal fodders and crop residues are major sources of forage but the nutritive value of these fodders is not adequate to achieve higher milk production.

Sorghum is the most important, widely adaptable and extensively grown as a fodder crop, which occupies about 52% of the total cultivated area under forage crops in Gujarat state (Yadavendra *et al.,* 2003). Owing to its quick regrowth, better nutritive value, high productivity and drought tolerance, forage sorghum alone is capable of giving continuous fodder supply for a long period among the cereal forage crops. Production can be increased by adopting improved packages including suitable varieties and an appropriate rate of fertilization.

Chemical fertilizers play an important role in fodder crop production. Nitrogen improves the quality by increasing the protein content of fodder crops and governs to a considerable degree, the utilization of protein, phosphorus and other elements. Ram and Singh (2003) also noted that nitrogen application to forage sorghum significantly increased the nitrogen uptake, leaf: stem ratio, crop growth rate, relative growth rate as well as the forage and crude protein yields of forage sorghum. The use of bio-fertilizers can have greater importance in increasing the availability of nutrients, fertilizer use efficiency and microbial biomass. Bio-fertilizers play an important role in the increasing availability of nitrogen and phosphorus. They increase the biological fixation of atmospheric nitrogen and enhance the availability to crop. Therefore, the introduction of an efficient strain of "*Azotobacter* and *Azospirillum* in the soil which is poor in nitrogen may help boost production and consequently more nitrogen fixation. *Azospirillum* inoculation increases the green and dry fodder yield varying from 7.8 to 11.3 percent (Kumar and Sharma, 2002).

With this background, a field trial was undertaken to study the “Varietal Response to Graded levels of Nitrogen and Biofertilizers on forage yield of Sorghum (*Sorghum bicolor* L. Moench) during the summer season” at Main Forage Research Station, Anand Agricultural University, Anand during the summer season of the year 2011. The present investigation has the following objectives.

To evaluate a suitable variety of sorghum for forage in Middle Gujarat conditions in the summer season, to find out the nitrogen requirement of forage sorghum, and to study the impact of bio-fertilizers on forage sorghum.

Materials and Methods

A field experiment was conducted during the summer season of the year 2011 in Plot No.J-4 at Main Forage Research Station, Anand Agricultural University, Anand, Gujarat. The average annual rainfall of this region is about 850 mm. April and May are the hottest months with the temperature rising as high as 45^{o}C and occasionally touching 48°c.

The Physico-chemical properties of the experimental plot were determined by drawing representative soil samples from 0-15 cm depth and analyzed for physical and chemical properties of soil. The values of soil analysis along with methods are furnished in Table 1 indicating that the soil of the experimental plot was low in available nitrogen, medium in available phosphorus and available potash.

Treatment detail

Fertilizer application

The crop was fertilized as per respective treatments i.e. 25, 50 and 75 kg N ha-l in the form of urea. The full dose of phosphorus (SSP) and half dose of nitrogen in the form of urea was applied as basal dose at the time of land preparation and the remaining 50 % quantity of nitrogen was applied as top dressing at 30 DAS as per treatment. Seeds treated with *Azotobacter+ Azospirillum* liquid biofertilizers @ 5 ml/kg of seed at the time of sowing.

To carry out the experiment the land preparation operation Seeds and sowing Irrigation Weeding and intercultural operations were done. Yield attributing parameters were recorded during the different growth stages and at the time of harvest. Biometric observations were recorded as:

Initial and final plant population

The initial plant population was recorded at 15 DAS from randomly selected and tagged five sites of one-meter row length in a net plot and the mean values were worked out and recorded for each plot.

Number of tillers per meter row

The numbers of shoots were recorded from three demarcated places having a one-meter row length of each experimental plot during harvest. The average number of tillers per meter row length was recorded for each plot.

Plant height (cm)

The height of previously selected and tagged five plants was recorded from ground level to the base of the last fully opened leaf at 25 and 50 DAS, while the height was measured from ground level to the base of the earhead at harvest. The average height was worked out and recorded for each plot.

