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Fodder productivity and nutritional value of sorghum (*Sorghum bicolor*) as influenced by seeding rate and harvesting time

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ABSTRACT

The experiment was conducted during rainy (*kharif*) seasons of 2023 and 2024 at Forage Research Farm, Punjab Agricultural University, Ludhiana, Punjab to investigate the effects of varying seeding rates (25, 37.5, 50, 62.5 and 75 kg/ha) and two harvesting times (booting and flowering stage) on the fodder productivity and nutritional quality of sorghum [*Sorghum bicolor* (L.) Moench]. Results revealed that the increase in seeding rate would significantly increase the emergence count, plant height and leaf area index. Moreover, leaf stem ratio, dry matter accumulation and crude protein were significantly highest with seed rates of 50–62.5 kg/ha being at par with 37.5 kg/ha. Significant increase in green fodder yield was recorded only up to 37.5 kg/ha over the lowest seeding rate of 25 kg/ha, further increase in seed rate beyond 37.5 kg/ha brought only a marginal increase in yield up to 62.5 kg/ha and a slight decline in yield with 75 kg/ha. Harvesting at flowering stage obtained significant increase of 10.8 % in green fodder yield with appreciable quality over the booting stage. A seeding rate of 37.5–50 kg/ha optimised plant population and resource use, achieving the highest net returns and B:C ratio. Thus, the results indicated that production input of seed can be reduced without negative effects on performance of variety SL-46 high biomass producing and late maturing variety and harvest at flowering stage (80–85 DAS) is recommended to achieve higher yield and satisfactory nutritional quality.

Keywords: Booting stage, Crude protein, Flowering, Green fodder yield, SL-46

India, with only 2.3% of the world’s land, supports approximately 20% of the global livestock population (Singh *et al.* 2022), making livestock farming a vital component of its agricultural economy. According to the 20th livestock census, the country's total livestock population stands at an impressive 536.76 million (Anonymous 2022). Livestock plays a crucial role in rural livelihoods by providing essential agricultural inputs, nutritional benefits and economic security. However, the productivity of India’s livestock sector remains low when compared to the global average due to inadequate nutrition, largely resulting from a significant deficit in quality fodder availability. Currently, the country faces a net deficit of 11.24% in green fodder and 23.4% in dry fodder (Roy *et al.* 2019). To alleviate the demand-supply imbalance, concerted efforts must be directed toward enhancing forage productivity and yield potential (Bharti *et al.* 2023). Considering the limited availability of land for fodder cultivation, improving forage yield through advanced agronomic practices is crucial.

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Sorghum [*Sorghum bicolor* (L.) Moench], a self-pollinated C_4 plant of Poaceae family also known as jowar or chari, is a dual-purpose crop which is grown both for grain and fodder. Sorghum is the fifth most important cereal crop of the world (Khalifa and Eltahir 2023). It is an important *kharif* fodder crop due to its high-yield potential, adaptability to drought-prone regions and ability to provide quality forage. It constitutes almost 60–70% of the total *kharif* forage supply in India and is widely cultivated in western Uttar Pradesh, Punjab, Haryana, Delhi, Gujarat and Rajasthan (Prasad 2024). Sorghum is widely recognised for its exceptional resilience and broad adaptability to a wide range of biotic and abiotic stresses (Huang 2018, Zhang *et al.* 2019). High fodder yield and nutritional quality, however, are dependent on optimal agronomic management practices, particularly seeding rate and harvest time (Kumar *et al.* 2018).

Seeding rate is a critical factor influencing forage yield and quality. Sorghum is highly responsive to variations in plant density (Szemerits *et al.* 2025). An optimal plant population ensures maximum productivity, deviations from the ideal density can result in poor resource utilisation. Maintaining an appropriate planting density is essential to balance yield and forage quality. Whereas, optimum harvesting time significantly affects the nutritional composition of sorghum fodder. Early harvesting results in tender, protein-rich fodder but with lower fibre content whereas delayed harvesting increases fibre accumulation, reducing digestibility and palatability. The trade-off between forage quality and quantity necessitates precise determination of the optimal harvesting time to maximise nutritional benefits while maintaining adequate biomass production. This study aimed to assess the impact of different seeding rates and harvesting time on the fodder productivity and nutritional quality of the recently released late maturing single-cut sorghum variety SL-46. The findings will contribute to sustainable fodder production strategies, optimising yield and forage quality for enhanced livestock productivity in India.

