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Influence of different microbial agents on the jute retting process in a stagnant condition

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ABSTRACT

The experiment was conducted at the Jute research substation, Tarabo, Narayanganj, in 2023 from March to August. A consortium of *Bacillus pumilus*, *Macrophomina phaseolina*, and *Aspergillus tererus* was prepared in the Central Laboratory, Plant Pathology Department, Sher-e-Bangla Agricultural University, Dhaka, and it was applied in field conditions at Tarabo with three replications. All the treatment combinations showed significant differences in all the parameters. The lowest retting duration (13 days) was recorded in Tossa pat treated with *Bacillus pumilus*, and in Deshi pat, it took 15 days. It showed 45.07 % greater results than the control. Fiber recovery and fire fineness were better at Tossa pat treated with *Bacillus pumilus*. On the other, fiber strength was better in Deshi pat compared to Tossa pat treated with *Bacillus pumilus*. The bark contains percentage was also lower (3.67%) at Tossa pat treated with *Bacillus pumilus*. Tossa pat and Deshi pat are relatively similar in terms of fiber colour, grade, and luster. The results concluded that the jute retting condition can be improved through microbial treatment in a stagnant state.

Keywords: Golden Fiber, Retting, Microbial Agents, retting duration, Fiber recovery, Fiber Strength, Fiber Fineness, Fiber Colour, Grade and Luster.

1. INTRODUCTION

Jute (*Corchorus* spp.), the golden fiber of Bangladesh, is eco-friendly, biodegradable, and has a much higher CO2 absorption rate, which is creating new avenues for the endurance and development of the jute industry in the era of ecological concerns (Datta et al., 2020). Currently, Bangladesh is in second place after India in terms of production, but it has ranked first in terms of exports. At present, on average, jute and allied fiber crops are being cultivated on 8 lakh hectares of land, and production is 82.55 lakh bel in Bangladesh. Another report showed that about 84.32 metric tons of bel jute fiber were produced from 16.85 lakh acres of land, covering 2.90% of the total cropped area in 2020–2021. However, due to climate change and other artificial causes, natural water bodies are decreasing. So, there is a huge threat to jute retting traditionally. That's why farmers are rotting jute plants in their fields with little water, covered with mud which seriously affects the quality of fiber.

As a result, farmers are producing low-quality fiber, and they are getting low market prices consistently year after year. A higher yield of jute failed to make farmers happy in Faridpur, as they were facing huge trouble with rotting and processing raw jute in the absence of adequate water in local water bodies (beels), canals, and ponds. Farmers said if the ongoing water crisis continues, they will have to count huge losses this year as quality fiber cannot be extracted without properly rotting. On the other hand, in the areas where water bodies are available, the jute farmers have continued rotting the plants in traditional ways in rivers and other water bodies, causing serious water pollution, and posing a threat to fish and other aquatic creatures. So, it will be a burning question shortly how fiber would be rotten. By employing lignin-degrading bacterial isolates instead of chemical delignification, it is possible to avoid the environmental damage caused by the chemical process of delignification (Barai et al., 2020).

There is one solution to the problem: To rot the huge amount of fiber in small areas in stagnant conditions. To resolve the problem, a modern jute fiber extraction machine has already been developed by the Bangladesh Jute Research Institute and the Bangladesh Agricultural Research Institute. Jute retting is performed by the joint action of water and various microbes present in the water of ponds, canals, ditches, air, and soil. They are usually available in water, which is useful for aquatic plants and animals. Mainly, special types of bacteria and fungi are responsible for jute retting. Jute retting microbes and their enzymes separate the fiber from the woody core of jute plants. Fungi from different natural sources like lemon, Orange, jute plants, loaf rot, tea leaf rot, and jute retting effluents can rot the jute quickly in sterile conditions. A study showed that microbial population varies from place to place in the jute-growing areas of Bangladesh.

The fungal load was higher in the post-retting water of Faridpur, Meherpur, and Jashore. The addition of post-retting microbes in the retting test, *in vitro*, accelerated the retting. The retting period was almost half in treatment with microbes from post-retting water than pre-retting water (Haque et al., 2002). Jute retting is also accomplished by the joint action of different bacteria in water. Due to the introduction of the microbial formulation consisting of three different strains of *Bacillus pumilus* in the improved method, retting duration was reduced by 6–7 days, fiber recovery increased by 9.7–12%, with the improvement in fiber quality (colour, luster, fiber strength, etc.) as compared to the conventional method (Das et al., 2018). The lignin percentage of jute fiber ranges from 13.3 to 15%, and a greater lignin level prevents jute fiber from being used as a textile fiber (Sengupta and Palit, 2004; Chakraborty et al., 2015).

A study was done to lower the lignin concentration in jute (Corchorus spp. L.) by using possible lignin-degrading bacterial isolates as an alternative to chemical de-lignification. The most effective of the five ligninolytic bacterial isolates used for the de-lignification research was a promising isolate (L9) characterized as Bacillus spp., which was able to reduce the lignin concentration of jute fiber from 11.33-8.84%, or an approximate reduction of 21.97%. Traditionally, retting with community pond water of poor quality or, occasionally, with an insufficient amount of water without the presence of any microbial consortium affects the quality of the fiber and renders it uncompetitive on a global scale (Das et al., 2015). It is essential to search and isolate newer retting organisms for good retting. As a result, jute farmers will be able to rot the fiber in a shorter period than the conventional process. It will help them to produce good quality fiber.

2. MATERIALS AND METHODS

Experimental Site

From March 2023 to August 2023, a field experiment was conducted in the Bangladesh Jute Research Substation at Tarabo, Narayanganj, Bangladesh (latitude: 23° 43′ 21″ North and longitude: 90° 30′ 31″ East). The study area is in the Agro-Ecological Zone 8 (AEZ-8), Permeable, silt loam to silty clay loam soil is seen on the hills and in the basins, which are neutral to slightly acidic in response (UNDP and FAO, 1988). The research site's soil had a pH of 6.2 and a low organic matter content, making it mildly alkaline. There was terrain of high to moderate height with a silty loam structure. Jute cultivation is generally cost-effective in the research area. The other part of the experiment, the microbial consortium, was made in the central laboratory, plant pathology department of Sher-e-Bangla Agricultural University, Dhaka-1207.

Plant materials

Two types of plant materials were used for this experiment. Mainly, the fiber of tossa pat and desi pat was used as plant material. For tossa pat, the high-yielding variety BJRI Tossa pat 8, popularly known as "Robi-1," was used, and for deshi pat, the most popular and high-yielding variety BJRI Deshi pat 10, which is popularly known as "Sobuj sona," was used.

Microbial Agents

Jute retting process is the combined process of water and microbial agents. Jute retting bacteria and fungus spp from natural sources were prepared in the laboratory and used for this study. Both bacteria and fungi do specific activities in the retting process. Various research activities showed that *Bacillus pumilus* is an active microbial agent for the retting process. It is available in multiple natural sources viz:- soil, water, air (spores), fermented foods, decomposing plant, and animal tissues and jute retting affluents. *Macrophomina phaseolina* is a prominent fungus for the active jute retting process, and it is available in natural sources- such as various rotten materials and jute retting affluents. Another widespread jute-retting fungus, *Aspergillus tererus,* was also used in this experiment, and available in jute retting affluent.

Design and Treatments

The BJRI Tossa pat 8 and BJRI Deshi pat 10 were sown on 10 March 2023 in Tarabo farm following the BJRI guidelines. After 120 DAS, both varieties were harvested, and the raw fiber was removed manually. 1 kg of raw fiber was used for each treatment. The treatment combination was made of the fiber of tossa and deshi pat and the microbial agents such as – P1M1= Tossa pat + *Bacillus pumilus,* P1M2= Tossa pat + *Macrophomina phaseolina,* P1M3= Tossa pat + *Aspergillus tererus,* P1M0 = Control for Tossa pat, P2M1 = Deshi pat + *Bacillus pumilius,* P2M2 = Deshi pat + *Macrophomina phaseolina,* P2M3 = Deshi pat + *Aspergillus tereus*, P2M0 = Control for Deshi pat. 2m×2m×1m sized retting hole was made. The experiment was laid out in RCBD design with three replications.

Preparation of microbial consortium and Data collection

The bacterial consortium Ahmed and Sarkar, (2022), Gamalero et al., (2022) and the fungal consortium Song et al., (2022) were made at the Central Laboratory, Plant Pathology Department at Sher-e-Bangla Agricultural University. After the preparation of the microbial consortium, it was applied to retting holes in field conditions. Retting was completed on different days for different treatment combinations. After retting, the fiber was washed with clean water properly, and then data was taken on retting duration, fiber recovery, fiber fineness, fiber strength, bark content, and pH of the retting water. The fiber bundle strength was estimated using an electronic fiber bundle strength tester Roy et al., (2009) and fiber fineness by airflow method (Bandopadhyay and Sinha, 1968). The root content and defects in jute fiber were recorded following the standard method of estimation (Roy and Saha, 2013). The water requirement per quintal green jute stem for retting and per quintal dry jute fiber production were measured using the total volume of water required, green weight of the stem, and dry fiber yield in each retting method.

Statistical analysis

The statistical analysis of all the gathered data was performed with the help of a computer statistical package named doe-bioresearch in R software. The Least Significant Difference (LSD) and T-test were used to determine the mean differences between the treatments at the 0.05 level (Gomez and Gomez, 1984). Graphs were created with the help of ggplot2 in R software.

