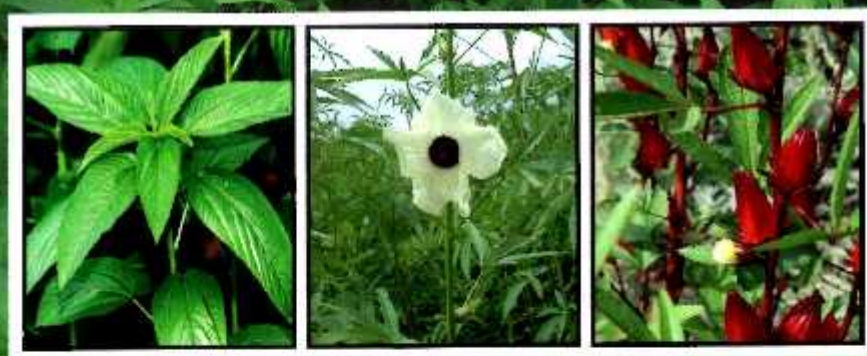


Jute, Kenaf and Mesta Crops Research Reviews



- Economic Importance of jute
- Varietal advances
- Agronomic advances
- Field weed advances
- Leaf as vegetable and medicine
- Soil nutrient management
- Contribution to environment
- Postharvest processing
- Jute seed research advances
- Jute yield and economics at charland areas
- Jute fibre marketing
- Climatic impact of jute
- Food and medicinal values of Mesta/Roselle
- Industrial research advances of jute

Dr. M. Mahbubul Islam



Bangladesh Jute Research Institute

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Dr. M. Mahbubul Islam

Director

(Planning, Training and Communication)



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Gift
of
Bangladesh Jute Research Institute
On





FORWARD

I am very pleased to know that A book entitled “Jute, Kenaf and Mesta Crops Research Reviews” is going to publish first time in English version with the research information developed by BJRI in printed form. This book contents the details of Research reviews works on jute, kenaf and mesta crop’s viz. Leaf, Weed, Varieties, Agronomic advances, Post harvest Processing, Raw jute Marketing, Jute Seed, Climate change impact on jute, Industrial research etc. I welcome the addition of Research reviews for jute and allied crops of Bangladesh.

This book will be use full for the public and private sector researcher, higher study students, extension peoples as well who are always related to the jute and allieds growing. The Institute’s efforts to publish the book would be worthwhile if extension provides and farm level people engaged in more jute and allieds crop production.

I express my thanks to the contribution of the resource scientists for writing, compilation and editing the book and also to the people who were engaged with the agricultural and Industrial research on jute and allied crops.

Dr. A.S.M. Anwarul Haque
Director General



FEW WORDS

The book entitled “Jute, Kenaf and Mesta Crops Research Reviews” has been published in a simple form with the available information and knowledge on various aspects of Research works. This will help the farm level officers, young researcher, higher study students and teachers by fulfilling their knowledge-demand on leaf, weed, varieties, agronomic practices, post harvest processing, jute seed research, climate change impact on jute production, industrial technologies etc. of jute and allied crops.

This is the first publication on agricultural and industrial research in English version printed material which details research review on jute, kenaf and mesta crops.

I am sure, this review book will be extremely helpful in disseminating the agricultural and industrial research information to the end users of Bangladesh and abroad. If it can add something to the advancement of knowledge and help inspire the future jute and allied crops growers, research workers, students and university teachers will consider the labour amply rewarded.

Dr. Mahmud Al Hossen
Director (Admin & Finance)



PREFACE

Bangladesh Jute Research Institute (BJRI) is the oldest research institute of the country. The institute has recognized to obtain some major objectives such as a) To promote agriculture, industrial and economic research on jute and allied fibers and their manufactures and dissemination of results thereof, b) To organize production, testing and supply of improved pedigree of jute seeds and multiplication, procurement and their distribution to recognized organization, selected growers and such other agencies as may be approved by the Board and c) To set up research centers, substations, pilot projects and farms in different regions of the country for carrying out research on different problems of jute and allied fiber crops, jute products and allied materials. From the ancient time so many good research works on jute and allied crops done at BJRI and other institutions of the world, however unfortunately the information scars in printed form at Bangladesh. There for an effort was undertaken to published a book with different review items as compiled form.

By publishing the book entitled “Jute, Kenaf and Mesta Crops Research Reviews”, I had tried to compiled some important issues on Jute, Kenaf and Mesta crops like economic importance, varietal advances, agronomic advances, field weed advances, leaf as vegetable and medicine, soil nutrient management, contribution to environment, postharvest processing, jute seed research advances, jute yield and economics at charland areas, jute fibre marketing, climatic impact of jute, food and medicinal values of mesta/roselle and industrial research advances etc. for quick dissemination of advanced research information to the end users.

Publishing the book, I like to express my deepest gratefulness to Dr. ASM Anwarul Haque, Director General, BJRI for his kind inspiration in planning and preparing this book and whole heartedly supported to undertake write up about the Reviews. I extended my sincere thanks to all of my respected colleague scientists, officers and stuffs of Agriculture, Technology, Jute Textile and Planning, training and communication Wings; and Director General’s offices of Bangladesh Jute Research Institute for providing me valuable suggestions, advices and helpful cooperation at the time I was writing and as well as publishing this book.

To write this book it took the effort of several people who directly or indirectly contributed to the writing. To all of them and to my family members I would like to express my sincere thanks and heartfelt gratitude.

The Author

Dr. M. Mahbubul Islam
Director

(Planning, Training and Communication)

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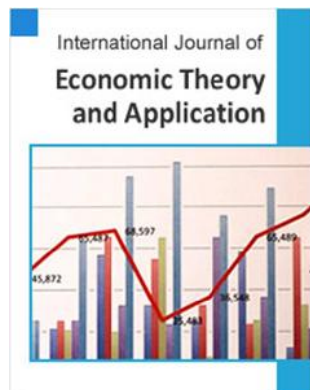
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Dedicated

to

**The peoples who engaged in
Jute, Kenaf and Mesta crops**



Keywords

Jute,
Research Strategy,
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Economic Importance of Jute in Bangladesh: Production, Research Achievements and Diversification

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Abstract

The secondary information sources were IJSG reports, BJRI reports, Bangladesh Journal of Jute and Fibre Research; Jute and Jute fabrics, Bangladesh, DAE, FAO statistics, different books, direct communications with related office and persons. Jute was found grown in Bangladesh almost solely as a rainfed crop without any irrigation or drainage provisions. The status of jute as a cash crop of Bangladesh was not at all satisfactory. Millions of people of Bangladesh depend on all affairs of jute crop. Lack of proper government policy on jute, lack of production of jute, random closures of jute mills, failure to modernize the cultivation system and manufacturing units, mismanagement and malpractice, fall of demand of jute in world market, use of alternative source to jute etc. were found as problems in the development of jute fibre in Bangladesh. Proper Government policy could solve the problems in jute sector of Bangladesh.

1. Introduction

Jute (*Corchorus* spp.) is now universally recognized that jute is the English version of the current bengali word 'Pat', a kind of fibre which is obtained from two species (annual and short day plants) of the genus *Corchorus* belonging to the family *Tiliaceae*. It is a common term used both for plant and the fibre obtained from the bark of the plants, *Corchorus capsularis* L. and *Corchorus olitorius* L. There are over 30 species, which belongs to the genus *Corchorus*. Jute (*Corchorus capsularis* & *Corchorus olitorius*), Kenaf (*Hibiscus cannabinus*) and Roselle (*H. sabdariffa* var (*Altissima*)) are vegetable bast fibre plants next to cotton in importance. In the trade there are usually two names of jute, White and Tossa. *Corchorus capsularis* is called White Jute and *Corchorus olitorius* is called Tossa Jute. In India & Bangladesh Roselle is usually called Mesta. Jute fibres are finer and stronger than Mesta and are, therefore, better in quality. Depending on demand, price and climate, the annual production of jute and allied fibres in the world remains around 3 million tonnes. The fibre finds its use in the producing as well as in consuming countries in the agricultural, industrial, commercial and domestic fields. Sacking and Hessians (Burlap) constitute the bulk of the manufactured products. Sacking is commonly used as packaging material for various agricultural commodities viz., rice, wheat, vegetables, corn, coffee beans etc. Sacking and Hessian Cloth are also used as packing materials in the cement and fertilizer manufacturing industries.

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*. As jute fibres

are also being used to make pulp and paper, and with increasing concern over forest destruction for the wood pulp used to make most paper, the importance of jute for this purpose may increase. Jute has a long history of use in the sackings, carpets, wrapping fabrics (cotton bale), and construction fabric manufacturing industry [1]. Traditionally jute was used in traditional textile machineries as textile fibres having cellulose (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 steadily heading towards its newer identity, i.e. wood fibre. As a textile fibre, jute has reached its peak from where there is no hope of progress, but as a wood fibre jute has many promising features. With these view the study was undertaken to see the past and future of jute in Bangladesh, its production, research achievements and diversification as well.

Once jute was our main exporting good, the golden days of that fiber have gone. Bangladesh earned huge foreign currency by exporting jute. Before the 70s till the readymade garments appeared we earned a fabulous sum of foreign currency from jute. Owing to mismanagement and lack of foresight we have already lost our golden age of jute. The present condition of jute as a cash crop in Bangladesh is very miserable. Why is it so? What are the reasons behind it? I have tried my level best to look into the above matter in my following study. Jute being the most important commercial crop plays a major role in our agriculture. Various development projects of Bangladesh are financed by the foreign exchange earnings from jute. Jute also holds an important position in the industrial sector of the economy of Bangladesh. Jute is a versatile and environment-friendly bio-degradable natural fibre widely grown in Asia, particularly in Bangladesh, India and China. It is an important cash crop in Bangladesh and India, which together accounts for about 84% of world production of jute fibre [2].

2. Materials and Methods

The study was based on secondary data. The secondary information used was collected from different sources of the Library of Bangladesh Jute Research Institute, Dhaka during the period from May to till October, 2015. The data sources were International Jute Study Group (IJSJ) reports, IJSJ website, BJRI reports, Bangladesh Journal of Jute and Fibre Research; Jute and Jute fabrics, Bangladesh. Department of Agricultural Extension, Food and Agriculture Organization statistics, different books, direct communications with related office and persons, accessing internet and using different national and international journals.

3. Results and Discussion

The history of jute cultivation in Bangladesh

Jute had been cultivated in the Bengal delta from time immemorial but no one can say when or from where it came. It is interesting to note that it was in emperor Akber's time that jute became an important feature of the economic life of Bengal. There are about 40 species of jute out of which only two, i.e. corchorus olitorius (Tos jute) and corchours capsularies (white jute) are widely used. The name of species of jute is Tiliace and genus is corchors. Best fibres of similar nature are also used commercially. These are called mesta, kenaf or allied fibres. The early cultivation of olitories was in Khulna and 2/1 pargana of west Bengal. After a lot of debate, there seems to be an agreement that White Jute originated in the Indo-Burma region and Tossa Jute in Africa. Kenaf originated in Angola in Africa and Roselle originated in Sudan of Africa. China is also considered as one of the places of origin of Jute. According to some scholars, some provinces of the southern parts of China are the secondary centres of origin of Tossa and White Jute.

Importance of jute in the economy of Bangladesh

Jute has always played an important role in the economy of Bangladesh. In the 1970s Bangladesh earned huge foreign currency by exporting raw jute, jute goods, arts and crafts made of jute fibre. That's why it was called the 'Golden Fibre of Bangladesh'. In recent few years Bangladesh Government is trying to promote the jute industry and to get back the lost position in the world market. The Government is trying to initiate a revolution in the jute industry and the current government policy is one of inducement and facilitation for promotion of investment and export of jute products. Subsequently, it has become an industrial raw material for production of packaging materials. Jute the 'Golden fibre' of Bangladesh has been considered as the major source of foreign exchange earnings of the country. It provides livelihood for millions of farmers, industrial workers. Cultivation of jute in the country has been drastically reduced from 25.42 lakh acres of land with production of 13.44 lakh tonnes jute fibre and 30.91 lakh tonnes of jute sticks in 1969-70 to 9.6 lakh acres of land with production of 10.35 lakh tonnes jute fibre and 16.72 tonnes jute stick in the year 2004-05. On an average, jute was cultivated between 10.00 to 11.85 lakh acres producing almost 53 to 57.5 lakh bales of raw jute in the country. The export market tried to sustain a steady trend showing positive and promising signal for jute. Jute sector could contribute to creation of huge employment opportunities, wide scale income generation and poverty alleviation, and ultimately higher contribution to GDP [2].

Cultivation and marketing of jute as well as the manufacturing of jute goods provide employment for lakhs of people. Bangladesh government earns revenue both from raw jute and jute goods. Jute also plays a major part in the development of banking and insurance in the country. The Sonali Bank originally known as the National Bank during

Pakistan period was established especially for financing jute trade. The welfare of the rural people which depends directly on agriculture is intimately bound up with the production and trade of jute. Import of various goods and services is a prime necessity for the economic development of Bangladesh. All these imports depend on the quantity and value of exportable surplus to which jute is the main contributor. In fact, jute is foreign trade and the financial barometer of the country [3]. Jute has an important bearing on employment. Jute farming, jute trade and industry provides about 10 percent of the total employment in the country, contributes approximately 12 percent to GDP [4]. At farm level, jute is a labor intensive activity and demands more laborers than most other major crops that are grown in Bangladesh. When jute is exported and/or used for local manufacturing, many laborers are involved at different stages of the crop and the business through which income distribution takes place. Therefore, jute is an economic issue bearing a social dimension as well. Bangladesh is the second largest raw jute producers accounting for about 30% of world production. About two-third of raw jute was processed domestically in 74 jute mills, producing mainly packaging fabric as hessian and sacking and carpet backing cloth [3]. Emission of green house gases into the atmosphere has led to Global warming. That caused glaciers melting, raising sea levels, cyclones, tornados, flood, drought Tsunami etc. Incremental raising of the temperature these calamities intensified many folds and causing havoc to life and properties. Bangladesh is facing the reality of climate change due to global warming. It will impact on the composition of atmosphere, hydrology, geomorphology, ecology, soil, land use, biodiversity, vegetation etc. As a result many natural ecosystem may be changed. Emergence of climate change would affect Bangladesh in two ways in two major contrasting regions. First one, the southern region would be in drainage congestion with rise of sea level and intrusion of saline water. Secondly the north-western part will be subjected to scarcity of water leading to drought condition; both will impaired the agro-ecosystem of the country. Agriculture is the main concern due to changes in climatic factors such as temperature, humidity, precipitation, wind flow, solar radiation; evaporation etc has direct effect on the production of crop. Jute is a fibre crop belongs to genus *Chorchorus* of the Tiliaceae family with two cultivated species—*C. capsularis* L. *C. olitorius* L. Fibre is extracted from the bark of the plants. It grows under an abundant range of climatic factors. Among the climatic factors, temperature, humidity rainfall, sunshine are the dominating component for the growth of jute plant. In 1970-80 decades about 15-16 lac hectare of the total cultivable land was occupied by jute has now been reduced to 4.50 to 5.0 lac hectare. Still jute is contributing to national economy. Its present contribution to GDP is about 5.5% [5].

Traditional use of jute

Jute is to-day a textile fibre of great commercial importance. In ancient time jute was probably a garden plant a “pot herb” whose leaves were used for vegetable and medicinal purposes. Later on jute became a field crop,

farmers learnt the process of extracting the fibre and of spinning it into yarn by hand. This yarn was used for making ropes and twines for domestic agricultural and navigation purpose. This was followed by the process of interlacing of the yarn into strips of narrow fabrics by means of primitive hand looms. These were used by farmers for various household purposes including bedding, matting or even garments. Sometimes they tiered several strips together to make containers or wrappers for agricultural products. It was for discovery of making bags out of the jute fabrics which brought about a turning point in the history of the fibre and when it responded to the mechanical processes of spinning and weaving, it assumed a leading position as a textile of supreme importance in the commercial world [6]. The hand-woven jute bags of Bangladesh has already earned a reputation in the Asian and American markets, and when the flax spinners of Dundee took to jute during the early thirties of the 19th century, they were also first interested in the manufacture of bags for packaging purpose from a much finer fabric called “Hessian” which became very popular in the markets of America and Europe. By the time the first jute mill was established in India. India made the Dundee industry explore the possibilities of new uses of jute. The progress in this direction was at first slow but as research activities advanced in the fields of production and technology, a large variety of profitable new uses were discovered. Being coarse and rough jute is not suitable for apparel purposes, but its use as packing and in industrial field is predominant. Its largest usage is for packaging purposes. Jute is used for manufacturing other industrial products such as wind screens, roofing fabrics, cordage, electric cables etc. It is also an important raw material used for preparation of tents, rifle pull-through, sand bags, netting and stip, water-bag etc. The jute fabric is further used as a base for linoleum and furniture and for failer’s padding etc. In addition, there are specialty manufactures such as union fabrics, dyed and printed furnishing fabrics, water and rot resistant jute goods, fire resistant brattice cloth, bituminized materials, suitable for roofing, needled felts and laminated materials made from jute in combination with natural and synthetic resins [7].

Modern use of jute

In recent years the use of synthetic fibre products, because of their preferential price over jute goods, dominated global market. This dominance of synthetic goods has adverse effects on jute market and resulted in lower price day by day. Researchers and scientists of the Bangladesh Jute Research Institute (BJRI) and Bangladesh Council for Scientific and Industrial Research (BCSIR) undertook various experiments to innovate new products from jute. Jute reinforced plastic is a new composite material. It is cheaper than fibre glass. Jute reinforced plastic is suitable for use of silver cans, furniture, grain seed, soil, water storage tanks and boats. Jute-plastic blended boat has already been commissioned in Bangladesh with the assistance of two Norwegian naval architects. The cost of 28 feet long jute plastic boat is taka 200000. Export market of jute plastic boat has tremendous prospects to Norway and Sweden [4]. It is very encouraging that a wide

range of diversified jute products can be manufactured with multi-fibre concept through vertical and horizontal extension for divergent end uses. With the help of the renowned jute technologists and scientist Jute Diversification Promotion Centre (JDPC) has identified a big list of diversified jute product and technologies for these products are readily available in country. Like paper, plastic, substitutes, medicare textiles, cellulose, floor tiles, panels, dyed yarn, polished yarn, multiplied yarn, shikha, shoe, tape, lakhe, union fabric, printed fabric, scrim cloth, drill, dress materials, pillow cover, carry bags, laundry bags, vanity bags, toys etc are also produced using jute fibre [2]. Bangladeshi scientists have successfully produced Novocel wool from jute. The Novocel wool blanket is now popular among the buyers in the home market. Polythene made nursery pot has proved to be harmful. At the time of plantation of the sapling polythene nursery bags needed to be removed as it is not bio-degradable. But jute nursery pot is bio-degradable and need not be removed. Bangladesh is trying to increase the non-traditional use of jute.

Major Producers

India, Bangladesh, China, Myanmar, Nepal and Thailand are at present the major producers of Jute, Kenaf and Roselle fibres. India, Bangladesh and China are the large producers.

Climate

Jute cultivation requires specific climate and land. It requires early rains in March, May and June and intermittent rain and sunlight thereafter till August, temperature between 28°C and 35°C and humidity between 70% and 90%. This type of climate is available in areas between 30° Latitude North and South of the earth. Kenaf and Roselle grow almost throughout the world both in tropical and temperate areas.

Soil

Soil conducive to producing jute is of three types:

Loamy soil, clayey soil and Sandy soil

Loamy soil usually produces the best fibre. The clayey soil yields a short crop. Also plants grown on clayey soil do not ret uniformly. The sandy soil produces coarse fibre.

High Yielding Varieties

A large number of high yielding varieties of Jute and Allied Fibres (JAF) have been evolved at the different research centres of the jute producing countries. The names of these varieties are given below against the names of these countries.

Growing Regions

Jute and Allied Fibres (JAF) are produced in many countries. India, Bangladesh, China, Thailand, Myanmar & Nepal are the major producing countries. Together they produce about 95% of the global production of JAF. India and Bangladesh produce mostly jute; China produces mostly kenaf while Thailand produces kenaf and roselle.

In Nepal, Jute is grown in about 11000 ha in Tarai belt of Eastern part of Nepal. In Thailand JAF are cultivated in about 20,000 ha. In India Jute and Kenaf are grown in about 1,000,000 hectares. Most of the production comes from the States of West Bengal, Bihar, Assam, Orissa, Andhra Pradesh & Tripura. Bangladesh grows mainly jute, only about 10%

kenaf and roselle in 500,000 hectares. China grows mainly kenaf and only about 10% jute in about 56,000 hectares. In Indonesia JAF are grown in 10,000-20,000 hectares. Among jute growing areas in Bangladesh the quality fibre produced in Faridpur Talma region.



Figure 1. Observation of regional yield trial for advanced line (*C. olitorius*) at Talma area, Faridpur, Bangladesh.

Table 1. Area and yield of jute and allied fibre production in major producing countries.

Country	Area (2002/2003) ('000ha)	Yield (1998 / 99-2002/03) (mt/ha)
Bangladesh	500	1.79
China	56	2.53
India	1000	1.86
Myanmar	58	0.85
Nepal	11	1.13
Thailand	19	1.54

Bangladesh: *C. olitorius*: O-4, O-9897 & OM-1; *C. capsularis*: D-154, CVL- 1, CVE-3, CC-45 & BJC-7370; *H. cannabinus*: HC-2 and HC-95 and *H. sabdariffa*: HS-24.

China: *C. olitorius*: Kuan Ye 075-22; *C. capsularis*: Ye Yuan No. 5; *H. cannabinus*: gingpi No. 3 and 722, 7804.

India: *C. olitorius*: JRO-878, JRO-632, JRO-7835, JRO-524, JRO-66, JRO-8432, and JRO-128; *C. capsularis*: JRC-7447, JRC-321, JRC-212, JRC-698 and JRC-"Hybrid C"; *H. cannabinus*: HC-583 and AMC-108 and *H. sabdariffa*: HS-4288, HS-7910, AMV-1, AMV-2, AMV-3 and AMV-4.

Indonesia: *C. capsularis*: CC-15 and CC-22; *H. cannabinus*: H- 33, HC-48, HC-G4 and HC-GR5 and *H. sabdariffa*: HS-40.

Thailand: *C. olitorius*: NS-1; *C. capsularis*: JRC-212; *H. cannabinus*: 977-044, Big Green and NS-2. Present situation of jute in Bangladesh

Year wise area and production of jute

Recently, jute is facing a stiff competition at the farm level also. This is due to the fact that jute land is equally suited for growing rice, and rice is commanding a record high price in the home market. Moreover, the production of high yielding varieties along with modern inputs and practices has further increased the possibilities of increasing profitability of rice over jute. The farmers are quickly adjusting their production plans accordingly and taking the advantage of the high price of rice. The price of jute was not very attractive compared to other competitive crops.

Table 2. Total area and production of jute in Bangladesh.

Years	Area (000 acres)	Decade average (000 acres)	Production (000 tones)	Decade average (000 tones)
70s Decade 1972-73	2214.70		1181.00	
1973-74	2196.40		1088.00	
1974-75	1416.55		630.00	
1975-76	1277.34		714.00	
1976-77	1603.45		873.00	
1977-78	1805.27		973.00	
1978-79	2051.58		1150.00	
1979-80	1874.31		1065.00	
1980-81	1568.77	1778.71	897.00	952.33
80s Decade 1981-82	1411.85		842.00	
1982-83	1425.44		886.00	
1983-84	1435.12		946.00	
1984-85	1484.20		928.00	
1985-86	2614.00		1571.00	
1986-87	1908.00		1221.00	
1987-88	1244.88		780.80	
1988-89	1269.58		799.40	
1989-90	1338.49		835.00	
1990-91	1461.50	1559.31	914.10	972.33
90s Decade 1991-92	1449.39		945.10	
1992-93	1235.49		885.60	
1993-94	1287.61		782.30	
1994-95	1402.47		929.50	
1995-96	1355.55		910.35	
1996-97	1253.00		883.00	
1997-98	1427.00		1057.00	
1998-99	1181.00		821.00	
1999-00	1008.00		711.00	
2000-01	1107.00	1270.65	821.00	874.59
2000s Decade 2001-02	1128.00		859.00	
2002-03	1079.00		800.00	
2003-04	1008.00		794.00	
2004-05	965.00		1035.00	
2005-06	500.00		990.00	
2006-07	500.00	863.33	990.00	911.33

Source: [8-12]

Year wise area and production of jute

Recently, Jute is facing a hard competition. Jute sector is crossing a miserable situation in the economy of Bangladesh. This is due to the fact that jute land is equally suited for growing rice, and rice is commanding a record high price in the local market. Moreover, the different hybrid varieties of rice have further increased the possibilities of increasing cultivation of rice over jute. The farmers are quickly adjusting their production plans accordingly and taking the advantage of the high price of rice. The price of jute was never stable. That is why farmers like to produce other crops rather than jute. As a result the area of production of jute was decreased over the year. The area and production situations of jute in Bangladesh were between 1972-73 and 2006-2007. There have been considerable variations in jute areas and production over the years. However there is a clear downward trend (Table 2). The area of jute production reduced to 965 thousand acres in 2004-05 from 2214.70 thousand acres in 1972-73. Table 3 also shows that the production of jute reduced to 1035 thousand tones in 2004-05 from 1181 thousand tones in 1972-73. The production of jute were 794 thousand tones and 800 thousand tones in 2003-04

and 2002-03 respectively while the areas of jute production were 1008 thousand acres and 1079 thousand acres in 2003-04 and 2002-03, respectively. The total jute acreage in 1972-73 was 2214.70 thousand acre and the production was 1181.00 thousand tones. It was 1908.00 thousand acres in 1986-87 and the area gone down to 500.00 thousand acres in 2006-07 from where producing 1221.00 and 990.00 thousand tones of jute fibre, respectively (Table 2). The jute production area decreased gradually during the decades from 70s to 2000s. It was observed the average cultivation areas (1778.71 thousand acres) in 70s. In contrast it was decreased up to 863.33 thousand acres in 2000s decade. On the other hand, the average production was found 952.33 thousand tons in 70s decade was increased up to 972.33 thousand tons in 80s, however, it was decreased 874.59 thousand tons in 90s and 911.33 thousand tons in 2000s (Table 2). It might be happened for day by day getting pressure of food crop production, change of jute cultivation zones, cultivation ratio of tossa and white jute etc [13].

Economic Performance of Jute

Jute (*Corchorus* spp.) is one of the most important biodegradable natural fibre and cash crop of Bangladesh.

Next to rice, jute has historically been an important crop playing a very vital role in economy of the country. In 2010-2011, about 1523.59 thousands metric of raw jute have been produced from 708.72 thousand hectares of land in Bangladesh. Currently, raw jute and jute goods occupy second position in foreign earnings of the country. In 2009-2010, about 1087 thousands metric of raw jute and jute goods have been exported from about 53961.28 million taka in Bangladesh [14]. About 5.08% of the foreign exchange is earned in Bangladesh during 2011-12 by exporting raw jute and jute materials [15]. Millions of people earn their livelihood from agricultural and industrial activities based on jute and allied fibres. Moreover, beyond the farmland and factory, jute and jute goods keep alive transport sector, servicing sectors like banks, insurance, and agro-industrial job market. Jute crop also greatly improve the soil fertility status by incorporating organic matter to the soil through

decomposition of shaded leaves and plant residues and helps in breaking plough-pans by its long tap root system. Again, jute and jute goods have recognized as being friendly to the environment [16]. Though cultivation of jute in the country has drastically reduced from earlier but for the last 3-4 years, the situation has conspicuously improved and recorded an increasing trend. Higher yield is not the main determinant for the success and variability of any crop production. The profitability is an important consideration in any crop production which dictates and influences the decision making process of the entrepreneurs in favour of accepting or rejecting a particular farming practices [17]. Studies on some aspects of cultural practices and economics of jute production have been made [18], but limited information is available concerning the labour utilization, input use pattern, profitability and socio-economic constraints of jute production under different cultural practices and areas.

Table 3. Annual average price, total area, production and yield of jute in Bangladesh.

Year	Total area ('000'ha)	Total production (lac bales)	Yield (kg/ha ⁻¹)	Average price (Tk.kg ⁻¹)
2007-08	441	46.22	1900	16.76
2008-09	421	46.78	2020	24.50
2009-10	416	50.89	2220	20.84
2010-11	709	83.96	2150	55.40
Last ten years average	449	49.42	1990	17.97

Source: Price data from Directorate of Agriculture Marketing (DAM); Area, Production and Yield Data from various issues of Yearbook of Agricultural Statistics

Foreign exchange earning

Economic development of Bangladesh is largely dependent on the availability of foreign exchange. Bangladesh has to develop her industrial and agricultural sectors very rapidly. For this reason she needs to import goods from foreign countries. The quantum of foreign exchange she can have from the export of the traditional items such as jute, tea, leather etc. is not at all sufficient and Bangladesh has to depend on foreign grants and loan.

Therefore, foreign exchange is a very scarce resource and the contribution of jute in earning this scarce foreign exchange has been traditionally very vital and this trend is not likely to change in future. Unfortunately, jute is facing problems in the international markets. In the world market, Bangladeshi jute has to compete with Indian jute on the one hand, and on the other hand, the importing countries reducing the import of jute goods (Table 3). The use of the synthetic fibre in the importing countries has also increased tremendously.

Table 4. Foreign exchange earnings from jute and jute goods (Taka in crore).

Year	Jute goods	Raw jute and mesta	Total earning from jute and jute goods	Total foreign exchange earning	Percentage of the total foreign exchange earning
1998-99	1168	270	1438	20851	6.90
1999-00	1131	370	1501	24923	6.02
2000-01	1274	402	1676	32419	5.17
2001-02	1398	379	1777	30934	5.74
2002-03	1272	401	1673	33242	5.03
2003-04	1271	454	1725	40581	4.25
2004-05	1677	564	2241	50835	4.41
2005-06	2159	860	3019	62608	4.82

Source: Economic Trend,[19]

Table 4 shows that the country's yearly total export earnings from jute and jute goods was 3019 crore taka in 2005-06 of which 860 crore taka was obtained from raw jute and 2159 crore taka from jute goods. The percentage of total export earnings from jute and jute goods was 4.82 in 2005-2006 while 4.41 percent, 4.25 percent were in 2004-2005, and 2003-2004, respectively. It appears that the total export earnings from jute and jute goods had increased since 1998-99, but its share of total foreign exchange earnings is falling.

Jute as a source of fibrous raw material

Bangladesh chemical industries corporation (BCIC) is the major user of fibrous raw materials in the country in the form of bamboo, wood baggage for production of pulp and paper in Karnaphuli Paper Mill (KPM), North Bengal Paper mill (NBPM), Khulna Newsprint Mill (KNM) and Sylhet Pulp and Paper Mill (SPPM). These industrial units need around 1.44 lakhs tonnes gewa wood annually. Due to pressure of the growing population there has been a steady decline in the

forest resources. BCIC is facing acute shortage of these fibrous raw materials in order to ensure sustained production in this mill with sharp decrease in the availability of traditional/conventional fibrous raw materials (Bamboo/wood etc.) and the tremendous increase in the requirement of packing materials for the export oriented industries. BCIC was seriously thinking about the economics of alternative raw materials. It may be recalled that the utility of jute containing cellulose material has been confirmed at different laboratories at home and abroad. But this laboratory finding has been put to industrial use at a commercial scale [7].

Consumption of jute in Bangladesh

Jute is the cheapest and the most widely used fibre in the world. Nearly 20 percent of the world’s annual output of natural industrial fibres consists of jute. The demand for jute is a derived demand as an input to the jute manufacturing industry. Jute is used for the production of Hessian, sack, carpet backing, yarn, gunny begs, fabrics etc. It is also used for rope making and handicrafts. Jute is second only to cotton in terms of production, consumption and quantity traded of natural fibers.

Table 5. Consumption of jute and jute goods.

Year	Raw jute consumption (lakh bales)	Jute goods		Internal consumption of jute goods ('000'tonnes)	Export overseas ('000'tonnes)
		Production ('000'tonnes)	Closing stock ('000'tonnes)		
1995-96	23.23	405.1	23.7	65.9	325.1
1996-97	23.39	410.5	37.3	76.4	293.4
1997-98	22.83	381.1	116.7	91.7	230.7
1998-99	21.13	365.3	93.3	79.5	303.0
1999-00	19.38	336.2	76.3	74.9	276.4
2000-01	18.92	325.6	54.8	75.7	265.9
2001-02	15.64	319.4	40.4	43.7	230.6

Source: Economic Trend, [19]

Table 5 shows that raw jute consumption reduced to 15.64 lakh bales in 2001-02 from 23.23 lakh bales in 1995-96. Table 5 also shows that inter consumption of jute goods reduced to 43.7 thousand tonnes in 2001-02 from 65.9 thousand tonnes in 1995-96. Jute is equally important both as agricultural product and industrial raw material in the economy. In spite of great importance of jute as a commercial crop, research studies on jute marketing in Bangladesh remains scanty.

Physical compositions of different Jute & Allied Fibre (JAF) plants

The ribbons, fibres, leaves and stick contents of different JAF plants vary considerably. The fibre content of *C. olitorius* jute plant is the highest and that of *H. sabdariffa* is the lowest. The green leaf content of *H. sabdariffa* plant is the highest. The dry ribbon contents of both *C. capsularis* and *C. olitorius* plants are higher than those of *H. cannabinus*.

Table 6. Physical compositions of different Jute & Allied Fibre.

Crop	Whole (100%)	Ribbons %		Leaf %		Sticks %		Fibres %
	Plant (t/ha)	Green	Dry	Green	Dry	Green	Dry	Dry
<i>C. olitorius</i>	46	38.7	11.7	11.0	2.7	50.3	16.6	6.8
<i>C. capsularis</i>	34	40.2	11.2	15.9	3.9	44.2	12.5	5.9
<i>H. sabdariffa</i>	48	35.2	9.6	16.3	3.6	48.5	15.0	4.8
<i>H. cannabinus</i>	36	34.0	9.5	14.2	3.3	57.8	15.9	4.9
Approx. Avg.	40	37.0	10.3	14.2	3.3	48.8	15.15	5.5

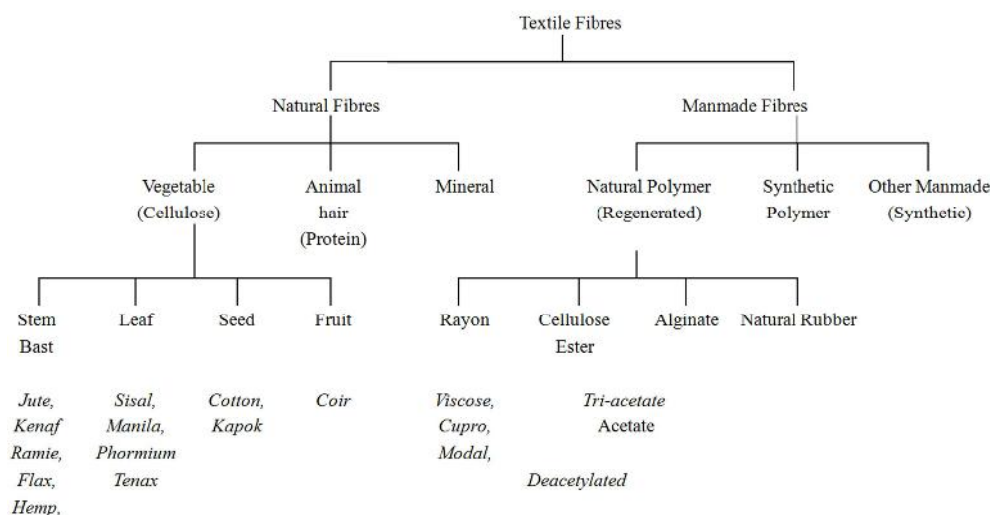


Figure 2. Jute in Textiles.

Table 7. Estimated Supplies, domestic requirements, exports and imports in Major Producing Countries (in '000 Tonnes).

	Bangladesh 2004-2005	Bangladesh 2003-2004	Bangladesh 2002-2003	Bangladesh 2001-2002
Opening Stock	58.3	1.8	262.5	166.14
Production	810	963	793.4	924.66
Imports	0	0	0	0
Total Supply	868.3	964.8	1055.9	1090.8
Mill Consumption	522	522	555.7	520.38
Village Consumption	39.7	54	45	54
Loss/Damage	0	0	0	0
Closing Stocks	0	64.8	1.8	262.47
Total Domestic Requirements	561.7	640.8	602.5	836.85
Exports	306.6	324	453.4	253.95

Table 8. Estimated Supplies, domestic requirements, exports and imports in Major Producing Countries (in '000 Tonnes).

	India 2004-2005	India 2003-2004	India 2002-2003	India 2001-2002
Opening Stock	605.5	617.8	258.1	76.5
Production	1350	1977.3	2060.6	1949.76
Imports	91.4	97.6	151.9	62.64
Total Supply	2046.9	2692.7	2470.6	2088.9
Mill Consumption	1330	1568.2	1681.9	1656.72
Village Consumption	144	171	171	144
Loss/Damage	0	0	0	0
Closing Stocks	272.3	953.5	617.8	288.18
Total Domestic Requirements	1746.3	2692.7	2470.7	2088.9
Exports	0	0	0	0

Research Achievements of jute and allied in Bangladesh

Systematic operations with continuous endeavor are Research. The objectives and directions of research are changed with changes of different requirements. The achievements establish as beneficial only when those are appropriately transferred or disseminate to and practiced by the target people. A brief description of the achievements of BJRI which have either been already adopted or have proved potential for adoption may be of interest to all concerned. The achievements of BJRI are being stated under two

different subheadings i.e. Agricultural and Technological Researches on Jute and allied crops considering the distinct difference in the nature and usefulness of researches.

*Agricultural Researches on Jute**Development of improved varieties*

It has always been regarded as the most important and continuous function is high yielding or high performed variety developed and released 36 jute and allied crop varieties to suit different agro-ecological zones of the country since inception.

Table 9. HYVs developed and released and are under cultivation at present.

Spices	Varieties
<i>Corchorus capsularis</i> L.(Desi jute)	D-154, CVL-1, CVE-3, CC-45, BJC-83, BJC-7370 & BJC-2142
<i>Corchorus olitorius</i> L.(Tossa jute)	O-4, O-9897, OM-1, O-72 & O-795
<i>Hibiscus cannabinus</i> (Kenaf)	HC-2 & HC-95
<i>Hibiscus sabdariffa</i> (Mesta)	HS-24

Source: [13]

Improved cultural practices

It has developed and extended a production technology package in respect to appropriate sowing time, land preparation, seeding rate, intercultural management, harvest time etc which have been proven potential to yield and quality of jute and allied fibre at farm level. Moreover, through manipulation of management practices cost effective technologies have been evolved to reduce the production cost. The present status of jute and jute seed can be overcome in two ways. One way is increasing the production of jute fibre per unit area through minimizing the cost, and the 2nd is

demand of good quality jute seed at sowing time. Involving jute, appropriate profitable three crop patterns in different areas and land types of the country have been identified and always tested with the newly developed and released jute varieties at different agro ecological areas. At present the jute growers may go for fibre cultivation without hampering major food crops as a means to increase net annual profit. Short day and low temperature tolerant jute varieties having shorter field life, may be now regarded as complementary crop in any existing three crop pattern and as well developed soil fertility [13].



Figure 3. Field visit (A&B) and intercultural operations (C&D).

Fertilizer Management

BJRI developed variety wise fertilizer recommendation. For all white and tossa jute varieties about 100-25-45-45-11 kg/ha Urea-TSP-MP-Gypsum-Zinc sulphate are recommended for fibre production in major jute growing areas. Only for Falguni tossa (O-9897) variety 200 kg/ha Urea recommended. Addition of organic matter to soil is

beneficial for all kinds of jute fibre and stick production. Gypsum and Zinc sulphate is needed only when soil is deficient in sulphur and Zinc. For jute seed production the recommended doses are 80-40-16-40-4 of Urea+ TSP, MP, Gypsum and Zinc sulphate for tossa jute and 70-20-12-18-4 for deshi jute [13].



Figure 4. Fertilizer management before sowing.

Management of Pest and Disease

Ten faugal, one viral and one nematode infected disease for jute (White and Tossa) and 18 different diseases for kenaf and mesta have identified which also causes by different fungus, virus and nematode. Among the diseases 10 for jute, 5 for kenaf and 3 for mesta were isolated as send born. There evolved jute and allied crop varieties have different resistant reactions against different disease. Jute seed dressing materials vilavax-200 (0.4%) and garlic paste foliar sprays of Dithane M-45 (20%) and Manner M45 (2.0%) have recommended. Infestation of root-knot diseases can be reduced by amendment of soil with lime, poultry litter, and mustard cake etc. and *Crotalaria juncea* could be a trap crop against root-knot disease. Besides chemical control cultural, mechanical, physical and biological measures have also been recommended [13].



Figure 5. Inspection of jute field status.

Jute Retting

Fibre yield and quality always depends on proper retting. Different operations of this important post harvest agriculture technology of jute have been identified and transferred to the end users. Good retting water quality, hastening and improving



Figure 7. Supervision for quality jute seed production.

retting by incorporation of Urea, washing fibre by tamarind solution (Urea acid solution) are some of the important techniques relating to conventional retting. In water scarce areas ribbon-retting technology is really a remarkable one to solve the problem of jute plant retting. It is now possible to get good quality fibre by retting the pecked barks (ribbons) in very shallow ditches or even in big earthen pots.



Figure 6. Demonstration of ribbon-retting technology.

Seed production from separated sub crop

Quality seed is a prerequisite to successful crop production. Conventionally jute seed production involving sowing in the monsoon has not proved dependable to meet the national seed demand for natural calamitous like flood, pest and diseases and occupation of land for a long duration. It has developed improved jute seed production technology in Bangladesh, in which seed sown at Rabi season as separate crop. Through these techniques seed can be produced by direct seeding, transplantation of top and stem cutting; and seedling of 30-40 days of age. These would ensure good quality and higher yield of jute seed within a very short period (about 3-4 months) during dry season. Proper use of these jute seed production technology could stopped the entrance of huge amount of bad quality low-grade jute seed in the country [13].

Industrial Achievements of research in Bangladesh Development of existing Apron Draft Spinning Machine

The existing Apron Draft Spinning Machine has been developed by adapting ring and Traveler at its delivery end.

Fine jute yarn between 60-150 tex can be spun through the developed system with higher productivity and acceptable textile properties. The conventional Apron Draft Spinning machine cannot produce yarn below 150 tex. The different machine components were changed for this modification. The optimization of different parameters are varies with variation of linear density of produced yarn. In this system optimization were done for 100 tex jute yarn. By using this information the Jute Mills of Bangladesh can be able to produce fine count jute yarn. The produced yarn will be used in decorative and fine fabrics.

Fine Jute Yarn

The method for the production of fine jute yarn (3-5 lb/spy) was developed in this division. In this method fine jute yarn can be produced by modification of existing apron draft spinning frame. The machine was converted in ring spinning system from original flyer spinning system. Speed of the machine was increased upto 8000 rpm which increase the productivity of the machine.

Technique for the production of blended yarn

With the blendind method, jute fibre was blended with three different man-made fibers, acrylic, rayon & polyester of different dimensions, each in the ratio of 90/10, 80/20 and 70/30. Then yarns of nominal counts 5 and 7.5 lbs/spy have been processed out of the above blends. Physico-mechanical properties, quality and spinning performance of the yarns have been studied. Simultaneously, dyeability and colour-fastness properties of the blended fibers, chemically processed and dyed were also studied. Finally, a range of diversified jute blended products out of the above gray, bleached and dyed blended yarns were produced. It has been possible to blend jute successfully with the man-made fibers, like acrylic, polyester and rayon in the conventional jute (long staple) spinning system.

Light Weight Low Cost Shopping Bag

The fabrics were woven with rapier loom and then scoured, bleached, dyed in jigger machine and dried through stenter machine for manufacturing of light and low cost shopping bags. These bags are used as a substitute of polyethylene bags. It is environment friendly, bio-degradable, free from hydrocarbon and health hazards. The weights of the bags are 50-100gms according to the shape and size. 10 to 15 kgs goods are easily carriable with these bags. It can be used several times through washing. Maximum cost per bags Tk. 5-10/= according to size and shape.

Jute Blanket

The blanket produced from jute have high strength, high abrasion resistance, high thermal insulation value (represented by conductivity) i.e. very warm. These blankets are not affected by moths and are cheaper than any other blanket made from cotton, wool or synthetic fibre. The blanket is washable, colour is fast to washing and free from health hazard.

