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Effect of integrated nutrient management on nutrient content, uptake and economics of forage sorghum under north Gujarat agro-climatic conditions

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Abstract

A field experiment was conducted during the *kharif* seasons of 2022 and 2023 at the Agronomy Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar, Gujarat, to study the effects of integrated nutrient management on nutrient content, uptake and economics of forage sorghum under North Gujarat's agro-climatic conditions. The experiment consisted of 9 treatment combinations, including 3 organic manures (no manure, FYM at 10.0 t/ha, and castor cake at 1.0 t/ha) and 3 fertility levels (100% RDF, 75% RDF, and 50% RDF), arranged in a split-plot design with four replications. Among the different organic manures and fertility levels applied to forage sorghum, the combination of castor cake at 1.0 t/ha and 100% RDF was significantly superior in terms of nitrogen content and nutrient uptake. However, this combination did not have a significant effect on the nitrogen and phosphorus content of the crop. Additionally, the economic returns were most profitable with the application of castor cake at 1.0 t/ha along with 100% RDF, indicating that this treatment combination was not only beneficial for nutrient uptake but also for maximizing profitability.

Keywords: Forage sorghum, FYM, castor cake, RDF, content, uptake, economics

Introduction

Sorghum (*Sorghum bicolor* L.), native to Africa, is one of the most important cereal crops globally, with many of its varieties originating from this continent. It was also cultivated in India long before recorded history and was known in Assyria as early as 700 BC. In India, sorghum is locally referred to as *juvar* or *chari*. Sorghum holds the position of the fifth most important cereal crop in the world, and beyond its use as food, it is highly valued for its fodder and stover. Forage sorghum, which can grow between 6 to 12 feet tall, is especially notable for producing more dry matter per unit area than grain sorghum (Pandey and Roy, 2011) [8]. In India, sorghum is a key forage crop, prized for its fast growth, palatability, and nutritional value. It is widely used as silage and hay, in addition to being fed fresh to livestock. While sorghum has a higher yield potential compared to many other forage crops, its overall production remains relatively low (Singh *et al.*, 2016) [4, 9].

Fodder crops are grown or harvested to feed livestock in the form of forage, silage, and hay. Sorghum (2.6 million hectares) and Egyptian clover (1.9 million hectares) together account for approximately 54% of the total fodder area cultivated during the *kharif* and *rabi* seasons, respectively (Dagar, 2017) [2]. Currently, the country faces a significant deficit in fodder resources, with a 35.6% shortage in green fodder, a 10.95% deficit in dry fodder, and a 44% shortfall in concentrate fodder (Anon., 2015). By 2050, the demand for green and dry fodder is projected to reach 1,012 million tonnes and 631 million tonnes, respectively. However, if the current rate of expansion in forage supplies continues, there will be an 18.4% deficit in green fodder and a 13.2% shortfall in dry fodder by that year. To address these challenges, Integrated Nutrient Management (INM), which combines the use of fertilizers, organic manures, and biofertilizers, is crucial for sustaining crop production, maintaining soil health, and preserving biodiversity. The benefits of using a combination of organic and inorganic nutrient sources in INM have been proven to be superior to using either source alone (Palaniappan and Annadurai, 2007) [7].

Therefore, adopting INM strategies is key to enhancing both the productivity and quality of crops in an environmentally sustainable manner.

Materials and Methods

A field experiment on “effect of integrated nutrient management on nutrient content, uptake and economics of forage sorghum under North Gujarat agro-climatic conditions” was carried out at the Agronomy Instructional Farm, S. D. Agricultural University, Sardarkrushinagar, Gujarat during *kharif* seasons of 2022 and 2023. The experimental site was situated geographically 24° 19' North latitude and 72° 19' East longitude with an altitude of 154.52 metre above the mean sea level. The soil of experimental plot was loamy sand in texture, free from excess salt, neutral in soil reaction with low in organic carbon and available nitrogen, medium in available phosphorus and potash during both the years at the beginning of the experiment in 0-15 cm soil layer. The experiment consisted of three sources of organic manures viz., M₀: No manure, M₁: FYM @ 10 t/ha and M₂: Castor cake @ 1.0 t/ha as main plot and three levels of inorganic fertilizers viz., F₁: 100% RDF (120:60:00 kg N:P₂O₅:K₂O/ha), F₂: 75% RDF and F₃: 50% RDF as sub plot treatments to forage sorghum in *kharif* season and replicated four times in split plot design. FYM and castor cake were applied 10 days before sowing of forage sorghum and incorporated in the soil as per treatments. The Sorghum cultivar GFS-5 was sown in June during 2022 and 2023.