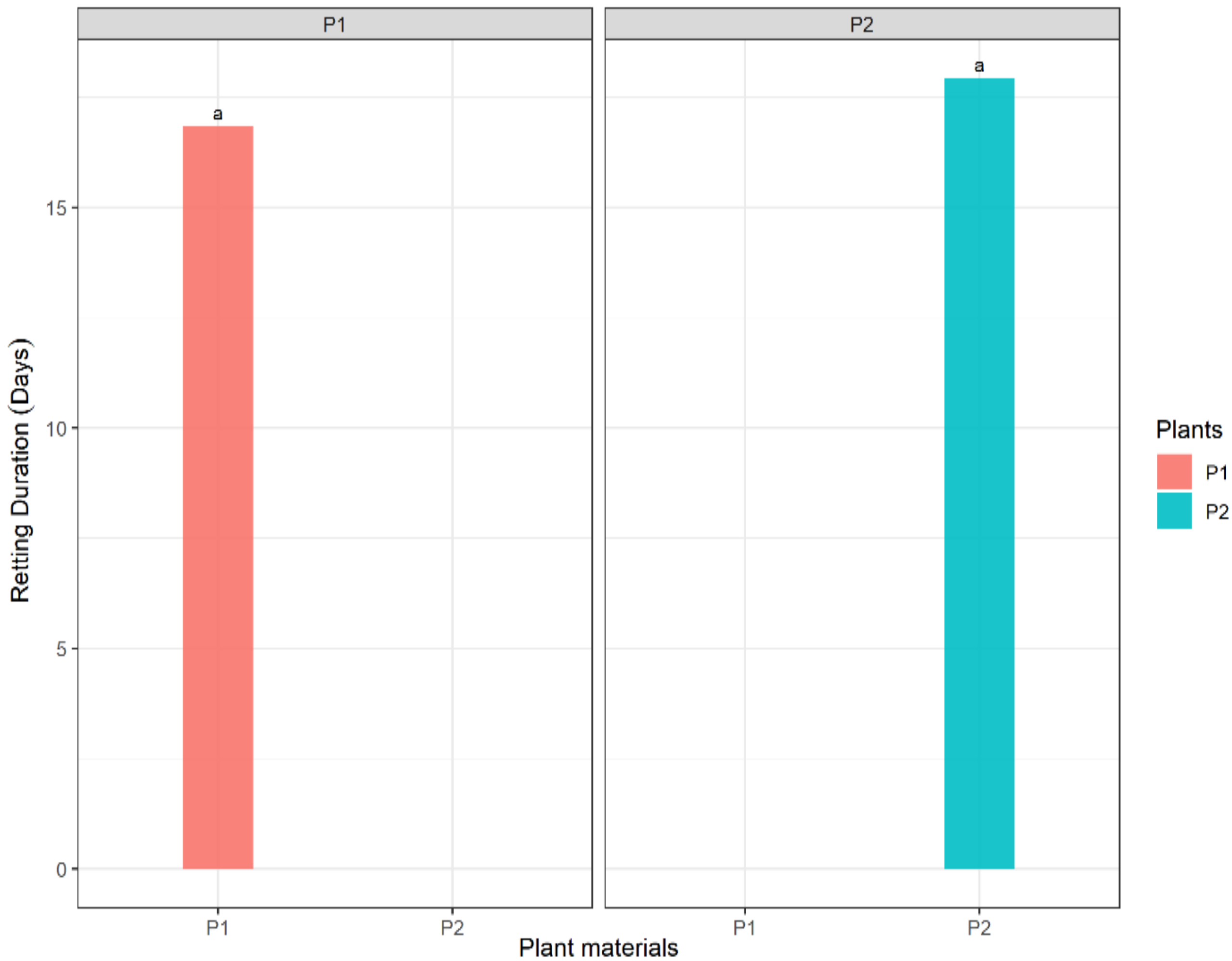
3. RESULT AND DISCUSSION

Effect of plant material on the retting duration

The data obtained from Figure 1 indicated no significant difference between P1 & P2. However, it indicated that P1 took a longer duration for retting than P2. Numerically P2 was greater than P1, but they were statistically similar. P1 took 16 days for retting, and P2 took 18 days for retting. The previous experiment showed the jute can be rotted more quickly with improved fiber quality by using *bacillus* strains rather than talc-based microbial formulations (Chattopadhyay et al., 2019).

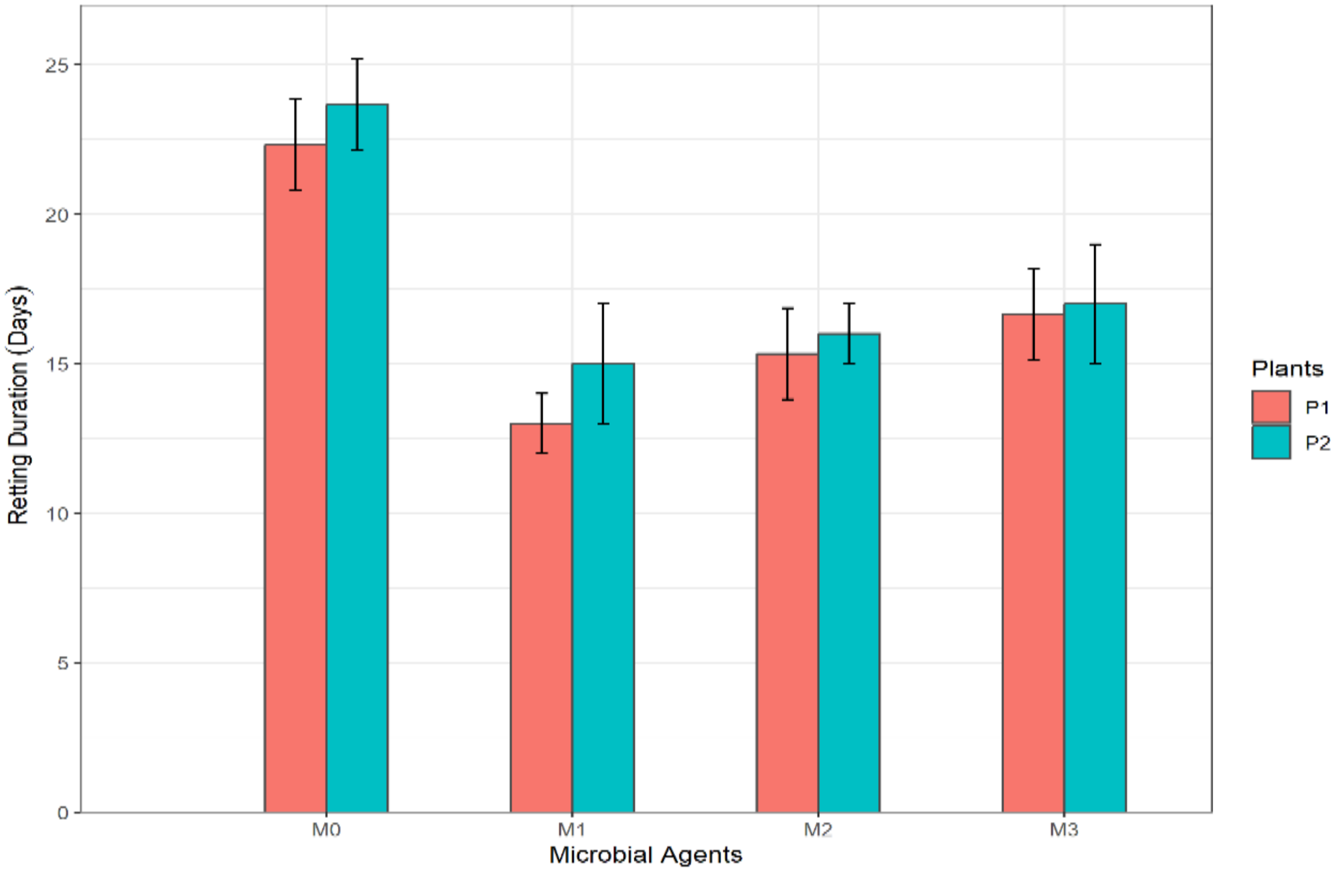
Effect of microbial agents on the retting duration

The results revealed that there was a significant difference among the treatments due to microbial agents (Figure 2). The lowest duration for retting was found in M1. It took 13 days for Tossa Pat and 15 days for Deshi Pat. The average day for retting was 14 days in M1. The longest days were taken in control (M0), where no treatment was given. It took 22 days for Tossa Pat and 24 days for Deshi Pat. The average day for retting was 23 days in M0. Here, M1 took 64.28 % less time for retting than control. Again, there were no significant differences between M1 & M2. M3 & M3 also gave statistically similar results. According to a ribbon retting trial with jute and mesta, the retting with a microbial consortium (CRIJAF Sona) took 7–10 days compared to 15–20 days without it (Naik et al., 2018).



