- Review articles

Plant Tissue Cult. & Biotech. **18**(2): 197-220, 2008 (December) **PTC&B**

Jute - Microbiological and Biochemical Research

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Key words: Jute, Chemical composition, Bast fibre, Jute-cotton yarn, Transformation

Abstract

The role of microorganisms obtained from jute *(Corchorus* spp.*)* in the retting of dry ribbons of jute was determined. Efficiency of fungus on retting of green ribbon and dry ribbon of jute was also examined. Attempt was made to determine the effect of nature of the harvested jute plants on the production of cuttings and improvement of their fibre quality, and the impact of stem-water ratio and retting of its top and basal parts separately on the quality of fibre. Distribution and activity of microbial population for jute retting and their impact on the water quality of jute growing areas of Bangladesh was also surveyed. Utilization and suitability of retting effluents as a fertilizer in vegetable crops production were also determined. *Micrococcus* spp. were identified as an accelerator of jute retting. Referring to the recent advancements made in isolating completed/partial genes controlling desirable traits, it is suggested to use the modern molecular technology not only to improve the quality of jute fibres but also bioengineer microbial flora to further reduce the retting time without sacrificing fibre qualities.

Introduction

Jute is a natural long, soft, shiny vegetable fibre that can be spun into coarse, strong threads. It is produced from plants in the genus *Corchorus*, belonging to the Malvaceae. Jute is one of the cheapest natural fibres and is second only to cotton in amount of production and the variety of uses. Jute fibres are composed primarily of the plant materials, cellulose (major component of plant fibre) and lignin (major components of the wood fibre). It is thus a ligno-cellulosic fibre that is partially a textile fibre and partially wood. It falls into the bast fibre category (fibre collected from bast or skin of the plant) along with kenaf, industrial hemp, flax (linen), ramie, etc. The industrial term for jute fibre is *raw jute*. The fibres are off-white to brown and 1 - 4 meters (3 - 12 feet) long. Jute fibre is often called hessian and jute fabrics are also called hessian cloth. Jute

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sacks are called gunny bags in some European countries. The fabric made from jute is popularly known as burlap in North America. The suitable climate for growing jute (warm and wet climate) is the monsoon season. Temperatures ranging 20 to 40°C and a relative humidity of 70 - 80% are favourable for successful cultivation. Jute requries a weekly rainfall of 5 - 8 cm with an extra amount during the sowing period. Due to its good spinning quality, it is a good textile fibre. -

Jute grows abundantly in Bangladesh having best quality in comparison with that of India. At present jute and jute goods are facing many problems both at home and abroad. There is steady fall of prices in the jute and jute goods in the International market in the face of tough competition with the synthetic fibre of the inferior quality. Moreover, quality control of jute and jute goods supplied by Bangladesh in the international market is not maintained properly thus contributing to unfair prices (Islam et al. 2002, Ahmed et al. 2003, Basu et al. 2005).

Features of jute

- Jute fibre is 100% bio-degradable and recyclable and thus environment friendly. They are possibly the world's largest source of lingo-cellulosic bast fibre which is extracted from plants by a natural microbial process known as retting (Pan et al. 2000, Roy et al. 2002, Mohiuddin et al. 1987).
- It is a natural fibre with golden and silky shine and hence called *The Golden Fibre*.
- It is the cheapest vegetable fibre procured from the bast or skin of the plant's stem.
- It is the second most important vegetable fibre after cotton, in terms of usage, global consumption, production and availability.
- It has high tensile strength, low extensibility and ensures better breathability of fabrics. Therefore, jute is very suitable in agricultural commodity bulk packaging.
- It helps to make best quality industrial yarn, fabric, net and sacks. It is one of the most versatile natural fibres that has been used in raw materials for packaging, textiles, non-textile, construction and agricultural sectors. Bulking of yarn results in a reduced breaking tenacity and an increased breaking extensibility when blended as a ternary blend (Basu et al. 2005).
- Advantages of jute include good insulating and antistatic properties, as well as having low thermal conductivity and a moderate moisture regain. Other advantages of jute include acoustic insulating properties and manufacture with no skin irritations (Pan et al. 2000).

- Jute has the ability to be blended with other fibres, both synthetic and natural, and accepts cellulosic dye classes such as natural, basic, vat, sulfur, reactive and pigment dyes. As the demand for natural comfort fibres increases, the demand for jute and other natural fibres that can be blended with cotton will increase (Sreenath et al. 1996; Basu et al. 2005). The resulting jute/cotton yarns will produce fabrics with a reduced cost of wet processing treatments. Jute can also be blended with wool. By treating jute with caustic soda, crimp, softness, pliability and appearance is improved, aiding in its ability to be spun with wool. Liquid ammonia has a similar effect on jute, as well as the added characteristic of improving flame resistance when treated with flameproofing agents (Basu et al. 2005, Pan et al. 2000).
- Some noted disadvantages include poor drapability and crease resistance, brittleness, fibre shedding and yellowing in sunlight. However, preparation of fabrics with castor oil lubricants result in less yellowing and less fabric weight loss, as well as increased dyeing brilliance. Jute has a decreased strength when wet and also becomes subject to microbial attack in humid climates.
- Jute can be processed with an enzyme in order to reduce some of its brittleness and stiffness. Once treated with an enzyme, jute shows an affinity to readily accept natural dyes, which can be made from marigold flower extract. In one attempt to dye jute fabric with this extract, bleached fabric was mordanted with ferrous sulphate, increasing the fabric's dye uptake value. Jute also responds well to reactive dyeing (Chattopadhyay et al. 2004). This process is used for bright and fast coloured value-added diversified products made from jute.
- Dioxane acidolysis lignin was isolated from jute stick. Jute seed cake was found low in protein and high in lysine, isoleucine and fibre content (Ahmed et al. 2001).

