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Effect of splitting of nitrogen dose and cutting management on yield, quality and economics of fodder sorghum (*Sorghum bicolor* (L.) Moench)

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Abstract
A field experiment was conducted on clayey soil at the Instructional cum Research Farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G), to study the "Effect of splitting of nitrogen dose and cutting management on yield, quality and economics of fodder sorghum (*Sorghum bicolor* (L.) Moench)" of variety CSH-43 MF, during the *Kharif* season of 2024. The experiment followed a factorial randomized block design, comprising of 16 treatment combinations of four nitrogen levels with its splitting at basal, 30 DAS, first and second cut, Four nitrogen levels are N_1:100 kg ha^{-1} (40+20+20+20 kg ha^{-1}), N_2:120 kg ha^{-1} (50+20+25+25 kg ha^{-1}), N_3:140 kg ha^{-1} (50+30+30+30 kg ha^{-1}), and N_4:160 kg ha^{-1} (60+30+35+35 kg ha^{-1}) and four different cutting managements of C_1: first cut at 50 DAS+ second cut at 80 DAS + third cut at 110 DAS; C_2: first cut at 50 DAS + second cut at 90 DAS + third cut at 130 DAS; C_3: first cut at 60 DAS + second cut at 90 DAS + third cut at 120 DAS; and C_4: first cut at 60 DAS + second cut at 100 DAS + third cut at 140 DAS, each replicated three times. Results revealed that application of 160 kg N ha^{-1} in four splits recorded maximum green fodder yield (497 q ha^{-1}), dry fodder yield (29 q ha^{-1}), green fodder productivity (1.33 q ha^{-1} day^{-1}), dry fodder productivity (0.23 q ha^{-1} day^{-1}) and crude protein yield (2.91 q ha^{-1}). Cutting management with first cut at 60 DAS, second cut at 90 DAS, and third cut at 120 DAS resulted in the highest total green fodder yield (485 q ha^{-1}), dry fodder yield (29.7 q ha^{-1}), green fodder productivity (1.35 q ha^{-1} day^{-1}), dry fodder productivity (0.24 q ha^{-1} day^{-1}), and crude protein yield (2.88 q ha^{-1}). The highest net returns (₹87,209 ha^{-1}) and benefit-cost ratio (3.43) were obtained under the combination of 160 kg N ha^{-1} with cutting at 60, 90, and 120 DAS. It can be concluded that for maximizing fodder yield and profitability in Chhattisgarh, application of 160 kg N ha^{-1} in four splits with cutting at 60, 90, and 120 DAS is most effective.

Keywords: Fodder sorghum, split application of nitrogen, cutting management, yield, economics

Introduction
Sorghum (*Sorghum bicolor* (L.) Moench), commonly known as *jowar*, is the fifth most important cereal after maize, rice, wheat, and barley, Called the "King of Coarse Cereals" and the "Camel Crop". It thrives in arid soils and drought conditions. Originating from East Africa, sorghum is widely grown in tropical and subtropical regions. In India, it is known as jowar, cholam and jonna. Being a C4 plant, it has high photosynthetic and water-use efficiency, making it ideal for dryland farming Getachew *et al.*, (2016) [4].
In fresh fodder sorghum, the dry matter content varied from 11.82 to 38.19%, crude protein ranged from 5.29 to 21.24%, total ash content 6.15 to 13.08%, NDF content 70.13 to 82.19% and ADF content 47.87 to 78.86%. Sorghum offers cattle wholesome food in a variety of forms, including silage, hay, and green chop. Maintaining a consistent, well-balanced supply of more nutrient-dense feed and fodder is crucial for the state Chakravarthi *et al.*, (2018) [3].

Materials and Methods
The experiment was conducted during the *Kharif* season of 2024 at the Instructional cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, (C.G). Raipur is situated in the central part of Chhattisgarh at a latitude of 21º16'N and a longitude of 81º36'E, positioned at an

