



RESEARCH ARTICLE

Evaluation of additional nitrogen doses on the growth and yield performance in jute (*Corchorus olitorius* L.) in Bangladesh

Md. Imran Ali^{1,2}, Sirajam Monira^{2,3}, Rifa Tamanna¹, Md. Saidul Islam¹, Shakila Khatun Bristy¹, Nusrat Jahan¹ & Md. Mukhtar Hossain^{1,4,5*}

¹Department of Crop Science and Technology, Faculty of Agriculture, University of Rajshahi, Rajshahi 6205, Bangladesh

²Graduate School of Environmental Life, Natural Science and Technology, Okayama University, Okayama, 700-8530, Japan

³Department of Agronomy, Faculty of Agriculture, Bangladesh Agricultural University, Mymensingh, 2202

⁴The United Graduate School of Agricultural Sciences, Kagoshima University, Kagoshima 890-0065, Japan

⁵Department of Tropical Bioresource and Plant Resource Production, Faculty of Agriculture, Saga University, Saga 840-8502, Japan

*Correspondence email - mhossain@ru.ac.bd

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Abstract

Nitrogen (N) is a key macronutrient governing plant growth, biomass accumulation and fibre development in jute (*Corchorus olitorius* L.). However, both insufficient and excessive N application can adversely affect fibre productivity and resource-use efficiency. Due to improper nutrient management in Bangladesh, the jute fibre yields have steadily declined. To address this, a field experiment was conducted at the Regional Jute Research Station, Kishoreganj, Bangladesh during March–September 2023 using the jute variety BJRI Tossa Pat-8. The experiment was arranged in a randomised complete block design (RCBD) with 3 replications. Six N treatments were evaluated: T₁ = no N (control), T₂ = recommended nitrogen dose (RDN) 80 kg ha⁻¹, T₃ = 120 % RDN (96 kg ha⁻¹), T₄ = 140 % RDN (112 kg ha⁻¹), T₅ = 160 % RDN (128 kg ha⁻¹) and T₆ = 180 % RDN (144 kg ha⁻¹). Nitrogen application significantly affected all measured growth and yield parameters. The tallest plants (291 cm) and highest number of leaves (113.34 plant⁻¹) were recorded under T₆, whereas the greatest basal stem diameter (19.46 mm), fresh weight (3.53 kg plant⁻¹) and stem weight without leaves were obtained under T₄. Fibre yield increased with N application up to T₄ and then declined at higher application rates. The maximum fibre yield (3.21 t ha⁻¹) and stick yield (6.71 t ha⁻¹) were achieved with T₄, while the lowest values were observed in the control treatment. Harvest index was highest in T₂ (33.43 %) and lowest in T₆ (24.83 %), indicating reduced assimilate partitioning efficiency under excessive N supply. Correlation and principal component analyses (PCA) revealed strong positive associations between plant height, stem diameter and fibre yield. Application of 140 % of the RDN (T₄) which is application of 112 kg ha⁻¹ provided the optimal balance between vegetative growth and fibre production, resulting in the highest fibre and stick yields. Excessive N promoted luxuriant vegetative growth but reduced harvest index and fibre productivity. Therefore, applying 140 % of the RDN may be an effective nutrient management strategy for maximising jute yield under similar conditions of Bangladesh.

Keywords: basal diameter; fibre yield; jute; nitrogen fertilisation; optimisation; stick yield

Introduction

Jute (*Corchorus* spp.) is one of the most crucial bast fibres in the world beyond cotton. Bangladesh and India produced about 90 % of the total fibre production (1). Raw jute is obtained from different species, namely *Corchorus capsularis* L., *Corchorus olitorius* L., *Hibiscus cannabinus* L. and *Hibiscus sabdariffa* L. Jute grows well throughout the country due to the favourable climatic conditions; Faridpur, Jashore, Manikganj, Kishoreganj, Mymensingh and Rangpur regions are renowned districts in Bangladesh. Among them, about 85 % of fibre is produced from the *olitorius* jute (2–4). It is widely cultivated because of its high fibre yield and edible leaves (5). It also contributes to the national economy by earning foreign currency. Several species of *Corchorus* are used as vegetables; among them, *olitorius* is the most used.

It is a very popular vegetable in Japan because it is rich in carotenoids, vitamins B1, B2, C and E, as well as minerals (6). The

dark green leaves of *C. olitorius* contain different amounts of calcium (Ca), iron (Fe), carotene, vitamin C, fibre and protein which are beneficial to human health (7). Plant nutrition, like nitrogen (N), phosphorus (P), potassium (K), sulphur (S), etc., is one of the most important factors for crop production as well as jute fibre production. Among them, N is very crucial for plant growth and development. Nitrogen greatly influences jute growth and fibre yield production (8). In *C. olitorius*, N fertiliser has a considerable influence on plant height, fibre product and stick yield (9).