Chemical composition of different jute varieties: Commercial jute fibres are derived from two species of *Corchorus.* Tossa jute fibre derived from cultivars of *C. olitorius* is softer, silkier and stronger than that of White jute produced by those of *C. capsularis*. Along with White, Tossa jute is cultivated in the soil of Bengal from the start of the 19th century. Currently, the Bengal region (West Bengal, India and Bangladesh) is the largest global producer of the Tossa jute. Islam et al. (2002) studied the physical and mechanical parameters of some exotic Tossa jute cultivars (JRO 632, JRO-878, JRO-524). They found that of the three varieties of Tossa jute, namely O-9897, OM-1 and O-4 released by Bangladesh Jute Research Institute (BJRI), the fibre yield of var. O-9897 is the highest (4.29) ton/ha. The same variety was also found to produce higher grade of fibre (BTB+) with significantly lower percentage of cutting (7.50%). The highest value of fibre strength was observed in the same variety (10.98 lbs/mg). Fibre strength varied from 6.65 to 13.38 lbs/mg. Some exotic varieties showed poor germination, premature flowering and a higher level of disease infestation (Islam et al. 2002). Chemical composition of fibres of different pipeline varieties of jute (*C. capsularis* and *C. olitorius)* have been studied by Ahmed et al. (2003). The selected promising varieties were C-718, C-2005, C-2193, C-2035 and OM-1. They were studied for their moisture content (%), cellulose content (%), hemicellulose content (%), lignin content (%), ash content (%) and fat content (%) in three different parts of the plant- top, middle and bottom. Moisture content was found the highest (12.6855%) in the bottom part of C-2035 and the lowest (8.24%) in the top part of C-2005. In the bottom part of C-718, cellulose content was found the lowest (58.24%) and the highest in the top part of C-2035 variety. Hemicellulose was found highest (23.73%) in the top part of OM-1 and the lowest (16.39%) in the middle part of C-718. The lignin content was 17.98 in the bottom part of C-718 which seems to be the highest and the lowest (13.61%) in the top part of C-2193. In the top and bottom parts of C-2005, ash content was found the lowest (0.112%) and the highest (0.995%), respectively. Fat content was highest (2.172%) in OM-1 and lowest (1.099%) in C-2193 (Ahmed et al. 2003). Hussain et al. (2002; Table 1) analyzed the lignin content of different jute samples where the values of the lignin content as determined from the Kappa Numbers of different samples of jute showed conformity with the values of Klason lignin estimated by sulphuric acid method.

Table 1. Klason lignin, Kappa Number and Kappa lignin of different jute samples (Hussain et al. 2002).

Samples	Klason lignin (%)	Kappa number	Kappa lignin (%)
Hard jute cutting	14.60	91	14.10
Raw jute fibre	12.50	78	12.09
Over retted jute	11.60	74	11.47
Mercerized jute	12.00	79	12.24
Sulphonated jute	8.50	67	10.38
Half bleached jute	7.20	60	9.30
Bleached jute	6.70	52	8.06
Double bleached jute	3.50	30	4.65

Uses of jute: With the rise in sales of synthetic fibres, traditional jute markets have been lost and researchers have sought to develop new products. One application is manufacture of strong, durable fabrics made from 20 to 30% jute and 70 to 80% cotton blends. Jute is the second most important vegetable fibre after cotton; not only for cultivation, but also for various uses. Jute is used chiefly to make cloth for wrapping bales of raw cotton and to make sacks and coarse cloth. The fibres are also woven into curtains, chair coverings, carpets, area rugs, hessian cloth and backing for linoleum. While jute is being replaced by synthetic materials in many of these uses, some uses take advantage of jute's biodegradable nature, where synthetics would be unsuitable (Pan et al. 2004). Examples of such uses include containers for planting young trees which can be planted directly with the container without disturbing the roots and land restoration where jute cloth prevents erosion occurring while natural vegetation becomes established.

The fibres are used alone or blended with other types of fibres to make twine and rope. Jute butts, the coarse ends of the plants, are used to make inexpensive cloth. Conversely, very fine threads of jute can be separated out and made into *imitation silk*. Jute fibres are also used to make pulp and paper, to mitigate an ever increasing concern over destruction of forest which currently provide materials for wood pulp, ingredients for paper manufacture industry. As a result the importance of jute for this purpose may increase in the foreseeable future. Jute has a long history of use in the sackings, carpets, wrapping fabrics (cotton bale), and construction fabric manufacturing industry (Maulik 2001). Traditionally jute was used in textile machineries as fibres being rich in cellulosic vegetable fibre content and lignin wood fibre content. But, the major breakthrough came when the automobile, pulp and paper, and the furniture and bedding industries started to use jute and its allied fibres with their non-woven and composite technology to manufacture nonwovens, technical textiles and composites. Therefore, jute has changed its textile fibre outlook and is steadily heading towards its newer identity, i.e. wood fibre. As a textile fibre, jute has reached its peak from where hardly there is any scope for further progress, but as a wood fibre jute has many promising features.

Geotextile is another area that made this agricultural commodity more popular in the agricultural sector. It is a lightly woven fabric made from natural fibres that is used for soil erosion control, seed protection, weed control, and many other agricultural and landscaping uses. The geotextiles can be used for more than a year and the bio-degradable jute geotextile material left to rot on the ground keeps it cool making the land more fertile (Maulik 2001, Madhu 2002). Such methods may be used to transfer the fertility of the Ganges Delta to the deserts of Sahara or Australia. Moreover, jute can be grown in four - six months with a huge amount of cellulose produced from the jute hurd (inner woody core or parenchymateous tissue of the jute stem) that can meet most of the fuel wood that the world needs. Jute is the major crop among others that is able to protect deforestation caused by industrialisation. Thus, jute is one of the most environment-friendly fibre crops starting from the seed to expired fibre, as the expired fibres can be recycled more than once. Diversified byproducts which can be cultivated from jute include uses in food, cosmetics, medicine, paints, and other similar products. Jute leaves are also a popular vegetable in West Africa and some parts of the Indian subcontinent. The Yoruba of Nigeria call it "ewedu". It is made into a common slimy soup in some West African cooking traditions.

Utilization of jute wastes: Environmental engineers find lots of pentoses in natural environments and in wastes that have plant materials, such as undigested foods and paper. Knowledge about pentoses helps in understanding waste treatment, bioconversion of cellulosic materials, and deterioration of wood (Ahmed 2001, Chiang et al. 1981, Winkelhausen and Kuzmanova 1998). The major potential biodegradable agricultural and agro-industrial cellulosic wastes available in Bangladesh are rice straw, rice husk, wheat straw, sugar cane bagasse, saw dust, jute stick**s,** jute mills wastes etc. (Tareq 1985). Every year there is a mass production of various cultivars of the two jute species throughout the jute growing areas of Bangladesh. But the jute sticks are discarded almost as a waste or used as a burning fuel in rural areas. Jute stick is a ligno-cellulosic material and in nature this is one of the most abundant, continuously renewable organic resources. Their major components are cellulose, hemicellulose and lignin, vary with plant species. It has a great potential as an ecologically advantageous feedstock for the production of valuable products including a number of useful chemicals and liquid fuels. Hemicellulose is a polymer of several different sugars and sugar derivatives. Roughly 75% of the monomers for hemicellulose are pentoses, and the sugar D-xylose is roughly 75% of these sugars. This is the reason why hemicellulose is also known as xylan. Hemicellulose can constitute up to 39% of agricultural residues by dry weight with aldopentose D-xylose (usually not less than 95%) (Winkelhausen and Kuzmanova 1998) forming the main constituent of this fraction**,** when it is derived from hardwood or agricultural residues (Singh and Mishra 1995, Kern et al. 1998).