elevation of 298 meters above mean sea level. The experimental site falls under the dry, moist sub-humid agro-climatic zone. The region receives an average annual rainfall ranging between 1200 to 1400 mm. Throughout the duration of the experiment, the temperature generally ranged between 12°C and 33.8°C. The physio-chemical properties of soil at the experimental site was clayey with neutral pH (7.46), electrical conductivity EC (0.38 dSm^{-1}), organic carbon OC (0.67%), deficient in nitrogen (188.70 kg ha^{-1}), moderate in phosphorus (23.92 kg ha^{-1}), and rich in potassium (345.30 kg ha^{-1}). The experiment followed a factorial randomized block design, comprising of 16 treatment combinations of four nitrogen levels with its splitting at basal, 30 DAS, first and second cut, N_1:100 kg ha^{-1} (40+20+20+20 kg ha^{-1}), N_2:120 kg ha^{-1} (50+20+25+25 kg ha^{-1}), N_3:140 kg ha^{-1} (50+30+30+30 kg ha^{-1}), and N_4:160 kg ha^{-1} (60+30+35+35 kg ha^{-1}) and four different cutting managements of C_1: first cut at 50 DAS+ second cut at 80 DAS + third cut at 110 DAS; C_2: first cut at 50 DAS + second cut at 90 DAS + third cut at 130 DAS; C_3: first cut at 60 DAS + second cut at 90 DAS + third cut at 120 DAS; and C_4: first cut at 60 DAS + second cut at 100 DAS + third cut at 140 DAS, each replicated three times. The variety of the fodder sorghum is a hybrid named CSH-43 MF, and with a row-to-row spacing of 30 cm and a seed rate of 20 kg ha^{-1}. Sowing was done manually, placing the seeds at a depth of 3-4 cm in pre-opened furrows and then covering them with soil. The economics of the fodder sorghum was calculated using the cost of cultivation (Rs. ha^{-1}), gross return (Rs. ha^{-1}), net return (Rs. ha^{-1}), and benefit-cost ratio, dividing gross returns by the cost of cultivation of the crop.

Results and Discussion

1. Green fodder yield (q ha^{-1})

Splitting of nitrogen doses had a significant impact on green fodder yield in total yield. There was a steady increase in green fodder yield with successive increase in the levels of nitrogen from 100 to 160 kg ha^{-1}. Application of nitrogen 160 kg ha^{-1} with a splitting of 60 kg at basal, 30 kg at 30 DAS, 35 kg at first cut & 35 kg at second cut was found significantly superior in respect to highest green fodder yield of 497 q ha^{-1} in total. Lowest green fodder yield was recorded under application of nitrogen 100 kg ha^{-1} in all cuts due to the lowest dose of nitrogen as compared to the other.

An appraisal of the given data revealed significant differences in green fodder yield due to cutting management at each cut and total values. Treatment C_3: Total crop duration of 120 days (first cut at 60 DAS, second cut at 90 DAS & third cut at 120 DAS) produced the significantly highest amount of green fodder yield of 485 q ha^{-1} in total. The lowest green fodder yield in all cuttings was recorded under treatment C_1: Total crop duration of 110 days except second cutting. Similar findings were reported by Mahdi *et al.* (2012) [6] & Azam *et al.* (2010) [1].

Interaction effects splitting of different nitrogen levels and cutting management had not exerted any significant difference in green fodder yield.

2. Dry fodder yield (q ha^{-1})

Data with respect to dry fodder yield of forage sorghum as influenced by splitting of different levels of nitrogen and cutting management. Application of 160 kg N ha^{-1} with a splitting of 60 kg at basal, 30 kg at 30 DAS, 35 kg at first cut & 35 kg at second cut was found significantly superior in respect to highest dry fodder yield of 29.0 q ha^{-1} in total. This might be due to nitrogenous fertilizer because nitrogen is integral part of chlorophyll which plays important role in photosynthetic activity of leaves finally helped to accumulate more biomass increases the dry matter yield. The lowest dry fodder yield was recorded under application of nitrogen 100 kg ha^{-1}. Similar findings were reported by Meena *et al.* (2017) [8] and Rewatkar *et al.* (2011) [10].

Treatment C_3: Total crop duration of 120 days gave significantly highest yields of 29.7 q ha^{-1} in total fodder yield. Lowest dry fodder yields was recorded treatment C_1: Total crop duration of 110 days in all except first cut. Similar findings were reported by Kumar *et al.* (2010) [5] & Trivedi and Mundra (2010) [15].

Interaction effects splitting of different nitrogen levels and cutting management had not exerted any significant difference in dry fodder yield.

3. Green fodder productivity (q ha^{-1} day^{-1})

The green fodder productivity of fodder sorghum was significantly influenced by splitting of different nitrogen levels in total result. There was a steady increase in green fodder productivity with successive increase in the levels of nitrogen from N_1 (100 kg N ha^{-1}) to N_4 (160 kg N ha^{-1}). Application of 160 kg N ha^{-1} was found significantly superior in respect to highest green fodder productivity of 1.33 q $ha^{-1}day^{-1}$ in total. While treatment N_3, in which nitrogen 140 kg ha^{-1} was applied in split statistically at par in total. The lowest green fodder productivity was recorded under application of 100 kg nitrogen per hectare with a splitting of 40 kg at basal, 20 kg at 30 DAS, 20 kg at first cut & 20 kg at second cut in all cuts due to lowest dose of nitrogen as compared to other.