Previous studies have demonstrated that N fertilisation plays a pivotal role in improving the growth, development and productivity of jute. Increasing N application generally enhances vegetative growth, stem elongation, leaf area development and biomass accumulation up to an optimum threshold, beyond which the beneficial effects gradually decline (10). Nitrogen is a fundamental component of chlorophyll, amino acids, proteins and

nucleic acids, making it essential for photosynthesis, cell division and overall plant metabolism. Adequate N supply promotes vigorous plant growth and contributes to higher fibre yield by increasing stem length and diameter, which are important yield-contributing traits in jute. However, excessive N application may result in luxuriant vegetative growth at the expense of fibre development, causing lodging, delayed maturity, poor fibre quality, reduced nutrient-use efficiency and increased production costs (11). Therefore, determining the optimum N dose and its proper application timing is essential for maximising jute productivity while maintaining fibre quality and environmental sustainability. The importance of balanced nutrient management has also been reported in several horticultural and field crops. The appropriate fertiliser management significantly improved plant growth, flowering performance and biochemical composition in Chinese carnation, highlighting the critical role of nutrient availability in crop productivity (12).

Similarly, the combined application of humic acid and plant growth regulators enhanced vegetative growth and flowering attributes of marigold, emphasising that optimal nutrient supply is necessary to achieve maximum plant performance (13). Another study, highlighted those substantial improvements in the growth and physiological characteristics of fig seedlings through biochar application and foliar supplementation, indicating that nutrient management strategies can substantially influence plant growth and development (14).

Furthermore, micronutrient application improved the chemical composition and growth performance of orange saplings demonstrating the importance of balanced fertilisation in enhancing crop productivity and quality (15). In Bangladesh, however, soil fertility is generally declining because of continuous cropping, inadequate organic matter incorporation and imbalanced fertiliser use (16, 17). Many agricultural soils are deficient in essential nutrients, particularly N, which often limits crop growth and yield potential. Despite the economic importance of jute as a major fibre crop, farmers frequently apply either insufficient or excessive amounts of N fertiliser without prior soil testing or scientific recommendations.

Under-fertilisation often results in poor plant growth, lower fibre yield and reduced economic returns, whereas excessive fertiliser use increases production costs and may negatively affect fibre quality and environmental health. Consequently, identifying an optimum N application rate for jute production under local agro-ecological conditions is crucial for improving yield, enhancing resource-use efficiency and ensuring sustainable fibre production in Bangladesh. Therefore, an investigation was conducted to determine the effectiveness of additional N on the growth and fibre yield of jute for getting maximum fibre yield.

Materials and Methods

Experimental conditions and plant material

A field experiment was conducted at the Jute Research Regional Station, Kishoreganj, Mymensingh, Bangladesh (latitude: 24°44'35" N and longitude: 90°44'49"E) from March–September 2023. The research area lies in Agro-Ecological Zone 9 (Old Brahmaputra Floodplain). The soil ranged from sandy loam to clay in texture and was acidic in nature and has pH values ranging from 4.5–6.4. The organic matter content is low to medium. The levels of other nutrients, including N, P and K. This area is well known for jute cultivation for the last eight decades. The average temperature,

rainfall and relative humidity are presented in Table 1 (18). The plant material used in this study was the jute variety BJRI Tossa Pat-8. It was developed by the Bangladesh Jute Research Institute (BJRI) in 2019 and produces approximately 15–20 % higher yield than the existing varieties. This variety was developed by crossing O-4 with an indigenous Tossa jute genotype to combine desirable yield-related traits.

Table 1. The climatic factors in experimental area during the period of conducting the experiment based on monthly average (12)

Month	Average temperature (°C)	Rainfall (mm)	Relative humidity (%)
March	24.80	102.00	76.00
April	28.30	16.00	73.00
May	28.50	244.00	75.00
June	26.50	261.00	83.00
July	30.40	348.00	83.00
August	29.90	394.00	85.00
September	30.10	197.00	84.00

Experimental design and treatments

This study was conducted in a randomised complete block design (RCBD) with 3 replications. The treatments consisted of different N fertiliser levels as T_1 = control (no N), T_2 = RDN (80 kg ha⁻¹), T_3 = 120 % RDN (96 kg ha⁻¹), T_4 = 140 % RDN (112 kg ha⁻¹), T_5 = 160 % RDN (128 kg ha⁻¹) and T_6 = 180 % RDN (144 kg ha⁻¹). The jute variety BJRI Tossa Pat-8 was used in the experiment. Each plot measured 12 m² (4 × 3 m). The spacing between adjacent plots and blocks was maintained at 1.0 m and 0.5 m respectively. The distance between the lines was 30 cm. The field was ploughed three times using a power tiller and followed by levelling using a wooden ladder. All fertilisers except urea were applied uniformly according to the national recommended dose. Triple superphosphate (TSP) and muriate of potash (MoP) were each applied at 40 kg ha⁻¹. Urea fertilisers were divided into two parts; one-half was applied during the final preparation of land and the remaining half was top-dressed at 45 days after sowing (DAS). All other agronomic practices were performed as per requirements.