Leaf: stem ratio

The leaf: stem ratio was worked out using the following formula:

$$\text{Leaf: Stem Ratio} = \frac{\text{Weight of leafy part (g)}}{\text{Weight of Stem (g)}}$$

Dry matter content

Dry matter content (%) was calculated using the formula given below:

$$\text{Dry matter content (\%)} = \frac{\text{Oven dried fodder weight (g)}}{\text{Fresh fodder weight (g)}} \times 100$$

Dry matter yield

Dry matter yield (q ha^{-1}) was calculated using the following formula:

$$\text{Dry matter yield (q ha}^{-1}) = \frac{\text{Green forage yield (q ha}^{-1}) \times \text{Dry matter content (\%)}}{100}$$

Plant analysis

Representative plant samples of sorghum were taken from each net plot at the time of harvest for chemical analysis. Samples were oven dried at 60^0C till constant weight was obtained. The dried samples were ground in a Willey mill. The samples thus prepared were analyzed for crude protein and NDF content.

Crude protein content

The nitrogen content (%) was estimated from the powder of representative oven dried samples using Kjeldhal's method (Jackson, 1973). Crude protein content (%) was calculated by multiplying the percentage of nitrogen with the factor of 6.25.

Crude protein yield

The amount of crude protein per hectare was calculated based on the final dry matter yield per hectare. The crude protein yield was computed by using the following formula

$$\text{Crude protein yield (kg ha}^{-1}\text{)} = \frac{\text{Crude protein percent X Dry matter yield (kg ha}^{-1}\text{)}}{100}$$

Neutral detergent fiber content (NDF)

Thoroughly grind and mixed dry sample of each treatment was taken for estimation of neutral detergent fiber (NDF) content (%) by Von Soest and Wine (1967) method.

HCN content

The HCN content in forage plants was determined by the Picric acid method of Hogg and Ahgren (1942).

Statistical analysis

The statistical analysis of the various growth, yield and quality characters studied in the investigation was carried out by using statistical methods appropriate to Split Plot Design by a computer system at the computer center, Department of Agricultural Statistics, BACA, AAU, Anand, Gujarat as per the procedure described by Cochran and Cox (1967). The values of "F" was worked out and compared with the value of table F at a 5 % level of significance. The values of S.E m.t, C.D. and C.V. % were also calculated.

Economics

The cost of cultivation for each treatment was worked out considering the cost of all the operations and the inputs used. The current rate of agricultural operations and market price of inputs were used for calculation. The total cost of cultivation was subtracted from the gross realization to obtain net income per hectare for the individual treatments and recorded accordingly.

Benefit: cost ratio (BCR)

The BCR was computed by using the following formula:

$$\text{Benefit: cost ratio (BCR)} = \frac{\text{Total income (Rs. ha}^{-1}\text{)}}{\text{Total expenditure (Rs. ha}^{-1}\text{)}}$$

Results and Discussion

Available results in a table (3 and 4) explain the effect of Graded levels of Nitrogen and Bio-fertilizers on growth and yield attributing characters, yield and quality of forage Sorghum, on soil nutrient content and economics of given treatments.

Growth and yield attributing characters

Plant population

The plant population at 15 DAS was not affected due to different varieties, different levels of nitrogen and inoculation of bio-fertilizers It is revealed from the data (Table 3) that the plant stands in both the varieties, in all the treatments was uniform and hence variations obtained in the results were due to treatment effects only and not due to the effect of the plant stand. The interaction effect of varieties, nitrogen levels and biofertilizers on the initial plant population (per meter row length) of forage sorghum was also found non-significant.

Plant height (cm)

Plant height (At 25 DAS)

The data presented in Table 3 indicated that the plant height at 25 DAS was not affected by varieties of different nitrogen and levels of bio-fertilizers. It was revealed from the data that the plant height of both varieties was uniform. The interaction effect of varieties, nitrogen levels and biofertilizers on plant height of forage sorghum at 25 DAS was found non-significant.

Plant height (At harvest)

Plant height measured at harvest was significantly influenced due to varieties (Table 3). Variety GFS- 5 (V_2) produced a significantly taller plant (182.67 cm). Plant height generally depends on the genetic makeup of a particular variety. The results conform to the findings of Dixit *et al.*, (2005); Shivadhar *et al.,* (2005) and Anon. (2011).

Plant height at harvest was increased with an increase in nitrogen from 25 to 75 kg ha^{-1}. The increase in plant height at harvest was to the tune of 2.85 and 5.43 percent at 50 and 75 kg N ha^{-1} over 25 kg N ha^{-1}, respectively. The increase in plant height with an increase in successive levels of nitrogen might be due to more supply of nitrogen to crop resulting in rapid synthesis of carbohydrates and consequently converted into protoplasm and thereby smaller portion available for cell wall formation. This has served consequences one of them is an increase in the size of the cell which is expressed morphologically through an increase in plant height. The results conform with the findings of Sadhu *et al.,* (1991); Karwasra and Dahiya (1997); Gadhethariya *et al.,* (2000); Agrawal *et al.,* (2005); Singh and Symeriya (2005); Sheoran and Rana (2006) and Gupta *et al.,* (2008).

