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Hybridization Among Tossa Jute Genotypes (*Corchorus olitorius* L.) to Create Genetic Variability for Higher Fiber Yield and Quality

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Abstract: Hybridization is a fundamental breeding approach for generating genetic variability and developing high-yielding cultivars in self-pollinated crops like tossa jute (*Corchorus olitorius* L.). In August 2024, a total of 22 genotypes including four released varieties, nine advanced lines, six accessions, and three low-lignin experimental lines were planted at the Bangladesh Jute Research Institute (BJRI), Dhaka. To ensure synchronized flowering, seeds were sown in three intervals at 15-day gaps. Partial hybridization was performed, resulting in 440 attempted crosses. Among these, 150 successful single crosses were obtained, leading to 88 distinct progeny types. These crosses included combinations among high-yielding varieties, stress-tolerant accessions, and low-lignin genotypes, creating opportunities to pyramid desirable traits into a single genetic background. The harvested hybrid seeds will be evaluated in subsequent generations (F_1–F_2) for morphological variability, fiber yield and quality. This study demonstrates the effectiveness of strategic hybridization for broadening the genetic base of tossa jute, particularly for breeding high-yielding, climate-resilient and low-lignin varieties.

Keywords: *Corchorus olitorius*, hybridization, genetic variability, lignin reduction, fiber crops, Jute breeding

INTRODUCTION

Jute (*Corchorus* spp.) is one of the most important bast fiber crops, providing eco-friendly natural fiber for textiles, composites and packaging industries (Ahmed et al, 2025; Saha et al., 2020). Tossa jute (*C. olitorius* L.) is particularly valued due to its superior fiber strength, luster and productivity compared to white jute (*C. capsularis*) (Mukul et al, 2021; Roy & Sinha, 2012). Bangladesh and India contribute more than 90% of global jute fiber production, making improvement of this crop critical for both rural livelihoods and export earnings (Rahman & Akter, 2021).

Despite its economic importance, jute improvement has historically been limited by narrow genetic diversity, high lignin content and susceptibility to biotic and abiotic stresses (Islam & Rashid, 2020). Traditional breeding programs have primarily focused on yield, while recent efforts emphasize lignin modification to improve fiber softness, ease of retting, and industrial applicability (Saha et al., 2020; Haque et al., 2019).

Hybridization, the crossing of genetically distinct parents, is a cornerstone of plant breeding for creating new genetic combinations. It facilitates recombination of alleles governing yield, fiber quality, stress tolerance, and adaptability (Kar et al., 2009). For jute, hybridization enables breeders to overcome self-pollination barriers, widen the genetic base and develop superior recombinants (Abbott et al., 2013; Singh et al., 2017).

Previous studies have demonstrated the potential of hybridization in jute for improving yield stability and adaptability across environments (Chowdhury & Hossain, 2017; Kundu & Ghosh, 2015). However, systematic hybridization involving diverse genetic resources—such as commercial varieties, advanced breeding lines, landraces, and experimental low-lignin lines—remains underexplored.

This study was therefore undertaken to generate genetic variability through controlled hybridization among selected tossa jute genotypes. By combining high-yielding varieties, advanced lines, stress-tolerant accessions, and low-lignin genotypes, the objective was to create diverse recombinant populations for future selection of superior fiber-quality cultivars.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted during August 2024 at the crossing block of Bangladesh Jute Research Institute (BJRI), Dhaka (23.77°N, 90.38°E), under natural field conditions. The soil was sandy loam with moderate fertility and standard cultural practices for jute cultivation were followed.