Legends: P1= Tossa Pat, P2= Deshi Pat

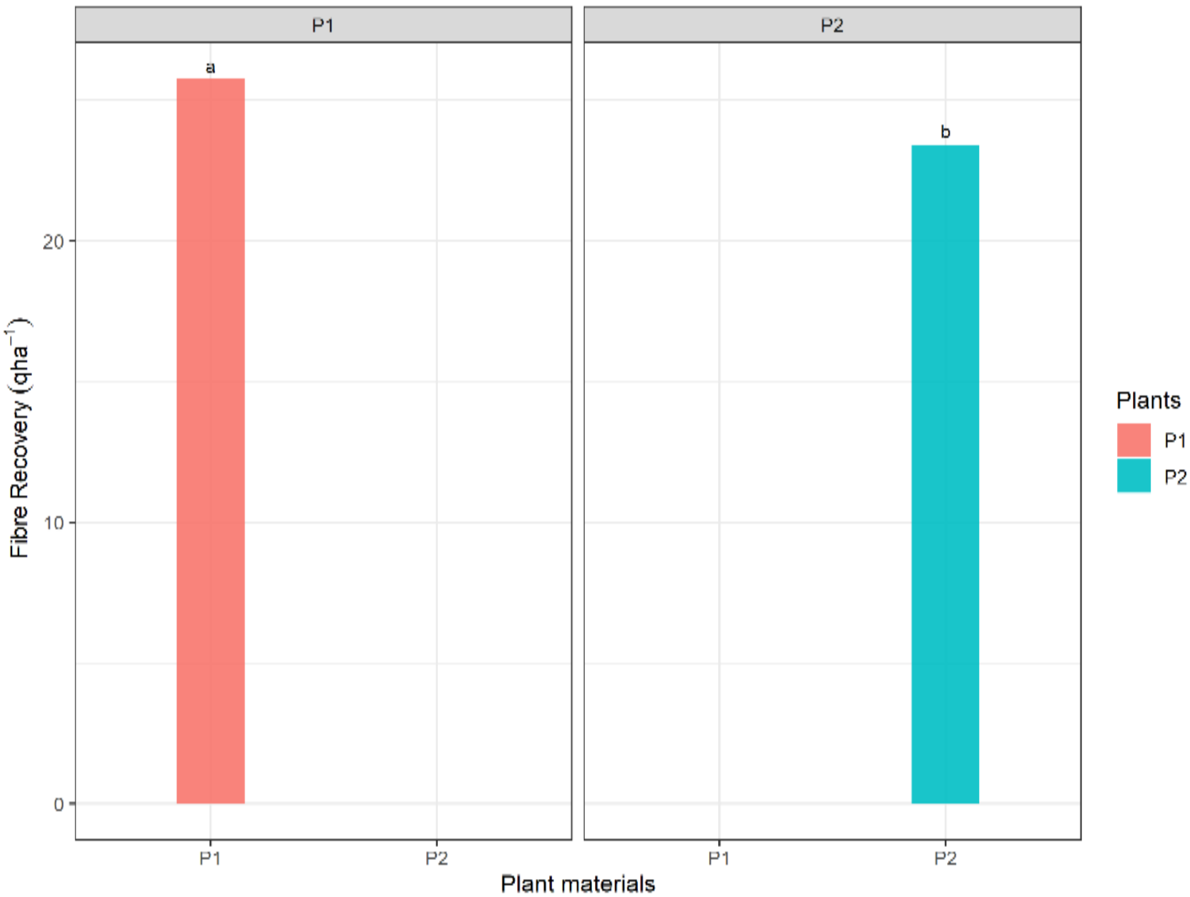
Figure 1 Effect of plant material on the retting duration



Legends: M1= *Bacillus pumilius*, M2= *Macrophomina phaseolina*, M3= *Aspergillus tererus*, M0= Control, P1= Tossa Pat, P2= Deshi Pat
Figure 2 Effect of microbial agents on the fiber retting duration.

Effect of plant material on fiber recovery

Fiber recovery was greatly influenced by the effect of plant materials (Figure 3). The results showed that the highest fiber recovery was found in P1 (25.75 qha-1). The lowest fiber was found in P2 (23.42 qha-1). The values showed a significant difference between P1 and P2. The previous study found the same results Tossa jute had a higher fiber recovery rate (Banik et al., 2003).

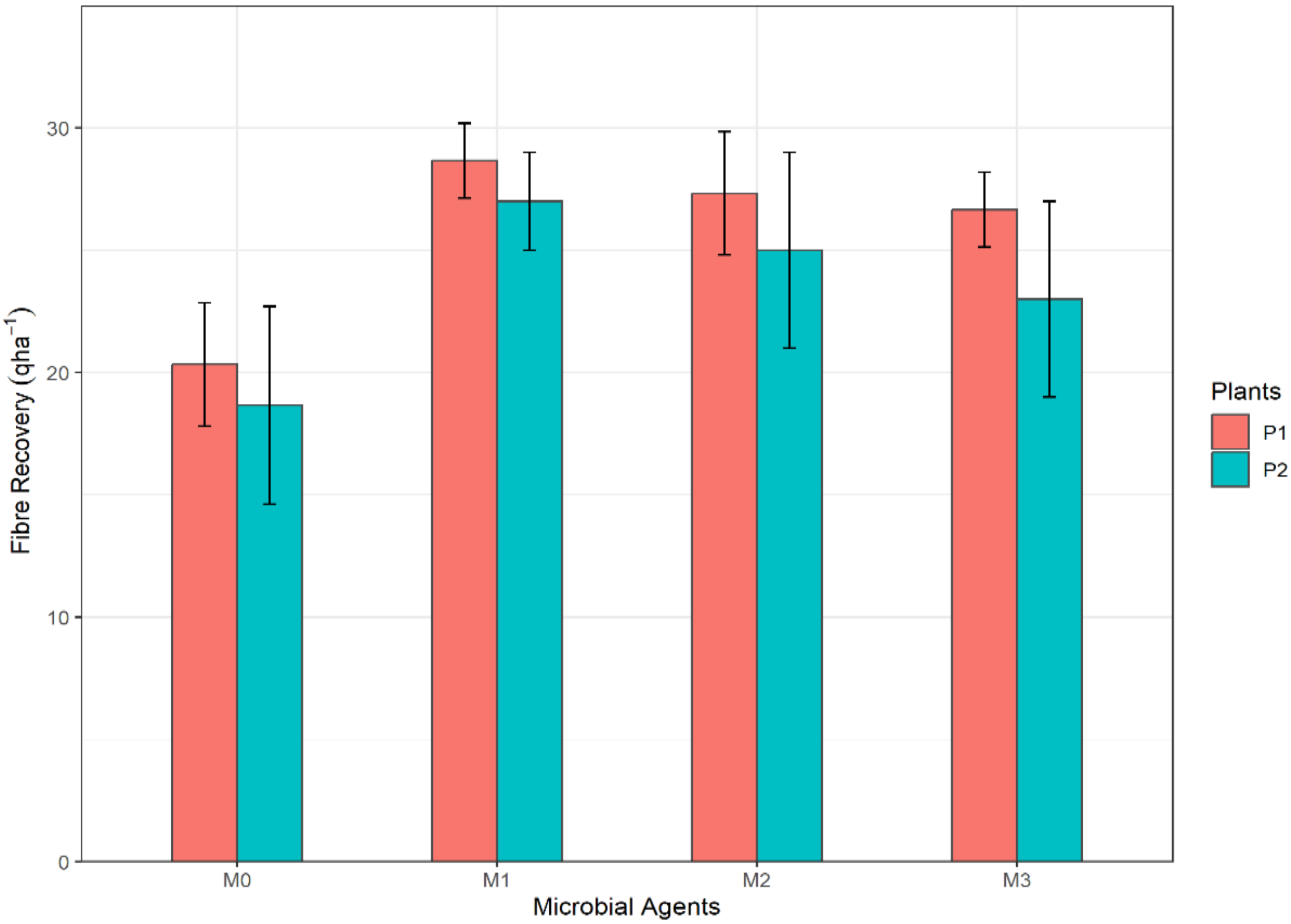


Legends: P1= Tossa Pat, P2= Deshi Pat

Figure 3 Effect of plant material on the fiber recovery

Effect of microbial agents on fiber recovery

In the case of fiber recovery, an essential distinction among the treatments was identified as a result of the application of microbial agents in retting holes (Figure 4). The highest value was found in M1 (27.83 qha-1), which was statistically similar to M2 and M3. There were no significant differences among M1, M2 and M3. The lowest value was found in M0 (19.50 qha-1). The results indicated that the fiber recovery rate was better in Tossa pat than in desi pat. The M1 showed 29.93% greater than M0. Higher fiber recovery of 20 - 25% helped to secure a higher price. The use of microbial consortium-treated Tossa jute had a greater positive influence on fiber recovery than Deshi jute. It also reduced the amount of work and drudgery that the people involved had to do.



Legends: M1= *Bacillus pumilius*, M2= *Macrophomina phaseolina*, M3= *Aspergillus tererus*, M0= Control, P1= Tossa Pat, P2= Deshi Pat

Figure 4 Effect of microbial agents on the fiber recover

The combined effect of plant material and microbial agents on the retting duration and fiber recovery

Table 1 shows that retting duration differed significantly due to the combined effect of plant material and the application of microbial agents. The lowest retting duration was found in the P1M1 (13 days) treatment combination. The application of *Bacillus pumilius* agents on Tossa pat showed better performance among the treatment combinations, but it was statistically similar to P1M2 and P2M1. The most prolonged time was found in P2M0 (23.67 days), which was statistically identical to P1M0. Again, there were no significant differences among the P1M2, P1M3, P2M1, P2M2, and P2M3. P1M1 showed 45.07% better results than P2M0. Microbial treatment enhanced the retting duration greatly and reduced it by 10–12 days compared to conventional retting (Majumdar et al., 2022).