Standard agronomic practices were adopted for raising healthy crop. Data of growth and yield attributes were taken from 10 tagged plants. Biological and economic yields were taken from net plot.

Results and Discussion

Nutrient content and uptake

Effect of organic manures

Different organic manures did not show a significant effect on the nutrient content of forage sorghum. However, a significant improvement was observed in the nitrogen (N) content and the total uptake of nitrogen (N), phosphorus (P), and potassium (K) by forage sorghum. The maximum nitrogen content and nutrient uptake were recorded with the application of castor cake at 1.0 t/ha. Interestingly, the nutrient content and uptake in plots treated with both castor cake at 1.0 t/ha and farmyard manure (FYM) at 10.0 t/ha were similar. This similarity could be attributed to the fact that both castor cake and FYM promoted the release of nutrients in optimal amounts and provided a steady nutrient supply over an extended period. Nutrient uptake by the crop is influenced by both the nutrient content in the plant and the crop yield, with yield being the primary factor determining nutrient uptake. Therefore, the higher nitrogen uptake in forage sorghum was a result of both increased nutrient content and higher dry forage yield. These findings are in line with the studies by Kumar *et al.* (2015) in maize and Singh *et al.* (2016)^[9] in forage sorghum.

Table 1: Nutrient content and uptake by forage sorghum as influenced by organic manures and inorganic fertilizers (pooled data of two years)

Treatments	Content (%)			Uptake (kg/ha)		
	N	P	K	N	P	K
Main plot: Organic manures (M)						
M ₀ : No manure	1.565	0.240	1.37	90.09	13.77	78.87
M ₁ : FYM @ 10 t/ha	1.651	0.245	1.40	129.32	19.17	109.60
M ₂ : Castor cake @ 1.0 t/ha	1.707	0.248	1.43	139.41	20.27	116.30
S.E.m. ±	0.021	0.002	0.01	3.21	0.48	2.69
CD (P = 0.05)	0.064	NS	NS	9.9	1.48	8.27
CV %	6.17	4.57	5.13	13.13	13.27	12.95
Sub plot: Inorganic fertilizers (F)						
F ₁ : 100% RDF	1.680	0.246	1.41	133.32	19.46	111.57
F ₂ : 75% RDF	1.642	0.244	1.40	123.37	18.31	105.12
F ₃ : 50% RDF	1.601	0.242	1.38	102.13	15.44	88.08
S.E.m. ±	0.014	0.002	0.01	2.82	0.41	2.43
CD (P = 0.05)	0.041	NS	NS	8.1	1.18	6.98
Interaction (M × F)						
S.E.m. ±	0.025	0.003	0.02	4.89	0.71	4.22
CD (P = 0.05)	NS	NS	NS	14.02	2.04	NS
CV%	4.29	3.58	4.06	11.56	11.37	11.74
Significant interactions with year	-	-	-	-	-	-

Table 2: Interaction effect of M × F on nitrogen uptake (kg/ha) by forage sorghum (pooled data of two years)

Treatments	F ₁ : 100% RDF	F ₂ : 75% RDF	F ₃ : 50% RDF
M ₀ : No manure	93.59	101.54	75.14
M ₁ : FYM @ 10 t/ha	146.80	125.85	115.32
M ₂ : Castor cake @ 1.0 t/ha	159.57	142.73	115.93
S.E.m. ±: 4.09			
CD (P = 0.05): 14.02			

Table 3: Interaction effect of M × F on phosphorus uptake (kg/ha) by forage sorghum (pooled data of two years)

Treatments	F ₁ : 100% RDF	F ₂ : 75% RDF	F ₃ : 50% RDF
M ₀ : No manure	14.17	15.33	11.80
M ₁ : FYM @ 10 t/ha	21.65	18.61	17.24
M ₂ : Castor cake @ 1.0 t/ha	22.55	20.98	17.29
S.E.m. ±: 0.71			
CD (P = 0.05): 2.04			