Novotex Fabrics

The fabrics are woven using finer jute yarn as weft and cotton yarn as warp, are then chemically modified by hot wolllenisation process, bleached and dyed in order to make

them soft, lustrous and light weight. Novotex fabrics are strong, durable, both light and colour fast, attractive and cheaper than any other fabrics made from other fibres. These are free from health hazard and naturally decomposable.

Wool substitute softening Yarn

Jute yarn is converted to have wool like appearance and feel by chemical modification, dyeing and finishing. It may be used for making sweater, cardigan, scarf, socks, etc. It is free from health hazard and also free from hydro-cardon. It is very warm comparable to wool but much cheaper than wool and synthetic fibres like acrylic, polyester etc.

Fire Proof Jute Fibre /Fabrics

Jute fabrics are made fire-proofed by treating them in a composite solution and mixed with some phosphate compounds, fulfils the requirement of flame-proof fabrics according to international standard. These fabrics are suitable for all specialized uses wherever fire proofing or insulation is desirable. The fire proof jute fibre may be used in Automobile industries for making interior pats of car/vehicles, mattresses, insulating materials etc.

Jute-Geo Textiles

Jute-geo textiles are flexible, foldable, less biodegradable and water resistant in nature, particularly suitable for reinforcement, flood affected climate condition. These may be used as geotechnical engineering products like fibre drain, separator, filter and reinforcing materials.

Improvement of Low Quality Jute

Low quality jute like SMR and jute cuttings may be improved by enhancing the growth of micro organism in the fibre or by the application of microbial enzymes. The technology provides opportunity for improving and using low grade jute for manufacturing different products while reducing the cost of raw materials.

Absorbent Cotton Substitute

Ideal absorbent cotton substitute can be produced from jute/jute wastes by scouring hot mercerizing, bleaching, activating and then blending with cotton/rayon. The absorbent cotton substitute can be used for making body napkin and sanitary napkin.

Prayer Mat

The jute prayer mat is comfortable, durable and attractive. The production cost is within the reach of general public. It will meet the local demand of the people with cheap and quality prayer mat. Moreover, the quality of the product is good as that of the imported products made of wool or synthetics.

Rot Proof Hessian Fabric

Jute Hessian can be made rot proof by chemical modification. Rot proofing agents containing copper gives the best rot proof finish. There are many diversified uses of rot proofing fabrics, such as, hessian squares, burlap, different types of tents (military tents, wedding tents etc.) nursery pot, sand bag, timbers, fishing nets and also in the cold countries to protect the trees from fog and snow. Nursery pot is one of the basic requirements for plantation. Presently, polythene bags are being used as nursery pot but it is not environment friendly. Rot proof jute based nursery pots

on the other hand are environment friendly, excess water can pass through the pots, so roots are not destroyed due to excess water in the soil. None of the chemicals used in treatment are health hazardous or has negative impact on the environment. In order to reduce the extent of pollution problem efforts have been made throughout the world to use rot-proofing Hessian for making nursery pot for seedling to solve global environment problem.

4. Conclusion

Jute price, target acreage, yield and production before sowing would be helpful to the farmers in allowing them to adjust their jute acreage. Jute production problems might be removed by ensuring supply of inputs, insecticides and pesticides and credit in proper time. Lack of proper government policy on jute, lack of production of jute, random closures of jute mills, failure to modernize the cultivation system and manufacturing units, mismanagement and malpractice, fall of demand of jute in world market, use of alternative source to jute etc. were found as problems in the development of jute fibre in Bangladesh. Government should provide training facility on grading, retting, practices of balanced use of fertilizer and assorting through DAE and BJRI. Preparation and implementation of proper jute policy was found necessary. Market information for the farmers should be provided by the government that the farmers could get the profitable price from jute. Diversified and new items from jute should be manufactured to cope with the present demand of the world market. Millions of people of Bangladesh depend on all affairs of jute crop. Lack of proper government policy on jute, lack of production of jute, random closures of jute mills, failure to modernize the cultivation system and manufacturing units, mismanagement and malpractice, fall of demand of jute in world market, use of alternative source to jute etc. were found as problems in the development of jute fibre in Bangladesh.

Recommendations

Jute and the environment in Bangladesh are mutually supplementary to each other. However, there is no room for complacency because we are yet to fetch the real benefit from the match of jute and the environment in Bangladesh. On the basis of the findings of this study the following recommendations may be put forward for policy formulation with a view to improving the existing marketing system of raw jute. The jute agricultural research bodies could be given the additional function on training the jute farmers on the best methods of cultivation, harvesting and retting. Forecasting of jute price, target acreage, yield and production before sowing will be helpful to the farmers in allowing them to adjust their jute acreage. Proper jute policy should be prepared and implemented. Supply of good seeds for the farmers, timely supply of fertilizer must be ensured. Modern scientific method of jute cultivation should be implemented. Production cost of jute should be reduced into a minimum level so that we can compete with India in oversea market.

Honest and dedicated persons should be appointed at the jute factory. Labour politics should be controlled. Diversified and new items from jute should be manufactured to cope with the present demand of the world market.

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Biography



Md. Mahbulul Islam (Corresponding Author) awarded PhD in 2008 from the Department of Agronomy of Bangladesh Agricultural University especially on Jute seed quality, plant establishment and yield. He had done his M.Sc. (Agriculture) in Agronomy and B.Sc. Agriculture (Hons.) from the same University. He is working at Bangladesh Jute Research Institute (BJRI) since 1989. At present he is serving as Chief Scientific Officer & Head of Agronomy Division. He has 6 books, 67 scientific papers and more than 70 popular articles published in international and national journals, newsletters etc. He visited United Kingdom, Malaysia, India for training, seminar, workshop purpose.



Review Article

Varietal Advances of Jute, Kenaf and Mesta Crops in Bangladesh: A Review

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Abstract: Jute is a cash crop of Bangladesh. Jute, kenaf and mesta fibre cultivation, trade and industry provide sustenance to over 4 million people of Bangladesh. The productivity of jute had doubled from 1.50 t/ha during 1970-80 to about 2.04 t/ha during 2015-16. Development of high-yielding varieties were the one of the main specific technologies which made this possible. Therefore a review was undertaken on research and development of jute, kenaf and mesta varieties at Agronomy Division, Bangladesh Jute Research Institute (BJRI), Dhaka during 2018. The sources of secondary data were BJRI annual reports, thesis, news letter, national and international journals and accessing internet. Nearly 8 lack hectares of land cultivated by jute and allied crops per year in Bangladesh, which produced 80-90 lack bales of fibre. Over all 49 jute and allied varieties (White jute 25, Tossa jute 17, Kenaf 4 and Mesta 3 varieties) developed by BJRI. CVL-1, BJRI Deshi Pat-5, BJRI Deshi Pat-6, BJRI Deshi Pat-7, BJRI Deshi Pat-8, BJRI Deshi Pat Shak-1 and BJRI Deshi Pat-9 of *C. capsularis* L., O-9897, BJRI Tossa Pat-4, BJRI Tossa Pat-5, BJRI Tossa Pat-6, BJRI Tossa Pat-7 of *C. olerorius* L., HC-2, HC-95, HC-3 and BJRI Kenaf-4 of *Hibiscus cannabinus* and HS-24, BJRI Mesrta-2 and BJRI Mesta-3 of *H. subdariffa*. found important could cultivated in farmers field. Premature flowering in jute varieties found harmful to fibre production. Premature or untimely flowering happened mainly due to early sowing of jute varieties in short day length period and partly due to prolonged drought, dry air, stunted growth, low fertility of soil, cloudy weather etc.

Keywords: Jute, Kenaf and Mesta Crops, Variety, Research and Development, Maintenance, Premature Flowering

1. Introduction

Jute is a cash crop of Bangladesh. Jute (*Corchorus* spp.) is now universally recognized that jute is the English version of the current bengali word 'Pat', a kind of fibre which is obtained from two species (annual and short day plants) of the genus *Corchorus* belonging to the family *Tiliaceae*. It is a common term used both for plant and the fibre obtained from the bark of the plants, *Corchorus capsularis* L. and *Corchorus olerorius* L. There are over 30 species, which belongs to the genus *Corchorus*. It is grown in the summer season (Kharif-I) [1].

Jute is a rain-fed crop and its cultivation is concentrated in Bangladesh, India, China, and Thailand. The jute fibre comes from the stem and ribbon (outer skin) of the jute plant. The fibres are first extracted by retting. The retting process

consists of bundling jute stems together and immersing them in low, running water. There are two types of retting: stem and ribbon. After the retting process, stripping begins. In the stripping process, non-fibrous matter is scraped off then the workers dig in and grab the fibres from within the jute stem. It is one of the most cheapest and economical vegetable fiber after cotton, obtained from the skin or bast of plant's stem [2-3]. Recyclable, 100% biodegradable and eco friendly jute has low extensibility and high tensile strength. Jute is the versatile natural fiber widely used as a raw material in many textile, non textile, packaging, construction and agricultural applications. Jute is a type of vegetable fiber used to make items such as rope, twine, carpet, rugs, hessian cloth, and much more.

In 2010-2011, 0.803 million ha land cultivated for jute. Production of raw jute was 1.5 million MT by volume in

2010-2011. Jute cultivation area was 6% of total land area of 13 million ha, of which 8.44 million ha belongs to agricultural land. Jute cultivation area was 10% of agricultural land area. Jute production was 26% as of all agricultural crops [4]. Jute, kenaf and mesta fibre cultivation, trade and industry provide sustenance to over 4 million people of Bangladesh. The productivity of jute had doubled from 1.50 t/ha during 1970-80 to about 2.04 t/ha during 2015-16. Development of high-yielding varieties were the one of the main specific technologies which made this possible. In 1970-80 decades

about 15-16 lakh hectare of the total cultivable land was occupied by jute has now (2014-15) been reduced to about 7.00 to 8.00 lakh hectare which produced about 16-17 lakh tons of fibre. However, national average yield is increased from 1.59 to 2.04 tons per hectare. It is happened due to use of high yielding jute varieties and production technologies, which together contributed toward higher yield [5]. Therefore a review was undertaken on research and development of jute, kenaf and mesta varieties at Agronomy Division, Bangladesh Jute Research Institute (BJRI), Dhaka during 2018.

Table 1. Jute cultivated land areas and fibre production.

Year	Jute Cultivated land (Lakh ha)	Fibre Yield lakh/ha	Fibre Production	
			Lakh ton	Lakh bale
2005-06	4.02	2.08	8.38	46.19
2006-07	4.19	2.12	8.86	48.84
2007-08	4.41	1.90	8.39	46.22
2008-09	4.20	2.02	8.49	46.78
2009-10	4.16	2.22	9.24	50.89
2010-11	7.08	2.15	15.24	83.95
2011-12	7.60	2.03	14.52	80.03
2012-13	6.81	2.03	13.81	76.11
2013-14	6.66	2.03	13.49	74.36
2014-15*	6.73	2.01	13.52	75.01
2015-16*	7.25	1.90	13.74	75.58
2016-17*	8.17	2.04	16.67	91.72

BBS, *DAE

2. Materials and Methods

The study was based on secondary information. The secondary data used were collected from different studies of the Library of Bangladesh Jute Research Institute, Dhaka during from January to November 2018. These secondary data were BJRI annual reports, different thesis, Books, Bangladesh Journal of Jute and Fibre Research, Jute and Jute Fabrics, Bangladesh (News letter) of BJRI and other national and international journals.

3. Findings/Results

3.1. Jute

Taxonomy

Jute belongs to the Kingdom: Plantae – Plants, Sub kingdom: Tracheobionta – Vascular plants, Super division: Spermatophyta– Seed plants, Division: Magnoliophyta – Flowering plants, Class: Magnoliopsida – Dicotyledons, Subclass: Dilleniidae, Order: Malvales, Family: Tiliaceae – Linden family, Genus: *Corchorus* L. – corchorus, Species: *Corchorus olitorius* L. – nalta jute and *Corchorus capsularis* L. – white jute, English name: Jute and Bengali name: Pat, Paat, Naila etc.

There are two types of jute (*Corchorus capsularis* L. and *Corchorus olitorius* L.) cultivated in Bangladesh.

3.2. Tossa Jute (*Corchorus olitorius* L.)

Annual or biennial herb, erect, stout, branched, to 1.5 m high; rootstock woody. Leaves lanceolate to ovate-lanceolate,

subobtusate at base, serrate at margin with basal most serrations extending into filiform processes, acute at apex, glabrous except sparsely hairy nerves, 3-5 nerved; petioles 2-3 cm long, pubescent; stipules subulate, 8-12 mm long, glabrous. Flowers in 1 or 2 flowered leaf opposed cymes, 12-15 mm across, subsessile; bracts subulate, 4-5 mm long. Sepals linear-oblong, apiculate, 5-7 mm long. Petals oblong-spatulate, obtuse, 5-7 mm long. Stamens numerous, somewhat connate at base. Ovary cylindrical, sparsely hairy, 5-loculed; style short; stigma 5-lobed, minutely papillate. Capsules solitary or paired, subcylindrical, 2-7 cm long, 10-ribbed, glabrous, 5-loculed; locules septate between seeds; beak entire, 4-8 mm long; seeds 3-gonous, ca 2 x 1.5 mm, inconspicuously verrucose, black (Dr. N Sasidharan (Dr. B P Pal Fellow), Kerala Forest Research Institute, Peechi) [6-9].

3.3. White Jute (*Corchorus capsularis* L.)

Annual, much branched, spreading herbs; stems pilose, often reddish. Leaves 2.5-7 x 1.5-3.5 cm, ovate to elliptic-lanceolate, base rounded, margins serrate, the basal pair of serrations ending in setae or not, apex acute, basally 3-5-nerved; petioles upto 3 cm long; stipules 4-8 mm long, setaceous. Flowers 2-3 in leaf opposed, shortly pedunculate cymes; pedicels c. 2 mm long. Sepals 5, 3-4 mm long, linear-oblong, hooded and apiculate. Petals 5, yellow, 3-5 mm long, obovate, obtuse. Stamens many. Ovary c. 2 mm long, cylindrical, 3-loculed; style 3-fid; stigma 2-lobed. Capsules 1-3 x 0.4-0.6 cm, 6-angled, 3 of the angles winged, 3-loculed. Seeds numerous, dark brown (Dr. N Sasidharan (Dr. B P Pal Fellow), Kerala Forest Research Institute, Peechi) [4, 7-9].



Source: [10]

Figure 1. *Corchorus olitorius L.*

Source: [11]

Figure 2. *Corchorus capsularis L.***Table 2.** Botanical Comparison of *Corchorus capsularis L.* White Jute and *C. olitorius L.* (Tossa Jute).

Corchorus capsularis L. White Jute	Points	C. olitorius L (Tossa Jute)
Generally 1.5 to 3.7m tall, can withstand water logging in later stages, herbaceous annual, 3-5 month duration for fibre yield depending upon sowing time. It's stem cylindrical, green to dull coppery red to pink, periderm in the basal portions in later stages. Cylindrical, green to dull coppery to pink; periderm in the basal portions in later stages.	General	Plants generally 1.5-4.5 m tall; cannot withstand water logging; herbaceous annual, 4-5 months duration depending on time of sowing, flowers prematurely if sown very early.
Branched or unbranched; axillary buds may or may not develop into branches.	Stem	Cylindrical, green, light or dark red, fewer shades of colour than capsularis; no periderm but lenticules in later stages.
Leaves are glabrous, 5-13 cm by 2.5-8.2 cm length and bright. Ovate oblong, acuminate, coarsely toothed, lower most pair of serrations enlarged and end in hairy appendages. Petiole 4-8 cm, various from green to pink in different varieties, stipules 0.5-2.0 cm or more, foliaceous in some varieties, tip coloured or green.	Branching habit	Branched, but branches normally develop less vigorously.
Flowers are small generally in extra axillary cymes in groups of 2-5 or more; 0.3-0.5 cm long and 0.5-0.6 cm wide; sepals 5, coloured or green, petals 5, yellow or pale yellow, stamens 20-30; anther yellow to pale yellow, ovary rounded, 5-carpelled, syncarpous, ovals axile, usually 10 in each locale in 2 rows, giving about 50 ovules in each ovary; style 2-4 mm; stigma pubescent.	Leaves	Leaves are glabrous, 7-18 cm by 4-8 cm, oblong, acuminate coarsely toothed, lowermost pair of serrations more enlarged than in capsularis and hairy appendages longer. Petiole 4-9 cm, various from green to dark red, stipules 0.5-1.5 cm or slightly more, tip coloured or green, base coloured except in the full green types.
One or two hours after sunrise.	Flower	Flowers generally in extra axillary cymes in groups of 2-5, about 1 cm in length, 2-2.5 times the size of capsularis flower, sepals 5-6, coloured or green, tips prolonged in flower buds. Petals 5-6. Yellow, entire or split. Stamens 30-60, anthers yellow, ovary inengated, 5-variably 6- carpelled, syncarpous, ovals axile, usually 40 in each locale in 1 row giving about 200 ovules in each ovary, style 3-5 mm, stigma globular, entire, pubescent.
Capsules rounded, 1.0-1.5 cm in diameter, wrinkled, rarely smooth, muricate, 5-locular, seed- 7-10 in 2 rows in each ocular, without transverse partitions, 30-50 seeds in each fruit.	Anthesis	An hour or before sunrise.
Seeds are small, chocolate brown, 4-5 faced about 300-350 per gm.	Capsule	Capsule elongated, 6-10 cm long, 0.3-0.8 cm in diameter, ridged lengthwise, 5-6 locular, seed 25-40 in single row in each loculus, with transverse partitions between each seed and 140-200 in each fruit.
	Seed	Seed smaller than those of capsularis, green to steel grey to even black, about 450-500 per gm.

3.4. Kenaf (*Hibiscus cannabinus*)

Taxonomy

Kenaf belongs to the Kingdom: Plantae, *Clade*: Angiosperms, *Clade*: Eudicots, *Clade*: Rosids, Order: Malvales, Family: Malvaceae, Genus: *Hibiscus*, Species: *H. cannabinus*, Binomial name: *Hibiscus cannabinus L.*

Kenaf (*Hibiscus cannabinus L.*) is an annual fibre crop related to cotton and okra. It is native to Africa, where it has been cultivated for use in ropes and animal consumption for at least 4,000 years. This tropical plant thrives best on land with good water-holding capacity and is drought tolerant. Kenaf

grows up to a height of 3-4 metres within a period of 120-150 days, and is then ready for harvesting. Kenaf is a short day, annual, herbaceous plant cultivated for the soft bast fibre in the stem. It belongs to the Malvaceae, a family notable for both its economic and horticultural importance. The genus *Hibiscus* is widespread, comprising some 200 annual and perennial species. Kenaf is closely related to cotton and the holly hocks (*Althea sp.*). The name kenaf is of Persian origin and is most generally used to describe the plant *Hibiscus cannabinus L.* and the fibre. At present, in Bangladesh, so many areas are covered by Kenaf like, Bhrambaria, Voirab, Netrokona, vast areas of Kishoregonj; Laksmipur, Noakhali,

Shriatpur, Madaripur, some sporadic areas of Tangail, Mymensingh and Jamalpur.

Stem: Erect, prickly, cylindrical, branched or un-branched reaching a height of 1 to 4m, either entirely green green with pinkish or raddish pigmentation, or red.

Leaves: Eigher entirely cordated and very shallowly lobed with serrated margins or 3-5-7 deeply palmate, alternate, stipulate, stipulates free lateral, pubescent 0.5 to 0.8 cm long. Petiole 3.0 to 18.0 cm long, finely pubescent on the adaxial surface and bristled on the abaxial surface, green to red, scabrous.

Lamina: Lobed or unlobed, when unlobed ovagte margin serrated, apex acuminagte, 5-7 nerved palmately reticulate, when lobed palmately 5-7 deep, each lobe lanceolate, margin serrated, apex acute, one green gland present on the mid-vein on the under surface, upper surface glabrous, lower surface hairy along with veins, scaberulous.

Flowers: Salitary, axillary, pedunculate, pednecle 0.2 to 0.4 cm long, bristled, pentamerous, 8.0 to 10.0 cm in diameter when open, yellow with red center or completely yellow, showy, bractoles (epicalyx) 7-9, segmented, linear, bristled, 1.0 to 1.5 cm long, green attached to the base of the calyx.

Calyx: Cepals 5, lanceolate, cornate below the middle into a cap, green bristled and tormentosed with a large green gland on the back of each sepal, persistent.

Corolla: Large, spreading, bell shaped, full yellow with or without deep enter, petals 5, free, very slightly united at the base twisted outer side pubescent, 7-9 cm long.

Stamens: Many monadulhous, stamined coluran epipetatous truincate, 2.5 cm long with glandular hairs, yellow or light red, filaments 0.1 to 0.2 cm long, red yellow anthers semiform, pollen spiny.

Carpels: 5, ovary ovoid, 0.7 to 0.8 cm long. Densely covered weith white silky adressed hairs, 5, chambered with many ovules in each chamber arranged in 2 vertical rows stigma-5, hairy, capitate, red or yellow, exerted.

Capsule: Ovoid, pointed, villose, half of the length of the calyx with about 20 to 26 seeds.

Seed: Traiangular, angles more or less acute, ash gray with pointed light yellowish warty spots. Hilum brown, relatively small. Most of the better known kenaf varieties produce seed

that range from 36000 to 40000 per kg.; however some Africand types from Sadan, Uganda abnd Central African Republic produce small seed that range from 100,000 to 110,000 per kg.



Figure 3. Leaves and plants of kenaf.



Figure 4. Kenaf Flower.



Figure 5. Kenaf seed.

Table 3. A morphological differences between Kenaf and Jute.

Characteristics	Kenaf	White Jute
Stem	Erect, prickly, cylindrical, branched or un-branched reaching a height of 1 to 4m, either entirely green green with pinkish or raddish pigmentation, or red.	It is generally 1.5 to 3.7m tall, can withstand water logging in later stages, herbaceous annual, 3-5 month duration for fibre yield depending upon sowing time. It's stem cytindrical, green to dull coppery red to pink, periderm in the basal portions in later stages.
Leaves	Eigher entirely cordated and very shallowly lobed with serrated margins or 3-5-7 deeply palmate, alternate, stipulate, stipulates free lateral, pubescent 0.5 to 0.8 cm long. Petiole 3.0 to 18.0 cm long, finely pubescent on the adaxial surface and bristled on the abaxial surface, green to red, scabrous.	Leaves are glabrous, 5-13 cm by 2.5-8.2 cm length and bright. Ovate oblong, acuminate, coarsely toothed, lower most pair of serrations enlarged and end in hairy appendages. Petiole 4-8 cm, various from green to pink in different varieties, stipules 0.5-2.0 cm or more, foliaceous in some varieties, tip coloured or green.
Flowers	Salitary, axillary, pedunculate, pednecle 0.2 to 0.4 cm long, bristled, pentamerous, 8.0 to 10.0 cm in diameter when open, yellow with red center or completely yellow, showy, bractoles (epicalyx) 7-9, segmented, linear, bristled, 1.0 to 1.5 cm long, green attached to the base of the calyx.	Flowers are small generally in extra axillary cymes in groups of 2-5 or more; 0.3-0.5 cm long and 0.5-0.6 cm wide; sepals 5, coloured or green, petals 5, yellow or pale yellow, stamens 20-30; anther yellow to pale yellow, ovary rounded, 5-carpelled, syncarpous, ovals axile, usually 10 in each locales in 2 rows, giving about 50 ovules in each ovary; style 2-4 mm; stigma pubescent. Anthesis one or two harms after sun rise.

Characteristics	Kenaf	White Jute
Capsul	Ovoid, pointed, villose, half of the length of the calyx with about 20 to 26 seeds.	Capsules rounded, 1.0-1.5 cm in diameter, wrinkled, rarely smooth, muricate, 5-locular, seed- 7-10 in 2 rows in each ocular, without transverse partitions, 30-50 in each fruited.
Seed	Triangular, angles more or less acute, ash gray with pointed light yellowish warty spots. Hilum brown, relatively small. Most of the better known kenaf varieties produce seed that range from 36000 to 40000 per kg.; however some African types from Sudan, Uganda and Central African Republic produce small seed that range from 100,000 to 110,000 per kg.	Seeds are small, chocolate brown, 4-5 faced about 300 per gm.
Fibre	Fine fibre with lower weght than Kenaf	Course fibre higher weight than white Jute
Growing areas	Brammanbaria, Voirab, vast areas of Kishoregonj; Lakkhipur, Shriatpur, Madaripur, some sporadic areas of Tangail, Mymensingh and Jamalpur.	All over Bangladesh except Sylhet, Chattagram Hill Tracts, Southern areas like Barishal, Borguna, Volla, Piotuakhali, etc
Processing (Post harvest)	Similar processing as jute	Similar processing as Kenaf
Qualities/grading	Similar grading maintained as white jute	Similar grading maintained as kenaf
Rules and regulations	Not at all	Rules are maintained

3.5. Roselle/Mesta (*Hibiscus subdariffa* L.)

Taxonomy

Roselle/Mesta belongs to 6th Kingdom: Plantae, *Clade*: Angiosperms, *Clade*: Eudicots, *Clade*: Rosids, Order: Malvales, Family: Malvaceae, Genus: *Hibiscus*, Species: *H. subdariffa*, Binomial name: *Hibiscus subdariffa* L.

Roselle is the most common name used specifically for *Hibiscus subdariffa* var. *altissimum* Hort, both for plant and fibre, although the edible *Hibiscus subdariffa* L. is called roselle. Other common names for the plant and fibre include: Kenaf in most countries; mesta, roselle, hemp, and pusa or pusa hemp in India; Kasi gogu in Andhra Pradesh, India; roselle in Indonesia; Siam jute and paw keo in Thailand; voam bombazaha in Madagascar; azedinha, Curura-de-guine, and quiabo-roseo in Brazil; and Oiselle-de-Guinee in West Africa. Roselle is a short day, annual herbaceous, bast fibre-bearing plant belonging to the Malvaceae family. The subspecies is the most economically important member of the genus *Hibiscus* in terms of fibre production. It is closely related to kenaf (*Hibiscus cannabinus* L.) and okra (*Hibiscus esculentus* L.), young seed pods of the latter being widely used for food in many temperate, subtropical and tropical continents.

A morphological description of the Roselle/Mesta is as follows:

Stems are erect, solid, cylindrical, unbranched, mostly bristled, rarely glabrous, green, red, or regimented in various shades, reaching a height of 1 to 5 m.

Leaves are simple on young plants, later becoming lobed alternate, stipulate, stipules free lateral, 0.5 to 1.0 cm long, green or red. Petiole 4 to 14 cm long, green to red, pubescent

on the abaxial surface and densely bristled or sparsely hairy on the abaxial surface, green to deep and red, scabrous or smooth. Lamina are mostly 3 to 5, deeply palmately lobed, each lobe ovate to oblong lanceolate, margin serrulose, apex-acute, pubescent and bristled along the veins on both the surface, scabrous or scaberulous, green to red, one green gland present in the mid vein on the undersurface. Flowers solitary, axillary, pedunculate, peduncle 0.2 to 0.4 cm long, bristled, pentamerous, completely yellow or yellow with red center, when open 3.0 to 5.0 cm in diameter, bracteoles (epicalyx) 8 to 10, short ovate, bristled, 0.5 to 0.7 cm long, green or red, persistent, attached to the base of the calyx.

Calyx, sepals 5, lanceolate, connate below the middle in to a cup, 1.5 to 2.0 cm lobes 1.5 to 2.0 times the length of the cup, bristled slightly tomentose, gland not prominent, persistent.

Corolla large, spreading, bell-shaped, full-yellow or yellow with deep red center, petals 5, free, twisted, outside pubescent and with glandular hairs in the inner portion, 3 to 5 cm long.

Stamens many, monadelphous, staminal column epipetrous, truncate, 1.0 cm long, with glandular hairs, yellow or red, filaments 0.1 to 0.2 cm long, yellow to red, anthers reiform, pollen spiny. Carpels 5, ovary ovoid 0.3 to 0.4 cm long, broadly globular ovoid, with dense silky hairs, 5 chambered with many ovules in each chamber arranged in 2 to 3 rows, stigma 5, hairy, capitate, red or yellow exerted.

Capsule ovoid, pointed densely villose with about 30 to 40 seeds. Seeds reiform, smaller than those of kenaf reddish brown with many small yellowish brown warty spots. Hilum reddish brown, relatively long seed average, 60000 per kg.

Table 4. Per hectare production of green jute and different green and dry parts of Jute, Kenaf and Mesta crops.

	Desi Jute	Tossa Jute	Kenaf	Mesta
Green Plants	34 mt/ha (100%)	46 mt/ha (100%)	36 mt/ha (100%)	48 mt/ha (100%)
Green leaves	5304 kg (15.6%)	5060 kg (11.0%)	5155 kg (14.2%)	7890 kg (16.3%)
Dry leaves	1326 kg (2.9%)	1242 kg (2.7%)	1176 kg (3.26%)	1704 kg (3.58%)
Green Ribbons	13688 kg (40.2%)	17802 kg (38.7%)	12246 kg (34.0%)	16820 kg (35.2%)
Dry Ribbons	3788 kg (11.2%)	5111 kg (11.11%)	3429 kg (9.51%)	4609 kg (9.65%)
Green Wood	15028 (44.2%)	23138 kg (50.3%)	18658 kg (51.8%)	23175 kg (48.5%)
Dry wood	4250 kg (12.5%)	7636 kg (16.6%)	5747 kg (15.95%)	7184 kg (15.03%)
Dry retted fibre	2006 kg (5.9%)	3128 kg (6.8%)	1742 kg (4.83%)	2110 kg (4.42%)



Figure 6. Mesta plant with leaf, flower and fruits.

3.6. Kenaf/Mesta Cultivation

Area under Mesta & Kenaf in Bangladesh: 34,000 ha (Kenaf - 19,611 ha & Mesta - 14,489 ha)

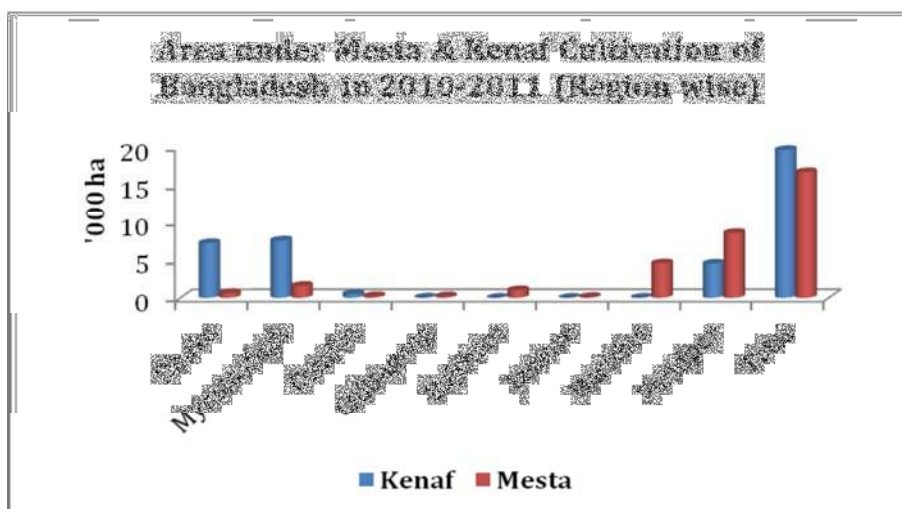


Figure 7. Area under mesta and kenaf cultivation of Bangladesh in 2010-2011 (Region wise).

3.7. Variety Development Related Research Works at BJRI

Ali *et al.*, [12] reported that four irrigation treatments and four nitrogen doses were tested on jute (var. O-9897). The highest seed yield of 745.50 kg/ha was obtained from 30 days of irrigation with the application of 100kg N/ha. The lowest seed yield 236.75 kg/ha was obtained from no irrigation and no fertilizer application. Irrigation at 45 days and 30 and 60 (twice irrigation) days didn't show better seed yield compared to 30 days of irrigation treatment.

Ali *et al.*, [13] reported that significant effect of different NPKS levels on BJRI Kenaf-4 yield and yield contributing characters over control. The highest fibre (3.14t/ha) and stick (7.65t/ha) yield were obtained by the combination dose of N100 Kg/ha with PKS 10-60-20 kg/ha at Kishoreganj. The plant height (3.14m), base diameter (19.47mm) also found highest with the same fertilizer treatment combination. By the same treatment produced higher fibre yield and yield contributing characters at Manikganj though that yield was slightly lower than Kishoreganj. Economic analysis

suggested the best combination is N100-P10-K60-S20 kg/ha. The findings of the present experiment clearly indicated a great prospect of nutrient combination of N100-P10-K60-S20 kg/ha on the growth and yield of fibre production on the variety BJRI kenaf-4.

Ali *et al.*, [14] conducted an experiment to determine the effects of inorganic fertilizer on growth, yield and economic potential of BJRI Mesta-3. The results indicated significant affect of different NPKS levels on Mesta yield and yield contributing characters over control. The highest fibre (3.10t/ha) and stick (7.20t/ha) yield were obtained by the combination dose of N100 Kg/ha with PKS 10-60-20 kg/ha at Manikganj. The plant height (3.08m), base diameter (20.10mm) also found highest with the same treatment of fertilizer combination. By the same treatment produced higher fibre yield and yield contributing characters at Kishoreganj though that yield was slightly lower than that of Manikganj location. Economic analysis favored the use of 100-10-60-20 kg/ha NPKS for yield of 3.10 t/ha Mesta fibre.

Therefore this combination seemed to be optimum for good growth and high potential Mesta production in Bangladesh. Application of modern fertilizer technologies on the mechanized management of Mesta will greatly increase grower profit.

Ali *et al.*, [15] reported that nitrogen, phosphorus, potassium and sulfur are main mineral elements that affect yield and quality in fibre plant production. Experiments to determine the effects of four nitrogen (0, 50, 75 and 100 kg/ha), four phosphorus (0, 5, 10 and 15 kg/ha), four potassium (0, 30, 60 and 90 kg/ha) and three sulfur (0, 10 and 20 kg/ha) levels to increase fibre yield and quality of BJRI tossa (*Corchorus olitorius*) pat 6 plants were conducted in a field experiment. Plant height and stick yield were significantly affected by nitrogen applications. Higher rate of potassium fertilization impact upon plant height and fibre yield was observed. Nitrogen significantly increased fibre yield of plants. Fibre yield was reduced with the highest dose of phosphorus in comparison to yield by the supreme dose of nitrogen. It was concluded that nitrogen mostly improved plant growth and fibre yield while the increase in the level of phosphorus does not have an effect on the increase in yield of fibre and stick.

Akter *et al.*, [16] reported that Bangladesh Jute Research Institute (BJRI) had released an improved variety of high yielding and better quality fibre of *Corchorus olitorius* L. in December 2008 namely “BJRI Tossa-5” (Lal Tossa)/(O-795). The variety was evolved from a single cross between a wild African germplasm (Uganda Red) and a late sowing photosensitive released variety (cv. O-4), where pure line selection was made subsequently. The first red-pigmented tossa jute variety having distinct morpho-agronomic feature, was a great achievement of BJRI. Its stem tall, cylindrical and reddish with red stipule and light reddish petiole. Golden bright better quality fibre than the other existing high yielding cv. O-9897 and cv. O-72 (BJRI Tossa-4). This improved variety performed higher as compared to cv. O-72 in terms of On-Farm yield trails at all the Regional Research Stations during 2004-05 to 2007-08. It was observed less photosensitive than the others having a wider sowing range from 14 March to April. Agronomic trials proved no early flowering occurred even seeding could be done one week before 14 March and crop could be harvested at 110 days of field duration to fit the crop in three cropped pattern. Potential yield of the variety was about 5.0 tha^{-1} by maintaining the plant population 3.5-4.0 lac.ha^{-1} , however in farmers field the average yield was observed 3.4 tha^{-1} , was calculated 10% higher than the check cv. O-72. Pest and disease infestation recorded lower in BJRI Tossa-5 (O-795) than those of Pedi-11/95 and the cv. O-9897 studied.

Hossain *et al.*, [17] reported that an experiment was conducted at Jute Agriculture Experimental Station (JAES), Manikganj; Jute Research Regional Station (RS), Rangpur and Kishoreganj; Sub-station Monirampur, Jessore and Pakhimara, Patuakhali in 2012, 2013 and 2014 to determine the optimum sowing date of white jute breeding line BJC 5003. The

experiment was laid-out in RCBD with three replications. Cultivar CVL 1 was used as control. Crop sown on five different dates like 10 March, 20 March, 30 March, 10 April and 20 April regarded as treatment. All crops were attended normal BJRI recommended cultural practices. Crops were harvested at 120 days after sowing. Results revealed that white jute breeding line BJC 5003 yielded significantly higher fibre than control at Manikganj, Rangpur, Kishoreganj and Jessore. The variety CVL 1 produced higher fibre at Patuakhali than BJC-5003. Results also showed the highest yield at Manikganj sown on 30 March to 10 April, at Regional station Rangpur, Kishoreganj and Patuakhali Sub-station it was 20 March to 30 March. The highest yield produced at Jessore 30 March to 10 April.

Hossain *et al.* [18] reported that an experiment was conducted to determine the optimum sowing date of BJRI Tossa Pat 5 (O-795) for seed production at late season at Manikganj, Jessore and Dinajpur, Jute Research Farms during the year 2010-2013. The experiments were laid out in RCBD design with three replications. The cultivar BJRI Tossa Pat 4 (O-72) was used as control. Five different sowing dates viz., 15 July, 30 July, 15 August, 30 August and 15 September were used as treatment. The crop was harvested at proper maturity of the pods. Results revealed that date of sowing and variety differed significantly in all the locations studied. BJRI Tossa Pat-5 produced the highest seed of 1045 kgha^{-1} at Manikganj and 594.67 kgha^{-1} at Dinajpur on 15 August sowing. On the other hand, seed yield of 973.33 kgha^{-1} was observed the highest in 30 July sowing at Monirampur location. The lowest seed yield and yield attributes were recorded sown on 15 September at all the locations.

Khatun *et al.*, [19] reported that Bangladesh Jute Research Institute (BJRI) had evolved an improved variety of deshi jute (*Corchorus capsularis* L.) in 2007 namely “BJRI Deshi-7” (Basanti)/(BJC-2142). The variety was derived from a single cross between an early sowing photo-insensitive released variety, cv. CC-45 and a blue seeded breeding line BJC-718, where hybridization followed by pedigree method of selection was made subsequently. The first snow white and quality fibre with blue seed coat deshi jute variety having distinct morpho-agronomic feature, was a great achievement of BJRI. This improved variety performed significantly higher yield as compared to cv. CVE-3 at farmers field in Faridpur region during the years from 2003 to 2006. It was observed less photosensitive than the check variety CVE-3, having a wider sowing range from third week of March to Mid-April. Agronomic trials proved absence of premature flowering in appropriate sowing and harvested on 110 days of field duration to fit the crop in three cropped pattern. The variety is suitable for Faridpur jute growing zone. Potential yield of the variety was observed 4.0 tha^{-1} , maintaining the plant population 3.50-4.50 lac.ha^{-1} , however in farmers field the average yield was observed 2.50 tha^{-1} , was calculated 3.24% higher than cv. CC-45 and 9.33% higher than cv. CVE-3. Pest and disease infestation recorded lower in BJRI Deshi-7 (BJC-2142) than those of some other cv. CVL-1, CVE-3 and CC-45.

Table 5. List of varieties of jute and allied crops of Bangladesh.

Sl No	Varieties	Released year	Pedigree
White jute (<i>C. capsularis</i> L.)			
1.	Oocarpus	1910	PLS
2.	Kakya Bombai	1910	PLS
3.	R-85	1916	PLS
4.	D-154	1919	PLS
5.	D-386	1931	PLS
6.	Funduk	1939	PLS
7.	C-212	1939	PLS
8.	C-13	1941	PLS
9.	C-412	1942	PLS
10.	C-1	1952	PLS
11.	C-2	1952	PLS
12.	C-3	1952	PLS
13.	C-4 (C-320)	1955	PLS
14.	C-5 (C-321)	1955	PLS
15.	D-154-2	1961	PLS
16.	C-6 (C-322)	1967	PLS
17.	CVL-1	1977	PLS
18.	CVE-3	1977	PLS
19.	CC-45	1979	PLS
20.	BJRI Deshi Pat-5 (BJC-7370)	1995	D-154 x CC-45
21.	BJRI Deshi Pat-6 (BJC-83)	1995	CVL-1 x Fuleshwari
22.	BJRI Deshi Pat-7 (BJC-2142)	2008	CC-45 x BJC-718
23.	BJRI Deshi Pat-8 (BJC-2197)	2013	CC-45 x FDR
24.	BJRI Deshi Pat Shak-1 (BJC-390)	2014	Cap dwarf red x BINA Pat Shak-1
25.	BJRI Deshi Pat-9 (BJC-5003)	2017	CVL-1 x Acc.1831
Tossa jute (<i>C. octorius</i> L.)			
26.	Chinsura green (D-38)	1915	PLS
27.	R-26	1929	PLS
28.	R-27	1929	PLS
29.	O-620	1939	PLS
30.	O-632	1939	PLS
31.	O-753	1939	PLS
32.	O-1	1955	PLS
33.	O-2	1955	PLS
34.	O-3	1955	PLS
35.	O-4	1967	PLS
36.	O-5	1964	PLS
37.	O-9897	1987	O-5 x BZ-5
38.	OM-1	1995	PLS
39.	BJRI Tossa Pat-4 (O-72)	2002	O-9897 x O-2021 x O-9897
40.	BJRI Tossa Pat-5 (O-795)	2008	O-4 x Uganda Red
41.	BJRI Tossa Pat-6 (O-3820)	2013	PLS
42.	BJRI Tossa Pat-7 (MG-10)	2017	PLS
Kenaf (<i>Hibiscus cannabinus</i>)			
43.	HC-2	1977	PLS
44.	HC-95	1995	PLS
45.	HC-3 (Bot kenaf)	2010	PLS
46.	BJRI Kenaf-4 (KE-3)	2017	PLS
Mesta (<i>H. subdariffa</i>)			
47.	HS-24	1977	PLS
48.	BJRI Mesrta-2 (VM-1)	2010	PLS
49.	BJRI Mesta-3 (SAMU'93)	2017	PLS

3.8. Identifying Characters of Different jute Varieties Developed by BJRI

3.8.1. White Jute Varieties (*Corchorus capsularis* L.)

i. D-154 (2)

Variety D-154 (2) was released in 1961. Its stem green, light coppery red on old branches, upper portion of the petiole is coppery red, leaf length breadth ratio 2:1. Fruit very light pink, single or cluster of 2-4, seed chocolate brown. Medium to

medium low land is suitable for this variety. Seed sowing time last week of March to mid April. Seed rate 7-8 kg/ha. Plant height about 2.50 to 3.00 meter. Fibre recovery rate 6.34%. Time of flowering is 110-120 days after sowing. Time of harvest is 120 days or a bit earlier/later according to need. Yield about 4.89 t/ha (53 mds/acre). Special features are wider adaptability, variation in fruit colour, suitable for medium low land of late sown area. After harvest late Aman can be transplanted [1].



Figure 8. Variety D-154 (2).

ii. CVL-1 (Shabuj Pat)

Variety CVL-1 (Shabuj Pat) was released in 1977. Its plant is full green, stipule green, petiole green, leaf ovate lanceolate, shape and size as D-154. light coppery red on old branches, upper portion of the petiole is coppery red, leaf length breadth ratio 2.1:1. Fruit green, single or in cluster of 2-4, seeds chocolate brown. Medium to medium low land is suitable for this variety. Seed sowing time is end of March to first week of April. Seed rate 7-8 kg/ha. Plant height 3.00 to 3.25 meter. Fibre recovery rate 6.51%. Time of flowering is 120-130 days after sowing. Time of harvest is 120 days or a bit earlier/late according to need. Yield about 5.16 t/ha (56 mds/acre). Special features are most tolerant to mosaic virus. Fine and strong fibre, less cutting, suitable for late sown areas. After harvest late Aman can be transplanted [1]



Figure 9. Variety CVL-1 (Shabuj Pat).

iii. CVE-3 (Ashu Pat)

Variety CVE-3 (Ashu pat) was released in 1977. Its stem green, bright coppery red on older branches, upper portion of the petiole and stipule bright coppery red. leaf ovate lanceolate, length breadth ratio of lamina 2.1:1. Fruit bright red, single or in cluster of 2-5, seeds chocolate brown. Medium to medium low land is suitable for this variety. Seed sowing time is last week of March to last week of April. Seed rate is 7-8 kg/ha. Plant height is about 3.00 to 3.50 meter. Fibre recovery rate 5.91%. Time of flowering is about 105-110 days after sowing. Time of harvest is 120 days or at time of flowering. Yield is

about 4.52 t/ha (49 mds/acre). Special features are suitable for early sown area. Quick growing variety. Early maturing. After harvest early Aman can be transplanted. Fibre fine and lusturous [1].



