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BJRI-developed Tossa jute (*Corchorus olitorius*) varieties: agronomic traits, fiber quality, economic significance and future prospect in Bangladesh

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ABSTRACT

Tossa jute (*Corchorus olitorius*), often termed Bangladesh's "golden fiber," remains integral to the nation's agrarian economy, industrial sustainability, and rural livelihoods. This review critically synthesizes advancements in the development, agronomic traits, fiber quality, and socio-economic significance of BJRI-released Tossa jute varieties, while exploring their evolving role in climate-resilient and sustainable agriculture. The Bangladesh Jute Research Institute (BJRI) has spearheaded varietal improvements through conventional breeding, mutation, and hybridization, resulting in high-yielding, disease-resistant cultivars like O-9897, Tossa Pat 5, and Sobuj Sona. These varieties exhibit superior fiber attributes, early maturing traits, and adaptability to diverse agro-ecological zones, making them pivotal to enhancing national productivity and farmer income. The study evaluates the cost structure of Tossa jute cultivation, highlighting its economic viability relative to high-input cash crops (Average total production cost: BDT 32,000–38,000 ha^{-1}). Labor remains the largest expenditure, but moderate input requirements and favorable market returns ensure attractive profitability, especially when integrated into rice–jute cropping systems. Tossa jute's efficient nutrient acquisition, driven by extensive root systems, mycorrhizal associations, and adaptive physiological traits, is pivotal for sustaining productivity in nutrient-poor soils. Balanced macro- and micronutrient management, combined with innovations in retting techniques, have significantly enhanced fiber yield, quality, and environmental outcomes. Fiber and seed production timelines are critically examined, emphasizing the importance of timely harvesting (110–120 days) for optimal fiber quality and extended field retention for seed production. The review also discusses eco-friendly retting innovations, such as microbial and ribbon retting, which reduce environmental impacts while improving fiber brightness and softness. A key focus is Tossa jute's agroecological functions, including carbon sequestration, improving soil health, suppressing weeds, and enhancing biodiversity. Cultivation of Tossa jute on flood-prone and marginal lands supports environmental

resilience and aligns with global efforts toward low-carbon, circular economies. The crop's fully biodegradable fibers position it as a strategic alternative to plastics, offering broad industrial applications in textiles, geotextiles, packaging, and bio composites. The review concludes by addressing the market dynamics, trade potential, and policy imperatives necessary to unlock Tossa jute's full economic and ecological value. Research priorities include advanced breeding, product diversification, and climate-smart cultivation practices, supported by robust institutional frameworks. Thus, Tossa jute emerges as a multifunctional crop capable of advancing Bangladesh's sustainability goals, industrial competitiveness, and rural development in the context of global environmental challenges.

Keywords: Tossa jute, BJRI varieties, Fiber quality, Sustainable agriculture, Climate resilience

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1. Introduction

Jute, celebrated as the "golden fiber" of Bangladesh, has long been a cornerstone of the nation's agrarian economy and rural livelihoods. Among the two cultivated species, Corchorus capsularis (white jute) and *Corchorus olitorius* (Tossa jute), the latter is particularly valued for its golden fibers with superior tensile strength and greater length (Islam et al., 1992; Anita et al., 2020). Bangladesh controls approximately 62% of the world's jute goods market and remains the sole exporter of raw jute (Mohiuddin, 2015).

The Bangladesh Jute Research Institute (BJRI), established in 1951, has played a central role in developing improved Tossa jute varieties adapted to diverse agro-ecological zones. These varieties combine high yield potential, stress tolerance, and enhanced fiber attributes (Ferdous et al., 2019), thereby sustaining both farmer income and national economic competitiveness. With their relatively short growth cycle (110–130 days), resilience to climatic fluctuations, and compatibility with multiple cropping systems, BJRI-developed Tossa jute varieties represent a strategic option for smallholder farmers seeking both fiber and seed income opportunities (Mahapatra et al., 2012).

Global interest in Tossa jute has grown in recent years due to its potential as a sustainable and biodegradable alternative to synthetic fibers. Applications in eco-friendly textiles, geotextiles, composites, and packaging align with circular economy principles and climate-smart agriculture (Chakraborty, 2021; Rahman et al., 2025). National policy interventions, such as the Mandatory Jute Packaging Act (2010), have further stimulated domestic demand, while global markets in Europe, North America, and beyond increasingly prioritize natural fibers (Pavel & Supinit, 2017).

Despite these advantages, several challenges constrain the sector's growth. Declining cultivation areas, market volatility, weak post-harvest and retting infrastructure, and limited policy incentives undermine farmer profitability (Amin et al., 2024; Sheheli & Roy, 2015). In comparison with other cash crops, jute receives less research investment, slowing the pace of innovation and limiting the crop's contribution to national and global sustainability agendas.

This review seeks to provide the first integrated synthesis of the agronomic, economic, and environmental dimensions of BJRI-developed Tossa jute. Unlike earlier works that focus narrowly on varietal performance, fiber quality, or market trends, this article connects varietal development with nutrient management, retting innovations, agroecological functions, and market dynamics. Such a multidisciplinary perspective allows for a holistic understanding of the crop's potential to support climate resilience, industrial diversification, and rural income security in Bangladesh.