Again, Table 1 revealed that the treatment combinations showed significant differences from one another for fiber recovery. The highest fiber recovery found in P1M1 (28.67 qha-1) was the application of *Bacillus pumilus* on Tossa pat which is statistically similar to P1M2, P1M3, P2M1 and P2M2. The lowest value was found in P2M0 (18.67 qha-1), which was statistically identical to P1M0, and P2M3. The highest value was 34.87% greater than the lowest value. The banana fiber treated with Bacillus sp. yielded the best fiber recovery (Patel and Patel, 2022).

Table 1 The combined effect of plant material and microbial agents on the retting duration and fiber recovery

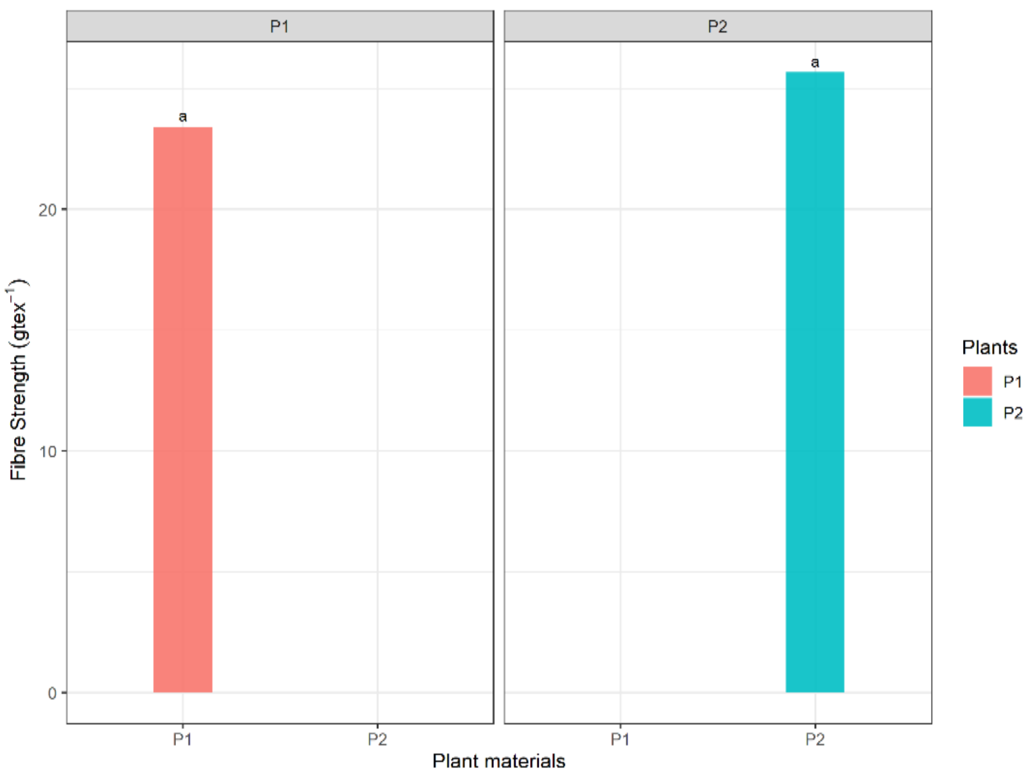
Treatment	RD (Days)	FR (qha-1)
P1×M0	22.33 a	20.33 c
P1×M1	13.00 c	28.67 a

P1×M2	15.33 bc	27.33 ab
P1×M3	16.67 b	26.67 ab
P2×M0	23.67 a	18.67 c
P2×M1	15.00 bc	27.00 ab
P2×M2	16.00 b	25.00 ab
P2×M3	17.00 b	23.00 bc
LSD (0.05)	2.82	4.36
% CV	9.28	10.13

Legends: RD= Retting Duration, FR= Fiber recovery, M1= *Bacillus pumilius*, M2= *Macrophomina phaseolina*, M3= *Aspergillus tererus*, M0= Control, P1= Tossa Pat and P2= Deshi Pat

Effect of plant material on the fiber strength

The results obtained from the data revealed no significant difference between P1 and P2 (Figure 5). But, P2 (25.67 gtex-1) was numerically higher than P1 (23.42 gtex-1). The strength of Deshi Pat was better than Tossa Pat. P2 was 8.77% greater than P1. Deshi pat showed higher fiber strength than Tossa pat; it might be the genetic characteristics of Deshi pat (Mitra, 2022).



Legends: P1= Tossa Pat, P2= Deshi Pat

Figure 5 Effect of plant material on the fiber strength

Effect of microbial agents on the fiber strength

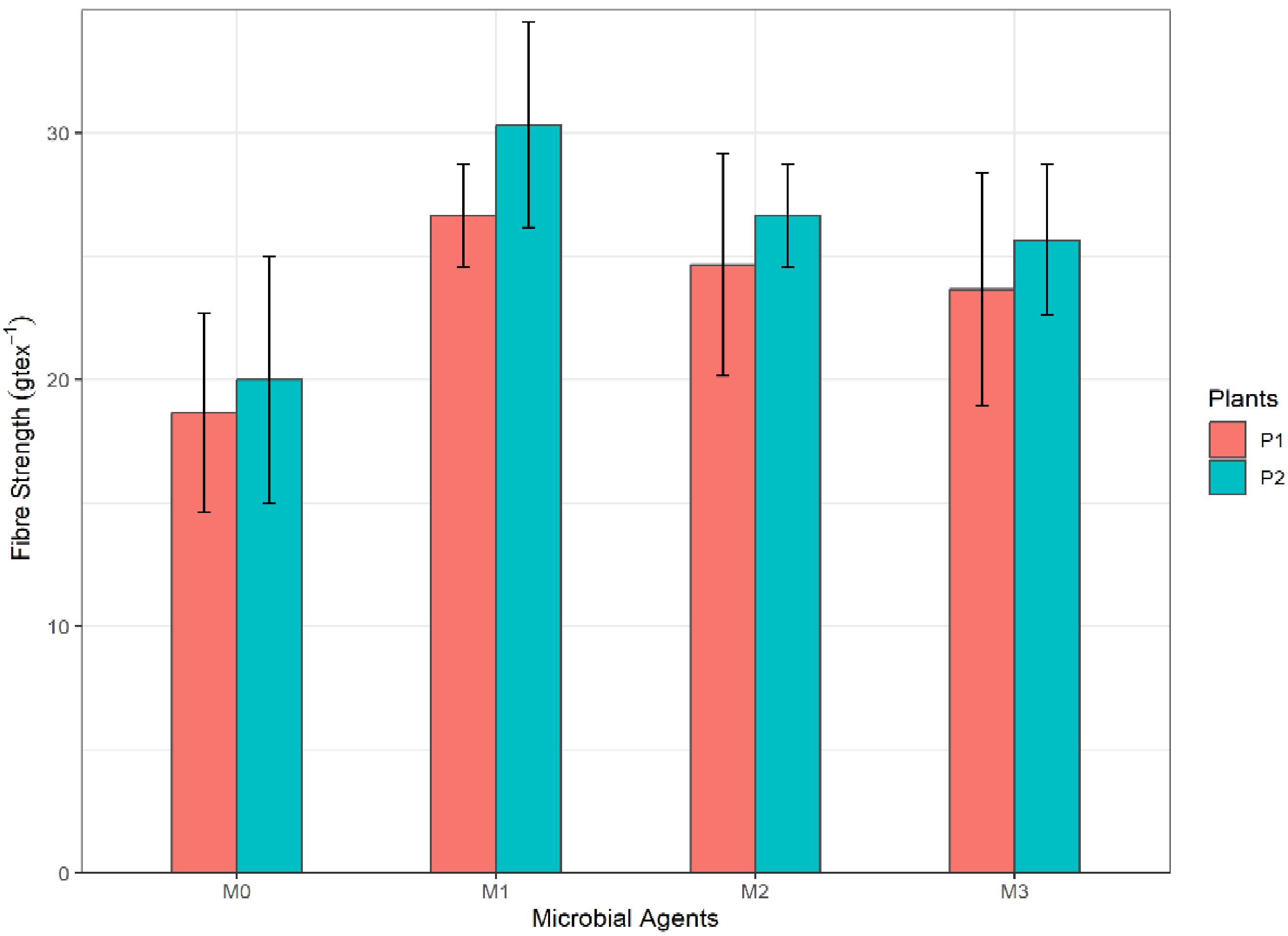
The outcomes from the experiment showed there was a significant difference in the application of microbial agents for fiber strength (Figure 6). The highest results came from the M1 (28.50 gtex-1), which was statistically similar to M2 and M3. The lowest results came from the control M0 (19.33 gtex-1). The M1 was 32.18% greater than M0. The bacterial strains of the microbial consortium were used to create a talc-based microbial formulation to extend its shelf life and make it portable. In field tests, it was discovered that this talc-based formulation could ret jute and mesta in 13 to 15 days with a fiber strength of 27.8 to 29.9 gtex-1.

Effect of plant material on the fiber fineness

In respect of fiber fineness, there was no significant difference between P1 and P2 (Figure 7). But P1 was numerically greater than P2. The value of P1 was 2.56 tex. and P2 was 2.52 tex. P2 was 1.56 % smaller than P1. A previous study showed that fiber fineness is comparatively better in Tossa jute than in Deshi jute (Molla et al., 2010). Fiber fineness is more or less the same at Tossa or Deshi jute.

