Original Research Article

Optimizing Fodder Sorghum Quality: Unveiling the Impact of Varied Nitrogen Levels in Multicut Genotypes

ABSTRACT

An experiment was conducted to study the effect of varied levels of nitrogen on the quality of multicut fodder sorghum genotypes at the ICAR-Krishi Vigyan Kendra in Vijayapur, during the Kharif 2019–20 under irrigated conditions. The soil, characterized by a clay texture, exhibited a medium level of nitrogen, phosphorus, and potassium availability. The experiment involved two fodder sorghum genotypes (CoFS-29 & CoFS-31) and five nitrogen levels (100, 125, 150, 175 and 200 kg N ha^{-1}), arranged in a split-plot design with three replications. The study aimed to assess the nutritional quality and yield of multicut fodder sorghum comprising genotypes and nitrogen levels.Results indicated that the CoFS-31 genotype outperformed CoFS-29, demonstrating higher yields in terms of crude protein (438 kg ha^{-1}), crude fiber (1237 kg ha^{-1}), green fodder (130.49 t ha^{-1}), and dry matter (29.67 t ha^{-1}). Furthermore, in comparison to lower nitrogen levels across all cuttings, the application of 200 kg N ha^{-1} significantly increased yields in crude protein (554 kg ha^{-1}), crude fiber (1495 kgha^{-1}), green fodder (154.32 t ha^{-1}), and dry matter (34.97 t ha^{-1}). The study concludes that the application of 200 kg N ha^{-1} enhances the yield of green forage and improves the quality of fodder produced by multicut fodder sorghum.

*Keywords***:** CoFS-29, CoFS-31, Fodder, Fodder sorghum, Forage, Crude fibre

INTRODUCTION

India has the largest livestock population in the world. As per 20th livestock census, India secured first position in livestock population which, accounts for 15% of all domesticated animals globally, totalling 536 million heads. India supports 55%, 16%, 20%, and 4% of the world's cattle, sheep, and goats, respectively. The total livestock population in the country was increased by 4.6 per cent over 19th livestock census. On the other hand, the availability of green fodder, dry fodder and concentrates are 734.2, 326.4 and 61.0 million tonnes against the present requirement of 827.2, 426.1 and 85.8 million tonnes with a net deficit of 11.24, 23.40 and 28.90 per cent, respectively in the country [1].Likewise, in Karnataka, the quantities of green fodder, dry fodder, and concentrates stand at 85 million tonnes, 15 million tonnes, and 7.5 million tonnes, respectively. This contrasts with the current demand of 122 million tonnes, 25.4 million tonnes, and 29.5 million tonnes, resulting in deficits of 30%, 40.95%, and 74.50%, respectively [2].This has led to a significant gap between the demand and supply of green fodder, with a shortage of 61% in dry forage and 22% in green forage. Consequently, the nation's current fodder and feed resources can only meet 48% of the total requirement.This shortfall has a direct impact on realizing the full milk production potential of livestock, as the available fodder is of poor quality [3]. Moreover, the expensive nature of concentrate feeds further exacerbates the issue, making them unaffordable for various sections of farmers.

Dry fodder of the sorghum crop after harvesting of grain which is typically fed to the livestock. However, such straws offer low-quality fodder for dairy animalsdue to their lower crude protein content and higher crude fiber content.In response to this need, TNAU, Coimbatore introduced a multicut fodder sorghum variety, CoFS-29, in 2001 for widespread cultivation in Tamil Nadu. This variety was later introduced in Karnataka, particularly at the University of Agricultural Sciences, Dharwad, in 2007-08. Further efforts were undertaken at the Department of Forage Crops, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore. Mutation breeding using gamma rays was employed to address the seed-shattering behaviour. Subsequently, a high-yielding, non-seed-shattering multicut fodder sorghum, CoFS-31, was identified and released at the state level in 2014.

Among various factors, optimal crop nutrition and varietal characteristics play a crucial role in achieving increased green fodder yield and enhanced quality. Nitrogen, among the key supplementary elements, has been recognized for its role in enhancing both the green fodder yield and quality parameters such as crude protein and crude fiber content in multicut fodder sorghum.