Accordingly, this review aims to (1) summarize the agronomic traits, fiber quality, and economic significance of BJRI-developed Tossa jute (*Corchorus olitorius*) varieties, (2) evaluate recent

advances in nutrient management, retting technologies, and environmental benefits, and (3) identify research gaps and future priorities to enhance Tossa jute's role in sustainable agriculture and green industrial development.

2. Methodology

The literature reviewed in this article was identified through a structured and systematic approach to ensure both comprehensiveness and relevance. The process was carried out between January 2024 and March 2025 and followed four main stages: database searching, screening, selection, and synthesis. The review incorporates several detailed tables that consolidate dispersed information into concise, accessible formats. These include side-by-side comparisons of BJRI-developed varietal traits and a structured breakdown of cultivation costs, enabling readers to quickly grasp key data without consulting multiple sources.

2.1 Data sources and search strategy

The following sources were used to identify relevant literature:

- Databases: Scopus, Web of Science, CAB Abstracts, AGRICOLA, Google Scholar.
- Institutional repositories: Bangladesh Jute Research Institute (BJRI) online archive.
- Grey literature: Government policy documents, conference proceedings, FAO publications, and industry reports.

Search strings were designed using Boolean operators:

("Tossa jute" OR "*Corchorus olitorius*") AND ("BJRI varieties" OR "Bangladesh Jute Research Institute") AND ("fiber quality" OR "agronomic traits" OR "economic significance" OR "retting techniques" OR "climate resilience" OR "nutrient management")

Additional notes:

- Only English-language sources were included.
- No geographic restrictions were applied, but priority was given to research relevant to Bangladesh's jute sector.

2.2 Inclusion criteria

Studies were included if they:

- Were published between 2000 and 2025.
- Were peer-reviewed journal articles, theses, institutional reports, or policy documents.
- Focused on BJRI-developed Tossa jute varieties or closely related agronomic, economic, or environmental studies.
- Provided empirical data, experimental trials, or substantial policy analysis relevant to jute production.

2.3 Exclusion criteria

Studies were excluded if they:

- Were unrelated to Tossa jute or Bangladesh's production systems (unless offering relevant comparative context).
- Were published in languages other than English without translation.
- Were grey literature with unverifiable data or lacking references.

2.4 Screening and selection process

- All retrieved records were imported into a reference management tool (e.g., Mendeley).
- Step 1 – Title/abstract screening: Initial relevance check based on keywords and objectives.
- Step 2 – Full-text review: Detailed evaluation against inclusion/exclusion criteria.
- Step 3 – Duplicate removal: Eliminated repeated entries from multiple databases.
- Step 4 – Final selection: Prioritized peer-reviewed studies; high-quality institutional reports were retained for contextual insight.

2.5 Data extraction and thematic synthesis

From each selected study, the following data were extracted:

- Varietal traits: Yield potential, disease resistance, fiber characteristics.
- Agronomic practices: Nutrient management, sowing dates, and retting techniques.
- Economic aspects: Cost of production, profitability, market price trends.
- Environmental aspects: Carbon sequestration, soil fertility, biodiversity impacts.

Extracted information was grouped thematically to:

- Identify consistent findings across studies.
- Highlight contradictory results requiring further research.
- Pinpoint knowledge gaps for future investigation.

2.6 Limitations

- A significant proportion of the reviewed literature originates from BJRI research outputs. While highly relevant, this may introduce institutional bias in performance evaluations.
- Future reviews should incorporate a greater number of independent, multi-institutional studies to improve the robustness and generalizability of conclusions.

3. Development and evolution of Tossa jute varieties

The Bangladesh Jute Research Institute (BJRI) has played a pivotal role in the genetic improvement of Tossa jute (*Corchorus olitorius*) since the 1960s. Early varieties were developed primarily through pure line selection, but later advances incorporated mutation breeding and hybridization, leading to high-yielding, disease-resistant, and stress-tolerant cultivars. These breeding efforts were designed to address recurring challenges in jute cultivation, including low productivity, fiber quality deterioration, and susceptibility to pests, diseases, and environmental stress (Mia, 2020; Islam, 2019). Over time, BJRI has released a series of improved varieties that combine superior fiber yield with adaptability across diverse agro-ecological zones of Bangladesh. Earlier introductions such as O-9897 (Falguni Tossa, 1987) significantly enhanced yield potential, while subsequent varieties such as BJRI Tossa Pat 4 (O-72, 2002) and BJRI Tossa Pat 5 (Lal Tossa, 2008) were tailored to improve disease tolerance and fiber quality. More recent releases, including BJRI Tossa Pat 8 (Robi-1, 2019) and BJRI Tossa Pat 9 (Sobuj Sona, 2023), highlight progress in breeding for climate resilience, higher productivity, and early harvesting traits, ensuring better adaptability to changing climatic conditions and farmer needs. Table 1 presents the chronological release of BJRI-developed Tossa jute varieties along with their pedigrees, reflecting the evolution from conventional selection methods to modern mutation breeding and hybridization.