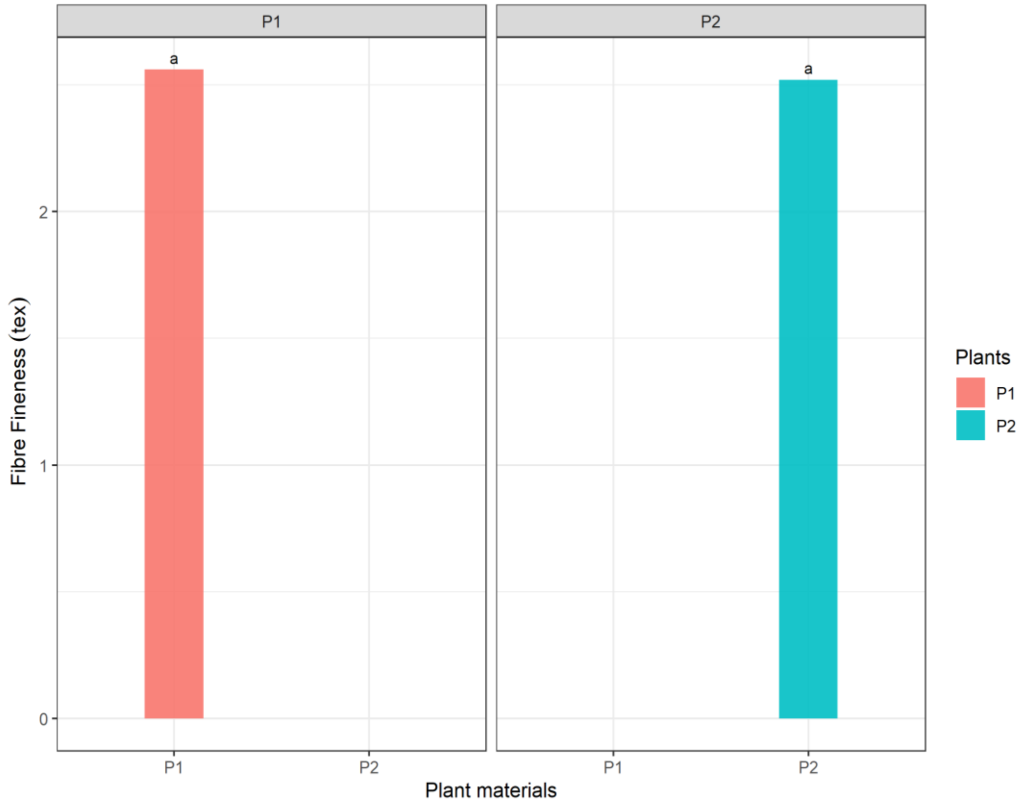
Effect of microbial agents on fiber fineness

A significant difference was observed among M1, M2, M3, and M4 concerning fiber fineness (Figure 8). The highest value was obtained from M1 (2.87 tex.), which was similar to M2 (2.78 tex.). Again, the lowest value was obtained from M0 (1.87 tex.). On the other hand, there was no significant difference between M2 and M3. Here, M1 was 34.84% greater than M0. Adding microbial agents improved the fiber fineness up to 14.7–22.8% (Ray et al., 2022).



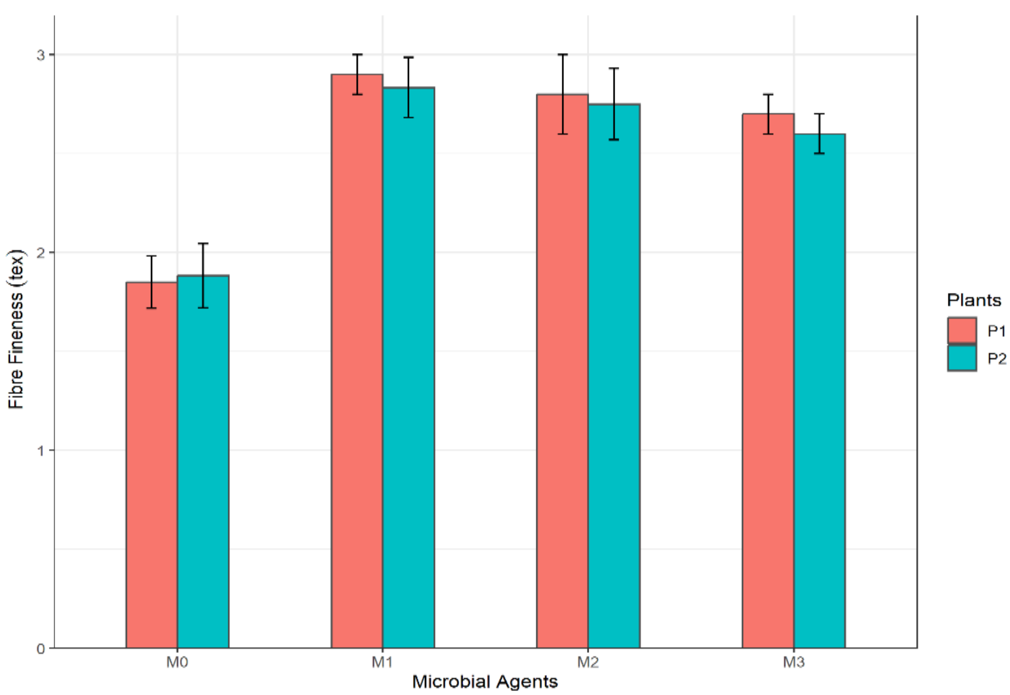
Legends: M1= *Bacillus pumilius*, M2= *Macrophomina phaseolina*, M3= *Aspergillus tererus*, M0= Control, P1= Tossa Pat, P2= Deshi Pat

Figure 6 Effect of microbial agents on the fiber strength



Legends: P1= Tossa Pat, P2= Deshi Pat

Figure 7 Effect of plant material on the fiber fineness



Legends: M1= *Bacillus pumilius*, M2= *Macrophomina phaseolina*, M3= *Aspergillus tererus*, M0= Control, P1= Tossa Pat, P2= Deshi Pat

Figure 8 Effect of microbial agents on the fiber fineness

The combined effect of plant material and microbial agents on the fiber strength and fiber fineness

For fiber strength, there was a significant difference among the treatment combinations (Table 2). The height fiber strength came from the P2M1 (30.33 gtex-1.) combination, which was statistically similar to P2M2, P2M3, P1M1, P1M2, and P1M3. The second highest value came from P1M2 and P2M2, which were statistically identical to P1M2, P1M3, P2M0, P2M2, and P2M3. The lowest value came from the P1M0 (18.67 g tex.) treatment combination, which was statistically identical to P1M2, P1M3, P2M0, and P2M3. The highest value was 38.44% greater than the lowest value. Fiber strength was better in ribbon retting than in traditional retting due to applying microbial agents such as bacterial-bacillus.

For fiber fineness, a significant variation was obtained from the application of microbial agents (Table 2). The highest value for fiber fineness was obtained from the P1M1 (2.90 tex.) treatment combination, which was statistically similar to P1M2, P1M3, P2M1, and P2M2. The second value was obtained from P2M1, which was statistically similar to P2M2, P2M3, P1M2, and P1M3. The lowest value was obtained from P1M0 (1.85 tex.), which was statistically identical to P2M0. The height value was 36.20 % greater than the lowest value. A similar result was found from the previous study: Tossa jute fiber fineness increased due to the application of microbial agents (Ahmed et al., 2023).

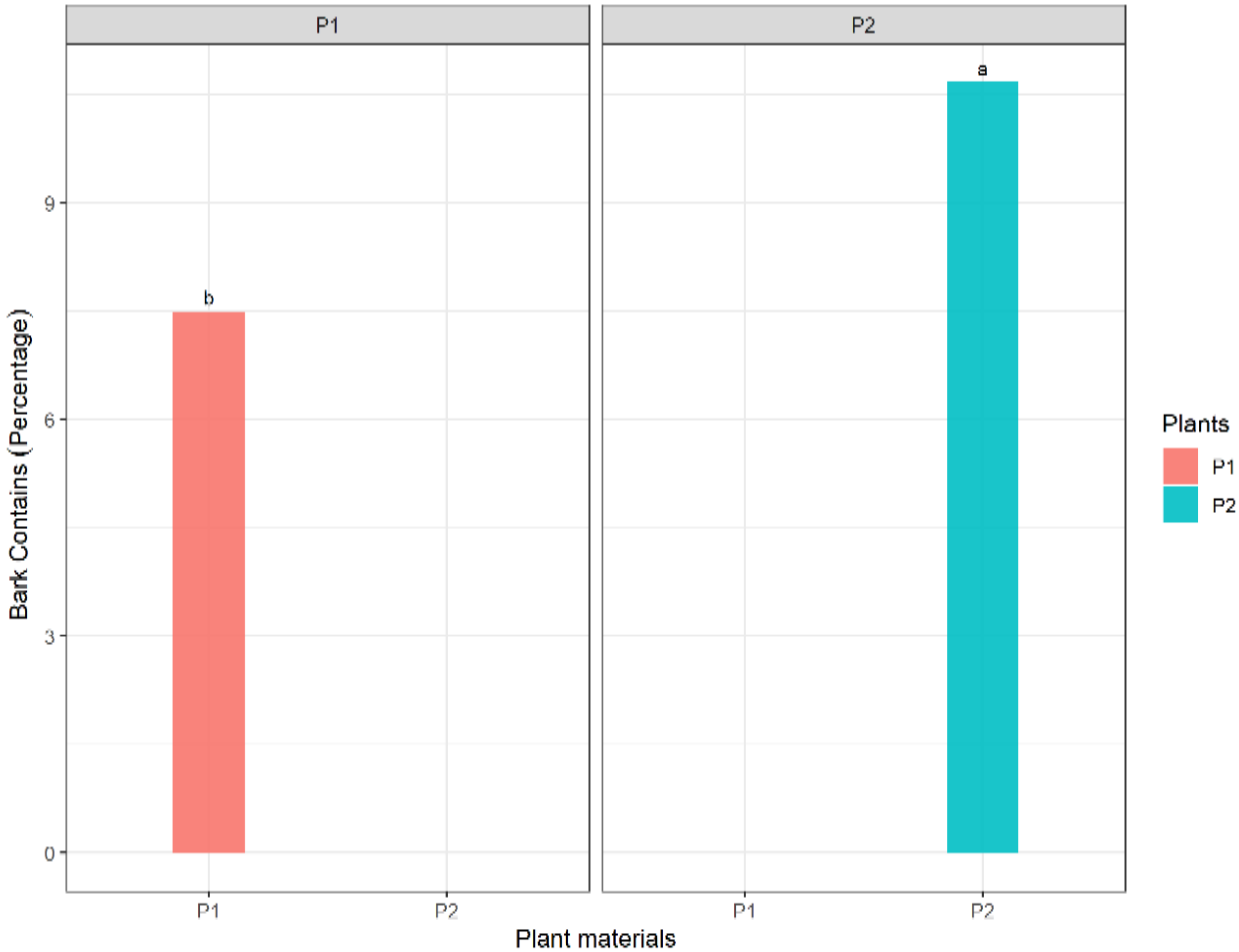
Table 2 The combined effect of plant material and microbial agents on the fiber strength and fiber fineness