The seed inoculation with *Azotobacter* + *Azospirillum* (B_1) recorded taller plants over no inoculation (B_0). The results are in agreement with those reported by Sadhu *et al.,* (1991); Gadhethariya *et al.,* (2000); Agrawal *et al.,* (2002); Agrawal *et al.,* (2005); Sheoran and Rana (2006) and Gupta *et al.,* (2007). The interaction effect on plant height of forage sorghum was found non-significant.

No. of tillers

The data indicated that the number of tillers per meter row length was significantly affected by varieties, wherein variety GFS-5 (V_2) gave significantly the highest number of tillers per meter row length (38.03). It appeared that variety GFS-5 (V_2) produced a 13.42 percent higher number of tillers per meter row length. The results conform with the findings of Anon. (2011).

The application of nitrogen at different levels gave a significant effect on the number of tillers per meter row length in forage sorghum. It appeared that the application of 50 and 75 kg N ha^{-1} helped to increase the 4.61 and 8.19 percent higher number of tillers per meter row over 25 kg N ha-1, respectively. The results conform with the findings of Sheoran and Rana (2006) and Gupta *et al.,* (2008).

The seed inoculation with *Azotobacter* and *Azospirilhum* produced a significant effect on the number of tillers per meter row length and the treatment B_1 recorded 36.21 numbers of tillers per meter row length at harvest which was increased a 2.46 percent higher number of tillers per meter row length over no bio-fertilizers inoculation (B_0). The results are in agreement with those reported by Agrawal *et al.,* (2002).

The interaction effect of varieties, nitrogen levels and biofertilizers on the number of tillers per meter row length of forage sorghum at harvest was found non-significant.

Leaf: Stem ratio

The results reported in Table 3 indicated that the variety GFS-5 (V_2) recorded a significantly higher leaf: stem ratio (0.50) and it was a 6.38 percent higher leaf: stem ratio over S-1049 (V_1). The results conform with the findings of Singh and Sumeriya (2010) and Anon. (2011).

Application of 75 kg N ha^{-1} was recorded the maximum leaf: stem ratio (0.53). It accounted for 17.78 and 10.42 percent higher than 25 and 50 kg N ha^{-1}, respectively. Higher leaf: stem ratio with increasing level of nitrogen might be due to more supply of nitrogen, leading to more protein synthesis. The extra protein might have allowed the leaves to grow larger and ultimately larger surface area. An increase in leaf: stem ratio, with the increase in nitrogen rates, has been recorded by Sadhu *et al.,* (1991) and Agrawal *et al.,* (2005).

The seed inoculation with bio-fertilizers (B_1) recorded a higher leaf: stem ratio over no inoculation. The results are in agreement with those reported by Nanda *et al.,* (2001) and Agrawal *et al.,* (2002).

The interaction effect of varieties, nitrogen levels and biofertilizers on leaf: stem ratio of forage sorghum was found non-significant.

Yield and quality

Green-forage yield (q ha^{-1})

Data presented in Table 4 showed that variety GFS-5 (V_2) recorded significantly higher green forage yield (389.74 q ha^{-1}). The variation in green forage yield of varieties might be related to inherent differences and high vigor in growth parameters i.e. plant height, no. of tillers per meter row length, and leaf: stem ratio. The results corroborate the finding of Anon, (2011).

Among the different nitrogen levels, the application of 75 kg N ha^{-1} (N_3) recorded a significantly higher green forage yield (333.30 q h^{-1}). The remarkable increase in yields with higher levels of nitrogen might be attributed to the favorable effect on yield attributes of plant height, the number of tillers per meter row and leaf: stem ratio. The increase in leafy part due to nitrogen application might have ultimately resulted in higher photosynthetic activities and also in the production of more photosynthates. This readily supplied food-growing part might have helped in the improvement of growth and yield attributes. As a result of which, nitrogen yielded a better response on forage yield in the present study. Earlier workers have also reported such responses of nitrogen in forage sorghum. In the case of forage sorghum, linear response to nitrogen has been reported by Sadhu *et al.,* (1991); Niranjan and Arya (1992); Patel *et al.,* (1993); Patel *et al.,* (1998); Gadhethriya *et al.,* (2000); Kumar and Sharma (2002); Agarwal *et al.,* (2005); Singh and Sumeriya (2005) and Gupta *et al.,* (2008).