MATERIALS AND METHODS

The field experiment was conducted during rainy (*kharif*) seasons of 2023 and 2024 at Forage Research Farm, Punjab Agricultural University, Ludhiana (30°54' N, 75°48' E; at an elevation of 247 m amsl), Punjab. It lies in the central plain region of Punjab within the Trans-Gangetic agro-climatic zone of India. The region experiences a sub-tropical climate characterised by hot and humid summers during the *kharif* season. The soil in the top 30 cm layer was loamy sand with a *p*H of 8.3 and EC of 0.13 dS/m (1:2 soil-water ratio). It had low organic carbon content (3.52 g/kg) and low available nitrogen (164.8 kg/ha) while being moderate in available phosphorus (18.97 kg/ha) and available potassium (143.12 kg/ha). The average annual rainfall for the experimental site was 759 mm with 391.4 mm and 519.1 mm rainfall recorded during the crop growth period in 2023 and 2024, respectively.

The crop was planted on 11 June 2023 and 13 June 2024 using the *kera* method with a row-to-row spacing of 25 cm. As recommended by Punjab Agricultural University, Ludhiana, Punjab a basal application of 50 kg nitrogen (108 kg urea) and 20 kg P_2O_5 (125 kg single superphosphate) per hectare was made at sowing and a further 50 kg N/ha was top-dressed one month after sowing during both years. Recognising the significant adverse effect of weeds on the overall quality and productivity of fodder crops, one hand weeding was done at 35 days after sowing (DAS) during both the years of study. This manual weeding facilitated effective weed removal while improving soil aeration, which consequently enhanced root development. Harvesting of all treatments at various growth stages was carried out manually using sickles.

The treatments were laid out in factorial randomised complete block design (F-RCBD) with three replications. The treatments comprised combinations of five seed rates (25, 37.5, 50, 62.5 and 75 kg/ha) and two harvesting times (booting; 65 DAS and flowering stage; 85 DAS). The area of each treatment combination was 12 m^2 (4 m × 3 m). The data on emergence count was recorded at 15 DAS. Whereas, growth and yield attributing data was recorded at 30, 50 DAS and at both the harvesting times. While stem diameter, green fodder yield and sample for crude protein analysis were taken at each harvesting time. Leaf area index (LAI) was measured with the help of Sun Scan Canopy Analyser (Model: Sun scan SSI, Delta-T Devices, Cambridge, England). The data recorded for different parameters were analysed with the help of analysis of variance (ANOVA) technique for randomised complete block design (Gomez and Gomez 1984) and statistical mean differences were found by Fisher's protected least significant difference test at 5% significance level.

RESULTS AND DISCUSSION

Yield attributes: Yield attributes were greatly affected by both seeding rate as well as harvesting time. Seedling emergence, plant height, leaf area index, number of leaves, leaf stem ratio, dry matter accumulation and stem diameter were examined during the years 2023 and 2024.

Seedling emergence assessed at 15 DAS was found to be significantly highest with seeding rate of 75 kg/ha, with 21.2 and 23.3 plants per meter row length in 2023 and 2024, respectively. In contrast, the lowest emergence counts were observed at 25 kg/ha, with 8.8 and 9.5 plants in 2023 and 2024, respectively (Table 1). Higher seeding rates likely promoted better emergence due to the greater number of viable seeds sown per unit area, a finding consistent with previous studies by Kumar *et al.* (2016) and Mekasha *et al.* (2022). Lower seeding rates, on the other hand, showed reduced emergence due to fewer seeds sown. However, harvesting time had no significant effect on seedling emergence in either year.

Data pertaining to plant height was non-significant at 30 DAS but increases progressively with higher seeding rates at 50 DAS and at harvest. The maximum plant height was recorded with 75 kg/ha (255.2 cm in 2023 and 267.7 cm in 2024), which is at par with the heights of 50 and 62.5 kg/ha in 2023 and 62.5 kg/ha in 2024 at harvest (Table 2). The lowest plant height was observed at 25 kg/ha, with values

Table 1 Effect of seeding rate and harvesting time on emergence count of fodder sorghum

Treatments	Plants per meter row length (15 DAS)	
	2023	2024
Seeding rate (kg/ha)		
25	8.8	9.5
37.5	12.7	12.2
50	15.8	16.5
62.5	18.9	18.2
75	21.2	23.3
CD (*p*=0.05)	1.8	1.4
Harvesting time		
Booting	15.8	16.3
Flowering	15.2	15.6
CD (*p*=0.05)	NS	NS

DAS, Days after sowing.

