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Production potential, nutrient uptake, economics and soil properties as influenced by fodder sorghum (*Sorghum bicolor*) cultivars, nitrogen levels and FYM under semi-arid condition of Rajasthan

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Abstract
A field experiment was conducted during summer season of 2007 and 2008 on sandy loam soil at Avikanagar to study the effect of cultivars, nitrogen levels and farmyard manure on performance of fodder sorghum [*Sorghum bicolor* (L.) Moench]. Cultivar 'SSG 5001' proved superior in green fodder yield (60.48 t /ha), dry matter (11.74 t /ha), crude protein content (7.79 %), protein yield (830.21 kg / ha), N content (1.20 %) and uptake (131.79 kg /ha) than other cultivars. The net return and benefit: cost ratio was also highest in 'SSG 5001' cultivar. The soil organic carbon content was improved but bulk density and soil pH was decreased under 'SSG 5001' cultivar. The growth parameters like plant height, dry matter production, green leaves /plant and crop growth rate (g /plant /day) were significantly increased upto 120 kg N /ha. The green fodder (62.08 t /ha), dry matter (10.69 t /ha), crude protein content (7.51 %), N content (1.15 %) and uptake (130.40 kg /ha) were maximum at 120 kg N /ha. But nitrogen use efficiency showed reverse trend with increasing N levels from 0 to 120 kg N /ha. Net return and benefit: cost ratio were accrued highest with the application of 120 kg N /ha (Rs. 32,070 /ha and 2.61) compared to other levels. Maximum green fodder, dry matter, crude protein yield, nitrogen use efficiency and economic returns were recorded with FYM (farmyard manure) @10 t /ha than control (without farmyard manure). The soil fertility was also improved significantly over control where FYM was applied @10 t /ha.

Key words: Crude protein, Cultivar, Economics, Farmyard manure, Fodder yield, Nitrogen, Soil fertility, Sorghum

Introduction

In India, fodder sorghum [*Sorghum bicolor* (L.) Moench] occupies the highest area among fodder crops (2.93 mha) with an average green fodder production of (52.5 t /ha). Judicious use of nutrients, especially nitrogen and FYM, in fodder sorghum may improve the yield and quality of fodder and optimize its production cost (Shiva Dhar *et al.*, 2005). Sorghum being a heavy nutrient feeder needs ample nitrogen to achieve a high fodder yield. Nitrogen is one of the most important nutrients playing an important role in growth and development of plant, as it is the main constituent of protein of plant body (Thakral, 2008). The productivity of fodder sorghum is considerably low in semi-arid region because of poor supply of nitrogen fertilizer and use of traditional cultivars. A large number of cultivars, varying in growth habits, have been developed and recommended for cultivation in different situations. The inherent production potential of these cultivars can be realized by their proper nutrition. In view of the present energy crisis and increased cost of chemical fertilizers, integrating the use of FYM with fertilizers in fodder production may be a good option for increasing nutrient use efficiency and obtaining higher yields. In the beginning organic manure (FYM) releases nutrients at much slower rate than inorganic fertilizer. Therefore, combined use of organic and inorganic fertilizers may have more pronounced effect on crop production rather than their individual application. However, information on proper fertilization of newly developed multi-cut fodder cultivars is lacking. Keeping these facts in view the present investigation was planned on fodder sorghum cultivars with management of nitrogen and farmyard manure.

Materials and Methods

A field experiment was conducted at Central Sheep and Wool Research Institute, Avikanagar (Rajasthan) under transfer of technology project during summer seasons of 2007 and 2008. The soil of the experimental site was sandy loam in texture, low in organic carbon content (0.36 %), available N (158.3 kg /ha) and medium in available phosphorus (16.8 kg /ha) and potassium