Table 1. List of varieties of Tossa jute (BJRI)

No.	Variety	Year of release	Pedigree
01	Chinsurah Green (D-38)	1915	Pure line selection (PLS)
02	R-26	1929	Pure line selection (PLS)
03	R-27	1929	PLS
04	O-620	1939	PLS
05	O-632	1939	PLS
06	O-753	1939	PLS
07	O-1	1955	PLS
08	O-2	1955	PLS
09	O-3	1955	PLS
10	O-4	1967	PLS
11	O-5	1964	PLS
12	O -9897	1987	O-5 × BZ-5
13	BJRI Tossa pat 3 (OM-1)	1995	PLS (Uganda)
14	BJRI Tossa pat 4 (O-72)	2002	(O-9897 × O-2012) × O-9897
15	BJRI Tossa pat 5 (O-795)	2008	Uganda red × O-4
16	BJRI Tossa pat 6 (O-3820)	2013	PLS
17	BJRI Tossa pat 7 (MG-1)	2017	PLS
18	BJRI Tossa pat 8 (Robi-1)	2019	Mutation Breeding
19	BJRI Tossa pat 9 (Sobuj Sona)	2023	Hybridization between JRO 524 and Acc 1746

Source: Bangladesh Jute Knowledge, BJRI (https://bjri.gov.bd/).

Table 2 provides a comparative overview of morphological, agronomic, and economic traits of major BJRI-released varieties. This comparative framework highlights the diverse attributes-such as early sowing ability, high-density planting, disease tolerance, and superior fiber yield-that underpin their economic and ecological value in Bangladesh's jute sector. Fiber yield values are based on BJRI-conducted multi-year varietal trials in representative agro-ecological zones of Bangladesh. Yields reflect optimal management conditions with recommended fertilizer rates and retting practices (BJRI, 2020).

Table 2. Morphological, agronomic and economic traits of Tossa jute (*Corchorus olitorius* L.) varieties in Bangladesh

Parameter	O-9897 (Falguni Tossa)	Tossa Pat 4 (O-72)	Tossa Pat 5 (Lal Tossa)	Tossa Pat 6 (O-3820)	Tossa Pat 8 (Robi-1)	Tossa Pat 9 (Sobuj Sona)
Year of Innovation	1987	2002	2008	2013	2019	2023
Local Name	Falguni Tossa	Sonali Bangla Tossa	Lal Tossa	–	Robi-1	Sobuj Sona
Plant Color/Type	Full green	Green, 3–3.5 m tall	Tall, reddish stems	Dark green, smooth stem	–	Fully green, narrow leaves
Leaf Type/Features	Ovate-lanceolate	Rounded, bright green	Ovate-lanceolate, red petioles	Long lanceolate	–	Narrow lanceolate, 3:1 ratio
Fruit/Seed Color	Green fruits, bluish seeds	Bluish-green seeds	Copper red grooves, bluish seeds	Green fruits, bluish seeds	–	Indehiscent fruit, deep green-blue seeds
Flowering Time (DAS)	140–155	140–155	140–155	135–145	–	–
Sowing Time	10 Mar – 30 Apr	10 Mar – 30 Apr	15 Mar – 30 Apr	1 Apr – 30 Apr	–	15 Mar – 10 Apr
Life Span (days)	110–120	110–120	110–120	110–120	–	100–110
Seed Rate (kg/ha) – Line/Broadcast	5–6 / 6–7	5–6 / 6–7	5–6 / 6–7	5–6 / 6–7	–	4.5–5 / 5–7
Fibre Yield (t ha^{-1})	2.7–3.0	2.6–3.0	2.7–3.2	2.5–2.8	15–20% ↑	3.25
Fertilizer Recommendation (kg/ha)	195 Urea, 50 TSP, 30 MoP, 110 Gypsum	195 Urea	195 Urea, 50 TSP, 30 MoP, 110 Gypsum	Same as O-795	–	217 Urea, 20 TSP, 50 MoP, 15 S
Soil Suitability	Highland, loamy/sandy-loam	Suitable for all soils	High-medium loamy/sandy-loam	High-medium loamy soils	High-medium well-drained	High-medium, even medium-low
Special Features	Early sowing, high yield	Early sowing, 10 days earlier	Disease, insect, flood tolerance	Late sowing, fast growing	15–20% higher yield	High density, early harvest
Economic Benefit	High yield, good price	Financially profitable	High-quality golden fiber	Marketable fiber, high income	Better income	High yield, bright fiber

Photographs	

Source: Bangladesh Jute Knowledge, BJRI (https://bjri.gov.bd/).

Collectively, these improved varieties have significantly boosted national jute production and strengthened the raw material base for jute-based industries. By integrating stress tolerance, yield stability, and market-preferred fiber quality, BJRI's breeding initiatives have transformed Tossa jute from a traditional subsistence crop into a commercially viable enterprise with national and international significance.