1. MATERIALS AND METHODS

2.1 Experimental Site and Soil

In *Kharif* 2019-20, a field experiment was carried out at the instructional farm, Krishi Vigyana Kendra, Vijayapur, to investigate the impact of graded levels of nitrogen application on the quality of multicut fodder sorghum genotypes (CoFS-29 & CoFS-31). The soil type present at KVK Vijayapur was medium-deep black soil withclay texture, alkaline in reaction (pH 8.14), salinity (0.54 dSm^{-1}), medium in available Nitrogen (289 kg N ha^{-1}) medium in available Phosphorus (35.6 kg P_2O_5 ha^{-1}), and medium in available Potassium (460.5 kg K_2O ha^{-1}). The annual rainfall for 2019-20 was 634.5 mm, slightly above the average of 622 mm, with well-distributed rainfall of 542.3 mm during the cropping period from June fourth week to May fourth week.

2.2 Design ofExperiment and Treatment Details

The experiment was laid out in a split-plot design with 10 treatment combinations of two genotypes (CoFS-29, CoFS-31 as V_1 and V_2 respectively) and five levels of nitrogen (100, 125, 150, 175 and 200 kg ha^{-1} as N_1, N_2, N_3, N_4 and N_5 respectively). Nitrogen at all levels is divided into six equal parts and applied at sowing, 30 days after sowing and after each cutting four times. An entire dose of Phosphorus and potassium were applied at the time of sowing (40:40 kg ha^{-1}). Since the crop was sown in *the Kharif* season, no irrigation was provided till November, five months after sowing because of sufficient rain. Later on, 10 irrigations were given at an interval of 15-20 days. The crop was harvested for green forage at 50 per cent flowering in each treatment at all the five cuttings. The first cutting was made 90 DAS and subsequent cuttings were made at an interval of 60 days. The plant was cut 5 cm above the ground level at the time of each cutting. The green fodder weight per plot was recorded in the field immediately after harvest. Totally, five cuts were taken from June 2019 to May 2020. The treatment wise green forage yield was multiplied by the respective dry matter percentage to get the dry matter yield. Later samples were powdered for quality estimation.The forage quality traits like crude protein and crude fibre were determined by the standard procedure Association of Official Agriculture Chemist [4].

2.3 Statistical Analysis

The data recorded during the investigation were compiled and analysed for statistical significance as per the analysis of variance for the split plot design. Fisher's method of analysis of variance (ANOVA) as described by Gomez and Gomez [5] was adopted for the purpose. Standard error of mean and coefficient of variability have been worked out for a set of observations under each character at P=0.05 to interpret the significance. The analysis was carried out using Microsoft Excel.

2. RESULTS AND DISCUSSION

3.1 Effect of genotypes and varied levels of nitrogen on quality parameter of fodder sorghum

3.1.1 Crude protein content

The genotypes varied significantly with respect to crude protein content at harvest, with the highest crude protein content observed under CoFS-31 (7.19%). The significantly lowest crude protein content was recorded with the CoFS-29 genotype. Among the varied nitrogen levels, the application of 200 kg N ha^{-1} recorded significantly higher crude protein content (7.80 %) and this was on par with an application of 175 kg N ha^{-1} (7.45 %). The significantly lower crude protein content was recorded with the application of 100 kg N ha^{-1}(5.53 %)(Table 1).The interaction between genotype and nitrogen levels was found to be non-significant. The higher crude protein content is mainly due to the superior genetic characteristics of CoFS-31 as per the findings of Senthilkumar *et al.* [6]. This increase in crude protein content is due to that, nitrogen being an essential constituent of chlorophyll, protoplasm, protein and nucleic acids and required for protein synthesis. These results are in accordance with Pankhaniya*et al*.[7] and Meena and Meena [8]. Increased availability of nitrogen thereby improves uptake and a corresponding increase in the protein content of herbage [9].

3.1.2 Crude protein yield

Crude protein yield differed significantly and higher mean crude protein yield was recorded with CoFS-31 (438 kg ha^{-1}) as compared to CoFS-29 (329 kg ha^{-1}). The crude protein yield increased significantly with increase in levels of nitrogen(Table 1). Application of 200kg N ha^{-1} recorded significantly higher crude protein yield (554 kg ha^{-1}) compared to lower levels of nitrogen. The interaction between genotypes and nitrogen levels was found to be significant. The combination of CoFS-31 with 200 kg N ha^{-1} recorded the statistically highest crude protein yield (637 t ha^{-1}). In theCoFS-31, the higher protein yield was mainly attributed to its considerably higher dry matter yield (11.89 per cent) compared to CoFS-29 [10]. It was believed that the nutritional values of the fodder crop influenced with the genotypes. The results of investigation strongly supported by the findings of Himani *et al.*[11] and Gurjar *et al.* [12].

