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Mechanical Extraction of Jute and Mesta for Quality Fibre Production

R. K. NAIK*, S. P. MAZUMDAR, B. MAJUMDAR and M. S. BEHERA
ICAR-Central Research Institute for Jute and Allied Fibres
Barrackpore, Kolkata - 700 120, West Bengal

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Jute and mesta termed as raw jute is one of the cheapest natural fibres and is second to cotton in production and variety of uses. The fibre from jute and mesta is obtained by biochemical process *i.e.,* retting in water. Retting is the most critical operation for getting quality fibre. Due to unavailability of sufficient water and water bodies, quality of fibre produced becomes inferior. To avoid scarcity of water, the barks/ribbons consisting fibre are mechanically separated prior to retting. Among the three machines used for ribbon extraction, the throughput capacity of jute decorticator was found to be 230 kg plants h^{-1}, which is higher than the bast fibre extractor (130 kg h^{-1}) and manual jute extractor (120 kg h^{-1}). The average retting duration for microbial consortium mediated ribbons was found to be 7-10 days against 13-15 days without microbial consortium. The fibre recovery in ribbon retting for jute was 7.23-8.66% and for mesta it was 7.08 per cent on green weight basis. The fibre fineness of 2.8 to 3.4 tex was obtained with ribbon retting.

*(**Key words:** Extraction, Fibre, retting, Ribbon)*

Jute *(C. olitorius* and *C. capsularis),* kenaf (*Hibiscus canabinus*) and roselle/mesta (*Hibiscus sabdariffa*) constitutes very important natural fibre crops next to cotton. In India jute is mainly grown in Eastern and North-Eastern states, while mesta is grown throughout the country. In trade and industry, both the jute and mesta together is known as raw jute (Naik and Karmakar, 2016). Raw jute plays an important role in the country's economy. India accounts for about 60% of world production of jute, kenaf and allied fibres, thus leading a way in protecting the environment. Even in the era of manmade synthetic fibres, jute fibre now-a-days has good world market. The demand of jute goods in the international market is around 0.75 Mt (Uddin *et al*., 2014). From gunny bags to carpets, it is being accepted due to its bio-degradable characteristics.

Unlike cotton, fibres from jute and mesta are not obtained during the harvest of the crop. The fibres in their original state are usually tightly bound in the stems of plants. The bio-chemical process *i.e.,* retting separates the fibres from the woody stem and gummy substances that bind them together. Jute fibre quality largely depends on the process of retting. Hence, fibre extraction has to be carried out with much care in order to obtain the best yield and quality. Traditional whole plant retting method is easier to follow but requires more human labour and large volume of water. Retting by traditional method consumes around 30% of total cost of cultivation (Chapke and Borkar, 2011). In the past, availability of cheap human labour and abundant water did not hinder quality jute fibre production. But, in recent years, farmers are facing many constraints in following traditional retting method due to lack of retting site, scarcity of water and high cost of labour (Borkar and Das, 2006). The traditional whole plant retting method for jute and mesta does not suit the farmers under water crisis situation (Sarkar and Sengupta, 2015). Also, the method causes several problems to the environment and fish cultivation apart from resulting in bad quality fibre (Ahmed and Akhter, 2001). Defective retting, very often results in the production of inferior quality fibre *i.e., "shyamala"* colour causing serious economic loss to farmers as well as to industry (Banik *et al*., 2008). For water crisis areas, mechanical/ribbon retting may be the alternative option on the basis of the suitability and simplicity of the technologies involving less involvement. Such realization led to study the mechanical extraction of ribbon from plant stalks and retting of ribbon for quality fibre production.

MATERIALS AND METHODS

For study on ribbon retting technology, widely cultivated jute variety "Suren" (cv. JRO-204) and mesta (cv. HC-583) were grown under rainfed condition at ICAR-CRIJAF farm at Barrackpore. The field is situated

**Corresponding Author :* E-mail: ranjanagrieng@rediffmail.com

at 22°4″N latitude, 88°26″E longitude with altitude of 9 meter. The soil texture varied from sandy loam to clay loam. Sowing of jute and mesta seeds were done in the month of April and May, respectively. Optimum land preparation and fertilizer applications were followed in both the jute and mesta fields as per the standard agronomic practices (Singh, 1997; Anonymous, 1987). Jute plants were harvested at 110 and 120 DAS; whereas mesta plants were harvested at crop age of 130 DAS.

Since water availability is the major constraint for retting, the concept was evolved to ret only ribbon (containing fibre) instead of whole plant and thereby, reducing the mass (about 70%) of material to be retted. Methods were developed to separate bark / ribbons from the harvested plants first with the machine and then retting of extracted ribbons in water.

Tests on mechanical ribbon extraction from freshly harvested jute and mesta plants were conducted with three developed machines *i.e.,* bast fibre extractor (Fig. 1), manual jute extractor (Fig. 2) and jute decorticator (Fig. 3) separately as per the RNAM test codes and Procedures for Farm Machinery, Technical Series No. 12:1983 and PAES 229: 2005; recommended by Philippine Agricultural Engineering Standard (Agricultural Machinery - Fibre Decorticator - Methods of Test). The detailed description of the machine and their principle of operation are mentioned below.