(205.3 kg /ha) with pH 7.9. The experiment was laid out in factorial randomized block design (FRBD) with three replications. The treatments comprised of 3 cultivars of fodder sorghum *viz*. 'Hara sona', 'SSG 777' and 'SSG 5001', 4 levels of nitrogen (0, 40, 80 and 120 kg N /ha) and 2 levels of FYM (without FYM and FYM @ 10 t/ha). Nitrogen as per the treatment was applied in 3 splits *i.e*. half basal and the remaining half top dressed in 2 equal splits at 45 and 60 days after sowing (DAS) in the form of urea. Full dose of farmyard manure (having 0.45 % N, 0.087 % P and 0.35 % K on dry weight basis) was incorporated in the soil as per the treatments 30 days before sowing. The seed rate of fodder sorghum was 40 kg /ha with a row spacing of 22.5 cm. The crop was sown on 27th April 2007 and 29th April in 2008. The seed was treated with fungicide (Bavistin @ 2 g /kg seed). Methyl parathion (2 % dust @ 25 kg /ha) was incorporated in soil before sowing to prevent harmful insects**.** Irrigations were given as and when required. One hand weeding was done after 35 DAS. The harvested herbage was weighed immediately for green fodder yield and 500 g sample was drawn randomly for dry matter determination. The soil samples were collected after harvest of crop to determine the changes in soil organic carbon content, bulk density and soil pH as per the standard procedures. The data for individual year were pooled and subjected to statistical analysis.

Results and Discussion

Growth parameters

Fodder sorghum cultivars differed significantly for growth parameters in terms of plant height, dry matter production/ plant, green leaves/ plant and crop growth rate (g /plant /day) during both the years (Table 1). Sorghum cultivar 'SSG 5001' had registered taller plants, more number of green leaves/ plant than 'Hara sona' and 'SSG 777' cultivars, respectively. Different growth variables like plant height, dry matter accumulation/plant, green leaves /plant and crop growth rate (g/ plant/ day) showed increasing trend with successive increase in levels of N from 0 to 120 kg /ha. However, individual N level could not produce significant difference in these parameters with its successive level. However, plant height and crop growth rate (g /plant/ day) with 40 kg N /ha was found significantly higher over control. Yadav *et al*., (2007) also reported beneficial effect of N nutrition in various growth parameters of fodder sorghum. Application of FYM @ 10 t/ha had brought about significant improvement in plant height, dry matter accumulation/plant, green leaves/plant and crop growth rate (g/plant/day) in comparison to without farmyard manure in both the years.

Green fodder, dry matter and protein yield: The cultivar 'SSG 5001' resulted in significantly higher green fodder, dry matter, crude protein content, nitrogen content and N uptake, protein yield, nitrogen use efficiency as compared to other cultivars under test during both the years as well as in pooled data (Tables 2 & 3). On an average, the green fodder (14.26 and 30.79%), dry matter yield (9.69 and 46.25 %), protein content (9.25 and 38.12%), protein yield (103.66 and 261.52 kg/ha) and nitrogen use efficiency (228.84 and 408.05 kg green fodder yield /kg nitrogen applied) of 'SSG 5001' cultivar was higher over 'Hara sona' and 'SSG 777' cultivars, respectively. The green fodder, dry matter and crude protein content were influenced significantly with increase in N levels up to 120 kg N /ha during both the years as well as in pooled data. Application of nitrogen @ 120 kg/ha gave 40.10, 21.94 and 14.49% higher green fodder yield over 0, 40 and 80 kg N /ha, respectively. The corresponding value of dry matter yield was also increased to the extent of 15.06, 10.89 and 5.84 % when nitrogen was applied at 120 kg/ ha as compared to lower doses. This might be attributed to higher supply of N increased the protoplasmic constituent and accelerated processes like cell division and elongation thereby resulted in luxuriant growth and higher tonnage of green fodder (Tripathi *et al.,* 2007). Nitrogen and crude protein content were not influenced significantly between control and 40 kg N /ha. Further, nitrogen content also did not influence significantly among the nitrogen levels except control and 40 kg N / ha. Further, N uptake, protein yield and nitrogen use efficiency were increased progressively with each level of nitrogen and these exhibited maximum where 120 kg N /ha was supplied. The remarkably higher green fodder, dry matter and crude protein content were recorded with FYM @ 10 /ha over the control. The magnitude of increase in green fodder, dry matter and crude protein content were to the tune of 35.96, 23.14 and 16.40%, respectively over without FYM. It showed that organic manure has stimulatory effect on efficiency of chemical fertilizers and mitigates micronutrient deficiency besides supply of major nutrients and improving the physico-chemical properties of soil. Singh and Kang (2005) also reported that enhanced fodder yield of fodder sorghum due to addition of FYM. Application of farmyard manure resulted in increased N content by 22.77% and N uptake of 67.71 kg/ha over control. FYM application increased the nitrogen use efficiency over without FYM in fodder sorghum crop.

