



Response of nitrogen rates on jute fiber (*Corchorus olitorius*) production in Sunsari district of Nepal

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ABSTRACT

Jute is an important cash crop in Nepal but national fiber yields remain suboptimal due to imbalance nitrogen application. Optimum rates of nitrogen are crucial for maximizing jute fiber yield. A field experiment was conducted during 2024 and 2025 in Sunsari district aimed to determine the optimal nitrogen rates for the promising genotype 'NJ 7010 (Rani)'. Seven nitrogen rates (0, 20, 40, 60, 80, 100, and 120 kg N ha⁻¹) were evaluated in a randomized complete block design with three replications. Standard agronomic practices were followed as when needed. Growth, yield attributes and yield data were collected using standard protocol. Results demonstrated very good response to nitrogen for vegetative growth, with plant height, basal diameter, and green biomass linearly to a maximum at 120 kg N ha⁻¹. However, a critical finding was the evidence of diminishing returns for the primary economic product. Under favorable conditions, dry fiber yield plateaued at 80 kg N ha⁻¹, beyond which no significant gains were achieved, indicating a threshold for efficient nitrogen partitioning into harvestable fiber. The study concluded that high N rates (100–120 kg N ha⁻¹) maximized vegetative biomass, a rate of 80–100 kg N ha⁻¹ was optimal for sustainable fiber production.

Keywords: fiber, jute, nitrogen, yield.

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INTRODUCTION

Jute (*Corchorus olitorius*), a bast fiber crop of global significance, is a cornerstone of the natural fiber industry and a vital cash crop for smallholder farmers in the Eastern Terai of Nepal. As a biodegradable and renewable resource, jute fiber is increasingly sought after as an eco-friendly alternative to synthetic materials, aligning with global sustainable development goals (Islam 2021). In Nepal, particularly in districts like Sunsari, jute cultivation is not only a source of raw material for the domestic and international market but also a critical component of crop rotation systems, contributing to soil health and rural livelihoods (Sharma et al 2024). However, national average fiber yields remain substantially below potential, constrained by suboptimal agronomic practices.

Among agronomic inputs, nitrogen (N) fertilization is a primary determinant of jute growth, photosynthesis, and fiber development. While nitrogen is crucial for vegetative biomass the precursor to fiber yield its application must be carefully calibrated. Excessive nitrogen can

lead to excessive vegetative growth at the expense of fiber quality, increased lodging, environmental pollution through leaching, and heightened production costs (Basir et al 2013). Conversely, nitrogen deficiency directly limits plant growth and fiber yield. Current fertilizer recommendations for jute in Nepal are often generalized and lack regional specificity. The agro-climatic conditions, soil types (particularly the alluvial soils), and prevalent farming practices in Sunsari District necessitate localized research to determine the optimal nitrogen rate that maximizes both fiber yield and quality for this specific context.

Given the growing demand for sustainable fiber production and the economic reliance of farmers on jute, it is imperative to refine nutrient management strategies that maximize yield while minimizing environmental impact. The findings of this study evidence-based, location-specific nitrogen management guidelines for jute farmers in Sunsari and similar agro-ecological zones of Nepal. By This research was carried out to enhance farm profitability, improve resource-use efficiency, and promote the environmental sustainability of jute cultivation.

MATERIALS AND METHODS

Field experiments were conducted consecutively during the rainy seasons of 2024 and 2025 at the research farm of the Jute Research Program, Itahari, Nepal to determine the optimal nitrogen level for jute growth and fiber yield. The site is geographically located at approximately 26°66'46" N latitude and 87°27'18" E longitude. The site is geographically situated at 26°39' N latitude and 87°16' E longitude at an altitude of approximately 130 meters above sea level. The region experiences a humid subtropical monsoon climate, characterized by high temperatures (mean 28–32°C) and heavy rainfall (>2000 mm annually) during the growing season (May–September), which is ideally suited for jute cultivation. The soil of experimental field was characterized as sandy loam (Typic Haplustept) with initial soil properties determined prior to sowing. Baseline soil fertility analysis for the Jute Research Program farm at Itahari indicated moderately acidic soils (pH 6.2) with low organic matter (0.55 %), low total nitrogen (0.02 %), low available phosphorus (14.65 kg/ha), and medium available potassium (158.25 mg/kg) in the top 0–15 cm soil layer.

The different seven nitrogen rates, N0: 0 kg N ha⁻¹ (Control), N20: 20 kg N ha⁻¹, N40: 40 kg N ha⁻¹, N60: 60 kg N ha⁻¹, N80: 80 kg N ha⁻¹, N100: 100 kg N ha⁻¹, and N120: 120 kg N ha⁻¹ were evaluated in a randomized complete block design (RCBD) with three replications. The gross plot size for each plot was 4 m x 2m (8 m²), with a 1-meter buffer between plots to minimize interference. The test crop was a promising jute (*Corchorus olitorius*) genotype, NJ 7010 (Rani).