The treatment B_1 (*Azotobacter* +*Azospirilum*) produced the highest green forage yield (325.01 q ha^{-1}) than non-inoculation (309.56 g ha^{-1}). The remarkable increase in yield with seed inoculation with bio-fertilizers might be due to improvement in vegetative growth, activation of certain proteolysis enzymes and also necessary synthesis in certain co-enzymes. Thus, these bio-activities of bio-fertilizer might have played important role in improving yield attributes and hereby forage yield of sorghum in the present study. The results are in agreement with the findings of Sadhu *et al.,* (1991); Tomar and Agrawal (1993); Nanda *et al.,* (2001) and Patel *et al.,* (2010).

The interaction of different varieties, nitrogen levels and bio-fertilizers was found non-significant.

Dry matter yield (q ha^{-1})

The variety GFS-5 (V_2) recorded a significantly higher dry matter yield (93.18 q ha^{-1}) over the variety S-1049 (61.18 q ha^{-1}). The significant increase in dry matter yield under V_2 variety was 52.30 % as compared to S - 1049 (V_1). The results corroborate the finding of Anon. (2011).

The significantly dry matter yield (80.71 q ha^{-1}) was produced by the application of nitrogen @ 75 kg ha^{-1}. This fact is also substantiated by an increase in yield attributing characters. The dry matter yield followed the same trend as observed in the green forage yield due to the application of nitrogen. Nitrogen is used largely in the synthesis of protein, but structurally it is a constituent of chlorophyll molecule combined with carbohydrates and fatty acids. It helps in the formation of protoplasm, which is the physical base of the life of the plant. Thus, more production of dry matter can be explained at higher nitrogen rates. The higher dry matter yield with higher nitrogen rates was also reported by

Gadhethriya *et al.,* (2000); Kumar and Sharma (2002); Agarwal *et al.,* (2005); Singh and Sumeriya (2005) and Gupta *et al.,* (2008)

A Similar trend was also observed for dry matter yield with seed inoculation. Inoculation of *Azotobacter* and *Azospirilum* (B_1) produced a higher dry matter yield of 79.14 q ha^{-1}. It depends on yield attributing characters. Increased leaf area due to the seed inoculation, the effect was found to increase photosynthetic activity and thereby dry later production. The present results closely support the results of Nanda *et al.,* (2001); Agrawal *et al.,* (2005); Singh *et al.,* (2005); Sheoran and Rana (2006) and Gupta *et al.,* (2007)

The interaction effect of varieties, nitrogen levels and bio-fertilizers on dry matter yield of sorghum was found non-significant.

Crude protein yield (q ha^{-1})

The variety GFS-5 (V_2) recorded a significantly higher crude protein yield (7.98 q ha^{-1}) over the variety S-1049 (5.02 q ha^{-1}). The increase in crude protein yield under variety GFS-5 (V2) was by 58.96 percent as compared to the S-1049 (V2). The results corroborate the finding of Anon. (2011).

Application of 75 kg N ha^{-1} (Na) recorded significantly the highest crude protein yield (7.12 q ha^{-1}). This increase in P crude protein yield with a higher level of nitrogen could be ascribed to the additive effect of increased dry matter yield. These results are in line with the findings of Sadhu *et al.,* (1991); Patel *et al.,* (1998); Singh and Sumeriya (2005) and Gupta *et al.,* (2008).

The crude protein yield of sorghum was significantly influenced by the application of bio-fertilizers. (B_1) produced a higher crude protein yield (6.72 q ha^{-1}). This increase in crude protein yield with seed inoculation could be ascribed to the additive effect of increased dry matter yield. These results are in line with the findings of Nanda *et al.,* (2001); Agrawal *et al.,* (2005); Singh *et al.,* (2005); Sheoran and Rana (2006) and Gupta *et al.,* (2007).

The interaction effect of varieties, nitrogen levels and biofertilizers on crude protein yield of sorghum was found non-significant.

Crude protein content (%)

The result reported that Variety GFS-5 (V_2) recorded higher crude protein content (8.56%), which recorded 4.52 percent higher crude protein content over the variety S-1049 (V_1). The results corroborate the finding of Anon. (2011).

