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RESEARCH COMMUNICATION

Assessment of the potentially of low seeding rate on the growth, yield and economy of jute in Bangladesh

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Abstract

The optimisation of seeding rate is crucial for enhancing the growth, fibre yield and profitability of jute (*Corchorus olitorius* L.). A field experiment was conducted to assess the effects of varying seeding rates on the growth, yield and economic performance of jute. The experiment followed a randomized complete block design (RCBD) with 6 different seeding rates as treatments. Seeding rate ranged from 1.50 to 6.00 kg ha^{-1}, each mixed with inert material to maintain uniform application. Results demonstrated that seeding rate significantly influenced plant growth, yield and profitability. Increasing the seeding rate from 1.5 to 6.0 kg ha^{-1} increased plant density but reduced plant height, basal diameter and leaf number due to intensified intra-specific competition for light and nutrients. The highest fibre yield (3.70 t ha^{-1}), net return (100057 BDT) and benefit–cost ratio (BCR = 2.07) were achieved at 2.50 kg ha^{-1}, while higher rates (≥ 6.0 kg ha^{-1}) resulted in yield and profit decline. Correlation analysis revealed positive associations between fibre yield and both plant height (r = 0.776) and basal diameter (r = 0.771). Principal component analysis (PCA) confirmed these relationships, with the first 2 components explaining 76.6 % of the total variance. Overall, a low seeding rate (2.5–3.0 kg ha^{-1}) ensured optimal plant population, efficient resource use and maximum profitability, with 2.50 kg ha^{-1} identified as the most economically viable rate for *C. olitorius* cultivation in southwestern Bangladesh.

Keywords: basal diameter; economic return; fibre yield; harvest index; jute; low seeding rate

Introduction

Jute (*Corchorus spp.*) considered as the crucial fibre crops on the earth as well as Bangladesh that belongs to the *Corchorus* genus under the Tilliace family, occupying the about 10 % the cultivated land from total area of crop production (1). Bangladesh produced as the leading jute fibre (85.15 lac bales) recent year and exported the highest raw (226.0 thousand tonnes) to jute the world business for producing jute and related products that contributing the significant role in earning the foreign currency (2, 3). Jute is categorised among the 3 species as tossa jute (*Corchorus olitorius* L.), deshi jute (*Corchorus capsularis* L.) and kenaf (*Hibiscus cannabinus* L.). *Corchorus olitorius, C. capsularis* and *H. cannabinus* covered about 85 %, 8 % and 7 % respectively area of total jute production (4).

Different agronomic practices like weed management (5, 6), nutrient management (7–10), plant spacing (11) and seeding rate (12) have substantial impact on the growth and yield on crop. Among this seeding rate is more important to produce jute in Bangladesh. Because seed of jute in Bangladesh is not sufficient for jute fibre production. Every year a lot of foreign currency is lost for this reason. The approximately amount of jute seed requirement in fibre season about 6400 tonnes, among them 1300 tonnes supplied by Bangladesh Agricultural Development Corporation (BADC) and rest (5200 tonne) would be imported from India for cultivating the 7.64 lakh hectors of land including Kenaf and Mesta fibre (13).

Farmers are also using the high seed rate as well as do not follow the recommendation from Bangladesh Jute Research Institution (BJRI). Additionally, the imported seeds are not good quality as well as sometime lack varietal purity and resulting germination failure and farmers did not benefit, but we paid a lot of foreign currency every year. The fine tuning of seeding rate becomes a burning issue in jute fibre production in Bangladesh. However, production cost has been raising, thus resulting the reducing in income is considered as the major reason of reduction of fibre of jute area in Bangladesh (14).

Additionally, the production of jute has been decreasing because of weed infestation, genetically lowering yield ability, conventional sowing practices, higher seed rate, diseases, insects, agronomic practices like extraction of fibre is very expensive and

labour consuming task and other constraints (15). Among the seeding rate is substantially affecting productivity and economy of jute. The effect of low seeding rate (LS) on the growth, yield attributes, yield and economic performance of jute (*C. olitorius*) is a multifaceted issue that involves understanding the balance between plant density, resource utilisation and economic returns. Low seeding rates can influence various aspects of jute cultivation, including plant growth, yield components and overall economic viability (16).

Low seeding rates can lead to an increase in individual plant growth and yield attributes, such as larger pod size and higher seed weight, due to reduced competition for resources (17). However, the miniature seed of jute comprises various constraints in sowing and alongside in weeding and other agronomic practices. Farmers are unconscious about the seeding rate and usually use higher seed rates by recommended, that farmers mixture seed with poses lower germination (12). When the plant population surpasses the uniform standard, there occurring the contest in the crops for the above ground and nutrient competition under the ground become essential issues resulting in the retardation of plant growth and grain yield reduction (18–20). Yield attributes are influenced by the seeding rate from maximum to minimum (21–23).

Additionally, the lodging percentage of the plant expanded by increased the seeding rate. It is very crucial to identify the optimal seeding rate of plant density for maximising the fibre yield as well as the net income for growers (24). The economic performance of jute under LSRs is influenced by the balance between input costs and yield. Lower plant densities can reduce costs associated with seeds and thinning, potentially improving the benefit-cost ratio if managed correctly (25, 26). Optimum as well as regular plant establishment are the essential components of crop production to understanding the highest genetical yield ability (27).

Plant population and distribution are therefore vital indicators for exploring crop production (28). Hence, this investigation was investigated to boost jute production by means of upgradation of seeding rate for maximum fibre yield and net return at investigation area.

Materials and Methods

Experimental conditions and plant material

An investigation was carried out from March 2023 September 2023 at Bangladesh Jute Research Substation, Manirampur, Jashore, Bangladesh (latitude: 23˚01′ 0.12″ N and longitude: 89˚13′ 59.88″ E) and 200 cm over the sea level. During growth period the average maximum and minimum temperature was recorded as 27.64 ℃ and 16.16 ℃ respectively, while the average precipitation was 32 mm and humidity was 80.2 % (Table 1) and is a calcium deep greyish floodplain soil part of a series of calceric combosols and gleysols (29). The soil properties of the investigation area were recorded as pH; 8.0 (indicates light alkaline) whereas the organic matter is 2.4 % including the medium high land with silty loam soil. Available N: 0.062 %, P (37.76 mg/g^{-1}), K (0.33 mg/g^{-1}), CEC (15–30+ cmol(+) kg^{-1}), Bulk density: 1.2–1.4 g/cm^{-3} (medium density), EC: generally, < 2 dS/m^{-1}, Macronutrient condition was low to medium, Texture percentage: silt ~65–68 %, clay ~23–30 %, sand ~7–10 %. The investigation location is suitable for *C. olitorius* jute production. The plant material was jute, namely BJRI tossa pat-8, that is developed by the BJRI, in 2019 resulting in about 15–20 % additional yield than the existing variety. This variety was made by the crossing between 0–4 and ancient tossa jute matching the different yield related traits. From the last week of March to last week of April is the suitable date of sowing for attaining maximum yield.