Seeds was treated with a recommended fungicide (Carbendazim @ 2 g/kg seed) before sowing to prevent seed-borne diseases. Sowing was completed manually in the first week of May in lines spaced 25 cm apart. Seeds were sown at a higher density and later thinned at 10-15 days after sowing (DAS) to maintain a uniform intra-row spacing of 5-7 cm, achieving a final plant population of approximately 400,000 plants per hectare. A uniform basal dose of phosphorus (P₂O₅) and potassium (K₂O) was applied to all experimental plots at a rate of 20:40 kg ha⁻¹, supplied through ammonium phosphate (DAP) and muriate of potash (MOP), respectively. Nitrogen treatments were imposed using urea (46% N) and applied in two equal splits: 50% as a basal dose during final land preparation with thorough soil incorporation, and the remaining 50% as a top-dressing at 30 days after sowing (DAS). The fertilizers were evenly distributed and incorporated to ensure uniform nutrient availability across all plots except for the nitrogen treatment

variation. All other intercultural operations, including weeding, irrigation, and plant protection measures against pests (semi-looper, mites) and diseases (stem rot), were carried out as per the standard package of practices recommended by JRP, Itahari, to ensure a healthy crop stand.

Harvesting was performed when plants in a plot showed flower bud formation, the physiological stage for optimal fiber yield. Data were recorded from the net harvest area of the central six rows (4.5 m²) in each sub-plot to avoid border effects. Observations recorded included: Phenological and Morphological Traits: Days to flowering, plant height at harvest (cm), and basal stem diameter (mm), Yield and Yield Attributes: Green plant weight (kg/plot), green stick weight (kg/plot), green fiber yield (kg/plot), dry fiber yield (kg/plot), and dry stick yield (kg/plot). Dry yields were obtained after sun-drying the fibers and sticks to a constant weight. Fiber Quality Parameter: Fiber fineness/thickness (Tex) was measured using a standard gravimetric method.

The data for all recorded parameters for both years were subjected to Analysis of Variance (ANOVA) appropriate for the Split-Plot Design using STAR 2.0 (Statistical Tool for Agricultural Research, version 2.0) software developed by IRRI. The significance of treatment effects (main and interaction) was tested using the F-test at a 5% probability level ($p \leq 0.05$). Where the ANOVA indicated significant differences, the treatment means were compared using Least Significant Difference (LSD) test at the 5% level of significance. A combined analysis over the two years was performed after confirming the homogeneity of error variances to draw stable and reliable conclusions.

RESULTS

Effect on plant height

Plant height was significantly influenced by nitrogen fertilization rate in both experimental years and in the combined analysis (Table 1). Plant height exhibited a positive, dose-dependent response, with maximum height achieved at the highest application rate (N120). In the combined analysis, mean plant height ranged from 244.3 cm in the unfertilized control (N0) to 366.1 cm under the N120 treatment. Separation of means confirmed that plants receiving higher nitrogen rates (N80 to N120) were significantly taller than those receiving lower or no nitrogen (N0 to N40). A significant year $\times$ nitrogen interaction indicating a reversal in the annual response across the treatment gradient. While lower nitrogen levels (N0 to N40) produced taller plants in the first year, the highest nitrogen levels (N80 to N120) resulted in greater height in the second year (Figure 1). These results demonstrate a clear and significant enhancement of vegetative growth with increased nitrogen availability.

Effect on basal diameter

Basal diameter was not significantly affected by nitrogen in 2024, but showed significant increases in 2025 and in the combined analysis (Table 1). Basal diameter generally increased with higher nitrogen rates, although the magnitude and pattern of the response varied between seasons. In 2025, nitrogen promoted a clear dose-dependent increase in basal diameter, whereas the lowest rates (N0 and N20) produced thinner stems than the previous year's control (Figure 2), indicating greater nitrogen demand or environmental stress. These results suggest that nitrogen enhances stem thickening, but the extent of this response is strongly influenced by seasonal conditions.