Figure 10. Variety CVE-3 (Ashu pat).

iv. CC-45 (Jo Pat)

Variety CC-45 (Jo Pat) was released in 1979. Its stem green, upper part of the petiole light coppery red, lamina smaller than D-154, seeds smaller with light brown colour. Leaves nearly ovate, leaf length breadth ratio 2:1. Fruit very light pink, single or in cluster of 2-3, seeds small with light brown colour. Medium low to medium high land is suitable for cultivation. Seed sowing time February to April or beyond. Seed rate is 7-8 kg/ha. Plant height about 3.00 to 4.00 meter. Fibre recovery rate is 6.62%. Time of flowering about 135-180 days after sowing. Time of harvest is 100 days after sowing or as per need. Yield is about 5.16 t/ha (56 mds/acre). Special features are short day insensitive, no risk of premature flowering, very wider time for sowing, suitable for a 3 crop pattern in early sown Aus, So more profitable in early cropping with onion/garlic, Fibre fine and very strong. After early harvest early Aman can be transplanted [1].



Figure 11. Variety CC-45 (Jo Pat).

v. BJRI Deshi Pat-5 (BJC-7370)

Variety BJC-7370 (BJRI Deshi pat-5) was released in the year 1995. Its stem tall, cylindrical and unbranched, leaves serrated, upper surface of the petiole coppery red, fruit round capsule and light coppery red at young stage. Medium to

medium low land of alluvial, loamy and sandy loam is suitable for the variety. Seed sowing time last week of March to second week of April. Seed rate 7-8 kg/ha. Plant height normally 3.00 to 3.50 meter. Time of flowering is about 105-115 days after sowing. Time of harvest is 110 to 120 days after sowing. Yield is about 2.75-3.25 t/ha (Research station yield) and special features are short day tolerant, free from early flowering, produce sufficient seed and can be harvested one month earlier than the existing varieties of white jute, which can provide the land for rabi cropping [1].



Figure 12. Variety BJRI Deshi pat-5 (BJC-7370).

vi. BJRI Deshi Pat-6 (BJC-83)

Variety BJRI Deshi pat-6 (BJC-83) was released in 1995. Its stem tall, unbrabched, cylindrical, leaves serrated, wavy margin, Narrower than CVL-1, fruit round capsule. Medium to medium low land with alluvial loamy and sandy loam soil is suitable for cultivation of this variety. Seed sowing time last week of March to mid April. Seed rate 7-8 kg/ha. Plant height 3.00 to 3.25 meter. Time of flowering 90-95 days after sowing. Time of harvest is about at flowering or earlier/later according to need. Yield 2.50-3.00 t/ha (Research station yield). Special features are its whole plant is green, fast growing and early maturing type and can be harvested at about one month earlier than the existing varieties, suitable for 3 crop pattern [1].



Figure 13. Variety BJRI Deshi pat-6 (BJC-83).

vii. BJRI Deshi Pat-7 (BJC-2142)

Variety BJRI Deshi pat-7 (BJC-2142) was released in the year 2007. Its stem green tall, unbrabched, cylindrical, leaves lanceolate, length breadth ratio 1:2.6. Petiole green, length 6.9cm. Flower regular, sepal-5, petals-5. Fruit round capsule,

green, 5-chambred. Seed is blue in colour, 1000 seed weight – 2.97g (10% M. C). Medium high land with alluvial loamy and sandy loam soil is suitable for this variety. Seed sowing time is March to June. Seed rate is 7-8 kg/ha. Plant height is normally 3.50 to 4.60 meter. Time of flowering is 105-115 days after sowing. Time of harvest is about 110 days after harvest. Yield normally 2.50-3.00 t/ha (Research station yield). Special features are short day and low temperature tolerant, early seeding white jute. Performed better than existing varieties CC-45 and CVE-3 at farm level. Better fibre quality give additional return [1].



Figure 14. Variety BJRI Deshi pat-7 (BJC-2142).

viii. BJRI Deshi Pat-8 (BJC-2197)



Figure 15. Variety BJRI Deshi pat-8 (BJC-2197).

Variety BJRI Deshi pat-7 (BJC-2142) was released in the year 2013. Its stem light coppery red (P₄) tall, unbrabched, cylindrical. Leaves are lanceolate, Petiole slightly red. Flower regular, sepal-5, petals-5. Fruit round capsule, redish green, 5-chambred. Seed is brownish in colour, 1000 seed weight

2.97-3.15g (10% M. C). Medium high land with alluvial loamy and sandy loam soil is suitable for this variety. Seed sowing time is 01-30 April. Seed rate is 7-8 kg/ha. Plant height is normally 3.50 to 4.60 meter. Time of flowering is 110-115 days after sowing. Time of harvest is about 110 days after harvest. Yield normally 2.70-2.90 t/ha (Research station yield). Special features are quick growing, medium salt tolerant and mosaic virus tolerant [1].

ix. BJRI Deshi Pat Shak-1 (BJC-390)

Variety BJRI Deshi pat shak-1 (BJC-390) was released in the year 2014. Plant full green (P₀) short, branched and bushy. Leaves are lanceolate and highly dense. Fruit round capsule, redish green, 5-chambered. Seed is brownish in colour, 1000 seed weight 2.90-3.10g (10% M. C). Medium high land with alluvial loamy and sandy loam soil is suitable for this variety. Seed sowing time is 28 February-15 September. Seed rate is 5-6 kg/ha. Time of flowering is 50-60 days after sowing. Time of harvest is about 35-45 days after harvest. Green leaf yield normally 3.00-3.50 t/ha (Research station yield). Special features are growing not for fibre and leaf taste is sweet [1].



Figure 16. BJRI Deshi Pat Shak-1 (BJC-390).

x. BJRI Deshi Pat-9 (BJC-5003)

Variety BJRI Deshi pat-9 (BJC-5003) was released in the year 2017. Its stem green tall, unbranched, cylindrical, leaves lanceolate, length breadth ratio 1:2.6. Petiole light red, length 6.1cm. Flower regular, sepal-5, petals-5. Fruit round capsule, green, 5-chambered. Seed is blue in colour, 1000 seed weight -2.91g (10% M. C). Medium high land with alluvial loamy and sandy loam soil is suitable for this variety. Seed sowing time is 30 March to 26 April. Seed rate is 7-8 kg/ha. Plant height is normally 3.50 to 4.00 meter. Time of flowering is 100-110 days after sowing. Time of harvest is about 100 days after harvest. Yield normally 2.60-3.00 t/ha (Research station yield). Special features are its fibre comparatively white with low cuttings. Better fibre quality gives additional return [1].



Figure 17. BJRI Deshi Pat-9 (BJC-5003).

3.8.2. Tossa Jute Varieties (*Corchorus olitorius* L.)

i. Variety O-4

Variety O-4 was released in 1967. It is fully green, unbranched, leaves ovate lanceolate. Length-breadth ratio of lamina 2.9:1, Fruit green, cylindrical dehiscence, seeds steel gray with red in three edges. Medium high to high land with loamy and sandy loam soil is suitable for cultivation. Seed sowing time is mid April to mid May. Seed rate 5-6 kg/ha. Plant height 3.50 to 4.50 meter. Fibre recovery 6.62%. Time of flowering is 118-132 days after sowing. Time of harvest is 100 days after harvest or as per need. Yield normally 3.00-3.50 t/ha at Research station. Special features are wider adaptability, suitable for late sown areas, fibre fine and strong with least cutting, after early harvest late transplanted aman can be grown [1].



Figure 18. Variety O-4.

ii. Variety O-9897

Variety O-9897 was released in 1987. Its plant fully deep green, unbranched, leaves ovate deep green, succulent, fruit indehiscent, leaves ovate lanceolate. Length-breadth ratio of lamina 2.7:1, Fruit green, cylindrical indehiscence, single or in cluster of 2-5, seeds brown with green tinge on seed coat. Medium high to high land with loamy and sandy loam soil are suitable for the variety. Seed sowing time mid March to mid May. Seed rate 5-6 kg/ha. Plant height 4.00 to 5.50 meter. Fibre recovery 6.70%. Time of flowering 130-150 days after

sowing. Time of harvest 100 days after harvest or as per need. Yield 3.00-4.00 t/ha at Research station. Special features are short day insensitive, free from premature flowering, wide time of sowing, suitable for 3-crop pattern, fibre fine, strong and lower cutting, after early harvest early aman can be transplanted [1].



Figure 19. Variety O-9897.

iii. OM-1

OM-1 was released in 1995. Its stem tall, cylindrical and deep green, leaves ovate, lanceolate in shape, Length-breadth ratio of lamina 2.5:1, Fruit long cylindrical indehiscence, seeds brownish. Medium high to high land with loamy and sandy loam soil is suitable for cultivation. Seed sowing time 15 March to 15 May. Seed rate 5-6 kg/ha. Plant height 3.00 to 3.25 meter. Fibre recovery 6.72%. Time of flowering 120-130 days after sowing. Time of harvest 100 days after harvest or as per need. Yield 2.50-3.40 t/ha at Research station. Special features are Less photosensitive, performed better than the existing variety O-9897, suitable for early sowing and for 3-crop pattern, fibre fine, strong and lower cutting than the existing varieties [1].



Figure 20. OM-1.

iv. BJRI Tossa Pat-4 (O-72)

BJRI Tossa Pat-4 was released in 2002. Its stem tall, unbranched, cylindrical and green, length breadth ratio of leaves 1:2.2, flower regular, sepal-5, normal green, petals-5, deep yellow, fruit cylindrical, long pod green, indehiscent,

seeds brownish grey, 120-125 seeds per fruit, 1000 seeds weight-2.21g. Medium high to high land is suitable for cultivation. Seed sowing time 15 March to 30 April. Seed rate 5-6 kg/ha. Plant height 4.00 to 4.50 meter. Fibre recovery 6.75%. Time of flowering 140-155 days after sowing. Time of harvest 110 days after harvest or as per need. Yield 2.50-3.40 t/ha at Research station. Special features are less photosensitive, performed better than the existing variety O-9897, fibre fine, strong and least cutting than the existing varieties [1].



Figure 21. BJRI Tossa Pat-4 (O-72).

v. BJRI Tossa Pat-5 (O-795)

BJRI Tossa Pat-5 was released in 2008. Its stem tall and red or reddish in colour, unbranched, quick growing, cylindrical, leaf ovate lanceolate, length breadth ratio of leaves 1:2.4, flower regular, sepal-5, normal green, petals-5, deep yellow, fruit cylindrical, long pod green, indehiscent, seeds brownish grey, 125-130 seeds per fruit, 1000 seeds weight-2.28g. Medium high to high land is suitable for cultivation. Seed sowing time 15 March to 30 April. Seed rate 5-6 kg/ha. Plant height 3.50 to 4.00 meter. Fibre recovery 6.75%. Time of flowering 140-155 days after sowing. Time of harvest 110 days after harvest or as per need. Yield 2.70-3.20 t/ha at Research station. Special features are less photosensitive, performed better than the existing variety O-9897, fibre fine, strong and least cutting than the existing varieties [1].



Figure 22. BJRI Tossa Pat-5 (O-795).

vi. **BJRI Tossa Pat-6 (O-3820)**



Figure 23. BJRI Tossa Pat-6 (O-3820).

BJRI Tossa Pat-6 was released in 2013. Its stem tall and green in colour, unbranched, quick growing, cylindrical, leaf long lanceolate, length breadth ratio of leaves 1:2.5, flower regular, sepal-5, normal green, petals-5, deep yellow, fruit cylindrical, long pod green, indehiscent, seeds brownish grey, 122-126 seeds per fruit, 1000 seeds weight-2.24g. Medium high to high land is suitable for cultivation. Seed sowing time 01 April to 30 April. Seed rate 5-6 kg/ha. Plant height 3.50 to 4.00 meter. Fibre recovery 6.75%. Time of flowering 135-145 days after sowing. Time of harvest 110 days after harvest or as per need. Yield 2.50-2.80 t/ha at Research station. Special features are less photosensitive, fibre fine, strong and least cutting than the existing varieties [1].

vii. **BJRI Tossa Pat-7 (MG-1)**

BJRI Tossa Pat-7 was released in 2017. Its stem tall and green in colour, unbranched, quick growing, cylindrical, leaf ovate lanceolate, length breadth ratio of leaves 1:2.5, flower regular, sepal-5, normal green, petals-5, deep yellow, fruit cylindrical, long pod green, indehiscent, seeds brownish grey, 122-126 seeds per fruit, 1000 seeds weight-2.27g. Medium high to high land is suitable for cultivation. Seed sowing time 15 March to 15 April. Seed rate 5-6 kg/ha. Plant height 3.50 to 4.00 meter. Fibre recovery 6.75%. Time of flowering 140-155 days after sowing. Time of harvest 110 days after harvest or as per need. Yield 2.70-3.30 t/ha at Research station. Special features are less photosensitive, fibre fine, strong and least cutting than the existing varieties [1].



Figure 24. BJRI Tossa Pat-7 (MG-1).

3.9. **Identifying Characters of Different Kenaf Varieties Developed by BJRI**

3.9.1. **Kenaf Varieties (*Hibiscus cannabinus* L.)**

i. **HC-2 (Joly Kenaf)**

HC-2 was released in 1977. Its stem green pigmented and petiole green, leaves simple cordated, petiole is longer than lamina. Fruit capsule ovoid, indehiscent, seeds subreniform grayish brown. Bright fibre. Medium to medium low land is suitable for cultivation. Seed sowing time mid March to mid April. Seed rate 12-15 kg/ha. Plant height 4.00 to 5.50 meter. Fibre recovery 7.3%. Time of flowering 150-165 days after sowing. Time of harvest 120 days after harvest or as per need. Yield 2.50-2.70 t/ha at Research station. The variety suitable for medium low, less fertile and flood affected land. Fibre is bright and shiny. Green plants are excellent raw materials for paper pulp. Tolerant to water logging [1].



Figure 25. HC-2 (Joly kenaf).

ii. **BJRI Kenaf-2 (HC-95)**



Figure 26. BJRI Kenaf-2 (HC-95).

BJRI Kenaf-2 was released in 1995. Its stem tall cylindrical, unbranched, whole plant deep green, Fibre bright. leaves lobed, the petal is light cream colour with very light pink tinge on the inner basal part of the petals. Fruit capsule ovoid, indehiscent, seeds subreniform grayish brown. Medium to medium low land. Loom or slightly clay to sandy loam are suitable for cultivation. Seed sowing time Mid March to Mid

April. Seed rate 12-15 kg/ha. Plant height 3.50 to 4.00 meter. Fibre recovery 6.23%. Time of flowering 150-170 days after sowing. Time of harvest 120 days after harvest or as per need. Yield 2.80-3.30 t/ha at Research station. This variety is suitable for medium low, less fertile and flood affected land. Fibre is bright and shiny. Green plants are excellent raw materials for paper pulp, seeds contain about 20% edible oil. Tolerant to water logging [1].

iii. BJRI Kenaf-3 (Bot Kenaf)

BJRI Kenaf-3 was released in 2010. Its stem tall cylindrical, unbranched, whole plant deep green, Fibre bright. leaves cordated, the petal is light cream colour with very light pink tinge on the inner basal part of the petals. Fruit capsule ovoid, indehiscent, seeds subreniform grayish brown. Medium to medium low land. Loom or slightly clay to sandy loam are suitable for cultivation. Seed sowing time 15 March to 30 April. Seed rate 12-15 kg/ha. Plant height 3.50 to 4.00 meter. Fibre recovery 6.53%. Time of flowering 150-170 days after sowing. Time of harvest 120 days after harvest or as per need. Yield 2.60-3.00 t/ha at Research station. This variety is suitable for medium low, less fertile and flood affected land. Fibre is bright and shiny. Green plants are excellent raw materials for paper pulp, Tolerant to water logging [1].



Figure 27. BJRI Kenaf-3 (Bot Kenaf).

iv. BJRI Kenaf-4 (KE-3)



Figure 28. BJRI Kenaf-4 (KE-3).

BJRI Kenaf-4 was released in 2017. Its stem tall cylindrical, unbranched, whole plant deep green, Fibre bright. leaves lobed, the petal is light cream colour with very light pink tinge on the inner basal part of the petals. Fruit capsule ovoid, indehiscent, seeds subreniform grayish brown. Medium to medium low land. Loom or slightly clay to sandy loam are suitable for cultivation. Seed sowing time 15 March to 15 May. Seed rate 12-15 kg/ha. Plant height 3.50 to 4.00 meter. Fibre recovery 6.75%. Time of flowering 140-160 days after sowing. Time of harvest 120 days after harvest or as per need. Yield 2.80-3.30 t/ha at Research station. This variety is suitable for medium low, less fertile and flood affected land. Fibre is bright and shiny. Green plants are excellent raw materials for paper pulp, Tolerant to water logging [1].

3.10. Identifying Characters of Different MESTA Varieties Developed by BJRI

3.10.1. Mesta Variety (*Hibiscus Subdarifa L.*)

i. Variety HS-24 (Tani Mesta)

Variety HS-24 was released in 1977. Its stem green with nodes purple, pigmented leaves fine lobed, petiole is smaller than lamina. Leaves 5 lobed with lanceolate segments which are serrated, central lobe longest, leaf lobed dark green with veins and margins purple, rough, sepals light green with purple spots at maturity, petals yellow with crimson red at the inner basal portion, fruits capsule ovoid hairy, dehiscent seeds dull brown reniform. High land (Less fertile) is suitable for cultivation. Seed sowing time mid February to mid May. Seed rate 12-18kg/ha. Plant height 4.00 to 6.00 meter. Fibre recovery 6.23%. Time of flowering 190-210 days after sowing. Time of harvest 120-130 days after harvest or as per need. Yield 2.00-2.70 t/ha at Research station. This variety is suitable for high, less fertile and drought affected land. After harvest T. aman can be grown. Resistant to root-knot nematodes [1].



Figure 29. Variety HS-24 (Tani mesta).

ii. BJRI Mesta-2 (VM-1)

BJRI Mesta-2 (VM-1) was released in 2010. Its stem red with nodes purple, pigmented leaves fine lobed, Long petiole similar as lamina. Leaves 3 lobed with lanceolate segments which are serrated, central lobe longest, leaf lobed dark green

with veins and margins purple, rough, sepals light green with purple spots at maturity, petals yellow with crimson red at the inner basal portion, fruits red and cone type. Plants are bushy in type. High land (Less fertile) is suitable for cultivation. Seed sowing time 15 April to 30 June. Seed rate 12-18kg/ha. Plant height 1.00 to 1.50 meter. Time of flowering 180-200 days after sowing. Time of harvest from 60 days to onward for fruit or as per need. Red coloured fruit yield 2.00-2.50 t/ha and leaf 6.0-7.0 t/ha at Research station. This variety is suitable for high, less fertile and drought affected land. Could produced 20% edible oil from seeds, Resistant to draught and root-knot nematodes [1].



Figure 30. BJRI Mesta-2 (VM-1).

iii. BJRI Mesta-3 (SAMU'93)



Figure 31. BJRI Mesta-3 (SAMU-93).

BJRI Mesta-3 (SAMU'93) was released in 2017. Its stem green with nodes purple, leaves green and fine lobed, long petiole than lamina. Leaves 5 lobed with lanceolate segments which are serrated, central lobe longest, leaf lobed dark green with veins, fine, sepals light green with purple spots at maturity, petals yellow with crimson red at the inner basal portion, fruits capsule oval hairy, dehiscent seeds dull brown reniform. High land (Less fertile) is suitable for cultivation. Seed sowing time 15 March to 15 May. Seed rate 12-18kg/ha. Plant height 4.00 to 5.00 meter. Time of flowering 180-210 days after sowing. Time of flowering 190-210 days after sowing. Time of harvest 120-130 days after harvest or as per

need. Yield 2.50-2.80 t/ha at Research station. This variety is suitable for high, less fertile and drought affected land. Quick growing and resistant to root-knot nematodes [1].

3.11. Maintenance of Varieties

Maintenance of variety means to maintain the genetical purity and also quality of seed. At the time of variety release a small quantity of seed is available with the breeder. The relatively small amount of seed of variety needs to be multiplied and made available to farmers as quickly as possible. During seed multiplication, varietal purity and identity needs to be maintained. Each multiplication cycle starts from the 'breeder seed'. If the breeder seed is not of high purity, the contaminants present get multiplied several times in the succeeding generations of foundation and certified seed production. The presence of contaminants may even lead to complete loss of the improved features of the variety. Prevention of contamination is the heart of a successful breeder seed production programme. Breeders of Bangladesh Jute Research Institute (BJRI) develop nucleus seed when a new variety released and produce "Breeder seed" from nucleus seed. The seed certification agency (SCA) is not in the network of seed production but plays an important role provides quality control services from Breeder seed to Foundation seed to Certified seed [21].

3.11.1. Nucleus Seed Production of Jute and Allied Fibre

During seed multiplication process, several factors may reduce the genetic purity of seed. The maintenance of genetic purity is largely dependent on the genetic makeup of the variety. Genetic variation may appear within a seed stock for a number of reasons including mechanical contamination, hybrids resulting from undesirable pollination, recombination, residual segregation, selective influence of environment and mutation. These factors ensure that no cultivar is likely to retain the precise frequencies established by the breeder without continuous intervention through maintenance breeding techniques [22].

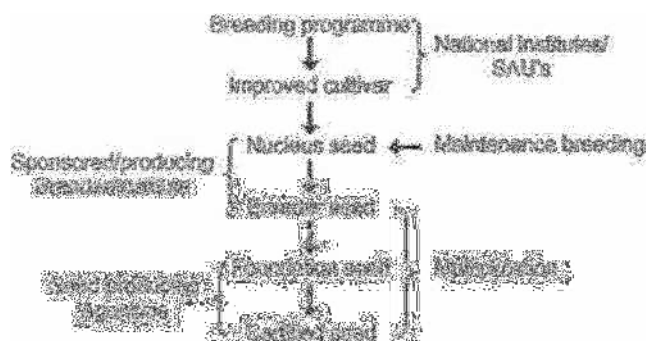


Figure 32. Figure showing the development of a variety, maintenance and multiplication in Bangladesh, which also applicable for jute.

3.11.2. Nucleus Seed

Once a variety is released for cultivation, the breeder usually supplies a small quantity of seed for further multiplication and maintenance. The responsibility of breeder seed production centre is to produce breeder seed and varietal

maintenance. In order to release seed of an improved variety to farmers, it has to be multiplied. Each multiplication cycle has to start from its basic seed stock, 'Nucleus Seed'.

3.11.3. Maintenance of Nuclear Seed Stock

Our basic objective of variety maintenance is to maintain the purity and identity of a variety. The maintenance procedures are in fact the extension of the normal breeding process. The difference is that during maintenance breeding, selection process is relatively mild and breeder's aim is not improvement but to keep the identity unchanged. Selection should maintain the plant type, its uniformity and free from diseases. The fields where plants and progenies are to be assessed should be uniform. Essentially these should be grown under optimal growing conditions.

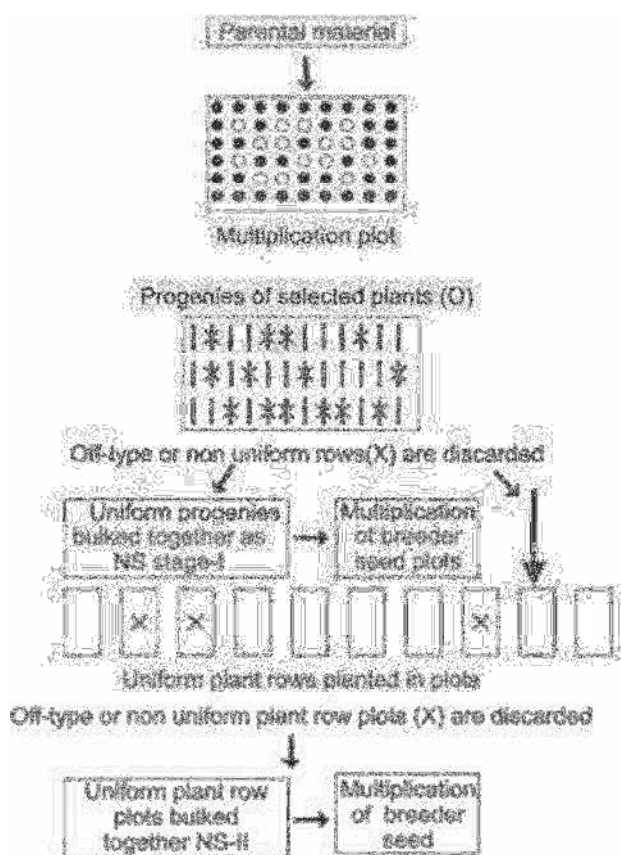


Figure 33. Figure showing the jute and allied varietal maintenance pattern.

3.11.4. Plant to Row Method

The maintenance procedure starts with a small plot raised from the parental material received from the breeder or uniform seed multiplication field in case of released variety. About 100 (depends on requirement) healthy plants typical of the cultivar are selected and marked for progeny testing (Figure 2). The seeds of the marked true-to-type plants are harvested separately. The seeds of each plant are planted in a 3m long progeny row. These progeny rows are assessed critically several times during the growing season. Progeny rows that deviate in one or other characteristics are discarded and entire plant progeny rows is rejected. The plant progenies that are uniform and true to type are selected and bulked

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together as nucleus seed. This nucleus seed is used for planting larger breeder seed plots.

All the steps of maintenance a variety are very essential to maintain field standard and also seed standard of jute. The field standard and seed standard of jute seeds are shown in the tables 6 and 7.

Table 6. Field standard of jute seed.

Criteria	Breeder's seed	Foundation seed	Certified seed
Isolation distance(M)			
a) Field of other variety of same species	50	30	20
b) Field of other species	5.0	3.0	3.0
Other varieties (Max%)	0.0	0.1	0.2
Other crops(Max %)	-	-	-
Obnoxious weed(Max %)	-	-	-
Diseases (infection by seed born pathogen: Max% of infected plants)			
1. Stem rot	0.0	0.1	0.5
2. Blackband	0.0	0.1	0.5
3. Leaf mosaic	0.0	0.05	0.5

Table 7. Seed standard of jute seed.

Criteria	Breeder seed	Foundation seed	Certified seed
Pure Seed(Min % by wt)	99.0	98.0	96.0
Seeds of other varieties (Max%)	0.0	1.0	1.0
Seed of other crops (Max%)	0/kg	5/kg	10/kg
Obnoxious weed (Max. no.)	0/kg	5/kg	10/kg
Inert materials (Max %)	1.0	1.0	3.0
Germination (Min%)			
a) Fresh Seed	80.0	80.0	80.0
b) Carry over seed	70.0	70.0	70.0
Moisture content (Max %)			
a) C capsularis L.	10.0	10.0	10.0
b) C olitorius L.	8.0	8.0	8.0
Diseases (infection by seed born pathogen: Max% of infected plants)			
1. Stem rot	0.0	0.1	0.5
2. Blackband	0.0	0.1	0.5
3. Leaf mosaic	0.0	0.01	0.1

3.12. Premature Flowering in Jute Varieties

Experimental evidences are that the proper time for sowing of White jute is after 15th March to 15th April and for Tossa 15th April to 15th May. If sowing made earlier than the actual time produces complication to the plants and gives lower yield. Jute when planted in time, it flowers in the month of August when starts of shortening of day length as it is a short day plant. Like all other plants jute plants are influenced by photoperiods in the formation of flowers. They also appear to be affected by drought or any other stresses though it could not be proved yet. In case of low lands as well as in any year of early rainfall farmers grow jute early and in early sown plots jute plants flower early when they are hardly 1 or 2 feet tall [23]. This early flowering is due to the effect of short photoperiod only. This may be happens if the soil is poor. They have not been proved.

Untimely flowering in jute is mainly due to-

- I. The early sowing in short day length period and may be partly-

II. Prolonged any type stress and drought, dry air, stunted growth, low fertility of soil, cloudy weather, etc.

Effect of untimely flowering in jute-

I. Stunted jute plant growth

II. Starts branching

III. Drastically lower the yield and quality of fibre.

In Bangladesh, the day length is about 12 hours by the end of March and by the mid April it increases to over 12.5 hours. Sowing White jutes from end of March and Tossa from mid

April is safer from induction of premature flowering though some plants here and there may tend to show a few flowering without any harm in fibre production, because those plants continue to grow vegetatively without further flowering until again by the mid August to September when day length begins decreasing from 12.5 to 12 hours [23]. Bangladesh Jute Research Institute developed different White and Tossa jute variety's optimum sowing dates for fibre production are given below-



Figure 34. Normal flowering in jute plants.

Factors responsible for premature flowering in jute variety

Jute is short day length tolerant plant so, some white jute varieties produced premature flowering if sowing completed before Mid March and some before end March sowing. As same if Tossa jute variety O-4 sown on or before mid April will produced premature flowering. So many old jute varieties were produced untimely flower if sown on or before mid April.

Registered or certified jute variety specially Tossa varieties produced premature flower of few percentage which differed with the specific genetic characters of main variety could be identified by seeing their leaves, again sometimes it could be difficult to identify. These Tossa jute varieties seeds could be produced from local varieties and sometimes produced from cross pollination where not maintained standard distance at the time of seed production.

Jute seed sown on soil with high fertility and moisture content, plant germination and growth will be quick and vigorously, at the same time early flowering happened. Same characters of early flowering might be found at the time if drought, water logging, and other stress conditions in early growth stages. Which do not found if jute seed sowing completed after critical photoperiod. However, for more appropriate information, it is depend on more research work in future [23].

Management of premature flowering in jute

Premature flowering is harmful to jute fibre production. It often makes fibre yield and quality loss to the farm level. It may however be said that premature or untimely flowering happened was mainly due to early sowing of jute varieties in short day length period and might be partly due to prolonged drought, dry air, stunted growth, low fertility of soil, cloudy weather etc. Even when day length exceeds the critical level throughout growth, instances of premature flowering in jute have been recorded in Bangladesh. This suggests an effect on flowering additional to simply that of photoperiod but the

actual cause is yet to be identified. Resolution of differing results for jute flowering is required detailed study using controlled environmental facilities set to photoperiods encompassing the range from 10½ to 12½ h. Thus, there is a need to identify the possible reasons and effects of different climatic change and environmental factors that responsible for flowering in jute timely and as well as untimely [23].

4. Conclusion

Nearly 7.0-8.0 lack hectares of land cultivated by jute and allied crops per year in Bangladesh, which produced 80-90 lack bales of fibre. Over all 49 jute and allied varieties (White jute 25, Tossa jute 17, Kenaf 4 and Mesta 3 varieties) developed by BJRI. CVL-1, BJRI Deshi Pat-5, BJRI Deshi Pat-6, BJRI Deshi Pat-7, BJRI Deshi Pat-8, BJRI Deshi Pat Shak-1 and BJRI Deshi Pat-9 of *C. capsularis* L., O-9897, BJRI Tossa Pat-4, BJRI Tossa Pat-5, BJRI Tossa Pat-6, BJRI Tossa Pat-7 of *C. olitorius* L., HC-2, HC-95, HC-3 and BJRI Kenaf-4 of *Hibiscus cannabinus* and HS-24, BJRI Mesrta-2 and BJRI Mesta-3 of *H. subdariffa* found important could cultivated in farmers field. Maintenance of variety means to maintain the genetical purity and also quality of seed. During seed multiplication, varietal purity and identity needs to be maintained. The presence of contaminants may even lead to complete loss of the improved features of the variety. Breeders of Bangladesh Jute Research Institute (BJRI) develop nucleus seed when a new variety released and produce "Breeder seed" from nucleus seed. The seed certification agency (SCA) is not in the network of seed production but plays an important role provides quality control services from breeder seed to foundation seed to certified seed. Premature flowering in jute varieties found harmful to fibre production. Premature or untimely flowering happened mainly due to early sowing of jute varieties in short day length period and partly due to prolonged drought, dry air, stunted growth, low fertility of soil,

cloudy weather etc. The article will help future breeder, higher study students, farm level extension workers and the university teachers as well.

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Biography



Mohammad Mahbubul Islam an eminent Agronomist of Bangladesh was graduated in 1984, completed MSc. Ag. (Agronomy) in 1987 and awarded PhD from Bangladesh Agricultural University in 2008. Dr. Islam obtained 'Seed Research Methodology' training from Edinburgh University, Scotland, UK. Dr. Islam is working as Chief Scientific Officer & Head, Agronomy Division, Bangladesh Jute Research Institute (BJRI), Dhaka from December 2011. He has about 30 years of agronomic and seed technological research experience. Dr. Islam acting as Research Supervisor, Technical Editor and as Editorial Board member of different national and international journals. He is active life-member of Krishibid Institution, Bangladesh; Bangladesh Agronomy Society; Seed Science Society, Bangladesh; Weed Science Society, Bangladesh; Registered Graduate of SAU etc. Dr. Islam has more than 125 publications (Scientific and popular) in different reputed national and international peer reviewed journals including 8 books of home and abroad.



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Abstract

Agronomic research advances of jute crops in Bangladesh were selected for its being large concentration points in relation to cultivation methods, climate and soil, cropping pattern etc. The high and medium high land where rain and flood water does not stand is suitable for tossa jute cultivation. Jute requires a warm and humid climate with temperature. Rainfall ranges from 250mm to 270mm for good growth and yield. Proper seed rate for plant population, growth and for maximum yield. Jute varieties are to be planted starting from 15 March, will help incorporate Tossa jute into three crop pattern. To concern *Hibiscus cannabinus* L. varieties planting around 15 March to 30 April and *H. sabdarifa* L. varieties planting around 15 March to 15 May for optimum fibre yield. For seed production, the best time of seed sowing, in case of *C. capsularis* L. whole July and of *C. olitorius* L. within August 30, which give more seed yield. Weed poses a major problem in jute cultivation and weeding operation constitute about one third of the total cost of production. The major weeds in jute field are detected. Weeding, mulching; simultaneous thinning and topdressing of urea fertilizer followed by hoeing are recommended. Besides, one tanabatch and one katabatch provide good effect on fibre yield. Improved cultivation technologies such as good quality seed of improved variety, proper sowing and harvesting time, recommended intercultural management with inputs increases the fibre and seed yields over conventional practices. The cropping patterns Jute-T. aman-Wheat, Potato-Jute-T. aman, Onion-Jute-T. aman, Vegetable-Jute-T. aman and Jute-T. aman-Mastard were sorted agronomically feasible and economically viable.

1. Introduction

Bangladesh Jute Research Institute (BJRI) was established in 1951 with the mandate to complete research on both agricultural and industrial aspects on jute and allied fibres right from sowing seeds to preparing the products in the industries for its various uses at the end users level. Jute is a fibre crop belongs to genus *Corchorus* of the Tiliaceae family with two cultivated species- *Corchorus capsularis* L. and *C. olitorius* L. Fibre is extracted from the bark of the plants [1, 2]. In 1970-80 decades about 15-16 lakh hectare of the total cultivable land was occupied by jute has now (2010-11) been reduced to about 6.00 to 6.76 lakh hectare. However, national average yield is increased from 1.59 to 1.98 tons per hectare. It is happened due to use of high yielding jute varieties and production technologies, which together contributed toward higher yield. Improved technologies such as improved seed, line sowing, recommended fertilizer and plant protection measures increase the fibre yield of jute by 20, 23, 27 and 13%, respectively over conventional practices. Jute is still contributing about 4% GDP to the national economy and earns about 5% of foreign exchange as well.

Agronomy is one of the most important research component of Agriculture Research of BJRI. From the inception of BJRI, the Agronomy division is working with an individual Programme Area, "Improvement of Cultural Practices". However, after restructuring of BJRI in 1997, Agronomy Division was restructured with three main departments i.e. (i) Crop Management Department, (ii) Soil Science Department and (iii) Plant Physiology Department. So Agronomy Division at present working on three different Program Areas with three departments. Before conducting experiments the programs are approved in a internal review workshop. A research review work was therefore undertaken to explore out research advances on agronomic means like land selection and preparation technique, fibre and seed crop planting time, intercultural managements and weed control, cost reduction technique, fibre and seed crop harvesting time, post harvest processing of fibre and seed, cropping pattern etc. for jute crop.

2. Materials and Methods

The study was based on secondary data. The secondary data used were collected from different studies of the Library of Bangladesh Jute Research Institute, Dhaka during from December 2012 to till July 2013. These secondary data were BJRI annual reports, different thesis, Books, Bangladesh Journal of Jute and Fibre Research, Jute and Jute Fabrics, Bnagladesh (News letter) of BJRI and other national and international journals.

3. Results and Discussions

3.1. Soil and Climate

Bangladesh forms the largest delta in the world and is situated between 88.50^o and 92^o50' East longitudes and between 20^o50' and 26^o50' north. Tropical monsoon rain drench the land and the rivers. The topography of the lands has been divided into high land, medium land, medium low land and low land, very low land and hilly land. The new grey alluvial soil, good depth receiving silt from the annual floods, is nature's best gift, but jute is widely grown in sandy loams, clay loams with varying soil management practices. Sandy soils and heavy clay soil are unsuitable for jute production at the same time soil with a low pH give a poor crop, The optimum pH being around 6.4. High and medium high land where rain and flood water does not

stand is suitable for tossa jute cultivation. In the seedling stage water logging is not tolerated by both species. To concern soil type, silt is the best for jute and allied crop production. However, it can be grown in any intermediate soil other than the extreme sand and extreme clay soil. The extreme sand soil is not suitable, because, its water holding capacity is very poor and jute plants suffer from moisture stress in this soil. In the extreme clay soil, proper root growth cannot take place due to hardness of soil, which ultimately affects plant growth. Jute requires a warm and humid climate with temperature fluctuating between 24°C and 37°C. The permissible relative humidity favorable to growth ranges between 70 and 90 percent. Rainfall is one of the most important factor for growing jute and the ranges from 250-270 mm are essential requisite for good growth and yield of jute [3].

3.2. Land Preparation and Fertilization

Jute seed requires fine tilth for its proper germination, as its seeds are very small in size. Number of plough also varies depending on soil type. If it is of light soil, three ploughs may be enough. For heavy soil increased number of ploughs must be needed. The main point is that the soil is to bring to fine tilth by plough and harrowing. Number of plough may vary from 3-6 depending on the texture of soil. During land preparation weeds and plant debris are to be collated and removed from the land. Otherwise, the crop field will be heavily infested by weeds, which involve excess weeding cost. Jute field also needs proper leveling of soil. During land preparation, the land should be supplied organic fertilizer before 2-3 weeks of seed sowing. This also may be applied at the time of opening the land. It should always remember, the soil of Bangladesh is miserably deficient in organic matter, which plays a vital role for improve the physical health and nutrient elements of soil available to the plants. Most of the cultivable lands of Bangladesh are certainly deficient in organic matter. The jute field soil is to replenish with the supplement of organic matter during land preparation. Bangladesh soil is deficient in six elements in its present condition. Those are N, P, K, S, Zn and Mg. Due to intensive cultivation, Bangladesh soil is getting deficient with more nutrient elements. The following chart indicates the emergence of nutrient deficiencies on time scale in Bangladesh. At the present situation, jute crop for its potential yield requires N, P, K, Zn, S and Mg nutrient elements. Required doses of fertilizers are given in the following Table 1.

Table 1. Variety-wise fertilizer requirement and time of application (When sown without application of organic matter).

Variety (Deshi)	Urea		TSP	MP	Gypsum	Zinc Sulphate
	On sowing (kg ha ⁻¹)	45DAS (kg ha ⁻¹)	On sowing (kg ha ⁻¹)	On sowing (kg ha ⁻¹)	On sowing (kg ha ⁻¹)	On sowing (kg ha ⁻¹)
D-154, CVL-1, CC-45, CVE-3	83	83	25	30	45	11
BJC-7370	55	55	25	40	-	-
BJC-83	110	110	50	40		
(Tossa)						
O-4	83	83	25	30	45	11
O-9897	100	100	50	60	95	11
OM-1	88	88	50	40	95	11
O-72	83	83	51	80	100	11

(Source: Islam and Rahman, 2008) [3]

When planted with application 5t ha⁻¹ of cowdung then the fertilizer doses become a bit different. Then one is to follow the following recommendation

Variety	Urea		TSP	MP	Gypsum	Zinc Sulphate
	At sowing (kg ha ⁻¹)	45DAS (kg ha ⁻¹)	At sowing (kg ha ⁻¹)	At sowing (kg ha ⁻¹)	At sowing (kg ha ⁻¹)	At sowing (kg ha ⁻¹)
(Deshi)						
D-154, CVL-1, CC-45, CVE-3	27	88	-	-	-	-
BJC-7370	55	55	-	-	-	-
BJC-83	55	55	-	-	-	-
(Tossa)						
O-4	27	88	-	-	-	-
O-9897	45	100	-	10	50	-
OM-1	33	88	-	-	50	-
O-72	28	83	-	-	-	-

(Source: Islam and Rahman, 2008) [3]

DAS: Days after sowing

*For each 1000 kg dry cowdung the doses of urea, TSP and MP will be reduced by 11, 10 and 10 kg respectively

Table 2. Time and amount of fertilizer application of jute, kenaf and mesta fibre production (Medium soil fertility and medium production target kg/ha).

Variety	Dry cowdung	Chemical fertilizer (Amount and time of application)						
		2-3 weeks before sowing	Urea		TSP	MP	Gypsum	Zinc Sulphate
			At sowing date	After 45 days of sowing	At sowing date			
Whitejute: CVL-1, CC-45, CVE-3, BJC-7370, BJC-83 Tossajute: O-4	*	83	83	25	30	45	11	
O-9897 (Tossa jute)	*	100	100	50	60	95	11	
OM-1 (Tossa jute)	*	88	88	50	40	95	11	
O-72 (Tossa jute)	*	83	83	50	40	95	11	
Kenaf: HC-2HC-95	*	66	66	25	30	-	-	
Mesta: HS-24	*	55	55	25	-	-	-	
Whitejute: CVL-1, CC-45, CVE-3, BJC-7370, BJC-83 Tossajute: O-4	5000	27	88	-	-	-	-	
O-9897 (Tossa jute)	5000	45	100	-	10	50	-	
OM-1 (Tossa jute)	5000	33	88	-	-	50	-	
O-72 (Tossa jute)	5000	61	61	-	10	50	-	
Kenaf: HC-2HC-95	5000	11	66	-	-	-	-	
Mesta: HS-24	5000	-	55	-	-	-	-	

(Source: Islam and Rahman, 2008) [3]

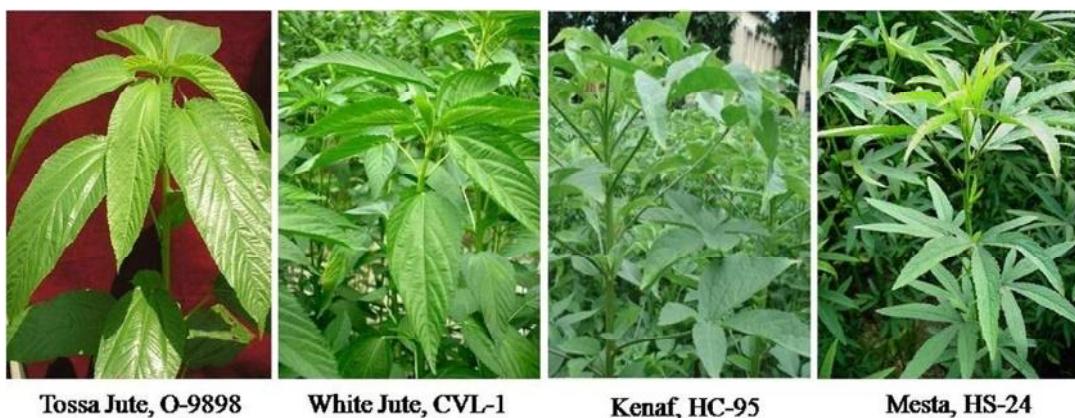


Figure 1. Land preparation.