Fig. 1. *Bastfibre extractor*

Fig. 2. *Manual jute extractor*

Fig. 3. *Jute decorticator*

Bast fibre extractor

The machine 'CRIJAF Bast fibre extractor' is developed at ICAR-CRIJAF, Barrackpore for extraction of green ribbon from harvested bast fibre crops like jute, mesta, sunnhemp and ramie. The machine is operated with 1 hp electric motor and can be operated by 1.5 hp kerosene engine with modification of power transmission system. The machine works on the principle of beating canes progressively down its length and scrapping when the operator pulls out the canes. Two-beater rollers having iron blades are rotated in opposite direction to break and scrap out the sticks. It needs two workers for operation, one for feeding the canes and its ribbon separation in the machine and the other for helping in relay of the canes and removing wastes. Five to ten canes (depending on the diameter of the canes) are fed at a time into the machine. The machine extracts ribbons in full length by breaking the sticks into small pieces. The machine waste (chips of sticks and leaves of the plants) may find use in compost pit and as mixture in cow-dung cake. Utilization of stick chips for resin-bonded hard boards and in paper industry is promising. It performs well with the plants harvested on or before maturity. The weight of the machine is about 125 kg.

Manual jute extractor

Manually operated machine, 'CRIJAF Jute Extractor' is developed at ICAR-CRIJAF, Barrackpore for extraction of green ribbon from harvested jute and mesta crop without breaking the inner stick. Stick separating mechanism has been mounted on the foundation frame, which is made operative by pressing a foot-operated pedal. The canes are fed into the machine by the tip end, about half a meter length, and then the pedal is pressed to activate the stick separating mechanism. The operator holds the tip end of the canes and pulls in opposite direction (towards the operator) from the top. Thus the ribbon is separated and remains in the hand of the operator whereas the stick is ejected forward on the other side. In this way, unbroken stick and full ribbon are obtained. Five to ten plants (depending on the diameter of the canes) can be fed at a time into the machine. The machine is portable, light in weight (about 50 kg), low cost and easy to operate in the field itself. It performs well with the fresh plants without defoliation.

Jute decorticator

The machine 'Jute decorticator' has been fabricated at ICAR-CIAE, Bhopal for high capacity extraction of

green ribbon from harvested jute and mesta plants. It is operated by three phase 5 hp electric motor or can be operated by 7.5 hp Diesel engine. The machine is having two feeding fluted rollers rotating in opposite direction and passes the input material horizontally in to beater roller section. The beating section of the machine consists of two sets of four hammer rollers revolving high speed in opposite direction for separating ribbons from stick. The machine ensures complete extraction of ribbon in one pass with breaking the sticks into pieces. The broken sticks of the plants fall below the ground before passing of ribbon through outlet. The two ground wheels provided are meant for movement of machine. The machine can handle 750-1000 kg plants day^{-1}. The major constraints in using the machine are i) sorting of extracted ribbons at outlet of machine, ii) presence of tendered stick at tip end of the ribbon, which created problem during washing, and iii) availability of power source and high cost.

The machines were run at no load condition to ensure that each component of machine is working properly. To find out the efficiency of machines i.e. quantity and quality of ribbon, a known weight approximately 10 kg of the harvested and defoliated plants were processed for each test run. The ribbon extraction was carried out by a single operator for all the machines. The ribbon extraction time for each test run for each machine was recorded with a stop watch. The following observations were recorded for each treatment.

I) total weight of sample plant^{-1}, g;

ii) time of operation, sec;

iii) green ribbon obtained, g

iv) dry fibre obtained after retting, g;

For each observation the mean of the three replications were taken. The following values were calculated from the above observations for each test run:

Extraction efficiency

It is defined as the ratio of total weight of fibre obtained to the weight of potential fibre content of the sample on a dry basis and expressed in percentage.

$$EE, \% = \frac{wef}{wpf} \times 100 \quad ...(1)$$

where,

wef = weight of dried extracted fibre, g;

wpf = weight of potential fibre content, g.

Fibre recovery

It is defined as the ratio of the dry weight of fibre obtained to the total fresh weight of plants and expressed in percentage.

$$FR, \% = \frac{Fw}{Fp} \times 100 \quad ...(2)$$

where

Fw = dry weight of extracted fibre, g;

Fp = fresh weight of the sample, g.

The extracted ribbons were collected and retted in polythene lined rectangular soil pits of size 2m x 1m x 1m in different retting conditions i.e. with and without the application of talc based microbial consortium consists of pectinolytic bacteria of genus *Bacillus* (Trade mark as CRIJAF Sona) and were subjected to vertical and horizontal steeping of ribbons. After the completion of retting, the fibre from ribbons was washed, sun dried and weighed. The dry fibres obtained in different retting conditions were evaluated for their quality parameters i.e. strength and fineness and was compared with the fibres obtained in traditional retting method.