Agronomic operations

The experimental field was prepared by four ploughings by power tiller and laddering with mechanical tools maintaining the well and uniform soil level. Weeding, thinning, sorting, insect, pest and disease management, harvesting of plant, retting, stripping, washing and drying were performed as treatments. Jute seeds were collected from the Jute Research Regional Station, Kishoreganj and sown on 20 March 2023 at a seed rate of 4.5 kg ha⁻¹ in line. A uniform plant population was maintained during the whole study period. The jute plant was harvested on 19 July 2023 at the age of 120 days. The harvested plants from each treatment were kept separately and each bundle was properly tagged on each individual plant bundle.

After harvesting, the plants were tied into bundles with rope and kept for 4–5 days to allow the leaves to shed naturally from the plant. The bundles were submerged in a pond to submerge the plants. The bundles were submerged into the water by using bricks as weights and covering them with rice straw to obtain good fibre colour. The retting of the jute plant was completed after 20 days. It was noted that the fibre bark became loose and removed from the stem through the retting procedure as a result of removal of pectin, gums and other mucilaginous components. The fibre was removed from the stem and washed with water. The extracted fibre was dried in an open area under sunlight.

Data collection and processing

Ten plants were randomly selected from each treatment for data collection. The specimens were collected randomly from the study area before harvesting to investigate the growth, yield component and fibre yield. Fibre and stick yields were recorded after complete drying. Harvest index is the ratio of economic and biological yield (19).

$$\text{Harvest index} = \text{Economic yield} / \text{Biological yield} \times 100$$

Here, economic yield is the fibre yield; biological yield is the biological yield, including the dry weight of leaf, stick and fibre yield.

Statistical analysis

The data were collected and tabulated in Excel and analysed using R statistical software (v4.1.2; R Core Team 2024) for the analysis of variance (ANOVA). Treatment means were compared using the multiple mean comparisons of least significant differences (LSD) at the 5 % level of significance. When significant differences were identified, the treatment means were compared by applying Tukey's honest significant difference (HSD) test. A correlation analysis between growth and yield parameters at different N levels and a principal component analysis (PCA) were also performed.

Results

Growth parameters

The growth parameters were significantly influenced by the different N doses ($p < 0.001$). The maximum plant population (291 plants m^{-2}) was recorded in T6, whereas the lowest plant population (232 plants m^{-2}) was observed in T1 (Fig. 1A). Plant height also varied significantly among the treatments. The maximum plant height (3.58 m) was recorded in T4, followed by T5 (3.21 m), whereas the minimum plant height (2.30 m) was observed in T1 (Fig. 1).

Basal, middle and terminal stem diameters were all significantly influenced by the N treatments. The maximum basal diameter (19.46 mm) was recorded in T4, whereas the minimum value (9.03 mm) was observed in T1 (Fig. 2). The middle diameter was highest (12.56 mm) in T5, whereas the lowest value (6.10 mm) was recorded in T1 (Fig. 2). Similarly, the maximum terminal diameter was observed in T4, followed by T6, whereas the minimum terminal diameter was recorded in T1 (Fig. 3).

Fresh weight was significantly affected by the different N levels. The highest fresh weight (3.53 g)* was recorded in T4, which was statistically similar to that in T5, whereas the lowest fresh weight

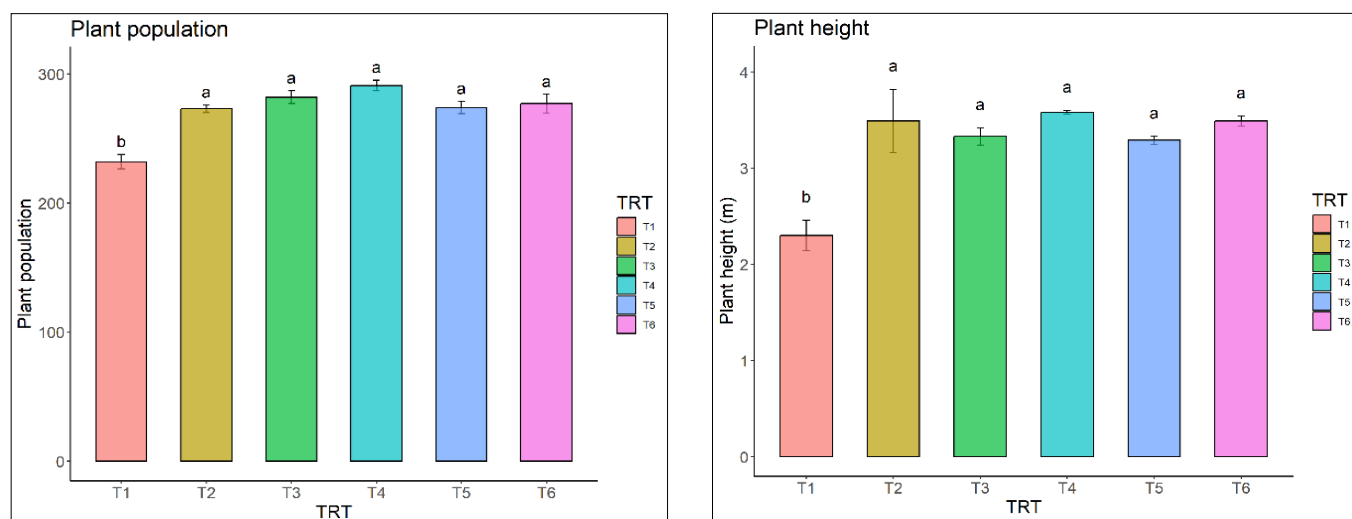


Fig. 1. The effect of elevated nitrogen doses in plant population and plant height of jute.