3.3. Planting Time of Fibre and Seed Crop

Jute is a photoperiod sensitive and short day plant. Any early planting provides premature flowering, reduces plant growth and yield of fibre. It accomplishes its vegetative growth in the long days and induces flowers in the short days. In Bangladesh condition, day length goes above 12 hrs from 22 March and 12.50 hrs from 14 April. So, all the varieties, except O-4, can be safely planted after 22 March and O-4 to be planted after 14 April, because, O-4 is more sensitive to photoperiod. Sowing should be ensured within a month thereafter. However, some new varieties such as CC-45, BJC-7370, BJC-83, BJC-2142, O-9897, OM-1, O-72 and O-795 can be planted 15 days earlier without any fear from premature flowering, but that is not suggested, since growth of jute plant is also related to thermal sensitivity. It provides luxuriant growth under temperature between 30°C to 40°C and relative humidity over 70%, and growth rate becomes stunted gradually when temperature comes below 30°C. So planting too early obviously brings no beneficial effect rather it involves extra cost due to cultural management, nutrient and soil moisture. To concern *C. capsularis* L. varieties planting around 30 March register optimum fibre yield and provides room for other crops to fit into 3 crop pattern. However, some recently developed high yielding varieties

can be planted on one month ahead. To concern *C. olitorius* L. varieties, the conventional variety like O-4 (less photoperiod sensitive), planting should be done after 14 April. However, varieties are to be planted starting from 15 March, will help incorporate Tossa jute into three crop pattern. To concern *Hibiscus cannabinus* L. varieties planting around 15 March to 30 April and *H. sabdarifa* L. varieties planting around 15 March to 15 May produce optimum fibre yield. For seed production, the best time of seed sowing is mid July to last of August. In case of *C. capsularis* L. whole July and in case of *C. olitorius* L. within August 30, which give more seed yield. Sowing times varies 15-30 days from north to south. In northern districts (Dinajpur, Rangpur, Rajshahi, Bogra) 15 days earlier than that of southern districts (Jossore, Kustia) sowing can be done even up to 15 September [3]. Different varieties have their respective time for sowing (Figure 3). If sown untimely the growth is retarded and yield is reduced. When sown earlier, premature flowering occurs and yield is drastically reduced with deterioration in quality. Generally the sowing of *capsularis* varieties starts from late February to April in low lying areas that retain moisture of the previous flood or monsoon. On the other hand in case of *olitorius* jute seeds are sown from 15 March to April.



Tossa Jute, O-9898

White Jute, CVL-1

Kenaf, HC-95

Mesta, HS-24

Figure 2. Jute and Bast fibre crops.

LIST OF VARIETIES OF JUTE, KENAF AND MESTA				
Total Sl.	Sp. Sl.	Name of variety	Year of release	Pedigree
A. White Jute (<i>Corchorus capsularis</i>) সাদা/দেশী পাট				
01.	01.	Oocarpus	1910	Pure line selection (PLS)
02.	02.	Kakya Bombai	1910	PLS
03.	03.	R-85	1916	PLS
04.	04.	D-154 (Dhaka-154)	1919	PLS
05.	05.	D-386	1931	PLS
06.	06.	Funduk	1939	PLS
07.	07.	C-212	1939	PLS
08.	08.	C-13	1941	PLS
09.	09.	C-412	1942	PLS
10.	10.	C-1	1952	PLS
11.	11.	C-2	1952	PLS
12.	12.	C-3	1952	PLS
13.	13.	C-4 (C-320)	1955	PLS
14.	14.	C-5 (C-321)	1955	PLS
15.	15.	D-154-2	1961	PLS
16.	16.	C-6 (C-322)	1967	PLS
17.	17.	CVL-1	1977	PLS
18.	18.	CVE-3	1977	PLS
19.	19.	CC-45	1979	PLS
20.	20.	BJRI Deshi pat-5 (BJC-7370)	1995	D-154 x CC-45
21.	21.	BJRI Deshi pat-6 (BJC-83)	1995	CVL-1 x Fuleswari
22.	22.	BJRI Deshi pat-7 (BJC-2142)	2007	CC-45 x BJC-718
23.	23.	BJRI Deshi Pat-8 (BJC-2197)	2013	CC-45 x FDR (Formusa Deep Red)
24.	24.	BJRI Deshi Pat Shak-1 (BJC-390)	2014	Cap Dwarf Red x BINA Pat Shak-1
25.	25.	BJRI Deshi Pat-9 (BJC-5003)	2017	CVL-1 x Acc. 1831 (Blue seeded)
B. Tossa Jute (<i>Corchorus olitorius</i>) তোষা পাট				
26.	01.	Chinsurah Green (D-38)	1915	Pure line selection (PLS)
27.	02.	R-26	1929	PLS (Red stem)
28.	03.	R-27	1929	PLS
29.	04.	O-620	1939	PLS
30.	05.	O-632	1939	PLS
31.	06.	O-753	1939	PLS
32.	07.	O-1	1955	PLS
33.	08.	O-2	1955	PLS
34.	09.	O-3	1955	PLS
35.	10.	O-4	1967	PLS
36.	11.	O-5	1964	PLS
37.	12.	O-9897	1987	O-5 x BZ-5
38.	13.	BJRI Tossa pat-3 (OM-1)	1995	PLS (Uganda)
39.	14.	BJRI Tossa pat-4 (O-72)	2002	(O-9897 x O-2012) x O-9897
40.	15.	BJRI Tossa pat-5 (O-795)	2008	Uganda red x O-4
41.	16.	BJRI Tossa Pat-6 (O-3820)	2013	PLS
42.	17.	BJRI Tossa Pat-7 (MG-1)	2017	PLS
C. Kenaf (<i>Hibiscus cannabinus</i>) কেনাফ				
43.	01.	HC-2	1977	PLS
44.	02.	HC-95	1995	PLS
45.	03.	BJRI Kenaf-3 (Bot kenaf)	2010	PLS
46.	04.	BJRI Kenaf-4 (KE-3)	2017	PLS
D. Mesta (<i>Hibiscus sabdariffa</i>) মেস্তা				
47.	01.	HS-24	1977	PLS
48.	02.	BJRI Mesta-2 (VM-1)	2010	PLS
49.	03.	BJRI Mesta-3 (SAMU '93)	2017	PLS

British Period Pakistan Period Bangladesh Period

Figure 3. Released year and pedigree of different jute, kenaf and mesta varieties developed by BJRI.

It was observed less photosensitive than the others having a wider sowing range from 14 March to April [4]. Agronomic trials proved no early flowering occurred even seeding could be done one week before 14 March and crop could be harvested at 110 days of field duration to fit the crop in three cropped pattern. Potential yield of the variety O-795 was about 5.0 tha^{-1} by maintaining the plant population $3.5\text{-}4.0 \text{ lac.ha}^{-1}$, however in farmers field the average yield was observed 3.4 tha^{-1} , was calculated 10% higher than the check cv. O-72. It was observed less photosensitive than the check variety CVE-3, having a wider sowing range from third week of March to Mid-April [5]. Agronomic trials proved absence of premature flowering in appropriate sowing and harvested on 110 days of field duration to fit the crop in three cropped pattern. The variety BJC-2142 is suitable for Faridpur jute growing zone. Potential yield of the variety was observed 4.0 tha^{-1} , maintaining the plant population $3.50\text{-}4.50 \text{ lac.ha}^{-1}$, however in farmers field the average yield was observed 2.50 tha^{-1} , was calculated 3.24% higher than cv. CC-45 and 9.33% higher than cv. CVE-3.

3.4. Seeding Rate

To get optimum plant population and desired yield, seeding rate was optimized and found that seeds having 80% viability,

5 kgha^{-1} of tossa jute, 7 kgha^{-1} of deshi and $12\text{-}15 \text{ kgha}^{-1}$ of Kenaf and Mesta seeds could offer desired population and optimum yield. For seed crop seed rate depends on the soil condition and planting methods followed. As a thumb rule, for Deshi jute $4.0\text{-}4.5 \text{ kg/ha}$ in line sowing and $5.0\text{-}5.5 \text{ kg/ha}$ in broadcast sowing should to be maintained. On the other hand for Tossa jute $3.0\text{-}3.5 \text{ kg/ha}$ in line sowing and $4.0\text{-}4.5 \text{ kg/ha}$ in broadcast sowing should be maintained. As jute seeds have no other alternative uses, it is to sow even if it is of 50% viability by adjustment the seed rate [3].

Proper seed rate is the main factor for plant population, growth of jute plant and for obtaining maximum yield. Quality seeds of an improved variety itself provide 20% additional yield of the crop. Farmers commonly use 7-8 kg/ha for *C. capsularis* and 5-6 kg/ha for *C. olitorius* (tossa). For broadcast seeding, seed rates are the flowing which has the germinability of seed being 80% or above:

* *C. capsularis* (white) 7.00 to 8.00 Kg per hectare.

* *C. olitorius* (tossa) 5.00 to 6 Kg per hectare.

The seed rate in the case of line sowing depends on the spacing and a plant to plant distance. However the following seed rate are recommended for line sowing:

* *C. capsularis* (white) 5.00 to 6.00 Kg per hectare.

* *C. olitorius* (tossa) 3.00 to 4 Kg per hectare.



Figure 4. Seed sowing.

3.5. Intercultural Operations

Weed poses a major problem in jute cultivation and weeding operation constitute about one third of the total cost of production. Some of the weeds are found major in jute field are listed here. *Cyperus rotundus*, *Cynodon dactylon*, *Echinochloa colonum*, *Digitaria sanguinalis*, *Cyperus iria*, *Eleusine indica*, *Panicum disticum*. Two experiments were conducted with deshi and tossa jute varieties at Manikganj, Kishoreganj, Chandina; and Monirampur, Faridpur, Rangpur during 2011-12 with a view to generate information about *Jute, Kenaf and Mesta Crops Research Reviews*

weeds in jute field and their related affairs. In 1st experiment results showed species viz., Khudesama, Mutha, Durba, Fuskabegun, Katanotey, Anguli, Knotgrass/Gitlaghas, Gaicha, Nuniasak, Matichech, and Helencha were infested in deshi jute growing areas. Among the growing weeds 6 major species at Manikganj, 5 at Kishoreganj and Chandina were observed. Manikganj, Kishoreganj and Chandina jute fields were highly infested by Mutha which was followed by Durba. In another experiment of tossa jute growing areas, the weed species viz., Khudesama, Mutha, Basketgrass, Durba, Fuskabegun,

Knotgrass/Gitlaghass, Chechra, Chapra, Nuniasak, Shialleza, Gaicha, Shaknotey, Chanchi and Hajardana were found. Among the infested weeds 8 major species were observed at Monirampur, 10 at Faridpur and 4 at Rangpur station. Jute field of Monirampur station was highly infested by Khudesama whereas Faridpur and Rangpur were infested by Mutha. From the two separate experiment it was observed and calculated that twenty two type of weeds viz., Khudesama, Basketgrass, Mutha, Durba, Fuskabegun, Katanotey, Shaknotey, Chapra, Shialleza, Knotgrass/Gitlaghass, Borododhia, Sutododhia, Chechra, Hajardana, Gaicha, Chanchi, Nuniasak, Helencha, Anguli, Matichech, Borosama, Angta grown which were identified at both deshi (Manikganj, Chandina, Kishoreganj) and tossa (Monirampur, Faridpur and Rangpur) jute growing stations. Timely weeding and thinning are most important operation to obtain a good establishment

and healthy crop. First weeding, mulching and simultaneous thinning at 10-15 days after sowing (DAS), second weeding, mulching and simultaneous thinning at 25-30 Days After Sowing third weeding, mulching and simultaneous final thinning and topdressing of urea fertilizer followed by hoeing, 40-50 DAS, entomological and pathological care as and when necessary are most effective for higher yield. Besides, one tanabatch between 60-70 DAS and one katabatch around 90 DAS provide good effect. The highest plant height, base diameter, fibre and stick yield were produced when improved seed, line sowing method, recommended dose of fertilizer and plant protection measures were applied. Chemical method of weed control also has been tried and Dalapon and Stam F-34 were found effective in control of weeds in the jute field. However, considering the fodder value of weeds these chemicals are not recommended [17, 19].

Table 3. Intercultural operation that are to be attended.

Intercultural operation	Time of operation
First weeding, mulching and simultaneous thinning	10-15 DAS*
Second weeding, mulching and simultaneous thinning	25-30 DAS
Third weeding, mulching and simultaneous final thinning and topdressing of urea fertilizer followed by hoeing	40-50 DAS
Entomological care	When necessary
Pathological care	When necessary

*DAS=Days after sowing



Figure 5. Weeding and weeds from Jute field.

3.6. Harvesting Time of Jute Fibre

Harvesting of jute usually begins from middle of July and continues upto end of September depending on the time of sowing and the characteristics of variety grown. Different results of the investigations reveal that fibre yield increases with the increases of field duration till 140 DAS, but fibre quality degrades. Delay the harvest increases the fibre yield but produced coarser fibre. On the other hand harvest the crop too early result in a lower yield and weakened fibre. To

make a compromise between yield and quality, field duration and harvest time of both jute species has been accorded and fixed on 120 days after sowing. On average tossa jute varieties could be harvest 10 days before than deshi jute varieties for good quality and as well as optimum yield [3].

3.7. Reduction of Cultivation Cost

Adopting improved technologies, it took 255 human labour, 18 mechanical labour, 5-7 kg of seeds besides fertilizer and insecticides to cultivate one hectare of jute. At

the time of costing of jute cultivation, it can be seen that the major share is taken by weeding and thinning followed by stripping, washing and land preparation. So, reduce the labour involvement in different management operations are in effective action. Experiments were undertaken to reduced

the cost and found that cultivation of jute after its preceding crops such as onion, garlic, potato tuber and sweet potato reduces its cultivation cost by about 20%. In other words manipulation of different cultural practices found the cultivation of jute and allied crops were cost effective.



Jute crop harvesting



Jute crops awaiting for retting

Figure 6. Jute crop harvesting and preparation for retting.

Seed yield, gross margin (GM) and benefit cost (BC) ratio were higher in D-154 on May 30; in CVL-1 on May 15; in O-4 on June 30 and O-9897 on July 30 sowing. Among the varieties O-9897 gave higher seed yield and incurred higher GM and BC ratio compared to others [6]. The marginal rate of return (MRR) suggested that every taka that was spent in cash for O-9897 will earn Tk. 47.98 instead of growing O-4. MRR was Tk.36.30 on every single taka cash spent on O-9897 in lieu of D-154.

3.8. Cropping Pattern

To fit jute in the cropping sequence multiple of trials were conducted and found that Jute-T. aman-Wheat, Potato-Jute-T. aman, Onion-Jute-T. aman, Vegetable-Jute-T. aman and Jute-T. aman-Mastard were agronomic feasible and economically viable. Incorporation of tossa and deshi high yielding jute varieties generates higher income to the jute growers in different cropping pattern studied. It was suggested that recently released white and tossa jute varieties (BJC-83,

BJC-7370, BJC-2142 and OM-1, O-72, O-795) could be incorporated as a component crop in three cropped patterns with T. aman and Wheat [3].

3.9. Switching over of Planting Time of Jute Seed Crop

Jute seed production along with fibre crop was not remunerative at all. Switching over of production season of jute seed crop from early summer to late summer, found that planting of jute seed crop during the month of July and August provide three-four folds higher seed yield. However, there were variations in yield in region specific situation. Dead line of planting time in different regions were also demarcated and found that in Rangpur Region, planting jute seed crop should not be done beyond 15 August, at Monirampur beyond 30 August, at Faridpur, Manikgonj and Kishoregonj beyond 15 September. However, investigation showed that at Comilla Regional Station, late season jute seed crop can be planted till end of September.



White Jute fruits



Tossa Jute fruits

Figure 7. Jute fruits.

Top cutting method gave highest seed yield of 738 kg ha⁻¹ in *C. capsularis* L. and 913 kg ha⁻¹ in *C. olitorius* L. compared to that of conventional method of 467 kg ha⁻¹ in *C. capsularis* L. and 529 kg ha⁻¹ in *C. olitorius* L. and their differences were highly significant [7, 18]. However, late sowing method gave statistically similar seed yield of 715 kg ha⁻¹ in *C. capsularis* L. and 869 kg ha⁻¹ in *C. olitorius* L. to top cutting. Irrespective of planting methods the varieties CVL-1 and CVE-3 of *C. capsularis* L. and O-9897 and O-4

of *C. olitorius* L. produced statistically similar seed. The interaction effect of seed production method and variety were significant in pod plant⁻¹, seed pod⁻¹, seed weight plant⁻¹, 1000 seeds weight and seed yield except branch plant⁻¹. Moreover, all the varieties under top cutting and late sowing methods produced much higher seed yields compared to their corresponding yields under conventional method of seed production technique (Table 4).

Table 4. A comparative study among different methods of jute seed production.

Some considerable points	Conventional/ Traditional method	Direct seeding	Top/stem cutting method	Transplanting method
Land requirements	Land with fine tillage	Land with fine tillage	Land with fine tillage having available moisture	Land with fine tillage having high moisture
Sowing time	April to May	Mid August to 1 st week of September	Throughout the July	Mid June to mid July
Seed rate	6-8 Kg/ha	4-5 Kg/ha	It requires mother plants to collect top/stems	50-100gm seed for a seed bed of (3x1) m ² area
Field duration	240 days	120 days	135 days	150 days
Infestation of pests and diseases	Very high	Very low	Very low	Low
Survivability	Medium	Higher	High	Lower
Seed yield	150-250 Kg/ha	500-700 Kg/ha	600-900 Kg/ha	400-700 Kg/ha

(Source: Islam, 2009) [8]

3.10. Seed Crop Harvesting Weather and Time

The seed crop becomes ready to harvest between mid October to mid December when 60-70% capsules/fruits become brown in color, indicated the optimum time of harvesting seed crop. Over maturity mainly in *C. olitorius* L. promotes shattering. Jute seed crops are to be harvested in sunny day so that it can be dried immediately after harvest. It is also found that harvesting jute seed in sunny days in between 10 AM to 12 PM showed better result. As some fruits are burst due to over maturity and these fruits receive moisture from night dews and seeds get wet. If these seeds

are harvested at an early hour before drying of seeds, this moisture certainly affects seed quality of the seed lot. Wetted plant due to rain should always be avoided to harvest. Maturity of a seed at the time of harvest is one of the important factor that contribute to seed quality. The harvest stage of about 165 days in *C. capsularis* L. and about 160 days in *C. olitorius* L. coincide with 60% in *C. capsularis* L. and 70% in *C. olitorius* L. fruits browning. Such stage of fruit browning confirm to physiological maturity i.e. optimum germinability, lowest moisture content, optimum dry weight for both the species and at the same time it appears higher seed yield [8, 12-19].

Table 5. Effect of interaction between production method and variety of jute on seed yield and its components.

Methods of production	Variety	Branches plant ⁻¹ (no.)	Pod plant ⁻¹ (no.)	Seeds pod ⁻¹ (no.)	Seed weight plant ⁻¹ (g)	Weight of 1000 seeds (g)	Seed yield (kg ha ⁻¹)
<i>Corchorus capsularis</i> L.							
Conventional method	CVL-1	2.83	41 b	33 b	3.11 d	3.20 c	452 d
	CVE-3	2.49	38 c	30 c	2.67 c	2.98 d	485 c
Top-cutting method	CVL-1	4.05	55 a	38 a	4.37 a	3.63 a	750 a
	CVE-3	3.97	43 b	34 b	4.21 b	3.59 a	709 b
Late sowing method	CVL-1	3.98	51 a	39 a	4.31 a	3.61 a	745 a
	CVE-3	3.89	42 b	32 bc	4.07 c	3.52 b	696 b
<i>C. olitorius</i> L.							
Conventional method	O-9897	2.63	41 c	209 c	15.73 d	1.67 c	537 d
	O-4	2.41	39 c	197 d	14.98 d	1.53 d	511 d
Top cutting method	O-9897	3.13	53 a	239 a	24.13 a	1.93 a	969 a
	O-4	3.02	51 a	228 ab	23.10 b	1.85 b	865 b
Late sowing method	O-9897	4.31	52 a	225 b	23.56 b	1.89 a	889 b
	O-4	4.01	48 b	221 b	21.91 c	1.80 b	759 c

3.11. Post Harvest Processing and Storage of Jute Seed

The harvested tops of jute seed crop should be placed in sun immediately after harvest. If not seed quality must deteriorate within some days because of contaminate with fungal and saprophytic organisms for high moisture content. The harvested tops should be dried in sun for 4-5 days to bring it into threshing condition. Investigation were undertaken and found that beating with stick is suitable for retention of seed quality. Cattle threshing rather smash wet seeds made seed injurious and ultimately deteriorate quality. Drying in the oven at 56°C for 24 hour has found suitable for jute seed to bring its moisture content below 10%. However, it is not applicable to farmers' level. Jute seed should be dried for 3-6 (for 8 hours a day) days in sun. This will help retain seed moisture content between 7-9%, is the most safe moisture level for storage of jute seed. Drying on gunny sack

helps retain seed quality better than those drying on tin sheet, polyethylene sheet or even on cemented floor, where seeds become twisted and wrinkled. Moreover, drying on the earthen ground seeds, get contaminated with disease and saprophytic fungi. Initial seed moisture content plays a vital role in the maintenance of seed quality in storage. The effect of types of seed drying condition/floor is very important in terms of reduction of moisture during seed drying. Seed drying on gunny bag or sacking was found very effective to reduce seed moisture without any damage of its embryo. Jute seeds are very delicate and it is comparatively very difficult to maintain viability in storage condition. Before storing seed, it must be dried through 5-6 days sundry. The dried seed then is stored in airtight tin or plastic container. The sealed lamofoil is the best of all. If the quantity is more, it can be stored in airtight plastic/tin drum [8, 13, 14, and 16].

Table 6. Interaction among storage container, storage condition and drying period in jute (*C. olitorius L.*) seed (variety, O-4).

Storage container	Storage condition					
	1000 seed wt. (g)			Moisture content (%)		
	Breaks house	Bamboo house	% gain	Breaks house	Bamboo house	% gain
Drying period (4 days) sunning						
Cloth bag	2.03	2.09	2.96	8.6	11.31	31.51
Earthen pot	2.05	2.07	0.98	8.87	10.96	23.56
Poly bag	2.01	2.02	0.50	8.37	8.8	5.14
Tin pot	2.02	2.03	0.50	8.6	8.94	3.95
Drying period (5 days) by sunning						
Cloth bag	2.03	2.07	1.97	8.6	12.09	40.58
Earthen pot	2.01	2.06	2.49	8.28	10.83	30.80
Poly bag	1.99	2.00	0.50	8.12	8.48	4.43
Tin pot	1.95	2.01	3.08	7.9	8.57	8.48
Drying period (6 days) by sunning						
Cloth bag	2.00	2.07	3.50	8.13	11.05	35.9
Earthen pot	1.99	2.06	3.52	8.09	10.72	32.5
Poly bag	1.92	1.95	1.56	7.4	7.74	4.59
Tin pot	1.94	2.00	3.09	7.81	8.56	9.60
LSD	Ns			ns		

Table 6. Continued.

Storage container	Storage condition					
	Germination			Vigour value		
	Breaks house	Bamboo house	%loss	Breaks house	Bamboo house	% loss
Drying period (4 days) by sunning						
Cloth bag	78	69	11.54	53.96	43.58	19.24
Earthen pot	77	65	15.58	62.00	45.75	26.21
Poly bag	78	71	8.97	66.76	65.41	2.02
Tin pot	76	71	6.58	66.31	64.28	3.06
Drying period (5 days) by sunning						
Cloth bag	76	73	3.95	55.13	51.32	6.91
Earthen pot	77	68	11.69	65.55	48.82	25.52
Poly bag	77	76	1.30	68.81	68.23	0.84
Tin pot	78	75	3.85	67.35	65.30	3.04
Drying period (6 days) by sunning						
Cloth bag	79	74	6.33	56.66	52.33	7.64
Earthen pot	79	68	13.92	65.81	56.16	14.66
Poly bag	78	77	1.28	68.97	68.87	0.14
Tin pot	80	78	2.50	70.12	68.68	2.05
LSD	0.52			0.21		

(Source: Islam *et al.* 2002) [9]



Post harvest processing of jute seed crop

Jute seed drying activities

Figure 8. Post harvest processing activities of jute seed.

3.12. Seed Preservation

Seeds preservation are influenced by the moisture content of seed, temperature and relative humidity which are related to the seed viability and germination for sowing. Jute seeds are delicate to lose their viability sharply if they are not stored properly. Jute seeds are harvested in October to November and November to December for *Corchorus capsularis* and *Corchorus olitorius* respectively. Freshly harvested jute seeds have a high moisture content which are estimated about 20-25 percent. This content of moisture of seeds are harmful for preservation. So, that after threshing of jute, seeds moisture needs to be reduced to 7-9 percent by 4-6 sunning (6 hrs. a day). Even jute seed having below 7 percent moisture may be stored for about two years. It is noted that after each days sunning the seed should be cooled and stored. Beside, storage temperature also plays a vital role for seed viability and vigour. It was reported the effect of moisture content on jute (*Corchorus* spp.) kenaf and mesta seeds at storage temperature +20°C, +4°C and -20°C upon viability and vigour. Storage at room temperature jute seeds with 4.0% to 7.75 moisture maintained above 80% viability up to 12 months of storage, the mesta seed maintained 80% viability up to 6 months of storage with 5.3% to 7.5% moisture. Storage condition plays a significant role in seed preservation also. Storage containers having semipermeable to

nonpermeable status may be note worthy for short term as well as long term seed preservation. Seed grower at farm level use different types of containers. The farmers of Bangladesh use four types of containers which are metal, clay pot, polythene bag, jute sacks. The storage efficiency of clay pot and jute sacks are permeable to relative humidity. Therefore, the tin container and nonpermeable plastic container are suitable for long time preservation with cool and dry storage condition (Table 6) [9, 14, 16].

3.13. Appropriate Time of Jute Seed Crop Harvest

The crop becomes ready to harvest between mid October-mid December when 60-70% capsules become brown in color. This is the optimum time of harvesting the crop. Over maturity mainly in *C. olitorius* L. promotes shattering. Wetted plant due to rain should be avoided to harvest. Jute seeds are to be harvested in sunny day so that it can be dried immediately after harvest. It is also found that harvesting jute seed in sunny days before noon. As some fruits are burst due to over maturity and these fruits receive moisture from night dews and seeds get wet. If these seeds are harvested at an early hour before drying of seeds, this moisture certainly affects seed quality [10, 13, 16].



White Jute seed

Tossa Jute seed

Figure 9. Jute seeds.



Figure 10. Clarification of Agronomic Research Programs.

3.14. Physiological Maturity of Jute Seed

Maturity of a seed at the time of harvest is one of the important factors that contribute to quality seed production. The harvest stage of 194 days in *C. capsularis* L. and 178 days in *C. oitorius* L. coincide with 60% browning of fruits in *C. capsularis* L. and 70% browning of fruits in *C. oitorius* L. Such stage of fruit browning confirms physiological maturity i.e. optimum germinability, lowest moisture content, optimum seed dry weight for both the species and at the same time it appears maximum fruit bearing and highest seed yield. Seed should be collected at harvest stage of 194 and 178 days which coincide with 60% and 70% browning of fruits for *C. capsularis* L. and *C. oitorius* L. respectively. Seed crop will be harvested when physiological maturity will come up [10, 11, 15, 16].

3.15. Suitable Floor for Jute Seed Drying at Farmers Level

Initial seed moisture content plays a vital role in the maintenance of seed quality in storage. The effect of floor types on the reduction of moisture during seed drying is very important. Seed drying on gunny bag or sacking was found very effective to reduce seed moisture without any damage of its embryo. Seeds will be dried just after harvest on gunny bag or sacking. Gunny bag or sacking is more suitable for seed drying at farmers level than those of polythene sheet, cowdung plated floor and cemented floor [10, 15].

3.16. Easy Viability Test of Jute Seed at Farm Level

We know quality seed increases the production about 15 to 20 percent. We are facing the scares of quality seed at the sowing time of every crop in every year in our country. So it is very important to test the viability of jute seed for quality before sowing. It is very easy and cost effective to test the viability of jute, kenaf or mesta seeds. Firstly one hundred seeds with four replications will be evenly distributed on the top of four bloating papers or news paper or old cloths placed in four soil made plates. The seeds and bloating or news paper or old clothes are kept moist throughout the test period by adding water. Seeds that germinated will be counted and recorded daily till fifth day. A seed will be considered to be

germinated as seed coat ruptured and radicle come out up to 0.2 cm or more length. Germination test will be carried out in room temperature. Above 80% of germinated seeds are considered as good quality seed. However below 70% viability are considered as bad as not to sow in the field for production purpose [10, 14, 15, 16].

3.17. Seed Treatment Method of Jute Seed at Farm Level

In jute field the incidence of many diseases are found to occur from seedling stage to late stages. These are seedling die, seedling wilt, stem rot, black band, anthracnose and yellow mosaic. Any severe incidence may affect yield by 50%. As we all know prevention is better than cure. For this purpose, we can treat seeds before sowing. Seeds should be treated before sowing to prevent seed and soil born diseases and insect-pests infestations. For this, 1 kg of jute seed is to be treated mixing with 4-5 gm of Vitavax-200 for 10 minutes in a soil pot [8, 10, 14, 16].

4. Conclusion

It could be concluded from the study that high and medium high land where rain and flood water does not stand is suitable for tossa jute cultivation. Jute requires a warm and humid climate with temperature fluctuating between 24°C and 37°C. The permissible relative humidity favorable to growth ranges between 70 and 90 percent. Rainfall ranges from 250mm to 270mm are essential requisites for good growth and yield of jute. The major weeds in jute field were detected *Cyperus rotundus*, *Cynodon dactylon*, *Echinochloa colonum*, *Digitaria sanguinalis*, *Cyperus iria*, *Eleusine indica*, *Panicum disticum*. First weeding, mulching and thinning at 10-15 days after sowing (DAS), second weeding, mulching and simultaneous thinning at 25-30 DAS, third weeding, mulching and simultaneous final thinning and topdressing of urea fertilizer followed by hoeing 40-50 DAS were recommended. Besides, one tanabatch between 60-70 DAS and one katabatch around 90 DAS provide good effect on fibre yield. Improved cultivation technologies such as good quality seed of improved variety, proper sowing and harvesting time, recommended fertilizer application [12] and intercultural management with inputs increases the fibre and seed yields over conventional practices.

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Biography



Md. Mahbul Islam (Corresponding Author) awarded PhD in 2008 from the Department of Agronomy of Bangladesh Agricultural University especially on Jute seed quality, plant establishment and yield. He had done his M.Sc. (Agriculture) in Agronomy and B.Sc. Agriculture (Hons.) from the same University. He is working at Bangladesh Jute Research Institute (BJRI) since 1989. At present he is serving as Chief Scientific Officer & Head of Agronomy Division. He has 6 books, 67 scientific papers and more than 70 popular articles published in international and national journals, newsletters etc. He visited United Kingdom, Malaysia, India for training, seminar, workshop purpose.

Thinning: An important crop management practice for maintaining plant population in jute field

Kd. Dr. Md. Mahbubul Islam

Jute (*Corchorus* spp.) is an important cash crop of great socio-economic importance in Bangladesh. It is now universally recognized that jute is the English version of the current Bengali word 'Pat', a kind of fibre which is obtained from two species (annual and short day plants) of the genus *Corchorus* belonging to the family Tiliaceae. It is a common term used both for plant and the fibre obtained from the bark of the plants, Deshi jute (*Corchorus capsularis* L.) and Tossa jute (*Corchorus olitorius* L.). Among the jute growing countries of the world, Bangladesh ranked second in respect of fibre production and jute alone contributes about 1.58% to GDP without involving any foreign investment (BBS 2011). In 2011-2012, 1523 thousand tones of jute fibre were produced from 7 lakh hectares of land (FAO stat). Jute plants improve soil productivity by its massive leaf fall and root proliferation in the field. Jute fibre is primarily used for making hessian, sack, carpet backing and cloths etc.

There are so many attributes responsible for yield of jute fibre viz. plant population, plant height, base diameter, fibre thickness etc. Among the attributes plant population is very important and effective



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for yield. In traditional jute cultivation at farm level the farmers are usually using seed rate higher than the recommendation. Farmers use 8 to 10 kg jute seeds ha⁻¹ at sowing time, however recommendation is 7 kg ha⁻¹ for white jute. Plant population in jute field usually retain 2 to 3 lac plant ha⁻¹ and yield comes from that population 2 to 3 t ha⁻¹. Our national average of yield of jute is nearly 2.01 t ha⁻¹. Usually the jute seed used at the sowing time, on that basis, the plant population should be nearly 4.0 to 4.5 lac ha⁻¹. From that population yield should be increased

as much as the population's increment.

Research works attended for intercultural operation like thinning

Like other field crops jute also requires intercultural operations. Successful crop production mainly depends on its cultural and intercultural operations. Among the intercultural operations, the thinning is a must to be practiced in jute cultivation. Some research works are stating below-

Kundu (1959) reported that seeds with a germination percentage of about 80 produce about 1,089,600 potential plants per acre, whereas the final stand (number of plants) harvested in an acre usually ranges from 100,000 to 200,000. The seed-rate of jute, therefore, is very high. Although it is possible to raise a good crop of jute with much lower seed-rates under favourable conditions, this high seed-rate is considered necessary for the following reasons: (i) the germinating seedling is very delicate and often cannot singly break through the soil crust that may form when there is rain soon after sowing and therefore requires the help of other seedlings for emergence; (ii) until the regular monsoon sets in some time in Jute, the young crop is



Thinning done at 20-25 days after sowing



Thinning done at 20-25 days after sowing



Thinning done at 40-45 days after sowing



Jute field

often subjected to long periods of drought as the northwester showers, on which it depends, are irregular; therefore, in the event of mortality of seedlings during drought, an adequate population is ensured; (iii) the thick stand in the initial stages helps to check the growth of weeds in the field. During the first two months of the crop, a large number of plants has to be thinned out gradually. When the plants are about three to nine inches high, a hand or bullock-drawn rake (bida or anchra) is drawn over the land to thin out the plants and loosen the soil slightly. This operation may be repeated twice at an interval of about a fortnight.

Ghosh, 1978, reported that thinning is an essential operation, which must be carried out in a timely manner. In a broadcast plot, if the seedlings are much crowded, light raking precedes manual thinning. Raking is never done in wet soil and is dropped altogether if the seedlings are not too crowded. When seedlings are about 10cm tall, thinning is convenient. Normally first thinning is done when seedling are 18 to 21 days old by which time seedlings can withstand the operators' treading. During the first thinning operation the gap left between plants is less than the desired final spacing. The second or final thinning is done

about 30 days crop age when plants are spaced 101-5cm apart. In broadcast plots the minimum plant-to-plant spacing is 10cm and maximum 15cm. When the soil is highly fertile, close spacing is undesirable since harvestable plants grow faster and become tall. Their foliage forms a canopy that suppresses the growth of the shaded plants, which then remain thin and short. Such dwarfed plants soon shed their leaves and succumb to microbial attacks. In fertile soil wider spacing of 15cm is preferable. Plots with different population is how similar yield; 49,504 plants yielded 24.8md per acre, while 1,20,980 plants also

yielded 24.3 md per acre. The former were tall and stout, the latter were thinner and less tall, but they are greater number compensated for the thinness and shortness, since it is known that jute base diameter and plant height have strong positive correlation with yield.

Alim (1978) reported that the growth rate of jute for the first 5 weeks after sowing is slow. Thus in the early stages of growth like all other crops jute requires frequent inter-culture. Thinning is carried out along with weeding and hoeing. The labour required for weeding and thinning for broadcast jute is almost 40% of the total labour required for the crop. So there is a very costly operation. The usual method of weeding and thinning of broadcast planted crop is done mostly during the first 8 weeks after sowing. First the thinning is done with an animal-drawn rake (bida). This operation simultaneously uproots weeds and thins the jute. The operation is repeated twice or thrice in the course of a month or so. After raking the plants are weeded and thinned by hand-hoe (nirani), two or three times. The final spacing between plants is about 10-15cm and 1,00,000-1,50,000 plants per acre. The earlier the thinning is done the better it is for the growth of the rest of the plants and it is reported that best results are obtained when it is done within 3 weeks. There is practice of thinning even at the age of 3 months. The plants thinned at this stage are generally retted for the extraction of fibre and fetch some monetary return to the growers.

According to Dargan (1969), the growth rate of jute for the first 40

days after sowing is slow, averaging between 0.5 and 0.6cm/day. Thus in the early stages of growth jute requires frequent and timely cultivation. Thinning is carried out at two or three intervals along with the cultivation. The labour

tively. However in Taiwan it was observed 165,000-246,000 per hectare with spacing of 40x9-12 or 50x9-12cm line and plant to plant. On the other hand, India showed the similar results like Bangladesh (Table 1).

Table 1. Line-sown jute spacing recommended by various workers

Reference	Country	Between rows (cm)	In row (cm)	Plant population (no./ha)
Sanyal (1953)	India	30	7.5	444,000
JARI (1956/57)	India	30	7.5	444,000
Ghosh (1963)	India	30	7.5	444,000
Dargan (1969c)	India	30	10.0	333,000
Chaudhuri & Kasem Ali (1962)	Bangladesh	30	8.0	416,000
Dept. Agri. East Pakistan (1964)	Bangladesh	30	7.5	444,000
Chi <i>et al.</i> (1966)	Taiwan	40-50	9-12	165,000-246,000

(Source: Dempsy, 1975)

required for the weeding and thinning of broadcast-planted jute amounts to 1,400 man-hours per hectare according to Ghosh (1967), or about 40.5% of the total man labour required for producing the crop.

Sarma (1969) states that the unwanted jute plants are gradually thinned out; the final thinning takes place when the plants are about 23cm in height. The final spacing of the plants in the row is 7.5-10.0cm or 333,000 to 444,000 plants per hectare. Das and Palchoudhuri (1958) state that the best yields are obtained from line-sown jute when the thinning is completed with 3 weeks after sowing.

"Fibre Crops" by Dempsy (1975), it was evident that Chaudhuri & Kasem Ali (1962) and Department of Agriculture East Pakistan (1964) reported in Bangladesh, line-sown jute with spacing 30x7.5cm and 30x8.0cm produced 444,000 and 416,000 plants per hectare, respec-

Thinning at present

According to Islam and Rahman (2008), thinning is done simultaneously during weeding. During weeding, smaller and weaker plants are to thin out from the field. If it is a line sown crop, plant-to-plant distance is to be maintained from 7-10 cm with in row at final thinning. For broadcast sowing, 40-50 seedlings are to be maintained m⁻². Intercultural operations related to thinning are attended in jute cultivation.

An analysis of jute plant population from seed to plant harvest

Total seeds number in 5 kg of Tossa jute were 25,00,000 and of Deshi jute 21,00,000. Again the viable seeds of those total seeds (@ 80% of germination capacity) were 20,00,000 in Tossa and 16,80,000 in Deshi, respectively. The traditional assumption that from this amount of population, seedlings and matured plants uprooted or cut out at different stage of jute crop cultivation viz. environmental stress, seedling dead & damage, uprooting and by

thinning and cutting etc. So after all jute crop management stage the field plant population remain about 10-12% of the viable seeds at harvest. Normally at farmers field of Bangladesh, the plant population found 2,50,000-3,00,000 per hectare in Tossa and 1,68,000-2,01,600 per hectare in Deshi jute field, respectively (Table 3).

economic research experiences that fibre yield could be focused by jute field's plant population number, viz. 3,00,000 per hectare plant population with optimum plant height (3.5-4.0m or above) and base diameter (16-18mm or above) could provide good quality fibre yield of 3.0 tha-1 or very close to this.

ing period. Dr. Islam is acting as a member of Academic Council for the period of two years (2013 & 2014) of Sher-e-Bangla Agricultural University (SAU) and Registered Graduate (life-member) of the same. He is active life-member of different professional associations like Krishibid Institution, Bangladesh; Bangladesh Agronomy Society; Bangladesh Society for Seed Science and Technology; Seed Science Society of Bangladesh, Weed Science Society, Bangladesh, Bioscience Associates, Bangladesh etc.

Table 3. Seed rate to field plant population per hectare of jute crop at harvest

Required jute seed to Field population	Tossa jute seed%= Plant population	Deshi jute seed%= Plant population
(1) Tossa or white jute seed rate per hectare 5 kg or 7 kg. (100%)	100% = 25,00,000 @ 5 kg	100% = 21,00,000 @ 7 kg
(2) Germination(%) of viable number of seed	80% = 20,00,000	80% = 16,80,000
(3) Emergence at field level for different environmental stress (20%)	80-20=60%	80-20=60%
(4) Rate of seedling dead (5%)	60-5=55% remain	60-5=55% remain
(5) Seedling damage at weeding (5%)	55-5=50% remain	55-5=50% remain
(6) Uprooting seedling by weeding and 2 times thinning (30%)	50-30=20% remain	50-30=20% remain
(7) Damage made by disease & insect attack and by human and animal (5%)	20-5=15% remain	20-5=15% remain
(8) Plant cut out by tana and kata batches (5%)	15-5=10% remain	15-5=10% remain
(9) Plant population at farmers field remain (10%-12%)	2,50,000-3,00,000	1,68,000-2,01,600

Conclusion

Thinning is one of the most important practices in jute cultivation. Many researchers worked on this management operation. The optimum thinning practice could provide an effective number of plants (with optimum plant height and base diameter) in the jute field at harvest time. This plant population is one of the vital yield contributing factors of jute. In an average plant population at farmers field of Bangladesh usually found 2,50,000-3,00,000 per hectare in Tossa and 2,25,000-2,50,000 per hectare in Deshi jute field, respectively. Which deals the national average yield of jute fibre in Bangladesh is 2.01tha-1. It could be assumed from the agro-

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Research Advances of Jute Field Weeds in Bangladesh: A Review

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ABSTRACT

A review was undertaken at Agronomy Division, Bangladesh Jute Research Institute (BJRI), Dhaka on jute weeds, their management, weeding cost and control measures through collecting secondary information in 2013. The sources of secondary data were BJRI annual reports, thesis, news letter, national and international journals and accessing internet in 2013. Results revealed that out of 129 species of both monocotyledonous and dicotyledonous jute weeds generally found in Bangladesh belonging to 99 genera or 39 families. Only 13 weed species like *Cyperus rotundus*, *Echinochloa colonum*, *Cynodon dactylon*, *Physalis heterophylla*, *Paspallum distichum*, *Eleusine indica*, *Jussiaea repens*, *Euphorbia hirta*, *Euphorbia microphylla*, *Portulaca oleracea*, *Fimbristylis dochotama*, *Amaranthus spinosus* and *Phyllanthus niruri* were found vigorous and common in both tossa and white jute field. Six location specific weeds like *Panicum javanicum*, *Scirpus mucronatus*, *Setaria viridis*, *Amaranthus viridis*, *Paspalum commersonii* and *Alternanthera sessile* in tossa and five like *Digitaria sanguinalis*, *Echinochloa crusgalli*, *Panicum repens*, *Fimbristylis dochotama* and *Paspalum commersonii* in white jute growing areas of Bangladesh observed vigorous. The hot and humid environment and wet soil in summer season of Bangladesh reported highly favourable for jute weed germination and growth. The cost of weeding alone comes to 30% to 40% or even more of the total cost of jute cultivation. Weeds competed with jute crops for water, light and mineral nutrients, which directly reduce the quality and quantity of fibre. Jute weeds indirectly reduce fibre yield by serving as alternate host for diseases and pests. The traditional methods for control were observed hand pulling, pressing by foot, weeding by khurpy or weeder or by racker. Among the chemical herbicides, Fenoxaprop-p-ethyl WCE (86.6%) and Quizalofop ethyl (79%) reported successful only for *Echinochloa colonum*, *Echinochloa crusgalli* and *Digitaria sanguinalis* were found location specific. Farmers should know the major species of jute weeds and their cost effective and easiest control measures for achieving maximum benefit from jute production. Since the cost as well as availability of agricultural labour is being copped up as problem, more attention in the field of scientific methods of jute weed control and sequence of weed vis-à-vis cropping pattern is warranted.

Keywords: *Jute (Corchorus capsularis L. and Corchorus olitorius L.)*, weed, herbicide, management, control

1. INTRODUCTION

Jute is an important fibre crop of Bangladesh. Among the jute growing countries of the world, Bangladesh ranked second in respect of fibre production. Jute alone contributes about 1.58% to GDP without involving any foreign investment. In 2011-2012, 1523 thousand tones of jute fibre were produced from 7 lakh hectares of land [9]. The area under jute cultivation in Bangladesh remained almost static during the 2006-2010. In the year of 2011 Jute cultivation areas of Bangladesh sharply increased by 70% compared with the figure of 2010. The jute production in Bangladesh was relatively stable. In 2011 production of jute in Bangladesh increased by 79.5% compared with the production of the year 2008 (Table 1).

Jute fibres are mainly used for making hessians, sacks, bags, wall mats, carpet backing cloths etc. Jute crop enriches the top soil by adding organic matter through dropping leaves and left over roots in the field. Cultural practices are important management factors that affect the yield of a crop. Weeding is one of the most important cultural practices for the crop plants to take nutrients, moistures, light, space and sometimes controlling many diseases organisms and insect pest (Anonymous, 2002). An effective weed management practice is necessary for higher crop production and better economic return (Gaffer et al., 1988). But, most effective

and economic cultural practices for weed control in jute crop are not clearly known to our farmers. In Bangladesh, weeds are generally controlled by raking and niri (hand weeding) and weeding and thinning operations involve about 50% or more of the labour cost [2].