Cellulose, the most abundant carbohydrate on earth, is almost always found associated with hemicellulose and lignin. Most fast-growing woody and annual crops are high in hemicellulosic sugars such as D-xylose. In industrial application, the ability to utilize readily available cheap resources as starting substrates for bioconversion processes is considered to be one of the desirable properties. Sugarcane was the basis for the world's first renewable biofuel program in Brazil. Corn is the basis for the present renewable ethanol fuel industry in the United States. The sucrose produced by sugarcane, sugar beet and sweet sorghum can be fermented directly after squeezing them from the crop. The residues left over after removing fermentable sugars can also be utilized. Ahmed et al. (2001) extracted D-xylose from jute stick by very simple method. They hydrolyzed jute sticks and rice husks to extract D-xylose. When jute sticks was used as substrate, 1 N H_2SO_4 was found to be suitable for D-xylose extraction at boiling temperature after a period of 1 hr. 1 N H_2SO_4 was also found best for D-xylose extraction from rice husks. No cellobiose was detected in hydrolysate. It was found that only 1N H_2SO_4 showed the best result where only D-xylose was extracted without producing any residual by-product during the reaction. It was also observed in the experiment that 1 h hydrolysis with 1N H_2SO_4 seemed to be the optimum for extraction of D-xylose; and prolonged hydrolysis was found to produce a by-product in the hydrolyzed substances besides D-xylose. In case of D-xylose extraction from small pieces of jute stick and jute stick powder, it was found that small pieces of stick are better than the powder (Ahmed et al. 2001).

Table 2. Influence of CWC on post harvest soil (Gani et al. 2001).

Parameter*		Treatments**							
		T1	T2	T3	T4	T5	T6	T7	T8
BD	Total	1.250	1.244	1.200	1.200	1.100	1.000	0.900	1.341
(g/cc)	%ROC	-	0.80	44.00	4.00	12.00	20.00	28.00	ND
PD	Total	2.000	2.000	2.220	2.100	2.200	2.220	2.300	2.120
(g/cc)	%IOC	-	10.35	16.00	44.76	9.91	10.00	12.50	5.00
PS	Total	40.900	52.500	52.600	60.200	61.100	61.010	62.000	50.200
(%)	%IOC	-	28.36	28.60	47.18	49.38	49.16	51.59	22.70
MWRC	Total	30.000	44.100	48.200	48.800	49.000	44.600	50.240	39.800
(%)	%IOC	-	46.90	60.55	62.55	64.49	48.56	67.35	32.57
pH		6.50	6.50	6.49	6.47	6.47	6.46	6.30	6.60
OC	Total	1.200	1.860	2.000	2.100	2.250	2.230	2.490	1.990
(%)	%IOC	-	55.00	66.66	75.00	87.50	87.83	107.50	65.83
OM (%)		2.10	2.98	3.42	3.60	3.99	3.69	4.41	3.66
N	Total	0.410	0.420	0.720	0.750	0.820	0.790	0.920	0.580
(%)	%IOC	-	2.44	75.61	82.93	100.00	92.68	124.39	41.96
P	Total	14	15	15	18	19	17	20	17
(ppm)	%IOC	-	7.140	7.140	28.570	35.710	21.420	42.850	21.420
K	Total	0.16	0.17	0.19	0.20	0.22	0.18	0.25	0.19
(Meq/100)	%IOC	-	6.250	18.700	25.000	37.500	12.500	56.200	18.700

*BD - bulk density, ROC - reduced over control, ND - not reduced, PD - particle density, PS - pores space, IOC - increment over control, OC - organic carbon, OM - organic matter, MWRC - maximum water retentive capacity, N - nitrogen, P - phosphorus, K - potassium.
**T1 - control, T2 -CWC ½ t/ha, T3 - CWC@ 1 t/ha, T4 - CWC@ 2 t/ha, T5 - CWC@ 3 t/ha, T6 - CWC@ 4 t/ha, T7 - CWC@ 5 t/ha, T8 - RDF.

Gani et al. (2001) stated that the water retention capacity, percentage of pore spaces of soil increased and bulk density was reduced over control treatments due to addition of city waste compost (CWC). Incorporation of CWC in soil increased organic carbon (OC), nitrogen (N), phosphorus (P) and potassium (K) content over control. The organic matter content of soil was found at the highest rate with CWC@ 5t/ha. The highest growth and yield of jute was recorded every year or on alternate year with CWC @ 4t/ha over control and recommended dose of fertilizer (Table 2).

In 2003, Akhter et al. conducted an experiment in order to know the utilization and feasibility of retting effluent as fertilizer in vegetable crops production where jute retting was conducted in the corner of rice filed by making artificial ditches. Retting could be efficiently conducted in the rice field. The fibres produced there of were also of good quality and as the ribbons were retted, the percentage of cutting in the basal parts were also very nominal. The fertilizer value of the retting effluent was tested on three vegetable crops of cabbage, brinzal and tomato. In all the cases, retting effluent showed better yield than the control. The tithe of the soil was also increased (Akhter et al. 2003).

Jute retting and microorganisms: The quality of the jute fibre among varieties differs on the basis of anatomical features of the fibre cells and their orientation and is genetically controlled. Coarser and light-body fibre is obtained from sandy soils, whereas clay-loam soils with silt give fibre of superior quality. Climate and the nutrition pattern also affect the fibre qualities. But the most important single factor is ‘retting’ which, if faulty, mars the positive contributions of the variety, soil, climate etc. Under-retting gives coarse and over-retting dazed and weak fibres. The bundles are kept standing in water (30 cm deep) and later placed side by side in retting water, usually in 2 to 3 layers and are tied together. They are covered with water-hyacinth or any weed that does not release tannin and iron. The float is then weighed down with seasoned logs or with concrete blocks or are kept submerged (at least 10 cm below the surface of the water) with bamboo-crating. Clods of earth, used as a covering material or as a weighing agent produce dark (shyamla) fibre of low value. Gently flowing, fairly deep, clear and soft water is ideal for retting. The optimum temperature is around 34°C**;** ditches, tanks and pools are also used for retting. Incomplete submergence produces ‘croppy’ fibre of extremely low value. Most of the defects in fibre are due to faulty retting. Over-retting results in ‘dazed’ weak fibres. Retting is a microbiological process and, therefore, the end-point is determined by inspecting a few plants each day from the tenth day onwards. If fibre slips out easily from the wood on pressure from the thumb and fingers, retting is considered complete. Various fungi, aerobic and anaerobic bacteria are involved in the retting process. The aerobic organisms grow first and consume most of the dissolved oxygen, ultimately creating an environment favorable for the growth of anaerobes. It has been observed that the greater part of decomposition is carried out by anaerobic species. Various factors are responsible for proper retting *viz.,* nature and volume of water, temperature and pH of the water and weighting down material etc.