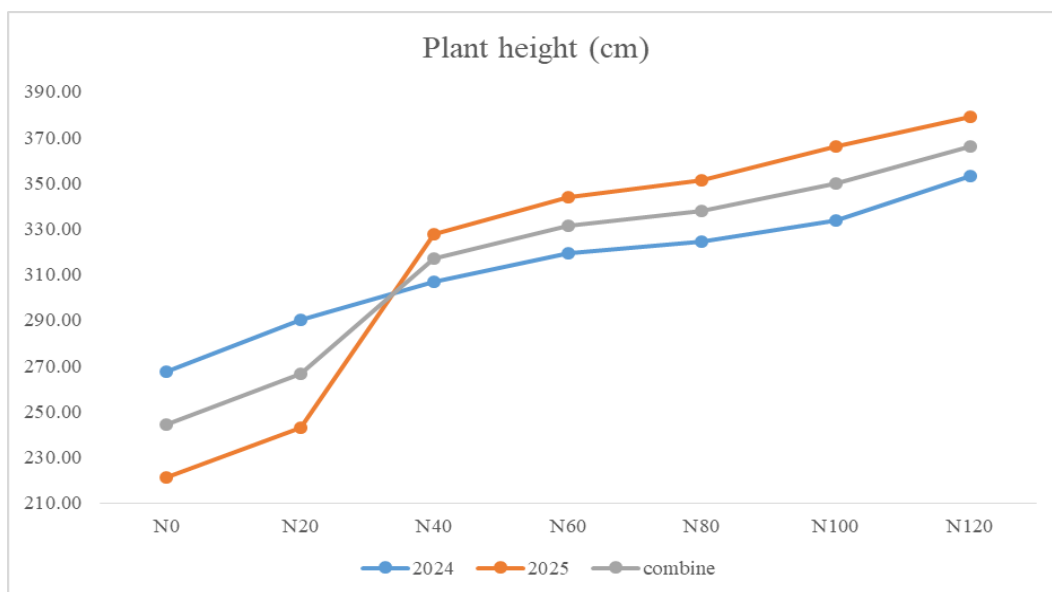


Figure 1. Response of nitrogen rates on plant height of jute

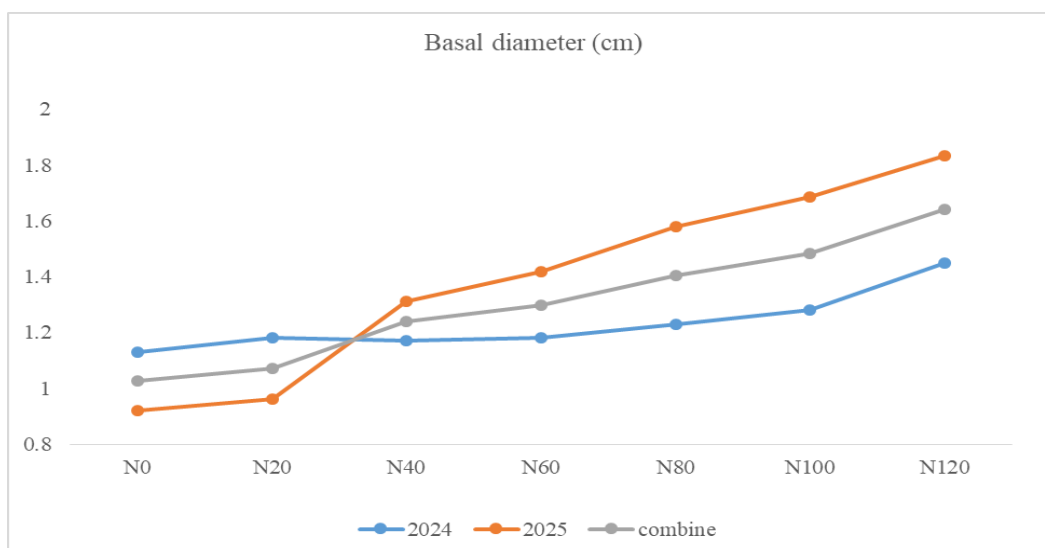


Figure 2. Response of nitrogen rates on basal diameter of jute

Effect on fiber thickness

Fiber thickness was not significantly affected by nitrogen in 2024, but showed significant increases in 2025 and in the combined analysis (Table 1). Combined analysis showed significant different on fiber thickness ranging from 0.11 cm (N0) to 0.16 cm (N120), with a plateau observed at rates above N80 (Figure 3). This plateau is reflected that the N120, N100, and N80 treatments formed a statistically homogeneous top-performing group. The year $\times$ treatment interaction reflected a stronger response in 2025, where thickness increased by 64% in N120 compared to control and only 27% increase in 2024. These results indicate that nitrogen enhanced fiber thickness, but the magnitude of this effect was highly dependent on seasonal growing conditions.