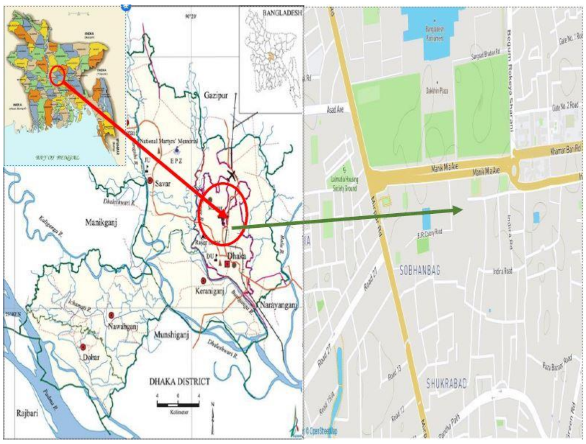

Figure 1. Map of the study area

Plant Materials

A total of 22 genotypes of tossa jute were used (Table 1).

Table 1. Parents and their characteristics for hybridization

Sl.	Genotype	Character
01	O-9897	High yielding variety, lanceolate leaf
02	BJRI Tossa Pat-5	High yielding variety, lanceolate leaf
03	BJRI Tossa Pat-8	High yielding variety, Quick growing
04	JRO-524 G	High yielding variety, Narrow lanceolate leaf
05	O-043-7-9 G	Narrow lanceolate leaf with good yield
06	O-043-7-9 R	Narrow lanceolate leaf with good yield
07	O-0512-6-2 G	High yielding line, Narrow lanceolate leaf
08	O-0512-6-2 R	High yielding line, Narrow lanceolate leaf
09	O-0419-3-1 G	High yielding line, lanceolate leaf
10	O-0419-3-1 R	High yielding line, lanceolate leaf
11	O-049-1-3 R	High yielding line, lanceolate leaf
12	O-0411-10-4 R	High yielding line, lanceolate leaf
13	O-0412-9-4 R	High yielding line, lanceolate leaf
14	Acc. 1306	Waterlog tolerant, lanceolate leaf
15	Acc. 1318	Waterlog tolerant, lanceolate leaf
16	Acc. 4582R	Good yielding accession with narrow leaf
17	Acc. 4582G	Good yielding accession with narrow leaf
18	C_3H-T_5 G	Low lignin content
19	C_4H-T_7 G	Low lignin content
20	C_5H-T_4 G	Low lignin content
21	Acc. 6099	High yielding
22	Acc. 6100	High yielding

Synchronization of Flowering

Due to variation in flowering time, seeds of all genotypes were sown at three intervals spaced 15 days apart to synchronize flowering starting at 28 August, 2024. This staggered planting ensured overlapping reproductive phases for successful cross-pollination.

Hybridization Technique

Controlled hand pollination was conducted using the standard emasculation and bagging method (Rahman et al., 2017). Flower buds at pre-anthesis were emasculated in the evening, covered with butter paper bags and pollinated the next morning with fresh pollen from selected male parents.

Figure 2. Hybridization activities among tossa jute genotypes

Crossing Design

Each variety and line was crossed in multiple combinations, targeting traits such as:

- **High yield** (from commercial varieties and advanced lines)

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- **Stress tolerance** (from accessions like Acc. 1306 and 1318, waterlogging tolerant)
- **Low lignin content** (from experimental lines C3H-T5, C4H-T7, C5H-T4)

A total of **440 crossing attempts** were made across different parental combinations.

Data Collection

The number of attempted crosses, successful crosses, and hybrid pods obtained were recorded. Mature pods from each successful cross were harvested, dried, and stored separately for future evaluation.

RESULTS AND DISCUSSION

Crossing Success

Among 440 attempted crosses, 150 crosses were successful, representing a success rate of ~34%. These crosses yielded 88 distinct progeny types (Table 2).