Munshi and Chattoo (2008) studied the bacterial population structure of the jute-retting environment. It is a fact that retting is one of the most important determining factors for the quality of jute fibre. Traditional retting requires sufficient clean water. Jute cultivation has gradually shifted towards marginal land, where sufficient clean water is scarce. Availability of adequate water for retting of jute has become a matter of great concern to jute producing countries like Bangladesh, India and Nepal. Moreover, with the increase of diversification of jute, the demand for good quality jute fibre is on the upward trend. To combat the situation different techniques of retting have been developed. The traditional and most common method of retting is what is known as `stem retting', in which the complete plant stem is immersed in water in bundles of multiple layers termed `rets'. With sufficient water supplies, cheap and available labor, and growing and retting in the same locality the technology is well-suited to the industry. In many areas, however, these conditions no longer exist. Water is restricted, the crop is grown at a distance from the water supply and laborers are unavailable or unwilling to work for low wages. Moreover, the quality of the fibre produced can be variable. The Bangladesh Jute Research Institute (BJRI) screened a wide range of fungi of different origins and found that the saprophytic fungus (*Sporotrichum*) was capable of retting dry ribbons of jute satisfactorily under laboratory conditions. BJRI workers have also developed a technique for dipping the dry ribbons into the fungal solution prior to separation. Post-retting treatments with the use of fungal cultures were also examined to minimize the adverse effects of cuttings on the fibres by removing the hard and barky bottom portion without detrimentally affecting other fibre qualities. *Aspergillus* sp. was found to be beneficial in improving the quality of fibres produced by one or two grades. During retting and at the end of retting the microbial content per ml of retting water was found to increase greatly. Ribbon, dry and chemical retting are alternative methods over the conventional retting**.** The application of these recent techniques can overcome the problem of scarcity of retting water. However, the desired level of success by adopting these methods can be achieved if (i) retting is done on a comparative basis (ii) proper care is taken to identify the end point of retting and (iii) retting cum pisiculture and retting cum paddy cultivation are adopted to reduce the BOD and COD of water after retting. Haque et al. (2001a) studied the effect of nature of harvest of jute plants on the production of cuttings and improvement of fibre quality, in which jute plants were harvested leaving 1″, 2″, 3″, 4″, 5″ and 6″ of the basal portion of the stem in the soil and retted separately. Such a practice produced significant effects on the production of jute cutting and fibre quality. Harvesting plants leaving 4″- 6″ from the soil eliminated cutting completely and produced

A-grade fibre. But harvesting plants leaving 4″- 6″ of basal portion of the stem in the soil apprehend loss of fibre weight. Haque et al. (2001a) designed an experiment to know the impact of stem-water ratio and separately retting the top and basal parts of the jute stem on the quality of fibre. The experiment was carried out under laboratory conditions maintaining plant stems and water ratio in the range of 1 : 5, 1 : 10, 1 : 15, 1 : 20, 1 : 25 and 1 : 30 at 30ºC. The best results were observed at the ratio of 1:20, which yielded top quality of fibres. Top and bottom parts of the jute plant, if retted separately followed by malleting 40 cm of the basal part (Table 3) improved the fibre quality and showed more or less uniform retting and sometimes the cutting was completely eliminated fungal efficiency on retting of green ribbon of jute was studied by Haque et al. (1998). They isolated a number of fungal species, namely *Aspergillus niger, Micor* sp., *Schizophylum communae, Sporotrichum* sp., *Trichoderma* sp., *Penicillium* sp.-1 and sp.-2 from rotten fruits, wood and manure pits. These specimens were tested for their retting efficiency on green ribbons of *C. capsularis* (bark of the jute plants) of variety CVL-1. Among them, *Sporotrichum* sp., *Schizophylum communae* and *Trichoderma* sp. retted green ribbons of jute (var. CVL-1) in 7, 9 and 11 days, respectively, while the others did not show any retting efficiency (Table 3).

Table 3. Comparative studies of retting properties of different released varieties of jute (Haque et al. 2001).

Variety	Retting time (Days)	Final pH	Fibre colour	Fibre grade	Cuttings (%)	Fibre yield (kg/100 kg bark wt.)
C-718	12	6.80	White	A	2.00	10.50
OF-390	11	6.59	Golden	B	4.00	9.00
C-2035	14	7.00	Brown	C	15.00	9.00
OM-1	11	6.90	Golden	B	6.00	10.50
C-2005	14	6.77	Shamla	C	20.00	10.50
C-2143	13	6.81	Brown	C	10.00	10.50
Control-1 (CVL-1)	16	7.01	Light brown	C	25.00	11.05
Control-2 (O-9897)	17	7.00	Light golden	C	30.00	10.75
*Level of significance	0.01	0.01	**NS	*		

*Mean followed by a common letter are not significantly different at the 5% level of DMRT. **NS=Non significant.

The properties of jute fibre can be improved through biochemical retting. Haque et al. (2001b) carried out a comparative study of retting properties of different varieties of jute, in which two were chosen from *C. olitorius* (OM-1 and OF-390) and four from *C. capsularis* (C-718, C-2035, C-2005 and C-2143). These varieties were compared for their retting properties, morphological differences as well as their physical properties of the fibre extracted from them. Among them, white fibre with fewer cuttings and "A" and "B" grade fibres were obtained by retting from C-718 and OF-390 varieties, respectively yielding higher quantity of fibres. Other varieties were found inferior in quality in all aspects (Table 4). Ahmad (2008) isolated aerobic and anaerobic bacteria from samples of retted jute stems. These were found to belong to three genera, *Bacillus, Micrococcus*, and *Pseudomonas* with a total of 13 species. Only one new species, *Micrococcus corchorus* and one new variety, namely, *Micrococcus leteus* var. *liquefaciens*, have been reported. Different bacterial strains within each species usually differ in their capacity to ret jute. Active retting strains gradually lose their retting ability either from loss of adaptive enzymes or from mutations. Among the aerobes and facultative anaerobes, *B. subtilis* has been found to be most common, while *B. macerans, B. polymyxa, Micrococcus corchorus,* and *Pseudomonas aeruginosa*, the most active retting agents. On account of the acute shortage of water for retting and the environmental pollution created from conventional system of retting the demand for new methods of retting are on the increase. One new method of retting has been recognized to be ribbon retting. In ribbon retting barks are removed from jute- and kenaf plants mechanically or manually in the form of ribbon. The ribbons are coiled and then allowed for retting in water with or without a microbial inoculum.