Experimental design and treatments

The investigation was carried out at three replications in randomized completely block design (RCBD). The treatment was consists of as 6 LSR 1.50 kg ha^{-1} live seed + 4.50 kg ha^{-1} inert materials + hand weeding (T1), 2.00 kg ha^{-1} live seed + 4.00 kg ha^{-1} inert materials + pretilachlor 50 EC and one hand weeding (T2), 2.50 kg ha^{-1} live seed + 3.50 kg ha^{-1} inert materials + one hand weeding at 25 DAS (T3), 3.00 kgha^{-1} live seed + 3.00 kg ha^{-1} inert materials + pendimethilin 33 % EC + one hand weeding (T4), 4.00 kg ha^{-1} live seed + 2.00 kg ha^{-1} inert materials + one hand weeding at 25 DAS hand weeding at 25 DAS (T5), 6.00 kg ha^{-1} live seed + one hand weeding at 25 DAS (T6), respectively. Due to the small size of seed of jute, it was mixed with inert materials of ash from burn wood for uniform distribution of seed in the field. Each plot size was 10 m^2. The distance between plot to plot and block to block was 1 m with 50 cm deep drainage system.

Agronomic operations

The experiment plot was ready by four ploughing by power tiller and laddering with machinal tools maintaining the well and uniform soil level. The fertilisation: N in the form of urea at the rate of 195 kg ha^{-1} (half part at the time of land preparation and half part at 40–45 days after sowing), P_2O_5 in the form of tripple super phosphate 50 kg ha^{-1}, K_2O in the form of Muriate of potash 30 kg ha^{-1}, Zn and sulphate in the form of gypsum at the rate of 110 kg ha^{-1} gypsum were applied at the time of end of preparation of land) as BJRI recommendations. Herbicides were provided on recommended days with proper doses.

Weeding, thinning, sorting, insect, pest, disease management, harvesting of plant, retting, stripping, washing and drying were performed as treatment wise. Seeds of BJRI tossa pat-8 were collected from the Jute Research Substation Manirampur, Jashore, Bangladesh. The test percentage of germination of seed was about 90 %. Seed was sown on March 26 at the rate of treatment combination. Seed were sown in line to line maintaining the recommended spacing by BJRI (30 cm). When the jute plant reached 120 days, the plant was cut on 24th July 2023. Ten plant samples were collected and separated from the individual plot to

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

Month	Average temperature (°C)	Rainfall (mm)	Relative humidity (%)	Sunshine (hr)
March	26.40	58.00	69.00	332.00
April	30.60	62.00	72.00	331.00
May	30.50	220.00	77.00	349.00
June	31.00	162.00	84.00	378.50
July	30.50	85.00	84.00	375.4
August	29.85	309.00	86.00	337.0
September	29.80	171.00	86.00	331.0

BBS (Bangladesh Bureau of Statistics) 2024. Statistical Yearbook Bangladesh 2023.

determine the growth, yield components and yield of jute. The rest of the plants were harvested and bundled into treatment wise and prepared ready for retting. Plant leaves were removed by preparing small bundles and keeping them in the soil for 4 to 5 days. After removing the leaves of the jute plant was immersed in the water pond based on the treatments.

After soaking, it was retted and washable after 25 days. Due to the removal of pectin, gums and other mucilaginous substances, the fibre was looser and easy to remove in retting from stick. Combination of water temperature and microorganisms enhanced the procedure of retting. The fibre was peeled off and consequently water washed for suitable retting. The fibre was collected in the treatment wise and dried in the bamboo made hanger. The fibre yield was recorded. The stick of the jute plant was dried in the sunlight following them standing on the same structure made from bamboo. The stick yield was measured in treatments wise after completing dry of stick. The plant samples were also retting, washed, dried and weighed in the same procedure as previously mentioned.

Data collection and processing

The data were collected on the day of harvesting and the day after drying of the fibre and stick yield. Ten plant samples were marked during the growing season with tag randomly excluding the border raw area based on individual treatments for calculating the growth and yield of jute. Plant population was measured by counting manually whereas the plant height (m) was calculated from the plant bottom to top through scale. Basal diameter was measured by using the slide calipers (Insize Digital Slide Caliper 0–150 mm Type No. 1108-150) at the basal part of the plant. Fresh weight of plant was determined by using digital scale (WPCS-DS982, 30KG made by Walton).

The leaves were measured by manually counting. The fibre and stick yield were computed by using the digital scale as previously mentioned. Harvest index (%) was determined by the proportion of the dry weight of fibre of the jute to dry weight of the total above ground biomass yield and multiplied by one hundred. The harvest index was measured below the equation.

$$HI\ (\%) = EY/BY \times 100$$

Here, HI = Harvest Index, EY= Economic yield as dry weight of jute fibre yield, BY = Total dry weight of total above ground biomass yield including fibre yield, stick yield and leaf weight.

Budget analysis. The labor cost of individual treatments was recorded as the final activities of the experiment. The labor cost was calculated based on an 8 hr basis working individual day of 400 BDT. The gross benefit was determined by farmers received from the local market price of fibre and stick yield (kg ha^{-1}). The price of fibre was 40 BDT per kg whereas the stick price was 10 BDT. Total cost that varied from individual treatment was measured and resulting the cost variation and benefit cost ratio (BCR) in each treatment. Net return was measured by deducting total cost of production to from gross return. The BCR was determined by total return divided by total cost of production.

Statistical analysis

The recorded data were compiled and organised using Microsoft Excel and subsequently analysed with R software (version 4.3.1; R Core Team, 2023). The analysis was performed following a RCBD using analysis of variance (ANOVA) to evaluate treatment effects.

The linear statistical model for ANOVA under RCBD was:

$$Y_{ij} = \mu + T_i + \beta_j + \varepsilon_{ij}$$

where

Y_{ij}= observed value of the i^{th} treatment in the j^{th} block,

μ = overall mean,

T_i= effect of the i^{th} treatment,

β_j= effect of the j^{th} block (replication) and

ε_{ij}= random error associated with each observation, assumed to be independently and normally distributed with mean zero and constant variance ($\varepsilon_{ij} \sim N(0,\sigma^2)$).

Treatment means were compared using the Least Significant Difference (LSD) test at the 5 % probability level to determine statistical significance.