Table 2. List of successful cross combinations

Sl.	Female ♀	Male ♂	No. of crosses
1	O-9897	O-043-7-9R	1
2		O-0419-3-1R	2
3		ACC. 1306	2
4		ACC 4582G	1
5		C4H-T7	1
6		*C. Incicifolius*	1
7		ACC. 6100	2
8		O-0411-10-4R	1
9		O-0412-9-4R	1
10	BJRI Tossa pat 5	O-043-7-9R	3
11		O-0419-3-1R	1
12		ACC 4582G	1
13		*C. Incicifolius*	1
14		ACC. 6100	2
15		O-0411-10-4R	1
16		O-0412-9-4R	1
17	BJRI Tossa pat 8	O-043-7-9R	2
18		O-0419-3-1R	2
19		ACC 4582G	2
20		C4H-T7	1
21		*C. Incicifolius*	1
22		ACC. 6100	1
23		O-0411-10-4R	2
24		O-0412-9-4R	1
25	BJRI Tossa pat 9	O-043-7-9R	2
26		Acc. 1306	2
27		ACC 4582G	1
28		C4H-T7	4
29		C5H-T4	1
30		*C. Incicifolius*	2
31		ACC. 6100	5
32		O-0411-10-4R	1
33		O-0412-9-4R	2
34	JRO-524G	O-043-7-9R	2

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Sl.	Female ♀	Male ♂	No. of crosses
35		ACC. 1306	2
36		ACC 4582G	2
37		C4H-T7	2
38		C5H-T4	1
39		*C. Incicifolius*	1
40		ACC. 6100	1
41		O-0411-10-4R	1
42		O-0412-9-4R	2
43	O-0419-3-1G	O-043-7-9R	1
44		ACC. 1306	1
45		C4H-T7	1
46		C5H-T4	1
47		*C. Incicifolius*	2
48	Acc. 1318	O-043-7-9R	1
49		ACC 4582G	1
50		C4H-T7	1
51		ACC. 6100	1
52		O-0412-9-4R	2
53	C_3H-T_5	O-043-7-9R	1
54		ACC. 1306	3
55		C4H-T7	2
56		C5H-T4	1
57		*C. Incicifolius*	2
58		ACC. 6100	1
59		O-0411-10-4R	1
60		O-0412-9-4R	1
61	Acc. 6099	O-043-7-9R	3
62		O-0419-3-1R	2
63		ACC. 1306	2
64		ACC 4582G	5
65		C4H-T7	3
66		C5H-T4	2
67		*C. Incicifolius*	3
68		ACC. 6100	1
69		O-0411-10-4R	1
70		O-0412-9-4R	3
71	O-0512-6-2G	O-043-7-9R	6
72		ACC. 1306	1
73		ACC 4582G	2
74		C5H-T4	2
75		*C. Incicifolius*	1
76		ACC. 6100	2
77		O-0411-10-4R	1

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Sl.	Female ♀	Male ♂	No. of crosses
78		O-0412-9-4R	1
79	Acc. 1148	O-043-7-9R	2
80		ACC. 1306	2
81		ACC 4582G	1
82		*C. Incicifolius*	1
83		O-0411-10-4R	3
84		O-0412-9-4R	2
85	Acc. 6100	O-9897	1
86	*C. Incicifolius*	Acc. 4582G	1
87	O-9897	Tossa-5	1
88	O-9897	Acc. 6099	3
		Total successful cross	150

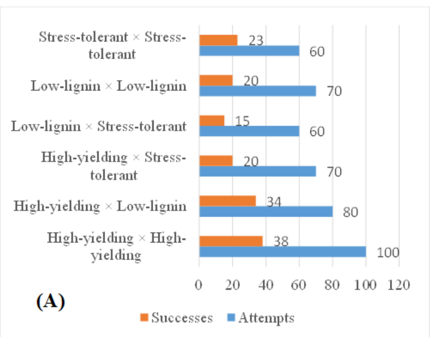
Highest success was observed in crosses involving BJRI Tossa Pat-5, O-0512-6-2, and Acc. 6099 with low-lignin lines (C3H-T5, C4H-T7, C5H-T4). Several promising crosses combined waterlogging tolerance (Acc. 1306, 1318) with high-yielding lines (O-0419-3-1, O-0411-10-4R). Crosses involving low-lignin parents were particularly valuable, as lignin reduction is a key target for industrial processing improvement.

