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Popular Article

Comprehensive Technique for Jute Fibre Retting

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Abstract

Jute is one of the important cash crops of in the South East Asian countries like India, Bangladesh etc. The extraction of mature jute fibre by natural microbial process known as retting. The microbes involves in retting process consume the non-fibrous cementing materials like pectin and hemicellulose. Both over and under retting reduce the fibre quality. The main problem of Jute cultivation of these areas is the retting problem due to unavailability of sufficient amount good quality of free flowing mild water during the harvesting time of the Jute due to irregularity of Monsoon rain i.e. May-June. In conventional retting process, decomposition of whole jute plant in stagnant water, so retting causes environmental pollution as well as reducing the quality of fibre. In ribbon retting, ribbons are stripped out mechanically from the stem of mature jute plants, coiled and allowed to ret under water. Ribbon retting reduces time of normal retting by 4 to 5 days. Moreover, requirement of water for ribbon retting is almost half in comparison to conventional whole plant retting under normal condition. This also reduces environmental pollution to a great extent. But use of efficient pectinolytic microbial consortium improves quality of fibre, further reduce the time of retting and the environmental pollution. There for the present study indicates the appropriate method of retting method to enhance the quality of the Jute fibre in terms of fibre strength, colour and txture for the thousands of jute growers South East Asian Countries based on the available technological resources.

1. Introduction

Jute (*Corchorus* spp.) is a very important fibre and cash crop (Talukder et al., 2001; Ali et al., 2002) in the Indian subcontinent and also Jute is also the second most common natural cellulosic fibre in the world, is currently attracting more attention than the petroleum-based fibres (Liu et al., 2010). Almost 85% of the world's jute cultivation is concentrated in the Gangetic delta of Bangladesh and India (Das et al., 2011). The total area under jute cultivation in India is about 0.91 mha which produces about 11.57 mt (Directorate of Economics and Statistics, 2014) which is highest in the world. Millions of poor and marginal farmers are confined to the cultivation of Jute especially in these areas. The retting process is the major limitation to an efficient and high quality fibre production (Das et al., 2011).

The retting of jute is a kind of fermentation process in which the cortical and phloem tissues of the bark of the plants containing free stands are decomposed to separate fibre from non-fibrous woody stem (Asaduzzaman and Abdullah, 1998). The fermentative microorganisms (Table 1) consume the cementing materials viz., the pectins, hemicelluloses and proteins with release of galacturonic acid and sugar in retting water (Basak et al., 1998). But in recent years gradual decrease in the production and quality of the jute is noticed (NABARD, 2013). One of the main factors of the reduction in the production & quality of the jute is the improper and traditional retting technique of Jute (Banik, 2008). Changing in the traditional retting method is very much urgent by speeding up retting process to improve the fibre quality and reduce production costs (Pallesan, 1996). At present, one of the most promising retting processes is the water based microbiological retting (Candilo et al., 2010). However, most of the problems of jute retting in the Indian subcontinent is the less availability of fresh water in the retting season (Ghorai et al., 2009) can be minimized through ribbon retting along with inoculation of retting mixed bacterial culture. This modified retting method reduces: (a) the requirement of water from 1:20 to 1:10 substrate liquor ratio; (b) the length of retting time from 14-15 to 7-8 days; and (c) the level of environmental pollution to almost one-fourth in comparison to that of whole plant retting besides assurance of producing better quality jute fibre in terms of fibre strength,

fineness, colour, lusture and overall absolutely bark free jute fibre (Alam, 1998; Data book on jute, 1999).

2. Traditional Jute Retting Method

Jute Fibre is one kind of stem fibres composed of the Cellulose, hemi-cellulose, lLignin, water soluble matter (Banik et al., 2003). The amount of the α-cellulose & lignin varies greatly with the method of retting process (Kozolowski et al., 2006). During retting the cortical and phloem tissues of the bark of jute plants containing free stands are decomposed to separate fibre from non-fibruos woody stem (Asaduzzaman et al., 1998). This is accomplished by allowing the harvested stalks to undergo a decomposition process in water. At the appropriate temperature, natural micro-organisms present in water act on jute tissues and gradually soften them, so that the residues are washed away leaving the fibre intact (Pritt, 1988). Although the process is basically a simple one, timing is important in obtaining good quality fibre. If the stem is under-retted, fibremay not be soft enough to remove it from the bark. Over-retting is equally harmful since the bacteria may break down the plant tissues as well as also attack the fibre bundles thus weakening the fibre strength (Banik, 2008).

The process of retting can be divided into two distinct phases' i.e. physical phase and biochemical phase (Paul, 1978). The physical phase begins when the harvested plants are put in water. The tissues absorb water and swell, releasing soluble components into the water. In the biochemical phase, the released substances (carbohydrates, nitrogenous compounds and salts of different kinds) facilitate growth and multiplication of the microbes in the retting water, prior to their entry into the reeds (Yadav, 2009). These organisms develop and multiply by utilizing free sugars, pectins, hemicelluloses, proteins of the plants as nutrients.