Results

The effect of low seeding rate on plant growth of jute

The result of ANOVA presented that the plant population was affected by the LSR. The maximum plant population (54.66) was recorded in T6 seeding rate where the lowest plant population (25.33) was recorded in T1, respectively (Table 2). The obtained result showed that the increment of seeding rate from 1.50 to 6.0 kg ha^{-1}, population of the plant increased. It might be due to the number of seeds showing in individual plot. The result of ANOVA presented that the plant height has substantial impact by the LSR. The maximum plant height (3.54 m) was found in T3 seeding rate where the lowest plant height (2.53 m) was found in T6, respectively (Table 2).

The obtained result showed that the increment of seeding

Table 2. Impact of low seeding rate (LSR) on growth and vegetative traits of jute

Treatments	Plant population (m^2)	Plant height (m)	Basal diameter (mm)	Fresh weight (kg m^{-2})	No. of leaves/plant
T1	25.33d	3.07ab	13.73ab	5.83a	4.83a
T2	34.67c	3.07ab	14.56ab	5.83a	5.03a
T3	32.66c	3.54a	15.46a	6.06a	6.53a
T4	38.33bc	3.45a	14.83ab	6.06a	5.0a
T5	42.0b	3.43a	12.20b	6.03a	5.30a
T6	54.66a	2.53c	8.83c	6.13a	5.50a
LS	***	***	***	***	***
SE	1.54	0.224	0.789	0.338	0.321
CV (%)	4.05	6.94	5.94	5.64	7.82

*** Indicated significant differences were found among the treatments at $p < 0.001$, n = 10 , SE = Standard error, CV = Correlation of variance T1 = 1.50 kg ha^{-1} live seed + 4.50 kg ha^{-1} inert materials + hand weeding, T2 = 2.00 kg ha^{-1} live seed + 4.00 kg ha^{-1} inert materials + Pretilachlor 50 EC and one hand weeding, T3 = 2.50 kg ha^{-1} live seed + 3.50 kg ha^{-1} inert materials + one hand weeding at 25 DAS, T4 = 3.00 kg ha^{-1} live seed + 3.00 kg ha^{-1} inert materials + Pendimethilin 33 % EC + one hand weeding, T5 = 4.00 kg ha^{-1} live seed + 2.00 kg ha^{-1} inert materials + one hand weeding at 25 DAS hand weeding at 25 DAS , T6 = 6.00 kg ha^{-1} live seed + one hand weeding at 25 DAS.

rate from 1.50 to 6.0 kg ha^{-1}, height of the plant becomes increased. The result of analysis of variance presented that the basal diameter has substantial impact by LSR. The maximum basal diameter (15.46 mm) was recorded in T3 seeding rate where the lowest basal diameter (8.83 mm) was recorded in T6, respectively (Table 2). The obtained result showed that the increment of seeding rate from T1 to T3, diameter of the plant becomes increased where decreased trends were recorded in T4 to T6 treatments. It may be due to the number of seeding rates in the experimental plot, the greater number of plants in the plot competed with the light, nutrient, so the plant growth was retarded. The result of analysis of variance presented that LSR has substantial effect on fresh weight.

The maximum fresh weight (6.06 kg m^{-2}) was recorded in T3 seeding rate where the lowest fresh weight (5.83 kg m^{-2}) was recorded in T1, respectively (Table 2). The obtained result showed that the increment of seeding rate from 1.50 to 6.0 kg ha^{-1}, fresh weight of the plant increased. It may be due to the number of plants present in the experimental plot. The result of analysis of variance showed that LSR has great influence on the number of leaves/plants. The maximum number of leaves (6.53) was recorded in T3 seeding rate where the lowest leaves number (4.83) was recorded in T1, respectively (Table 2).

The obtained result showed that the increment of seeding rate from T1 to T3, diameter of the plant becomes increased where decreased trends were recorded in T4 to T6 treatments. It may be due to the number of seeding rates in the experimental plot, the greater number of leaves in the plot competed with the light, nutrient, so the plant growth was retarded.

Effect of low seeding rate on fibre yield of jute

The LSR has a significant (p < 0.001) fibre yield of jute. The maximum fibre yield was obtained with 3.00 kg seeding rate. The second highest fibre yield was obtained from 4.0 kg seeding rate which is statistically equivalent to the yield of 2.5 kg and 5.0 kg seeding rate (Fig. 1). Plant height, basal diameter, is precisely contributed to the fibre yield. The precise impact of the yield attributes, the fibre yield from 2.0 to 5.0 kg ha^{1} seeding rate provided a good outcome. This might be due to the positive effect of seeding rate that allowed better agronomic management, which resulted in lower plant density, can be reduced the intra-specific competition for plant essential resources between the crops. This investigation presented that the increasing the seeding rate from the lowest to highest, the fibre yield was increased at a certain level then decreased but in the high seeding rate, the management cost was increased compared to the LSR treatments. After extracting the fibre from the jute plant, the remaining part is considered as stick.

Now stick is considered as good potential material for various uses. Stick is now used for making charcoal, cosmetics, coal for pens and others uses. The analysis of variance showed that low seeding has a substantial effect on the stick yield production. The maximum stick yield was recoded at T6 treatment that is statistically equivalent to the T3, T4 and T5. The lowest stick yield was recorded at T1 treatment. The maximum stick yield was obtained due to the maximum number of plants present in the plot whereas the lowest stick yield was obtained due to the comparatively lower number of plants produced the lowest stick yield (Fig. 2). Harvest index is an essential parameter of dry matter distribution to the productive parts. The LSR has strong significant effect on the harvest index of jute.

The maximum result was found at T3 treatment that was statistically equivalent to the T1 and T2 treatment. The lowest harvest index was recorded at T6 treatment. The harvest index was recorded as an increase in trends up to T3 then they started declining trends (Fig. 3). The LSR and low density of plant population take benefits of increasing the harvest index, which is due to the maximum utilisation plant nutrient, solar radiation of plant in better way that enhance the maximum fibre yield.