The diversity in cross combinations suggests a wide potential for generating novel segregants in the F_2 and subsequent generations. 88 hybrid types represent a broad genetic base for selection. Crosses such as O-9897 × Acc. 6099 and BJRI Tossa Pat-8 × C4H-T7 combined yield with fiber quality traits. Crosses between commercial varieties and low-lignin lines are expected to yield recombinants with desirable fiber softness.

Table 3 presents the performance of six selected tossa jute hybrids for seed-related traits, including F_1 seed yield per pod, 1000-seed weight, and pod length. The results show significant differences among crosses, as indicated by the lettering, with crosses C-3 (O-0512-6-2 × C5H-T4) and C-4 (Acc. 6099 × C3H-T5) performing best across most traits, while C-6 (O-0411-10-4R × C4H-T7) showed the lowest values.

Table 3: Performance of selected tossa jute hybrids for seed related traits

Cross ID	Female parent	Male parent	F_1 seed yield per pod (mg)	1000-seed weight (g)	Pod length (cm)
C-1	O-9897	C4H-T7	220^b	2.9^b	5.8^b
C-2	BJRI Tossa-5	Acc. 1306	210^b	3.1^a	5.5^b
C-3	O-0512-6-2	C5H-T4	250^a	3.3^a	6.1^a
C-4	Acc. 6099	C3H-T5	240^a	3.0^a	5.9^a
C-5	BJRI Tossa-8	O-0419-3-1R	230^b	2.8^b	5.6^b
C-6	O-0411-10-4R	C4H-T7	200^c	2.7^b	5.3^c



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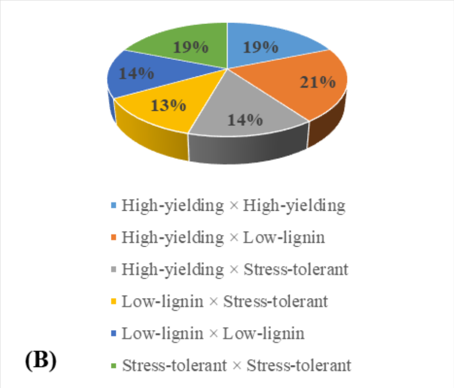

Figure 3. (A) Hybridization attempts and successes by parental group, and (B) Share of successful crosses (%) by the group

Figure 3 illustrates (A) the number of hybridization attempts and successful crosses by parental group, and (B) the percentage share of successful crosses. High-yielding × low-lignin and high-yielding × high-yielding combinations achieved the highest success rates, highlighting their potential in developing superior jute hybrids.

Discussion

The success of 150 controlled crosses demonstrates the feasibility of creating diverse genetic recombinants in tossa jute. Hybridization efficiency (~34%) was consistent with earlier reports in bast fiber crops, where cross-compatibility and floral biology often limit success (Ali & Haque, 2013). The 88 progeny types highlight the effectiveness of using diverse parental combinations (Gupta et al., 2018), where hybridization among advanced lines broadened variability for fiber yield and earliness. The incorporation of low-lignin lines in this study is particularly significant, as lignin reduction enhances retting efficiency and fiber softness (Saha et al., 2020). Accessions 1306 and 1318 contributed tolerance to waterlogging an important trait for flood-prone regions of Bangladesh. Combining stress tolerance with high yield can enhance resilience under climate variability (Kundu & Ghosh, 2015). The harvested hybrid seeds (F_1s) will be grown in 2025 to confirm hybridity and evaluate morphological variability. Subsequent backcrosses and multi-parental crosses may be used to pyramid yield, quality, and stress tolerance traits. Use of molecular markers for lignin biosynthesis genes could further accelerate selection process (Islam & Rashid, 2020).

CONCLUSION

This study successfully generated 150 crosses and 88 distinct hybrid types among 22 tossa jute genotypes, integrating traits for high yield, stress tolerance, and reduced lignin. The hybrids represent a valuable breeding resource for developing next-generation jute varieties tailored for industrial fiber quality and climate resilience. Future work will focus on evaluating the segregating populations, identifying superior recombinants and incorporating them into jute breeding.

Conflict of Interest

The authors declared no conflicts of interest.

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