3.1.3 Crude fibre content

The fodder having less crude fibre percentage is considered a good quality because higher the crude fibre percentage lesser will be digestibility [13]. The genotypes varied significantly with respect to crude fibre content at harvest, with lowest crude protein content was observed under CoFS-31 (19.37 %) compared to CoFS-29 (23.43 %). Among the different nitrogen levels, supply of 200 kg N ha^{-1} recorded statisticallylower crude fibre content (20.07 %) and this was on par with application of 175 and 150 kg N ha^{-1} (20.39 and 21.41 % respectively). The maximum crude fibre content was recorded with application of 100 kg Nha^{-1} (22.99 %). The interaction among genotype and nitrogen levels was found to be non-significant(Table 1). The lesser crude fibre content is mainly due to superior genetic characteristics of CoFS-31 as per the findings of Senthilkumar *et al.*[6] and Himani *et al*. [11].

The significant decrease in crude fibre content with increase in nitrogen level were due to higher nitrogen supply. The more rapidly synthesized carbohydrates are converted in to proteins and protoplasm and only smaller portion is available for cell wall material. Cells thus produced tend to contains more protoplasm than cell wall material. The leaves of a plant rich in nitrogen contain a relatively high proportion of water, low proportion of dry matter, more succulent and lower in crude fibre content [14]. Results of the present study are also in conformity with the findings of Patel *et al.*[15].

3.1.4 Crude fibre yield

There was no significant difference between genotypes with respect to crude fibre yield. The CoFS-29 genotype recorded numerically higher crude fibre yield (1332 kg ha^{-1}) than CoFS-31 (1237 kg ha^{-1}). Among different nitrogen levels, application of 200 kg N ha^{-1} recorded significantly higher crude fibre yield (1495 kg ha^{-1}) and was on par with 175 kg N ha^{-1}(1428 kg ha^{-1}). The lowest crude fibre yield was recorded with application of 100 kg N ha^{-1} (1024 kg ha^{-1})(Table 1). Lower the crude fibre percentage maximum will be the digestibility. The crude fibre yields however, increased significantly with increase in nitrogen level up to 175 kg N ha^{-1}, mainly because of significant increase in dry matter with increase in N level [16]. The increased crude fibre yield was due the maximum dry matter production[15, 17].

3.2 Effect of genotypes and varied levels of nitrogen on yield parameter of fodder sorghum

3.2.1 Green fodder yield

Green fodder yield was significantly influenced by genotypes and nitrogen levels. Genotype CoFS-31 recorded significantly higher green fodder yield (130.49t ha^{-1}) as compared to that with CoFS-29 (114.59 t ha^{-1}). The higher green fodder yield in CoFS-31 was mainly due to higher plant height, number of tillers per meter row length, and leaf stem ratio. These results are in conformity with the findings of Gaurkar and Bharad[18]. Among nitrogen levels, application of 200 kg N ha^{-1} recoded significantly higher green fodder yield (154.32 t ha^{-1}) as compared to that of other lower nitrogen levels(Table 2). This may be mainly attributed to improved growth and yield parameters, viz., plant height, number of tillers m^{-1} row, leaf stem ratio and the beneficial effects of nitrogen on cell division and elongation, formation of nucleotides and Co-enzymes which resulted in increased meristematic activity and photosynthetic area and hence more production and accumulation of photosynthates, yielding higher green fodder and dry matter. These results are in conformity with the findings of Verma*et al*.[19], Sheoran and Rana [20].

3.2.2 Dry matter yield

Dry matter yield was significantly influenced by genotypes and nitrogen levels. CoFS-31 recorded significantly higher dry matter yield (29.67 t ha^{-1}) as compared to that with CoFS-29 (26.14 t ha^{-1}). Among nitrogen levels, application of 200 kg N ha^{-1} recoded significantly higher dry fodder yield (34.97 t ha^{-1}) as compared to other nitrogen levels 100, 125, 150 and 175 kg N ha^{-1} (19.94, 24.12, 28.02 and 32.46, respectively) on mean data basis(Table 2).This was mainly due to application of higher rate of nitrogen met requirement of plants at different growth stages, resulted in higher uptake of nitrogen by plants. This might have accelerated the meristematic activity, vegetative growth and photosynthetic activity, consequently resulting in to increased plant height, number of leaves per plant, green and dry leaf weight per plant, green and dry stem weight per plant which had eventually increased green fodder and dry fodder yields (Chaudhary *et al.,* 2018) [16]. Similar trend was also observed by Ayub *et al.*[13], Verma *et al.*[19], Devi *et al.*[21], Meena *et al.*[22] and Rana *et al.*[23].