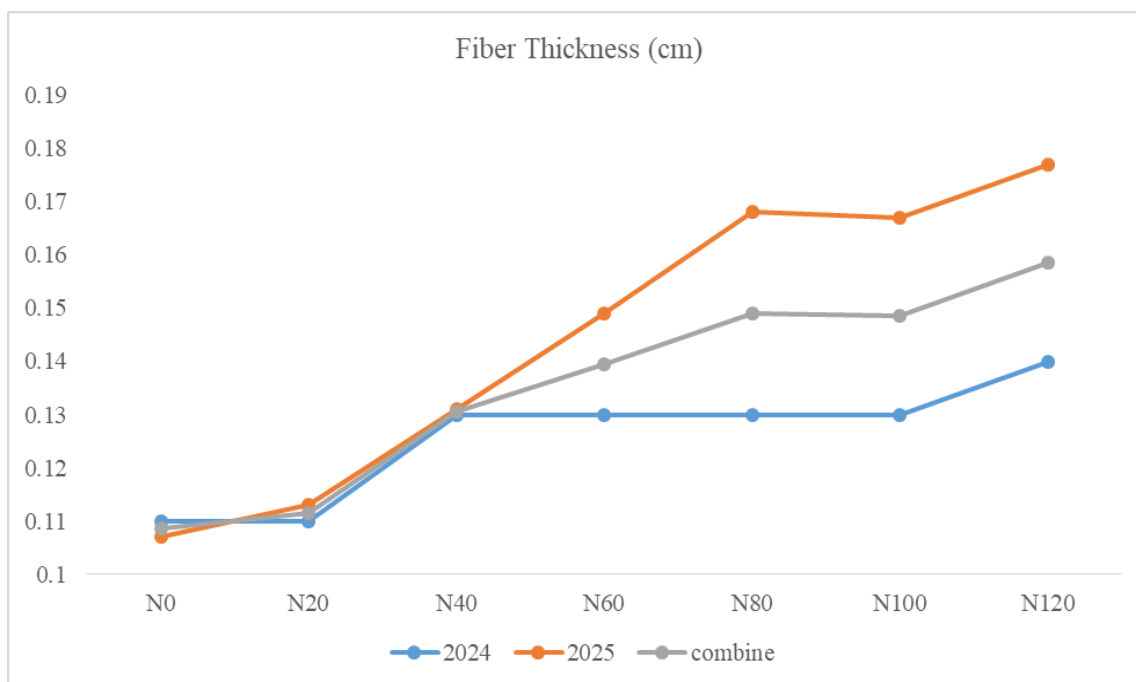


Figure 3. Response of nitrogen rates on Fiber thickness of jute

Table 1. Effect of different dose of nitrogen on jute plant height (cm), basal diameter (cm) and fiber thickness (cm) at JRP, Itahari

Treatment	Plant height (cm)			Basal Diameter (cm)			Fiber Thickness (cm)		
	2024	2025	combined	2024	2025	combined	2024	2025	Combined
N120	353.27	379.00	366.14	1.45	1.83	1.64	0.14	0.18	0.16
N100	333.83	366.00	349.92	1.28	1.68	1.48	0.13	0.17	0.15
N80	324.20	351.23	337.72	1.23	1.58	1.41	0.13	0.17	0.15
N60	319.10	343.70	331.40	1.18	1.42	1.30	0.13	0.15	0.14
N40	306.87	337.43	322.15	1.17	1.31	1.24	0.13	0.13	0.13
N20	290.27	243.00	266.64	1.18	0.96	1.07	0.11	0.11	0.11
N0	267.57	221.00	244.29	1.13	0.92	1.03	0.11	0.11	0.11
Mean	313.59	320.19	316.89	1.23	1.39	1.31	0.13	0.14	0.13
F-test	*	**	**	ns	**	**	ns	**	**
LSD(0.05)	65.09	5.95	35.52	-	0.07	0.09	-	0.04	0.07
C.V. (%)	12.8	1.59	7.20	25.9	1.73	13.82	26.2	1.46	13.83

Effect on green plant yield

Green plant yield responded strongly and positively to nitrogen application, with highly significant treatment effects in both individual years and the combined analysis (Table 2). Yields increased in a near-linear fashion with nitrogen rates, culminating in maximum values at the N120 treatment. A significant year $\times$ treatment interaction was observed, driven by differences in response magnitude and variability. The yield increase under N120 was 2.6 fold in 2025 and 2.3 fold in 2024 (Figure 4). These results demonstrated that nitrogen is a primary yield-limiting factor for jute green biomass, with the consistency of the yield gain improving under more stable or favorable growing conditions.