When retting is complete, bundles are taken out of water and fibre is extracted manually one by one i.e. single plant extraction or by beat-break-jerk method i.e. multiple plant extraction. The efficiency of retting depends on a number of factors such as age of the plant, water quality, pH and temperature (Bera et al., 2009). Mature plants of above 110 days accumulate more of lignin and are hence difficult for decomposition (Banik, 2008). Soft and slow moving water having a pH of 6.0 to 8.0 is convenient for retting (Broker, 2007). The optimum temperature for jute retting is around 34-36°C at which the process is completed in the minimum time due to the accelerated activity of the retting microflora. Microbial action in retting water is highest at a depth of 15 cm from the surface of water and retting is quicker and better at this depth. Some microbial action is evidenced even up to depth of 35 cm, but below this particularly no effect has been observed (Gupta D., 2006). Natural activators like Dhaincha (*Sesbania aculeata*) and sun hemp (*Crotalaria juncea*) which are generally introduced into the jute stem bundles before they are put in water for retting by the local farmers (AINPJAF, 2004). These leguminous plants being rich in nitrogen content help the growth and activity of retting microbes by supplying additional nutrients to them.

Owing to shortage of water, farmers are compelled to let their harvest decompose in local ditches, way side water bodies, canals and ponds which are meant for community use. Generally, the harvested jute out of traditional retting are of low quality as there is virtually no control over the water quality and temperature (Guha, 1999). This apart, results in polluting the stagnant water which subsequently becomes breeding ground of mosquitoes and thus pollutes the local environment (Mitra et al., 2006). Traditional retting also involves manual labour inside this polluted water causing irritation to skin and health hazards. Sometimes labours decline to process them owing to these reasons and they may charge a higher wage. Further, on account of poor quality jute out of traditional retting, it fetches a lesser price and limits its use for making jute diversified products (JDPs) (AINPJAF, 2008).

Depending on the sufficiency of the above factors, a conventional retting process takes about 16-20 days (CRIJAF, 2008). Thus, the conventional retting process is not only dependent on many natural factors but also is a potential reason of pollution, depending on water availability and likely to result in inferior quality jute.

3. Problem Faced in Retting

Most of the jute farming has taken up by small and marginal farmers with a poor resource base in Jute growing Asian countries (Nayak et al., 1996). Adoption of improved technologies by these farmers has shown lukewarm progress. Most of the farmers did not adopt any improved technologies for jute cultivation (Khairul, 2012). This situation has contributed to non-uniform productivity of jute growing

Table 1: Microbes involves in jute retting

Bacteria		Fungus
Aerobic	Anaerobic	
Bacillus subtilis, B. polymixa, B. macerans Sources:Kundu and Roy (1962); Bhattacharya (1974)	*Clostridium* sp. Source: Alam (1998)	*Aspergillus niger, Macrophomina phaseolina, Phoma* sp., *Trichoderma* sp. Sources :Kundu and Roy (1962); Haque et al. (2002)

regions in different agro-climatic regions of South East Asian countries especially India and Bangladesh (Kundu, 1964). Availability of high grade good quality fibre is limited due to scarcity of high volume of free flowing sweet water, improper retting technologies and post-harvest management that leads to shorter length, dull colour and rough surface with increased proportion of cuttings and faults (Azad, 2002). It is reported that numbers of problems (Mohammad et al., 2002) is faced by the marginal jute growers in this regions are

- Scarcity of water in the jute retting season due to erratic and unpredictable monsoon.
- Unavailability of skilled agriculture labour (Sikder, 1988).
- Improper and traditional retting technology among the farmers.
- Average land holding size of the marginal farmer, as they are unable to purchase any modern agriculture equipment and farm machineries to enhance their productivity.
- Unpredictable price fluctuation in every year of raw jute and jute based products.

4. Comprehensive Technique for Retting

Lack of availability of sufficient amount fresh water during retting time (Mohammad et al., 2002 and Banik, 2008) is the major problem for quality jute fibre production. So a modification or improvement in the traditional retting method is very much urgent. It may done by speeding up the retting process to improve the fibre quality, thus reduce the production costs (Pallesan, 1996). Researches have been conducted by various scientists (Bailey et al., 1992; Bandhopadhyay et al., 1964) to standardize appropriate technology in the Indian subcontinent. At present, one of the most promising retting processes is the water based microbiological retting (Candilo et al., 2010). But the benefit of this microbial retting of jute can be minimized through ribbon retting (Banik, 2008) along with inoculation of bacterial culture (Das et al., 2012) in the retting process. However, a economically efficient method is of utmost need to benefit farmers. Combination of the following methods and technologies may give best result under South East Asian countries