3.3 Effect of genotypes and nitrogen level on the economics of multicut fodder sorghum

The genotype CoFS-31 with nitrogen @ 200 kg ha^{-1} produced significantly higher gross, net returns and B: C (₹ 250575, ₹ 176270 and 3.37, respectively). However, it was on par with an application of nitrogen @ 175 kg ha^{-1} (₹ 234430, ₹ 160447 and 3.17 respectively)(Table 2). This might be due to the higher production of green fodder yield. The significantly lowest gross, net returns and B: C was observed on CoFS-29 with N @ 100 kg N ha^{-1}[24].

3. CONCLUSION

Based on the results it can be concluded that genotype CoFS-31 with a supply of 175 and 200 kg N ha^{-1} recorded higher crude protein, crude protein yield, green and dry fodder yield with lower crude fibre content and yield. Which was found to be optimum and profitable and produced higher green fodder yield in multicut fodder sorghum under irrigated conditions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

Table 1: Quality parameters of fodder sorghum as influenced by genotypes and nitrogen levels

Treatment	Crude protein content (%) *	Crude protein yield (kg ha^{-1}) *	Crude fibre content (%) *	Crude fibre yield (kg ha^{-1}) *
Varieties (V)				
CoFS-29 (V_1)	6.32	329	23.43	1332
CoFS-31 (V_2)	7.19	438	19.37	1237
S.Em. ±	0.13	15.46	0.46	23.39
C.D. at 5 %	0.80	93.13	2.78	NS
Nitrogen levels (N)(kg ha^{-1})				
100 (N_1)	5.53	216	22.99	1024
125 (N_2)	6.16	291	22.16	1170
150 (N_3)	6.83	383	21.41	1305
175 (N_4)	7.45	474	20.39	1428
200 (N_5)	7.80	554	20.07	1495
S.Em. ±	0.16	14.30	0.64	42.26
C.D. at 5 %	0.49	42.86	1.91	126.68
Treatment combinations (V × N)				
$V_1 N_1$	5.08	195	25.42	1123
$V_1 N_2$	5.69	253	24.51	1260
$V_1 N_3$	6.42	338	23.45	1342
$V_1 N_4$	7.01	390	22.32	1424
$V_1 N_5$	7.39	471	21.46	1508
$V_2 N_1$	5.99	238	20.55	925
$V_2 N_2$	6.63	329	19.81	1081
$V_2 N_3$	7.25	428	19.36	1268
$V_2 N_4$	7.90	558	18.46	1431
$V_2 N_5$	8.21	637	18.68	1481
S.Em. ±	0.23	20.22	0.90	59.76
C.D. at 5 %	NS	60.61	NS	NS

*** Mean of five cuts**

Table 2: Total green fodder yield (t ha^{-1}), Total dry fodder yield (t ha^{-1}) and benefit cost ratio (B:C) of multicut fodder sorghum genotypes as influenced by varied levels of nitrogen

Treatment	Total green fodder yield (t ha^{-1})	Total dry fodder yield (t ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C
Varieties (V)					
CoFS-29 (V_1)	114.59	26.14	171858	98196	2.33
CoFS-31 (V_2)	130.49	29.67	195729	122067	2.65
S.Em. ±	2.47	0.47	3685	3685	0.05
C.D. at 5 %	15.02	2.86	22420	22420	0.30
Nitrogen levels (N) (kg ha^{-1})					
100 (N_1)	87.76	19.94	131643	58623	1.80
125 (N_2)	106.00	24.12	158913	85571	2.17
150 (N_3)	122.62	28.02	183928	110265	2.50
175 (N_4)	142.00	32.46	213000	139017	2.88
200 (N_5)	154.32	34.97	231485	157180	3.12
S.Em. ±	3.27	0.70	4903	4903	0.07
C.D. at 5 %	9.80	2.10	14698	14698	0.20
Treatment combination (V × N)					
$V_1 N_1$	87.23	19.82	130845	57825	1.79
$V_1 N_2$	102.40	23.28	153435	80094	2.09
$V_1 N_3$	114.03	26.04	171045	97383	2.32
$V_1 N_4$	127.71	29.15	191570	117587	2.59
$V_1 N_5$	141.60	32.42	212395	138090	2.86
$V_2 N_1$	88.29	20.06	132440	59420	1.81
$V_2 N_2$	109.60	24.96	164390	91049	2.24
$V_2 N_3$	131.21	30.01	196810	123148	2.67
$V_2 N_4$	156.28	35.78	234430	160447	3.17
$V_2 N_5$	167.05	37.52	250575	176270	3.37
S.Em. ±	4.62	0.99	7344	7344	0.11
C.D. at 5 %	13.86	2.97	22158	22158	0.32

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