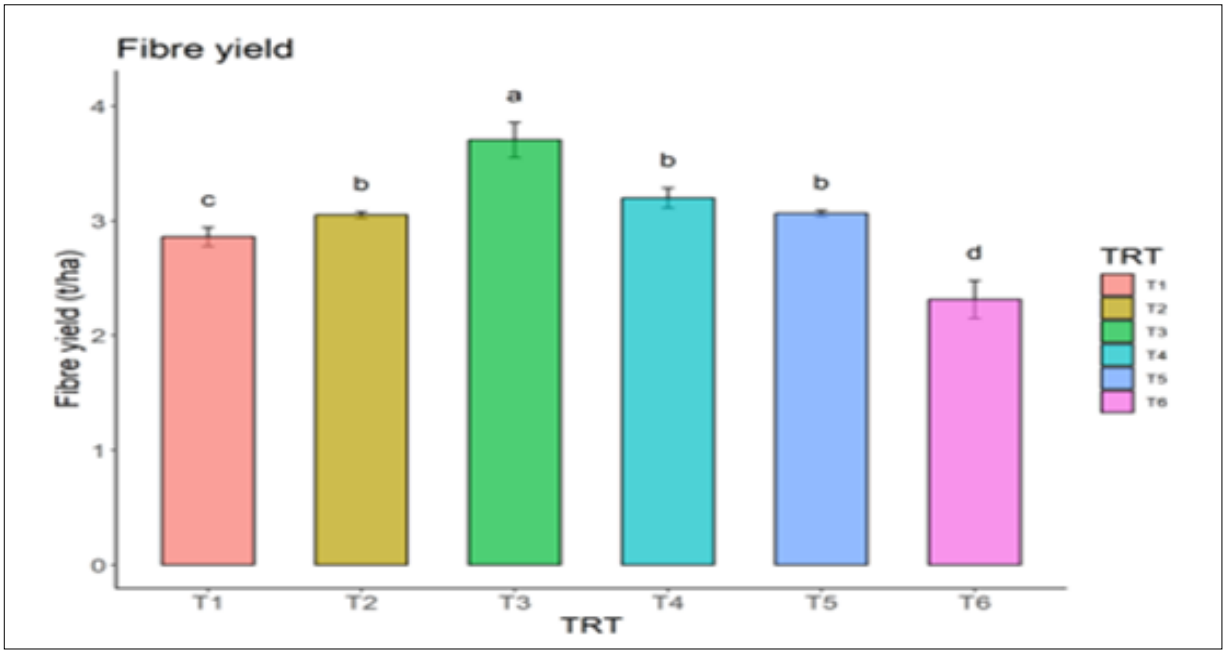


Fig. 1. Fibre yield (t ha^{-1}) of jute is affected by low seeding rate. Different letters indicate significance difference (p < 0.05; Turkey's HSD test, n = 5) while the same letter in a column indicate non-significant. T1 = 1.50 kg ha^{-1} live seed + 4.50 kg ha^{-1} inert materials + hand weeding; T2 = 2.00 kg ha^{-1} live seed + 4.00 kg ha^{-1} inert materials + Pretilachlor 50 EC and one hand weeding; T3 = 2.50 kg ha^{-1} live seed + 3.50 kg/ha inert materials + one hand weeding at 25 DAS; T4 = 3.00 kg/ha live seed + 3.00 kg ha^{-1} inert materials + Pendimethilin 33 % EC + one hand weeding; T5 = 4.00 kg ha^{-1} live seed + 2.00 kg/ha inert materials + one hand weeding at 25 DAS hand weeding at 25 DAS; T6 = 6.00 kg ha^{-1} live seed + one hand weeding at 25 DAS.

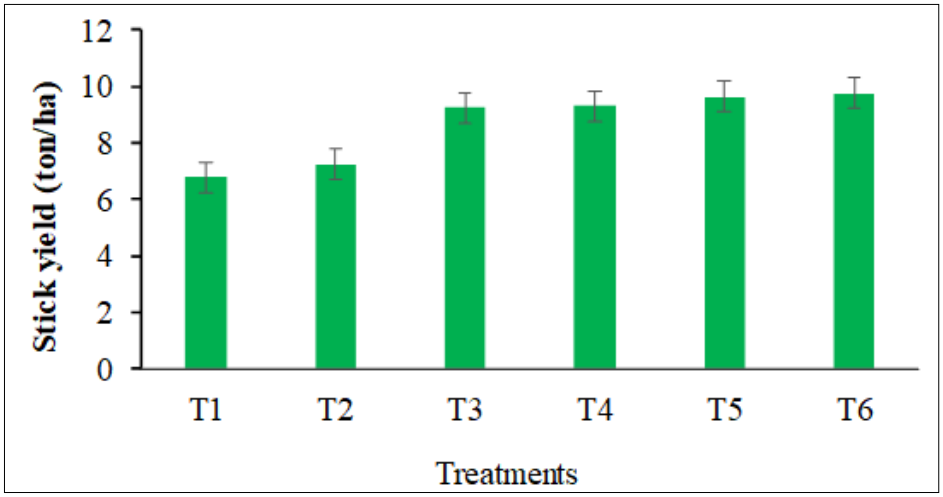


Fig. 2. Stick yield (t ha^{-1}) of jute is affected by low seeding rate. Different letters indicate significance difference ($p < 0.05$; Turkey's HSD test, n = 5) while the same letter in a column indicate non-significant. T1 = 1.50 kg ha^{-1} live seed + 4.50 kg ha^{-1} inert materials + hand weeding; T2 = 2.00 kg ha^{-1} live seed + 4.00 kg ha^{-1} inert materials + Pretilachlor 50 EC and one hand weeding; T3 = 2.50 kg ha^{-1} live seed + 3.50 kg ha^{-1} inert materials + one hand weeding at 25 DAS; T4 = 3.00 kg ha^{-1} live seed + 3.00 kg ha^{-1} inert materials + Pendimethilin 33 % EC + one hand weeding; T5 = 4.00 kg ha^{-1} live seed + 2.00 kg ha^{-1} inert materials + one hand weeding at 25 DAS hand weeding at 25 DAS, T6 = 6.00 kg ha^{-1} live seed + one hand weeding at 25 DAS.

Correlation analysis

Correlation analyses were conducted through the means of treatment to identify the impact of LSR on the fibre yield production (Fig. 4). Additionally, the positive correlation of fibre yield was recorded except plant population and fresh weight. Most parameters were correlated with each other except for a few parameters. Fibre yield was significant and positive correlated with plant height (r = 0.776), basal diameter (r = 0.771) and number of leaves (r = 0.285), where plant height and basal diameter considered as the prime yield contributing attributes in jute.

This indicates the fibre yield has been increased due to the increment of plant height, basal diameter and number of leaves. Stick yield has substantial impact and positive correlation with plant population (r = 0.776), fresh weight (r = 0.277) and number of leaves (r = 0.333). This indicates that the stick yield was increased with the increment of plant population, fresh weight and the number of leaves present in the plot.

Principal component analysis

Principal component analysis (PCA) was performed to evaluate the correlation among the treatments based on the measured traits, including plant height (PH), basal diameter (BD), fresh leaf weight (FLW), number of leaves (NL), fibre yield (FY), stick yield (SY) and harvest index (HI). The score plot and biplot, which indicate a significant correlation among the treatments is shown in Fig. 5. The PH and BD were strongly correlated with FY, as reflected in the first principal component (PC1). The PC1 had the highest eigenvalue (λ = 4.23), accounting for 52.8 % of the total variation, while the second principal component (PC2) had an eigenvalue of 1.90 and explained 23.8% of the variation. Together, PC1 and PC2 accounted for 76.6% of the total variation.