Different letters indicate significant differences ($p < 0.001$; Tukey's HSD test); $n = 10$; Error bar indicates standard deviation; T1: control (no nitrogen); T2: Recommended dose of nitrogen (RDN); T3: 120 % RDN; T4: 140 % RDN; T5: 160 % RDN; T6: 180 % RDN.

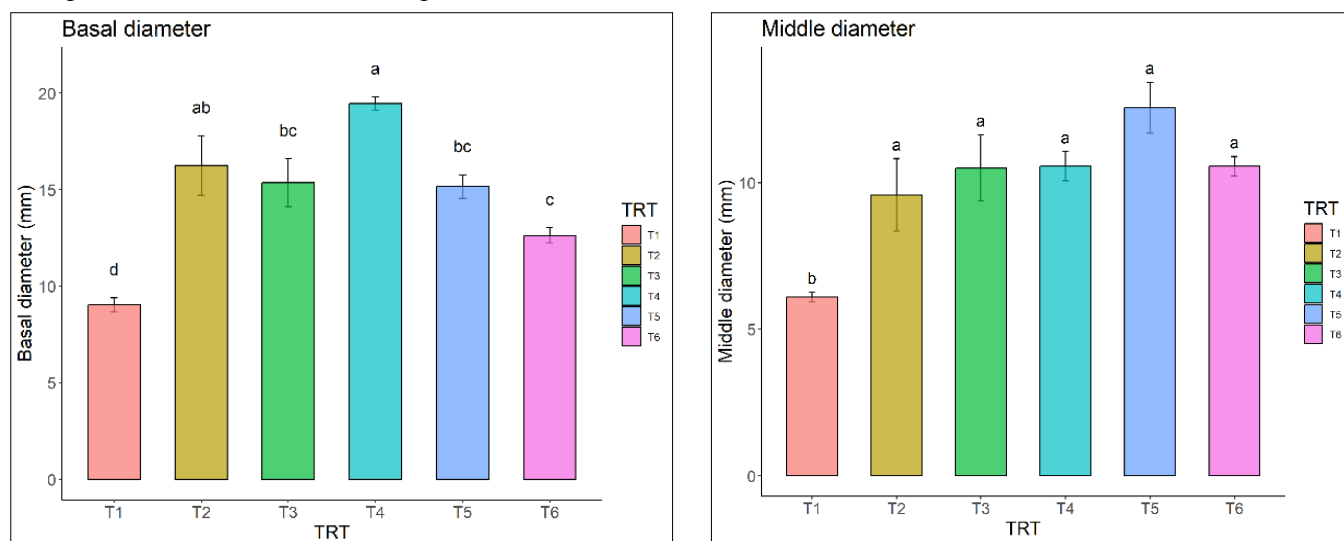


Fig. 2. The effect of elevated nitrogen doses in basal diameter and middle diameter of jute.

Different letters indicate significant differences ($p < 0.001$; Tukey's HSD test); $n = 10$; Error bar indicates standard deviation; T1: control (no nitrogen); T2: Recommended dose of nitrogen (RDN); T3: 120 % RDN; T4: 140 % RDN; T5: 160 % RDN; T6: 180 % RDN.