Application of 75 kg N ha^{-1} (N_3) recorded the highest crude protein content (8.78 %). The increase in crude protein content of forage sorghum with increasing levels of nitrogen is attributed to increased nitrogen absorption by sorghum. Nitrogen is the main constituent of protein and it is involved in the synthesis of amino acids and accumulation of protein in plants. These results are those of Patel (1991); Dadheech *et al.,* (2000) and Singh *et al.,* (2005).

Inoculation of *(Azotobacter + Azospirillum)* (B_1) produced higher crude protein content of 8.45 percent. This might be because fixation of nitrogen by *Azotobacter* and *Azospirillum* inoculation resulted in increased availability of nitrogen, which has helped in the synthesis of more protein as nitrogen is a constituent of various metabolites including protein and amino acids. Similar findings have been reported by Sadhu *et al.,* (1991); Tomar and Agrawal (1993); Nanda *et al.,* (2001) and Patel *et al.,* (2010).

The interaction effect of varieties, nitrogen levels and bio-fertilizers on the crude protein content of sorghum was found non-significant.

Table.1 Physico-chemical properties of the soil of experimental plot (initial)

particulars	Soil depth (0-15 cm)	Method adopted
Physical Properties		
Coarse sand (%)	0.54	International Pipette method (Piper, 1966)
Fine sand (%)	83.23	
Silt (%)	11.52	
Clay (%)	4.71	
Textural class Sandy loam		
Chemical properties		
Soil pH (1:2.5) (soil: water ratio)	6.81	Potentiometric method (Jackson, 1973)
Electrical conductivity EC) dSm^{-1} at 25° C	0.14	Conductometric method (Jackson, 1973)
Organic carbon (%)	0.43	Walkley and Black method (Jackson, 1973)
Available nitrogen (kg ha^{-1})	188.16	Alkaline $KMnO_4$ method (Subbiah and Asija, 1956)
Available P_2O_5 (kg ha^{-1})	36.99	Olsen's method (Olsen *et al*, 1954)
Available K_2O (kg ha^{-1})	198	Flame Photometric method (Jackson, 1973)

Table.2 Details of treatment combinations = 12

Sr. No.	Treatment combinations			
	Symbol	**Variety**	**Nitrogen kg ha^{-1}**	**Bio-fertilizers**
1.	$V_1N_1B_0$	S -1049	25	Un-inoculation
2.	$V_1N_1B_1$	S-1049	25	Inoculation
3.	$V_1N_2B_0$	S -1049	50	Un-inoculation
4.	$V_1N_2B_1$	S -1049	50	Inoculation
5.	$V_1N_3B_0$	S -1049	75	Un-inoculation
6.	$V_1N_3B_1$	S -1049	75	Inoculation
7.	$V_2N_1B_0$	GFS- 5	25	Un-inoculation
8.	$V_2N_1B_1$	GFS- 5	25	Inoculation
9.	$V_2N_2B_0$	GFS- 5	50	Un-inoculation
10.	$V_2N_2B_1$	GFS- 5	50	Inoculation
11.	$V_2N_3B_0$	GFS- 5	75	Un-inoculation
12.	$V_2N_3B_1$	GFS- 5	75	Inoculation

Where,

1) Main plot treatments
(A) Varieties
V_1 = S-1049
V_2 = GFS-5

(2) Sub-plot treatments
(Combination of B and C)
(B) Levels of Nitrogen N
N_1 =25 kg ha^{-1}
N_2 =50 kg ha^{-1}
N_3 =75 kg ha^{-1}

(C) Bio-fertilizers
B_0 =Un-inoculation
B_1 = Inoculation (*Azotobacter+ Azospirilum*)

Table.3 Growth and yield attributing characters of forage sorghum as influenced by varieties, nitrogen levels and bio-fertilizers