Table 1: Cultivated area and production of Jute during 2006-2011

Year	Cultivation Area (In 000 Hectare)	Production (In 000 Tonnes)
2006	419.0	884.0
2007	440.5	838.7
2008	420.5	848.7
2009	416.0	923.5
2010	416.4	923.5
2011	708.7	1523.3

Source: FAO Stat [13]

Weed is defined as "Any plant growing where it is not wanted". It can be native or non-native, invasive or non invasive, and noxious or not noxious. A noxious weed is commonly defined as a plant that grows out of place and is "competitive, persistent, and pernicious". Weeding is a must to concern jute cultivation, if not weeded properly yield reduction may incur about 90%. Weeds share nutrient elements from the same soil. Some weeds are voracious and quick growing. These cover desired crop plant within a short period of time. These

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weeds affect light interception and passing of wind and affect photosynthesis in jute plant and ultimately crop will receive stunted growth and in a consequence yield of crop will reduce [25], [28].

In Bangladesh about 350 species are recorded as weeds in cultivated land. The major weeds in Bangladesh are *Echinochloa crus-galli*, *Echinochloa colonum*, *Cyperus rotundus*, *Cynodon dactylon*, *Chenopodium album*, *Fimbristylis miliacea*, *Cyperus iria*, *Eichhornia crassipes* etc. One must take care in weed control. It would be better if jute field is kept weed free from sowing till 50 DAS. Jute grows under wide variation of climatic conditions and stress of tropic and subtropics. This paper reviews jute (*Corchorus* spp.) weeds identification, population in the field, control measures and other most related important management activities.

2. MATERIALS AND METHODS

The study was based on secondary data. The secondary data used were collected from different studies from the Library of Bangladesh Jute Research Institute, Dhaka during the period from April to till September, 2013. The sources of data were BJRI annual reports, different thesis, Bangladesh Journal of Jute and Fibre Research; Jute and Jute fabrics, Bangladesh, accessing internet and from different national and international journals.

3. RESULTS AND DISCUSSIONS

3.1 Jute-weed Competition

Competition between jute plants and weeds a critical factor in the growing of jute crops. The relative absorption capacity of the different elements from the soil varies among weeds as well as jute plants. Minimum absorption occurs in the pre flowering stage of plants. *Cynodon dactylon*, *Cyperus rotundus*, *Digitaria sanguinalis*, *Echinochloa crus-galli*, *Oxalis corniculata*, *Sateria*, *gluca Solanum nigrum* etc. were found to grow in jute fields, prefers nitrogenous soil while *Polygonum hydro-piper* proved as moderate user of fertilizer [38].

In Bangladesh *Cyperus rotundus*, *Cynodon dactylon*, *Echinochloa colonum*, *Digitaria sanguinalis*, *Panicum disticum* and *Panicum repens* are major weeds of jute crop. At initial stage jute plants are slow growing. So control of weeds in early stage of the crop is most important. The presence of previously mentioned weeds especially, *Cyperus rotundus* frequently causes crop failure if frequent weeding are not done. Timely weeding reduces competition among jute plants and weeds and incidentally promotion was observed that when jute plants attain about feet in height weed growth subside. However, among the 3 species of *Eragrostis* i.e. *E. gnetica* and *E. unioloides* were found in the jute fields at later stage of the crop. Generally a cultivated crop or weed whichever establishes itself first tend to retard or restrict the growth of the other. Keen competition occurs between weeds and crop plants when the competing individuals are alike in their vegetative habits, methods of

proliferation and demand upon the environment. Between crop plants and weeds factors for composition are chiefly-water, light and mineral nutrients [38].

3.2 Weed characteristics (Harmful aspect, host for insects and Affect on cost):

- a) Harmful aspect of jute weeds: Weeds not only compete with crops for water, light and mineral nutrients. It directly reduces the fibre quality and quantity of jute. Besides, it indirectly reduce fibre yield by serving as alternate host for diseases and pests. Sometimes weed acts as an agent of health host for diseases and pests. Sometimes weed acts as an agent of health hazard to man of animals [38].
- b) Jute weeds as host for insects: Weeds such as, *Triumfetta rhomboidea* and *Leucas aspera* acts as alternate host of jute *Apion* (*Apion corchori* Marsh). *Ageratum conyzoides* and *Heliotropium indicum* acts as alternate host of jute hairy caterpillar (*Diacrisia oblique walker*). *Echinochloa crassipes*, *Amaranthus* sp are alternate hosts of *Spodoptera litara* Fab. *Cynodon dactylon*, *Chenopodium album*, *Solanum nigrum* serves as alternate host of aphids. Besides, harboring insects, weeds harbour fungus and bacteria that cause disease to jute and other crop [38].
- c) Affect on cost of jute production: In jute cultivation 35% to 40% of total man days and 22.5% to 27% of total cost of production are required in weeding and thinning operations. According to the reports cost of weeding alone comes to 32.40% or even more of the total cost of cultivation. In India, estimates for weed control in jute is said to be 300-400 Taka per acre. The cost however, varies with time and frequencies of weeding and variation in rainfall [38]. Manual weeding by age old hand hoe or nirani requires 110 man days for controlling weeds of one hectare of jute, which cost about 30% of total cost of cultivation. Weeding cost can be reduced by 29% in row cropped jute where wheel hoe was used [4]. The highest net return and B:C ratio was recorded under mulching with locally available cheap organic waste (wheat straw) @10t/ha treatment. Second highest B:C ratio was obtained under Intercropping of jute + red *amaranthus* treatment followed by *Quizalofop ethyl* @ 50g ai/ha + adjuvant @1ml/lit of water (21 days post emergence) + one hand weeding treatment [11]. The combination of weeding and thinning operation in T₃ (Two raking at 15 and 30 days after sowing and one weeding at 45 days after sowing) gave better fibre yield (2.25 to 2.27 tha⁻¹) at lower cost along with the highest net profit (Tk. 14848.00 to 15489.21 ha⁻¹) and the highest benefit cost ratio (1.67 to 1.72) [3].

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Weeding and thinning operations involve nearly 70% of the labour cost investment in jute cultivation [24].

3.3 Weeds Identification in Jute Field

It has been found in the report that out of 129 species belonging to 99 genera or 39 families (Table 2) only 27 species has marked intensity of infestation in the jute fields, depending on different agronomic conditions. Some weed species thrived well in *Corchorus capsularis* L. field and multiplied so fast that hand weeding was practically impossible. These species according to Hatchion's classification included. Dicotyledonous: *Mollugo spergula* (Ficoidaceae), *Polygonum hydropiper* (Polygonaceae). Monocotyledons: *Cyperus iria* (Cyperaceae), *Dactyloctenium aegyptium* (Gramineae), *Echinochloa colonum* (Gramineae), *Echhornia crassipis* (Potentillaceae), *Fimbristylis miliacca* (Cyperaceae), *Monochoria hastata* (Pontederiaceae), *Monochoria vaginalis* (Pontederiaceae) and *Seirpus squarrosus* (Cyperaceae) [38].

In *Corchorus olitorius* fields 19 species of weeds vigorously competed with the crop and grew better and occupied more area than jute plant. These species included: Dicotyledonous: *Allernanthra sasillis* (Compositae), *Amaranthus spinosus* (Amaranthaceae), *Enhydra auctuana* (Compositae), *Leucas aspera* (Labiatae), *Minnous pudica* (Mimosaceae) and *Portulaca quadrifala* (Portulacaceae). Monocotyledons: *Cynodon dactylon* (Gramineae), *Cyperus iria* (Cyperaceae) [38].

Table 2: Name of families, genera and species recorded in jute field

	Families	Genera	Species
Monocotyledons	6	32	51
Dicolyledons	33	67	78
Total :	39	99	129

Talukder and Ali [37] reported that depending on the intensity of individual weed's in jute field of Dacca Farm only 7 species of monocotyledonous deserved special attention and as such their extent of damage and infestation on different growth phase of jute plants were recorded (Table 3).

Table 3: Density of major weeds of jute fields of Dacca Farm

Name of weed	Weed density/ 3 feet ²
<i>Cyperus rotundus</i>	102
<i>Cynolon dactylon</i>	59
<i>Echinochloa colonum</i>	31
<i>Digitaria sanguinalis</i>	13
<i>Cyperus iria</i>	7
<i>Eleusine indica</i>	7
<i>Panicum disticum</i>	5

In Bangladesh, jute is grown during April to September. The warm and humid weather condition and wet soil during the sowing period of jute favorably contribute to uniform germination and profuse growth of weeds. Heavy weed infestation is, therefore, a general view of jute field. In Bangladesh, two species of jute, i.e. *Corchorus capsularis* L and *Corchorus olitorius* L. are cultivated. *Capsularis* jute can withstand standing water and it is generally raised in comparatively low lands with the seeds sown during mid March to mid April, Some semi-aquatic weeds like *Commelina bengalensis*, *Cyanotis axillaries*, *Paspalum districhum* and aquatic weeds like *Ipomoea aquatica* are identified as major weeds of *capsularis* jute. The *olitorius* jute generally cannot tolerate stagnant water, so it is cultivated on high land with the seeds sown during mid April to mid May. The weeds, which germinate profusely with this crop in the up lands in April-May are *Cyperus rotundus*, *Echinochloa colonum*, *Cynodon dactylon*, *Eleusine indica*, *Leptochloa chinensis* and a few broad leaved weeds like *Amaranthus spinosus*, *Amaranthus viridis*, *Euphorbia hirta* and *Protolaca oleracea* [38]. The hot and humid environment in summer is highly favourable for weed germination and weed growth [24]. The present status of weed management in jute fields of Bangladesh is not enough for maximizing fibre yield and improving their quality. A good number of research works proved that chemical control measures are better than traditional methods of weed management. Now-a-days, chemical methods are widely used in developed countries of the world, whereas developing countries like, Bangladesh are not using this technology, because, chemicals have some adverse effects [24].

3.4 Major Weeds Grown In Jute Growing Fields of Bangladesh



Common Name: Mutha
Scientific Name: *Cyperus rotundus*
Family Name: Cyperaceae



Common Name: Khude shama
Scientific Name: *Echinochloa colonum*
Family Name: Graminae



Common Name: Basketgrass
Scientific Name: *Panicum javanicum*
Family Name: Graminae



Common Name: Durba
Scientific Name: *Cynodon dactylon*
Family Name: Graminae



Common Name: Shialleza
Scientific Name: *Setaria viridis*
Family Name: Graminae



Common Name: Fuska begun
Scientific Name: *Physalis heterophylla*
Family Name: Solanaceae



Common Name: Helencha
Scientific Name: *Jussiaea repens*
Family Name: Amaranthaceae



Common Name: Chanchi
Scientific Name: *Alternanthera sessilis*
Family Name: Amaranthaceae



Common Name: Boro dodhia
Scientific Name: *Euphorbia hirta*
Family Name: Euphorbiaceae

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Common Name: Suto dodhia
 Scientific Name: *Euphorbia microphylla*
 Family Name: Euphorbiaceae



Common Name: Chapra
 Scientific Name: *Eleusine indica*
 Family Name: Graminae



Common Name: Gaicha
 Scientific Name: *Paspalum commersonii*
 Family Name: Graminae



Common Name: Gitla ghas/Knotgrass
 Scientific Name: *Paspallum dictichum*
 Family Name: Graminae



Common Name: Nunia
 Scientific Name: *Portulaca quadrifida*
 Family Name: Portulacaceae



Common Name: Chechra
 Scientific Name: *Scirpus supinus*
 Family Name: Cyperaceae



Common Name: Hajardana
 Scientific Name: *Phyllanthus niruri*
 Family Name: Euphorbiaceae



Common Name: Kantanotey
 Scientific Name: *Amaranthus spinosus*
 Family Name: Amaranthaceae



Common Name: Saknotey
 Scientific Name: *Amaranthus viridis*
 Family Name: Amaranthaceae

Hossain et al. [20] and Hossain et al. [21] reported that the thirteen different common weed species viz., *Cyperus rotundus* (Mutha), *Echinochloa colonum* (Khudesama), *Panicum javanicum* (Basketgrass), *Cynodon dactylon* (Durba), *Digitaria sanguinalis* (Anguli), *Physalis heterophylla* (Fuskabegun), *Paspallum distichum* (Knotgrass/Gitlaghass), *Eleusine indica* (Chapra), *Jussiaea repens* (Helencha), *Euphorbia hirta* (Borododhia), *Euphorbia microphylla* (Sutododhia) were observed much more serious to both Tossa and

White jute fields (Table 4). Hossain et al. [20] again reported that the six different specific weed species viz., *Panicum javanicum* (Basketgrass), *Scirpus mucronatus* (Chechra), *Setaria viridis* (Shialleza), *Amaranthus viridis* (Shaknotey), *Paspalum commersonii* (Gaicha) and *Alternanthera sessile* (Chanchi) were observed much more serious to Tossa jute crop (Table 5). They also showed in their reported that there were five different specific weed species viz., *Digitaria sanguinalis* (Anguli), *Echinochloa crusgalli* (Borosama),

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Panicum repens (Angta), *Fimbristylis doctotama* (Matichech), *Paspalum commersonii* (Gaicha) were very serious to white jute (Table 6).

Table 4: Common major weeds in both tossa and white jute growing areas of Bangladesh (Common, scientific, family name and morphology) (Tossa jute areas: Jessore, Faridpur and Rangpur) (White jute areas: Manikganj, Kishoreganj and Comilla)

Sl.	Common Name	Scientific Name	Family Name	Morphology
1	Mutha	<i>Cyperus rotundus</i>	Cyperaceae	Sedge
2	Khudesama	<i>Echinochloa colonum</i>	Gramineae	Grass
3	Durba	<i>Cynodon dactylon</i>	Gramineae	Grass
4	Fuskabegun	<i>Physalis heterophylla</i>	Solanaceae	Broad leaved
5	Knotgrass/Gitlaghass	<i>Paspallum distichum</i>	Gramineae	Grass
6	Chapra	<i>Eleusine indica</i>	Gramineae	Grass
7	Helencha	<i>Jussiaea repens</i>	Amaranthaceae	Broad leaved
8	Borododhia	<i>Euphorbia hirta</i>	Euphorbiaceae	Broad leaved
9	Sutododhia	<i>Euphorbia microphilla</i>	Euphorbiaceae	Broad leaved
10	Nuniasak	<i>Portulaca oleracea</i>	Portulacaceae	Broad leaved
11	Matichech	<i>Fimbristylis doctotama</i>	Cyperaceae	Sedge
12	Katanotey	<i>Amaranthus spinosus</i>	Amaranthaceae	Broad leaved
13	Hajardana	<i>Phyllanthus niruri</i>	Euphorbiaceae	Broad leaved

(Source: Hossain et al. [20] and Hossain et al. [21])

Table 5: Specific major weeds in tossa jute growing areas of Bangladesh (Common, scientific, family name and morphology) (Jessore, Faridpur and Rangpur)

Sl.	Common Name	Scientific Name	Family Name	Morphology
1	Basketgrass	<i>Panicum javanicum</i>	Gramineae	Grass
2	Chechra	<i>Scirpus mucronatus</i>	Cyperaceae	Sedge
3	Shialleza	<i>Setaria viridis</i>	Gramineae	Grass
4	Shaknotey	<i>Amaranthus viridis</i>	Amaranthaceae	Broad leaved
5	Gaicha	<i>Paspalum commersonii</i>	Gramineae	Grass
6	Chanchi	<i>Alternanthera sessile</i>	Amaranthaceae	Broad leaved

(Source: Hossain et al. [20])

Table 6: Specific major weeds in white jute growing areas of Bangladesh (Common, scientific, family name and morphology) (Manikganj, Kishoreganj and Comilla)

Sl.	Common Name	Scientific Name	Family Name	Morphology
1	Anguli	<i>Digitaria sanguinalis</i>	Gramineae	Grass
2	Borosama	<i>Echinochloa crusgalli</i>	Gramineae	Grass
3	Angta	<i>Panicum repens</i>	Gramineae	Grass
4	Matichech	<i>Fimbristylis doctotama</i>	Cyperaceae	Sedge
5	Gaicha	<i>Paspalum commersonii</i>	Gramineae	Grass

(Source: Hossain et al. [21])

3.5 Weed Population and Fresh Weight

Among the total weed vegetation, sedge shared 52%, grass 37% and the broad leaved weeds 11% on the basis of weed population m^{-2} and weed vegetation, sedge shared 66%, grass 24% and the broad leaved weeds 10% on the basis of weed green weight (gm^{-2}). Infestation of sedge weeds mainly *Cyperus rotundus* was very serious at Faridpur where density $290.83m^{-2}$ and green weight $287.13gm^{-2}$ were observed at 1st weeding and second weeding it was $227.64m^{-2}$ and green weight $272.17gm^{-2}$. *Cynodon dactylon*, *Panicum javanicum*, *Eleusine indica*

were also infested at Faridpur. Rangpur was also infested by *Cyperus rotundus*. But as secondary weed *Eleusine indica*, *Cynodon dactylon* were also observed. The experimental plots of Jessore were seriously infested by *Echinochloa colonum* (Grass weed) at second weeding where weed density $230.52m^{-2}$ and green weight $154.22gm^{-2}$ was found and first weeding it was $81.85m^{-2}$ and green weight $32.22gm^{-2}$. *Cyperus rotundus*, *Panicum javanicum*, *Cynodon dactylon* were also grown at Jessore (Figure 1) [20].

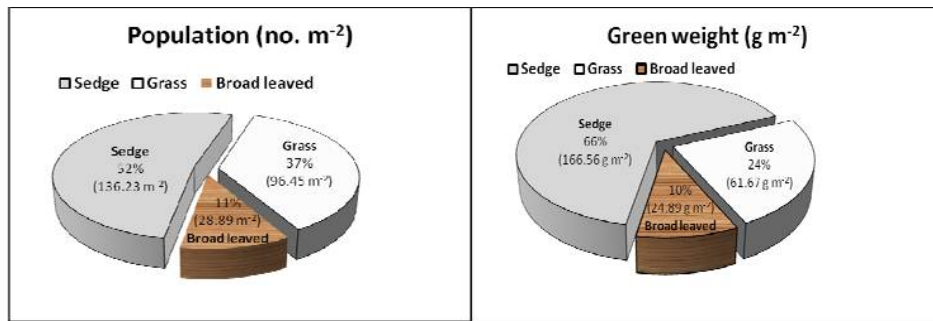


Fig 1: Weed population and fresh weight in Tossa jute crop field. (Source: Hossain et al. [20])

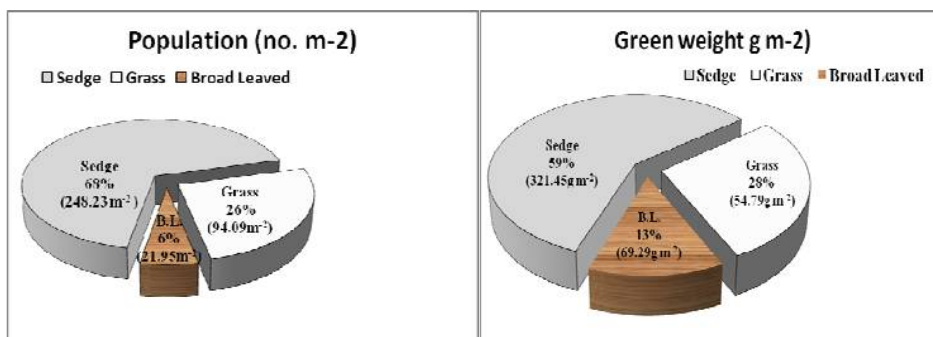


Fig 2: Weed population and fresh weight in White jute crop field. (Source: Hossain et al. [21])

The total weed vegetation, sedge shared 68%, grass 26% and the broad leaved weeds 6% on the basis of weed population (m^{-2}) and weed vegetation, sedge shared 59%, grass 28% and the broad leaved weeds 13% on the basis of weed green weight (gm^{-2}). According to total weed vegetation Chandina of Comilla was highly infested where density was $876.57m^{-2}$ and green weight was $632.64gm^{-2}$. Infestation of sedge weeds, mainly *Cyperus rotundus* was very seriously affected at Kishoreganj where density of $365.42m^{-2}$ and green weight of $660.87gm^{-2}$ were observed at 2nd weeding. *Echinochloa*

colonom, *Cynodon dactylon*, *Physalis heterophylla*, *Paspallum distichum* were also infested at Kishoreganj. Manikganj jute field was also infested by *Cyperus rotundus*. However, as secondary weed *Physalis heterophylla* was also observed. The experimental plots of Comilla were seriously infested by *Echinochloa colonom* (Grass weed) (density $468.24m^{-2}$) at second weeding and green weight ($316.86gm^{-2}$) was recorded. However, *Cyperus rotundus* was also observed there as secondary weed (Figure 2) [21].



Herbicidal trial management

Weed infested jute field

Hand weeding in jute field

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3.6 Jute Weed Managements

Talukder and Ali [37] reported that one hundred twenty nine species of weed belonging to ninety nine genera of 39 families were found to grow in the Aerobic jute lands of Bangladesh. Twenty seven species were found to be important as weeds of jute fields. Of them only 7 species of monocotyledons were found to cause maximum damage to the crop.

Alim [6] reported that the growth rate of jute for the first 5 weeks after sowing is slow. Thus in the early stages of growth like all other crops jute requires frequent inter-culture. From 3-6 weeding or hoeing are required depending upon weed and grass competition. Inadequate weeding will result into lowered fibre yields and the quality of fibres will be adversely affected. Thinning is also carried out along with weeding and hoeing. The labour required for weeding and thinning for broadcast jute is almost 40% of the total labour required for the crop. So there is a very costly operation. The usual method of weeding and thinning of broadcast planted crop is done mostly during the first 8 weed after sowing. First the thinning is done with an animal-drawn rake (bida). This operation simultaneously uproots weeds and thins the jute. The operation is repeated twice or thrice in the course of a month or so. After raking the plants are weeded and thinned by hand-hoe (nirani), two or three times. The final spacing between plants is about 10-15cm and 1,00,000 to 1,50,000 plants per acre. The earlier the thinning is done the better it is for the growth of the rest of the plants and it is reported that best results are obtained when it is done within 3 weeks. There is practice of thinning even at the age of 3 months. The plants thinned at this stage are generally retted for the extraction of fibre and fetch some monetary return to the growers. There is need for research work on the proper time of thinning of jute seedling and the demonstration of this aspect of culture of jute to the growers in order to contribute increased production.

Tosh [39] reported that in trials during the kharif [monsoon] seasons of 1976-7 with lowland capsularis jute cv. JRC 212 hand weeded at 7-day intervals throughout the crop period, weed-free conditions up to 35 and 42 days after sowing were highly effective in increasing the fibre yields. An initial 28 weed-free days with no weeding later or no weeding up to 28 days but weeded later decreased yield significantly compared with weed-free conditions for an initial 35 or 42 days. Weed wt. increased with a decrease in the weed-free period. Where no weeds were allowed to grow for 35-42 days, even later growth of weeds was suppressed.

Ali [4] reported that among the jute weeds nutgrass is a serious and difficult one to eradicate. Weeds compete with jute plants from germination to 60 days of growth depriving the jute plants of nutrients, water and light. He again reported that herbicide "Dalapon" was trialed in Dhaka farm and showed no deleterious effect on the growth and yield of jute but not commercially practiced. Other methods of weed control such as smother

cropping, hedge planting and transplanting of jute seedlings were experimented with some success.

Saraswat and Mukerjee [31] reported that a study in occurrence and habitat of weeds in jute fields, conducted from 1976-1981 showed a wide variation in the habitat and the lifespan of different weed species under varying climatic and edaphic conditions of the weeds. *Cyperus rotundus* was prevalent in all jute growing areas, present abundantly in light-textured upland soils, but rare in heavy lowland soils. A list of 17 grasses, 8 sedges and 11 broad leaved weeds is presented, with a note on their occurrence in 5 states.

Anonymous [7] reported the cultural practices are important management factors that affect the yield of a crop. Weeding is one of the most important cultural practices for the crop plants to take nutrients, moistures, light, space and sometimes controlling many diseases organisms and insect pest. Gaffer et al. (1988) reported effective weed management practice is necessary for higher crop production and better economic return

Alam [2] concluded in an article that weed is a critical problem against better fibre yield of jute. For successful jute production it needs to be controlled. But one question comes up as how much loss the weed may cause and how much cost may be needed to combat weed. On the basis of cost and benefit of control measure it is to be decided when and at what extent weeds need to limit.

Islam [23] reported that heavy infestation of weed is a general view of jute field. White/Deshi jute can withstand standing water and it is generally raised in comparatively low lands with seed sowing during Mid March to Mid April. Some semi-aquatic weeds like *Commelina bengalensis*, *Cyanotis axillaries*, *Paspalum distichum* and aquatic weeds like *Ipomoea aquatica* are identified as major weeds for deshi jute. The Tossa jute cannot tolerate stagnant water, so it is cultivated on high land areas with the seed sown during Mid April to Mid May. The weeds germinate profusely with Tossa jute are *Cyperus rotundus*, *Echinochloa colonum*, *Cynodon dactylon*, *Eleucina indica*, *Leptochloa chinesis* and a few broad leaved weeds like *Amaranthus spinosus*, *Amaranthus viridis*, *Euphorbia hirta* and *Protolaca oleracea*. In Bangladesh weed management/control is still done in an unplanned way. Normally jute farmers used traditional methods for control the weeds in jute field like hand pulling, pressing by foot, weeding by khurpy or weeder, racking by racker. This can be controlled by chemically. However, the extent of damage varies from year to year and area to area. For successful quality fibre production weed control is very important. As the chemical control of disease, insects and weeds are very effective in jute field but we have to think first to apply the chemicals that jute seedlings and some weeds are normally used in Bangladesh as leafy vegetables for men and as fodder for animals also.

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Alam et al. [3] reported that the plant height, base diameter, fibre and stick yield were significantly influenced by different combination of weeding and thinning operations at 1% level of significance. The highest fibre and stick yields were obtained from the treatment T₁ (Three weeding at 15, 30, and 45 days after sowing). But the combination of weeding and thinning operation in T₃ (Two raking at 15 and 30 days after sowing and one weeding at 45 days after sowing) gave better fibre yield (2.25 to 2.27 tha⁻¹) at lower cost.

3.7 Integration of Tillage and Method Of Sowing

Perennial weeds like *Cyperus rotundus* can effectively be controlled by integration of tillage and sowing method in jute i.e. land preparation by rotavator followed by ridge and furrow making by cultivator which helps in easy uprooting the *Cyperus* tubers [16]. These tubers remain embedded shallow on the ridges which are easily pulled out manually while germinating at 8-10 DAS [27].

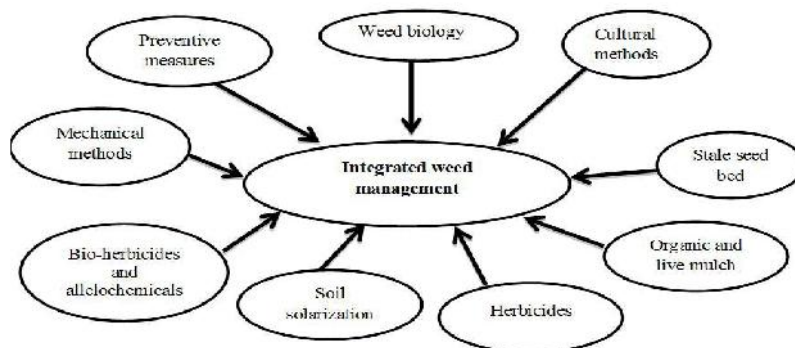


Fig 3: Model for Integrated weed management (Kumar et al. [27])

- **Integration of herbicides and hand weeding:** Herbicides like butachlor @ 1.0 to 1.5 kg ai/ha or pretilachlor 50 EC @ 0.83 to 0.90 kg ai/ha as pre-emergence or quizalofop- ethyl @ 5% EC @ 60 g a.i. /ha as post-emergence herbicides with one mechanical/ manual weeding at 20 to 35 days after sowing has been found much effective in controlling weeds in jute [27].
- **Integrated weed management:** Integrated weed management is integration of cultural, mechanical, chemical and all other available technologies in compatible and effective manner to control the weeds by the most economical means, while posing the least possible risk to the human being and environment (Figure 3). Using different appropriate management practices in combination, farmers have more viable options for effective weed control in jute. It reduces the possibility of escapes, weed adaptation and development of resistance to any single herbicide or weed control methods [27].
- **Control means of jute weeds:** Weed control means keeping the seeds at a level that does not interfere with crop production whereas eradication means distraction of all possible ways of re-infestation. Many methods of weed

control and weed eradication have been followed in jute field. Those might be grouped as follows:

3.8 Mechanical Methods

- Tillage: It is a practical method for controlling annual biannual and perennial weeds. By tillage weeds are destroyed and number of their seeds reduced. This happened in both cropped and uncropped lands. For annuals destruction of top growth by tillage is sufficient for their control. For biennials destruction of top and crown; and for perennials destruction of underground and top growth is a must. Generally, shallow tillage is advised for control of annuals but for deep-rooted perennials tillage at intervals are required and for shallow rooted perennials. Such as *Cynodon dactylon* two ploughings may effectively control them, if by ploughing, the mass of root stocks are turned to the surface and get desiccated. If tillage is done at proper time, weeds of arable lands are prevented from maturation and dispersal of seeds. Moreover, it encourages previous weed seed to germinate and tillage in time will destroy the seeding. In Bangladesh, after the harvest of the crop farmers usually plough the land if the soil is moist enough to allow ploughing by local implements or ploughs it after the first shower of rain usually at the end of February. Thereafter generally 4.5

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cross ploughing and laddering is done at intervals to prepare the land for sowing jute. This repeated ploughing and laddering has some bearing on the reduction of annual weeds [38].

- b) Hoeing: After sowing operations, such as taking, wheel hoeing and hand weeding are done either to suppress the growth or to remove the growing weeds from the jute fields. So taking is done after the seedlings attains 2-4 inch in height and if the soil surface from crust due to rain. This operation makes the soil loose, uproots weeds and thins out jute plants. In line sown crop hand weeding is usually done 10-15 days after emergence of jute seedlings and thereafter, wheel hoeing is done at 10-15 days interval till the plants attain height of about 3 feet [38].

3.9 Cropping Management

- a) Cropping and competition method: Smother crops also known as competitive crops have great value in weed control program because they compete with weeds for water, light and nutrients. The competitive crop must be one that grows quickly producer an abundance of shade and can be harvested before the weed plants matures to permit cultivation and destruction of mature weed plants which will result reduced re-infestation of those weeds that were present previously. The principal competitive crops for weed control for Bangladesh condition might be Arhar (*Gajan cajanus*), Sugarcane (*Saccharum officianarum*), Mesta (*Hibiscus sabdariffa*), Mashkalai (*Phaeolus mungo*), Cowpeas (*Vigna sinensis*) etc. [38].
- b) Crop rotation: If one type of crop has been grown year after year in the same land characteristic weeds of particular crop tend to accumulate. By proper rotation and sequence of crop results healthy growth of the different crop and reduces accumulation of particular prevalent weed of the crop field. In Bangladesh jute is often cultivated in traditional rice fields to control rice weeds [38].

3.10 Chemical Methods

3.10.1 Recommended herbicides for weed control in jute

i) **Pre-emergence herbicides:** Butachlor 50EC or butachlor 5G @ 1.0 to 1.5 kg a.i./ ha applied from 7 days before sowing to 72 hour within sowing of jute controlled annual grass and some broadleaved weeds for three weeks. It also effectively reduced the *Cyperusdifformis* in jute field. The granular formulation of butachlor has to be mixed thoroughly with soil under proper moist condition. Early post-emergence weed killing ability of butachlor@1.0 kg/hahas also been observed, when applied 48 to 72 hours after rain (dry

sown jute) without any damage to emerging jute seedlings [27].

Pretilachlor 50 EC @ 0.83 to 0.90 kga.i. /ha (within 24 to 48 hours of sowing following sufficient rain or irrigation) killed almost all grasses and also found effective against *Trainthema portulacurum*, *Physalis minima*, *Amaranthes viridis* [27].

ii) **Post emergenceherbicides:** If jute field is infested with grassy weeds selective herbicides are Quizalofop-ethyl 5% EC @ 60 g a.i./ha+Dhanuvit @ 0.5 to 0.6 l/ha at 15-20 days after sowing was found very effective [27]. Application of propaquizafop 10% EC (@ 150 ga.i/ha or clodinafop propagryl (60 g a.i./ha) at 15 days after emergence (DAE) followed by one hand weeding recordedbetter control of grassy weed in jute [17].

3.11 Directed Spray

A non- selective herbicides glyphosate can be a selective one by using directed spray (mike nozzle guarded by plastic bottles, 10 x 10cm) at right time and right dose. Glyphosate 41%SL @ 0.82 litre/hausing directed spray (mike nozzle guarded by plastic bottles, 10 x 10cm) with 2% urea/NH₂SO₄ at 25 days after sowing in between jute lines (25-30 cm) effectively controlled composite weed flora in jute field. The practice is very useful for controlling composite weed flora including *Cyperus rotundus* in line [27].

- **Research works on herbicides**

Dempsey [12] reported that trials were enlarged in 1967 and again hand-weeding gave the highest fiber yield, exceeding the herbicides by about 200kg/ha of fiber. Herbicides that gave the best yields included : (a) 3-amino-2, 5-dichlorobenzoic acid (Amiben) applied at the rate of 4l/ha 10 days before sowing plus Dowpon at 5 kg/ha after sowing; (b) dowpon applied at the rate of 5.3 kg/ha 10 days before sowing and Dowpon at 5kg/ha after sowing; (c) 1,1'-dimethyl-4-4'-bipyridylum ion (paraquat) 2.5 l/ha 3 weeks after sowing; (d) S-propyl butylethylthiocarbamate (PBEC) applied 10 days before sowing at the rate of 4 l/ha and again at the same rate as a post-emergence spray; (e) paraquat applied 1 day before sowing at the rate of 2.5 l/ha plus Dowpon as post-emergence at the rate of 5 kg/ha.

Hashim et al. [19] found that most prevalent weeds of *Corchorus capsularies* field were *cynodon duclyon* followed by *Pan cum repens*, *Echinochloa colorum*, *Cyperus rolundus*, *Brachiaria replans* and *Eleusine indica*. Application of weedicides viz *Ansar-529* and *Dalapon* reduced the number of weeds in all the treatments and had little adverse effect on the stand of jute plants and its survival till harvest. Four new species of weeds viz. *Alternanthera sessilis*, *Mimosac pudica*, *Scirpus squarrosus* and *Colocasia sp.* were found in the month of June which was not present in May at the time of spray. At the time of harvest 3 species of *Eragrastis* were found in the jute field.

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Saraswat and Ray [32] reported that tetrapion at 3 kg a.i./ha applied before sowing jute largely suppressed grassy weeds and also controlled nutsedge by 30-40%. MSMA as Ansar 529 or Daconate at 4.5 kg a.i./ha also gave good control of weeds when applied as a directed spray to 3 wk-old jute plants. Dalapon at 6 kg a.i./ha alone or in combination with MSMA at half the rates as directed sprays gave good suppression of weeds. All the herbicides increased the fibre yields compared to no hand weeding. Wheat or oat grown in the following season, showed no phytotoxicity of the herbicides on germination, stand or grain/fodder yields.

Singh et al. [35] reported that field trials were conducted on sandy loam soil at Bahraich during 1988-89 and 1989-90 to study the relative efficiency of herbicides (1.0 and 1.5 kg/ha fluchloralin (applied 3 or 1 d before sowing, or just after sowing), and 0.4 and 0.6 kg fluzifop-butyl (applied 21 d after sowing)) for the control of weeds (mainly *Cynodon dactylon*, *Cyperus rotundus*, *Euphorbia hirta* and *Echinochloa colonum*) in jute cv. UPC 94, and the effects of these herbicides on jute yield. Herbicides resulted in weed densities of 52.0-165.0 and 46.0-105.5, 40.0-97.0 and 30.0-102.5, and 18.5-60.5 and 15.5-84.0 plants/m² for 4 and 6 weeks after sowing, and at harvest in 1988-89 and 1989-90, resp. The dry mass of weeds was 25.0-52.0 and 18.5-48.0, 24.0-58.5 and 17.0-57.5, and 9.5-47.0 and 10.5-56.0 g/m² for 4 and 6 weeks after sowing and at harvest in 1988-89 and 1989-90, resp., the greatest control being due to fluzifop-butyl (0.6 kg). The greatest fibre yields were obtained with manual weeding (2.035 and 2.288 t/ha) in 1988-89 and 1989-90, resp., and the greatest fibre yields as a result of herbicide treatment were 1.277-1.853 and 1.396-1.940 t/ha in 1988-89 and 1989-90, resp. (the best herbicide treatment being fluzifop-butyl at 0.6 kg/ha in both years), compared with 1.102 and 1.120 t/ha in the weedy control during 1988-89 and 1989-90, respectively.

Mishra and Bhol [29] reported that in a field experiment during the kharif (monsoon) seasons of 1990-91 at Kendrapara, Orissa, jute cv. JRC 7447 was treated with fluzifop-p-butyl (0.4 or 0.6 kg a.i./ha), fluchloralin (1 kg a.i./ha) or pendimethalin (0.75 kg a.i./ha) alone or with hand weeding 35 days after sowing (DAS) or the plots were hand weeded 21 and 35 DAS or left unweeded. The dominant weeds were *Echinochloa colonum*, *Paspalum distichum*, *Eclipta alba*, *Ageratum conyzoides*, *Commelina benghalensis*, *Sida cordifolia*, *Cyperus iria* and *Cyperus rotundus*. In the herbicide treated plots, the application of 1 kg fluchloralin/ha 3 days before sowing +

1 hand weeding at 35 DAS produced lowest weed dry matter (DM), highest mean fibre yield of 2.64 t/ha and the highest net return. While the hand weeding treatment produced the lowest weed DM and the highest fibre yield (2.87 t), the net return was markedly lower than most of the herbicide treatments.

Smith [36] reported that field experiments and bioassay tests were carried out to evaluate the relative response of the crops, tossa jute (*Corchorus olitorius* L.) and okra [*Abelmoschus esculentus* (L.) Moench], and their associated weeds to pre-emergence application of pendimethalin at 0.33, 0.66, 0.99, 1.32 kg ai ha⁻¹ and a pendimethalin+atrazine tank mixture at 1.32+2.05 kg a.i. ha⁻¹. Bioassay tests were carried out using herbicide solutions of corresponding concentrations and herbicide-treated soil. Field application of pendimethalin at ≥ 0.66 kg ai ha⁻¹ and the herbicide mixture in both crops effectively controlled most seedling weeds including *Rottboellia cochinchinensis*, *Euphorbia heterophylla* and *Calopogonium mucunoides*, which persisted from 2 weeks after treatment (WAT) were not controlled. Herbicide application during crop establishment markedly inhibited the growth of both seedling weeds and crops. The mixture caused the highest weed and crop injury. Pendimethalin at 0.33 kg ha⁻¹ had minimal effect on these crops. Weed growth, weed tolerance of herbicide treatment and crop seedling injury were higher in tossa jute than that in okra, under the conditions of this study. The use of low pendimethalin doses in an integrated weed management system will ensure effective control of seedling weeds, and prevent crop injury and residue accumulation in edible plant produce.

Sarkar [33] reported that a field experiment was conducted in the medium fertile neutral soil (pH 7.1) of Barrackpore, West Bengal to screen post-emergence herbicides for weed management in jute (cv. JRO 524). Highest weed control efficiency (WCE) of 96.6% was noted for the hand weeding treatment. Among the herbicides, Fenoxaprop-p-ethyl at 75 g ha⁻¹ showed highest WCE (86.6%), closely followed by Quizalofop ethyl (79%). The dominant grass weed was *Echinochloa colona* (96%) and the broadleaved weeds (3%) included *Physalis minima* and *Phyllanthus niruri*. Post-emergence application of Fenoxaprop-p-ethyl @ 75 g ha⁻¹ or Quizalofop ethyl @ 50 g ha⁻¹ at 21 days after sowing (when the grass weeds are at four-leaf stage) effectively controlled the grass weeds giving higher jute fibre yield and net return per rupee invested (2.0 and 1.87, respectively).

Table 7: Herbicide trials conducted Agronomy Division of Bangladesh Jute Research Institute during 2009 to 2012

Trade name and Company	Chemical name	Weeds common name
Year of Trial 2009		
Whip Super 9EC 650 ml/ha (Bayer Crop Science)	Fenoxapro-p-ethyl	Khudesama, Anguli
Year of Trial 2011		
Torga Super 50EC 650 ml/ha (S. I. Agro International)	Quizalofop-p-ethyl Quizalofop-p-tebaryl	Khudesama, Anguli, Knotgrass
Torga Power 50EC 650 ml/ha (Gurpukur Corporation)		
Pantera 4.41EC 650 ml/ha (Hossain Enterprise C.C. Ltd.)		
Torga Super 50EC 650 ml/ha (Sweet Agrovet Ltd.)		
Weednil 5EC 650 ml/ha (ACI Formulation Ltd.)		
Juteox 50EC 650 ml/ha (Corbel International Ltd.)		
Recover 9EC 650 ml/ha (ACI Formulation Ltd.)		
Sua 9EC 650 ml/ha (Intefa)		
Year of Trial 2011-12		
Rex 90EC 650 ml/ha (Agrolinkbd)	Fenoxapro-p-ethyl	Khudesama, Anguli
Dead 9EC 650 ml/ha (Aama Green Care)		
Party Fop 50EC 650 ml/ha (Taj Agro Enterprise)	Quizalofop-p-ethyl	Khudesama, Durba
Eraser 5EC 650 ml/ha (Glovet Agrovet Ltd.)		
Year of Trial 2012		
Clean Super 10EC 650 ml/ha (General Agro Chem. Ltd.)	Fenoxapro-p-ethyl	Khudesama, Anguli
Unitop 9EC 650 ml/ha (United Agricare Ltd.)		
Lionox 9EC 650 ml/ha (Asia Trade International)		
Sanzola 50EC 650 ml/ha (Sun Seed Pesticides)	Quizalofop-p-ethyl	Khudesama, Anguli
Whiper 50EC 650 ml/ha (Newlife Agro Chemicals)		
Quilop 5EC 650 ml/ha (Asia Trade International)		
Pyzero 10EC 750 ml/ha (FMC)	Metamifop	Khudesama, Anguli

(Source: Hossain [22])

Presently, Jute has identified as a major segment for herbicide use in following table. Only after 2009 herbicide application was started mostly in Jute of Bangladesh; at present 20 products of only Fenoxapro-p-ethyl, Metamifop and Quizalofop-p-ethyl have been found to be recommended suitable for weed control for Jute crop, which were mostly used against lower infesting weeds (Table 7) [22].

- **Biological Method:** So far in Bangladesh no systematic attempt has been made to control noxious weed by this method. However, in India aquatic weed are satisfactorily controlled by the release of Chinese grass carp. *Glenopharygodo indella* Val in Pakistan promising results has been obtained in control *Cyperus rotundas* using an insect known as *Althesapeuta cyperi* [38].

3.12 Future Strategies for Weed Management of Jute Crop

The jute weeds have impact as fodder crop in Bangladesh. On the other hand there are no lands are kept fallow for grazing. So, to meet up the fodder shortage we could utilize the thinned out weeds of jute for dairy rearing. Not only that, the young jute plants are popularly used as vegetable in rural and urban areas of Bangladesh. If we go through chemical control for jute of weeds, cannot be used as fodder and jute leaves as vegetable due to chemical's harmful residual effects. Therefore, it should be emphasis on cultural method of weed management along with physical and mechanical measures. In case of cultural method for weed management, the following could be practiced.

1. Pure and clean jute seed should be used at the time of sowing; because seed is a common carrier of weed seed.
- i. To control jute crops weed growth, sowing time could be manipulated as germination of weed seed depends on season or time.
- ii. Weed tolerant cultivars of jute should be selected, because weed infestation varies with different jute cultivars observed.
- iii. Properly maintained the crop rotation, which could be checked the jute weeds by cultivating non-associating crop for that particular weed.
- iv. High but cost effective seed rate might ensure the intense plant cover to reduce weed prevalence and weeding cost may thereby be reduced. In that case, the excess population of young jute plants may be "harvested" as vegetable.