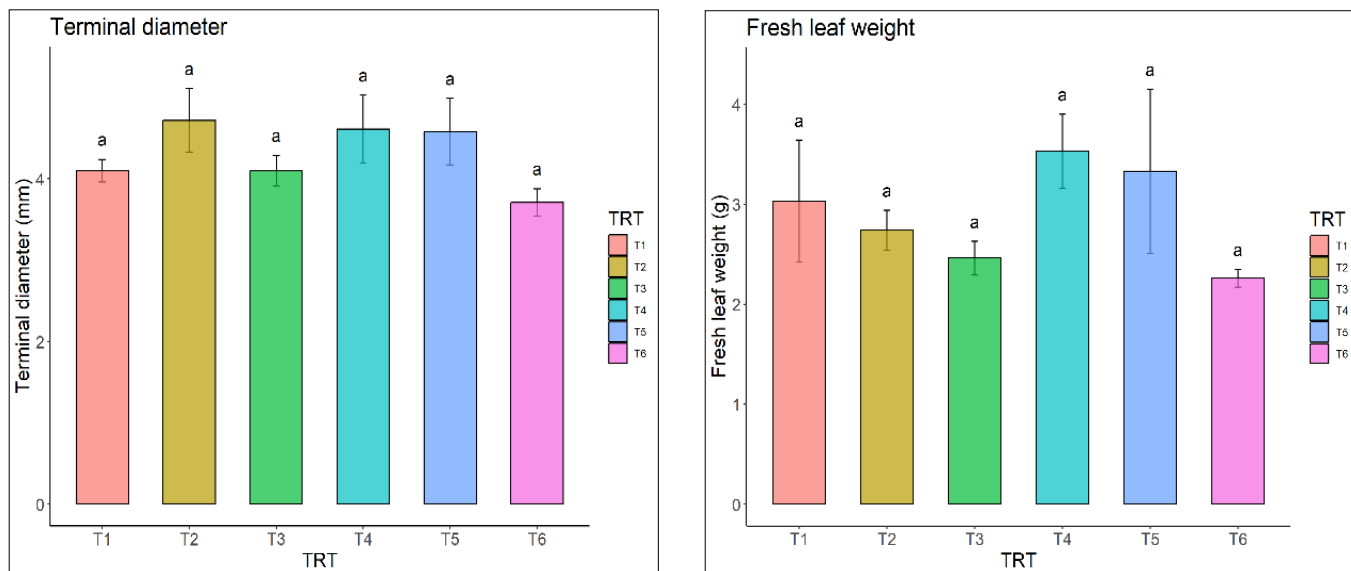


Fig. 3. The effect of elevated nitrogen doses in terminal diameter and fresh leaf weight of jute.

Different letters indicate significant differences ($p < 0.001$; Tukey's HSD test); $n = 10$; Error bar indicates standard deviation; T1: control (no nitrogen); T2: Recommended dose of nitrogen (RDN); T3: 120 % RDN; T4: 140 % RDN; T5: 160 % RDN; T6: 180 % RDN.

(2.26 g)* was observed in T6 (Fig. 3). Stem weight without leaves was also significantly influenced by the N treatments. The maximum stem weight without leaves was recorded in T4, whereas the minimum value was observed in T6 (Fig. 4).

The number of leaves was significantly affected by the different N levels. The maximum number of leaves (113.34 plant⁻¹) was recorded in T6, followed by T5 (109.00 plant⁻¹) (Fig. 4). In contrast, the minimum number of leaves (68.67 plant⁻¹) was recorded in T1 (Fig. 4).

Fibre yield and stick yield of jute

Fibre yield was significantly influenced by the different N levels. The maximum fibre yield (3.21 t ha⁻¹) was recorded in T4, followed by T3 and T5, whereas the minimum fibre yield (1.84 t ha⁻¹) was observed in T1 (Fig. 5).

Stick yield, the second most important product of jute, was also significantly affected by the different N levels. The maximum stick yield (6.71 t ha⁻¹) was recorded in T4. The second-highest stick yield was observed in T5, which was statistically similar to those

recorded in T3 (5.54 t ha⁻¹) and T6 (5.40 t ha⁻¹). The lowest stick yield (2.70 t ha⁻¹) was recorded in T1 (Fig. 5).

Harvest index, which represents the ratio of economic yield to total biological yield, was also influenced by the N treatments. The highest harvest index (33.43 %) was observed in T2, which was statistically similar to those of T1, T3, T4 and T5. The lowest harvest index (24.83 %) was recorded in T6 (Fig. 6).

Correlation analysis

The correlation matrix revealed the relationships among the growth and yield parameters of jute under different N levels (Fig. 7). A strong positive correlation was observed between fibre yield and several growth parameters, including plant height, basal diameter and middle diameter. Similarly, stick yield showed strong positive correlations with plant height and basal diameter, indicating that these traits contribute substantially to fibre productivity. In contrast, the number of leaves exhibited a negative correlation with both fibre yield and harvest index.

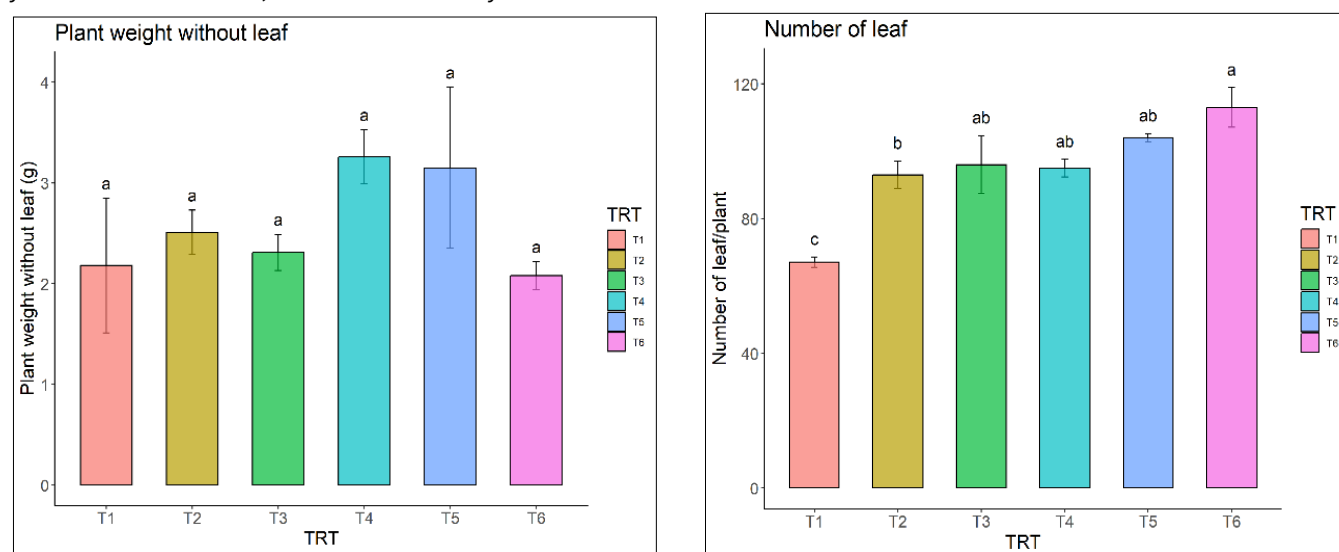


Fig. 4. The effect of elevated nitrogen doses in plant weight without leaf and the number of leaves/plants of jute.