Treatment	Plant population m^{-1} row length	Plant height (cm)		No. of tillers per meter row length	Leaf: Stem ratio
		At 25 DAS	At harvest		
Variety (V)					
V_1 - S - 1049	44.10	55.21	160.29	33.53	0.47
V_2 - GFS - 5	42.99	55.67	182.67	38.03	0.50
S. Em. +	0.34	0.35	1.18	0.52	0.004
C.D. (P=0.05)	NS	NS	5.33	2.32	0.02
C.V. %	3.80	3.08	3.38	7.07	4.19
Nitrogen levels (kg ha^{-1}) (N)					
N_1- 25	43.36	54.81	166.88	34.31	0.45
N_2-50	43.79	55.38	171.63	35.89	0.48
N_3-75	43.49	56.13	175.94	37.12	0.53
S. Em. +	0.52	0.37	0.88	0.36	0.006
C.D. (P=0.05)	NS	NS	2.55	1.03	0.02
Bio-fertilizers (B)					
B_0 – Un-inoculation	43.02	55.33	170.96	35.34	0.48
B_1 - Inoculation *(Azotobacter +Azospirillum)*	44.07	55.54	172.00	36.21	0.49
S. Em. +	0.43	0.30	0.72	0.29	0.005
C.D. (P=0.05)	NS	NS	NS	0.84	NS
Interactions					
V x N	NS	NS	NS	NS	NS
V x B	NS	NS	NS	NS	NS
N x B	NS	NS	NS	NS	NS
V x N x B	NS	NS	NS	NS	NS
C.V. %	4.79	2.69	2.06	4.01	4.76

Table.4 Yield and quality attributing characters of forage sorghum as influenced by varieties, nitrogen levels and bio-fertilizers

Treatment	Green-forage yield (q ha^{-1})	Dry matter yield (q ha^{-1})	Crude protein Yield (q ha^{-1})	Crude protein content (%)	NDF content (%)	HCN (ppm)
Variety (V)						
V_1 - S - 1049	244.84	61.18	5.02	8.19	74.85	45.96
V_2 - GFS - 5	389.74	93.18	7.98	8.56	76.36	46.92
S. Em. ±	7.53	1.44	0.15	0.05	0.55	0.42
C.D. (P=0.05)	33.90	6.50	0.69	0.23	NS	NS
C.V. %	11.63	9.17	11.60	3.01	3.57	4.41
Nitrogen levels (kg ha^{-1}) (N)						
N_1- 25	299.69	72.97	5.89	8.03	77.91	43.88
N_2-50	318.87	77.86	6.49	8.31	76.12	46.06
N_3-75	333.30	80.71	7.12	8.78	72.79	49.38
S. Em. ±	6.14	1.65	0.14	0.04	0.63	0.40
C.D. (P=0.05)	17.73	4.76	0.41	0.12	1.81	1.17
Bio-fertilizers (B)						
B_0 – Un-inoculation	309.56	75.21	6.29	8.30	76.15	46.13
B_1 – Inoculation *(Azotobacter+Azospirillum)*	325.01	79.14	6.72	8.45	75.06	46.75
S. Em. ±	5.01	1.35	0.11	0.04	0.51	0.33
C.D. (P=0.05)	14.48	3.89	0.33	0.10	NS	NS
Interactions						
V x N	NS	NS	NS	NS	NS	NS
V x B	NS	NS	NS	NS	NS	NS
N x B	NS	NS	NS	NS	NS	NS
V x N x B	NS	NS	NS	NS	NS	NS
C.V. %	7.74	8.54	8.64	2.05	3.31	3.48

Table.5 Available nitrogen, phosphorus and potassium in the soil after harvest of forage sorghum as influenced by varieties, nitrogen levels and biofertilizers

Treatment	Available nitrogen (kg ha^{-1})	Available Phosphorus (kg ha^{-1})	Available Potassium (kg ha^{-1})
Variety (V)			
V_1 - S - 1049	211.67	47.56	**216.16**
V_2 - GFS -5	207.58	46.33	**211.36**
S.Em. +	2.09	0.29	**1.29**
C.D. (P=0.05)	NS	NS	**NS**
C.V. (%)	4.89	3.03	**2.96**
Nitrogen levels (kg ha^{-1}) (N)			
N_1-25	202.96	46.12	**211.16**
N_2-50	208.99	46.92	**213.83**
N_3-75	216.91	47.80	**216.29**
S. Em. +	1.50	0.32	**1.42**
C.D. (P=0.05)	4.32	0.93	**NS**
Biofertilizers (B)			
B_0- Un-inoculation	208.09	46.68	**212.9**
B_1- Inoculation *(Azotobacter + Azospirillum)*	211.16	47.21	**214.62**
S.Em. +	1.22	0.76	**1.16**
C.D. (P=O.05)	NS	NS	**NS**
Interactions			
V x N	NS	NS	**NS**
V x B	NS	NS	**NS**
N x B	NS	NS	**NS**
V x N x B	NS	NS	**NS**
C.V. (%)	**2.85**	**2.76**	**2.66**