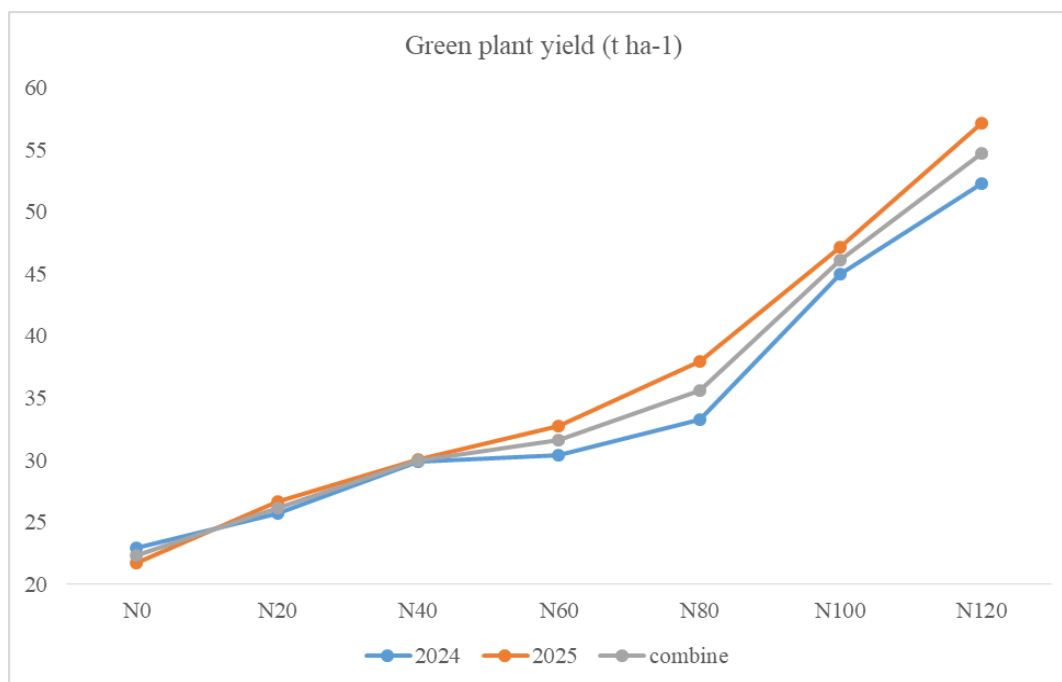


Figure 4. Response of nitrogen rates on green plant yield of jute

Effect on green fiber yield

Green fiber yield was significantly influenced by nitrogen application in both years and in the combined analysis (Table 2), showing a clear dose-dependent increase (Figure 5). A pronounced year $\times$ treatment interaction was observed, with a stronger response in 2025. In that year, yield under N120 was 3.7-fold higher than the control, whereas in 2024 the increase was less than two-fold. In combined analysis, mean green fiber yield increased 3.73 fold in N120 than control treatment. However, separation of means indicated that the highest yields were achieved only at the two uppermost nitrogen levels (N100 and N120), which formed a statistically superior group. The results demonstrated that high nitrogen dose is critical for maximizing fiber production, and the potential yield gain is highly dependent on annual growing conditions, as evidenced by the three-fold greater response in the second year.

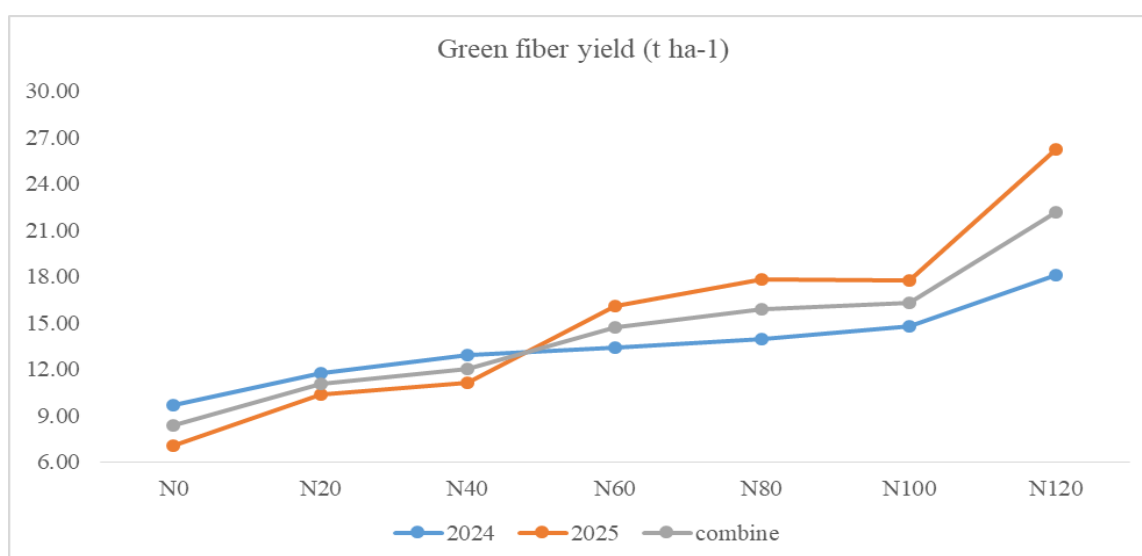


Figure 5. Response of nitrogen rates on green fiber yield of jute

Effect on green stick yield

Green stick yield responded significantly and positively to nitrogen application in both years and in the combined analysis (Table 2), with a pronounced year $\times$ treatment interaction (Figure 6). In 2025, yield increased nearly linearly with nitrogen, at N120 reaching three times higher than the control. In 2024, the response was moderate, with N120 yield only 1.7-fold higher than the control. In the combined analysis, mean stick yield increased 1.35 times in N120 than the control. The data confirmed that yields at higher nitrogen levels (N80 to N120) were superior to those at lower rates. The results indicated that nitrogen consistently enhances green stick production, the degree of enhancement was strongly influenced by yearly environmental factors, with optimal conditions allowing for a substantially greater yield potential at high nitrogen inputs.