4. CONCLUSION

From the above review, it may be concluded that eighteen different categorized species of weeds found to grow at different areas of tossa jute. Infestation of sedge weeds like *Cyperus rotundus*, *Cynodon dactylon*, *Panicum javanicum*, *Eleusine indica* etc. were very serious at Faridpur and Rangpur. On the other hand seventeen different very dense populated weed species (like *Cyperus rotundus*, *Echinochloa colonum* etc.) were identified as serious in different white jute growing areas (Manikganj, Kishoreganj and Comilla). Weeding in jute crop is very much cost involving, if farmers could know the major species of weeds, they can apply the easiest control methods of weeding to achieve maximum benefit. In the recent years due to labour cost, different herbicides are getting popularity at farm level. However control effectiveness, effective time of application, cost should be kept in the consideration, and then the practice could get popularity. Since the cost as well as availability of agricultural labour is being copped up as problem, more attention in the field of scientific methods of jute weed control and sequence of weed vis-à-vis cropping pattern is warranted.

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Biochemistry, Medicinal and Food values of Jute (*Corchorus capsularis* L. and *C. olitorius* L.) leaf: A Review

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Abstract: Jute (*Corchorus* spp.) leaf has long been used as a remedy in many cultures. Jute leaf products, which include the leaf juice, fried leaf, and some time whole green leaf, are used, among other reasons, as laxatives, in creams for skin care, and as a treatment for a wide range of diseases, respectively. The heterogeneous nature of jute leaf products may contribute to the diverse biological and therapeutic activities that have been observed. Variations in the composition of jute leaf can result in products with different chemical and physical properties, making the comparison of products difficult. The green, leafy vegetable is rich in beta-carotene for good eyesight, iron for healthy red blood cells, calcium for strong bones and teeth, and vitamin C for smooth, clear skin, strong immune cells, and fast wound-healing. Vitamins A, C and E present in jute leaf/Saluyot “spongeup” free radicals, scooping them up before they can commit cellular sabotage. Jute leaf as vegetable contains an abundance of antioxidants that have been associated with protection from chronic diseases such as heart disease, cancer, diabetes, and hypertension as well as other medical conditions. Fresh jute leaf has higher demand. Ayurvedics use the leaves for ascites, pain, piles (laxative), and tumors. Elsewhere the leaves are used for cystitis, dysuria, and fever. The cold infusion is said to restore the appetite and strength. In this article, the biochemistry, uses and pharmacological activity of jute leaf fry, juice and curry compounds are reviewed.

Keywords: Biochemistry, Medicine, Food, Jute (*Corchorus* Spp.) leaf.

1. Introduction

The fibre-yielding plant jute was once known as the golden fibre of Bangladesh, since it was the most important cash crop for the country. Demand for medicinal plants is increasing in both developed and developing countries due to growing recognition of natural products being equally effective, safe, non-narcotic, affordable and having no side effects. There is large scale international trade in the medicinal plants. One such medicinal plant part is jute leaf. Bangladesh and India has been a traditionally rich in various types of medicinal plants. Since ancient times, people have been using herbal medicines to cure diseases. About 20,000 species of plants are being used as medicinal plants world over. The plant products constitute about 25% of the prescribed medicines in world (Anwar, 2011; Alim, 1978; Dempsey, 1975 and Calleja, 2010).

Jute dicotyledenous fibre-yielding plant of the genus *Corchorus*, order Tiliaceae. Jute was once known as the golden fibre of Bangladesh, since it was the most important cash crop for the country. Jute fibre is produced mainly from two commercially important species, namely White Jute (*Corchorus capsularis* L.), and Tossa Jute (*Corchorus olitorius* L.). The centre of origin of white jute is said to be Indo-Burma including South China, and that of tossa Africa. The word jute is probably coined from the word jhuta or jota, an Orrisan word. However, the use of jutta potta cloth was mentioned both in the Bible and Monushanghita-Mahabharat. This indicates the ancient uses of jute materials by the people of these areas (Alim, 1978; Islam, 2009; Islam and Rahman, 2008).

Jute leaves are the leaves of certain jute plants, used as a food source in Asia, the Middle East, and parts of Africa. In addition to adding a distinct flavor to food, jute leaves also have nutritional value, and they act as thickeners in soups, stews, and sauces. Jute leaves may also be called saluyot or ewedu, depending on the region of the world in which one is cooking. It is possible to grow jute for its fresh leaves in some parts of the world, and some specialty stores also stock it in fresh, frozen, or dried form, depending on their location and size (Annon., 2003; Calleja, 2010).

The leaves of these plants are simple, and they may have slightly serrated edges. When harvested young, jute leaves are flavorful and tender; older leaves tend to be more woody and fibrous, making them less ideal for consumption. Jute leaves are consumed in various parts of the world. It is a popular vegetable in West Africa. The Yoruba of Nigeria call it "ewedu". The Hausa people of Nigeria and their Fulbe neighbours call it "rama." They use it to produce soup

("taushe") or boil the leaves and mix it with "Kuli-kuli" or groundnut cake and consume the mixture which they call "kwado" in Hausa. It is eaten with 'ugali', which is also a staple for most communities in Kenya. The leaves are rich in betacarotene, iron, calcium, and Vitamin C. The plant has an antioxidant activity with a significant α -tocopherol equivalent Vitamin E (<http://en.wikipedia.org/wiki/Jute>). Vitamins A, C and E present in jute leaf/Saluyot "spongeup" free radicals, scooping them up before they can commit cellular sabotage. Jute leaf as vegetable contains an abundance of antioxidants that have been associated with protection from chronic diseases such as heart disease, cancer, diabetes, and hypertension as well as other medical conditions. Jute grows under wide variation of climatic conditions and stress of tropic and subtropics. Jute is as old as civilization and has been used in almost as many applications as one can imagine. This paper reviews history, chemical constituents, plant morphology and the most interesting studies on the various biological activities of jute (*Corchorus* spp) (Duke, 1979).

2. History

Tossa and white jute varieties are thought to be native to Bangladesh and India, and are also the world's producer. It is grown for both fiber and culinary purposes. It is used as an herb in Middle Eastern and African countries, where the leaves are used as an ingredient in a mucilaginous potherb called "molokhiya" (ملوخية, of uncertain etymology). It is very popular in some Arab countries such as Egypt, Jordan, and Syria as a soup-based dish, sometimes with meat over rice or lentils. The Book of Job, in the King James translation of the Hebrew Bible mentions this vegetable potherb as "Jew's mallow". It is high in protein, vitamin C, beta-carotene, calcium, and iron. Along with white jute, tossa jute has also been cultivated in the soil of Bengal where it is known as paat from the start of the 19th century. Currently, Bangladesh is the only global producer of white jute variety, However the Bengal region (West Bengal in India, and Bangladesh) is the largest global producer of the tossa jute varieties (Annon., 2007a; Annon., 2011b).

3. Climate

Jute needs a plain alluvial soil and standing water. The suitable climate for growing jute (warm and wet) is offered by the monsoon climate, during the monsoon season. Temperatures from 20°C to 40°C and relative humidity of 70%–80% are favourable for successful cultivation. Jute requires 5–8 cm of rainfall weekly, and more during the sowing period (Dempsey, 1975; Alim, 1978; Islam, 2008; Kundu et al. 1959).

4. Botany

4.1 Jute Taxonomy

Rank	Scientific Name and Common Name
Kingdom	Plantae – Plants
Subkingdom	Tracheobionta – Vascular plants
Superdivision	Spermatophyta – Seed plants
Division	Magnoliophyta – Flowering plants
Class	Magnoliopsida – Dicotyledons
Subclass	Dilleniidae
Order	Malvales
Family	Tiliaceae – Linden family
Genus	<i>Corchorus</i> L. – corchorus
Species	<i>Corchorus olitorius</i> L. – nalta jute <i>Corchorus capsularis</i> L. – white jute
English name	Jute
Bengali name	Pat, Paat, Naila etc.

4.2 Medicinal Species

White Jute (*Corchorus capsularis* L.), and Tossa Jute (*Corchorus olitorius* L.) both the species have medicinal values. The dried material is there known as "nalita." Injections of olitoriside markedly improve cardiac insufficiencies and have no cumulative attributes; hence, it can serve as a substitute for strophanthin. Deobstruent, diuretic, lactagogue, purgative, and tonic, tussah jute is a folk remedy for aches and pains, dysentery, enteritis, fever, dysentery, pectoral pains, and tumors (Duke and Wain, 1981; List and Horhammer, 1969-1979). Ayurvedics use the leaves for

ascites, pain, piles, and tumors. Elsewhere the leaves are used for cystitis, dysuria, fever, and gonorrhoea. The cold infusion is said to restore the appetite and strength (Duke, 1983; Annon.,).

4.3 Plant Description

Tossa jute (*Corchorus olitorius* L.): Annual or biennial herb, erect, stout, branched, to 1.5 m high; rootstock woody. Leaves lanceolate to ovate-lanceolate, subobtusate at base, serrate at margin with basal most serrations extending into filiform processes, acute at apex, glabrous except sparsely hairy nerves, 3-5 nerved; petioles 2-3 cm long, pubescent; stipules subulate, 8-12 mm long, glabrous. Flowers in 1 or 2 flowered leaf opposed cymes, 12-15 mm across, subsessile; bracts subulate, 4-5 mm long. Sepals linear-oblong, apiculate, 5-7 mm long. Petals oblong-spatulate, obtuse, 5-7 mm long. Stamens numerous, somewhat connate at base. Ovary cylindrical, sparsely hairy, 5-loculed; style short; stigma 5-lobed, minutely papillate. Capsules solitary or paired, subcylindrical, 2-7 cm long, 10-ribbed, glabrous, 5-loculed; locules septate between seeds; beak entire, 4-8 mm long; seeds 3-gonous, ca 2 x 1.5 mm, inconspicuously verrucose, black (Dr. N Sasidharan (Dr. B P Pal Fellow), Kerala Forest Research Institute, Peechi) (<http://indiabiodiversity.org/species/show/229280>) (Dempsey, 1975; Alim, 1978; Kundu et al. 1959).

White jute (*Corchorus capsularis* L.): Annual, much branched, spreading herbs; stems pilose, often reddish. Leaves 2.5-7 x 1.5-3.5 cm, ovate to elliptic-lanceolate, base rounded, margins serrate, the basal pair of serrations ending in setae or not, apex acute, basally 3-5-nerved; petioles upto 3 cm long; stipules 4-8 mm long, setaceous. Flowers 2-3 in leaf-opposed, shortly pedunculate cymes; pedicels c. 2 mm long. Sepals 5, 3-4 mm long, linear-oblong, hooded and apiculate. Petals 5, yellow, 3-5 mm long, obovate, obtuse. Stamens many. Ovary c. 2 mm long, cylindrical, 3-loculed; style 3-fid; stigma 2-lobed. Capsules 1-3 x 0.4-0.6 cm, 6-angled, 3 of the angles winged, 3-loculed. Seeds numerous, dark brown (Dr. N Sasidharan (Dr. B P Pal Fellow), Kerala Forest Research Institute, Peechi) (<http://indiabiodiversity.org/species/show/229281>) (Dempsey, 1975; Alim, 1978; Kundu et al. 1959).

4.4 Geographical Distribution

Jute is grown in Bangladesh, India, Myanmar, Nepal, China, Taiwan, Thailand, Vietnam, Cambodia, Brazil and some other countries. Bangladesh used to enjoy almost a monopoly of this fibre commercially. Although jute is grown in almost all the districts of Bangladesh, Faridpur, Tangail, Jessore, Dhaka, Sirajganj, Bogra, and Jamalpur are considered the better growing areas (Alim, 1978; Islam, 2010; Kundu et al. 1959). Total area under the crop cultivation of Bangladesh in the year 2010 was 708,000 ha and the total production was 8395,000 bales (BBS 2011). On the other hand in India during 2011 area under the crop cultivation was 768,000 ha and the total production was 1799,000 bales (FAO 2011).

5. Jute leaf Biochemistry

Jute leaf is a unique plant part which is a rich source of many chemical compounds and plays an important role in the national and international market. Prof. Tom D. Rowe (1941) was probably first to take vital steps in the chemical analysis of the plant. Jute leaves now reported to contain as many as 17 active nutrients compounds including protein, fat, carbohydrate, fiber, ash, Calcium, Potassium, iron, sodium, phosphorous, beta-carotene, thiamine, riboflavin, niacin, ascorbic acid etc (Islam, 2010; Calleja, 2010).

Leaves contain oxydase and chlorogenic acid. The folic acid content is substantially higher than that of other folacin-rich vegetables, ca 800 micrograms per 100g (ca 75% moisture) or ca 3200 micrograms on a zero moisture basis (Chen and Saad, 1981). This green, leafy vegetable is rich in beta-carotene for good eyesight, iron for healthy red blood cells, calcium for strong bones and teeth, and vitamin C for smooth, clear skin, strong immune cells, and fast wound-healing. Vitamins A, C and E present in Saluyot “sponge-up” free radicals, scooping them up before they can commit cellular sabotage (Chen and Saad, 1981; Duke, 1983).

Table 1. Nutritional values of jute leaves as saluyot (Boiled/100 grams edible portion)
 (Annon., 2010; Islam, 2010; Islam, 2012)

Nutrients	Boiled
Moisture (%)	80.4 – 84.1
Food energy (cal.)	43 - 58
Protein (g)	4.5 –5.6
Fiber (g)	1.7 –2.0
Total Carbohydrates (g)	7.6 – 12.4
Ash (g)	2.4
Calcium (mg)	266 - 366

Phosphorus (mg)	97 - 122
Iron (mg)	11.6
Sodium (mg)	12
Potassium (mg)	444
Vit. A (I.U.)	6,390
Thiamine (mg) (Vit.B1)	15
Riboflavin (mg) (Vit.B2)	28
Niacin (mg) (Vit.B3)	1.5
Ascorbic acid (mg)	95

The phytochemical screening of the leaves of capsularis showed the presence of flavonoids, saponins, tannins, steroids and triterpenes. It is also rich in vitamin, carotenoid, calcium, potassium and dietary fiber. *C. capsularis* L. leaves contain two functional compounds; phytol (3,7,11,15-tetramethyl-2-hexadecen-1-ol) and monogalactosyldiacylglycerol (1,2-di-O- α -linolenoyl-3- β -D- galactopyranosyl-glycerol). *C. capsularis* L. also contains capsin, a glycoside, which is responsible for the major bitter taste of the leaves of *C. capsularis* L. ;Another glycoside (capsugenin-3-O- β -glucopyranoside) was also isolated from the leaves of *C. capsularis* L. The capsin was identified as the 3-glucoside of 20, 24-epoxy-3 β , 12 β , 25, 30-tetrahydroxydammarane (<http://www.globinmed.com/>, Furumoto et al., 2002; Meara and Sen, 1952; Zainul et al., 2007; Mosihuzzamana et al., 1982; Quader et al., 1987; Hasan et al., 1984; Mosihuzzaman et al., 1988; ([http://www.pfaf.org/database/plants](http://www.pfaf.org/database/plants;); http://www.skeuroltd.bd.com/about_jute.html; <http://www.stuartxchange.org/PasauNaBilog.html>).



Jute plants



Jute plant/ Jute seedling of 30-40 days of age with leaves



Jute leaf packet for marketing



Jute leaf packets for marketing

Figure 1: The jute plant and jute leaf marketing packet

6. Jute leaf's medicinal values and uses

6.1 While perhaps better known as a fiber crop, jute is also a medicinal "vegetable", eaten from Tanganyika to Egypt. Dried leaves were given me by an Egyptian friend who had brought them with him to this country. They are used in soups under the Arabic name "Molukhyia." In India the leaves and tender shoots are eaten. The dried material is there known as "nalita." Injections of olitoriside markedly improve cardiac insufficiencies and have no cumulative attributes; hence, it can serve as a substitute for strophanthin (Annon., 2011b).

6.2 Reported to be demulcent, deobstruent, diuretic, lactagogue, purgative, and tonic, tussah jute is a folk remedy for aches and pains, dysentery, enteritis, fever, dysentery, pectoral pains, and tumors (Duke and Wain, 1981; List and Horhammer, 1969-1979; Watt, and Breyer-Brandwijk, 1962). Ayurvedics use the leaves for ascites, pain, piles, and tumors. Elsewhere the leaves are used for cystitis, dysuria, fever, and gonorrhoea. The cold infusion is said to restore the appetite and strength (Duke, 1983; Kirtikar and Basu, 1975).

Table 2: Mechanisms of action of jute leaf and its components as medicine

PROPERTIES	MECHANISMS
Antinociceptive/ Antiinflammatory	Study showed the extract of CC exhibited significant antinociceptive and antiinflammatory activities confirming its traditional use for ailments associated with inflammation and pain. It is used traditionally to address concerns related to inflammation and pain. It is also been connected with curing the chronic inflammation of the urinary bladder.
Galactolipid / Anti-Tumor	Galactolipid I has been shown to be responsible for the anti-tumor promoting activity of jute (<i>Corchorus capsularis</i> L. and <i>C. olitorius</i> L.).
Antipyretic / Antinociceptive / Antiinflammatory	Study on the aqueous extract of jute plant leaves, <i>C. capsularis</i> L., exhibited significant antinociceptive, anti-inflammatory and anti-pyretic activities in a dose-dependent manner and supports its claim of traditional use to treat various ailments.
Capsugenin	Study yielded a glycoside-capsugenin-30-o-B-glycopyranoside, from the leaves of <i>Corchorus capsularis</i> L.
Headaches, Liver disorders	The powdered leaves, dried, 1 or 1 1/2 tsp to a cup of water, steep for 3 to 5 minutes, and strain before drinking.
Dysentery, coughs and phthisis, and poulticing sores	Malays use a decoction of the leaves for dysentery, for coughs and phthisis, and as a tonic for children. Also, used for poulticing sores.
Antiseptic	Finely carded fiber sometimes used as base for antiseptic surgical dressings
Acute dysentery	Cold infusion of the leaves as a bitter tonic; used in patients recovering from acute dysentery
Atonic dyspepsia, liver disorders, chronic cystitis, gonorrhoea, dysuria, worms in children, hepatic and intestinal colic, and gastric catarrh.	Infusion of leaves used for atonic dyspepsia, liver disorders and as febrifuge. Also used for chronic cystitis, gonorrhoea, dysuria, worms in children, hepatic and intestinal colic, and for gastric catarrh.
Eyesight	Its vitamin content is good for eyesight, as the vegetable contains beta-carotene.
Swine flu	The Philippine Department of Health advises the public to increase their intake of jute leaf vegetable, to include malunggay and banana as well, in order to build resistance against the threat of swine flu
Carminative, demulcent, laxative, stimulant and stomachic	The leaves are appetizer, carminative, demulcent, laxative, stimulant and stomachic. An infusion is used in the treatment of dysentery, fevers, dyspepsia and liver disorders.

(Sources: <http://stuartxchange.com/PasauNaBilog.html>, Chopra. R. N., Nayar. S. L. and Chopra. I. C. Glossary of Indian Medicinal Plants (Including the Supplement). Council of Scientific and Industrial Research, New Delhi. (1986-00-00), <http://herbs.indianmedicinalplants.info/index.php/sanskrit-names-of-plants/44-2012-02-24-07-34-36/427--corchorus-capsularis->, <http://www.naturalmedicinalherbs.net/herbs/c/corchorus-capsularis=jute.php>)

6.3 *Corchorus olitorius* L. is a native plant of tropical Africa and Asia, and has since spread to Australia, South America and some parts of Europe. Its leafy vegetable is popularly used in soup preparation and folk medicine for the treatment of fever, chronic cystitis, cold and tumours. A comparative study of the antioxidant properties of hydrophilic extract (HE) and lipophilic extract (LE) constituents of the leafy vegetable has been assessed. HE and LE of the leaf were prepared using water and hexane, respectively and their antioxidant properties were determined. HE had a significantly higher ($P < 0.05$) 1,1-diphenyl-2-picrylhydrazyl radical-scavenging ability (aqueous, 9.6-84.4%; hexane, 2.0-20.4%), reducing power (aqueous, 0.67 mmol ascorbic acid equivalent/g; hexane, 0.49 mmol ascorbic acid equivalent/g) and trolox equivalent antioxidant capacity (aqueous, 2.3 mmol/g; hexane, 1.1 mmol/g) than LE; conversely, LE had a significantly higher ($P < 0.05$) OH. scavenging activity (44.5-46.2%) than HE (11.6-32.3%), while there was no significant difference ($P > 0.05$) in their Fe(II) chelating ability (HE, 57.7-66.7%; LE, 56.4- 61.1%). The higher 1,1-diphenyl-2-picrylhydrazyl radical-scavenging ability, reducing power and trolox equivalent antioxidant capacity of the hydrophilic extract may be due to its significantly higher ($P < 0.05$) total phenol (630.8 mg/100 g), total flavonoid (227.8 mg/100 g) and non-flavonoid polyphenols (403.0 mg/100 g), and its high ascorbic acid content (32.6 mg/100 g). While the higher OH. scavenging ability of LE may be due to its high total carotenoid content (42.5 mg/100 g). Therefore, the additive/synergistic antioxidant activities of the hydrophilic and lipophilic constituents may contribute to the medicinal properties of *C. olitorius* L. leaf (Obloh et al., 2009).

6.4 Research reveals that this plant originated in Egypt and was the source of health and beauty of the Egyptian royalties, including Cleopatra. Due to the high anti-oxidant activity of saluyot, eating it reduces the appearance of wrinkles and fine lines in the face and body. Regular consumption of saluyot can make you appear young (Ali, 2013; healthrecipes.ws, 2010).

6.5 Antinociceptive and anti-inflammatory activity

The chloroform extract of *C. capsularis* L. leaves was investigated for antinociceptive activity using acetic acid-induced abdominal constriction and hot plate tests in male Balb-C mice and the formalin tests in rats. [4] The extract was given 30 minutes prior to subjection to acetic acid-induced abdominal constriction and the hot plate tests. All concentrations used (10, 50 and 100% strength) showed significant reductions in the number of abdominal constrictions when compared to the control. The effective antinociceptive activity was seen at 100 mg/kg of the chloroform extract when compared to acetylsalicylic acid (100 mg/kg). The thermally induced nociceptive peripheral stimulus in male Balb-C mice using the hot plate test at 50°C showed a significant concentration-independent antinociceptive activity in the chloroform extract of *C. capsularis* L. leaves. This activity was observed 30 min after the extract administration compared to morphine (5 mg/kg) which showed significant activity after 1 hour of its administration. These findings revealed the extract's effectiveness in inhibiting chemically and thermally-induced nociception (<http://www.globinmed.com/> Furumoto et al., 2002; Meara and Sen, 1952; Zainul et al., 2007; Mosihuzzamana et al., 1982; Quader et al., 1987; Hasan et al., 1984; Mosihuzzaman et al., 1988; (<http://www.pfaf.org/database/plants>; Ali, 2013; http://www.skeuroltd.bd.com/about_jute.html; <http://www.stuartxchange.org/PasauNaBilog.html>).

In the formalin test in rats, the chloroform extract of *C. capsularis* L. leaves was given 30 minutes prior to formalin injection. The extract exhibited significant antinociceptive activity at the early phase of nociception, indicating a neurogenic type of pain response, and also at the late phase of nociception, indicating an inflammatory type of pain response. (<http://www.globinmed.com/>).

The anti-inflammatory profile of the chloroform extract of *C. capsularis* L. leaves was measured using carrageenan-induced paw edema test in rats. The extract at all concentrations (20, 50 and 100 mg/kg) caused a significant decrease in the thickness of edematous paw for the first 6 hours compared to the control. The activity diminished in the last 2 hours of the experimental time compared to the control group (<http://www.globinmed.com/>).

The positive reference compound used was acetylsalicylic acid (100 mg/kg) which produced significant anti-inflammatory activity. This test revealed the ability of the extract to block the inflammatory phase of the formalin test, which confirmed the folkloric use of *C. capsularis* L. as a demulcent (<http://www.globinmed.com/>).

Based on all of these findings, the chloroform extract of *C. capsularis* L., possessed antinociceptive and anti-inflammatory activities which confirmed the traditional claims of using *C. capsularis* L. to treat various ailments related to inflammation and pain (Furumoto et al., 2002; Meara and Sen, 1952; Zainul et al., 2007; Mosihuzzamana et al., 1982; Quader et al., 1987; Hasan et al., 1984; Mosihuzzaman et al., 1988; (<http://www.pfaf.org/database/plants>; http://www.skeuroltd.bd.com/about_jute.html; <http://www.stuartxchange.org/PasauNaBilog.html>).

6.6 Antitumor promoting activity

Two active components of *C. capsularis* L. were identified. These components showed activity against tumor promoter-induced Epstein-Barr virus (EBV) activation in Raji cells. They were isolated from the fresh leaves of *C. capsularis*. The active components were colorless oils and were identified as phytol (3,7,11,15-tetramethyl-2-hexadecen-1-ol) and monogalactosyl-diacylglycerol (1,2-di- α -linolenoyl-3- β -D-galactopyranosyl-glycerol) (<http://www.globinmed.com/>).

The antitumor-promoting activity was examined by an immunoblotting analysis using a mouse antiserum against EBV producer P3HR-1 cells. Phytol and monogalactosyldiacylglycerol completely inhibited the induction of EBV early antigen at concentrations of 15 μ g/mL (50.7 μ M) and 30 μ g/mL (38.8 μ M), respectively. However insufficient inhibitory effects were shown by both compounds at concentrations of 10 μ g/mL and 25 μ g/mL, respectively (Furumoto et al., 2002; Meara and Sen, 1952; Zainul et al., 2007; Mosihuzzamana et al., 1982; Quader et al., 1987; Hasan et al., 1984; Mosihuzzaman et al., 1988; (<http://www.pfaf.org/database/plants>; http://www.skeuroltd.bd.com/about_jute.html; <http://www.stuartxchange.org/PasauNaBilog.html>).

This study also revealed that both components increased gradually with an increasing in the period of treatment with hot water, indicating that the components were not easily decomposed by high temperature. These findings suggest that treatment of vegetables with hot water effectively increased the amount of active components with activity against tumor-promoting chemicals that may be consumed together with food (<http://www.globinmed.com/>).

7. Use of jute leaf as food/vegetable diet

Jute leaves are consumed in various parts of the world. It is a popular vegetable in West Africa. The Yoruba of Nigeria call it "ewedu". The Hausa people of Nigeria and their Fulbe neighbours call it "rama." They use it to produce soup ("taushe") or boil the leaves and mix it with "Kuli-kuli" or groundnut cake and consume the mixture which they call "kwado" in Hausa. The Hausa peasant farmers cultivate it beside their corn-stalk constructed homesteads or among their main crops in their farms. There are commercial jute farmers in Northern and South Western Nigeria. They (jute commercial farmers) have a strong National Association registered by the authorities. In Northern Sudan it's called "Khudra" meaning green in Sudanese Arabic. The Hausa and Fulbe peoples also use jute leaves to treat some diseases. And the Songhay of Mali call it "fakohoy" whereas Tunisians call it mulukhiyah. It is made into a common mucilaginous (somewhat "slimy") soup or sauce in some West African cooking traditions, as well as in Egypt, where it is called mulukhiyya, Cypriots call it molocha - and that refers to food - in terms of fibre this would be unknown - and it is sometimes eaten as boiled vegetable with lemon and olive oil. It is also a popular dish in the northern provinces of the Philippines, where it is known as saluyot. Jute leaves are also consumed among the Luyhia people of Western Kenya, where it is commonly known as 'mrenda' or 'murere'. It is eaten with 'ugali', which is also a staple for most communities in Kenya (<http://en.wikipedia.org/wiki/Jute>; Islam, 2006).

Young fresh leaves eaten as vegetable in various parts of the world - Bangladesh, Middle East, Africa, SE asia. In Bengal, where it is considered a tonic, leaves are used as a condiment, commonly added to the daily diet of rice. In Japan, considered a health food item, dried leaves sometimes used as a substitute for coffee and tea. Leaves sometimes used as condiment. In Rumpf's time, when slaves from India were detained in Amboina, there was much use for it as vegetable (<http://stuartxchange.com/PasauNaBilog.html>; Islam, 2006).

After irradiation, a dwarf mutant CM-18 with more number of leaves has been selected. The mutant CM-18 was selected out for its higher leaf yield. Then it was tested in farmers' fields. Fresh twigs (edible portion) of 30 days old seedling of both the genotypes were analyzed for Protein, Fiber, Alkaloid, Carotene and Vitamin C. The mutant line CM-18 produced 32 per cent higher twig yield than its parental variety CVL-1. Qualitative characters compared with its parental variety CVL-1 are shown below: The mutant CM-18 contains higher protein and carotene contents than parent variety. Fiber, Alkaloid and Vitamin C contents are more or less similar with CVL-1. Low alkaloid contained in leaves make it tasty. The mutant CM-18 has high vegetable yield potential, protein and carotene content. Due to better performance in respect of yield and quality the mutant CM-18 has been registered as the first jute variety in Bangladesh for vegetable purpose in the name of Binapatshak-1 in 2003.

Corchorus leaves are consumed in the cuisines of various countries. Corchorus olitorius is used mainly in the cuisines of southern Asia, the Middle East, and North Africa, Corchorus capsularis in Japan and China. It has a mucilaginous (somewhat "slimy") texture, similar to okra, when cooked. The seeds are used as a flavouring, and a herbal tea is made from the dried leaves. The leaves of Corchorus are rich in betacarotene, iron, calcium, and vitamin C. The plant has an antioxidant activity with a significant α -tocopherol equivalent vitamin E.

In North Africa and the Middle East, the young leaves of Corchorus species are known in Arabic as malukhiyah and are used as green leafy vegetables. Malukhiyah is eaten widely in Egypt and some consider it the Egyptian national dish. It is featured in cuisines from Lebanon, Palestine, Syria, Jordan and Tunisia. In Turkey and Cyprus, the plant is known as molohiya or molocha and is usually cooked into a kind of chicken stew. The leaves of Corchorus have been a staple Egyptian food since the time of the Pharaohs and it is from there that it gains its recognition and popularity. Varieties of mallow-leaves stew with rice is a well known Middle Eastern cuisine (Annon., 2011b; Islam, 2006; Whitlock et al. 2003).

In Nigerian cuisine, especially amongst the Yorubas, it is commonly used in a stew known as ewedu, a condiment to other starch-based foods such as amala. The Hausa people of Nigeria and their Fula neighbours call it rama. They use it to produce soup (taushe) or boil the leaves and mix it with kuli-kuli (groundnut cake) to form a dish known as kwado in Hausa. The Hausa peasant farmers cultivate it beside their corn-stalk constructed homesteads or among their main crops in their farms. The Hausa and Fulbe peoples also use jute leaves to treat some diseases. In Sierra Leone it is known as krain krain (or crain crain) and is cooked as stew. The stew is usually eaten with rice or fofofo (a traditional food made from cassava). Jute leaves are also consumed among the Luhya people of Western Kenya, where it is commonly known as mrenda or murere. It is eaten with starchy foods like ugali, a staple for most communities in Kenya. In Northern Sudan it is called khudra, meaning "green" in Sudanese Arabic. The Songhai people of Mali call it fakohoy. In India, it is locally known as nalta sag. It is a favorite food during the summer months, especially in Sambalpur and the western part of Odisha. Usually it is lightly sauteed and eaten along with rice or rice gruel. In the Philippines, C. olitorius is known as saluyot. It is commonly consumed as a leafy vegetable together with bamboo shoots. In Thai cuisine, the leaves of the Corchorus olitorius L. (locally known as bai po; Thai: ใบพ้อ) are eaten blanched, together with plain rice congee. The taste resembles that of spinach and samphire (Islam, 2005; Islam, 2006).

Because the saluyot or jute plant is by nature a vegetable, it is easy to prepare and can be incorporated to various dishes that would allow individuals to benefit from its vitamins and mineral content. Since it can be found easily, there are a lot of local viands and/or dishes that use saluyot as an ingredient. For instance, the Ilocanos use saluyot in their preparation of dinengdeng and bulangbulang. Fried saluyot are also mixed with sautéed bamboo shoots and dried beans. Other dishes include, but are not limited to chicken viands, wherein saluyot are mixed in either sautéed or pureed form. It is also integrated in mongo dishes, and in soups. (<http://rullanamador.blogspot.com/2010/01/saluyot-or-jute-corchorus-capsularis-l.html>; Hepzibah, 2008; Islam, 2006).

The leaves of *C. capsularis* L. have been claimed to possess stimulant, demulcent, laxative, appetizer and stomachic effects. The infusion of the leaves is traditionally used to treat fever, constipation, dysentery, liver disorders and dyspepsia. In Japan, the young leaves were used as a substitute for coffee or tea and were regard as a health food (<http://www.globinmed.com/>).

Comparison study of jute leaf with spinach

Like spinach and other leafy greens, jute leaves can be cooked whole as a major component of a dish, or can be loosely chopped so that they blend better with other ingredients. Some cooks like to salt their jute leaves and rest them before cooking, to draw out some of the slime which can make them troubling to the palate. The longer jute leaves cook, the more slimy and dense they get, so it is important to pay attention to cooking times in recipes which call for jute leaves. Ingredients comparison of jute leaf with leafy vegetable spinach is given below-

Table 2. Nutritional comparison between jute leaf and spinach (per 100 gm each), (Annon., 2010; Islam, 2010)

Ingredients and unit	Spinach leaf	Jute leaf
Calories (kl cal)	25	73
Protein (g)	3.3	3.6
Lipid (g)	0.2	0.6
Calcium (mg)	55	298
Iron (mg)	3.9	11
Carotene (mg)	5200	6400
Vitamin B-1 (mg)	0.13	15
Vitamin B-2 (mg)	0.23	28
Vitamin C (mg)	65	64

Pesticide use in biotic areas

Jute leaves contain Hydrogen cyanide (HCN) and several cardiac glycosides. Negm et al. (1980) report the LD50 of issue extracts to mice. The "lethal dose" of Corchoroside A to cats is 0.053-0.0768 mg/kg and Corchoroside B 0.059-0.1413, but some authors say that Corchoroside A is twice as active as Corchoroside B (Duke, 1983).

Anthraxnose spots caused by *Colletotrichum gloeosporioides* may infect 50-90% of a jute population, but spraying with copper oxychloride at 0.5% strength checked the spread, holding it to 5-10%. This species was badly infested by 3 species of weevils (*Myllocerus* spp.) while *C. capsularis* L. was unaffected. The semilooper (*Anomis sabulifera*) may stunt the growth, reducing fiber yields by ca 13-32%. The yellow mite, (*Polyphagotarsonemus latus*) may also reduce yields (Duke, 1983).

Conclusion

There are so many jute and allied fibre crops varieties developed, released and used at farmers' level for commercial cultivation. All those varieties leaves have both vegetable and medicinal values. Jute leaf has long been used as a remedy in many cultures. The jute leaf contains over 17 active nutrient compounds including many minerals, amino acids and vitamins. Today, this multiutility versatile plant part is considered to cure Mankind's different health problems. There are many natural medicinal herbs, but jute leaf is granted with vast array of healing benefits. Although, jute leaf has wide spectrum of the properties and uses. Jute leaf contains protein, calories, fibres and as well as antitumor promoters; Phytol and Monogalactosyl-diacylglycerol. It may reduce risk of cancer. Therefore jute leaf has a great importance in terms of human nutrition, health and beauty care. In future, controlled studies are required to prove the effectiveness of jute leaf under the various conditions.

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Efficiency of BJRI Kenaf-4 Yield Under Different Fertilizer Levels

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Abstract: The present study was conducted to clarify the fertilizer requirement on the growth and yield of the variety Bangladesh Jute Research Institute Kenaf-4. Consequently the experiment was conducted in Jute Agriculture Experimental Station, Manikganj and Jute Research Regional Station, Kishoreganj of Bangladesh Jute Research Institute. The results indicated significant effect of different NPKS levels on Bangladesh Jute Research Institute (BJRI) Kenaf-4 yield and yield contributing characters over control. The highest fibre (3.14t/ha) and stick (7.65t/ha) yield were obtained by the combination dose of N₁₀₀ Kg/ha with PKS 10-60-20 kg/ha at Kishoreganj. The plant height (3.14m), base diameter (19.47mm) also found highest with the same fertilizer treatment combination. By the same treatment produced higher fibre yield and yield contributing characters at Manikganj though that yield was slightly lower than Kishoreganj. Economic analysis suggested the best combination is N₁₀₀P₁₀K₆₀S₂₀ kg/ha. The findings of the present experiment clearly indicated a great prospect of nutrient combination of N₁₀₀P₁₀K₆₀S₂₀ kg/ha on the growth and yield of fibre production on the variety BJRI kenaf-4.

Keywords: BJRI Kenaf-4, Fertilizer Requirements, Fiber Yield

1. Introduction

Bangladesh Jute Research Institute is the major organization of Jute and allied fibre crops research and Kenaf (*Hibiscus cannabinus L.*) is a promising fibre crop in Bangladesh [1, 2]. It can be grown as an alternative crop of cotton that may be economically feasible to produce in Bangladesh [3]. Kenaf fiber used to make quality fine paper, as well as lower grade papers and cordage, also used to produce rope, canvas, sacking, carpet backing, fishing nets, interior automobile parts, such as door panels, headliners, animal bedding, and composite lumber substitutes [1]. Fertilizer application is necessary for high yielding Kenaf. There are many reports published on fertilizer requirement for kenaf production [4-19]. In Bangladesh farmers are not well known of better kenaf production technology that hinders the expected production of Kenaf and fibre and seeds are grown conventionally [20]. Poor fertilizer management practices also a cause for low yield of Kenaf. Therefore, the production of quality kenaf fibre in the country is very much

essential to meet the increasing demand and expand this valuable crop. Taking into account all these essentials, upgrading of fiber yield and quality of Kenaf is the prime need of Bangladesh. In this aspect, research regarding development of new high yielding variety of Kenaf and determination of its fertilizer requirement is very important. Therefore, the present study has been undertaken to observe the effects of N, P, K and S fertilizers on the growth and yield of the pre-released Kenaf variety, BJRI Kenaf-4 and to find out the finest requirement of nutrients combination to obtain highest fibre production.

2. Materials and Methods

The experiment was set up at the Jute Agriculture Experimental Station (JAES) of BJRI, Jagir, under Sadar Upazila of Manikganj district and Regional Station, Kishoreganj of BJRI.

The experiment was laid out in randomized complete block design (RCBD) with three replications. A total 10 treatment combinations along with a control were distributed

randomly in each plot as one replication (Table 1). The dimension of unit plots was 3 m × 3 m having 1 m space between the plots, blocks and around the field. There was 20 cm deep drain around each block and plot. Each replication

was divided into 10 unit plots. At the beginning of the experiment, the land was well prepared and fertilizers were applied as per treatment.

Table 1. Treatment combinations of N, P, K and S.

Treatment combinations	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)	Sulfur (kg/ha)
T ₁ : N ₀ P ₀ K ₀ S ₀	00	00	00	00
T ₂ : N ₅₀ P ₀₅ K ₃₀ S ₁₀	50	05	30	10
T ₃ : N ₅₀ P ₁₀ K ₆₀ S ₂₀	50	10	60	20
T ₄ : N ₅₀ P ₁₅ K ₉₀ S ₃₀	50	15	90	30
T ₅ : N ₁₀₀ P ₀₅ K ₃₀ S ₁₀	100	05	30	10
T ₆ : N ₁₀₀ P ₁₀ K ₆₀ S ₂₀	100	10	60	20
T ₇ : N ₁₀₀ P ₁₅ K ₉₀ S ₃₀	100	15	90	30
T ₈ : N ₁₅₀ P ₀₅ K ₃₀ S ₁₀	150	05	30	10
T ₉ : N ₁₅₀ P ₁₀ K ₆₀ S ₂₀	150	10	60	20
T ₁₀ : N ₁₅₀ P ₁₅ K ₉₀ S ₃₀	150	15	90	30

Required amounts of N, P, K, S fertilizers were applied in the form of urea, TSP, MoP and gypsum. Urea was applied in two splits: half amount was applied at sowing and the rest half was top dressed at 45 DAS (days after sowing) while all other fertilizers were applied at the time of sowing. Kenaf seeds were broadcasted at the rate of 12 kg/ha. All cultural operations were done as and when necessary. The crop was harvested when 80% of the plants showed the sign of maturity. After shedding of leaves, the bundles were steeped plot-wise in pond water for 15-20 days for retting and fiber was extracted. At harvesting time, six plants were selected at random from each plot and tagged in the field to note plant height (PH), base diameter (BD), fiber yield (FY) and stick yield (SY).



Figure 1. BJRI Kenaf-4 plant.

3. Results and Discussion

Results revealed that combined fertilizer doses focused the significant positive effect on the yield contributing parameters like plant height, base diameter, (Table 2 & 3). The yield and yield components i.e. plant height, base diameter, yield of fibre and stick were significantly increased over control by different rates of nitrogen. The highest dose of N150 kg/ha reduced the fibre yield (3.06t/ha) in compare to N100 kg/ha (3.13t/ha) at Kishoreganj. Results showed that 100 kg N/ha is enough to produce the variety BJRI Kenaf-4. Incremental N doses enhanced the plant height and base diameter than control.

Phosphorus levels (5, 10 and 15 kg/ha) were used in the experiment. The dose of P 10 kg/ha contributed significantly highest yield of fibre (3.13t/ha) and stick (7.65t/ha) (Table 3). In Kishoreganj, the longest plant (3.14m) found with P 10Kg/ha that was statistically identical with plant height found by P 15Kg/ha. Significantly highest base diameter (19.47mm) found also with P 10Kg/ha (Table 3).

The rate of potassium 0 kg/ha, 30 kg/ha, 60 kg/ha and 90 kg/ha were used to conduct this experiment. In Manikganj the rate 60 kg K/ha gave the highest plant height (3.1m), base diameter (19.16mm), fibre (3.03t/ha) and stick (6.98t/ha) in compare to 90 Kg/ha. Study noticed that the variety BJRI Kenaf-4, needs K 60 Kg/ha to produce maximum yield.

All the treated plots with Sulphur increased the different growth parameters and yield of the variety BJRI Kenaf-4 over control. The highest rate of S 30 kg/ha reduced the plant height. Maximum plant height (3.14m) observed with 20 kg S /ha. Base diameter found the highest (19.47mm) with a medium dose of S 20 kg S/ha. The yield of fibre (3.13t/ha) and stick (7.65t/ha) achieved the highest with 20 kg S/ha (Table 3). The study showed that combined dose of NPK and S 100-10-60-20 Kg/ha was a suitable dose for the cultivation of the variety BJRI Kenaf-4.

Table 2. Results of nutrient combinations on growth and yield of the variety BJRIKenaf-4 at JAES, Manikganj.

Treatment (N-P-K-S kg/ha)	Plant height (m)	Base diameter (mm)	Yield of fibre (t/ha)	Yield of stick (t/ha)
T ₁ : N ₀ P ₀ K ₀ S ₀	1.30f	10.55d	1.10f	3.17e
T ₂ : N ₅₀ P ₀₅ K ₃₀ S ₁₀	2.18e	15.26c	1.96e	4.58de
T ₃ : N ₅₀ P ₁₀ K ₆₀ S ₂₀	2.19de	15.66bc	2.03de	5.03cd
T ₄ : N ₅₀ P ₁₅ K ₉₀ S ₃₀	2.43c	16.36abc	2.38cd	5.26bcd
T ₅ : N ₁₀₀ P ₅ K ₃₀ S ₁₀	3.06ab	17.16abc	2.65b	6.58abc
T ₆ : N ₁₀₀ P ₁₀ K ₆₀ S ₂₀	3.1a	19.16a	3.03a	6.98a
T ₇ : N ₁₀₀ P ₁₅ K ₉₀ S ₃₀	3.01ab	19.11a	2.93ab	6.93ab
T ₈ : N ₁₅₀ P ₀₅ K ₃₀ S ₁₀	2.98ab	19.06a	2.9ab	6.86ab
T ₉ : N ₁₅₀ P ₁₀ K ₆₀ S ₂₀	3.08ab	19.04a	2.93ab	6.83ab
T ₁₀ : N ₁₅₀ P ₁₅ K ₉₀ S ₃₀	3.1a	19.06a	2.94ab	6.78ab
CV (%)	4.95	5.08	4.75	6.42

Table 3. Results of nutrient combinations on growth and yield of the variety BJRIKenaf-4 at Regional Station Kishoreganj.

