International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(1): 173-176

Received: 15-11-2017
Accepted: 16-12-2017

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Effect of integrated nutrient management on green forage yield, quality and nutrient uptake of fodder sorghum (*Sorghum bicolor* L.)

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Abstract
A field experiment was conducted during *kharif* season of 2016 at Agronomy Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar, Gujarat to study integrated nutrient management on green forage yield, quality and nutrient uptake of fodder sorghum. The experiment consist of 16 treatment combinations of 4 organic manures, *viz*., 10.0 t FYM/ha, 15.0 t FYM/ha, 1.0 t castor cake/ha and 2.0 t castor cake/ha and 4 fertility levels, *viz*., *Azotobacter* + PSB (Control), 50 % RDF + *Azotobacter* + PSB, 75 % RDF + *Azotobacter* + PSB and 100 % RDF + *Azotobacter* + PSB. The use of castor cake @ 2.0 t/ha resulted in significantly higher green and dry fodder yield being at par with 15.0 tonnes FYM/ha as compared to its lower levels. Significantly higher leaf area per plant, stem diameter, number of internodes per plant, length of internode and leaf stem ratio were recorded with the application of 2.0 t castor cake/ha. Similarly, 100% RDF along with *Azotobacter* + PSB significantly improved all growth and yield attributes as compared to 50 % RDF + *Azotobacter* + PSB and control. Application of castor cake 2.0 t/ha recorded significantly the highest protein content, NPK uptake and available nutrients in the soil (N & P), whereas it registered the lowest crude fibre content. Use of 100% RDF along with seed inoculation of *Azotobacter* + PSB also rewarded significantly highest protein content, NP uptake and post harvest soil available nutrients (N & P) as compared to lower levels and control. However, it also rewarded significantly lower crude fibre content in the fodder.

Keywords: *Azotobacter*, Castor cake, Green fodder yield, Dry fodder yield, Economics, Farmyard manure, PSB, Nutrient uptake

Introduction
In India, the area under sorghum is approximately 7.38 million hectares with an annual production of 61.88 million tonnes (World Sorghum Production, 2014-15). The stem and foliage of sorghum are used as a green fodder, hay, silage and pasture. Though, sorghum is known for its versatile use, hardiness, stability of yield and adoptability over a wide range of cultures and climates. Sorghum (*Sorghum bicolor* L.) is an important cereal fodder crop. It can withstand heat, drought and also tolerate water logging better than other forage crops. Due to its excellent growing habit, high potential, better nutritive value and quick regrowth, it is extensively grown in Northern, Central and North-West regions of the country. Imbalance use of fertilizers has been one of the key factors in declining crop productivity and depleting the soil fertility. Optimum nutrition is required for getting the maximum forage yield and quality. Organic manures are good complimentary sources of nutrients and improve the efficiency of the applied mineral nutrients on one hand and improve physical and biological properties of soil on other hand (Chaudhary *et al*., 2004) [1]. Therefore, a nutrient management practices that can improve organic matter status of soil is important. A judicious and combined use of organic and inorganic sources of plant nutrients is essential to maintain soil health and manage the efficiency of nutrients. Additionally, such integration of organic and inorganic nutrients plays an important role in economizing the use of fertilizer under increasing cost, which is restricting their use to an optimum level. Hence, present experiment was carried out to find out the effect of integrated nutrient management on green fodder yield, quality and nutrient uptake of fodder sorghum.

Materials and Methods
A field experiment was carried out during rainy season at Agronomy Instructional Farm,

Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar on loamy sand soil having low in organic carbon (0.32 %) and available nitrogen (154.0 kg/ha), medium in available phosphorus (39.8 kg/ha) and potash (269.5 kg/ha). The treatments consisted of four levels of organic manure *viz*., M_1: 10.0 t FYM/ha, M_2: 15.0 t FYM/ha, M_3: 1.0 t castor cake/ha, M_4: 2.0 t castor cake/ha and four levels of fertility *viz*., F_1: *Azotobacter* + PSB (Control), F_2: 50 % RDF + *Azotobacter* + PSB, F_3: 75 % RDF + *Azotobacter* + PSB and F_4: 100 % RDF + *Azotobacter* + PSB. The experiment was laid out in factorial randomized block design with three replications. Recommended dose of fertilizer was 80 and 40 kg NP/ha. Well decomposed FYM and castor cake were applied in previously opened furrows as per treatments and incorporated thoroughly in the soil. Full dose of phosphorus and half dose of nitrogen (as per treatments) were applied at sowing. Remaining half of nitrogen was applied at 30 DAS. Fodder sorghum variety CSV 21 F was sown in rows at 30 cm apart on July 21, 2016 with a seed rate of 60 kg/ha. Data were recorded on plant height, number of leaves per plant, leaf area per plant, diameter of plant, number of internodes per plant, length of internodes and leaf stem ratio from five random plants/plot in the net plot area at harvesting. Green fodder yield was recorded separately for each treatment from net plot area and converted into hectare basis.

The crop was harvested on September 30, 2016. The processed plant samples were analyzed by micro Kjeldahl method (Jackson, 1978) [4] to determine nitrogen content and wet digestion (di-acid) method (Jackson, 1978) [4] was used for preparation of aliquot to determine P content in plant samples. The uptake of nitrogen and phosphorus by crop was estimated by the using the formula.

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{Nutrient content (\%) x Fodder yield (kg/ha)}}{100}$$

Crude protein content of fodder was determined by multiplying the nitrogen percentage with 6.25 and was expressed as percentage on dry weight basis. Crude fibre was estimated by using Mahadevan (1955) [7] method and percent crude fibre was worked out by using the following formula.

$$\text{Crude fibre (\%)} = \frac{\text{Weight of crude fibre}}{\text{Weight of oven dry sample}} \times 100$$

The soil samples were collected from each plot after harvesting of fodder sorghum at 0 - 15 cm depth and analyzed using standard procedures. For economic analysis (cost of cultivation and net returns) cost of inputs and price of outputs were used according to prevailing market price. Statistically analysis were done using standard methodology of randomize block design. The statistical analysis of green and dry fodder yield was done by using DNMRT (Duncan New Multiple Rank Test).

Results and Discussion

Growth and yield attributes

Application of castor cake @ 2.0 t/ha resulted significantly higher leaf area per plant, stem diameter, number of internodes per plant, length of internode and leaf stem ratio (Table 1) as compared to other treatments. However, all growth and yield attributes in the plot treated with castor cake @ 2.0 t/ha and FYM @ 15.0 t/ha was found similar. This may be owing to continuous availability of nutrients to fodder sorghum plants because of their slow release of nutrients during crop season. Application of castor cake at higher rate increase length of internode, number of leaves per plant and leaf area per plant as a result of faster cell division and cell expansion due to supply of macro and micro nutrients in adequate quantity which provide balanced nutrition to sorghum plants. Organic manure did not influence plant height and number of leaves per plant significantly.

Application of fertility levels increased plant height, leaf area per plant, stem diameter, number of internode per plant, length of internode and leaf stem ratio significantly, which further increased successively and significantly with the increasing level of NP upto 100% RDF along with seed inoculation with *Azotobacter* and PSB over control. However, application of 100% and 75% RDF to sorghum did not vary significantly with respect to leaf area per plant and leaf stem ratio. This might probably due to significant increase in post harvest fertility of the soil which increased the availability of major nutrients i.e. N and P to plants with increase in fertility levels and hence, ultimately improvement in bio chemical activities in plant responsible for remarkable increase in all growth and yield attributes of sorghum.

Table 1: Growth and yield attributes of *kharif* fodder sorghum as influenced by different treatments