Table.6 Economics of sorghum as influenced by varieties, nitrogen levels and biofertilizers

Treatment	Green Forage Yield (q ha^{-1})	Gross realization (Rs ha^{-1})	Total Cost of cultivation(Rs ha^{-1})	Net realization (Rs ha^{-1})	BCR
Variety (V)					
V_1- S-1049	244.84	30605	14740	15865	**1.08**
V_2- GFS-5	389.74	48718	14740	33978	**2.3 1**
Nitrogen levels Kg ha^{-1} (N)					
N_1-25	299.69	3746 1	14422	23039	**1.60**
N_2-50	318.87	39859	14740	25119	**1.70**
N_3-75	333.30	41663	15058	26605	**1.77**
Bio-fertilizers (B)					
B_0- Uninoculation	309.56	38695	14706	23989	**1.63**
B_1-Inoculation *(Azotobacter +Azospirillum)*	**325.01**	**40626**	**14774**	**25852**	**1.75**

(Selling price of Green forage= 1.25 Rs kg^{-1})

Table.7 Gross realization, the total cost of cultivation, net realization and B.C.R. as influenced by different treatment combinations

Treatment combination	Green Forage Yield (q ha^{-1})	Gross realization (Rs ha^{-1})	Total Cost of Cultivation (Rs ha^{-1})	Net realization (Rs ha^{-1})	B: C ratio
$V_1N_1B_0$	225.00	28125	14389	13736	**0.95**
$V_1N_1B_1$	242.58	30322	14462	15860	**1.10**
$V_1N_2B_0$	241.41	30176	14707	15459	**1.05**
$V_1N_2B_1$	247.73	30969	14780	16 189	**1.10**
$V_1N_3B_0$	249.79	31223	15026	16197	**1.08**
$V_1N_3B_1$	262.50	32813	15093	17720	**1.17**
$V_2N_1B_0$	347.76	43470	14389	29081	**2.02**
$V_2N_2B_1$	383.44	47930	14462	33468	**2.31**
$V_2N_2B_0$	388.36	48545	14707	33838	**2.30**
$V_2N_2B_1$	397.97	49746	14780	34966	**2.37**
$V_2N_3B_0$	405.07	50634	15026	35608	**2.37**
$V_2N_3B_1$	**415.84**	**51980**	**15093**	**36887**	**2.44**

(Selling price of Green forage= 1.25 Rs kg^{-1})

NDF content (%)

The data presented in Table 4 indicated that the effect of varieties on NDF content was found non-significant. However, variety GFS-5 (76.36 %) recorded higher NDF content over the variety S-1049 (74.85 %). The neutral detergent fiber content of forage sorghum was found significantly influenced by different nitrogen levels and it decreased with increasing levels of nitrogen from N_1 (25 kg ha^{-1}) to N_3 (75 kg ha^{-1}). Nitrogen application at 25 kg ha^{-1} (N_1) gave significantly higher NDF content (77.91 %) and it was at par with 50 kg N ha^{-1} (N_2). Treatment N_2 and N_3 recorded NDF content of 76.12 and 72.79 %, respectively. The reduction in NDF content was observed with an increase in the level of nitrogen might be due to increasing in succulence i.e. leaf stem ratio of a plant by reducing the formation of polysaccharides viz., cellulose, hemicellulose and lignin, which generally account for the content of NDF in the plant.

The application of bio-fertilizers (*Azotobacter* + *Azospirillum*) increased neutral detergent fiber content in forage sorghum, but it could not attain the level of significance. However, no inoculation treatment recorded numerically higher NDF content (76.15 %) over inoculation with bio-fertilizer (75.06 %) treatment (B_1).

The Neutral detergent fiber (NDF) content of forage sorghum as influenced by the interaction of different varieties, nitrogen 1evels and bio-fertilizers was found non-significant.

HCN (ppm)

The HCN content of forage sorghum was found non-significant due to varieties. However, Variety S-1049 (V_1) recorded minimum HCN content (45.96 ppm) over the variety GFS-5 (V_2) which was 46.92 ppm.