Ribbon retting has the following advantages over conventional retting: (1) It requires smaller volume of water (2) it is faster (3) it produces lesser environmental pollution while (4) improving fibre. quality Ribbon retting gets completed in a shorter period compared to that of stem retting. The fibre quality improves because of almost cutting free fibres. Colour and luster of the stem retting is better than ribbon retting, while the root content and defects are less in ribbon retting. Ribbon retting is economic and more suitable for making handicraft products. Addition of efficient pectinolytic microbial inoculum may further boost up or improve the ribbon retting process (Haque et al. 1998, Banik et al. 2007). Under laboratory conditions as well as in field, *Sporotrichum* sp. retted green ribbons of jute (var. CVL-1) in seven days, whereas both *Trichoderma* sp. and *Curvularia* sp. the process took 11 days. No adverse effects on the fibre bundle strength and fibre yield were observed when *Sporotrichum* sp. was used for retting (Table 5). In case of retting by *Sporotrichum* sp., no adverse effects on the fibre bundle strength and fibre yield were observed and according to Pressley Index, fibre strength was found to be 10.82 Ibs/mg and fibre yield was about 2.8 Kg out of 40 Kg green ribbons (Chakravarty et al. 1962).

Microbial population varies from place to place in the jute growing areas of Bangladesh. Akhter and Mandal (1996) studied the bacterial populations in the Rhizosphere of jute and allied fibrous plants. The study revealed that the fungal load was higher in post-retting water and the addition of post-retting microbes in the *in vitro* retting tests accelerated the retting process. Retting period was reduced by almost half in treatment with microbes from the post-retting water than that of pre-retting water. Chemical properties of post-retting water were within the range of environmental control (Table 6) (Haque et al. 2001c). Isolated fungi of *Aspergillus clavatus*, *Rhizopus* sp., *Zygorinchous* sp., *Sporotrichum* sp., *Trichoderma* sp., *Penicillium* sp. and *Curvularia* sp. were tested for their retting efficacy on green jute ribbons (Table 6). In 2002, Haque et al. (2002) surveyed the distribution and activity of microbial population for jute retting and their impact on water of jute growing areas of Bangladesh. Microbial population varies from place to place in the jute growing areas of Bangladesh (Tables 7-8).

Table 4. Growth pattern of the fungi, fibre bundle strength, softness score and duration of retting (Haque et al. 1998).

Fungi used	Growth pattern	Softness score	Bundle strength (ibs/mg)	Duration of retting (days)
Aspergillus sp.	-	-	Not applicable	Not retted
Mucor sp.	-	-	Not applicable	Not retted
Schozophyllum communae	+++	M	10.01	9
Sporotrochum sp.	+++	G	10.82	7
Trichoderma sp.	++	P	8.58	11
Penicillium sp. 1	+	-	Not applicable	Not retted
Penicillum sp. 2	++	P	8.85	Not retted
Traditional method	-	M	9.95	18
Control	-	-	Not applicable	Not retted

- = No growth. += Degree of uniform growth. G = Good growth. M = Moderate. P= Poor.

A great deal of work has been done on the microbiological deterioration of vegetable fibres. A large number of fungal species causing damage have been isolated and identified, and their properties (e.g., cellulose-decomposing ability) studied. A technique has been developed by Basu et al. (2005) for detecting fungal growth on and inside the jute fibre by differential staining of hyphae and fibres with Chlorazol Sky Blue stain. The test is also applicable to cotton. The active organisms attacking jute fibre under different practical conditions of damage have been found to be different. Granular bodies sometimes seen within the lumen of raw jute fibre have been isolated and traced to a *Bacillus* species (Basu et al. 2005). Although excessive humidity is an essential general requirement for the growth of mildew, the nature of the flora may vary depending on other conditions. For example, preliminary indications were obtained in the Principal author’s laboratory that, although dark colored fungi predominated on jute fabrics exposed to the weather (sun and rain), in shade these were suppressed by light-colored species (Kundu 1960). It was noted that certain slow-growing angiocarpous fungi were primarily involved in the decay

Table 5. Chemical properties of post-retting water from different areas of Bangladesh* (Haque et al, 2002).

Place	Dry residue (g) hardnes	Temporary (ppm)	Permanent hardness (ppm)	O_2 (ppm)	CO_2 (ppm)	Bicarbonate (ppm)	N_2 (%)	Ca (ppm)	Fe (%)	BOD (mg/l)	COD (mg/l)
Jessore											
Jikergacha	10	7.20	70.00	3.00	14.00	105.00	0.0286	13.50	0.20	5.1	940.00
Keshabpur	9	7.50	78.00	1.00	17.00	102.00	0.0321	28.50	0.15	5.7	980.00
Monirampur	10	8.10	85.00	1.00	16.00	108.00	0.0357	15.00	0.18	6.6	898.00
Rajganj	10	7.30	76.00	2.00	15.00	103.00	0.0271	21.30	0.19	7.1	873.00
Kushtia											
Alampur	8	8.00	80.00	2.00	11.00	106.00	0.0331	17.60	0.22	5.4	971.00
Jugia	9	7.00	77.00	1.00	18.00	100.00	0.0275	19.40	0.16	6.7	966.12
Vadalia	11	7.20	83.00	3.00	15.00	110.00	0.0319	18.10	0.13	7.4	888.70
Shastipur	10	8.20	73.00	1.00	10.00	105.00	0.0224	19.70	0.27.2		979.32
Dhaka											
Gazaria	8	6.00	18.50	2.80	4.40	36.60	0.0142	15.70	0.18	8.1	889.43
Daulatkandi	10	4.70	45.00	3.00	8.60	134.20	0.0145	21.50	0.21	5.7	997.12
Arikhola	11	8.50	53.00	2.20	17.60	91.50	0.0214	16.30	0.19	6.5	986.04
Kaoraid	9	6.70	50.00	3.80	10.30	112.92	0.0148	18.40	0.15	6.8	971.34
Sreepur	10	5.40	91.00	4.20	12.20	110.50	0.0285	15.00	0.22	7.2	967.81
Manikganj	9	4.60	40.00	3.80	15.40	121.40	0.0107	19.00	0.14	5.6	891.10