Partial budget analysis

Results obtained from the experiment, the cost of the LSR and labour cost for all agronomic operation of seed sowing, weeding, water management, insect pest and disease management, harvesting, extracting of fibre, washing and drying were recorded. The cost of individual treatment was not the same for the different plant populations and their management. It is essential to determine the lowest number of returns in the study area for suggestions from the present investigation result. The highest return (100057 BDT) was obtained from the T3 treatment with BCR: 2.07 (Table 3).

The seeding rate influenced fibre yield and stem diameter across treatments. As the seeding rate increased from the lowest to highest, fibre yield showed an increasing trend from T1 to T3, followed by a decline up to T6. The reduction in fibre yield at higher densities may be attributed to increased inter-plant competition, which limits photosynthesis and assimilate availability, as reported in previous studies. Similarly, the decline in stem diameter at higher densities is likely due to competition-induced redistribution of assimilates, a phenomenon observed in fibre crops under dense planting conditions. Conversely, LSRs significantly increased stem diameter and fibre yield, likely due to reduced intra-specific competition, allowing more efficient utilisation of available resources, consistent with earlier reports on plant density effects in fibre crops (10).

Table 3. Effect of low seeding rate (LSR) on economy of jute

Treatment	Labour cost	Fixed cost	Total cost	Gross income	Net return	BCR
T1	42132	40000	82132	148250	66118	1.8
T2	44800	40000	84800	157520	72720	1.85
T3	53068	40000	93068	193125	100057	2.07
T4	58132	40000	98132	167750	69618	1.70
T5	64000	40000	104800	167725	62925	1.60
T6	80000	40000	120000	137775	17775	1.14

T1 = 1.50 kg ha^{-1} live seed + 4.50 kg ha^{-1} inert materials + hand weeding, T2 = 2.00 kg ha^{-1} live seed + 4.00 kg ha^{-1} inert materials + Pretilachlor 50 EC and one hand weeding, T3 = 2.50 kg ha^{-1} live seed + 3.50 kg ha^{-1} inert materials + one hand weeding at 25 DAS, T4 = 3.00 kg ha^{-1} live seed + 3.00 kg ha^{-1} inert materials + Pendimethilin 33 % EC + one hand weeding, T5 = 4.00 kg ha^{-1} live seed + 2.00 kg ha^{-1} inert materials + one hand weeding at 25 DAS hand weeding at 25 DAS , T6 = 6.00 kg ha^{-1} live seed + one hand weeding at 25 DAS.

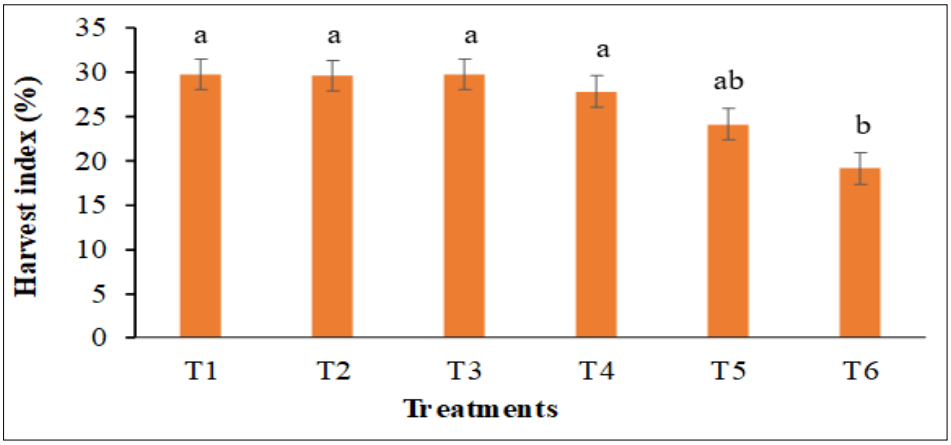


Fig. 3. Effect of different treatments on harvest index (%). Different letters indicate significance difference ($p < 0.05$; Turkey's HSD test, n = 5) while the same letter in a column indicate non-significant. T1 = 1.50 kg ha^{-1} live seed + 4.50 kg ha^{-1} inert materials + hand weeding; T2 = 2.00 kg ha^{-1} live seed + 4.00 kg ha^{-1} inert materials + Pretilachlor 50 EC and one hand weeding; T3 = 2.50 kg ha^{-1} live seed + 3.50 kg ha^{-1} inert materials + one hand weeding at 25 DAS; T4 = 3.00 kg ha^{-1} live seed + 3.00 kg ha^{-1}inert materials + Pendimethilin 33 % EC + one hand weeding; T5 = 4.00 kg ha^{-1} live seed + 2.00 kg ha^{-1} inert materials + one hand weeding at 25 DAS hand weeding at 25 DAS; T6 = 6.00 kg ha^{-1} live seed + one hand weeding at 25 DAS.

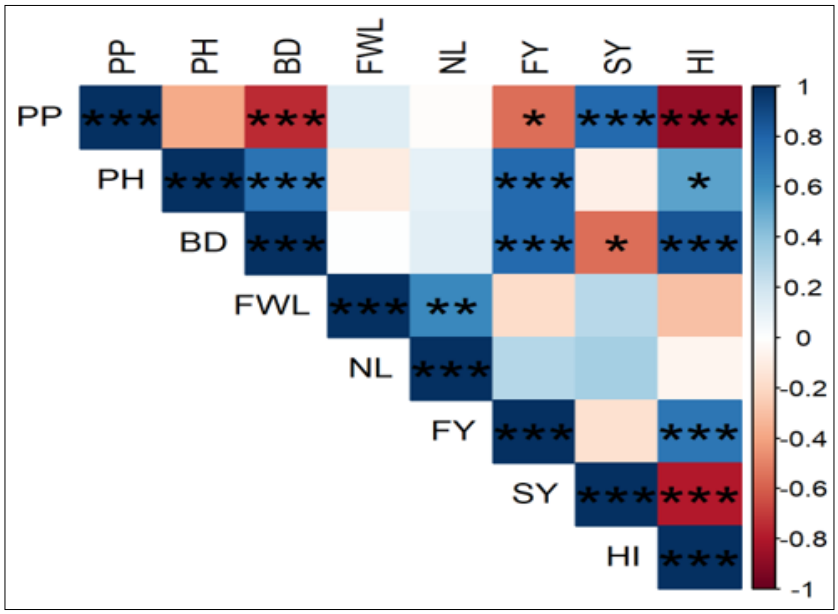


Fig. 4. Correlation matrix for yield and yield component of trait in jute. * indicates $p < 0.05$; ** indicates $p < 0.01$ level of significant; *** indicates $p < 0.001$ % level of significant; PP: Plant population; PH: Plant height; BD: Basal diameter; FWL: Fresh leaf weight; NL: Number of leaves; FY: Fibre yield; SY: Stick yield; HI: Harvest index.