Treatment	FS (gtex-1)	FF (tex.)
P1×M0	18.67 c	1.85c
P1×M1	26.67 ab	2.90a
P1×M2	24.67 abc	2.80ab
P1×M3	23.67 abc	2.70ab
P2×M0	20.00 bc	1.88c
P2×M1	30.33 a	2.83ab
P2×M2	26.67 ab	2.75ab
P2×M3	25.67 abc	2.60b
LSD (0.05)	7.01	0.24
% CV	16.31	5.34

Legends: FS= Fiber Strength, FF= Fiber Fineness, P1= Tossa Pat and P2 = Deshi Pat

Effect of plant material on the bark content

One of the most important characteristics of fiber retting is the bark content of the fiber. The results of the experiment showed that there was a distinct distinction between P1 and P2 (Figure 9). The Deshi pat contained more bark than the Tossa pat after retting with microbial agents. The highest value was obtained from P2 (10.67%); on the other hand, P1 contained 7.50% bark on fiber after retting. No bark was contained in microbial-treated fiber (Das et al., 2015).

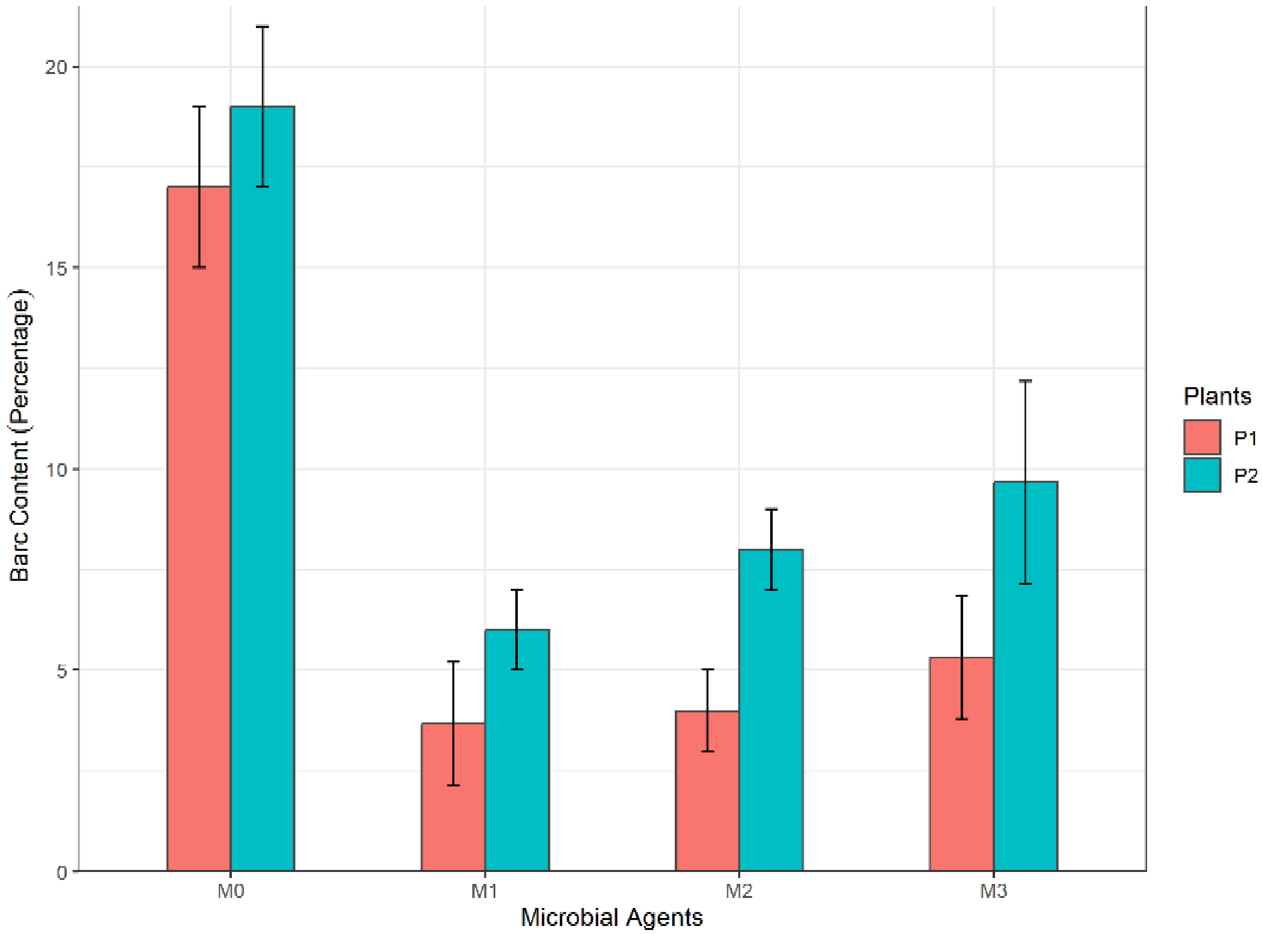


Legends: P1= Tossa Pat, P2= Deshi Pat

Figure 9 Effect of plant material on the bark contains

Effect of microbial agents on the bark contain

There was a substantial difference obtained from the experimental results. The M1, M2, M3, and M0 differ significantly concerning the bark content after retting (Figure 10). The highest bark was obtained from M0, and its numerical value was 18%. The lowest bark was found in M1, and that was 4.83%, which was statistically similar to M2. Again, there was no significant difference between M2 and M3. The percentage of bark in fiber treated with microbial agents ranged from 3-5%, whereas the fiber rate treated without microorganisms was 20–22% (Das et al., 2018).