Different letters indicate significant differences ($p < 0.001$; Tukey's HSD test); $n = 10$; Error bar indicates standard deviation; T1: control (no nitrogen); T2: Recommended dose of nitrogen (RDN); T3: 120 % RDN; T4: 140 % RDN; T5: 160 % RDN; T6: 180 % RDN.

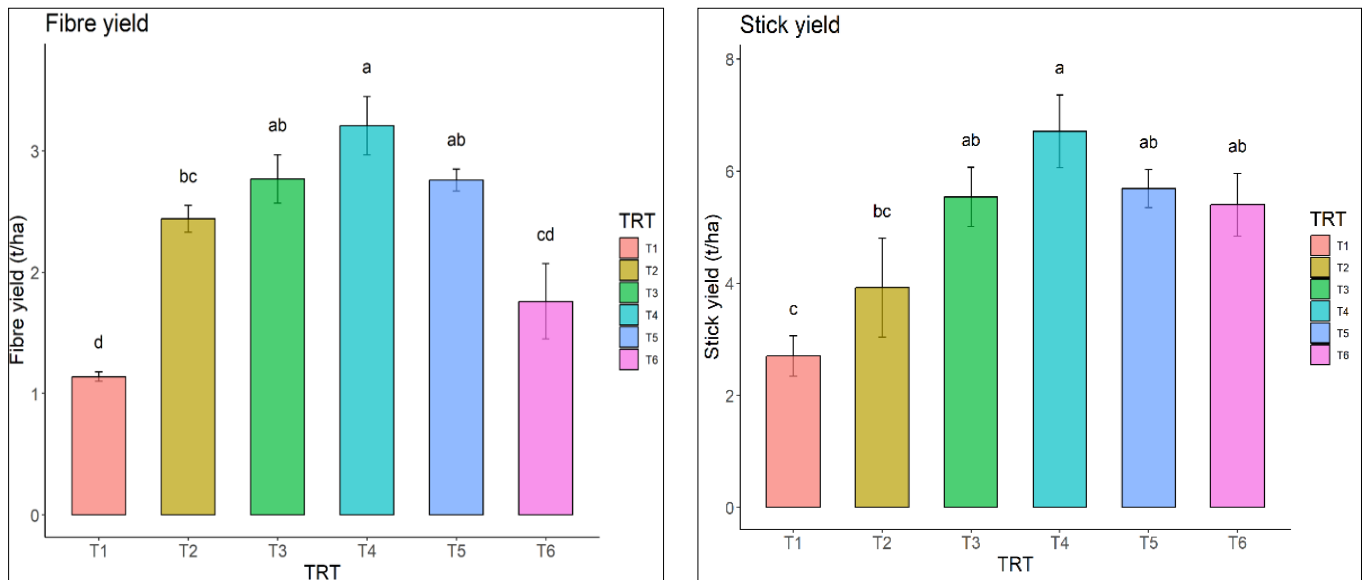


Fig. 5. The effect of elevated nitrogen doses in fibre yield and stick yield of jute.

Different letters indicate significant differences ($p < 0.001$; Tukey's HSD test); $n = 10$; Error bar indicates standard deviation; T1: control (no nitrogen); T2: Recommended dose of nitrogen (RDN); T3: 120 % RDN; T4: 140 % RDN; T5: 160 % RDN; T6: 180 % RDN.

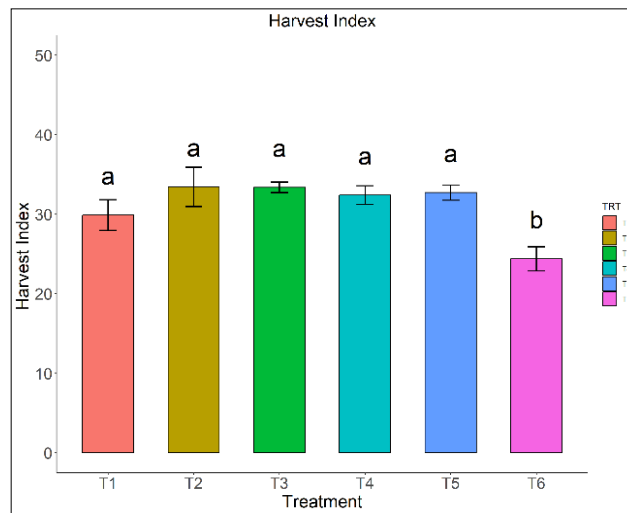


Fig. 6. The effect of elevated nitrogen doses in harvest index of jute.