Table 2 Effect of seeding rate and harvesting time on plant height and leaf are index of fodder sorghum

Treatments	Plant height (cm)						Leaf area index					
	2023			2024			2023			2024		
	30 DAS	50 DAS	Harvest	30 DAS	50 DAS	Harvest	30 DAS	50 DAS	Harvest	30 DAS	50 DAS	Harvest
Seeding rate (kg/ha)												
25	56.9	115.2	223.8	60.9	120.0	233.3	0.97	2.74	5.78	1.03	3.02	5.92
37.5	57.9	117.3	229.8	62.5	125.6	238.8	1.07	3.13	5.98	1.08	3.28	6.57
50	59.4	120.5	236.1	64.2	127.6	241.6	1.12	3.20	6.48	1.13	3.37	6.62
62.5	61.4	125.4	245.7	65.8	130.9	251.7	1.02	3.28	6.61	1.15	3.39	6.70
75	61.7	129.5	255.2	67.1	134.7	267.7	1.00	3.35	6.94	1.05	3.69	7.03
CD (p=0.05)	NS	9.2	21.6	NS	9.6	22.6	NS	0.32	0.47	NS	0.33	0.55
Harvesting time												
Booting	59.1	121.1	200.8	63.8	127.7	211.3	1.04	3.13	5.75	1.12	3.34	5.98
Flowering	59.8	122.1	275.5	64.4	127.8	282.0	1.03	3.15	6.97	1.06	3.36	7.15
CD (p=0.05)	NS	NS	13.6	NS	NS	14.3	NS	NS	0.30	NS	NS	0.35

DAS, Days after sowing; NS, Non-significant.

of 223.8 cm in 2023 and 233.3 cm in 2024. Higher seeding rates likely promoted greater plant height due to intensified inter-plant competition for light which stimulated vertical growth. Similar trends have been reported by Snider *et al.* (2012) who observed site-specific responses and Schmitt and Wulff (1993) who attributed such increases to internode elongation. Conversely, lower seeding rates resulted in shorter plants, potentially due to reduced competition. For harvest time, plants harvested at the flowering stage were taller than those at the booting stage, with heights of 275.5 cm and 282.0 cm at flowering compared to 200.8 cm and 211.3 cm at booting stage in 2023 and 2024, respectively. This could be attributed to the extended growth duration and greater biomass accumulation during the flowering stage. The significant effect of harvesting time was in align with the findings of Swathi *et al.* (2016), who emphasised the role of extended phenological stages in increasing plant height.

LAI of sorghum increased with higher seeding rates, particularly at 50 DAS and at harvest (Table 2). At harvest, the seeding rate of 75 kg/ha recorded the highest LAI values (6.94 in 2023 and 7.03 in 2024), which were statistically at par with those obtained at 50 kg/ha and 62.5 kg/ha. The lowest LAI values were observed with 25 kg/ha (5.78 in 2023 and 5.92 in 2024). The increased LAI with higher seeding rates is likely due to increased plant density leading to more canopy coverage, aligning with the findings of Mahdi *et al.* (2012) and Singh *et al.* (2012). However, harvesting time did not affect LAI at 30 and 50 DAS but significantly influenced it at harvest (Table 2) where the flowering stage resulted in higher LAI (6.97 in 2023 and 7.15 in 2024) compared to the booting stage (5.75 in 2023 and 5.98 in 2024). Higher LAI at the flowering stage reflects the extended growth period allowing greater light interception and leaf expansion, consistent with Chattha *et al.* (2017).

The highest leaves per plant at harvest was observed with 25 kg/ha in 2023 (13.17), statistically comparable to 37.5 kg/ha and 50 kg/ha. In 2024, the maximum leaf count was recorded with 37.5 kg/ha, statistically similar to 25 kg/ha and 50 kg/ha. Higher seeding rates beyond 50 kg/ha resulted in reduced leaf counts with the lowest values observed at 75 kg/ha during both years (Table 3). Leaf production is a vital trait linked to photosynthesis and biomass accumulation in fodder crops. Higher leaf counts at lower seeding rates (25–37.5 kg/ha) suggests that reduced plant densities improve individual plant vigour and leaf development. Conversely, higher seeding rates (75 kg/ha) likely result in over-crowding, limiting resource availability and leads to reduced leaf production. In conjunction with seeding rate, harvesting time exerted a significant impact on leaf production at harvest with the flowering stage producing more leaves than the booting stage (Table 3). The flowering stage recorded 14.0 leaves in 2023 and 14.4 in 2024 while the booting stage had 11.1 leaves in 2023 and 11.5 in 2024. The flowering stage consistently produced more leaves due to the prolonged growth period which allowed for extended light capture and photosynthesis facilitating additional leaf development and were in line with Chattha *et al.* (2017).