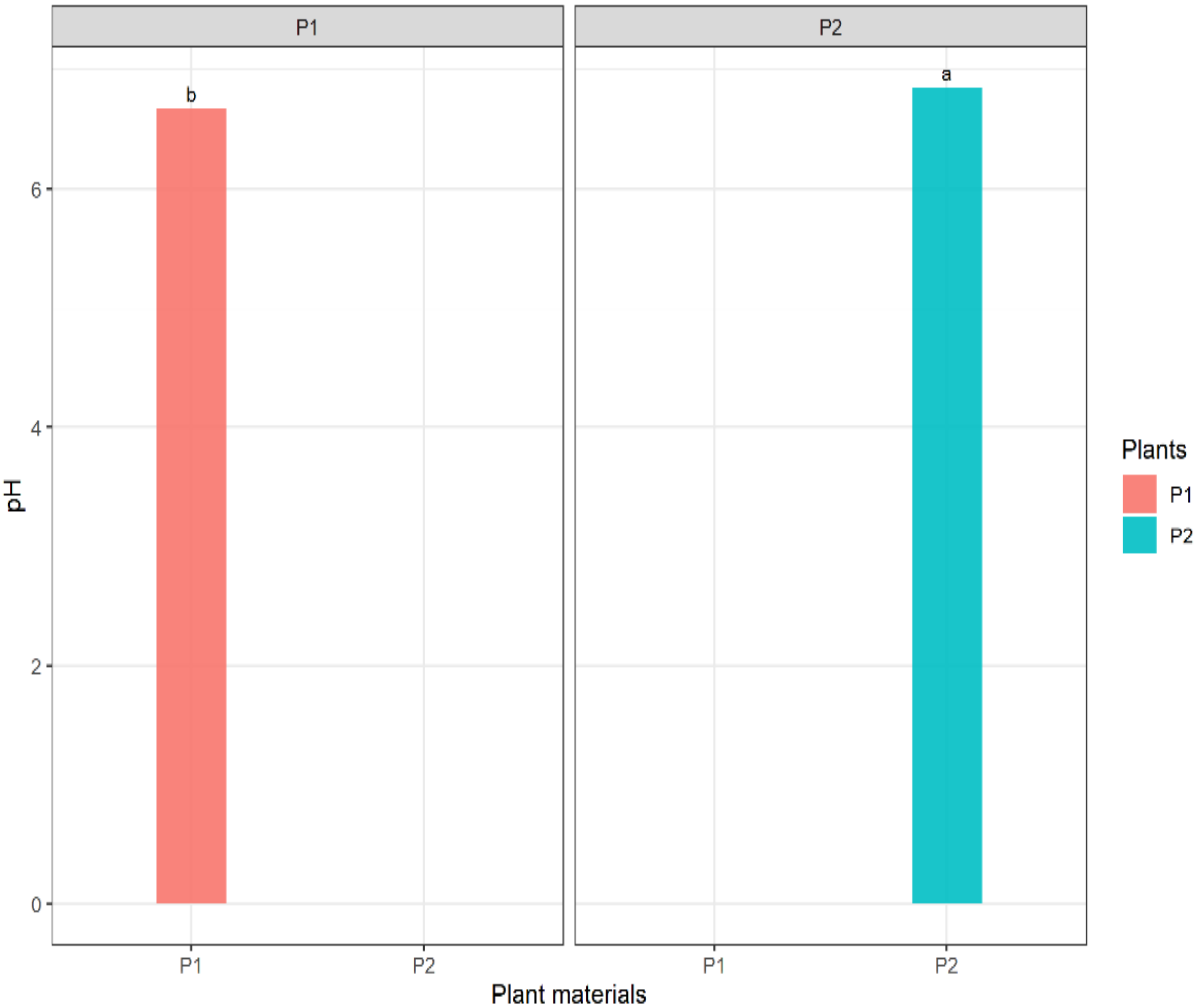


Legends: M1= *Bacillus pumilius*, M2= *Macrophomina phaseolina*, M3= *Aspergillus tererus*, M0= Control, P1= Tossa Pat, P2= Deshi Pat

Figure 10 Effect of microbial agents on the bark contain

Effect of plant material on pH of the retting water

Plant materials affect the pH of retting water. There was a distinct variation between P1 and P2 (Figure 11). The value of P2 was 6.85 and the value of P1 was 6.67. So, the pH value for the Deshi pat was greater than the Tossa pat. And it was 2.63% greater than that of Tossa pat. The pH of retting water decreased due to the application of microbial water. The same results were found in the previous study regarding pH conditions upon application of microbial agents.

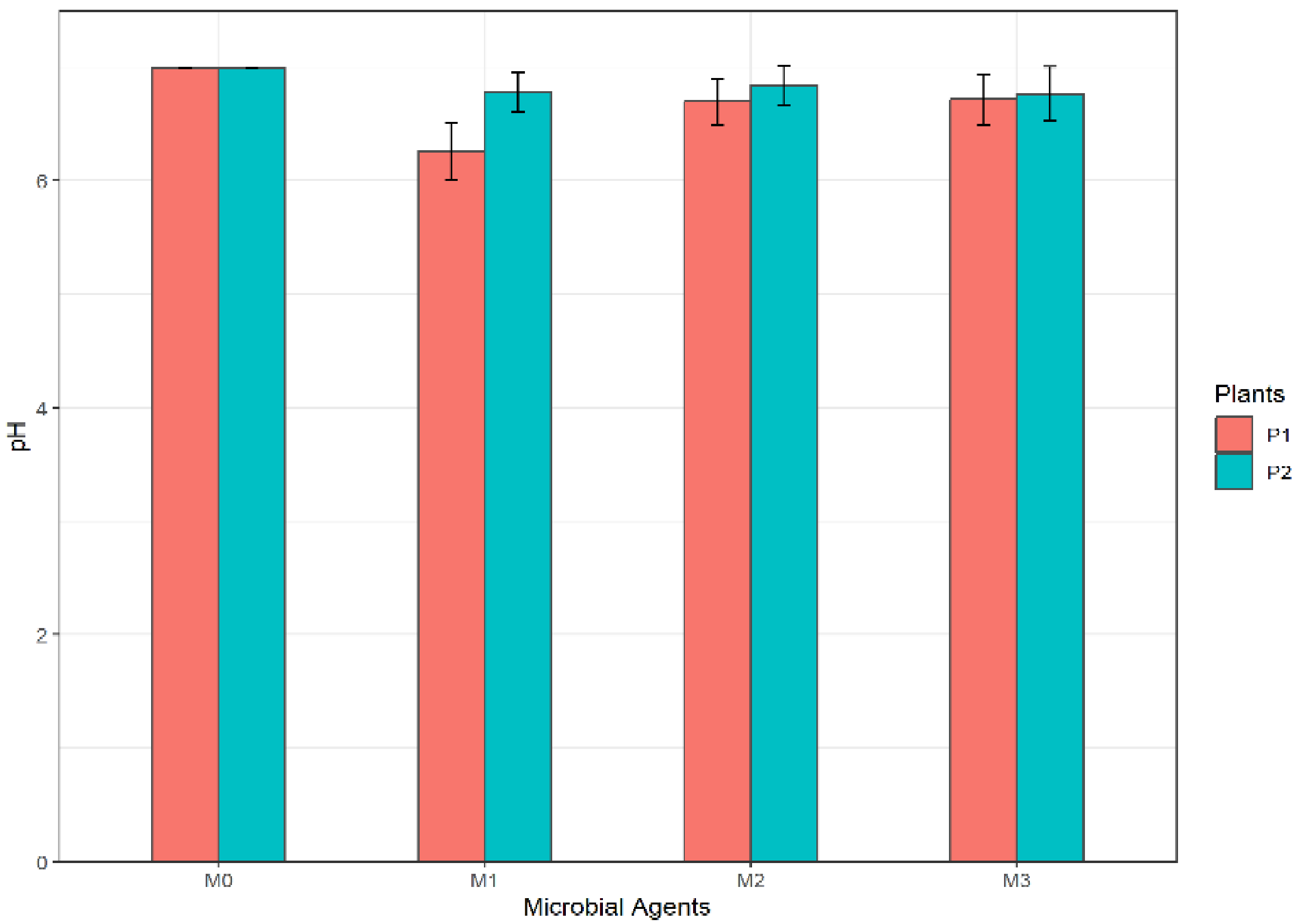


Legends: P1= Tossa Pat, P2= Deshi Pat

Figure 11 Effect of plant material on the pH of retting water

Effect of microbial agents on pH of retting water

The results obtained from the experiment showed a noticeable difference among M1, M2, M3, and M0 (Figure 12). There was an almost neutral pH condition in the case of M0, which means no application of microbial agents. M0 was statistically similar to M2. The pH condition of M1 was 6.53, which was statistically similar to M3. Microbial agents decreased the pH of water during retting due to the addition of microbial agents in retting water (Sumit et al., 2021).



Legends: M1= *Bacillus pumilius*, M2= *Macrophomina phaseolina*, M3= *Aspergillus tererus*, M0= Control, P1= Tossa Pat, P2= Deshi Pat
Figure 12 Effect of microbial agents on the pH condition of retting water

The combined effect of plant material and microbial agents on the bark content and pH

For the treatment combination, there was a valid significant distinction among the treatments concerning bark contain percentage (Table 3). The highest bark content rate was found in P2M0 (19%) treatment combination, which was statistically identical to P1M0 (17%). The lowest bark content rate was found in P1M1 (3.67%), which was statistically identical to P1M2 and P1M3. The second-lowest bark content percentage (4%) was statistically identical to P1M2, P1M3, and P2M1. The bark with the lowest percentage was 15.33 parts lower than the bark with the highest percentage. The low-quality fiber was indicated by a higher bark content in jute fiber, and only 2-3% bark content was found in microbial-treated fiber.

There was a significant difference among the treatment combinations concerning the pH condition of retting water (Table 3). The pH condition of retting water for P1M0 and P2M0 was neutral. And it was statistically identical to P1M2, P1M3, P2M1, P2M2, and P2M3. The pH condition of P1M1 was 6.27. The same results were recorded in an earlier study: The pH condition became somewhat acidic and reached 6.5-7 after adding microbial agents to retting water (Hasan et al., 2020).

Table 3 The combined effect of plant material and microbial agents on the bark content and pH

Treatment	BC (%)	pH
P1×M0	17.00 a	7.00 a
P1×M1	3.67 e	6.27 b
P1×M2	4.00 de	6.70 a

P1×M3	5.34 de	6.72 a
P2×M0	19.00 a	7.00 a
P2×M1	6.00 cd	6.78 a
P2×M2	8.00 bc	6.84 a
P2×M3	9.67 b	6.77 a
LSD (0.05)	2.14	0.33
% CV	13.45	2.82

Legends: BC= Bark Content, pH= Negative logarithm of Hydrogen ion, P1= Tossa Pat and P2 = Deshi Pat

The combined effect of plant material and microbial agents on the fiber color, fiber grade, and luster

The fiber color, fiber grade, and luster—these three parameters—were examined by the physical appearance of fiber and figure feel method by an expert. According to his examination, P1M1, P1M2, and P1M3 showed a bright golden color (Table 4). Again, P2M1, P2M2, and P2M3 showed a light golden color, which means Tossa pat showed a bright golden color and Deshi pat showed a light golden color after microbial treatment. The bacterial consortium could improve fiber color and fineness without using any chemicals (Islam and Rahman, 2013).