Table 1. Growth attributing characters of fodder sorghum as influenced by cultivars, nitrogen levels and farmyard manure

Treatments	Plant height at harvest (cm)		Dry matter production/ plant (g)		Green leaves /plant		Crop growth rate (g/plant/day)	
	2007	2008	2007	2008	2007	2008	2007	2008
Cultivar								
Hara sona	159.4	191.3	28.5	35.6	8.5	8.95	0.5	0.50
SSG777	167.4	200.4	33.4	40.1	9.1	9.10	0.8	0.80
SSG5001	178.7	215.7	37.1	43.6	9.6	10.5	0.9	1.00
CD (P=0.05)	7.29	10.42	3.53	4.57	NS	1.48	0.03	0.04
Nitrogen(kg/ha)								
0	163.4	193.7	29.0	34.8	8.4	8.77	0.6	0.65
40	172.1	199.6	32.1	38.0	8.9	9.10	0.7	0.70
80	177.3	206.8	35.1	41.3	9.7	9.70	0.8	0.80
120	182.2	208.4	36.1	45.2	10.5	10.6	0.9	0.90
CD (P=0.05)	8.43	12.41	5.27	4.08	1.27	1.48	0.03	0.05
FYM level								
Without FYM	186.1	190.7	27.3	35.9	8.10	8.95	0.7	0.70
With FYM @ 10t /ha	194.5	213.1	38.5	43.7	9.10	10.6	0.8	0.80
CD (P=0.05)	7.28	8.77	3.7	2.88	0.90	1.41	0.02	0.03

Table 2. Green fodder, dry matter and crude protein content as affected by cultivars, different doses of nitrogen and FYM

Treatment	Green fodder (t/ha)			Dry matter (t/ha)			Crude protein content (%)		
	2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
Cultivar									
Hara sona	40.6	49.9	46.2	7.7	8.3	8.1	5.53	6.67	5.64
SSG777	48.2	57.7	52.9	9.0	11.0	10.5	6.83	7.43	7.13
SSG 5001	58.9	61.0	60.5	11.3	12.1	11.7	7.71	7.89	7.79
CD (P=0.05)	1.83	2.42	1.59	1.29	0.71	0.84	0.20	0.28	0.25
Nitrogen (kg/ha)									
0	40.5	47.6	44.3	8.70	9.90	9.30	6.25	6.95	6.58
40	46.1	55.1	50.9	9.20	10.2	9.60	6.74	7.18	6.96
80	50.7	57.7	54.2	9.70	10.6	10.1	6.80	7.32	7.06
120	59.5	64.7	62.1	10.1	11.3	10.7	7.01	8.07	7.51
CD (P=0.05)	2.22	2.79	1.83	1.50	0.82	0.89	0.23	0.33	0.27
FYM level									
Without FYM	39.8	49.8	44.8	8.20	9.60	8.90	6.45	6.48	6.43
With FYM @ 10 t/ha	58.5	62.6	60.9	10.6	11.4	11.0	7.02	8.21	7.52
CD (P=0.05)	1.49	1.97	1.30	1.01	0.58	0.96	0.17	0.23	0.19

Interaction effect

The interactive effect between FYM and nitrogen levels was given in Table 4 for the year of 2008. The maximum green fodder yield (5.82 t /ha) was recorded with the application of 80 kg N /ha + FYM @ 10 t/ha. Further increase in nitrogen dose *i.e.* 120 kg/ha in conjunction of FYM @ 10 t/ha caused no significant difference in green fodder yield. This indicates that the nitrogen requirement of sorghum could considerably be managed up to application of 80 kg N/ha if the crop is supported with farmyard manure @ 10 t/ha. However, without FYM application, forage sorghum responded considerably up to 120 kg N/ha. This might be due to release of other nutrients from FYM application and subsequent process of mineralization into the soil. Such beneficial effect of FYM when combined with nitrogen in forage sorghum has also been reported by Thakral (2008).