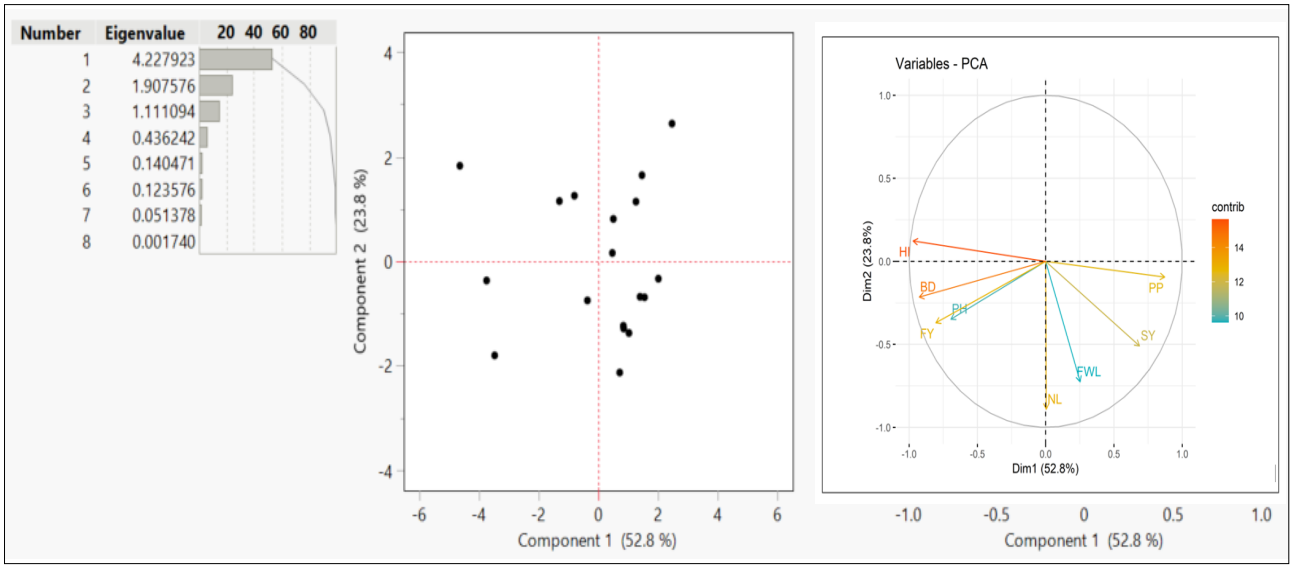


Fig. 5. Principal component analysis showed the correlation among the traits through the score plot and biplot diagram. PC1 (Dim1): First principal component; PC2 (Dim2): Second principal component; PH: Plant height; BD: Basal diameter; FWL: Fresh leaf weight; NL: Number of leaves; FY: Fibre yield; SY: Stick yield; HI: Harvest index.

It might be due to the number of plant populations in the treatment plot. The lot of plant populations have created their internal competition with solar radiation as well as plant nutrients for their growth, lacking this resulting in the numerous thin plants in this plot. The lowest net return (17775 BDT) with BCR: 1.14 was gained in the treatment T6 (Table 3). From the partial budget analysis, farmers can select the seeding rate from T1 to T5 for cost effective and economically feasible for the selective study area depending on their own choice.

The economic analysis was conducted by recording the total production cost, including seed cost (based on different seeding rates) and labour expenses for agronomic operations such as sowing, weeding, water management, insect pest and disease control, harvesting, fibre extraction, washing and drying. Because seed requirements and crop management intensity varied among plant populations, the total cost differed across treatments. Economic return was estimated using aggregated treatment means; however, no statistical test was performed to determine the significance of differences in net return or BCR among treatments.

Among the treatments, T3 produced the highest gross return (100057 BDT) with a BCR of 2.07 (Table 3), whereas T6 resulted in the lowest net return (17775 BDT) and a BCR of 1.14. The trend of economic return increased from T1 to T3 and subsequently declined from T4 to T6. Although this pattern may be associated with differences in plant population density, any mechanistic explanation (e.g., inter-plant competition for solar radiation or nutrients leading to reduced plant vigor) remains speculative, as variables related to resource use efficiency, light interception, or nutrient dynamics were not directly measured in the present study.

Correlation and PCA were performed using aggregated treatment mean to explore associations among yield and related traits; however, these analyses were descriptive in nature and do not establish causal relationships between plant density and economic return. Therefore, while partial budget analysis suggests that LSR 2.50 kg ha^{-1} offer comparatively favorable economic outcomes within the study area showed the highest gross return and benefit-cost ratio. However, these economic indicators were derived using treatment averages and should be interpreted considering the statistically significant changes in fibre yield.

Discussion

Influence of low seeding rate on plant growth attributes

The present study demonstrated that LSR significantly influenced the vegetative growth of jute plants (Table 2). This finding consistent with the previous researchers, they found lower seeding rate positively influences vegetative growth in jute plant (30). The observed variations in plant population, height, basal diameter and number of leaves under different seeding rates indicate that plant density strongly determines growth performance. Increasing seeding rates from 1.5 to 6.0 kg ha^{-1} led to a proportional increase in plant population, as expected, due to the greater number of seeds sown per unit area.

However, excessive seeding density negatively affected individual plant growth parameters such as plant height, basal diameter, leaf area index and leaf number (23, 31, 32). The reduction in these attributes under higher seeding rates (T4–T6) may be attributed to increased intra-specific competition for light, nutrients and space, which restricted canopy expansion, reduced leaf area due to shading effect of lower leaf and resource utilisation efficiency. As a results excessive elongation of stem were found which leading to lodging. Similar findings were reported earlier that emphasised that dense plant stands often result in thinner stems and reduced vegetative vigour due to shading effects and competition stress (12). Previous researchers noted that the LSR expands the plant height due to the more nutrient absorption and less competition among the plants (23, 24, 32).

It may be due to the number of seeding rates in the experimental plot. Substantial improvement in basal diameter and plant height under LSRs (around 2.5 kg ha^{-1}) suggests that an optimal plant population facilitates balanced resource partitioning and efficient photosynthetic activity (33) and efficient photosynthesis improve the physiological process as well as overall yield and quality (34, 35). Furthermore, the greater fresh biomass production at intermediate seeding rates implies that moderate plant densities allow plants to exploit available resources more effectively, thereby enhancing total productivity per unit area.