According to Table 4, P1M1, P1M2, P2M1, and P2M2 treatment was in grade A. So, there was no significant difference among P1M1, P1M2, P2M1, and P2M2 treatment combinations. P1M3 and P2M3 were in grade B. So, they were statistically similar. And P1M0 and P2M0 were in grade C. Microbes improve the fiber colour (Islam et al., 2013) and artificial inoculation bacteria improve the fiber colour two times better than conventional retting (Banik et al., 2003). P1M1, P1M2, P1M3, P2M1, P2M2, and P2M3 showed bright to shining luster (Table 4). So, there were no significant differences among the P1M1, P1M2, P1M3, P2M1, P2M2 and P2M3 treatment combinations. On the other hand, P1M0 and P2M0 showed dull luster. In the improved retting process, bacterial inoculation improved the luster quality (Das et al., 2018; Ramaswamy et al., 1994).

Table 4 The combined effect of plant material and microbial agents on the fiber colour, fiber grade, and luster

Treatment	**Fiber Colour**	**Fiber Grade**	**Luster**
P1×M0	Greyish to Blackish	C	Dull
P1×M1	Bright Golden	A	Bright to Shining
P1×M2	Bright Golden	A	Bright to Shining
P1×M3	Bright Golden	B	Bright to Shining
P2×M0	Greyish to Blackish	C	Dull
P2×M1	Light Golden	A	Bright to Shining
P2×M2	Light Golden	A	Bright to Shining
P2×M3	Light Golden	B	Bright to Shining
LSD (0.05)	1.14	2.00	1.27
% CV	2.89	6.53	5.79

4. CONCLUSION

Jute is the golden fiber of Bangladesh. It is used as a "cash crop" because of its economic importance, which mainly depends on fibre quality. Among several factors, retting is considered the most important to obtain high-quality fiber. Microbial treatment plays a vital role in retting where water is scarce. The results obtained from the experiment showed that all the parameters positively respond to microbial treatments. It reduced the retting duration from 22-24 days to 13-15 days both in Tossa pat and Deshi pat and improved the fiber quality. Moreover, further trials are required to conclude more specific results.

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Authors contributions

Ahmed M performed the investigation, data interpretation, and formal analysis and adopted the methodology. Tanni JF and Hasan MM were involved in the manuscript writing, microbial consortium preparation and adding scientific suggestions. Parvej SMS1, Jui SA1, Mamun MSA1, Mitra S1, Kader K1 and Sarkar YU1 did a formal analysis and revision of the manuscript. All the authors looked through the manuscript for accession.

Ethical approval

The microbial agents were collected from the retting pond jute research substation, Tarabo, Narayanganj. The ethical guidelines for plants & plant materials are followed in the study.

Informed consent

Not applicable.

Conflicts of interests

The authors declare that there are no conflicts of interests.

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Data and materials availability

All data associated with this study are present in the paper.

REFERENCES

1. Ahmed Z, Rahman T, Timmi UH, Mehrin S. Types, stages and mechanism of action of Jute retting: An overview. IJSRR 2023; 02(02):009–020. doi: 10.56781/ijsrr.2023.2.2.0026
2. Ahmed Z, Sarkar S. Microbial consortium: A new approach in jute retting of preserved dry ribbons. IJSRU 2022; 04(1):126–137. doi: 10.53430/ijsru.2022.4.1.0106
3. Banik S, Basak M, Paul D, Nayak P, Sardar D, Sil S, Sanpui B, Ghosh A. Ribbon retting of jute: A prospective and eco-friendly method for improvement of fiber quality. Ind Crops Prod 2003; 17(3):183-190. doi: 10.1016/S09266690(02)00097-3
4. Barai S, Chattopadhyay L, Majumdar B. Studies on delignification in jute (*Corchorus spp* L.) fiber with promising lignin degrading bacterial isolates. J Environ Biol 2020; 41(4):703–710. doi: 10.22438/jeb/41/4/MRN-1252
5. Chakraborty A, Sarkar D, Satya P, Karmakar PG, Singh NK. Pathways associated with lignin biosynthesis in lignomaniac jute fibers. Mol Genet Genom 2015; 290(4):1523–42. doi: 10.1007/s00438-015-1013-y
6. Chattopadhyay L, Majumdar B, Mazumdar SP, Saha AR, Saha R, Barai S. Use of bacterial endospore with longer shelf-life in improved retting of jute. J Environ Biol 2019; 40: 245–251. doi: 10.22438/jeb/40/2/MRN-854
7. Das S, Majumdar B, Saha AR. Biodegradation of plant pectin and hemicelluloses with three novel *Bacillus pumilus* strains and their combined application for quality jute fiber production. Agric Res 2015; 4:354–364. doi: 10.1007/s40003-015-0188-0
8. Das S, Majumdar B, Saha AR. Comparative study of conventional and improved retting of jute with microbial formulation. Proc Natl Acad Sci India Sect B Biol Sci 2018; 88: 1351–1357. doi: 10.1007/s40011-017-0872-x
9. Datta D, Saha R, Ghorai AK. Conservation agriculture and resource management under jute (*Corchorus* spp.) based cropping systems in eastern India. Curr Sci 2020; 119(6):926-932. doi: 10.18520/cs/v119/i6/926-933

10. Gamalero E, Santoyo G, Glick BR. Plant growth promoters. Encyclopedia of soils in the environment 2022; 418 -427. doi: 10.1016/B978-0-12-822974-3.00177-4
11. Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd Edition, John Wiley and Sons, New York, 1984; 680.
12. Haque MS, Ahmed Z, Asaduzzaman M, Quashem MA, Akhter F. Distribution and activity of microbial population for jute retting and their impact on water of jute growing areas of Bangladesh. Pakistan J Biol Sci 2002; 5(6):704-706. doi: 10.3923 /pjbs.2002.704.706
13. Hasan R, Aktar N, Kabir SM, Honi U, Halim A, Islam R, Sarker MD, Haque MS, Alam MM, Islam MS. Pectinolytic bacterial consortia reduce jute retting period and improve fiber quality. Sci Rep 2020; 10:5174. doi: 10.1038/s41598-020-61 898-z
14. Islam MM, Rahman MM. Advances in jute and allied fibers post-harvest processing technologies in Bangladesh: Adoption constraints, prospect and future thrust. Res Web Pub 2013; 1 (2):20-30.
15. Majumdar B, Saha AR, Sarkar S, Datta S, Mazumdar SP, Saha D, Chattopadhyay L, Barai S, Kar G. Improved microbial retting and quality jute (Corchorus spp.) fiber production in India: A review. Indian J Agric Sci 2022; 92(12):1415–1422. doi: 10.56093/ijas.v92i12.109075
16. Mitra A. Grading of raw jute fibers using criteria importance through inter-criteria correlation (CRITIC) and range of value (ROV) approach of multi-criteria decision making. J Nat Fibers 2022; 19(14):7517-7533. doi: 10.1080/15440478.2021.1951 422
17. Molla MAM, Asaduzzaman M, Shahidullah M, Mollah AK, Khan MAM. Quality assessment of tossa jute of Bangladesh about fiber fineness. J Innov Dev Strategy 2010; 4(1):22-26.
18. Naik RK, Mazumdar SP, Majumdar B, Behera MS. Mechanical extraction of jute and mesta for quality fiber production. J Indian Soc Coastal Agric Res 2018; 36(1):76-79.
19. Patel BY, Patel HK. Retting of banana pseudostem fiber using *Bacillus* strains to get excellent mechanical properties as a biomaterial in the textile & fiber industry. Heliyon 2022; 8: e10652. doi: 10.1016/j.heliyon.2022.e10652
20. Ramaswamy GN, Ruff CG, Boyd CR. Effect of bacterial and chemical retting on kenaf fiber quality. Tex Res J 1994; 64(5):3 05. doi: 10.1177/004051759406400507
21. Ray DP, Ghosh RK, Saha B, Sarkar A, Singha A, Mridha N, Das I, Sardar G, Mondal J, Manjunatha BS, Shakyawar DB. Accelerated retting technology for the extraction of golden fiber from the Indian tossa jute (Corchorus sp.). J Clean Prod 2022; 380(2):135063. doi: 10.1016/j.jclepro.2022.135063
22. Roy G, Bhattacharya GK, Sengupta S, Mukherjee M. A new electronic fiber bundle strength tester for jute. J Inst Eng 2009; 89:10–13.
23. Roy G, Saha SC. An automatic integrated jute grading instrument. IJCA 2013; 3–15.
24. Sengupta G, Palit P. Characterization of a lignified secondary phloem fiber-deficient mutant of Jute (*Corchorus capsularis*). Ann Bot 2004; 93:211–220. doi: 10.1093/aob/mch029
25. Song H, Qian J, Fan L, Toda T, Li H, Sekine M, Song P, Takayama Y, Koga S, Li J, Lu Q, Li J, Xu P, Zhou W. Enhancing biomass yield, nutrient removal, and decolourization from soy sauce wastewater using an algae-fungus consortium. Algal Res 2022; 68:102878. doi: 10.1016/j.a lgal.2022.102878
26. Sumit S, Shivani R, Sarita, Abhishek K, Manish K. Improved retting methods of jute to enhance fiber quality and retting waste management. J pharmacogn phytochem 2021; 10(1):261 4-2618. doi: 10.22271/phyto. 2021.v10.i1ak.13754
27. UNDP, FAO. Land Resources Appraisal of Bangladesh for Agricultural Report No. 2. Agro-Ecological Region of Bangladesh. United Nations Development Program in Food and Agriculture Organization, 1988; 212-221.