In 2023, the highest leaf-stem ratio at harvest was recorded at a seeding rate of 50 kg/ha (0.60), which was statistically at par with 37.5 kg/ha (Table 3). During 2024, the maximum ratio was observed at 37.5 kg/ha (0.49), remaining statistically comparable with 25 kg/ha and 50 kg/ha. During both years, the lowest leaf-stem ratios were consistently noted at the highest seeding rate of 75 kg/ha (0.42 in 2023 and 0.37 in 2024). The reduction in leaf-stem ratio at higher seeding rates may be attributed to fewer and narrower leaves with lower individual leaf weight coupled with increased plant height and greater stem length resulting in higher stem biomass as compared to leaf biomass. The leaf-stem ratio, a key forage quality indicator, was maximised at moderate seeding rates due to an optimal balance of plant density and resource availability, reducing stress and promoting leaf development relative to stem elongation. This aligns with findings by Somashekar *et al.* (2015) and Nabooji *et*

Table 3 Effect of seeding rate and harvesting time on number of leaves and leaf stem ratio of fodder sorghum

Treatments	Number of leaves						Leaf stem ratio					
	2023			2024			2023			2024		
	30 DAS	50 DAS	Harvest	30 DAS	50 DAS	Harvest	30 DAS	50 DAS	Harvest	30 DAS	50 DAS	Harvest
Seeding rate (kg/ha)												
25	5.77	8.38	13.17	5.98	8.55	13.45	1.07	0.86	0.53	1.10	0.78	0.46
37.5	5.58	8.30	13.13	5.72	8.52	13.47	1.05	0.87	0.59	1.09	0.80	0.49
50	5.68	7.72	12.92	5.62	7.87	13.42	1.08	0.82	0.60	1.04	0.84	0.48
62.5	5.28	7.67	12.08	5.37	7.83	12.50	0.98	0.83	0.45	1.07	0.79	0.41
75	5.25	7.58	11.38	5.45	7.78	11.77	1.07	0.80	0.42	1.01	0.72	0.37
CD (p=0.05)	NS	NS	0.81	NS	NS	0.87	NS	NS	0.06	NS	0.07	0.06
Harvesting time												
Booting	5.6	8.0	11.1	5.8	8.1	11.5	1.05	0.84	0.61	1.06	0.79	0.55
Flowering	5.4	7.9	14.0	5.5	8.1	14.4	1.04	0.82	0.42	1.06	0.78	0.33
CD (p=0.05)	NS	NS	0.5	NS	NS	0.6	NS	NS	0.04	NS	NS	0.04

DAS, Days after sowing; NS, Non-significant.

al. (2018). Harvesting time significantly influenced the leaf-stem ratio at harvest (Table 3). The booting stage consistently recorded higher leaf-stem ratios (0.61 in 2023 and 0.55 in 2024) than the flowering stage (0.42 in 2023 and 0.33 in 2024). The higher ratios observed at the booting stage may be attributed to limited stem biomass and a greater proportion of leaf biomass as weight of leaf sheath is weighed under leaf biomass, whereas the reduced ratios at the flowering stage reflect increased stem growth and higher stem biomass accumulation compared to leaf biomass.

Among seeding rates, the highest stem diameter was recorded with 25 kg/ha (1.93 cm in 2023 and 1.98 cm in 2024), statistically similar to 37.5 kg/ha and 50 kg/ha seed rate. The lowest diameter was observed with 75 kg/ha (1.64 cm in 2023 and 1.72 cm in 2024). At lower seeding rates (25 kg/ha), decreased inter-plant competition improved access to resources and promoted thicker stem development which aligned with the findings of Snider *et al.* (2012), who observed improved stem growth at lower planting densities. Conversely, the highest seeding rate of 75 kg/ha led to thinner stems due to resource competition, findings consistent with Gondal *et al.* (2017) where higher seeding rates increase stem density and interplant competition, resulting in reduced stem diameter. Consequently, high plant density produces thin, lodging-prone stems; thus, excessive seeding rates should be avoided in lodging-susceptible sorghum regions. However, harvesting time also significantly affected stem diameter (Table 4) with the flowering stage producing thicker stems (1.84 cm in 2023 and 1.88 cm in 2024) compared to the booting stage (1.74 cm in 2023 and 1.80 cm in 2024). The flowering stage's thicker stems might reflect a longer growth period and