*Average of three replications. BOD = Biological oxygen demand. COD = Chemical oxygen demand.

of gray cotton duck during exposure to air. By their very nature, jute materials in use are often exposed to such climatic influences as sunlight, rain, and dew; if the moisture content of the fabrics remains high for sufficient periods, fungal growth takes place, along with chemical changes in the fibre material due to actinic degradation. Mildew damage also takes place quite often under totally different conditions of storage, sometimes inside the bale. Chakravarty et al. (1962) observed that the routine isolations from such samples on the usual nutrient media have repeatedly given only a limited number of species which are common contaminants on jute (e.g., *Aspergillus terreus*, *A. fuminatus*, *Paecilomyces varioti*, *Penicillium citrinum*), but there have been indications to suggest that other organisms such as *Chaetomium* species played an important part but failed to appear on these media owing to their slow growth or other reasons. The need for using special media and techniques to gain a more comprehensive picture of the flora growing on textile materials has been realized also by other workers (Bhattacharyya and Basu 1981). Comparing the flora of weather-exposed jute and cotton canvases has revealed the presence of that *Helminthosporium halodes* and *Nodulisporium* sp. only from jute, while *Curvularia tetramera*, *Sporotricum* sp. and *Fusarium* spp. were isolated only from cotton. It was further observed that a single medium or even two media were not sufficient to bring out all of the fungal species (Nandi and Basu 1938); *Sporotrichum* sp., *Nodulisporium* sp., *Fusarium* sp., and unidentified species grew in the jute powder medium. Growth of *Sordaria hypocoproides* only on the jute fibre medium indicates that other species may occasionally be missed on agar media. The use of ordinary

Table 6. Microbial population in different plant parts of *C. capsularis* (var. CVL-1) and *C. olitorious* (var. O-9897) (Haque et al. 1998-99).

	Number of Bacteria (Aerobic)		Number of Fungi (Anaerobic)		(Aerobic) In PDA medium
Materials*	In PDA medium	In NA medium	In PDA medium	In NA medium	
CL	1.17×10^4	2.96×10^4	2.68×10^4	2.10×10^4	2.27×10^4
OL	2.65×10^4	2.93×10^4	4.11×10^4	3.00×10^4	2.33×10^4
CBS	5.40×10^4	2.92×10^3	2.05×10^4	3.30×10^4	3.20×10^4
OBS	1.12×10^4	1.86×10^4	5.65×10^4	1.40×10^4	1.95×10^4
CB	5.40×10^4	7.25×10^4	2.05×10^3	7.80×10^4	2.32×10^4
OB	1.92×10^4	2.05×10^4	3.15×10^4	5.00×10^3	1.30×10^4

CL= *C. capsularis* leaf; OL= *C. olitorious* leaf; CB= *C. capsularis* bark; OB= *C. olitorious* bark; CBS= *C. capsularis* bark and stick; OBS= *C. capsularis* bark and stick.

laboratory media has not been found enough for determining the taxa of fungi growing on vegetable textile materials under natural conditions. Several significant species were isolated only on special media, of which cellodextrin agar and Czapek's agar supplemented with jute extract proved best.

Table 7. Microbial population in different jute growing areas of Bangladesh (Haque et al. 2002).

Place	Aerobic bacteria		Anaerobic bacteria		Fungus	
	Pre-retting	Post retting	Pre-retting	Post retting	Pre-retting	Post retting
Jessore						
Jhikargacha	2.9×10^6	4.2×10^6	1.0×10^5	4.2×10^6	Nil	1.5×10^5
Keshabpur	2.1×10^6	3.0×10^6	5.5×10^5	1.7×10^6	1.0×10^5	3.0×10^5
Monirampur	2.7×10^6	6.0×10^6	2.0×10^5	3.1×10^6	2.0×10^5	3.0×10^5
Rajganj	1.7×10^6	3.2×10^6	5.5×10^5	1.0×10^6	1.0×10^5	3.0×10^5
Kushtia						
Alampur	1.1×10^6	2.4×10^6	Nil	4.0×10^5	2.0×10^5	3.5×10^5
Jugia	4.0×10^5	3.8×10^6	Nil	6.0×10^5	Nil	2.0×10^5
Vadalia	3.0×10^5	1.6×10^6	Nil	1.3×10^6	1.0×10^5	4.0×10^5
Shastipur	2.5×10^5	2.6×10^6	3.0×10^5	2.4×10^6	1.5×10^5	4.5×10^5
Dhaka						
Gazaria	1.5×10^5	2.0×10^6	2.9×10^5	4.3×10^6	3.7×10^5	3.2×10^6
Daulatkandi	1.2×10^6	2.9×10^6	5.3×10^4	2.5×10^5	2.2×10^5	6.6×10^6
Arikhola	1.6×10^5	2.3×10^6	3.2×10^5	3.3×10^6	4.1×10^6	5.8×10^6
Kaoraid	1.9×10^6	5.0×10^6	4.1×10^5	4.6×10^5	3.0×10^5	3.3×10^6
Sreepur	2.3×10^6	2.4×10^6	2.2×10^5	3.9×10^6	2.8×10^5	4.5×10^6
Manikganj	2.4×10^5	3.7×10^6	3.3×10^5	5.9×10^6	2.3×10^5	3.6×10^6

However, so far no single medium has proved to be adequate for the growth of all relevant fungi (Nandi and Basu 1938). *Sordaria hypocoproides*, appears to grow better in a liquid medium containing jute fibres than on solid media such as jute-agar. The advantage of cellodextrin as a carbon source no doubt lies in the fact that it partly eliminates superficial organisms while allowing somewhat quicker growth of cellulose decomposers than does cellulose itself. The callodextrin medium has the added advantage of often producing transparent zones around the colonies; their presence gives a rough idea of the cellulolytic capacity of the organism. The widespread need for micronutrients for the growth and sporulation of fungi, including cellulose decomposers, has been underscored by many authors. These micronutrients essential for the growth of microorganisms are present in jute along with a number of vitamins and trace elements (Ali et al. 1991). Different kinds of organisms were isolated from jute such as *Aspergillus niger, A. terreus*, *Chaetomium globosum*, *Ascochytula* sp.

Cladosporium sp., *Sporotrichum* sp., *Sordaria hypocoproides*, *Thielavia sepedonium*, *Penicillium* sp. *Curvularia tetramera*, *Sordaria hypocoproides* and *Helminthosporium halodes*; among these *Sporotrichum* has a weak cellulolytic activity (Bag et al. 1997).