Different letters indicate significant differences ($p < 0.001$; Tukey's HSD test); $n = 10$; Error bar indicates standard deviation; T1: control (no nitrogen); T2: Recommended dose of nitrogen (RDN); T3: 120 % RDN; T4: 140 % RDN; T5: 160 % RDN; T6: 180 % RDN.

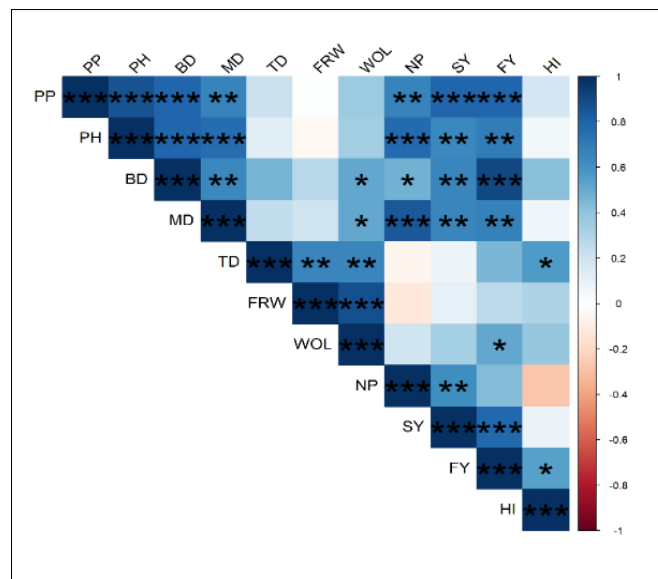


Fig. 7. Correlation matrix.

PP: plant population; NP: number of leaves; HI: harvest index; FY: fibre yield; PH: plant height; FRW: fresh weight of plant; WOL: weight without leaves; TD: terminal diameter; SY: stick yield; BD: basal diameter; MD: middle diameter.

Principal component analysis

The PCA revealed significant relationships among plant height, basal diameter, fresh weight, number of leaves, fibre yield, stick yield and harvest index (Fig. 8). Plant height and basal diameter were strongly associated with fibre yield and contributed primarily to PC1 (Fig. 8). In contrast, the number of leaves and fresh weight showed stronger associations with PC2, indicating that these variables were more closely related to vegetative growth than to fibre yield.

Discussion

Balanced nutrient management plays a crucial role in improving crop growth and yield (20–22). Among the essential plant nutrients, N is one of the most important macronutrients governing plant growth and development (23–25). It is a fundamental constituent of amino acids, proteins, nucleic acids and chlorophyll, thereby promoting vegetative growth and protein synthesis (26).

The present findings indicate that the intermediate N dose (T4) was optimal for maximising jute fibre yield, whereas both the RDN (T2) and excessive N application resulted in reduced productivity. This response can be attributed to differences in N availability, plant physiological processes and fibre development. Under the RDN as likely insufficient to meet the crop demand under the prevailing soil conditions, thereby limiting chlorophyll synthesis, photosynthetic activity and vegetative growth. Because N is essential for leaf development, stem elongation and biomass accumulation, an inadequate N supply restricts bast fibre formation and ultimately reduces fibre yield (26).

Plant height (PH) and plant population (PP), two important determinants of jute fibre yield, increased progressively from T1–T6. The highest plant population (291 plants m⁻²) and one of the greatest plant heights (3.49 m) were recorded under T6, indicating vigorous vegetative growth. Similar responses to varying N fertiliser levels have been reported in several crop species (27). Adequate N availability promotes stem elongation and internode development, resulting in taller plants with an optimum population density, which are associated with increased fibre length and greater biomass production. Higher N availability has also been shown to stimulate

cell division and cell elongation in jute stems (28). Basal diameter (BD) and middle diameter (MD), which are important indicators of stem thickness and fibre-bearing tissue development, reached their maximum values under T4 (19.46 mm and 10.68 mm respectively).

Thicker stems contain a greater number of bast fibre bundles in the phloem region and, consequently, produce higher fibre yields. This finding suggests that T4 provides a more balanced nutritional environment, promoting both radial stem thickening and vertical growth. The N treatments also had significant effects on terminal diameter, fresh weight (FW) and stem weight without leaves (WOL). T4 recorded the highest fresh weight (3.53 kg) and stem weight without leaves (3.26 kg), indicating enhanced biomass accumulation and structural stem development. Greater stem weight without leaves reflects increased bast fibre development and cellulose deposition in jute (*Corchorus* spp.), whereas terminal diameter serves as an important indicator of stem tapering and fibre -producing capacity (29).

Under the optimum N supply, assimilates were preferentially partitioned towards stem growth rather than leaf biomass. Enhanced structural development under balanced nutrient availability has been associated with stronger stems, improved biomass accumulation and higher fibre yield in jute. Therefore, the superior performance of T4 for these traits suggests that a balanced nutrient regime promotes both above ground structural development and fibre production, thereby maximising fibre yield and quality.