Changes in soil properties: The organic carbon content (0.03 and 0.08%) was higher with 'SSG 777' and 'SSG 5001' over 'Hara sona' cultivar, respectively. Values like bulk density and soil pH decreased greatly under 'SSG 5001' cultivar than that of 'Hara sona' and 'SSG 777'.

These results are in close conformity with the findings of Singh and Sumeriya (2010). Application of nitrogen in forage sorghum caused lower bulk density with an increasing doses from 0 to 120 kg/ha. The minimum bulk density (1.27 Mg/m^3) was recorded at 120 kg N/ha. Similarly, soil pH decreased with increasing nitrogen doses from control to 120 kg/ha and the difference in soil pH with different nitrogen doses remained at par with each other. The highest soil pH stood at control treatment.

35,220 /ha and 2.43). The highest net return and benefit: cost ratio were recorded with 120 kg N/ha application (Rs. 32,070 /ha and 2.61). Application of FYM @ 10 t /ha gave higher net return (Rs. 32,880 /ha). But the benefit: cost ratio was lower (1.70) than no use of FYM (1.86). It was mainly because of comparatively lower increased in fodder yield when compared with cost involved on FYM application. Puri and Tiwana (2008) also reported similar results due to application of FYM.

Table 3. Effect of cultivars, nitrogen levels and FYM on nutrient content and uptake by sorghum (pooled mean of 2 years)

Treatments	Nitrogen content (%)	Nitrogen uptake (kg/ha)	Protein yield (kg/ha)	NUE (kg green fodder yield/ kg nitrogen applied)
Cultivar				
Hara sona	1.03	91.0	568.7	467.1
SSG777	1.14	115.7	726.6	646.3
SSG 5001	1.20	131.8	830.2	875.2
CD (P=0.05)	0.03	5.7	34.6	27.1
Nitrogen (kg/ha)				
0	0.99	88.4	565.0	840.9
40	1.12	112.4	703.0	719.7
80	1.13	120.1	750.9	587.8
120	1.15	130.4	815.0	503.1
CD (P=0.05)	0.04	6.6	40.0	31.3
FYM level				
Without FYM	1.01	79.0	495.8	580.3
With FYM @ 10 t/ha	1.24	146.7	921.2	745.5
CD (P=0.05)	0.02	4.7	28.3	22.1

Table 4. Interaction effect of nitrogen and FYM levels on green fodder yield (t/ha) of sorghum (2008)

	FYM (t/ha)		
Nitrogen levels (kg /ha)	**Without FYM**	**With FYM**	**Mean**
0	5.28	5.65	5.46
40	5.38	5.74	5.56
80	5.44	5.82	5.63
120	5.68	5.76	5.72
Mean	5.45	5.74	
CD (P=0.05)	1.68		

Organic carbon content increased progressively with each dose of nitrogen as compared to control treatment and was highest (0.48%) with 120 kg/ha nitrogen applied. The improvement in fertility status could be attributed to addition of organic carbon content in the soil through supply of FYM and decrease in bulk density and soil pH leading to higher mineralization of applied and inherent plant nutrients in the soil (Table 5).

Economic analysis

The maximum economic return and benefit: cost ratio (Table 5) were recorded with 'SSG 5001' cultivar (Rs.

Response curve and optimum economic dose of nitrogen

Each increase in dose of nitrogen from 0 to 120 kg /ha consistently increased the green fodder yield of sorghum cultivars linearly (Fig 1, 2 and 3). The sorghum variety 'SSG 777' was more responsive to applied nitrogen with farmyard manure in comparison to without FYM. Similar trend was also observed in 'Hara Sona' and 'SSG 5001'. Further, the data were fitted in response equations to work out the optimum economic dose of nitrogen for all three varieties *i.e.* 100.83 kg/ ha for 'Hara sona', 60.38 kg/ha for 'SSG 777'and 77.66 kg/ha for 'SGG5001', respectively

Table 5. Effect of fodder sorghum cultivars, nitrogen levels and FYM on change in physico-chemical properties of soil and economic returns (pooled mean of 2 years).