4. Cost structure and economic viability of Tossa jute cultivation

The cost of cultivating Tossa jute in Bangladesh varies depending on input use, labor availability, and regional agro-ecological conditions. On average, the total production cost ranges from BDT 32,000–38,000 ha^{-1}, with major expenditures attributed to land preparation, fertilizers, labor, and post-harvest retting and processing. These costs are relatively moderate compared with high-input cash crops such as rice or vegetables, which reinforces the economic feasibility of jute for smallholder farmers (Mahapatra et al., 2012; Mukul & Akter, 2021). A breakdown of production costs (Table 3) shows that labor constitutes the single largest expense, accounting for 30–35% of total costs due to the intensive requirements of weeding, thinning, harvesting, and retting. Fertilizer and manure inputs contribute another 20–25%, while land preparation and retting together account for nearly 25% of overall costs. Seed costs are comparatively low, reflecting BJRI's success in developing high-yielding varieties that require relatively small seed quantities (10–12 kg/ha) (Guha et al., 2008).

Despite these costs, profitability remains attractive. Farmers adopting improved BJRI varieties in combination with balanced fertilization and integrated weed management practices report net profits of BDT 15,000–22,000 ha^{-1}. Profitability is further enhanced in rice–jute or jute–vegetable intercropping systems, which allow cost sharing and efficient land utilization. Additionally, the short duration of jute cultivation (110–120 days) enables sequential cropping, improving overall farm income without requiring significant additional investment (Alam et al., 2019).

Economic viability is reinforced by favorable market opportunities. BJRI varieties such as O-9897 and BJRI Tossa Pat 5, known for their high-quality golden fiber, consistently fetch premium prices in domestic and export markets. More recent varieties, including Robi-1 and Sobuj Sona, also offer higher yield stability and reduced production risks, translating into more reliable returns for farmers. Thus, the cost–benefit balance strongly supports the expansion of Tossa jute cultivation, particularly when supported by policy incentives such as the Minimum Support Price (MSP) for raw jute.

Table 03. Input cost breakdown for Tossa jute cultivation (per hectare). Data on cost structure are derived from BJRI field surveys and published reports conducted between [Butex, 2024], representing average values from smallholder farms across major jute-growing districts.

Input Component	Cost Range (BDT/ha)	Remarks
Land preparation	5,000–6,500	Includes ploughing and leveling
Seed cost	1,500–2,000	10–12 kg of seed required
Fertilizers and manure	6,000–8,000	Includes Urea, TSP, MoP, Gypsum
Irrigation (if needed)	1,500–2,500	May vary based on rainfall
Labor	10,000–12,000	For weeding, thinning, and harvesting
Retting and processing	4,000–5,000	Includes bundling, drying, and cleaning

Percentages for each cost component (e.g., 30–35% for labor, 20–25% for fertilizers) were calculated as the proportion of each input cost relative to the total average cultivation cost per hectare, using BJRI survey data from (BJRI, 2020). Source: Bangladesh jute Knowledge, BJRI (https://bjri.gov.bd/).

5. Nutrient uptake mechanisms and soil interactions in Tossa jute

Tossa jute (*Corchorus olitorius*) exhibits an efficient nutrient acquisition system that supports its rapid vegetative growth and high fiber yield. Its extensive and well-branched root architecture allows the plant to explore large soil volumes, thereby enhancing uptake of both macro- and micronutrients. This adaptive trait is particularly advantageous under Bangladesh's monsoon conditions, where fluctuating rainfall influences nutrient solubilization and mobility (Maitra et al., 2000).

Nitrogen (N), phosphorus (P), and potassium (K) are the most critical macronutrients for Tossa jute cultivation. Nitrogen drives vigorous vegetative growth and fiber strength, while phosphorus promotes root development and energy metabolism, and potassium improves water regulation, tensile fiber strength, and retting tolerance. Balanced fertilization with urea, TSP, and MoP, supplemented by gypsum, has been shown to significantly improve biomass accumulation and fiber quality (Alam et al., 2011).

Micronutrients, particularly boron (B), zinc (Zn), and sulfur (S), also play indispensable roles in jute physiology. Boron contributes to cell wall synthesis and reproductive development; its deficiency leads to poor fiber formation and seed sterility. Zinc supports enzyme activation, protein synthesis, and leaf health, while sulfur enhances chlorophyll formation, photosynthetic efficiency, and retting performance. Field studies confirm that targeted micronutrient application improves fiber brightness, softness, and strength (Alam et al., 2011).

Tossa jute also engages in beneficial symbiotic interactions with arbuscular mycorrhizal (AM) fungi, which extend hyphal networks beyond the root zone, facilitating the uptake of phosphorus and trace elements such as zinc and copper. These associations are especially important in phosphorus-deficient soils, where direct nutrient availability is limited. The plant further adapts to nutrient constraints by releasing root exudates—organic acids that solubilize otherwise unavailable phosphorus, thus improving its bioavailability (Ferrol et al., 2019).

Soil conditions strongly influence nutrient uptake efficiency. Jute thrives best in loamy, well-drained soils with a pH range of 5.5–7.0. In acidic soils (pH < 5.5), phosphorus availability declines due to fixation with iron and aluminum, necessitating liming practices to enhance nutrient efficiency. Similarly, in marginal or nutrient-poor soils, organic amendments combined with judicious fertilizer use can sustain productivity while improving soil organic matter and microbial activity (Majumdar et al., 2014; Rahman et al., 2021).