Treatments	Plant height (cm)	Number of leaves/ plant	Leaf area/ plant (cm^2)	Stem diameter (mm)	Number of internodes/ plant	Length of internode (cm)	Leaf: stem ratio
Sources of organic manure (M)							
M_1:10 t FYM/ha	151.7	10.0	3344.0	17.4	6.7	21.6	0.35
M_2:15 t FYM/ha	153.5	10.1	3431.4	18.0	7.1	22.4	0.36
M_3:1 t castor cake/ha	146.6	9.7	3188.4	16.0	5.8	20.6	0.34
M_4:2 t castor cake/ha	160.2	10.6	3652.6	19.9	7.5	23.4	0.37
S. Em. ±	4.0	0.2	99.5	0.4	0.2	0.5	0.00
C.D. (P = 0.05)	NS	NS	287.48	1.3	0.5	1.5	0.02
Fertility levels (F)							
F_1: Control (*Azotobacter* + PSB)	137.9	9.9	3215.2	14.9	5.7	19.3	0.33
F_2: 50 % RDF + *Azotobacter* + PSB	147.3	10.0	3279.2	16.4	6.2	21.1	0.35
F_3:75 % RDF + *Azotobacter* + PSB	154.9	10.2	3500.8	18.9	7.3	22.7	0.36
F_4:100 % RDF + *Azotobacter* + PSB	171.8	10.3	3621.2	21.1	7.9	24.9	0.38
S. Em. ±	4.0	0.2	99.5	0.4	0.2	0.5	0.00
C.D. (P = 0.05)	11.51	NS	287.48	1.3	0.5	1.5	0.02
Interaction (M x F)	NS	NS	NS	NS	NS	NS	NS
C.V. %	9.03	9.4	10.13	8.44	8.31	8.30	6.8

Green and dry fodder yield

Application of castor cake @ 2.0 t/ha resulted in significantly higher green and dry fodder yield of sorghum but did not differ significantly with application of FYM @ 15.0 t/ha. The lowest green forage yield was rewarded with application of castor cake @ 1.0 t/ha. The increase in green forage yield was 22.5% over latter. Same trend was found in case of dry fodder yield. Use of castor cake or FYM at higher rate provide adequate and balance nutrition to plant throughout crop growth period which remarkably improved plant growth and finally resulted into maximum green forage yield. Jat *et al*. (2013) [5] and Singh *et al*. (2016) [9] also reported similar results.

The 100% RDF resulted in significantly the highest green forage yield. However, application of 75% RDF was found statistically alike. Increase in green forage yield with 100% RDF was 32.3%, 22.6% and 11.7% over control, 50% RDF and 75% RDF, respectively. Higher yield might be due to cumulative effect of elevated growth stature as well as yield structure. Moreover, increase in uptake of nutrients due to optimum release of nutrients besides mobilizing unavailable plant nutrients into available form by bio fertilizers that in turn gave higher green forage production. These results are supported by findings of Gopalan *et al*. (2007) and Singh *et al*. (2012) [10].

Economics

Maximum net return and BCR were obtained from the crop received castor cake of 2.0 t/ha (Table 2). The lowest net return and BCR were recorded in castor cake of 1.0 t/ha. The 100% RDF along with boifertilizers recorded significantly higher net return and BCR followed by 75 % RDF + *Azotobacter* + PSB. The higher net return might be due to the remarkable improvement of growth and yield attributes which ultimately resulted in higher green fodder yield in these treatments.

Table 2: Effect of organic manures and fertility levels on green and dry fodder yield and economic returns of *kharif* fodder sorghum

Treatments	Green fodder yield (q/ha)	Dry fodder yield (q/ha)	Gross returns (Rs/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs /ha)	BCR
Sources of organic manure (M)						
M_1:10 t FYM/ha	331.79^{b}	100.25^{b}	66358	29687	36671	2.23
M_2:15 t FYM/ha	344.13^{ab}	104.27^{a}	68826	33207	35619	2.07
M_3:1 t castor cake/ha	298.10^{c}	90.62^{c}	59620	25907	33713	2.30
M_4:2 t castor cake/ha	365.10^{a}	107.34^{a}	73020	29167	43853	2.50
Fertility levels (F)						
F_1: Control (*Azotobacter* + PSB)	291.90^{c}	87.50^{d}	58380	26915	31465	2.17
F_2: 50 % RDF + *Azotobacter* + PSB	315.12^{bc}	95.11^{c}	63024	29380	33644	2.15
F_3:75 % RDF + *Azotobacter* + PSB	345.82^{b}	104.68^{b}	69164	30352	38812	2.28
F_4:100 % RDF + *Azotobacter* + PSB	386.28^{a}	115.19^{a}	77256	31321	45935	2.47
S. Em. ±	10.48	1.24				
Interaction (M x F)	NS	NS				
C.V. %	10.85	4.28				