The HCN content of forage was significantly influenced by different nitrogen levels and increased with each increase in nitrogen levels from N_1 (25 kg ha^{-1}) to N_3 (75 kg ha^{-1}). The treatment N_1 (25 kg N ha^{-1}) recorded significantly the lowest HCN Content (43.88 ppm), while maximum HCN content (49.38 ppm) was obtained in N_3 (75 kg N ha^{-1}). It appeared that application of 50 and 75 kg N ha^{-1} increased 4.97 and 12.53 percent HCN content over 25 kg N ha^{-1}, respectively. Similar results were also reported by Verma (1984).

However, no inoculation treatment recorded numerically higher HCN content (46.75 %) over inoculation with bio-fertilizer (46.13 %) treatment (B_1). The interaction effect of varieties, nitrogen levels and bio-fertilizers on HCN content of sorghum was found non-significant.

Soil analysis

After the harvest of forage sorghum the soil analysis was carried out to study the influence of varieties, nitrogen levels and biofertilizers on available nitrogen, phosphorus and potassium in the soil.

The data presented in Table 5 indicated that the effect of varieties on available N, P, and K status in the soil after harvest of the crop was found non-significant.

The effect of nitrogen levels on available nitrogen and phosphorus status in the soil after harvest of the crop was found to be significant due to different nitrogen levels and it was increased with an increase in nitrogen level from 25 to 75 kg N ha^{-1}.

Treatment N_3 (75 kg N ha^{-1}) recorded significantly the highest available nitrogen in the soil (216.91 kg ha^{-1}), while treatment N_1 (25 kg N ha^{-1}) gave the lowest (202.96 kg ha^{-1}) available nitrogen in the soil. Treatment N_3 (75 kg N ha^{-1}) recorded significantly higher available phosphorus (47.80 kg ha^{-1}), while the lowest available phosphorus (46.12 kg ha^{-1}) was recorded under treatment N_1 (25 kg N ha^{-1}) in soil.

The effect of nitrogen levels on available potassium status in the soil after harvest of the crop was found non-significant. Treatment N_3 (75 kg N ha^{-1}) recorded a maximum of 216.29 kg ha^{-1} available potassium, while the lowest available potassium was recorded due to N_1 (25 kg N ha^{-1}).

Bio-fertilizers inoculation did not manifest any significant effect on available nitrogen, phosphorus and potassium in the soil after harvest of the crop.

The interaction effect of varieties, nitrogen levels and bio-fertilizers on available nitrogen, phosphorus and potassium in the soil after harvest of the crop was found non-significant.

Economics

Economics plays an important role in deciding the adoption of particular treatment by the farmers. Therefore, the gross realization, net realization and benefit-cost ratio (B.C.R.) were calculated for varieties, nitrogen and bio-fertilizers.

The data on the effect of varieties on economics (Table 6) revealed that variety GFS-5 (V_2) recorded maximum gross and net realization of 48718 and 978 Rs ha^{-1}, respectively, followed by variety S-1049 (V_2) which gave gross and net realization of 30605 and 15865 Rs ha^{-1}, respectively. In SE of B.C.R., variety GFS-5 recorded a B.C.R. value of 2.31, while variety S-1049 gave B.C.R. of 1.08.

Among the different nitrogen levels, the application of 75 kg N ha^{-1} (N_3) recorded the highest net realization (Rs. 26605 ha^{-1}) and B.C.R. (1.77) values, while the lowest net realization of Rs. 23039 ha" and B.C.R. (1.70) were recorded in treatment N_1. This indicates that the application of more nitrogen is required for higher net returns from forage production.

Combined inoculation of *Azotobacter* + *Azospirillum* resulted in maximum net realization (Rs. 25852 ha^{-1}) and B.C.R. (1.75), while no bio-fertilizers inoculation (treatment B_2) gave lower net realization (Rs. 23989 ha^{-1}) and B.C.R. (1.63).

An average economic of forage sorghum as influenced by different treatment combinations are presented in table 7. The data revealed that treatment combination $V_2N_3B_1$ (GFS-5+ 75 kg N ha^{-1} + bio-fertilizers) registered the highest net realization of Rs. 36877 ha^{-1} with B.C.R. of 2.44. The lowest net profit Rs. 13736 was recorded with $V_1N_1B_0$ (S-1049 +25 kg N ha^{-1}).

In light of the results obtained from this investigation, it is Concluded that for securing maximum forage production with good quality and for getting higher net monetary realization, forage sorghum variety GFS-5 should be fertilized at 75 kg N ha^{-1} along with seed inoculation with *Azotobacter* + *Azospirillum* in sandy loam sols under middle Gujarat conditions.

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