The nutrient uptake efficiency of Tossa jute (Figure 1) arises from its robust root system, symbiotic mycorrhizal interactions, and physiological adaptability to soil nutrient constraints. These traits not only support high yields under diverse conditions but also underscore its potential as a resilient crop for climate-smart and sustainable agriculture in Bangladesh.

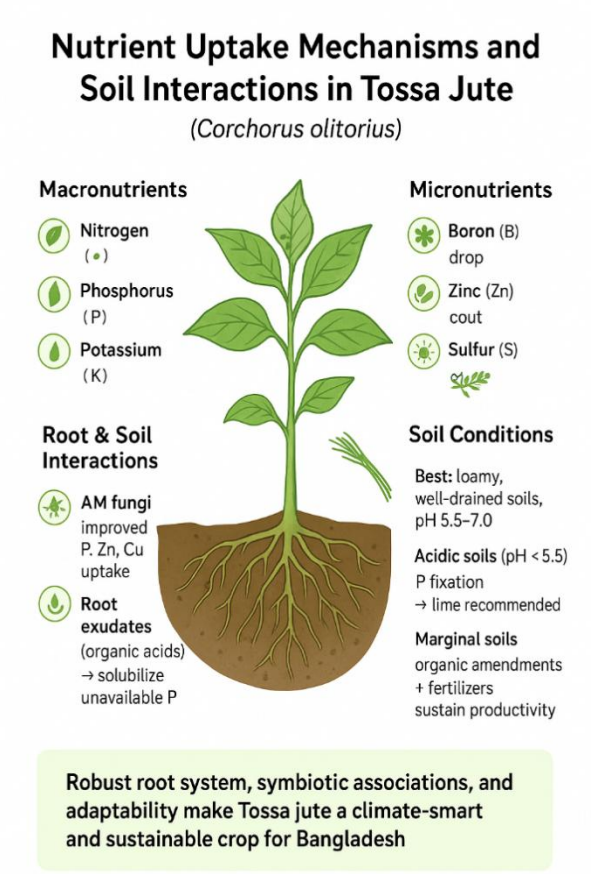

Figure 1. Nutrient uptake mechanisms and soil interactions in Tossa jute (*Corchorus olitorius*).

6. Fiber and seed production timelines

Tossa jute is a short-duration crop ideally suited to Bangladesh's monsoon-dependent agricultural system. Its rapid growth cycle—typically 100 to 120 days—enables farmers to fit it between major cereal or vegetable crops, thereby maximizing land use efficiency. Sowing generally occurs from mid-March to early May, aligning with pre-monsoon rainfall that ensures optimal soil moisture for germination and early seedling vigor (Ferdous et al., 2019; Ferdous et al., 2022).

Fiber production: Fiber production depends on timely harvesting, which directly influences yield and quality. BJRI (2020) recommends harvesting when approximately 50% of plants initiate floral bud formation, usually 110–120 days after sowing. (Alam et al., 2024) Harvesting at this stage ensures that fibers remain long, soft, shiny, and strong. Delayed harvesting, extending to full flowering or maturity, leads to excessive lignification of cell walls, resulting in coarse, brittle fibers of reduced market value. Early harvesting also facilitates more efficient retting, thereby improving fiber separation and brightness. (Ferdous et al., 2019).

Seed production: Seed production requires extending the growth period beyond the fiber harvest stage. To ensure full seed development, plants are retained in the field for 150–180 days until capsules mature and turn brown. Proper drying and storage of seeds after harvest are essential to maintain germination potential and seed viability for subsequent cropping cycles (Olasoji et al., 2012). Figure 2 shows the steps of a seed in a plant.

Figure 2. Sequential stages of Tossa jute (*Corchorus olitorius*) seed development, from floral initiation to full capsule maturity, as observed under BJRI field conditions in Bangladesh.

Retting Duration and Techniques: Retting is a critical stage in fiber processing and traditionally takes 12–15 days in slow-moving water bodies. Key factors influencing retting efficiency include water temperature (optimal 28–34 °C), pH (slightly acidic to neutral), and microbial activity. Innovations in retting practices, particularly BJRI-developed microbial consortium inoculants, have reduced retting duration to 7–8 days while simultaneously enhancing fiber softness, brightness, and tensile strength. Ribbon retting techniques are also gaining attention as eco-friendly alternatives to conventional whole-stem retting, reducing water pollution and improving uniformity of fiber extraction (Sarkar & Sengupta, 2015).

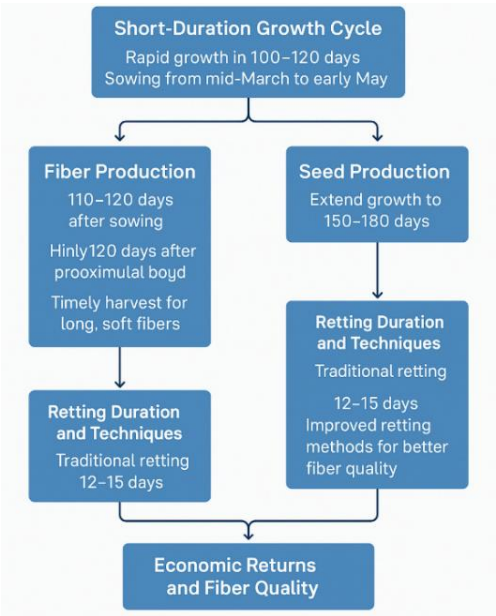

Figure 3. Infographic summarizing the growth stages of Tossa jute (*Corchorus olitorius*) and recommended harvest practices for fiber and seed production, including optimal days after sowing (DAS) for each stage.