Treatment (N-P-K-S kg/ha)	Plant height (m)	Base diameter (mm)	Yield of fibre (t/ha)	Yield of stick (t/ha)
T ₁ : N ₀ P ₀ K ₀ S ₀	1.38e	11.81f	1.07f	3.54f
T ₂ : N ₅₀ P ₀₅ K ₃₀ S ₁₀	2.04d	14.32e	1.88e	5.1e
T ₃ : N ₅₀ P ₁₀ K ₆₀ S ₂₀	2.49cd	15.77de	2.13de	5.35de
T ₄ : N ₅₀ P ₁₅ K ₉₀ S ₃₀	2.61bc	16.47cde	2.38cde	5.6cde
T ₅ : N ₁₀₀ P ₅ K ₃₀ S ₁₀	3.11ab	17.18bcd	2.68bc	6.55bc
T ₆ : N ₁₀₀ P ₁₀ K ₆₀ S ₂₀	3.14a	19.47a	3.13a	7.65a
T ₇ : N ₁₀₀ P ₁₅ K ₉₀ S ₃₀	3.09ab	19.12ab	3.08ab	7.29ab
T ₈ : N ₁₅₀ P ₀₅ K ₃₀ S ₁₀	3.06ab	18.92ab	3.06ab	7.45ab
T ₉ : N ₁₅₀ P ₁₀ K ₆₀ S ₂₀	3.11ab	18.72ab	3.08ab	7.55ab
T ₁₀ : N ₁₅₀ P ₁₅ K ₉₀ S ₃₀	3.1ab	19.07ab	3.1ab	7.6ab
CV (%)	5.33	4.86	5.15	5.61

Study exposed that high dose of K (60 kg/ha) caused highest plant height and base diameter (Table 3). Some studies revealed that yield; Plant height and Base diameter increased with increasing rate of K dose [21-28].

Fibre yield and stick yield found significantly positive in trends of different treatments combinations for BJRI Kenaf - 4 (Table 3). Highest fibre yield (3.13 t/ha) and stick yield (7.65 t/ha) were recorded with T₆ (N₁₀₀P₁₀K₆₀S₂₀ kg/ha) treatment, which was 192.52 and 116.10% higher than control (Calculated from Table 3). Based on Fibre yield among the treatments the treatment T₆ can be ranked first and T₁ for last position. The nutrient ratio is one of the key factors for kenaf production that is partially supported by previous report [1, 29].

Economic performance of a variety is a prime need for its cultivation and jute and allied fibre crops is not out of that. There are 1.2 million farmers are still directly connected with jute and allied fibre crops cultivation. Jute sector provides about 10% of total employment (production, transportation, processing and marketing) in the economy [30]. Therefore, economic analysis was made considering the variable cost of fertilizers, seeds, labor and price of fiber and stick (Table 4 & 5). Result reveals that T₆ (N₁₀₀P₁₀K₆₀S₂₀ kg/ha) treatment was the most cost effective treatment as it gives the highest gross return with benefit cost ratio (BCR) which is highly profitable.

Table 4. Economics for var. BJRI Kenaf-4 at Manikganj.

Treatment	Gross return (Taka/hectare)	Variable Cost (Taka/hectare)	BCR
T ₁ : N ₀ P ₀ K ₀ S ₀	51925	60750	0.854
T ₂ : N ₅₀ P ₀₅ K ₃₀ S ₁₀	89850	85930	1.045
T ₃ : N ₅₀ P ₁₀ K ₆₀ S ₂₀	93775	88760	1.056
T ₄ : N ₅₀ P ₁₅ K ₉₀ S ₃₀	108350	91590	1.182
T ₅ : N ₁₀₀ P ₅ K ₃₀ S ₁₀	122450	88030	1.391
T ₆ : N ₁₀₀ P ₁₀ K ₆₀ S ₂₀	138650	90860	1.526
T ₇ : N ₁₀₀ P ₁₅ K ₉₀ S ₃₀	134525	93690	1.435
T ₈ : N ₁₅₀ P ₀₅ K ₃₀ S ₁₀	133150	90130	1.477
T ₉ : N ₁₅₀ P ₁₀ K ₆₀ S ₂₀	134275	92960	1.444
T ₁₀ : N ₁₅₀ P ₁₅ K ₉₀ S ₃₀	134550	95790	1.405

Table 5. Economics for var. BJRI Kenaf-4 at Kishoreganj.

Treatment	Gross return (Taka/hectare)	Variable Cost (Taka/hectare)	BCR
T ₁ : N ₀ P ₀ K ₀ S ₀	51650	60750	0.850
T ₂ : N ₅₀ P ₀₅ K ₃₀ S ₁₀	87950	85930	1.023
T ₃ : N ₅₀ P ₁₀ K ₆₀ S ₂₀	98575	88760	1.110
T ₄ : N ₅₀ P ₁₅ K ₉₀ S ₃₀	109200	91590	1.192
T ₅ : N ₁₀₀ P ₅ K ₃₀ S ₁₀	123575	88030	1.403
T ₆ : N ₁₀₀ P ₁₀ K ₆₀ S ₂₀	144325	90860	1.588
T ₇ : N ₁₀₀ P ₁₅ K ₉₀ S ₃₀	141425	93690	1.509
T ₈ : N ₁₅₀ P ₀₅ K ₃₀ S ₁₀	141025	90130	1.564
T ₉ : N ₁₅₀ P ₁₀ K ₆₀ S ₂₀	142075	92960	1.528
T ₁₀ : N ₁₅₀ P ₁₅ K ₉₀ S ₃₀	143000	95790	1.492

4. Conclusions

Each and every one of the treatments influenced on growth and yield. Among the treatment combination $N_{100}P_{10}K_{60}S_{20}$ kg/ha (T_6) treatment performed best for the most valuable yield parameters fiber and stick yield. We found highest benefit cost ratio from economic analysis and it was originated by the nutrient combination of $N_{100}P_{10}K_{60}S_{20}$ kg/ha. Bearing in mind all these aspects, especially yield and economics, T_6 ($N_{100}P_{10}K_{60}S_{20}$ kg/ha) treatment seems to be the best combination for fibre production of this variety (BJRI Kenaf-4).

Conflict of Interest

The authors declared no conflict of interest exist.

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Jute Seed Yield Response to Irrigation and Nitrogen Fertilization in Field-Grown Environment

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Abstract

The experiment focuses the optimum utilization of irrigation water and fertilizer application on Jute seed production. Four irrigation treatments and four nitrogen doses were tested on jute (var. O-9897) in Jute Agriculture Experimental Station (JAES), Manikganj, Bangladesh during the late Jute season. The highest seed yield of 745.50 kg/ha was obtained from 30 days of irrigation with the application of 100kg N/ha. The lowest seed yield 236.75 kg/ha was obtained from no irrigation and no fertilizer application. Irrigation at 45 days and 30 and 60 (twice irrigation) days didn't show better seed yield compared to 30 days of irrigation treatment.

1. Introduction

Among the jute growing countries of the world, Bangladesh ranks second in respect of production. In 2003-2004, 0.794 million tons of jute were produced from 0.39 million hectares of land which covered 4.73 percent of total cropped area [1]. It is mainly grown for fibre rather than for seed. Nowadays, attention has also been given on its seed production technological researches. Most of the Bangladeshi farmers grow jute seed along with the fibre crop. Farmers harvest their jute crop in time for fibre and keep some jute plants at the corner of the field for seed production. Every year farmers face jute seed problem. Only 15.84 percent need of jute seeds are met by Bangladesh Agricultural Development Corporation [2]. Rest quantity of jute seed is solely produced and utilized by the farmers themselves. Sometimes farmers failed to produce quality seed because of improper management, imbalance fertilizer application or lack of appropriate production practices. Quality seeds of an improved variety itself provide 20 percent additional yield of the crop [3]. These seed crop due to long stay in the field are affected by hailstorm, diseases and insect pests thus produce lower yield of poor quality seeds. In recent years, the agro-ecological condition of the country has abruptly changed and jute seed production as a part of fibre crop is no longer remunerative. Farmers are also very reluctant to grow jute seed. So, the country has been facing acute shortage of quality jute seed every year. Quality seed of an improved variety itself provide 20 percent additional yield of the crop [3]. To overcome jute seed problems and to ensure supply of required quality seeds, Bangladesh Jute Research Institute has been advocating late or off season seed production for higher seed yield and economic return, which to be sown in the month of August and September and

harvested in December and January [3]. In jute production system, water management includes application of irrigation and draining out the excess water is needed from the jute fields. Irrigation is the artificial application of water to the crop field for its proper growth [4]. Nitrogen is one of the key nutrients needed for crop production; however, it is the most mobile and volatile and the most exhausted nutrients due to its ability to exist in different forms and its easy leach ability [5, 6, 7]. In the absence of site-specific recommendations, N management poses a serious challenge in the highlands [8]. Nitrogen management in agroecosystems has been extensively studied due to its importance in improving crop yield and quality [9, 10, 11, 12, 13, 14, 15, 16, 17, 18]. One of the ways of addressing nitrogen limitation is use of inorganic fertilizers [19]. However, there exists inadequate use of fertilizers to replenish the mined nutrients [20]. Jute growers are habituated to follow the technology or practice which has been developed through experiences and tradition and they are reluctant to change their practices [21]. Farmers will pay due attention to the research findings about which they have some experiences and seem to be more economical. Therefore, the present research was undertaken with a view to upgradation of nitrogen fertilizer requirement and frequency of irrigation for seed production of the Jute variety O-9897.

2. Materials and Methods

The field trial was conducted at JAES, Manikganj under Bangladesh Jute Research Institute (Annual Report, Agriculture Research on Jute, Bangladesh Jute Research Institute 2007-2008 and 2008-2009) to examine the nitrogen fertilizer requirement and frequency of irrigation for seed production of the Jute variety O-9897. The experiment was designed by split plot design with 4 nitrogen doses 0 (F_1), 50 (F_2), 100 (F_3), 150 (F_4) kg/ha and the irrigation schedules were (I_0) no irrigation, (I_1) irrigation at 30DAS (I_2) irrigation at 45 DAS (I_3) irrigation at 30 and 60 DAS. The unit plot size was 2.1m x 2.1m, space between plots, blocks and around the field was 1.0m. There were 20cm deep drain around each plot, block and around whole plot to drain out excess rain water. Experiment was set up in the month of august in every year. A common dose of PKSB from TSP, MP, Gypsum and borax respectively were applied to the plot at the time of sowing as per treatment. The pods and seeds were dried in

the air and cooled in desiccators. The data of different parameters of jute seed yield e.g., number of branch per plant, number of pod per plant, number of seed per pod, thousand seed weight and seed yield were recorded.

3. Identification of Lignin

Formation of lignin in the Jute plant was detected using phloroglucinol test. The fibres were separated from the jute plant and the presence of lignin was examined by treating carefully with phloroglucinol reagent.

4. Determination of Chemical Constituents

Chemical constituents of jute fibres from 15 days to 90 days of growth age were determined. The standard analytical procedures for estimation of alpha cellulose [22], Hemicellulose [23], Lignin contents [24, 25, 26], Fatty materials and ash content [27] were followed.

5. Results and Discussion

The seed yield parameters like branch per plant, number of pod per plant, number of seed per pod were more or less influenced with different irrigation and fertilizer treatments (Figure 1 and Figure 2). There was a significant effect of irrigation and nitrogen fertilizer on seed yield of O-9897. The highest seed yield obtained when irrigated at 30 DAS which was statistically significant and highest (Figure 1). 100 kg N/ha showed best performance for seed production (Figure 2). Similar results were also found for rice crop [28]. The higher seed yield from crops having higher number of branches and number of pods per plant [29]. This result also supported by other previous findings [30].

The highest seed yield of 745.50 kg/ha was obtained from 30 days of irrigation with the application of 100 kg N/ha (Table 1). The lowest yield of 236.75 kg/ha was obtained from no irrigation and no nitrogen fertilizer application. Irrigation at 45 days and 30 & 60 (twice irrigation) days didn't show better seed yield compared to 30 days of irrigation treatment (Table 1).

Table 1. Interaction between irrigation and fertilizer on jute seed yield.

Treatments	Number of branch/plant	Number of pod/plant	Number of seed/pod	1000 seed wt (g)	Seed yield (kg/ha)
$I_0 \times F_1$	2.0	6.0	119.11	1.890	236.75
$I_0 \times F_2$	2.75	9.0	120.33	1.883	377.13
$I_0 \times F_3$	2.85	10.18	125.52	1.902	401.36
$I_0 \times F_4$	2.82	9.96	122.27	1.914	390.33
$I_1 \times F_1$	2.1	6.20	140.20	1.902	301.15
$I_1 \times F_2$	3.33	15.15	150.50	1.966	602.0
$I_1 \times F_3$	3.5	16.9	164.29	2.011	745.50
$I_1 \times F_4$	3.42	16.17	160.21	1.980	711.03
$I_2 \times F_1$	2.11	5.90	134.05	1.901	300.0
$I_2 \times F_2$	3.34	15.97	147.07	1.961	577.80
$I_2 \times F_3$	3.42	16.33	167.66	1.980	729.03

Treatments	Number of branch/plant	Number of pod/plant	Number of seed/pod	1000 seed wt (g)	Seed yield (kg/ha)
I ₂ xF ₄	3.41	16.03	149.81	1.980	699.36
I ₃ xF ₁	2.2	6.1	120.05	1.882	296.18
I ₃ xF ₂	3.26	14.65	148.27	1.971	566.25
I ₃ xF ₃	3.44	16.7	167.62	2.00	740.55
I ₃ xF ₄	3.38	16.65	164.22	1.990	703.75
CV (%)	8.2	10.6	12.42	10.25	14.30

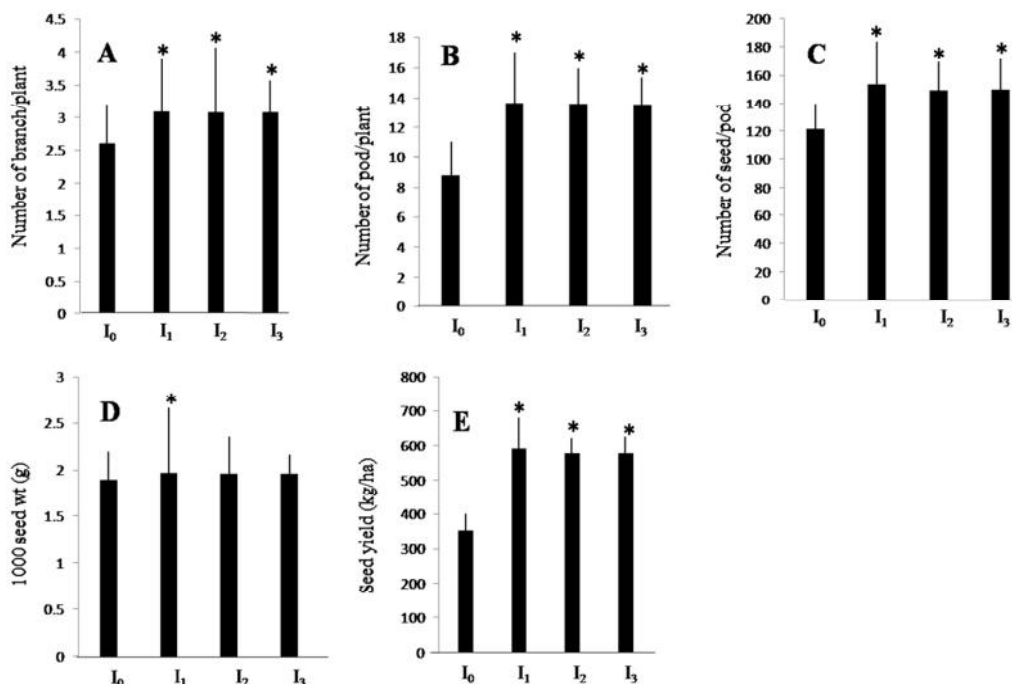


Figure 1. Seed yield and yield contributing characters of the variety O-9897 in different irrigation treatments. (A) Number of branch/plant, (B) Number of pod/plant, (C) Number of seed/pod, (D) 1000 seed wt (g), (E) Seed yield (kg/ha). The results are expressed as the mean ± S. E. M. Asterisks indicate p>0.05 significance by the Student's t-test.

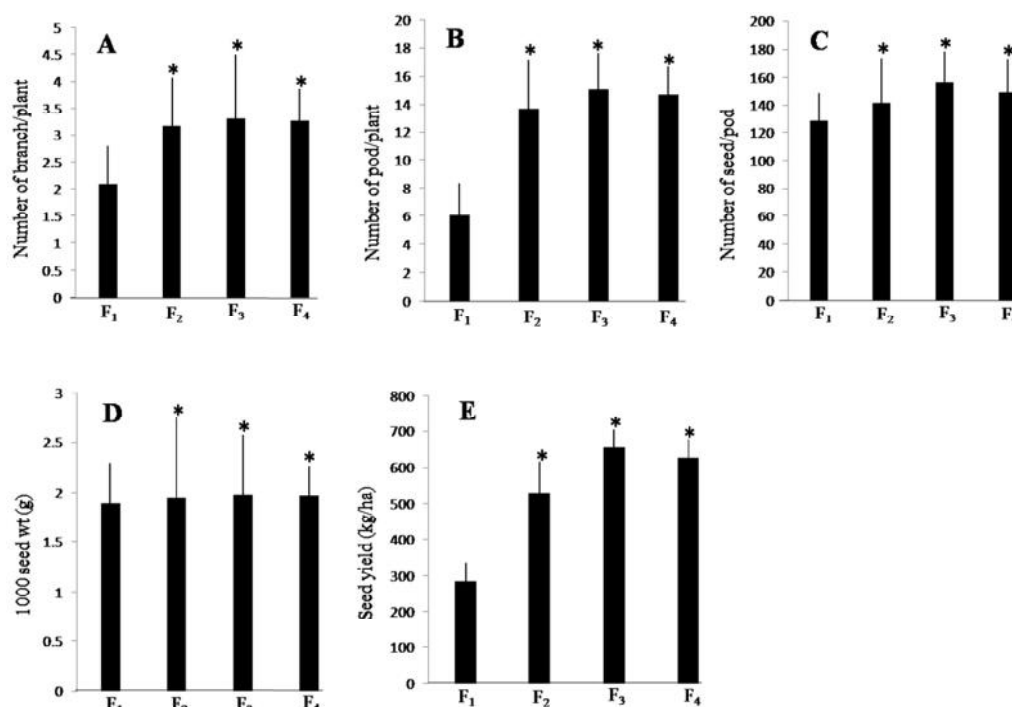


Figure 2. Seed yield and yield contributing characters of the variety O-9897 in different doses of nitrogen fertilizers. (A) Number of branch/plant, (B) Number of pod/plant, (C) Number of seed/pod, (D) 1000 seed wt (g), (E) Seed yield (kg/ha). The results are expressed as the mean ± S. E. M. Asterisks indicate p>0.05 significance by the Student's t-test.

In addition the chemical composition measured for the Jute variety O-9897 because Jute quality depends on its lignin content and biological growth started from lignin formation. Cellulose and Hemicellulose were comparatively lower in the fibre in the early stages and gradually increased (Table 2). Lignin and fat content were predominantly higher than the average values in mature fibre, because of the fact that they were naturally needed for the hardness of the plants to stand up during the growth periods.

Table 2. Chemical composition of jute fibre at different stages.

Name of constituents	% of Chemical constituents at different age of growth (days)			
	15	30	45	60
Alpha cellulose	33.15	43.30	48.60	50.45
Hemicellulose	10.05	16.80	17.65	19.30
Lignin	23.50	16.20	13.40	12.10
Fat	2.5	0.80	0.48	0.57
Ash	-	2.25	1.60	0.52

6. Conclusion

In conclusion, it can be assumed that the highest seed yield was mainly contributed by its higher number of branch per plant, higher number of pod per plant and higher number of seed per pod. Therefore irrigation and fertilizer must be substantial issue for optimum seed production. Irrigation after thirty days of sowing and 100 kg N/ha would be a better choice for late seed production for the Jute variety of O-9897.

Competing Interest

The author declared no competition of interest exists.

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Nutrition and Food Technology: Open Access

Research Article

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Nutrient Management on Growth and Yield of BJRI Tossa Pat 6

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Abstract

Nitrogen, phosphorus, potassium and sulfur are main mineral elements that affect yield and quality in fibre plant production. Experiments to determine the effects of four nitrogen (0, 50, 75 and 100 kg/ha), four phosphorus (0, 5, 10 and 15 kg/ha), four potassium (0, 30, 60 and 90 kg/ha) and three sulfur (0, 10 and 20 kg/ha) levels to increase fibre yield and quality of BJRI tossa (*Corchorus olitorius*) pat 6 plants were conducted in a field experiment. Plant height and stick yield were significantly affected by nitrogen applications. Higher rate of potassium fertilization impact upon plant height and fibre yield was observed. Nitrogen significantly increased fibre yield of plants. Fibre yield was reduced with the highest dose of phosphorus in comparison to yield by the supreme dose of nitrogen. It was concluded that nitrogen mostly improved plant growth and fibre yield while the increase in the level of phosphorus does not have an effect on the increase in yield of fibre and stick.

Keywords: *Corchorus olitorius*; BJRI Tossa pat 6; Nitrogen; Phosphorus; Potassium; Sulfur fertilizers

Introduction

Jute is the principal bast fibre crop of the World and a matter of pride to Bangladesh. Bangladesh and India produce over 92% of the total jute fibre of the world. In world trade, raw jute signifies fibre produced from two jute species, *Corchorus capsularis* (white jute) and *Corchorus olitorius* (tossa jute) and one mesta species *Hibiscus cannabinus* (Kenaf). Although mesta fibre is obtained from two species, roselle (*H. sabdariffa*) and kenaf (*H. cannabinus*), the former is primarily used for production of jams and jellies from calyx. The major jute growing areas in Bangladesh are Faridpur, Jessore, Manikganj, Kishoreganj, Mymensingh and Rangpur regions. *Corchorus olitorius*, belongs to the family-Tiliaceae. It is one of the most popular fibre crops in every districts of Bangladesh. *Corchorus olitorius* is mainly known for its fibre product, jute and for its leafy vegetables [1]. Several species of *Corchorus* are used as vegetable, of which *Corchorus olitorius* is most frequently cultivated. *C. olitorius* is consumed as a healthy vegetable in Japan, because it contains abundant carotenoids, vitamin B1, B2, C and E, and minerals. On the other hand, accidental death of cattle has occurred when the cattle were feed with vegetation containing the seeds, because the seeds contain cardiac glycoside [2]. The dark-green leaves of *C. olitorius* have varying proportion of Ca, Fe, -carotene, vitamin C, fibre and protein required for health [1,3]. Nutrition is an important aspect of Jute production system and this includes adequate supply of essential nutrients like nitrogen, phosphorus, potassium, sulfur etc to the plant. The availability of these nutrients to plant contributes a lot to its growth and yield. Therefore adequate amount of nutrients need to be supplied to plant at the right quantity and also at the right time to favour both growth and yield. NPKS have influence on the growth and yield of fibre crops [4-34]. Fertilizer studies showed positive responses of *Corchorus olitorius* to nitrogen [35]. Phosphorus is important in root development and helps hasten maturity of the fruit. Soils require extraneous inputs of phosphorus for optimum *Corchorus olitorius* growth [36]. The role of nitrogen and phosphorus in crop fertilization, leading to increased absorption of elements can be attributed to increase top growth particularly as a result of nitrogen absorption [37]. Similarly, application of any essential

element should have a marked effect on yield if the soils were deficient in the element. It is, therefore, necessary to determine the growth and yield performance of a *Corchorus olitorius* variety BJRI Tossa pat 6 as affected by NPKS fertilizers application.

Materials and Methods

The experiment was conducted at Jute Agriculture Experimental Station of Bangladesh Jute Research Institute. The experiment was laid out in randomized complete block design with three replications. A total of 10 treatment combinations along with a control were distributed randomly in each equal plot as one replication. Each replication was divided into 10 unit plots. At the time of final land preparation, the land was well prepared and fertilizers were applied as per treatment (Table 1). NPKS fertilizers were applied in the form of urea, TSP, MAP and gypsum respectively.

Half of urea was applied at sowing and the rest half was top dressed at 45 days after sowing while all other fertilizers were applied at the time of sowing. At harvesting time, ten plants were selected at random from each plot and tagged in the field to make a note of yield and yield contributing parameters. (Data Source: Annual report, Agriculture Research on Jute: 2008-2009. Bangladesh Jute Research Institute, pp. 78-80)

Results and Discussion

Nitrogen, phosphorus, potassium and sulfur are main essential elements for most of the biological processes in a plant. Their individual effects and interactions on fibre plants were investigated in many studies [38-41]. Root development, dry matter production and other plant functions regulating crop yield and quality are improved by nitrogen interactions with potassium [42]. In the present study, the different results noticed that application of higher dose of fertilizer influenced on growth and yield of fibre production of the variety BJRI Tossa pat 6 (Figures 1-4).

The plant height, base diameter, yield of fibre and stick were influenced over control by different incremental doses of nitrogen. The N dose 100 kgN/ha provided the best results for the mentioned parameters (Figures 1-4).

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Table 1: Treatment combinations of N, P, K, S

Treatment	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)	Sulfur (kg/ha)
T ₁	00	00	00	00
T ₂	50	05	30	10
T ₃	75	05	30	10
T ₄	100	05	30	10
T ₅	75	10	30	10
T ₆	75	15	30	10
T ₇	75	05	60	10
T ₈	75	05	90	10
T ₉	75	05	30	20
T ₁₀	75	05	30	00

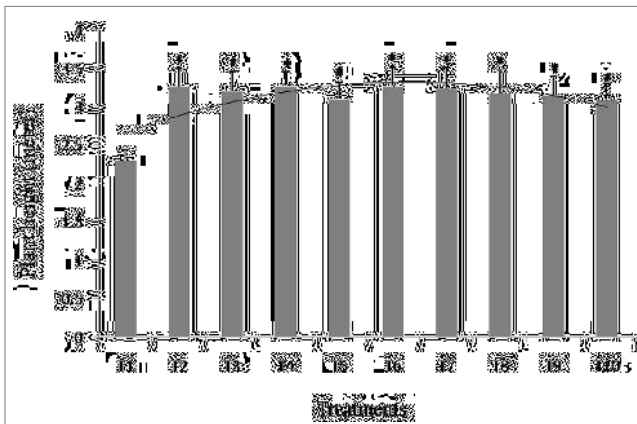


Figure 1: Plant height of the variety BJRI Tossa Pat 6 using different chemical fertilizer treatments. Each datum was calculated from three independent experiments. The results are expressed as the mean \pm S.E.M. * $p < 0.05$ significance by the Student's t-test.

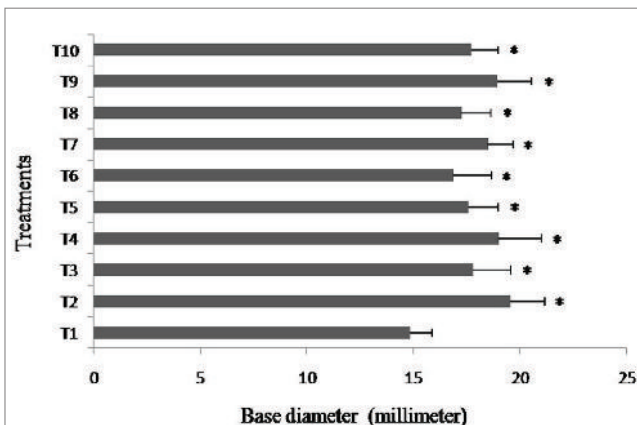


Figure 2: Base diameter of the variety BJRI Tossa Pat 6 using different chemical fertilizer treatments. Each datum was calculated from three independent experiments. The results are expressed as the mean \pm S.E.M. * $p < 0.05$ significance by the Student's t-test.

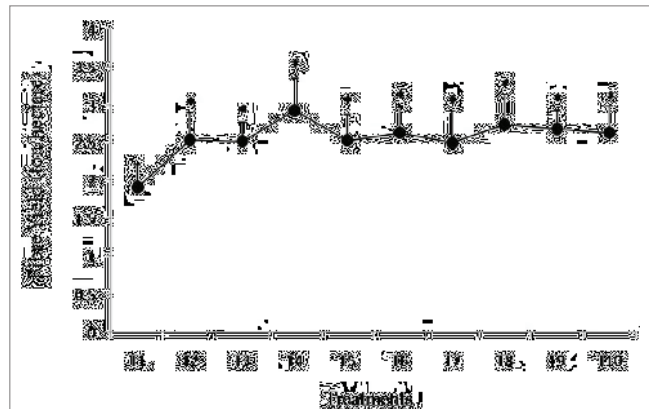


Figure 3: Fibre yield of the variety BJRI Tossa Pat 6 using different chemical fertilizer treatments. Each datum was calculated from three independent experiments. The results are expressed as the mean \pm S.E.M. * $p < 0.05$ significance by the Student's t-test.

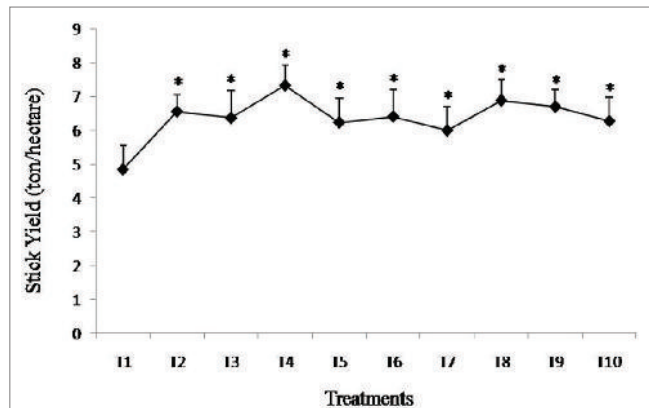


Figure 4: Stick yield of the variety BJRI Tossa Pat 6 using different chemical fertilizer treatments. Each datum was calculated from three independent experiments. The results are expressed as the mean \pm S.E.M. * $p < 0.05$ significance by the Student's t-test.

The highest plant height was observed with supreme dose of phosphorus 15 kgP/ha (T₆). The yield of fibre was reduced (T₆) with highest dose of 15 kgP/ha in comparison to supreme dose of nitrogen. The highest dose of Phosphorus (T₆) produced lower stick yield. However the effect of P was not much pronounced either on fibre and stick yield due to the incremental doses.

The average plant height, base diameter and stick yield were obtained by 30, 60 and 90 kg K/ha respectively. In case of fibre yield highest dose of K 90 kg/ha (T₈) yielded highest over all the treatments except the yield found by treatment T₄. It is evidence in producing higher rate of fibre needs potassic fertilizer [4,26-31].

There were used three doses of sulfur *viz.* 0, 10, and 20 kg/ha. It was observed from the result that higher dose of S (20 kg/ha) decreased the plant height (T₉) in compare to 10 kg S/ha (T₃). Although the fibre yield was increased with increasing doses of sulfur. Higher dose of sulfur (20 kg S/ha) produced higher fibre yield (T₉) compared to control, but 10 Kg S/ha produced significantly highest yield (T₄). Stick yield also showed similar trend of result.

Highest fibre yield and stick yield were obtained with T_4 ($N_{100}P_{5}K_{30}S_{10}$ kg/ha) treatment. The nutrient combination and their ratio is one of the key factors for BJRI Tossa pat 6 production that is supported by previous report [4,32,33].

Economic analysis was done considering the variable cost of fertilizers, seeds, labor and price of fibre and stick. The highest gross return (Figures 5 and 6), gross margin (Figure 7) and benefit cost ratio (Figure 8) were found with the treatment T_4 . This reveals that T_4 treatment was the most cost effective treatment as it gives the highest benefit cost ratio which is highly profitable. This result is due to efficient supervision and management practices (Figure 9).

Conclusions

The present study outlined specific effects of NPKS fertilization on growth and yield of BJRI Tossa pat 6. Taking into account the results of fibre yield and economic analysis, combination of $N_{100}P_{5}K_{30}S_{10}$ kg/ha showed better performance for BJRI Tossa pat 6. Nitrogen significantly increased fibre yield but highest dose of phosphorus reduced fibre yield in comparison to supreme dose of nitrogen. Further investigations are thus still required to understand response of BJRI Tossa pat 6 (Figure 10) to mineral fertilization.

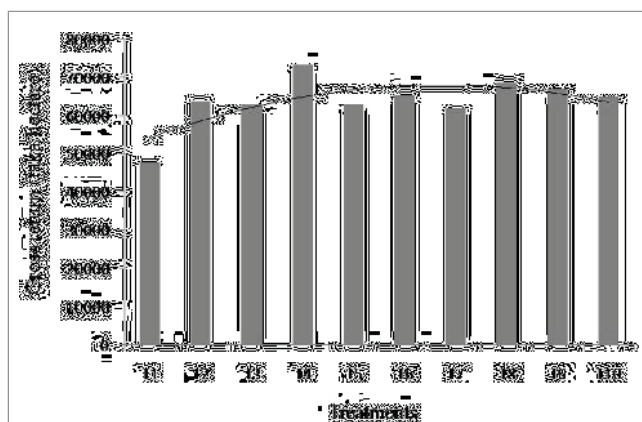


Figure 5: Gross return (Tk/ha) for the production of BJRI Tossa Pat 6

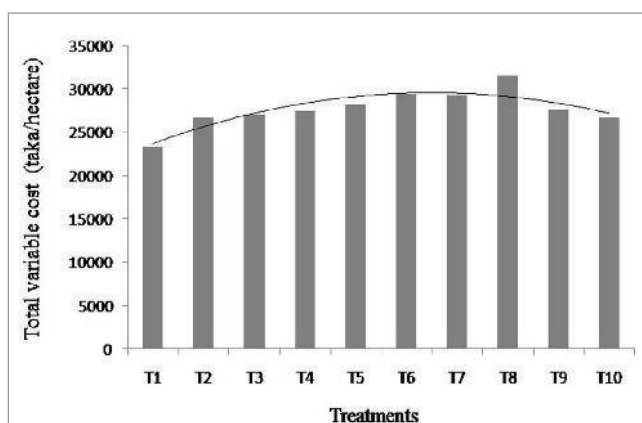


Figure 6: Total variable cost (TK/ha) for the production of BJRI Tossa Pat 6

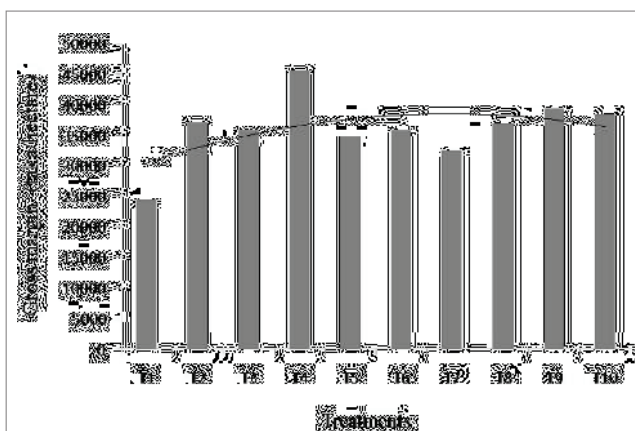


Figure 7: Gross margin (Tk/ha) for the production of BJRI Tossa Pat 6

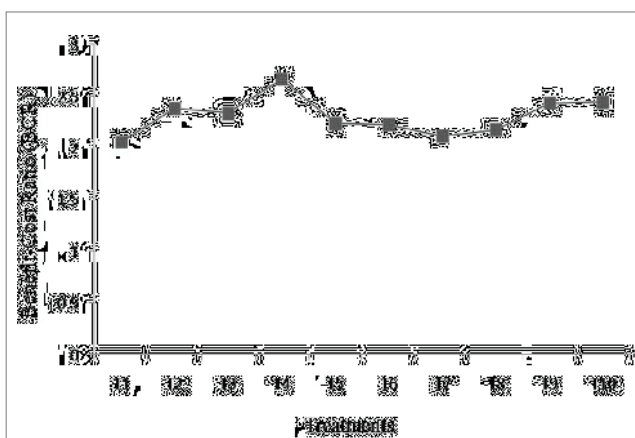


Figure 8: Benefit-cost ratio for the production of BJRI Tossa Pat 6



Figure 9: Intercultural operations; (A) Supervision suggesting for intercultural operations, (B) intercultural operations activities, (C) After intercultural operations



Figure 10: BJRI Tossa Pat 6 plant

Author Contribution

MdSA performed the research work and wrote the manuscript; MdNG and MdMI supervised the program.

Conflict of Interest

The authors declare that they have no competing interests.

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Keywords

NPKS Nutrients,
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Economics,
Location

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Variation in Inorganic Fertilizer Is an Important Regulator of Yield Potential in BJRI Mesta-3

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Abstract

A field experiment was conducted to determine the effects of inorganic fertilizer on growth, yield and economic potential of BJRI Mesta-3. The results indicated significant affect of different NPKS levels on Mesta yield and yield contributing characters over control. The highest fibre (3.10t/ha) and stick (7.20t/ha) yield were obtained by the combination dose of N100 Kg/ha with PKS 10-60-20 kg/ha at Manikganj. The plant height (3.08m), base diameter (20.10mm) also found highest with the same treatment of fertilizer combination. By the same treatment produced higher fibre yield and yield contributing characters at Kishoreganj though that yield was slightly lower than that of Manikganj location. Economic analysis favored the use of 100-10-60-20 kg/ha NPKS for yield of 3.10 t/ha Mesta fibre. Therefore this combination seemed to be optimum for good growth and high potential Mesta production in Bangladesh. Application of modern fertilizer technologies on the mechanized management of Mesta will greatly increase grower profit.

1. Introduction

Mesta is one of the most important bastfibre crops grown in Bangladesh. Mesta fibre is used for making rope, twines, carpet backing etc. The productivity of Mesta is high in some areas while in others it is low. Mesta (*Hibiscus sabdariffa L.*) is a botanical species of the family Malvaceae. Probably native to tropical Central and West Africa, Mesta is mainly cultivated in tropical and subtropical regions of the world for its attractive edible calyces [1-2]. Apart from nutritional and health importance, Mesta plays an important role in income generation and subsistence among rural farmers in developing countries. The different parts of Mesta are the leaves, calyces and seeds and these have been used for different uses as vegetables, source of oils, refreshing drinks and food preserves and for medicinal and health purposes [3-4]. The tender stems, leaves and calyces are used as vegetable in the preparation of soups and sauces – calyces are specially prepared into a textural form suitable for use as meat substitute. The seed of Mesta is a valuable food resource on account of its protein (20-33%), calorie (24%), and fat (22% on dry weight basis) and also substantial amount of fibre (14%) and valuable micro-nutrients [5]. It is also an excellent source of culinary oil. The oil content in Mesta seed is also reported to be of high lysine level. The calyx which may be green, light or dark- red is used as a vegetable or for food and beverages preservation in food industries. More recently the

nutritional attributes of the vegetable and potential health benefits of extracts from the calyx have been reported. Despite the importance of Mesta in Bangladesh, many constraints still limit its production. Yield and quality of the calyxes and seeds realized on farmers' fields are usually lower than what is being reported under experimental conditions. Application of fertilizer has been documented to enhance plant growth and development [6-11]. Many research activities have reported an increase in the vegetative development of crops with fertilizer application [12-29]. However, there are contrary views on the role of fertilizer on the quality of crop produced. Improved soil nutrients could improve the quality of the minerals, vitamins and protein content of Mesta. Research efforts are therefore required to formulate and recommend fertilizer requirement for sustainable production of this crop. The nutritional requirements for jute and allied fibre crops may be different due to their variation in genetic potentialities. Judicial application of NPK and S may increase the yield of a variety. Since the varieties of a species may differ in their nutritional requirements. Investigation is needed to find a suitable dose for a variety with different levels of nutrients. Present study was aimed to determine the nutritional requirements of the variety BJRI Mesta-3 (SAMU'93) for its optimum growth and yield.

2. Materials and Methods

The study was carried out at the Experimental farms of Bangladesh Jute Research Institute applying randomized complete block design (RCBD) with three replications. A total 10 treatments ($T_1:N_0P_0K_0S_0$; $T_2:N_{50}P_5K_{30}S_{10}$; $T_3:N_{50}P_{10}K_{60}S_{20}$; $T_4:N_{50}P_{15}K_{90}S_{30}$; $T_5:N_{100}P_5K_{30}S_{10}$;

$T_6:N_{100}P_{10}K_{60}S_{20}$; $T_7:N_{100}P_{15}K_{90}S_{30}$; $T_8:N_{150}P_5K_{30}S_{10}$; $T_9:N_{150}P_{10}K_{60}S_{20}$; $T_{10}:N_{150}P_{15}K_{90}S_{30}$) combinations along with a control were distributed randomly in each plot. The dimension of unit plots was 3.1 m × 3.1 m having 1m space between the plots, blocks and around the field. There was 20 cm deep drain around each block and plot. At the beginning of the experiment, the land was well prepared and fertilizers were applied as per treatment. Required amounts of chemical fertilizers were applied in the form of urea, TSP, MOP and gypsum. Urea was applied in two splits: half amount was applied at sowing and the rest half was top dressed at 45 days after sowing while all other fertilizers were applied at the time of sowing. Mesta seeds were broadcasted at the rate of 8 kg/ha. All cultural operations were done as and when necessary. The crop was harvested on 120 DAS. After shedding of leaves, the bundles were steeped plot-wise in pond water for 15–20 days for retting and fibre was extracted. At harvesting time, six plants were selected at random from each plot and tagged in the field to note plant height (PH), base diameter (BD), fibre yield (FY) and stick yield (SY). Statistical and economic analyses were also carried out.

3. Results and Discussion

Our research findings showed that among the ten nutrient combinations of chemical fertilizer, nutrient combination for treatment T_6 performed best for the test variety BJRI Mesta-3 yield and yield influencing factors. The growth attributes of field grown BJRI Mesta-3 (Figure 1) were significantly affected by the applied treatments like plant height (Figure 2), base diameter (Figure 3) and yield of fibre (Figure 3) and stick (Figure 4).



Figure 1. BJRI Mesta-3 plant.

Different levels of nitrogen @ 50, 100 and 150 kg/ha were used in the trial and increased plant growth and yield over control (Figure 2 to Figure 5). The highest dose of N150 kg/ha reduced the fibre yield (2.92t/ha) in compare to N100

kg/ha (3.1t/ha) in Manikganj (Figure 4A). Results showed that 100 kg N/ha is enough to produce BJRI Mesta-3 (Figure 4). Incremental N doses enhanced the plant height and base diameter than control (Figure 2 & Figure 3).

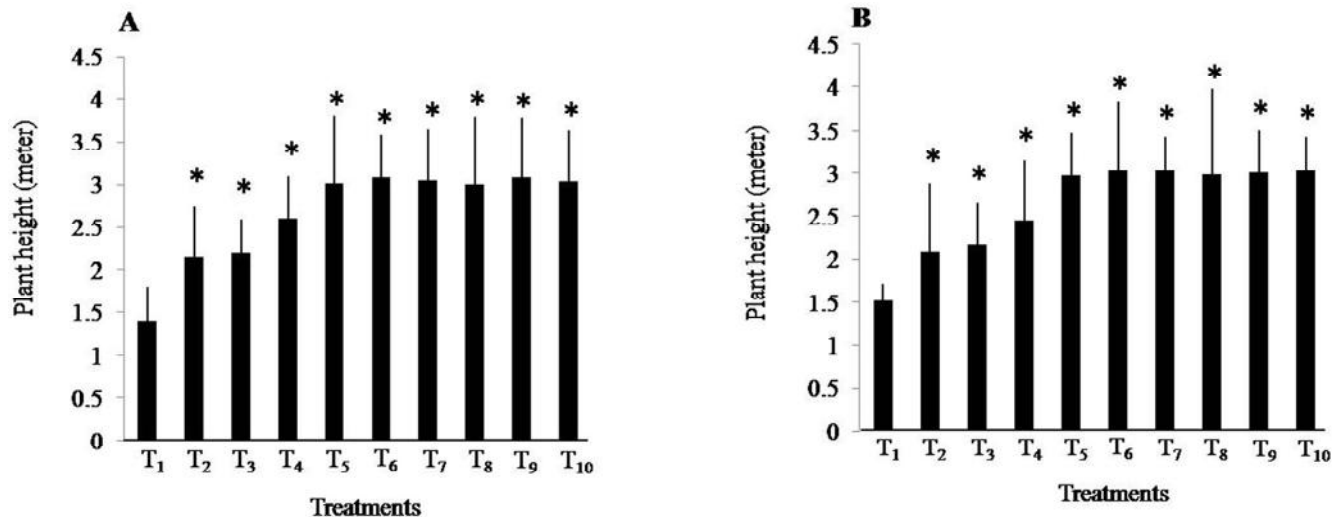


Figure 2. Plant height of the variety BJRI Mesta-3 using different chemical fertilizer treatments. (A) level of plant height (meter) in Manikganj location, (B) level of plant height (meter) in Kishoreganj location. Each datum was calculated from three independent experiments. The results are expressed as the mean \pm S.E.M. * $p < 0.05$ significance by the Student's *t*-test.