The number of leaves increased progressively from T1–T6, with the highest value (113.34 plant⁻¹) recorded in T6, indicating enhanced vegetative growth and a greater photosynthetic surface area. However, a higher leaf number alone did not result in increased fibre yield (30).

The highest fibre yield (3.21 t ha⁻¹) was recorded in T4, followed by T5 and T3, indicating that balanced vegetative growth is more important for fibre formation than excessive leaf proliferation. T4 also produced the highest stick yield (6.71 t ha⁻¹), reflecting greater stem thickness and increased stem biomass accumulation (31). Harvest index, which reflects the efficiency of assimilate partitioning towards the economic yield, was highest in T2 (33.43 %), followed by

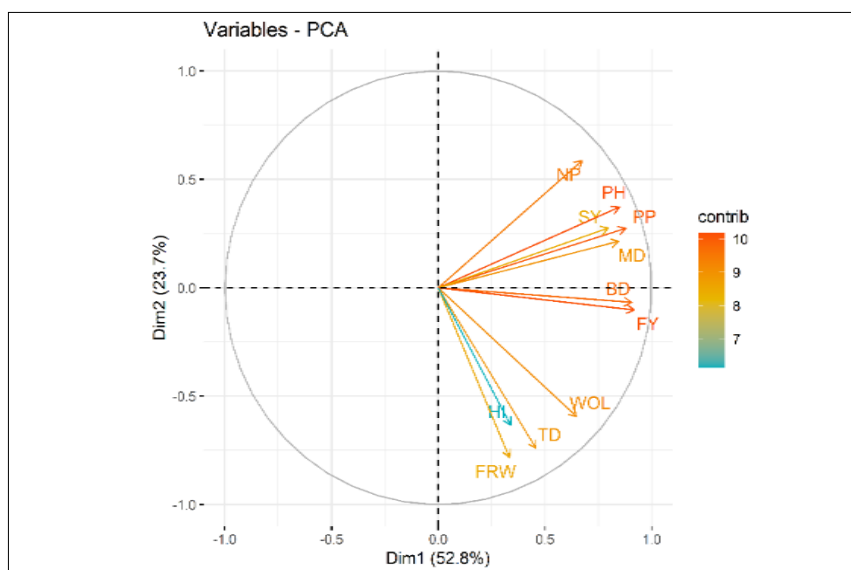


Fig. 8. Principal component analysis (PCA).

PP: plant population; NP: number of leaves; HI: harvest index; FY: fibre yield; PH: plant height; FRW: fresh weight of plant; WOL: weight without leaves; TD: terminal diameter; SY: stick yield; BD: basal diameter; MD: middle diameter.

T3, whereas the lowest value was recorded in T6 (24.38 %). The reduced harvest index in T6 suggests that excessive N application promoted luxuriant vegetative growth, resulting in greater assimilate allocation to leaves rather than to fibre-bearing stem tissues. These findings highlight the importance of maintaining an optimum balance between vegetative growth and stem development to maximise fibre yield in jute. However, excessive N application adversely affected fibre yield, likely because excessive vegetative growth occurred at the expense of fibre differentiation, as observed in T5 and T6.

High N levels may result in luxury consumption, lodging, delayed maturity and the development of thinner fibre cell walls. Excessive N can also reduce carbohydrate translocation to the stems and increase susceptibility to pests and diseases, ultimately decreasing fibre quality and yield (26, 28). These findings are consistent with previous studies (32–35), which reported that moderate N application maximises jute fibre yield, whereas excessive N results in poor fibre quality and inefficient biomass partitioning. Therefore, applying N at an optimal rate is essential for achieving sustainable jute production with higher fibre yield.

Conclusion

This study evaluated the effects of different nitrogen (N) levels on the growth and yield performance of *Corchorus olitorius* (BJRI Tossa Pat-8) in Kishoreganj, Bangladesh. The results demonstrated that N fertilisation significantly influenced all growth and yield parameters. Growth and yield increased with increasing N application up to an optimum level, after which they declined under excessive N supply. The findings indicated that 140 % of the recommended dose of nitrogen (RDN; 112 kg ha⁻¹; T₄) was superior to both lower and higher N levels for optimising jute growth and fibre production. The maximum fibre yield (3.21 t ha⁻¹) and stick yield (6.71 t ha⁻¹) were obtained under the T₄ treatment. In contrast, excessive N application (T₆) promoted luxuriant vegetative growth, resulting in a lower harvest index and reduced economic returns. Therefore, application of 140 % RDN (112 kg ha⁻¹) can be recommended for farmers in the Kishoreganj region of Bangladesh to maximise jute yield under similar agroecological conditions. Future research should focus on multi-location trials, economic profitability and the environmental impacts of different N application rates.

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Authors' contributions

Conceptualisation was carried out by MMH. MIA and SM contributed to the original draft preparation, visualisation, funding acquisition, data curation, methodology, investigation and review and editing of the manuscript. NJ contributed to writing, review and editing and funding acquisition. SM also contributed to writing, review and editing and funding acquisition. SKB contributed to writing, review and editing, resources and funding acquisition. MMH, RT and MSI also contributed to validation, writing, review and editing, resources and

funding acquisition. All authors have read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

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