Thus, the fiber and seed production timelines of Tossa jute illustrate a balance between biological growth stages, harvest management, and post-harvest retting innovations. The adoption of timely harvest practices and improved retting technologies ensures both higher economic returns for farmers and superior-quality fiber for industrial applications. Figure 3 shows the different stages of Jute production.

7. Environmental benefits and agroecological role of Tossa jute

Tossa jute (*Corchorus olitorius*) offers significant environmental and agroecological advantages, particularly within the monsoon-dependent ecosystems of Bangladesh (Figure 4). Well adapted to alluvial soils and humid subtropical climates, it utilizes flood-prone or marginal lands productively, thereby supporting both livelihoods and environmental resilience (Islam & Ahmed, 2012). Compared with high-input cash crops, Tossa jute requires minimal chemical fertilizers and pesticides, reducing risks of groundwater contamination and ecological degradation. Its dense canopy suppresses weeds naturally, limiting herbicide use, while its fibrous root system improves soil structure and prevents erosion (Datta et al., 2017).

One of its most important ecological functions is carbon sequestration. Carbon sequestration estimates are based on biomass accumulation measurements from Singh (2017) under typical Tossa jute cultivation in alluvial soils. With rapid biomass accumulation, one hectare of jute can capture 15–20 tons of atmospheric CO_2 annually (Singh, 2017). This makes jute a strategic crop for mitigating greenhouse gas emissions while simultaneously providing industrial raw material. Additionally, incorporating root residues and above-ground biomass after harvest enriches soil organic matter, stimulates microbial activity, and enhances long-term fertility (Singh et al., 2019).

Tossa jute cultivation also enhances agroecosystem biodiversity and soil health. Its rhizosphere supports beneficial microbial communities, including arbuscular mycorrhizal fungi and phosphate-solubilizing bacteria, which improve nutrient cycling and plant disease resistance (Asghar et al., 2024). When intercropped with legumes such as mung bean or lentil, biological nitrogen fixation complements organic residue inputs, reducing synthetic fertilizer needs and improving soil nutrient status for subsequent crops. This synergy enhances system sustainability and contributes to agroecological intensification (Kumar et al., 2021).

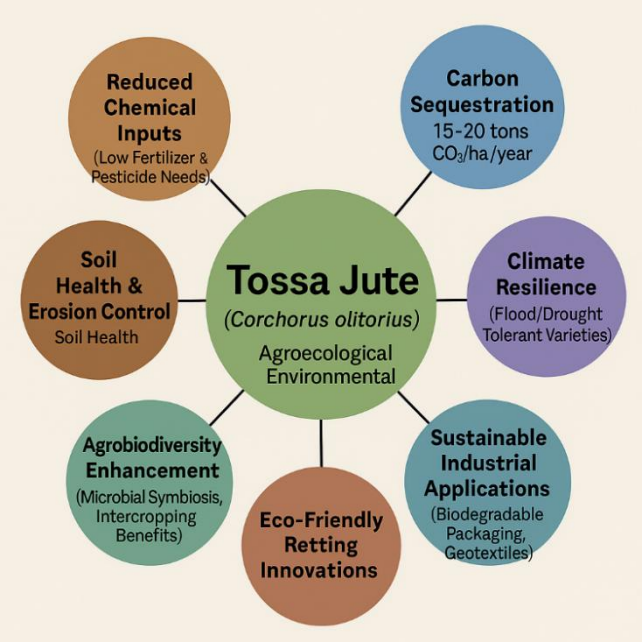

Figure 4. Conceptual framework illustrating the agroecological functions and environmental sustainability benefits of Tossa jute (*Corchorus olitorius*) cultivation in Bangladesh's monsoon-dependent farming systems, including weed suppression, soil health enhancement, biodiversity support, carbon sequestration, and climate resilience.

Agroecological and Environmental Benefits of Tossa Jute (*Corchorus olitorius*): A Conceptual Overview Highlighting Its Roles in Reducing Chemical Inputs, Enhancing Soil Health, Supporting Biodiversity, Sequestering Carbon, Improving Climate Resilience, Promoting Sustainable Industrial Uses, and Adopting Eco-Friendly Retting Innovations.

Moreover, Tossa jute contributes to climate resilience. Several BJRI varieties, such as O-9897 and BJRI Tossa Pat 6, demonstrate adaptability to flood-prone and drought-prone environments, respectively. This tolerance allows farmers to cultivate the crop in marginal lands and under variable rainfall conditions, stabilizing income in regions vulnerable to climate variability.

Finally, as a fully biodegradable and recyclable fiber, Tossa jute provides a sustainable alternative to synthetic materials (Rahman et al., 2025). Its expanding applications in biodegradable packaging, geotextiles, and composites align with the global transition toward low-carbon, circular economies (Sarkar & Sengupta, 2015). However, traditional retting practices may cause localized water pollution. Innovations such as microbial retting and ribbon retting offer eco-friendly alternatives, reducing retting time while lowering environmental impact (Rahman et al., 2025).