Table 4 Effect of seeding rate and harvesting time on dry matter accumulation and stem diameter of fodder sorghum

Treatments	Dry matter accumulation (g/m^2)						Stem diameter (cm)	
	2023			2024			2023	2024
	30 DAS	50 DAS	Harvest	30 DAS	50 DAS	Harvest	Harvest	Harvest
Seeding rate (kg/ha)								
25	69.7	150.9	265.7	75.6	154.3	270.2	1.93	1.98
37.5	76.6	153.3	272.2	84.5	156.2	282.2	1.86	1.88
50	77.4	164.2	290.1	86.3	168.1	288.9	1.82	1.87
62.5	80.7	163.3	287.7	83.3	174.7	299.7	1.72	1.83
75	77.7	159.3	281.2	79.5	159.1	284.7	1.64	1.72
CD (p=0.05)	4.9	NS	17.3	7.2	14.8	18.5	0.12	0.14
Harvesting time								
Booting	76.6	159.1	239.6	82.0	164.3	248.9	1.74	1.80
Flowering	76.2	157.3	319.1	81.7	160.6	321.4	1.84	1.91
CD (p=0.05)	NS	NS	10.9	NS	NS	11.7	0.08	0.09

DAS, Days after sowing; NS, Non-significant.

greater allocation of assimilates to structural development, corroborating Shahid (2012) where plots harvested 65 days after sowing produced significantly thicker stem than plots harvested 45 days after sowing.

At harvest, 50 kg/ha in 2023 (290.1 g/m) and 62.5 kg/ha in 2024 (299.7 g/m) showed the highest dry matter accumulation, statistically comparable to 62.5 and 75 kg/ha with 25 kg/ha consistently yielding the lowest accumulation in both years. Moderate to higher seeding rates consistently produced higher dry matter likely due to optimal plant density enhancing resource utilisation efficiently while minimising intra-plant competition and the findings were in line with Mekasha *et al.* (2022) which indicated that dry matter accumulation responds positively to increased seeding rate up to moderate-high densities. Conversely, lower seeding rates resulted in reduced dry matter due to insufficient plant density whereas higher rates caused over-crowding, restricting individual plant growth and reducing biomass production efficiency. Similarly, harvesting time significantly influenced dry matter accumulation at the harvest stage with the flowering stage consistently producing higher values than the booting stage during both years (Table 4). In 2023, dry matter accumulation at flowering reached 319.1 g/m^2, compared to 239.6 g/m^2 at the booting stage. Similarly, in 2024, the 50% flowering stage recorded 321.4 g/m^2, significantly exceeding the 248.9 g/m^2 observed at the booting stage. This aligned with the findings of Chattha *et al.* (2017), who reported greater biomass accumulation during later growth stages.

Green fodder yield: The green fodder yield of sorghum was significantly influenced by seeding rate and harvesting time during both years of the study (Table 5). Among the seeding rates, 62.5 kg/ha achieved the highest green fodder yield with 614 q/ha in 2023 and 642 q/ha in 2024, statistically comparable to 37.5, 50 and 75 kg/ha. Yields slightly declined at the highest seeding rate of 75 kg/ha (607 q/ha in 2023 and 639 q/ha in 2024) while the lowest yield was observed at 25 kg/ha (538 q/ha in 2023 and 557 q/ha in 2024). This outcome was primarily due to the optimal plant height, better stem diameter, increased plant density and higher dry matter accumulation. In contrast, a slight yield decline was observed at the highest seeding rate (75 kg/ha), as the excessive plant density likely caused competition for light and nutrients, resulting in thinner stems and elongated growth which reduced green fodder yield, as observed by Nabooji *et al.* (2018) and Somashekar *et al.* (2018). The lowest yield was consistently recorded at 25 kg/ha, reflecting insufficient plant density. Between the two harvest times, flowering stage produces significantly higher yields (621 q/ha in 2023 and 653 q/ha in 2024) compared to the booting stage (565 q/ha in 2023 and 585 q/ha in 2024). This is likely due to greater biomass accumulation due to extended growth period which aligns with findings by Chattha *et al.* (2017) and Kadam *et al.* (2019).