An appraisal of the given data revealed that significant differences in green fodder productivity due to cutting management in total values. Treatment C_3: Total crop duration of 120 days (first cut at 60 DAS, second cut at 90 DAS & third cut at 120 DAS) produced the significantly highest amount of green fodder productivity of 1.35 q $ha^{-1}day^{-1}$ in total and it was irreplaceable. Lowest green fodder productivity was obtained in second cutting management (C_2), 1.11 q ha^{-1} day^{-1}.

Interaction effects splitting of different nitrogen levels and cutting management had not exerted any significant difference in green fodder productivity.

4. Dry fodder productivity (q ha^{-1} day^{-1})

Data with respect to dry fodder productivity of forage sorghum as influenced by splitting of different levels of nitrogen and cutting management. Application of 160 kg N ha^{-1} with a splitting of 60 kg at basal, 30 kg at 30 DAS, 35 kg at first cut & 35 kg at second cut was found significantly superior in respect to highest dry fodder productivity of 0.23 q $ha^{-1}day^{-1}$ in total. This was due to enhanced photosynthesis and biomass accumulation. While treatments N_3:140 kg N ha^{-1} & N_2:120 kg N ha^{-1} were statistically at par with N_4 in total. The lowest dry fodder productivity 0.17 q ha^{-1} day^{-1} was recorded under application of 100 kg N ha^{-1}.

An appraisal of the given data revealed that significant differences in dry fodder productivity due to cutting management in total values. Treatment C_3: Total crop duration of 120 days produced the significantly highest amount of dry fodder productivity of 0.24 q $ha^{-1}day^{-1}$ in total. Lowest dry fodder productivity 0.17 q ha^{-1} day^{-1} was obtained in first cutting management in which total crop duration was 110 days.

Interaction effects splitting of different nitrogen levels and cutting management had not exerted any significant difference in dry fodder productivity.

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

The impact of splitting of nitrogen doses, cutting management on crude protein yield of fodder sorghum are summarized in Table 1. There was a steady increase in crude protein yield with successive increase in the levels of nitrogen from 100 to 160 kg ha^{-1}. Application of 160 kg nitrogen per hectare was found significantly superior in respect to highest crude protein yield of 2.91q ha^{-1} in total. Since application of nitrogen 160 kg ha^{-1} resulted in accumulation of dry matter and crude protein content in plant which turn increased crude protein yield. This may due to higher level of nitrogen because nitrogen is directly involved in protein synthesis. The lowest crude protein yield 1.77 q ha^{-1} was recorded under application of nitrogen 100 kg ha^{-1} in all cuts. Similar findings were reported by Sher *et al.* (2016) [11] & Singh *et al.* (2019) [13].

Treatment C_3: Total crop duration of 120 days produced the significantly highest amount of crude protein yield of 2.88 q ha^{-1} in total. Treatment C_4: Total crop duration of 140 days was statistically at par with highest one. The lowest crude protein yield was recorded under treatment C_1: Total crop duration of 110 days.

Interaction effects splitting of different nitrogen levels and cutting management had not exerted any significant difference in crude protein yield.

Table 1: Effect of nitrogen levels and cutting management on total fodder yield (q ha^{-1}) and productivity (q ha^{-1} day^{-1}) of multi-cut forage sorghum.

Treatments	Yield and quality parameters				
Nitrogen levels (Splitting of nitrogen) (kg ha^{-1})	**GFY**	**DFY**	**GFP**	**DFP**	**CPY**
N_1: 100 (40+20+20+20)	356	22.0	0.95	0.17	1.77
N_2: 120 (50+20+25+25)	438	24.7	1.17	0.21	2.26
N_3: 140 (50+30+30+30)	470	27.7	1.26	0.22	2.70
N_4: 160 (60+30+35+35)	497	29.0	1.33	0.23	2.91
S.Em.±	9.29	0.77	0.02	0.01	0.08
C.D.(P=0.05)	26.82	2.24	0.07	0.02	0.22
Cutting management (Days after sowing)					
C_1: 110 (50,80 &110)	367	19.2	1.12	0.17	1.71
C_2: 130 (50,90 &130)	431	25.4	1.11	0.20	2.25
C_3: 120 (60,90 &120)	485	29.7	1.35	0.24	2.88
C_4: 140 (60,100 &140)	478	28.9	1.14	0.22	2.79
S.Em.±	9.29	0.77	0.02	0.01	0.08
C.D.(P=0.05)	26.82	2.24	0.07	0.02	0.22
Interaction	NS	NS	NS	NS	NS

Economics

Among the different levels of nitrogen, application of nitrogen 160 kg ha $^{-1}$ (N_4) accrued maximum net realization of 76007 ha^{-1} and BCR of 3.1 followed by N_3 (140 kg N ha^{-1}). The increase in profitability was mainly due to higher green forage yield. The results support those achieved by Buldak *et al*. (2010) [2], Meena and Meena (2012) [7] and Singh *et al*. (2012) [12].