8. Fiber quality attributes and determinants in Tossa jute

Tossa jute (*Corchorus olitorius*) is globally distinguished for its superior fiber properties compared with white jute (C. capsularis). Its fibers are longer, stronger, and exhibit greater tensile strength, making them highly sought after in the global fiber market (Islam et al., 1992; Roy & Lutfar, 2012). The high cellulose content (58–65%) contributes to fineness and flexibility, while moderate lignin levels (12–14%) enhance tensile strength and durability without excessive coarseness (Roy & Lutfar, 2012). These structural properties give Tossa jute fibers a competitive advantage in both traditional and emerging industrial applications.

8.1 Key fiber quality parameters

The major parameters that define fiber quality include:
Length and fineness: Determine spinnability and suitability for high-value textiles.
Tensile strength: Critical for ropes, geotextiles, and composites.
Color, luster, and brightness: Influence market grading and pricing.
Cleanliness and uniformity: Affect processing efficiency and finished product quality.

8.2 Determinants of fiber quality

Several factors directly influence the quality of Tossa jute fiber:
Harvest timing: Harvesting at the onset of flowering (110–120 DAS) ensures fibers remain soft, shiny, and strong. Delayed harvesting increases lignification, producing coarse and brittle fibers of reduced commercial value.
Retting practices: Water quality, temperature (28–34 °C), and microbial activity are decisive for fiber separation and brightness. Slow-flowing, clean water produces superior fiber color and texture. BJRI's microbial retting inoculants have reduced retting time to 7–8 days while improving softness and luster. Ribbon retting further enhances fiber uniformity and minimizes environmental pollution.
Varietal selection: BJRI-developed varieties such as O-9897 and BJRI Tossa Pat 3 are widely recognized for producing fine, lustrous fibers with high tensile strength, underscoring the role of genetic improvement in quality enhancement.
Post-harvest handling: Proper stripping, washing, and sun-drying of fibers are essential to prevent microbial degradation and discoloration, ensuring higher grades in fiber markets.

8.3 Fiber Grading and Market Standards

BJRI and the Bangladesh Jute Mills Corporation (BJMC) follow a grading system based on fiber length, strength, color, luster, and cleanliness. Grades range from EX (extra) to X, M, and C**,** with higher grades commanding premium prices in both domestic and export markets (BJRI, 2020). Internationally, Bangladeshi Tossa jute is in demand for blending with synthetic fibers in non-woven textiles and composite manufacturing, reflecting its versatility and industrial adaptability.

9. Market dynamics and trade potential

The market for Tossa jute in Bangladesh is shaped by both strong domestic industrial demand and expanding global opportunities, particularly in the context of increasing restrictions on synthetic materials. As the world's leading producer of Tossa jute, Bangladesh supplies high-quality fiber for traditional textile applications as well as diversified products such as geotextiles, composites, and biodegradable packaging. However, despite these opportunities, the sector faces persistent structural and market challenges that influence farmer profitability and industrial competitiveness.

9.1 Domestic market

Tossa jute remains a critical raw material for Bangladesh's jute mills, which produce hessian, sacking, carpet backing cloth, and diversified jute products. The Mandatory Jute Packaging Act (2010) has boosted domestic demand, especially for packaging of food grains and other agricultural commodities. However, outdated machinery, inadequate fiber grading systems, and inconsistent enforcement of quality and price standards continue to limit the sector's efficiency. Weak enforcement of the Minimum Support Price (MSP) undermines farmer confidence, as prices often fall below MSP during peak harvest periods due to oversupply and limited storage capacity.

9.2 Export market and global demand

In FY 2021–22, Bangladesh earned over USD 1 billion from jute and jute goods exports, with Tossa jute contributing significantly due to its superior fiber quality. Major destinations include India (raw fiber and yarn), Turkey and China (diversified products), and the European Union, where biodegradable packaging is gaining market share. Expanding into non-traditional markets in Africa, Latin America, and the Middle East could reduce overreliance on a few major buyers. Strengthening the branding of Bangladeshi Tossa jute as a premium, eco-friendly fiber would also help capture niche, high-value segments.

9.3 Price volatility and structural constraints

Jute prices in Bangladesh exhibit strong seasonal fluctuations, typically peaking during export surges and declining sharply during the main harvest. This volatility is driven by:

- Seasonal oversupply without adequate storage or processing capacity.
- Dependence on middlemen who control fiber aggregation and market access.
- Limited domestic value addition, forcing farmers to sell raw fiber at low margins.
- Concentration of export markets, which makes prices vulnerable to trade policy shifts and demand fluctuations abroad.

9.4 Policy measures for market stabilization

Addressing these challenges requires more than MSP enforcement. Potential policy interventions include:

- Establishing regional jute marketing cooperatives to enable collective bargaining and better price realization.
- Expanding contract farming arrangements between mills/exporters and producer groups to secure fair, stable prices.
- Developing a warehouse receipt system that allows farmers to store fiber post-harvest and sell when prices improve.
- Investing in modern retting and fiber grading infrastructure to enhance quality and marketability.
- Supporting domestic value addition by incentivizing small and medium jute-processing enterprises to diversify products.