Effect of seeding rate on fibre and stick yield

This study indicated that the fibre yield of jute was significantly influenced by seeding rate, with the highest yield recorded at 2.50 kg ha^{-1} (T3) (Fig. 1). This indicates that moderate seeding rates ensure adequate plant density and better canopy structure, which favour the development of thicker and taller plants key contributors to fibre yield. The results are consistent with previous reports, which observed that seeding rates between 1.9 and 2.6 kg ha^{-1} produced optimal fibre yield in jute (12). Earlier studies also reported that moderate planting density resulted in higher cotton yield (36). Furthermore, low planting density has been shown to enhance plant physiological traits, leading to increased yield (19, 20, 23).

The positive association of fibre yield with plant height and basal diameter ($r = 0.776$ and $r = 0.771$, respectively) further confirms that these traits are the major yield-contributing factors (Fig. 4). However, excessive seeding beyond the optimal threshold led to a decline in fibre yield (13, 24, 37), likely due to overcrowding and reduced light interception at the lower canopy. High plant density also increased management costs, including harvesting and fibre extraction, reducing overall economic returns. In contrast, stick yield increased with higher seeding rates, as more plant biomass per unit area resulted in a greater volume of by-products (Fig. 2).

The positive correlation between stick yield and plant population ($r = 0.776$) and fresh weight ($r = 0.277$) supports this observation (Fig. 4). The harvest index also reflected these trends, increasing up to the optimal seeding rate (T3) and declining thereafter. This pattern indicates that LSRs enhance assimilate partitioning toward economically valuable fibre components. Lower seeding rates allow individual plants to maximise photosynthetic efficiency and nutrient uptake, contributing to higher fibre yield and improved harvest index.

Economic feasibility and agronomic implications

Economic evaluation through partial budgeting identified 3.0 kg ha^{1} (T3) as the most profitable treatment, producing a net return of 100057 BDT and a BCR of 2.07 (Table 3). This outcome reflects improved economic efficiency derived from balanced plant density and optimised resource utilisation. In contrast, excessive seeding rates (≥ 6.0 kg ha^{-1}) negatively affected profitability due to escalating

variable costs and reduced fibre productivity per plant. The minimum economic benefit was observed in T6, with a net return of 17775 BDT and a BCR of 1.14 (Table 3), indicating marginal financial gains at higher sowing densities. Overall, the results emphasise that careful optimisation of seeding rate is essential to maximise economic returns while maintaining agronomic efficiency and production sustainability.

Conclusion

The present study clearly demonstrated that low seeding rate significantly affects the growth, yield and economic return of *Corchorus olitorius* under the agro-ecological conditions of southwestern Bangladesh. The results revealed that moderate seeding rates, particularly 2.50–3.00 kg ha^{-1}, produced the most favorable outcomes in terms of plant growth attributes, fibre yield and profitability. While increasing seeding rate enhanced plant population, excessive plant density (≥ 6.0 kg ha^{-1}) led to intense intra-specific competition for light and nutrients, resulting in reduced plant height, basal diameter and fibre yield. The highest fibre yield (3.70 t ha^{-1}) and maximum net return (100057 BDT) with a benefit-cost ratio of 2.07 were obtained at 2.50 kg ha^{-1}, indicating that this seeding rate offers the best balance between productivity and economic feasibility. Correlation and principal component analyses further confirmed that plant height and basal diameter are the key yield-contributing traits influencing fibre yield. Overall, the findings suggest that adopting a seeding rate of 2.50–3.00 kg ha^{-1} ensures optimal plant population, efficient resource utilisation and enhanced economic returns for jute cultivation. This optimised seeding strategy not only supports sustainable fibre production but also offers a cost-effective approach for smallholder farmers in Bangladesh and similar agro-ecological regions.

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Authors' contributions

MIA contributed to conceptualisation, methodology, investigation, data curation and visualisation. MMH contributed to conceptualisation, formal analysis, data interpretation, manuscript preparation and validation. SMS and SNI contributed to software, data analysis and writing - review and editing. MSK, FA, NJ, TK and SM contributed to writing - review and editing and funding acquisition. SM contributed to supervision and project administration. All authors read and approved the final manuscript.

Compliance with ethical standards

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

Ethical issues: None

References

1. Bangladesh Bureau of Statistics. Statistical yearbook Bangladesh 2023: agriculture-crops, livestock, forestry and fishery section. 43rd ed. Bangladesh Bureau of Statistics; 2024:149–50.
2. Food and Agriculture Organization of the United Nations. Jute, kenaf, sisal, abaca, coir andallied fibres statistical bulletin. Vol. 2. 2023.
3. Akter S, Sadekin MN, Islam N. Jute and jute products of Bangladesh: contributions and challenges. Asian Bus Rev. 2020;10(3):143–52. https://doi.org/10.18034/abr.v10i3.480
4. Islam MM. Varietal advances of jute, kenaf and mesta crops in Bangladesh: a review. Int J Bioorg Chem. 2019;4(1):24–41. https://doi.org/10.11648/j.ijbc.20190401.15
5. Monira S, Ali MI, Sarker UK, Islam MS, Zaman F, Begum M, et al. Efficacy and economics of different weed control practices in boro rice under High Ganges River floodplain of Bangladesh. J Agric Food Environ. 2022;3(3):32–9. https://doi.org/10.47440/JAFE.2022.3307
6. Ali MI, Monira S, Rashed M, Salim M, Salam MA, Das RC. Effect of herbicidal weed control practices on yield performance of T Aman rice varieties in Bangladesh. J Agrofor Environ. 2022;15(2):14-20. https://doi.org/10.55706/jae1513
7. Hossain MM, Azad MAK, Soren EB, Alam MN, Ahmed MS, Islam MS, et al. Enhancing growth, yield andnutritional value of *Capsicum annuum*: evaluating micronutrient efficiency and varietal performance. J Agric Food Res. 2025;21:101945. https://doi.org/10.1016/j.jafr.2025.101945
8. Hossain MM, Shibasaki Y, Nakao R, Nitano K, Goto F. Optimization of ionic strength of nutrient solution for enhanced hydroponic watermelon yield and quality in greenhouse. Sci Rep. 2025;15(1):25976. https://doi.org/10.1038/s41598-025-07250-9
9. Ali MI, Sarkar MAR, Paul SK. Influence of plant nutrient management on the yield performance of transplant Aman rice (*Oryza sativa* L.). Arch Agric Environ Sci. 2018;3(1):49-53.https://doi.org/10.26832/24566632.2018.030106
10. Ali MI, Monira S, Kumar T, Islam MS, Das RC. Influence of plant nutrient management on yield and yield attributes of BJRI tossa pat -8. Asian J Crop Soil Sci Plant Nutr. 2023;8(1):293-8.
11. Masum SM, Ali MH, Islam MS, Sultana S. Influence of plant spacing and post emergence herbicide on the yield of white jute (*Corchorus capsularis*). Int J Sustain Agric. 2011;3(3):82-7.
12. Ghorai AK, Chakraborty AK. Economy of low density sowing in jute (*Corchorus olitorius* L.). Int J Curr Microbiol Appl Sci. 2020;9(9):292-300. https://doi.org/10.20546/ijcmas.2020.909.037
13. Ban Z. Effects of planting density on yield and fiber quality of transgenic hybrid Bt cotton Hanmian 646. 2014.
14. Islam MM, Xiaoying J, Uddin E, Bhuiyan F. Status and constraints of jute cultivation in Bangladesh: an experience from selected upazilas under Chandpur district. Asian J Agric Rural Dev. 2015;5(8):175-86.
15. Niloy AC. Jute: solution to global challenges and opportunities of Bangladesh. SEISENSE Bus Rev. 2021;1(2):59-75. https://doi.org/10.33215/sbr.v1i2.633
16. Mgolozeli S, Tesfamariam EH, Beletse Y. Yield, mineral content and root growth response of jute mallow (*Corchorus olitorius* L.) to planting density and water availability. J Agric Food Res. 2022;10:100384. https://doi.org/10.1016/j.jafr.2022.100384
17. Rakesh J, Sree Rekha M, Sujani CR. Yield and economics of olitorius jute at different plant densities and topping practices. Int J Environ Clim Change. 2023;13(7):489-94. https://doi.org/10.9734/ijecc/2023/v13i71901
18. Baloch AW, Soomro AM, Javed MA, Ahmed M, Bughio HR. Optimum plant density for high yield in rice (*Oryza sativa* L.). Asian J Plant Sci. 2002;1:25-7. https://doi.org/10.3923/ajps.2002.25.27
19. Abebe A, Filmon Y. Effect of seed rate on yield and yield components of tef (*Eragrostis tef* Trotter) at Konso and Arbaminch,