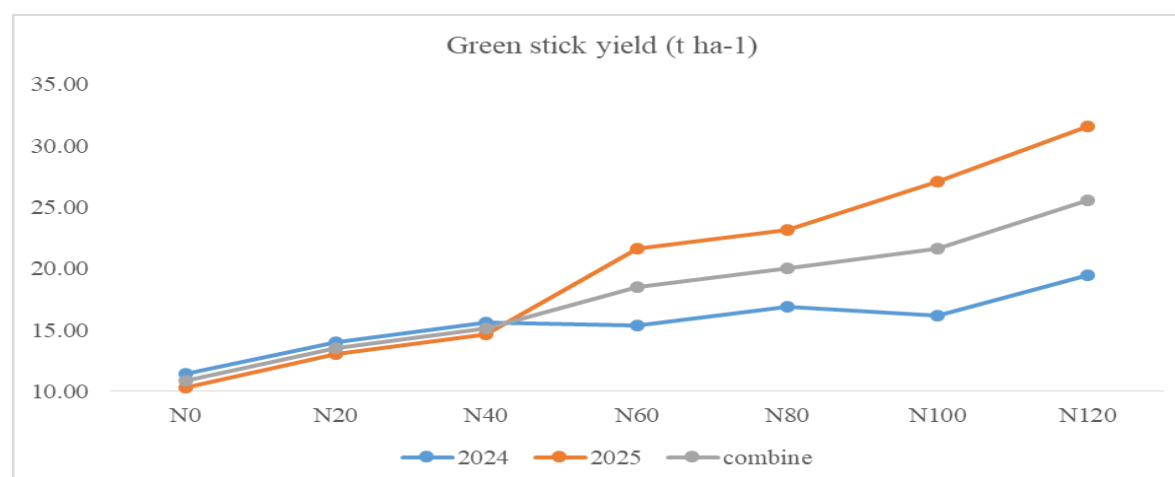


Figure 6. Response of nitrogen rates on green stick yield of jute

Table 2. Effect of different dose of nitrogen on green plant yield (t ha⁻¹), green fiber yield (t ha⁻¹) and green stick yield (t ha⁻¹) at JRP, Itahari

Treatment	Green plant yield (t ha ⁻¹)			Green fiber yield (t ha ⁻¹)			Green stick yield (t ha ⁻¹)		
	2024	2025	Combined	2024	2025	Combined	2024	2025	combined
N120	52.30	57.18	54.74	18.07	26.2	22.13	19.47	31.6	25.53
N100	45.04	47.18	46.11	14.77	17.77	16.27	16.19	27.1	21.64
N80	33.29	37.96	35.63	13.98	17.8	15.89	16.88	23.12	20.00
N60	30.42	32.73	31.58	13.38	16.08	14.73	15.33	21.65	18.49
N40	29.88	30.03	29.96	12.91	11.12	12.02	15.64	14.63	15.14
N20	25.73	26.63	26.18	11.72	10.37	11.05	13.97	13.02	13.49
N0	22.93	21.72	22.33	9.67	7.02	8.34	11.47	10.28	10.87
Mean	34.23	36.21	35.22	13.50	15.19	14.35	15.56	20.20	17.88
F-test	*	**	**	*	**	**	*	**	**
LSD(0.05)	16.66	2.57	9.62	7.17	3.31	5.24	9.4	1.86	5.63
C.V. (%)	28.40	5.20	12.51	10.1	1.77	5.94	16.2	8.35	12.28

Effect on dry fiber yield

Dry fiber yield was significantly influenced by nitrogen application in both years and in the combined analysis (Table 3), with a notable year $\times$ treatment interaction (Figure 7). In 2024, yield increased progressively across nitrogen rates, peaking at N120 whereas, the response was curvilinear, plateauing at N80 with no significant increase at higher rates in 2025,

resulting in a contrasting rank order of treatments between years. The combined analysis showed that mean dry fiber yield increased 1.21 times in N120 than in the control. However, the interaction effect indicated that the combined mean for N120 was influenced exceptionally high 2025. The results demonstrated that nitrogen is essential for dry fiber production, the most efficient application rate for maximizing yield might be lower (N80) in certain growing conditions, beyond which significant additional yield gains are not assured.