Most of the newly isolated fungi are generally missed on ordinary media; but they probably play an important role in the natural decomposition of jute materials. Therefore, Chakravarty et al. (1962) developed special media suitable for the isolation of fungi growing on jute where several strongly cellulolytic organisms not previously implicated in fibre decomposition were isolated from this source.

Table 8. Impact of microbial population on jute retting and production of quality fibre* (Haque et al. 2002).

Place	Pre-retting water Retting period (days)	Fibre quality**	Post-retting water Retting period (days)	Fibre quality**
Jessore				
Jikergacha	27	C	10	B^{+}
Keshabpur	28	C	8	A
Monirampur	27	C	8	B^{++}
Rajganj	29	C	9	B
Kushtia				
Alampur	28	B	11	A
Jugia	27	C	8	B^{+}
Vadalia	29	B	9	B
Shastipur	27	C	8	B^{++}
Dhaka				
Gazaria	28	C	8	B^{+}
Daulatkandi	27	C	9	B^{++}
Arikhola	30	C	10	B^{++}
Kaoraid	29	B	11	B
Sreepur	30	C	9	A
Manikganj	29	C	8	B^{++}

* Average of three replications. **A^{++} = Best grade fibre. A= Best grade fibre but inferior to A^{++} grade. B^{++} = Good grade fibre but inferior to A grade. B= Good grade fibre but inferior to B^{++} grade. C^{++} = Poor grade fibre, inferior to B grade. C= Bad grade fibre.

A pectinolytic fungus identified as *Aspergillus niger* was isolated by Ahmad (2008) from jute softening bin of a jute mill. Bag et al. (1997) quantitatively examined microbial population of the Jute mill dust indicating that the incidence of slime-producing bacteria and fuzzy fungi is higher in high dust zone; the former predominates over the latter throughout the mill area. The role of microorganisms obtained from jute in the retting of dry jute ribbons was examined by Haque et al. (1999). They isolated both aerobic and anaerobic bacteria, from barks, leaves and sticks of jute (*C. capsularis* and *C. olitorius*). The isolated microbial inoculum and effluent influence retting of dry ribbons of jute, kenaf and Mesta were studied. Microbial population was higher in the leaves of *C. olitorius* var. O-9897 and *C. capsularis* var. CVL-1 in potato dextrose agar media (Table 9).

Table 9. Growth of fungi in green ribbon and jute fibre grade and fibre bundle strength after retting with these fungi (Haque et al. 2001)

Fungi culture	Growth pattern	Fibre grade (lbs/mg)	Pressley index
Control	-	C	8.89
Aspergillus clavatus	+	C	9.00
Rhizopus sp.	+	C	8.88
Zygorinchous sp.	++	C	9.01
Sporotrichum sp.	++++	A	11.80
Trichoderma sp.	++	C	8.58
Penicillium sp.	+	B	10.13
Curvularia sp.	++	C	8.85

+ = Degree of uniformity in growth.

Fungal population was also higher in leaves of both the species of jute in the same media. Retting was conducted at 28 to 30°C *in vitro* using earthen plates (Sanki) with 800 ml of distilled water. Six percent microbial inocula plus 0.01% of urea retted dry ribbons of jute in 17 days, kenaf in 11 days and Mesta in 12 days. In control, the retting duration ranged from 19 to 28 days. The fungal effect on dry ribbon retting of CVL-1 jute (*C. capsularis*) was determined by Ahmed et al. (1999). They isolated ten active retting fungi from natural sources and grew them they in potato-dextrose medium for mass production. Maximum fungal growth was observed in 7 days incubation period. Fungal mass were then applied in dry ribbon of CVL-1 jute. *Mycelia sterilia, Aspergillus terreus* and *Selerotium* sp. showed better retting activity and retted dry ribbon at 6, 8 and 7 days, respectively. Attempt was undertaken by Haque et al. (1999) to isolate, identify and characterize - jute retting bacteria from the natural environment. Among all the isolates, *Micrococcus* sp. was found to be the most promising microbe which retted jute only within six days under control laboratory conditions.

Soil fertility and jute retting: Saha et al. (2000) investigated the changes in soil properties and crop productivity as affected by long-term fertilization for 25 years in the New Gangetic alluvial soil (Eutrochrept) with jute-rice-wheat cropping sequence. Highest response in fibre and grain yields was obtained with 150% NPK (nitrogen, phosphorus, potassium). Effect of FYM (farmyard manure) was perceptible in jute as well as in the succeeding crops of rice and wheat. A general decline in organic carbon and available zinc and an increase in available iron were observed (Tarafdar et al. 1981). The distribution of urease and acid and alkaline phosphatase in some jute-growing soils was also investigated. Akhtar et al. (2003) studied the utilization and feasibility of retting effluent as fertilier in vegetable crop production (Table 10).

Table 10. Utilization of retting effluent as fertilizer in cabbage (*Brassica* sp.) and Tomato (*Lycopersicum esculentum*) production (Akhter et al. 2003).

Plot No.	Number of plant	Average plant height (cm)	Average leaf number (cm)	Leaf height (cm)	Leaf breadth (cm)	Fruit weight (kg)
Cabbage						
Treatment	28	22.12	9.87	17.93	16.57	545.80
Control	28	2.65	13.06	22.55	18.10	516.00

Tomato		Average plant height (cm)	Average branch number	Average fruit number	Average fruit weight (kg)
Treatment	27	40.51	10.37	17.89	411.00
Control	27	41.07	20.59	19.17	358.77

Urease and alkaline phosphatase activities were significantly and positively correlated with organic carbon, fungal and bacterial populations, whereas acid phosphatase activity was only significantly correlated with organic phosphorus content. None of the soil enzyme activities was correlated significantly with pH, clay content or soil actinomycetes. Urease and alkaline phosphatase were significantly correlated with each other (Vijayakumar and Raajendraa 2005). Bag et al. (1997) characterized Jute mill dust collected from different processing zones by optical polarizing and scanning electron microscopy. The study revealed that the concentrations of toxic metals like V, Sr, Zr, Cr, Cu and particulates in the size range of 2 - 10 µm are higher in the high dust zone (softening to preparing) than those in the low dust zone (spinning to finishing).

Jute and enzyme: By removing the pectin sheath, the jute fibre is softened. Enzyme treatments can be carried out either before or after weaving. In either case, the jute fibre is smoothed through biopolishing. The concept of biopolishing was first developed in Japan. In cotton fabrics, the protruding fibres are removed by biopolishing the fabric surface using cellulases. Jute fibre consists not only of cellulose but also of hemicellulose, pectin and lignin. Microbial pectinases and xylanases allow selective removal of pectin and xylan thereby, making the jute fibre softer. Further reactions with cellulases could result in selective removal of protruding fibres. Ahmad (2008) stated that enzyme-treated low-grade jute could be blended in higher amounts with superior quality jute without any adverse effects on the blended product. Qualitative improvement of low grade jute and jute cuttings can be done using a crude enzyme extract prepared from *A. niger* (Ahmad 2008).