Effect of inorganic fertilizers

The application of different fertility levels significantly increased the nitrogen (N) content and total uptake of nitrogen (N), phosphorus (P), and potassium (K) by forage sorghum. This increase was particularly pronounced with the application of nitrogen and phosphorus (NP) at 100% of the recommended dose (RDF), compared to 50% RDF. However, there was no significant difference in nitrogen content and uptake between the application of 100% RDF and 75% RDF. It is well established that nutrient uptake by crops is primarily influenced by total biomass production, with the nutrient status at the cellular level also playing a secondary role. Therefore, the higher nutrient uptake observed with the application of 100% RDF can be attributed to the combined effect of increased biomass production and improved nutrient status within the plant. These findings align closely with the results of Kumar *et al.* (2022)^[3] in fodder sorghum.

Interaction effect

The higher-order interaction between sources of organic manures and levels of inorganic fertilizers was found to be

significant in terms of nitrogen (N) and phosphorus (P) uptake by forage sorghum, as observed in the pooled study (Table 3 and 4). The maximum nutrient uptake was recorded with the integrated application of castor cake at 1.0 t/ha in combination with 100% of the recommended dose of inorganic fertilizers (RDF). This combination resulted in the highest uptake of both nitrogen and phosphorus by the forage sorghum crop. The significantly higher uptake of nitrogen and phosphorus in the treatment combination of castor cake at 1.0 t/ha and 100% RDF can be attributed to the increased dry fodder yield of *kharif* forage sorghum. This improvement in yield was a result of enhanced growth and better yield parameters, which were promoted by the combined application of organic manure and inorganic fertilizers. The integrated nutrient management approach likely facilitated a more balanced and sustained release of nutrients, ensuring a consistent supply of phosphorus throughout the crop's growth period. This, in turn, supported greater nutrient uptake and contributed to overall improvements in crop performance. The present results are in line of those reported by Kumar *et al.* (2005)^[5], Kumar and Dhar (2006)^[6] and Buba *et al.* (2021)^[1] in forage sorghum.

Table 4: Gross and net returns as well as BCR of forage sorghum (mean of two years)

Treatments	Green forage yield (kg/ha)	Gross returns (₹/ha)	Cost of cultivation (₹/ha)	Net returns (₹/ha)	BCR
Main plot: Organic manures (M)					
M ₀ : No manure	22175	88700	34102	54598	2.60
M ₁ : FYM @ 10 t/ha	26906	107624	48983	58641	2.20
M ₂ : Castor cake @ 1.0 t/ha	28021	112084	50667	61417	2.21
Sub plot: Inorganic fertilizers (F)					
F ₁ : 100% RDF	27624	110496	46210	64286	2.39
F ₂ : 75% RDF	26337	105348	44584	60764	2.36
F ₃ : 50% RDF	23140	92560	42958	49602	2.15

Economics

The application of 1.0 t of castor cake per hectare resulted in the highest net return and a benefit-cost ratio (BCR) of 2.21 (Table 4), making it the most profitable treatment. This was closely followed by the treatment involving FYM at 10 t/ha, which also provided significant returns. These findings highlight the importance of using organic amendments, such as castor cake and FYM, in combination with inorganic fertilizers for optimizing economic returns from forage sorghum cultivation. Additionally, when comparing the impact of different fertility levels, forage sorghum fertilized with 100% of the recommended dose of fertilizers (RDF) yielded the highest gross returns, net returns, and BCR. The application of 75% RDF, while still profitable, resulted in slightly lower returns than the 100% RDF treatment. In contrast, the lowest gross returns, net returns, and BCR were observed under the 50% RDF treatment, indicating that insufficient fertilizer application significantly limits the economic potential of forage sorghum. These results underscore the importance of using an adequate fertilizer regime, such as 100% RDF, to maximize both yield and profitability.

Conclusion

On the basis of two years of experimentation, it can be concluded that application of castor cake @ 1.0 t/ha or FYM @ 10 t/ha along with 100% RDF (120:60:00 kg N:P₂O₅:K₂O/ha) to forage sorghum recorded maximum nutrient content and uptake as well as economically more profitable under North Gujarat agro-climatic condition.

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