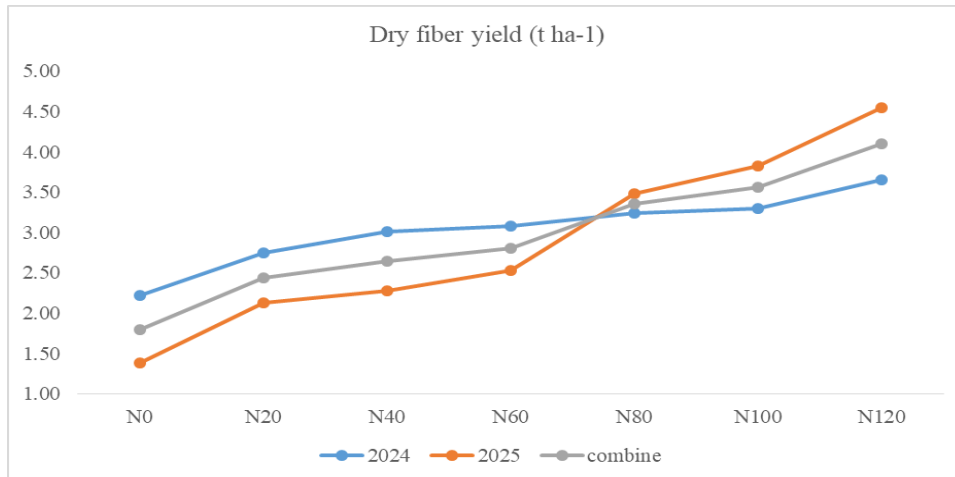


Figure 7. Response of nitrogen rates on dry fiber yield of jute

Effect on dry stick yield

Nitrogen application significantly increased dry stick yield in both years and the combined analysis (Table 3). Yield exhibited a strong positive response, with the highest application rate (N120) producing a yield more than three times greater than the unfertilized control (Figure 8). The analysis revealed a significant year $\times$ nitrogen interaction, showing difference in the magnitude of the response between growing seasons. The relative yield increase from the control to the N120 treatment was 3.6-fold in 2025, compared to 3.1-fold in 2024. Combined analysis confirmed that yields in the higher nitrogen rates (N80 to N120) were statistically superior to those under lower rates. The results demonstrated that nitrogen fertilizer is a critical driver of dry stick biomass accumulation, with the potential yield benefit being consistently large but might depend on annual growing conditions.

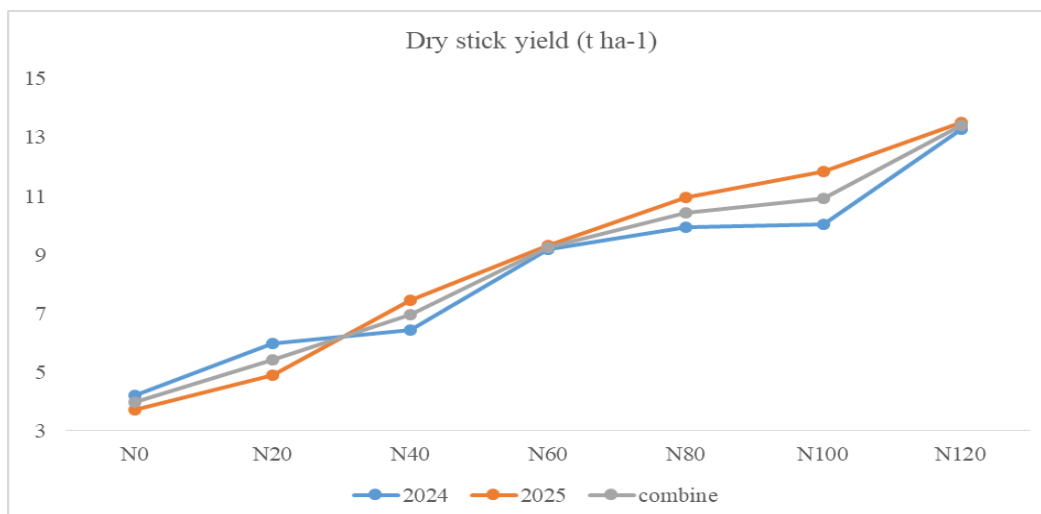


Figure 8. Response of nitrogen rates on dry stick yield of jute

Table 3. Effect of different dose of nitrogen on dry fiber yield (t ha⁻¹)) at JRP, Itahari