4.1. Use of jute fibre extractor

Jute fibre extractor is a light in weight (about 50 kg) machine fit for field condition. Freshly harvested jute plants (5-6 numbers) are fed into the machine by inserting 10-15 cm tip end; ribbon separation unit is operated by pressing with foot followed by pulling back the cane manually (CRIJAF, 2011). Green ribbon remains in the hand of the operator while unbroken stick is ejected forward. Green ribbon extraction capacity with this machine is equivalent to about 25 kg dry jute fibre hour^{-1}; whereas by traditional whole plant retting method, manual fibre stripping capacity of a labourer is about 5 kg dry jute fibre hour^{-1}.

The equipment is cheap, easy to operate and time saving, less amount of water required. Here, not only the quality is much higher than general method, but also total cost for transport and labour can be reduced sustainably.

4.2. Mechano-microbial retting for jute

The use efficient pectinolytic bacterial consortium identified and developed by ICAR-CRIJAF for retting has been exploited (Table 2). It was found that green jute ribbons extracted could be retted within 6 to 10 days for *Capsularus* jute and 12 to 18 days of *Olitorius* jute (Figure 1). Under various agro-climatic condition of jute growing areas, fibre quality of *Capsularis* can be improved above W-3 and above TD-3 for *Olitorius* jute (Table 3).

4.3. In situ jute retting method

By utilizing *in-situ* retting method, jute can be retted with less volume of ground water. A polyethylene lined circular micropond of 6.5 m floor diameter, 7.5 m top diameter, 1 m deep with 1 m wide earthen embankment is sufficient (CRIJAF, 2012) for 0.13 ha area. Microbial consortium used can complete retting within 12-18 days in case of *Olitorius* jute compared to 18-22 days under conventional retting (Banik et al., 2003).

4.4. Retting arrangement of the jute fibre in the in-situ retting tank

A modified and special retting arrangement is very essential for quality production of the fibre. Sand bag, straw, rock bolder etc. may be used for putting the jute plant in submerged condition (about 15 cm under water). It may help to avoid the production of the ferrous-tannin present in the soil and wood (Das et al., 2012). Farmers can use cement bags filled with soil or sand.

Removal of the dark water at 7 days interval two times can give better quality fibre. The water can be used in the rice

Table 2: Pectinolytic bacterial consortium identified by the CRIJAF

Bacterial strain isolated	Morphology	Gram character	Gen bank accession code
Bacillus pumilus strain IK-MB12-518F	Spore forming rod	+ve	GQ891105
Bacillus pumilus strain EK-17	Spore forming rod	+ve	GQ891098
Bacillus sp. L6	Spore forming rod	+ve	GQ891097
Bacillus pumilus strain Geo-03-422	Spore forming rod	+ve	GQ891103

Source: Das et al., 2012

cultivation because it is very rich in the nutrient such as N, P, K and Zn (Bhattacharyya, 1974).

4.5. Extraction of the jute fibre

Jute fibre should be extracted from the jute plants when they are completely retted. The fibre are extracted and cleaned in the good quality water to get golden-yellow coloured fibre.

4.6. Quality of the produce

The cleaned and extracted jute fibre which is produced from the modified retting method is of high quality fibre with less amount of pectin and high amount of α-cellulose content (Table 4) and also golden-yellow in colour (Das et al., 2012).

Table 3: Effects of the inoculation of a mixed bacterial culture on retting time, fibre strength, fibre fineness and grade of two different jute cultivars, harvested at various plant ages

Treatment	Age of plant (days)	Retting time (days)	Fibre strength (g tex^{-1})	Fibre fineness (tex)	Grade[b]
Capsularis jute: Water temperature (30°C)					
Control	100	8	24.3	1.7	W-3
Inoculated[a]	100	7	26.2	1.4	W-3 44% up
Control	110	9	23.2	1.9	W-4
Inoculated[a]	110	7	23.1	1.4	W-4 47% up
Control	122	14	25.0	2.2	W-5 67% up
Inoculated[a]	122	10	24.6	0.9	W-4
Olitorius jute: Water temperature (27°C)					
Control	100	19	22.1	2.0	TD-3 75% up
Inoculated[a]	100	16	21.6	2.3	TD-3 50% up
Control	112	21	24.3	2.4	TD-3 6% up
Inoculated[a]	112	18	22.1	2.3	TD-3 50% up
Control	120	22	23.9	2.5	TD-3 31% up
Inoculated[a]	120	19	22.1	2.3	TD-3 19% up

[a]Inoculated with retting mixed bacterial culture.

[b]Jute grading method as the guideline of NIFJAFT (W- Grading number Capsularis jute, TD- Grading number of Olitorius jute). Source: Banik, 2003; CRIJAF, 2007.