Treatments	Bulk density (Mg/m^3) 0-15cm	Organic carbon content (%)	pH	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Cultivar						
Hara sona	1.29	0.46	7.5	14,130	24,270	1.71
SSG777	1.32	0.41	7.8	14,285	31,620	2.21
SSG 5001	1.27	0.49	7.2	14,440	35,220	2.43
CD (P=0.05)	0.03	0.05	0.08			
Nitrogen (kg/ha)						
0	1.33	0.37	7.7	11,300	27,870	2.46
40	1.30	0.41	7.5	11,620	28,920	2.48
80	1.29	0.44	7.3	11,940	30,300	2.53
120	1.27	0.48	7.2	12,260	32,070	2.61
CD (P=0.05)	0.02	0.06	0.04			
FYM level						
With out FYM	1.33	0.41	7.8	14,280	26,700	1.86
With FYM @ 10 t/ha	1.28	0.52	7.6	19,280	32,880	1.70
CD (P=0.05)	0.03	0.04	0.06			

(Table 6). These results strongly corroborated with the findings of Meena *et al.,* (2010) reported that significant improvement in green fodder of sorghum with application of nitrogen up to 120kg/ha.

Table 6. Optimum nitrogen doses for different cultivars

Variety	Opt dose kg/ha
'Hara sona'	100.83
'SSG 777'	60.38
'SSG 5001'	77.66

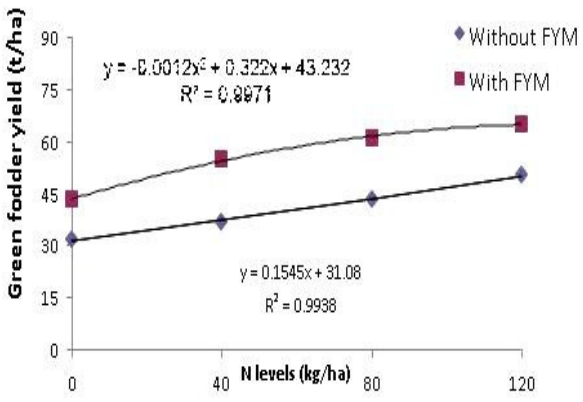

Fig.1. Response of fodder sorghum cultivar 'Hara sona' to nitrogen levels with and without FYM

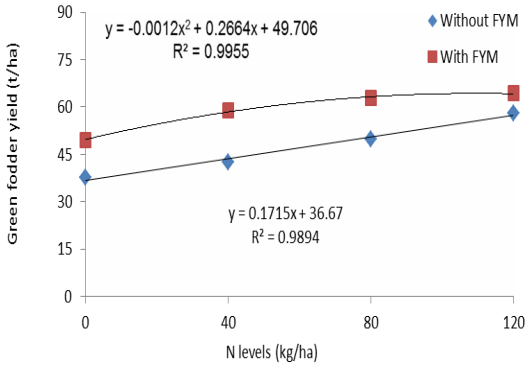

Fig.2. Response of fodder sorghum cultivar 'SSG 777' to nitrogen levels with and without FYM

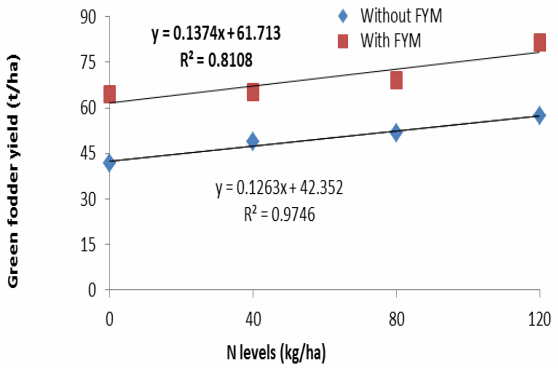

Fig.3. Response of fodder sorghum cultivar 'SSG 5001' to nitrogen levels with and without FYM

Conclusion

Thus, considering the fodder yield, quality, economic evaluation and physico- chemical properties of soil, fodder sorghum cultivar 'SSG 5001' should be sown with fertilization of 78 kg N /ha to get higher yield of nutritious forage. Among the fodder sorghum cultivar 'SSG 5001' can give highest yield when supplementation of FYM @ 10 t/ha in semi-arid region of Rajasthan.

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