By tackling these structural bottlenecks and stabilizing prices, Bangladesh can strengthen the position of Tossa jute in both domestic and international markets. Such reforms would also enhance farmer income stability, making the sector more resilient to global market shifts.

10. Future prospects and research priorities

Tossa jute holds substantial untapped potential as both an agricultural commodity and a foundation for green industrial development. As Bangladesh seeks to strengthen its role in sustainable agriculture and

eco-friendly industries, future advancements in jute research, product diversification, and policy support will be critical.

10.1 Genetic improvement and biotechnology

Conventional breeding has successfully produced high-yielding and stress-tolerant BJRI varieties, but modern biotechnological tools offer opportunities for accelerated improvement. Marker-assisted selection (MAS), genome-wide association studies (GWAS), and CRISPR-Cas9 gene editing can be deployed to develop varieties with enhanced drought and salinity tolerance, pest and disease resistance, and improved fiber fineness. Advances in functional genomics may also facilitate the identification of key genes regulating lignin and cellulose synthesis, opening pathways to tailor fiber quality for specialized industrial uses.

10.2 Diversification of jute products

The long-term viability of Tossa jute depends on diversification beyond traditional uses. Expanding into non-traditional sectors—such as jute-based composites for automobile interiors, bioplastics, geotextiles, and biomedical applications—will generate higher value and reduce dependence on raw fiber exports. Encouraging entrepreneurship, establishing technology incubators, and strengthening public–private partnerships can accelerate the commercialization of diversified jute products (DJP).

10.3 Integration into climate-smart agriculture

Tossa jute is uniquely suited to climate-smart agriculture (CSA) due to its short growth cycle, low input requirements, and resilience to variable rainfall. Integrating jute into conservation agriculture and crop rotation systems with legumes and vegetables enhances soil fertility, reduces pest build-up, and improves carbon sequestration. Promoting jute cultivation in saline- and drought-prone regions can also stabilize farmer incomes under climate change conditions. With proper extension services, jute can serve as a model crop for balancing productivity, environmental stewardship, and climate adaptation.

10.4 Policy and institutional support

Unlocking the future potential of jute requires supportive policy frameworks. Key actions include strengthening BJRI's research capacity, ensuring adequate investment in modern retting and processing technologies, and enforcing Minimum Support Price (MSP) mechanisms. Policies promoting export incentives, branding of Bangladeshi jute as a premium eco-product, and integration of jute into Sustainable Development Goal (SDG) strategies will also be critical to sustaining global competitiveness. In sum, the prospects of Tossa jute rest on a threefold agenda: genetic and biotechnological innovation, diversification into high-value products, and integration into climate-smart agricultural systems supported by strong policies. With these measures, Bangladesh can transform Tossa jute into not only a national economic asset but also a global leader in sustainable fiber production.

11. Limitations

While this review provides a comprehensive synthesis of the agronomic, economic, and environmental aspects of BJRI-developed Tossa jute varieties, several limitations should be acknowledged:

Institutional bias: A substantial proportion of the data and case studies discussed originate from the Bangladesh Jute Research Institute (BJRI) and affiliated publications. While these sources ensure direct relevance to the national jute sector, they may not fully capture on-farm realities outside controlled research conditions or reflect independent evaluations.

Geographic scope: The review focuses primarily on the context of Bangladesh. Although some findings may be relevant to other jute-producing regions, variations in climate, soil types, input availability, and market structures could limit the direct applicability of the conclusions to different agro-ecological and socioeconomic settings.

Methodological assessment: This review synthesizes findings from multiple studies but does not systematically evaluate or compare the methodologies used in those studies. As a result, it does not fully assess the robustness, reproducibility, or potential limitations of the underlying evidence base.
Future reviews could address these limitations by incorporating a broader range of international case studies, including more independent field evaluations, and conducting a critical appraisal of the research methods used in jute studies.

12. Conclusion

While this review underscores the considerable economic, agronomic, and environmental potential of Tossa jute, realizing this potential will depend on addressing persistent structural challenges. Declining cultivation areas, fluctuating market prices, inadequate post-harvest infrastructure, and limited farmer access to improved retting technologies remain significant constraints. Without targeted interventions, these issues could undermine the crop's capacity to deliver on its sustainability promise.

A policy framework would not only strengthen institutional research capacity but also include:

- Enforcement of the Minimum Support Price (MSP) to stabilize farmer income.
- Expansion of contract farming and warehouse receipt systems to reduce dependence on middlemen.
- Incentives for investment in modern retting, processing, and fiber grading infrastructure.
- Support for diversification into high-value jute-based products and eco-industrial applications.

Addressing price volatility requires tackling both structural and market-driven factors. Seasonal oversupply at harvest, weak fiber storage capacity, and dependence on a limited number of export markets all contribute to instability. Policy measures such as establishing regional jute marketing cooperatives, promoting value-added domestic processing, and diversifying export destinations would help stabilize prices and enhance farmer profitability.

The future of Tossa jute as a strategic crop is best viewed as a conditional opportunity-one that can be realized only if research, market development, and policy reforms are pursued in a coordinated and sustained manner.

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