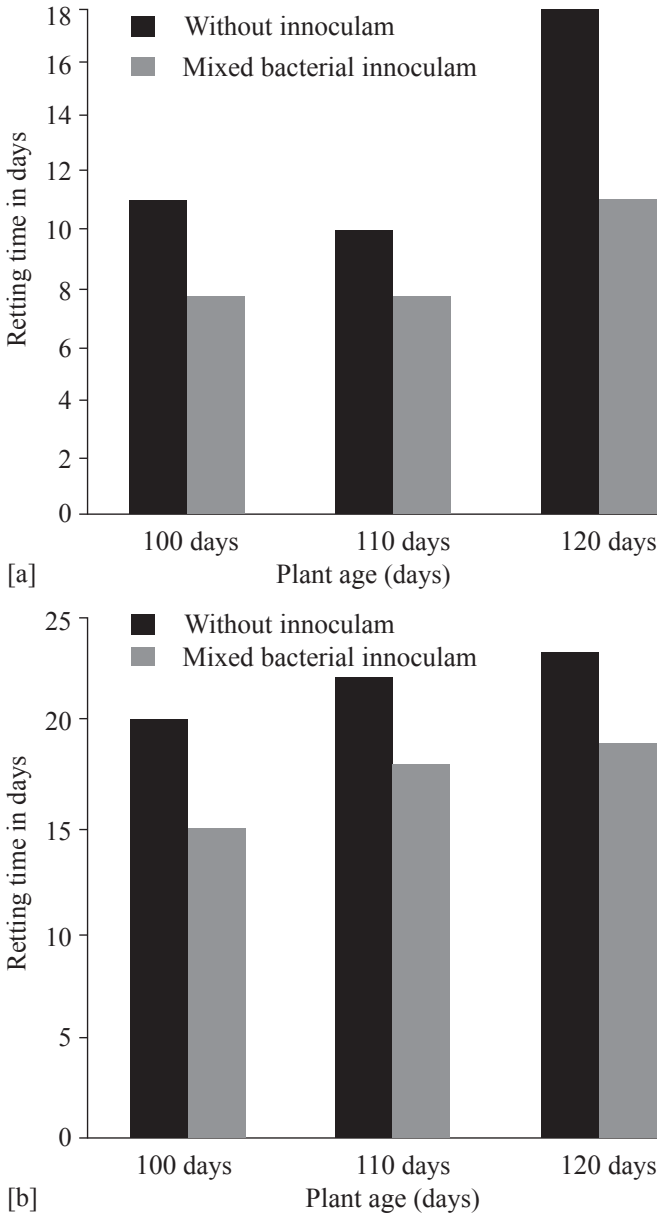

Figure 1: Effect of innoculation of bacterial culture on the retting time of ribbon retted of jute [a] *Capsularis* jute, [b] *Olitorius* jute. Source: Modified after Banik et al., 2003.

Table 4: Chemical constituents of *Capsularis* and *Olitorius* jute after ribbon and whole plant retting

Sample	Fat and wax	Pectin	Lignin	Pentosan	Holocellulose	α-Cellulose	Ash
Olitorius (%)							
Green ribbon	1.35	7.81	11.25	18.12	61.85	42.61	5.44
Ribbon retted jute	0.4	0	12.23	17.22	87.13	58.67	0.54
Whole plant retted jute	1.0	1.5	12.5	15.6	86.7	60.7	0.79
Capsularis (%)							
Green ribbon	1.4	7.5	11.0	14.9	62.8	43.0	6.3
Ribbon retted jute	0.72	0	11.63	16.29	86.27	58.6	0.75
Whole plant retted jute	0.9	1.5	13.2	15.9	86.5	61.0	0.5

Source: After Mitra, 2003; Banik et al., 2003

Table 5: Comparative study between the traditional retting method and modified method

Point identified	Traditional retting method	Modified retting method
Time of retting	18-20 days	12-15 days
Space of retting area	10 m diameter for 0.13 ha land	6.5 m diameter for 0.13 ha land
Stem:water ratio	1:20	1:10
Quality of the jute fibre	IV to V grade	I to II grade
Color of the fibre	More or less gray to white blackish	Generally yellow to golden yellow
Market price of the jute fibre	₹ 1800 q^{-1}	₹ 2300 q^{-1}
Labour required (in 8 hour man days) MD=Man days	100 MD	65 MD
Quality of the stick	Low and easily breakable	High graded and high fuel value
Amount of the root in the jute	Very high amount	Negligible amount

5. Constraint

Availability of the jute extractor and the microbial consortium is still a constraint to facilitate available technology at large scale in the farmers' field.

6. Conclusion

Ribbon retting of jute along with inoculation of bacterial culture may be one of the most promising eco-friendly technique to produce high quality of jute fibre.

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