Data on economics indicated that C_3 (First cut at 60 days after sowing, subsequent two cuts each at 30 days interval) amassed maximum net realization (73743 ha^{-1}) and BCR (3.1). This boost in profitability may be due to higher green fodder yield as compared to C_4: Total crop duration of 140 days.

The data revealed that the highest net realization of 87209 ha^{-1} and BCR of 3.43 was recorded under treatment combination N_4C_3 (160 kg nitrogen per hectare applied in split along with first cut at 60 days after sowing and two subsequent cuts at 30 days interval) followed by N_3C_3 (140 kg nitrogen per hectare applied in split along with first cut at 60 days after sowing and two subsequent cuts at 30 days interval) which recorded net realization of 79824 ha^{-1} with BCR 3.24. Similar findings were reported by Sutar *et al.* (2020) [14] & Rafi *et al.* (2023) [9].

Table 2: Effect of nitrogen levels and cutting management on economics of multi-cut forage sorghum.

Treatments	Economics			
Nitrogen levels (Splitting of nitrogen) (kg ha^{-1})	**Cost of cultivation (Rs. ha^{-1})**	**Gross monetary return (Rs. ha^{-1})**	**Net monetary return (Rs. ha^{-1})**	**B:C**
N_1: 100 (40+20+20+20)	34984	80196	45212	2.3
N_2: 120 (50+20+25+25)	35270	98592	63322	2.8
N_3: 140 (50+30+30+30)	35558	105749	70192	3.0
N_4: 160 (60+30+35+35)	35837	111844	76007	3.1
Cutting management (Days after sowing)				
C_1: 110 (50,80 &110)	35412	82506	47094	2.3
C_2: 130 (50,90 &130)	35412	97083	61671	2.7
C_3: 120 (60,90 &120)	35412	109155	73743	3.1
C_4: 140 (60,100 &140)	35412	107638	72226	3.0
Interaction	NS	NS	NS	NS

Table 3: Combined effects of different nitrogen levels and cutting management on gross realization, net realization and benefit cost ratio (BCR).

Treatment combinations	Green forage yield (q ha^{-1})	Gross realization (₹ha^{-1})	Total cost of production (₹ha^{-1})	Net realization (₹ha^{-1})	BCR
N_1C_1	264	59441	34984	24457	1.70
N_1C_2	338	76019	34984	41035	2.17
N_1C_3	407	91647	34984	56663	2.62
N_1C_4	416	93677	34984	58693	2.68
N_2C_1	353	79428	35270	44158	2.25
N_2C_2	432	97307	35270	62037	2.76
N_2C_3	474	106546	35270	71276	3.02
N_2C_4	494	111088	35270	75817	3.15
N_3C_1	407	91634	35558	56077	2.58
N_3C_2	469	105531	35558	69974	2.97
N_3C_3	513	115382	35558	79824	3.24
N_3C_4	491	110450	35558	74893	3.11
N_4C_1	442	99520	35837	63683	2.78
N_4C_2	487	109474	35837	73637	3.05
N_4C_3	547	123046	35837	87209	3.43
N_4C_4	513	115338	35837	79501	3.22

Conclusion

1. Effect of Nitrogen Levels

Application of nitrogen markedly improved yield, quality, and economics of fodder sorghum. The highest dose of 160 kg N ha⁻¹ gave maximum green fodder yield (497 q ha⁻¹), dry fodder yield (29 q ha⁻¹), crude protein yield (2.91 q ha⁻¹) and net returns (₹76,007 ha⁻¹) with a B:C ratio of 3.1. This was statistically comparable with 140 kg N ha⁻¹, which produced 470 q ha⁻¹ green fodder yield and net returns of ₹70,192 ha⁻¹ (B:C ratio 3.0). Lower nitrogen levels (100 kg N ha⁻¹) resulted in significantly reduced performance.

2. Effect of cutting management

Cutting management strongly influenced fodder sorghum performance. The 60–90–120 DAS schedule (C3) gave the highest green fodder yield (485 q ha⁻¹), dry fodder yield (29.7 q ha⁻¹), crude protein (2.88 q ha⁻¹) and net returns (₹73,743 ha⁻¹, B:C 3.1) comparable with C4, while the earliest schedule (C1) was least productive.

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