southern Ethiopia. J Nat Sci Res. 2018;8(5):38-45.

20. Getahun D, Tigist A, Adise D. Influence of seed rate and row spacing on growth and yield of tef (*Eragrostis tef*). Adv Crop Sci Technol. 2018;6:2329-8863.
21. Liang M, Baiser B, Hallett LM. Consistent stabilizing effects of plant diversity across spatial scales and climatic gradients. Nat Ecol Evol. 2022;6:1669-75. https://doi.org/10.1038/s41559-022-01868-y
22. Li J, Martin A, Carver LA, Armstrong S, Givens SR, Walters K. Optimizing sowing density for parsley, cilantro andsage in controlled environment production: balancing productivity and plant quality. Horttechnology. 2024;34(3):305-12. https://doi.org/10.21273/HORTTECH05381-23
23. Hall J, Bhattarai SP, Midmore DJ. Effect of industrial hemp (*Cannabis sativa* L.) planting density on weed suppression, crop growth, physiological responses andfibre yield in the subtropics. Renew Bioresour. 2014;2(1):1. https://doi.org/10.7243/2052-6237-2-1
24. Dimitriev VL, Makushev AE, Kayukova OV, Eliseeva LV, Shashkarov LG, Lozhkin AG. Influence of seeding rates on yield and technological qualities of hemp fiber. IOP Conf Ser Earth Environ Sci. 2021;677 (4):042038. https://doi.org/10.1088/1755-1315/677/4/042038
25. Mitra B, Samajdar T. Frontline demonstration: an effective tool for enhancing yield of jute fibre in sub-Himalayan plains (Terai zone) of West Bengal, India. Agric Sci Digest. 2013;33(1):38-41.
26. Roy AKGS. Weed smothering (*Corchorus olitorius* L.) in jute by its high-density broadcast sowing using cover crop principle. Int J Curr Microbiol Appl Sci. 2022;11(3):108-19. https://doi.org/10.20546/ijcmas.2022.1103.013
27. Ahmed K, Saleh A, Musa A, Kalu G. Determination of selected parameters that influence planting space uniformity on maize seed. Fudma J Sci. 2023;7(2):30-3. https://doi.org/10.33003/fjs-2023-0702-1702
28. Liu S, Baret F, Allard D. A method to estimate plant density and plant spacing heterogeneity: application to wheat crops. Plant Methods. 2017;13:38. https://doi.org/10.1186/s13007-017-0187-1
29. Ahmmed S, Jahiruddin M, Razia S, Begum RA, Biswas JC, Rahman ASMM, et al. Fertilizer recommendation guide-2018. Bangladesh Agric Res Council (BARC); 2018.
30. Tareq MZ, Sarker MSA, Islam MW, Rony MNH, Islam A, Hossain MA. Population density affects vegetative growth and yield of BJRI Deshi Pat Shak-3. Trop Agrobiodiversity. 2023;1:13-5. https://doi.org/10.26480/trab.01.2023.13.15
31. Thapa B, Katuwal DR. Effect of seedling density on growth characteristics of cabbage (*Brassica oleracea* var. *capitata*) cv. KF-65 in nursery. Turk J Agric Food Sci Technol. 2024;12(2):138-42. https://doi.org/10.24925/turjaf.v12i2.138-142.6126
32. Wang L, Ma L, Peng Z. Effects of planting density on seedling growth of *Elaeagnus angustifolia*. 2010.
33. Hossain MM, Shibasaki Y, Goto F. Assessment of watermelon (*Citrullus lanatus*) fruit photosynthetic performance based on chlorophyll fluorescence parameter and its impact on yield and quality. Sci Hortic. 2026;357:114685. https://doi.org/10.1016/j.scienta.2026.114685
34. Ahmed MS, Hasan MM, Islam MS, Hossain MM, Kaium MA, Islam MK. Response of onion (*Allium cepa*) to nitrogen and potassium fertilizers rate on growth and yield in the northwestern region of Bangladesh. Int J Agric Biol. 2025;34(1).https://doi.org/10.17957/IJAB/15.2347
35. Hossain MM, Shibasaki Y, Goto F. Enhancement of growth and quality of winter watermelon using LED supplementary lighting. Horticulturae. 2025;11(3):262. https://doi.org/10.3390/horticulturae11030262
36. Ghorai AK, Chakraborty AK. Low density jute sowing to minimise cost of different operations in integrated weed management system. In: Proc Int Seminar on Agri Skills for Convergence in Research, Industry andLivelihood (AGRIL), BCKV, Kalyani, West Bengal, India; 2019:110.
37. Deng G, Guanghui D, Yang Y, Bao Y, Feihu L. Planting density and fertilization evidently influence the fiber yield of hemp (*Cannabis sativa* L.). Agronomy. 2019;9(7):368. https://doi.org/10.3390/agronomy9070368

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