Treatment	Dry fiber yield (t ha ⁻¹)			Dry stick yield (t ha ⁻¹)		
	2024	2025	combine	2024	2025	combine
N120	3.65	4.55	4.10	1.45	1.83	1.64
N100	3.30	3.82	3.56	1.28	1.68	1.48
N80	3.24	3.48	3.36	1.23	1.58	1.41
N60	3.08	2.53	2.80	1.18	1.42	1.30
N40	3.01	2.28	2.64	1.17	1.31	1.24
N20	2.75	2.13	2.44	1.18	0.96	1.07
N0	2.22	1.38	1.80	1.13	0.92	1.03
Mean	3.03	2.88	2.96	1.23	1.39	1.31
F-test	*	**	**	Ns	**	**
LSD(0.05)	1.45	0.80	1.12	-	0.07	0.09
C.V. (%)	18.4	9.19	14.80	25.9	1.73	13.82

DISCUSSION

The results of the study demonstrated that nitrogen fertilization was a key factor influencing vegetative growth, fiber development, and biomass accumulation in jute (*Corchorus olitorius*), with strongly affected by seasonal conditions. all the important traits i.e. plant height, basal diameter, fiber thickness, green and dry biomass, and fiber and stick yields, exhibited a clear nitrogen dose dependent effect, confirming its critical role in jute productivity.

Plant height increased significantly with nitrogen application in both years and in combined analysis, reaching maximum values at the highest rate (N120). Higher nitrogen rates (N80–N120) consistently produced taller plants than lower or no nitrogen, indicating that nitrogen stimulated cell division and elongation, enhancing vegetative growth (Kady and Fatah 2009). The year × treatment interaction on plant height indicated that environmental factors such as temperature, soil moisture, and nutrient availability could influence the expression of nitrogen-induced growth (Li et al 2024). Similar patterns were observed for basal diameter and fiber thickness, where 2025 exhibited stronger, dose-dependent responses, while 2024 showed limited or non-significant effects at lower nitrogen rates. These findings highlighted the sensitivity of stem thickening and fiber development to both nitrogen rates and seasonal conditions. This could be attributed to differences in soil moisture, temperature, or solar radiation between years, factors known to influence cell wall biosynthesis and carbon partitioning (Pappaert et al 2025).

The most important finding of this study was the multiplicative effect of nitrogen on total biomass and harvestable yield components. The linear increase in green plant yield, culminating in 2.3 to 2.6 fold increase at N120, underscored nitrogen's role as the principal yield-limiting nutrient. This aligned with research on fiber crops like jute, hemp and flax, where N availability directly governed total biomass production (Ray and Chawdhary 2014). The pronounced interaction for green fiber yield, with a 3.7-fold increase in 2025 versus a less than two-fold increase in 2024, was particularly significant. This suggested that in favorable growing seasons, the plant's physiological capacity to translate abundant nitrogen into harvestable fiber is substantially enhanced. The plateau in fiber thickness at N80 and the formation of a superior yield group at N100-N120 for green fiber indicated a potential

threshold for efficient fiber development, beyond which luxury consumption or alternative partitioning might occur (Singh et al 2014).

The strong positive response of dry stick yield, with a more than three-fold increase, confirmed nitrogen's vital role in structural biomass accumulation. The plateau observed in dry fiber yield at N80 in 2025, however, introduced a critical role of nitrogen nutrient management. This suggested that the most economically efficient rate for dry fiber production might be lower than the rate required for maximum vegetative growth. Applying N beyond this rate (e.g., N120) might not translate into proportional increases in the final fiber yield, especially in certain environmental contexts. This pattern of diminishing returns at high N rates is common in agronomy and is essential for developing cost-effective and environmentally sound fertilizer recommendations (Ali et al 2017).

CONCLUSION

Nitrogen fertilization had a pronounced and consistent effect on jute growth, fiber development, and biomass production. Increasing nitrogen rates enhanced plant height, basal diameter, and fiber thickness, as well as green and dry yields of plant, fiber, and stick components, with the highest rates (N100 to N120) producing the maximum responses. The evidence of diminishing returns was a key finding: under favorable conditions, dry fiber yield plateaued at a moderate nitrogen rate (80 kg N ha⁻¹). This suggested a threshold for efficient nitrogen partitioning into fiber. High nitrogen promoted vegetative growth and did not guarantee proportional gains in harvestable fiber. We concluded that precision nitrogen management targeting 80–100 kg N ha⁻¹ and seasonal forecasts as well as yield goals is essential to optimize productivity and sustainability in jute cultivation.

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Authors' Contributions

Santosh Raj Tripathi was responsible for Conceptualization, Investigation, Formal Analysis, Data Curation, Methodology, and the writing of the original draft, as well as Review & Editing. Sujan Karki and Bishnu Prasad Poudel contributed to the Investigation and Methodology., Data curation. All authors contributed to revising the manuscript and gave final approval for submission.

Conflicts of Interest

The author(s) declare that they have no potential conflicts of interest with respect to the research, authorship, or publication of this article.

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