When blended with cotton it makes a sturdy but prickly fabric due to protruding surfaces of jute fibres. Samples of jute-cotton blended fabric were treated with commercial cellulases, xylanases and pectinases individually and in combination at various concentrations in order to smooth and soften the fabric (Shenai 2003). Enzyme treatment was carried out at 50°C in the presence of 0.1 M phosphate buffer (pH 7.0), for 3 h. Enzymatic activities were evaluated by the release of reducing sugars and changes in the surface appearance of the fabric. Addition of commercial cellulases alone extensively removed protruding jute and cotton fibres from the fabric, whereas addition of commercial pectinases or xylanases mainly loosened the protruding long jute fibre bundle (Hassan *et al.* 1996). Combined treatment of pectinases and xylanases with reduced amounts of cellulases was equally effective as high levels of cellulases in the removal of surface protruding fibres. The amount of reducing sugar released correlated with removal of fibres from the fabric surface. Thus, the fabric surface was smoother in enzyme-treated samples compared to untreated control; and treatments with mixtures of enzymes were more effective than cellulase alone (Moses and Ramasamy 2004; Haque et al. 2003). Moses and Ramasamy (Haque et al. 2001d) attempted to improve the quality of jute and jute-cotton materials using enzymes and natural dyeing.

Molecular analysis of jute: First successful hybridization between the two jute yielding species was reported by Islam and Rashid (1960) and Islam (1958). By means of a combined study of AFLP and RAPD, Hossain et al. (2002, 2003) at Dhaka University have shown the importance of using molecular markers in distinguishing between cold-tolerant and cold-sensitive jute varieties obtained from Gene bank at Bangladesh Jute Research Institute (BJRI). Sequencing is one of the most important methods to achieve genetic information. Sharma et al. (2005) developed Simple Sequence Repeat (SSR) markers for the study of DNA polymorphism, transferability and genetic diversity in jute. SSR markers and other types of molecular marker systems such as single nucleotide polymorphisms (SNP) are valuable genetic tools for the identification of useful polymorphisms (mutations) in genes in cultivated and wild species of *Corchorus*. Markers have utility in mapping the organization of the jute genome and in improving the efficiency and effectiveness of jute breeding. The two cultivated species of *Corchorus* (*C. olitorius* and *C. capsularis*) are diploid (2n = 14) and ~~shows~~ regular meiotic behavior, but do not cross without hormonal treatment and embryo rescue. Using simple sequence repeat (SSR) marker loci and AFLP assay, Basu et al. (2004) evaluated genetic diversity of 49 genotypes of the two jute species. In addition to the research on markers, procedure for successful regeneration (Seraj et al. 1992, Saha et al. 1999) and transformation of *C. capsularis* (Ghosh et al. 2002) have been developed. Ahmad et al. (2005) have isolated and sequenced random fragments with the objective of testing the DNA libraries; they deposited some of these sequences in Genbank. They also analyzed the DNA sequences that show homology with other plant genes including that of *Arabidopsis thaliana*. To characterize the genome and gene expression in jute, it is important to develop a suitable RNA isolation method. Khan et al. (2004) introduced a rapid method for high quality RNA isolation from jute. The isolation of RNA from herbaceous plants is difficult when there is an abundance of polysaccharides in the plant material. In *C. capsularis* and *C. olitorius*, conventional isolation procedures gave poor results with high polysaccharide contamination. Khan et al. (2004) reported a modified method, which yields a greater quantity of RNA compared to the use of conventional protocols in both jute species. This procedure yielded 500-600 µg of RNA per g of fresh tissue and took only 3 hrs to complete. The RNA obtained was of high quality and proved suitable for use in Reverse Transcription PCR. This method has been tested in other plants such as *Arabidopsis* and tomatoes and found to be quite effective (Khan et al. 2004). Mohamad et al. (2007) worked on the identification of a few new expressed sequence tags (ESTs) from a cDNA library of *C. olitorius* var. O-4. The sequence homology search revealed four complete and ten partial cDNA sequences. Basu et al. (2003a) worked on cloning and sequencing of mRNA for caffeoyl-CoA-o-methyltransferase from *C. capsularis*. They also studied the nucleotide sequence of cinnamyl alcohol cDNA isolated from *C. capsularis* (Basu et al. 2003b). Ghosh et al. (2002) analyzed the genetic transformation of cultivated jute (*C. capsularis*) by particle gun bombardment. Using a biolistic particle delivery system, they have developed an efficient protocol for the generation of stable genetic transformants in jute (*C. capsularis* var. JRC 321). DNA fingerprinting of jute germplasm was studied by Hossain et al. (2002). Ahmad et al. (2005) cloned and sequenced a limited number of genes from jute (*C. olitorius* and *C. capsularis*) and discussed the applications of jute genome analysis. As of December 2005, slightly over 200 DNA sequences have been deposited in GenBank. Although many of these sequences are partial and uncharacterized, this marks the beginning of a major step in the unraveling of hitherto unknown jute genome. Construction of both cDNA and genomic DNA libraries for *C. olitorius* var. O4 and *C. capsularis* var. CVL-1 in the plasmid vectors pSMART and pBluescript, respectively was also analyzed. Random clones were isolated and sequenced. These DNA sequences have been deposited in GenBank. It was shown that the early segregation of the parental chloroplasts did not occur in jute, although this is common in other plant species (Saha et al, 2008). Efficient transformation protocols are essential for genetic manipulation of jute for incorporation of important agronomic traits into standard cultivars. *Agrobacterium*-mediated transformation has certain advantages compared with "naked DNA" transfer procedures. The greatest need for research in developing and enhancing transformation efficiency lies in its applications in functional genomics. Transformation technology is essential for the discovery of gene function *via* changes in the phenotype attributed to the deletion or insertion of specific genes. To meet the pressing demand for this technology, improvements using latest molecular tools need to be made in areas that ensure greater efficiency and effectiveness of jute transformation. On the basis of recent breakthrough in jute molecular biotechnology, it is suggested that more and more efforts be directed to utilize these recent techniques with a view to improving fibre qualities in its strength, luster and a lower lignin content making it better-suited for spinning with cotton as well as bioengineering recombinant bacterial strains capable of further reducing retting time without compromise to its unique characteristics.

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