RESULTS AND DISCUSSIONS

The study on machine efficiency for ribbon extraction reveals that, the ribbon extraction capacity or throughput capacity of jute decorticator (powered by 5 hp electric motor) was found to be 230 kg plants ha^{-1} and which is higher than the bast fibre extractor - 130 kg ha^{-1} (powered by 1 hp electric motor) and manual jute extractor-120 kg ha^{-1}. The jute sticks were broken into small pieces in case of bast fibre extractor and jute decorticator due to beating action of rollers; whereas whole stick was obtained in manual jute extractor. The average retting time of talc based microbial consortium mediated ribbons was found to be 7-10 days against 13-15 days without microbial consortium, compared to whole plant retting of 23 days. The dry fibre recovery with bast fibre extractor was found to be 5-7 % more than jute decorticator and manual jute extractor with maximum fibre recovery of 6.65%. Average fibre recovery for jute was found to be 7.23% and 8.66% for 110 days and 120 days harvested plants, respectively and for mesta it was 7.08% on green weight basis against 5-6% in conventional method. The maximum mean fibre strength of 25.83 g tex^{-1} was obtained from ribbons obtained with manual jute extractor and which is 13-15% more than the fibre strength from other machines due to absence of mechanical beating on ribbons (Fig. 4). Fibre from the ribbons extracted with manual jute extractor exhibited 10-20 % more strength than other machines for

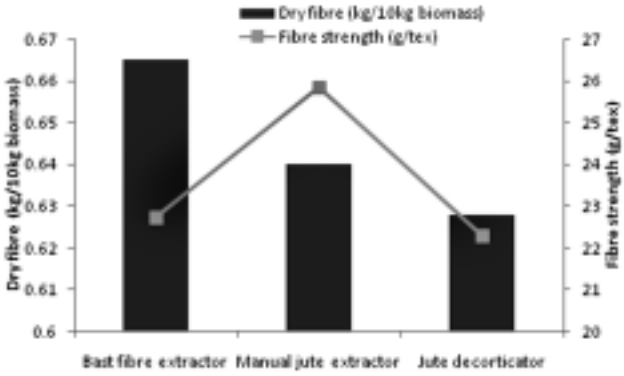

Fig. 4. *Effect of machine on recovery and strength of fibre*

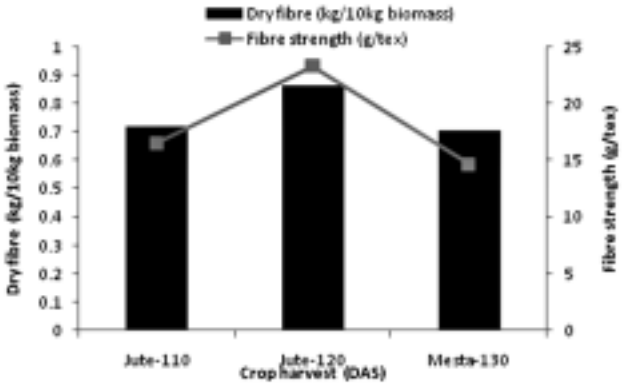

Fig. 5. *Effect of crop harvest on recovery and strength of fibre*

both jute and mesta. The average fibre strength of 16.54 g tex^{-1} and 23.26 g tex^{-1} was recorded for 110 and 120 days harvested jute, respectively; whereas 14.68 g tex^{-1} was for mesta (Fig. 5). Microbial consortium mediated retting improved the fibre strength by 10-12% and 30-35% for jute and mesta, respectively due to acceleration in retting period. The fibre strength from vertically retted ribbon declined the strength by 7% and 40% for jute and mesta, respectively compared to horizontal retted ribbons due to over retting in vertical steeping and under retting in horizontal steeping of ribbons inside water. The average fibre fineness of 2.8 to 3.4 tex was obtained with ribbon retting for both jute and mesta. The long sticks obtained in manual jute extractor exhibits more strength than traditional retted jute sticks. The broken sticks obtained in bast fibre extractor and jute decorticator are found to be suitable for utilization in briquetting purpose.

It was revealed from the study that, ribbon retting reduces the retting duration by 10-12 days against traditional whole plant retting duration of 21-25 days. Ribbon retting reduces the water requirement from 20-25 times to 4-5 times due to reduction of mass for retting. The fibres obtained in ribbon retting exhibited better quality in terms of strength and fineness. Traditional whole plant retting yields about 5-6% fibre on green biomass while ribbon retting improves the yield to about 7-8% on green biomass. Only 30-40% of biomass in the form of ribbons is handled in ribbon retting process as stick constitutes about 60% of biomass. The ribbon retting is controlled condition retting due to reduction of biomass and water requirement, which helps in proper monitoring. The retted ribbons can be washed easily on the banks of water bodies without entering into polluted retting water bodies in traditional retting. The ribbon retting yields fibre of better quality and higher yield, which would fetch higher market price.

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