Quality

The protein content in fodder was influenced significantly by different levels of organic manures and fertilizers (Table 4). As N is basic constituent of protein and with increase in rate of N application from organic manures and inorganic fertilizers along with biofertilizers, the N availability increased which resulted in enhanced protein content in fodder. Yadav *et al*. (2013) [11] reported maximum protein content under 100 % RDF to fodder sorghum and application of FYM @ 12.0 t/ha to maize crop (Kumar, 2015) [6].

Application of FYM @ 15.0 t/ha registered significantly lower crude fibre content in fodder but remained statistically at par with 2.0 tonnes castor cake/ha. The 100% RDF + *Azotobacter* + PSB noted the lowest crude fibre content (29.28%) and the highest under control treatment. Successive increase in N level significantly decreased crude fibre content. This shows that succulence and palatability improved with increase in N level from 50 to 100% RDF along with biofertilizers.

Table 3: Interaction effect of levels of organic manure and fertility levels on dry fodder yield of *kharif* fodder sorghum

Treatments	Dry fodder yield (q/ha)			
	Sources of organic manure (M)			
Fertility levels (F)	M_1	M_2	M_3	M_4
F_1	91.12^{e}	92.93^{de}	71.99^{f}	93.95^{de}
F_2	92.74^{e}	94.99^{de}	91.46^{e}	101.22^{cd}
F_3	106.98^{bc}	107.45^{bc}	91.90^{e}	112.39^{b}
F_4	110.13^{b}	121.68^{a}	107.12^{bc}	121.81^{a}
S. Em. ±	2.49			
C.D. (P = 0.05)	7.18			
C.V. %	4.28			

Nutrient uptake

Significantly the highest uptake of N and P was recorded with application of castor cake @ 2.0 t/ha than rest of the treatments. The increasing fertility levels upto 100% RDF along with biofertilizers resulted in the highest uptake of N and P than 75 % RDF + *Azotobacter* + PSB, 50 % RDF + *Azotobacter* + PSB and control plots. The higher uptake of nitrogen and phosphorus might be due to higher dry fodder yield due to application of castor cake and inorganic fertilizers along with biofertilizers increased availability of N and P to the crop throughout the crop period. Patil and Varade (2006) [8] also recorded the highest uptake of N and P with RDF + FYM in sorghum.

Post-harvest soil fertility

Application of castor cake @ 2.0 t/ha resulted in significantly higher soil organic carbon (0.34%), soil available N (161.1 kg/ha) and soil available P (29.3 kg/ha) followed by FYM @ 15.0 t/ha after harvest of fodder sorghum. The 100% RDF + *Azotobacter* + PSB resulted in increased organic carbon (0.33%) and available N and P followed by 75 % RDF + *Azotobacter* + PSB. The increase in organic carbon from its initial value in manured plots compared to control may be due to the fact that in manured plots microbial population might have increased, and as a result soil aggregation and decomposition have resulted in increased organic carbon content in soil. Castor cake/ farm yard manure increases the absorptive power of the soil for cations and anions particularly phosphates and nitrates. These absorbed ions are released slowly for the benefit of crop during the entire growth period and availability of these nutrients by plants is increased. The increase is available P might be due to the organic acids, which were released during microbial decomposition of organic matter which helped in the solubility of native phosphates as a result of which the availability of P content increased. These results are in accordance with the findings of Gundlur *et al*. (2015) [3].

Summary and conclusion

Based on one year study, it is concluded that application of castor cake @ 2.0 t/ha or FYM @ 15.0 t/ha along with 100 % RDF + *Azotobacter* + PSB to obtain higher green fodder yield, better fodder quality, higher net returns, soil available NP and nutrients uptake by *kharif* fodder sorghum under North Gujarat Agro-climatic conditions.

Acknowledgement

The authors are thankful to Professor & Head, Department of Agronomy and Dean, C. P. College of Agriculture, S.D. Agricultural University, Sardarkrushinagar for providing necessary facilities and permission to conduct the study.

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