Crude protein: The crude protein (CP) content of sorghum was significantly influenced by both seeding rate and harvest time (Table 6). In 2023, the highest CP content was observed at a seeding rate of 37.5 kg/ha (8.57%) which was statistically similar to 50 kg/ha (8.38%) and 62.5 kg/ha (8.01%) while the lowest CP content was noted at 75 kg/ha (7.11%) and 25 kg/ha (7.38%). A similar pattern was observed in 2024, where the highest CP content was recorded at 37.5 kg/ha (8.55%) and the lowest at 75 kg/ha (7.13%). This suggests that moderate plant densities optimise nutrient uptake and metabolism, enhancing protein synthesis while high seeding rates led to resource competition which contributed to lower CP content. These findings are in line with Aslam *et al.* (2011) and Sher *et al.* (2017). The harvest time also significantly affected CP content, with higher CP levels consistently recorded at the booting stage compared to the 50% flowering stage. The decline in CP content at flowering is attributed to physiological changes during plant maturation where metabolic processes shift from vegetative growth to reproductive development. This shift results in the translocation of nitrogenous compounds including proteins from the leaves and stems to seeds and reproductive

Table 5 Effect of seeding rate and harvesting time on green fodder yield of fodder sorghum

Treatments	Green fodder yield (q/ha)	
	2023	2024
Seeding rate (kg/ha)		
25	538	557
37.5	595	621
50	613	636
62.5	614	642
75	607	639
CD (p=0.05)	35	33
Harvesting time		
Booting	565	585
Flowering	621	653
CD (p=0.05)	22	21

Table 6 Effect of seeding rate and harvesting time on crude protein content of fodder sorghum at harvest

Treatments	Crude protein (%)	
	2023	2024
Seeding rate (kg/ha)		
25	7.38	8.15
37.5	8.57	8.55
50	8.38	8.23
62.5	8.01	7.52
75	7.11	7.13
CD (p=0.05)	0.67	0.62
Harvesting time		
Booting	8.60	8.84
Flowering	7.17	7.00
CD (p=0.05)	0.42	0.39

structures while the accumulation of structural carbohydrates such as cellulose, hemicellulose and lignin increases, thereby diluting protein content. These observations were consistent with findings by Shahid (2012), Swathi *et al.* (2016) and Chattha *et al.* (2017).

Economics: The production cost of sorghum increased with increase in seeding rate (Supplementary Table 1). The maximum gross return value was recorded with 62.5 kg/ha (₹122.7 × 10^3 in 2023 and ₹128.5 × 10^3 in 2024) which was at par with 37.5, 50 and 75 kg/ha seed rate during both the years. In case of net returns, during 2023, the highest value was obtained with 50 kg/ha (₹90.8 × 10^3) which was statistically similar to 37.5, 62.5 and 75 kg/ha seed rate. Whereas, during year 2024, 62.5 kg/ha of seed rate achieved the statistically highest net returns which was statistically comparable to 37.5, 50 and 75 kg/ha seed rate.

The benefit-cost ratio (B:C) was highest with 37.5 kg/ha (2.86 in 2023 and 3.00 in 2024), which was at par with 50 kg/ha and 62.5 kg/ha seed rate demonstrating the economic efficiency of moderate seeding rates. However, the lowest B:C ratio was associated with the highest seed rate of 75 kg/ha, reflecting reduced economic viability at excessive seeding densities.

The harvest time significantly influenced economic returns. The flowering stage out-performed the booting stage in gross returns, net returns and B:C ratio. This economic advantage is linked to higher green fodder yield at flowering, out-weighing the lower cultivation costs associated with the booting stage. The economic analysis underscores the importance of optimising seeding rates and harvest time for profitable fodder sorghum production. Seeding rates of 37.5–50 kg/ha proved to be the most economically viable with 37.5 kg/ha yielding the highest benefit-cost ratio, reflecting an optimal balance between input costs and economic returns. While 50 kg/ha produced higher net returns, it's slightly lower B:C ratio highlights the impact of increased cultivation costs. The harvest time also significantly influenced profitability with the flowering stage consistently delivering higher gross returns, net returns and B:C ratios compared to the booting stage.

This research provided actionable insights into the management of sorghum as a high-yielding, nutritionally valuable fodder crop. The two year study recommends sowing the newly released sorghum variety (SL-46) at a seed rate of 37.5–50 kg/ha to achieve higher green fodder yield, improved nutritional quality and greater profitability. The crop should be harvested for green fodder at 80–85 days after sowing, which corresponds to the flowering stage to achieve higher yield and satisfactory nutritional quality. By bridging the gap between fodder demand and supply, these findings contribute to the sustainability and resilience of India's livestock sector ensuring its continued role in supporting rural livelihoods and national food security.

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