Phosphorus doses viz: 5, 10 and 15 kg/ha were used in the experiment. The dose of P 10 kg/ha contributed significantly highest yield of fibre (3.1t/ha) and stick (7.20t/ha) (Figure 4A). In Kishoreganj, the longest plant (3.03m) found with P 10Kg/ha that was statistically identical with plant height found by P15Kg/ha (Figure 2B). Significantly highest base diameter (20.0mm) found also with P 10Kg/ha (Figure 2B).

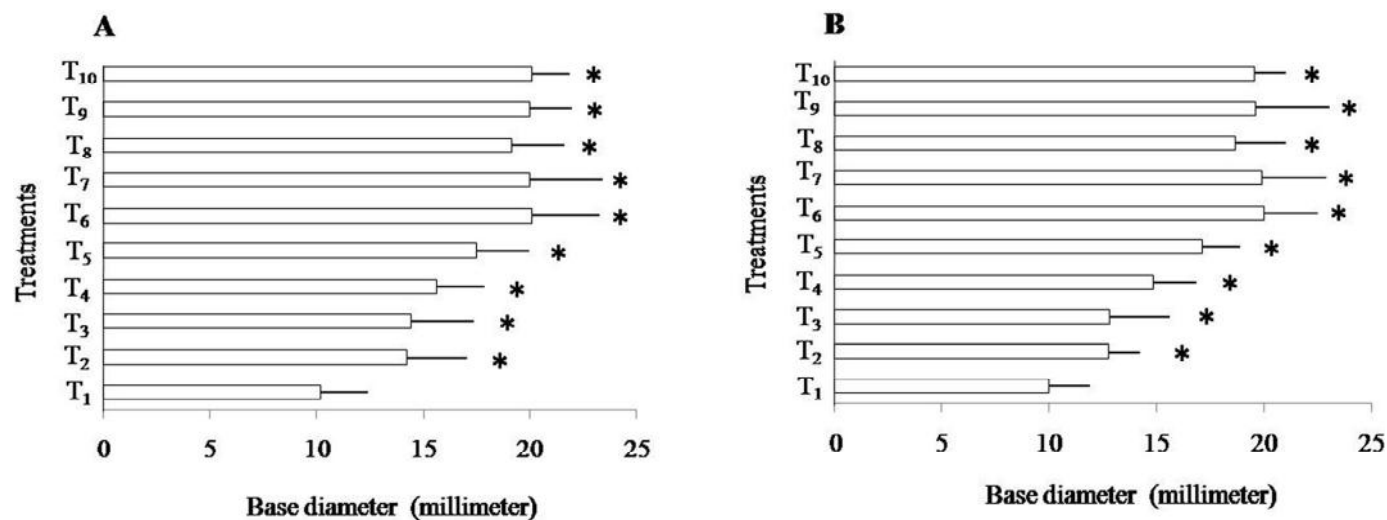


Figure 3. Base diameter of the variety BJRI Mesta-3 using different chemical fertilizer treatments. (A) level of base diameter (meter) in Manikganj location, (B) level of base diameter (meter) in Kishoreganj location. Each datum was calculated from three independent experiments. The results are expressed as the mean \pm S.E.M. * $p < 0.05$ significance by the Student's *t*-test.

Potassium was applied as 30, 60 and 90 kg/ha in the experiment. In Manikganj the rate 60 kg K/ha gave the highest plant height (3.08m), base diameter (20.10mm,) fibre (3.10t/ha) and stick (7.20t/ha) in compare to 90 Kg/ha (Figure 2A, 3A, 4A, 5A). Study noticed that BJRI Mesta-3, needs K 60 Kg/ha to produce maximum yield. High dose of K (60 kg/ha) caused highest plant height and base diameter. Some studies revealed that yield, Plant height and Base diameter increased with increasing rate of K dose [30-37].

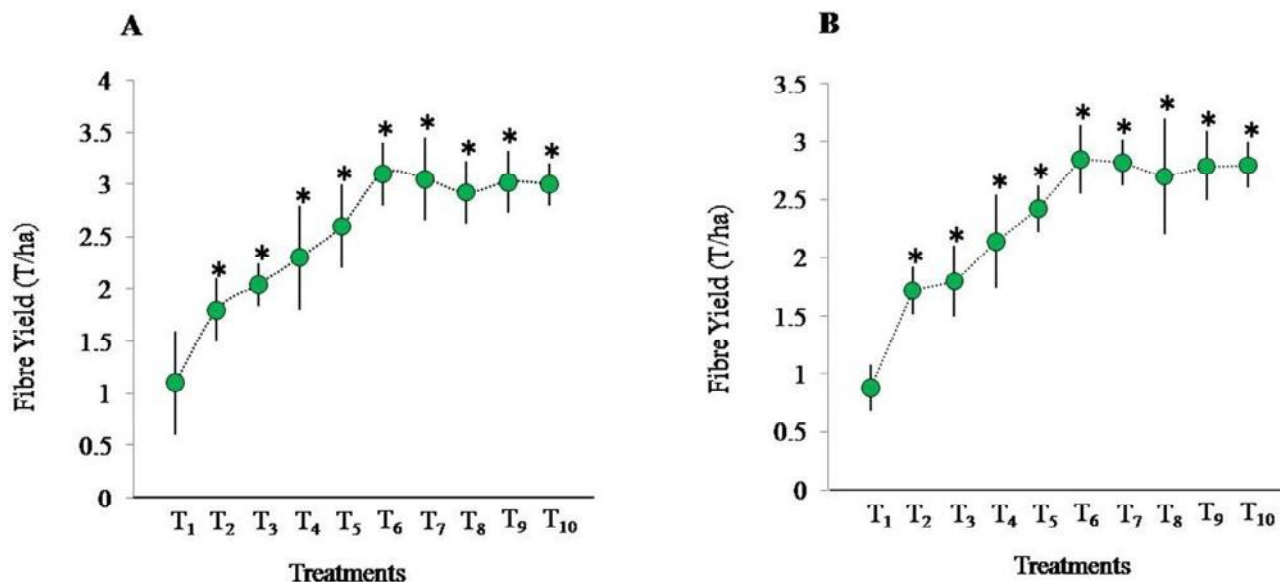


Figure 4. Fibre yield of the variety BJRI Mesta-3 using different chemical fertilizer treatments. (A) level of fibre yield (t/ha) in Manikganj location, (B) level of fibre yield (t/ha) in Kishoreganj location. Each datum was calculated from three independent experiments. The results are expressed as the mean \pm S.E.M. * $p < 0.05$ significance by the Student's *t*-test.

Sulphur was applied as 10, 20 and 30 kg S /ha in the experiment beside one control. The highest rate of S 30 kg/ha reduced the plant height (Figure 2). Maximum plant height (3.08m) observed with 20 kg S /ha (Figure 2A). Base diameter found the highest (20.10mm) with medium dose of S 20 kg S/ha (Figure 3A). Yield of fibre (3.10t/ha) and stick (7.20t/ha) achieved the highest with 20 kg S/ha (Figure 4A, 5A). Study showed that combined dose of NPK and S 100-10-60-20 Kg/ha was a suitable dose for the cultivation of BJRI Mesta-3.

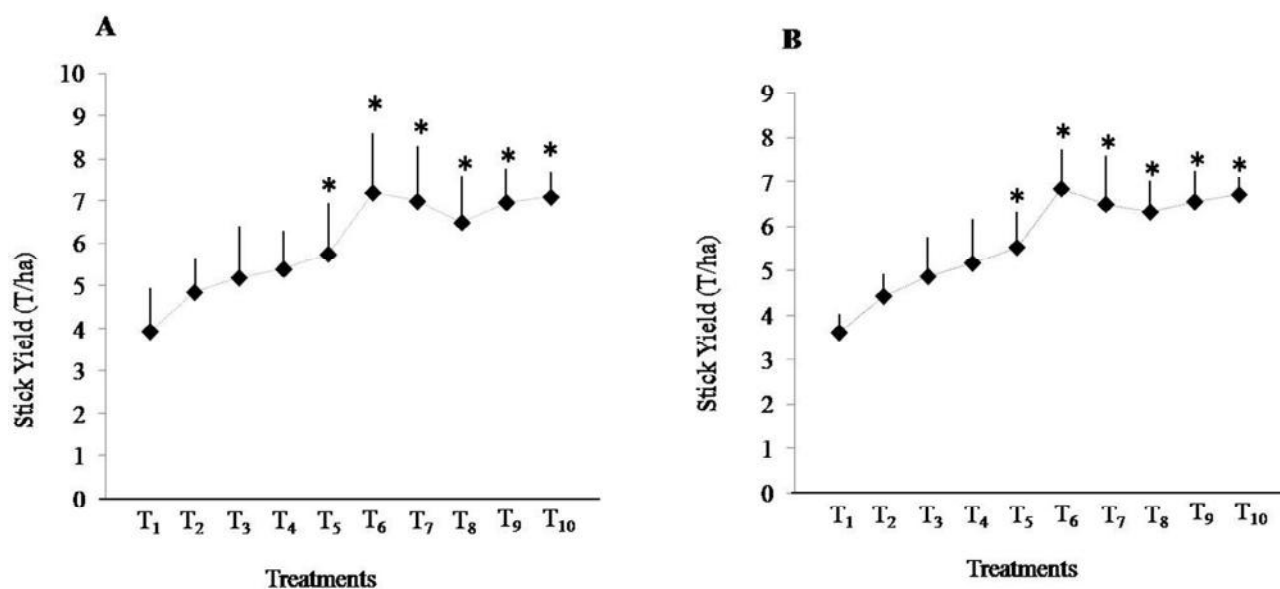


Figure 5. Stick yield of the variety BJRI Mesta-3 using different chemical fertilizer treatments. (A) level of stick yield (t/ha) in Manikganj location, (B) level of stick yield (t/ha) in Kishoreganj location. Each datum was calculated from three independent experiments. The results are expressed as the mean \pm S.E.M. * $p < 0.05$ significance by the Student's *t*-test.

Different treatments showed the statistically significant positive effect on fiber yield and stick yield of BJRI Mesta-3 (Figure 4 and Figure 5). Highest fiber yield and stick yield were recorded with T₆ (N₁₀₀P₁₀K₆₀S₂₀ kg/ha) treatment. The nutrient combination and their ratio is one of the key factors for Mesta production that is supported by previous report [38-39].

There is a great contribution of jute and allied fibre crops

in Bangladesh economy. About 1.2 million farmers are still directly associated with jute and allied fibre crops cultivation. Jute sector provides about 10% of total employment in the economy [40]. Economic analysis was made considering the variable cost of fertilizers, seeds, labor and price of fibre and stick. Results reveals that T₆ (N₁₀₀P₁₀K₆₀S₂₀ kg/ha) treatment was the most cost effective treatment as it gives the highest benefit cost ratio (BCR) (Figure 6) which is highly profitable.

Jute, Kenaf and Mesta Crops Research Reviews

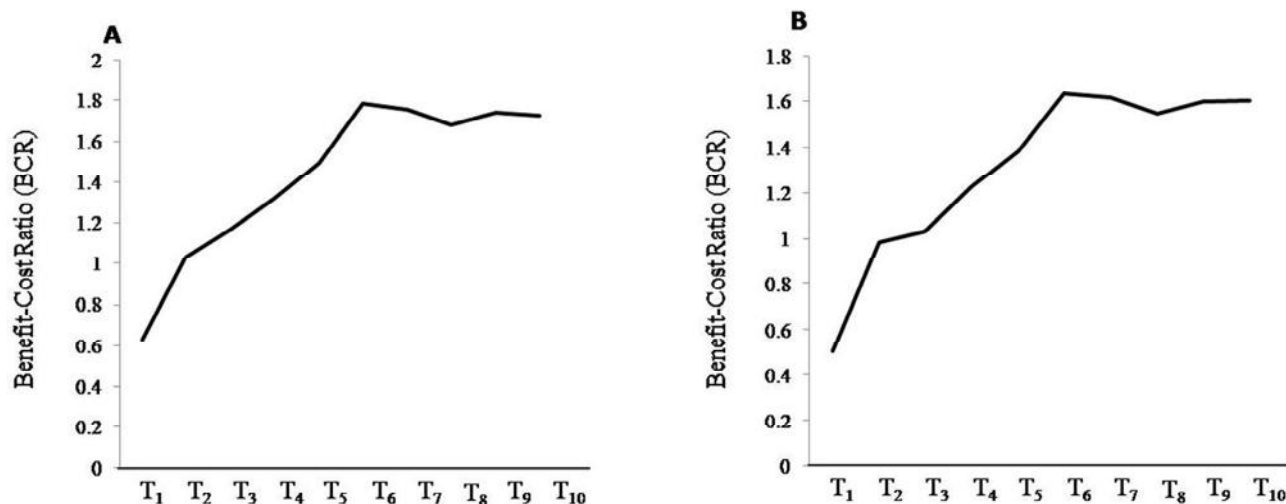


Figure 6. Benefit-cost ratio for the production of BJRI Mesta-2. (A) Yield potential in Manikganj, (B) Yield potential at Kishoreganj.

4. Conclusion

The overall treatments had significant positive impact over control (T₁) on growth and yield and quality parameters and effect of combined fertilizers on them were explained. The most important parameter, fibre yield (3.1 t/ha) and stick yield (7.2 t/ha), were recorded highest with T₆:N₁₀₀P₁₀K₆₀S₂₀ treatment. From the results of economic analysis, combination of N₁₀₀P₁₀K₆₀S₂₀ kg/ha showed higher BCR. Considering all these aspects, specially yield and BCR, T₆:N₁₀₀P₁₀K₆₀S₂₀ kg/ha treatment seems to be the best combination for the yield potential of the Mesta variety BJRI Mesta-3.

Significance Statement

This study discovers the economically profitable fertilizer level for BJRI Mesta-3 production that can be beneficial for farmers and farming related community. This study will help the researcher to uncover the critical areas of nutrient balance that will combine research and teaching.

Authors' Contribution

Ali, M. S. designed and performed research, analyzed data and wrote the manuscript; Hoque, M. M. analyzed data; Gani, M. N. supervised the research; and Islam, M. M., supervised and edited the first draft of the manuscript.

Conflict of Interest

The authors declare that they have no competing interests.

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Biography



Md. Mahbubul Islam (Corresponding Author) awarded PhD in 2008 from the Department of Agronomy of Bangladesh Agricultural University especially on Jute seed quality, plant establishment and yield. He had done his M.Sc. (Agriculture) in Agronomy and B.Sc. Agriculture (Hons.) from the same University. He is working at Bangladesh Jute Research Institute (BJRI) since 1989. At present he is serving as Chief Scientific Officer & Head of Agronomy Division. He has 6 books, 67 scientific papers and more than 70 popular articles published in international and national journals, newsletters etc. He visited United Kingdom, Malaysia, India for training, seminar, workshop purpose.

Jute of Bangladesh

It's contribution to environment and challenges

Dr. Md. Mahbulul Islam



Dr. Md. Mahbulul Islam
Chief Scientific Officer (cc)
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Jute (*Corchorus* spp.) is now universally recognized that jute is the English version of the current Bengali word 'Pat', a kind of fibre which is obtained from two species (annual and short day plants) of the genus *Corchorus* belonging to the family Tiliaceae. It is a common term used both for plant and the fibre obtained from the bark of the plants, *Corchorus capsularis* L. and *Corchorus olitorius* L. There are over 30 species, which belongs to the genus *Corchorus*. Jute is an important fibre crop of Bangladesh. Among the jute growing countries of the world, Bangladesh ranked second in respect of fibre production and jute alone contributes about 1.58% to GDP without involving any foreign investment (BBS 2011). In 2011-2012, 1523 thousand tones of jute fibre were produced from 7 lakh hectares of land (FAO stat). Jute fibres are mainly used for making hessian, sacks, bags, wall mats, carpet backing cloths etc. Jute crop enriches the top soil by adding organic matter through dropping leaves and left over roots in the field.

Jute was, once, the golden fibre of Bangladesh not only for the rich golden colour of the fibre but also, metaphorically, for jute's valuable contribution to the country's economy. Up to mid-twentieth century, about 80% of the world's jute was produced in Bangladesh and it was the country's highest foreign currency earner till early 80s. But, the emergence of petroleum-based synthetic substitutes, which were many times cheaper and convenient to use, quickly took over the market of jute. In 1980-81, jute and jute products jointly earned 68% of the country's total foreign exchange; the share came down to 6% in 1990-91.

The dramatic decline of jute's share in Bangladesh's export earning can partly be explained by the export growth of other industrial sectors, e.g. garments and the increase in remittance inflow. But, the substantial fall in jute's price and world demand was also largely responsible for the decline, which had a huge impact on the livelihoods of poor jute growers in the country. As Bangladesh's economy was mainly agro-based (though agriculture's contribution in the GDP has gone down to less than 30% in recent years, the sector is still the largest employer), jute was the only source of cash for millions of Bangladeshi farmers. Consequently, the falling price of jute had a disastrous impact on their lives. Gradually, the area under jute cultivation started to decline. At present jute is produced only in the core areas, where the production volume and quality are the best and where there is no other alternative to producing jute.

Yet, the importance of jute in Bangladesh cannot be ignored. About 1.2 million farmers are still directly associated with jute cultivation. Jute sector provides about 10% of total employment (production, transportation, processing and marketing) in the economy (Source: *Ministry of Textiles and Jute website*). For last 3/4 years, jute sector has been experiencing a slight revival. Growing awareness about environment around the world in recent years, along with the volatile price of petroleum, is bringing new market opportunities for jute. So, it is the high time to exploit the growing world market opportunities of jute to bring back the lost glory of Golden Fibre of Bangladesh.

In terms of environmental issues jute gradually lost its market to synthetic substitutes, which are a lot cheaper than jute. The market price per unit of synthetic goods in the short run is meager compared to jute goods because it excludes the environmental cost; synthetic goods degrade neither biologically nor chemically. As a result, social pollution arises, which should be considered as an environmental cost of producing and consuming synthetic goods. Production of polythene emits huge amount of carbon-di-oxide in the atmosphere, contributing to global warming. Soil degradation as a result of the use of polymers is well-known. These polymers make a layer in the upper surface of the soil; consequently a natural tilling system does not work well. The agricultural land is adversely affected nutritionally, and hence, land becomes afflicted from the standpoint of fertility, which in turn affects the usual growth of biomass. Synthetic products waste also block the natural flow of water causing water logging and flooding. Besides, the huge amount of non-degradable waste is a critical problem on its own. So, if the long-term environmental and social costs of synthetic products are considered, the price of synthetics would be much higher than that of jute.

Cultivated area and production of Jute

The area under jute cultivation in Bangladesh remained almost static during the 2006-2010. In the year of 2011 Jute cultivation areas of Bangladesh

sharply increased by 70% compared with the figure of 2010. The jute production in Bangladesh was relatively stable. In 2007 production in Bangladesh decreased by 45 thousand tonnes from the previous year but it turned again in increasing trend from the year 2008. In 2011 production of jute in Bangladesh increased by 79.5% compared with the production of the year 2008 (Table 1).

in the markets during the four months period from September to December in each jute marketing season. The export price of raw jute (two selected grades) from Bangladesh during 2006-2012, it is comprehended that the price was relatively high during 2009 -2011 but the prices of both the grade of raw jute declined sharply in jute year 2011-12. Local traders and industries of Bangladesh faced fund cri-

11 tons of oxygen during the jute growing season (about 100 days). Carbon dioxide (CO₂) emissions in the transport and milling of jute fibre also amounts to one-sixth of those generated during PP manufacture. Atmospheric CO₂ is the most important of the greenhouse gases implicated in global warming. Jute thus provides environmental benefit.

Table 1. Cultivated area and production of Jute during 2006-2011

Year	Cultivation Area (In 000 Hectare)	Production (In 000 Tonnes)
2006	419.0	884.0
2007	440.5	838.7
2008	420.5	848.7
2009	416.0	923.5
2010	416.4	923.5
2011	708.7	1523.3

Source: FAO Stat

Jute Prices at grower level of Bangladesh during 2008 - 2011

In 2010 growers of Bangladesh enjoyed better price comparing with the previous years' price. But in 2011 jute growers faced a sharp decline by around USD 200/Tonne in Jute price (Table 2).

In Bangladesh there is no Minimum Support Price (MSP) for jute as it is prevalent in India. On the other hand there is MSP for paddy/rice. As farmers get competitive returns from substitute crops like rice, they switched over to paddy cultivation from jute.

sis for jute procurement in last year which pulled down the jute prices in local market as well as export prices (Table 2).

Jute's contribution to environment

Jute, which has versatile uses because of its physical and chemical properties such as high tensile strength, low extensibility, and better breath-ability, has immense environmental benefits:

Biodegradability: Jute fibre and as such jute products are 100% biodegradable and recyclable. They are environment-friendly and can also be disposed

Biological efficiency: Jute is the second most important vegetable fibre after cotton, in terms of usage, global consumption, production, and availability. It is also the cheapest natural fibre. Dry stem of jute can be a substitute of wood in many ways such as firewood, fencing and raw-material of paper and hardboard. Whereas trees only produce between 8 to 12 tons of wood per hectare annually, Jute produces between 20 to 40 tons of dry stem. Again, jute can be harvested within 4 to 6 months. In comparison, the fastest growing trees take between 10 and 14 years to mature. Jute stem has very high volume of cellulose, which helps to save the forest and meet wood requirement of the world in an eco-friendly manner. Jute is an annually renewable energy source, an important source of firewood in rural Bangladesh. It has high tensile strength, low extensibility and it ensures better breath-ability of fabrics. Therefore, jute is very suitable in agricultural commodity bulk packaging.

Table 2. Jute Prices at grower and export level of Bangladesh

Year	Jute price (USD/Tonne)	Year	Jute export price (USD/Tonne)	
			BWC	BWD
			2006/07	365.0
		2007/08	422.9	382.9
2008	344.68	2008/09	564.6	516.7
2009	419.43	2009/10	831.3	788.1
2010	697.99	2010/11	830.8	741.7
2011	498.07	2011/12	698.8	536.3

Source: FAO Stat

Raw jute grower level price (2008-2011) and export price (2006-2012) movement in Bangladesh

Most of the raw jute producing farmers belong to the small and marginal farmer categories. These farmers have inadequate holding capacity which propels them to off load their produce by the earliest opportunity. More than 75 percent of the total fibre production arrives

of without causing any environmental hazard.

Cleansing of the air: Like all plants, jute absorbs CO₂ from the atmosphere when it grows and returns it when it decays. Studies indicate that, one hectare of jute plants can consume up to 15 tons of carbon dioxide and release

Improvement of soil conditions and other crops: Jute enriches soil with nitrogen and organic component as large portions of leaves and roots remain with the soil. Thus jute plays a vital role in maintaining the fertility of the intensively cultivated agricultural land. When jute is rotated with other crops, it can improve the health of those other crops and reduce their risk of pest attack and disease infestation.

Sound agricultural practices: Studies have found that typical jute agricultural practices are environmentally sound - they cause minimal impact to the natural environment. Relatively modest amounts of fertilizer, herbicide, and pesticides are required for jute cultivation-especially in comparison with cotton. The flooded fields in which jute grow support diverse fish populations, which play a critical role in the Bangladeshi diet (especially for the poor). Hence the fact that jute can be

grown without reliance on pesticides is an important environmental benefit. Jute also creates substantial employment for the poor. Cost of labour in the cultivation of raw jute ranges from nearly 60-70% of total cost per acre; it is a labour intensive crop.

Greener production of JDPs: Production of jute and jute diversified products is considerably less polluting than its commonly used substitute i.e. polypropylene (PP) cloth. Energy use in the production of PP cloth is estimated at 84 gigajoules/ton, at least six times the energy requirement for the production of jute cloth. Jute bags are much stronger than poly sacks and can be re-used and easily repaired. Jute bags have further advantages over synthetic bags as jute bags are longer lasting, reusable, have better porosity, breathability and the ability to withstand high temperature.

Reduced hazards: Jute has good insulating and antistatic properties with low thermal conductivity and moderate moisture regain. Unlike synthetic substitute, jute does not cause skin irritation.

Other uses: The edible leaves of the jute plant provide a cheap (often free) source of food for the poor. On the other hand, Jute stalks, left after the fibre is stripped away, are a renewable source of cooking fuel and building material, saving valuable trees.

Challenges for jute

Jute growers, more specifically marginal jute growers, are entangled in a complex web of interrelated problems, which have two major effects: *Unfavourable market price* and *Production inefficiency* (both lower productivity and higher cost). Consequently, jute growers remain poor as their income from jute is too low.

Unfavourable market price: Jute growers in Bangladesh are getting unfavourable market price for various reasons. Some of the reasons are-

a) Price volatility: India is world's largest producer of jute; at the same time it is the largest consumer too. Indian govt. has implemented a mandatory packaging order which stipulates that certain food crop must use jute packaging. As a result India has a strong local demand, which also

makes it feasible for the govt. to implement Minimum Support Price (MSP) for the farmers. Consequently farmers in India are getting a better price. But in Bangladesh, there is no policy of the govt. to increase domestic demand or set MPS for the jute growers. As a result, the price of jute in the local market largely depends on world demand situation as this sector is basically dependant on export.

b) Weak bargaining power: Most farmers are in serious liquidity crisis during jute harvesting season, which is between two rice growing seasons. So, they are bound to sell their jute as quickly as possible at whatever price is offered. Moreover, most of the jute growers are marginal; they produce in very small quantity. Cash crisis and small quantity leaves them with almost no bargaining power over price. Growers could gain bargaining power if they were organized in associations. But no such organization of grower exists.

c) Multiple intermediary levels: Typically jute trading involves multiple intermediary levels. Often jute is collected by a Faria (village level trader) who sells it to the local trader/purchase centre who sell it to the jute mills or raw jute exporter. These intermediaries are much richer than the growers, so they can wait for the price to increase, but our jute growers can't afford to wait. So, ultimately the price that the jute growers get is too low.

d) Government procurement policy: State owned jute mills procure substantial amount of jute at a declared price. But the procurement is usually done long after the jute harvesting time. By that time, jute is already in the store of the trader, who gets the benefit of the govt. declared price, not the jute growers.

e) Low quality: Sometimes, price gets even lower when the fibre is not of good quality. Farmers often fail to attain the desired quality mainly because of low quality seed and inappropriate retting.

Production inefficiency: The causes of production inefficiency are-

a) Low quality seed: National Annual demand of jute seed is around 4000 MT, of which only about 20% is sup-

plied by the Bangladesh Agricultural Development Corporation (BADC). The rest is imported from India; a considerable part of it is actually smuggled. Quality of the imported seed is questionable. Also, sometimes local traders counterfeit seed by mixing the old lot with the new. But the importers do not take any responsibility of quality as the seed is not sold under their brand name. Low quality seed often result in low production, lower quality and sometimes even crop failure.

b) Limited technical know-how: Though average current yield has increased over the years, jute growers are not getting maximum yield because of limited technical know-how. They do not have the knowledge of soil management, appropriate doses of fertilizers, disease and pest control. Govt. extension offices have limited manpower. It is not possible for them to reach out wider grower communities to provide these services.

c) Scarcity of water: Jute is traditionally grown and harvested during the monsoon. So, usually growers would not need to irrigate jute fields or would not face scarcity of water for retting and washing jute fibre. But water is getting scarcer day by day. Now, growers need to irrigate their fields, increasing cost of production. They are facing water crisis during harvesting. As a result, quality of fibre is going down because of poor quality water for retting and washing. Often, growers need to carry jute to different location where there is water, further increasing their cost. But they do not know the new technologies of retting that require less water without compromising quality. All these factors lead to low income of jute growers and continuation of poverty.

Conclusion: It can be concluded by the following words that recently jute growers of Bangladesh are started to getting fair price for their raw jute and products as well. If the market management through implementation of Minimum Support Price (MSP) for the growers of jute fibre at the jute marketing season (September to December) can be improved; and the agricultural and as well as product diversification technologies can be transferred properly, the jute sector will regain its glory and contribute to accelerate the economy of the country, Bangladesh.



Full Length Research Paper

Advances in Jute and allied fibres post-harvest processing technologies in Bangladesh: Adoption constraints, prospect and future thrust

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Abstract

Retting is a biological process by which the bast fibres are extracted by decomposing the plants by the combined action of water and aquatic microorganisms, mostly bacteria. In Bangladesh two kinds of Jute (namely; White Jute (*Corchorus capsularis* L.) and Tossa jute (*Corchorus olitorius* L.) are mainly grown for commercial purposes. Harvested Jute plants are made into bundles weighing about 10 kg each and then steeped under water of ponds, ditches, canals, lakes, rivers etc. as available in layers for retting. Water-hyacinth, water weeds, stems of banana plants, mango logs, earth chunks, bamboo etc. are used for submerging the rets under water. In about 15-20 days, the retting is completed and then fibres are extracted manually, washed and dried for sale. Since retting is the most important and predominant of all the factors influencing the fibre quality, Bangladesh Jute Research Institute has evolved many location specific improved Jute retting technologies. Since jute retting is a microbiological process, in the past researches more attention was given in its microbiological aspects. The microbial mechanism of retting and the microbes of the retting water of different places were studied in respect of their morphological and physiological characters and retting capabilities. Attempts were made to utilize the promising microorganisms in the practical field for reducing retting period and improvement of fibre quality, but only limited success was achieved. It is being observed that evolved location specific Jute retting technologies are being disseminated and demonstrated to the Jute growers with the limited resources and facilities. There is a great economic significance of fibre quality. In fact in the context of present situation in which a severe competition between Jute and synthetic fibres is going on in respect of fineness, strength and price, the future of Jute fibre is very greatly depending on its quality. Jute will never be able to win this competition unless its quality is greatly improved and ensured the grade-wise price for the farmers.

Key words: Jute, post harvest processing, microbiological and physical, fibre quality.

INTRODUCTION

In Bangladesh two kinds of jute, namely Deshi or White jute (*Corchorus capsularis* L.) and Tossa jute (*Corchorus olitorius* L.) are grown for commercial purposes. For extraction of fibre, the plants are retted in the water of lakes, rivers, ponds, ditches, roadside canals etc. Harvested plants are made into bundles

weighing about 10 lbs each steeped under water in layers. Stems of banana plants, mango logs, earth chunks, water-hyacinth etc. are used as weights for submerging the bundles of plants (Jaks) under water. It takes about 15-20 days to complete the retting. The fibres are then manually extracted, washed and dried

for sale. Of all the factors, namely variety, sowing time, weeding, thinning, manuring, pest controlling etc influencing the quality of fibre, retting is the most important one. The quality of fibre is ruined if retting is not carried out properly. The main characters which determine the quality of fibre include cuttings, strength, colour, lustre and texture of the fibre. Cuttings are the hard bottom parts of the fibre which are cut away before processing in the mill and sold separately at a much cheaper price. Retting alone greatly influences all these characters. (Ahmed, 1963; Ali et al., 1978b).

Considering the earlier characters, the raw jute fibres are classified under different grades and marketed. As per export statistics, although Bangladesh has a reputation as an exporter of good quality fibres, she has been exporting mostly low grade fibres. As such it becomes bounding on the scientists to improve the fibre quality by evolving improved method of jute retting so as to earn more foreign exchange for the country by exporting good quality fibres.

Retting is a biological process by which the bast fibres are extracted by decomposing the plants by the joint action of water and aquatic microorganisms, mostly bacteria. Bangladesh Jute Research Institute researches have been carried out to evolve improved methods of jute retting suitable for the different jute growing areas for the improvement of fibre quality for a long time and valuable findings were achieved. But unfortunately these findings have not been properly documented towards a common goal. The pooled knowledge on jute retting-the most important aspect of raw jute fibre production, is, therefore, extremely limited but very much essential. With this ends in view a complete review on Jute retting researches and achievements so far accomplished in Bangladesh have been completed here for proper use. (Ahmed, 1963; Ali and Alam, 1983;)

The different researches so far done are aimed at the major objectives concerned with: 1) Chemical composition of Jute plants, 2) Chemical and microbial composition of retting water , 3) Mechanisms of retting, 4) Retting microorganisms and their use in retting practices, 5) Acceleration of retting speed, 6) Reduction of fibre cuttings, 7) Improvement of fibre strength, 8) Improvement of fibre colour, Lustre and texture 9) Retting methods for water scarce areas, 10) Jute ribbon retting, 11) Retting of seed plants, 12) Production of Bio-gas from jute retting effluent, 13) Effect of jute retting on fish farming, 14) Relationship between lignin and pectin content with plant maturity and fibre quality of jute, 15) Comparative retting properties and fibre quality of *Corchorus capsularis* and *Corchorus olitorius* jute, *Hibiscus cannabinus* (Kenaf) and *Hibiscus sabdariffa* (Mesta), 16) Provision of retting water facilities, 17) Retting technique in rice field and finally 18) Up-gradation of Special Mora

Rejection SMR and low grade barky jute fibre through the application of fungi Ahmed, 1963; (Islam, 2010).

MATERIALS AND METHODS

The study was based on secondary data. Data were collected during May to December, 2011. The secondary data were accumulated from different records of BBS, BJRI, IJSG (IJO) etc. Post harvest processing specially retting related data (Chemical composition of jute plants, chemical and microbial composition of retting water, mechanism of retting, microorganisms and their use in jute retting practices, acceleration of retting speed, reduction of fibre cuttings, improvement of fibre strength, improvement of fibre colour, lustre, and texture, retting methods for water scarce areas, ribbon retting, retting of jute seed plants, fertilizer value (NPK-content) of retting effluent, production of biogas from jute retting effluent, jute retting on fish farming, retting technique in rice field etc.) were selected for its being large concentration point of relation with jute and allied fibre quality improvement of Bangladesh. Different microorganism, likely aerobic, anaerobic or microaerophilic bacteria involved in jute retting; fungal inoculum on retting of green jute ribbons; retting period on fibre yield and quality; comparative data of traditional methods of retting and ribbon retting; data of retting factors of jute etc were collected from different sources like BJRI annual reports, IJSG reports and different journals.

RESULTS AND DISCUSSION

Chemical composition of jute plants

To have proper understanding about the decomposition of the jute plants during retting it was considered necessary to acquire knowledge about the chemical composition of the plants through study of literatures and different tests in the laboratory. It appeared that defoliated jute plants contain about 75% water, 12% jute stick, 6% fibres and 6.7% other non-fibrous matters composed of hemicellulose, proteins, fats, pectins and minerals. The nitrogen, phosphorus and potassium contents of leaves and top, middle and basal portions of the plants are varied. The leaves contain about 2.85- 3.60% nitrogen, 0.85 - 1.20% phosphorus and 2.60 - 3.10% potassium. The bark contains about 0.35 - 0.46% nitrogen, 0.35 - 0.46% phosphorus and 1.5 - 1.80% potassium. The wood contains about 0.17- 0.25% nitrogen, 0.21 -0.28% phosphorus and 0.50 - 0.85% potassium. Dry Jute fibres are composed of about 0.7% water, 60% cellulose, 24% hemicellulose, 13.50% lignin, 0.5% fat and 0.8% minerals (Dempsey, 1975).

Chemical and microbial composition of retting water

Since retting is performed in water, studies were made

to determine the chemical and microbial contents of commonly used retting waters. It appeared that such waters greatly varied in respect of their chemical and microbial contents. Water samples from Rangpur, Pabna, Rajshahi, Khulna, Faridpur, Dhaka, Jamalpur and Comilla district contained 0.036, 0.187, 0.154, 0.187, 0.197, 0.143, 0.007, 0.194 percent nitrogen; 1.40, 58.90, 88.20, 13.90, 55.10, 2.00, 2.20, 34.90 ppm of calcium; 1.10, 26.40, 44.00, 6.60, 8.80, 4.40, 11.00, 6.60 ppm of carbonates and 54.90, 332.80, 217.60, 56.80, 198.50, 36.60, 76.25, 25.10 ppm of bicarbonates respectively. The microbial contents per ml of retting water before retting were usually to the tune of about one million. During retting and at the end of retting, the contents of the same of course increased greatly. The pH values of the water were usually between 6.60- 8.00 (Ali et al., 1962, 1970, 1972, 1973).

Mechanism of retting

Retting is a kind of fermentation process in which the cortical and phloem tissues of the bark of the plants containing the fibre strands are decomposed by the joint action of microorganisms, mostly bacteria and water. Immediately after steeping the plants under water, the soluble carbohydrates, proteins, minerals etc start leaching out of the plants and water becomes very rich in aerobic bacterial contents. This water together with these bacteria enters the plant tissues through stomata replacing the intercellular air. At this stage, because of the fermentation of the soluble carbohydrates, organic acids are formed, pH decreases and the retting water becomes very low in oxygen content. Butyric acid, acetic acid, lactic acid etc. have been identified as some of these acids. In such a condition of retting, mostly micro-aerophilic bacteria start multiplying, entering the tissues and decomposing the cementing materials mostly pectinous in nature connecting the fibre strands. At this stage, the pH value increases because of the formation of buffering organic compound and the retting of the plant is completed (Islam, 2010; Islam and Rahman, 2008; Ali et al., 1970, 1973).

The enzyme by which the microbes actually carry out the decomposition have also been studied. They have been found to be mostly of pectin polygalacturonase and pectin methyl esterase in nature (Ali, 1962; Choudhury, 1951, 1962).

Microorganisms and their use in jute retting practices

It appeared that most of the retting water contain

aerobic, anaerobic and microaerophilic bacteria, aquatic and other fungi, algae, protozoa and diatoms. Of all the microorganisms, aerobic and anaerobic or microaerophilic bacteria have been found to be mostly involved in jute retting. The most pre-dominant ones of such bacteria have been found to be *Bacillus polymyxa*, *B. subtilis*, *B. macerans*, *B. pumilus*, *B. sphaericus*, *Clostridium butyricum*, *C. terium*, *C. lacunarum*, *Pseudomonas putida*, *P. aeruginosa*, *P. pseudomollei*, *Micrococcus caseolyticum*, *M. corchorus*, *M. lutens* and *M. varians*. These bacteria completed retting in sterile water under laboratory condition in 2-10 days (Tables 1 and 2) whereas normal retting time under grower's condition is 15-20 days (Islam, 2010).

In case of fungi (Table 3) mostly the non-aquatic ones, as *Aspergillus niger*, *Penicillium frequentans*, *Mucor* sp., *Sclerotium rolfsii*, *Mycelia sterilia* have been found to ret jute under moist condition and special environments of temperature and nutrients in about 3-10 days (Ali, 1958; Jalaluddin, 1965).

Algae, Protozoas, Diatoms which are usually present in the surface layer of water, perhaps indirectly participate in the retting done by microaerophilic bacteria by providing appropriate environments since retting progressed faster in surface layer of water (Ali, 1958; Ali, 1977). (Ali and Islam, 1965)

Attempts have been made to make use of the active retting bacteria and fungi at grower's level but their activities were not quite as encouraging as in the laboratory since perhaps in non-sterile water at grower's conditions the presence of other bacteria inhibited their sufficient multiplication. It seemed possible to undertake large scale retting with the isolated active retting fungi, but this again calls for industrial approach under controlled conditions. Further more, fungal retted fibres were rather coarser than normal retted fibres (Islam, 2010; Islam and Rahman, 2008; Ali, 1962; Ali et al., 1965).

Acceleration of retting speed

Usually it takes 15-20 days for jute retting at grower's conditions. (Islam, 2010) If the retting speed could be accelerated, the retting could be conducted in the same water repeatedly and thus requirement of large quantity of retting water could be minimized. When use of special type of retting bacteria in field conditions for the acceleration of retting speed failed, other possible methods were explored. They included the use of (a) retting effluent, (b) suitable economic chemical agents serving as nutrients for the retting microbes and (c) other plant materials.

Retting effluents are usually very rich in retting bacteria. It was found that if these effluents were

Table 1. Retting period of jute by aerobic bacteria.

Name of the bacteria	Retting time (days)
<i>Bacillus alvei</i>	9
<i>B. brevis</i>	10
<i>B. cereus</i>	7
<i>B. circulans</i>	5
<i>B. ingramii</i>	7
<i>B. lentus</i>	8
<i>B. macerans</i>	7
<i>B. magaterium</i>	6
<i>B. manevalii</i>	5
<i>B. polymyxa</i>	7
<i>B. pumilus</i>	9
<i>B. sphaericus</i>	6
<i>B. subtilis</i>	5
<i>Micrococcus caseolyticum</i>	7
<i>M. corchorus</i>	5
<i>M. epidermidis</i>	6
<i>M. lutens</i>	10
<i>M. ureae</i>	2
<i>M. varians</i>	8
<i>M. candidus</i>	3
<i>Pseudomonas aeruginosa</i>	5
<i>P. paranacea</i>	5
<i>P. pseudomollei</i>	4
<i>P. putida</i>	2
<i>Gaffkya tetragena</i>	3

Table 2. Retting period of jute by anaerobic or microaerophilic bacteria.

Name of the bacteria	Retting time (days)
<i>Clostridium allenii</i>	5
<i>C. aurantibutyricum</i>	4
<i>C. breedi</i>	3
<i>C. butyricum</i>	4
<i>C. corallinum</i>	5
<i>C. eneboi</i>	5
<i>C. felsineun</i>	6
<i>C. haumann</i>	5
<i>C. histolyticum</i>	5
<i>C. laniganii</i>	4
<i>C. lacunarum</i>	3
<i>C. pectinovorum</i>	3
<i>C. rosenum</i>	7
<i>C. tertium</i>	4

added as inoculum to the retting water at the time of steeping of the plants at the rate of 1% of the green plant, retting speed was accelerated (Ali et al., 1978b)

Among the number of chemicals namely; ammonium phosphate, ammonium oxalate, ammonium chloride, urea etc. tested, urea greatly reduced the retting time

by maintaining the pH value at about neutral level and increasing the bacterial population greatly. Attempts were also made to use urea in the form of capsules for slow diffusion around the retting plants only in the large source of water, but no encouraging results were obtained. Any other device serving the same purpose

Table 3. Retting period of green jute ribbons by fungal inoculums.

Name of the fungus	Retting period (days)
<i>Penicillium frequentans</i>	4
<i>Aspergillus</i> sp.	3
<i>Sclerotium rolfsii</i>	4
<i>Macrophomina</i> sp.	5
<i>Mucor</i> sp.	8
<i>Mycelia sterilia</i>	9

would be very useful for retting (Ali and Rahman, 1966).

In another study in this line, it was observed that nitrate-nitrogen including potassium nitrate, ammonium nitrate and sodium nitrate retarded retting speed (Ali et al., 1978a). Retting could also be completed in hours using ammonium oxalate solution at about 90°C, but this method was considered costly. This method was called chemical retting (Ali, 1978; Ann. Reports, 1973, 1974, 1975).

Certain plant materials such as Dhanicha (*Sesbania* sp.), *Azolla* (*A. pinnata*), *Pistia* (*A. stratiotes*) etc. were believed to contain more nitrogenous matters. They were, therefore, incorporated into the bundles of retting plants but no significant difference in retting time could be observed (Ali et al., 1978). In another study attempts were made to purify the retting effluent by water-hyacinth and *Pistia*, it was found that addition of both water-hyacinth and *Pistia* in retting, reduced the retting period by about 5(five) days and improved the fibre quality (Ann.Reports,1981). In a preliminary study of retting in portable concrete tank, it was observed that the addition of Blue green algae (BGA) enhanced the retting speed by several days and improved the fibre colour (Ann. Report, 1983).

Attempts were also made to carry out retting using the enzymes of the retting microbes. Small samples could be retted in enzyme solutions under controlled laboratory conditions only. Large scale use of this enzyme solution in the study seemed unpromising (Ali et al., 1965; Choudhury, 1951; Ann. Reports, 1965, 1966, 1967, 1968, 1969, 1970).

Reduction of fibre cuttings

The hardy basal parts of jute fibres are called cuttings. This part is cut away and sold separately at a much lower price. They have a great role in the quality of fibre. The less the cuttings, the better is the quality of fibre. These cuttings are formed mainly because of the over-maturity of the plants and improper retting practices. Jute plants are thicker at the base than the top. If more time is given for retting of the basal parts, the middle and top parts become over retted and the fibres of these areas become weak. So usually retting

is stopped when middle areas are retted. This always results in some under retted basal areas form cuttings. Rise and fall of flood water around base level of the plants also give rise to these cuttings.

It appeared from the study that the cuttings could be greatly reduced by (i) harvesting the jute plants at right time, (ii) soaking the basal parts before steeping, (iii) malleting the basal parts before steeping, (iv) by special method of extraction, (v) separately retting the basal and top parts after cutting the plants in the middle.

If the plants are harvested at right time, the cuttings are also greatly reduced. When the plants are harvested 5-10 days before average flowering, the basal fibres are less lignified and thus cuttings are reduced. A little loss in yield is compensated adequately by the quality. Also in field all plants are not equal in thickness. If thick and thin plants are separately bundled and retted, the cuttings are greatly reduced.

In case of soaking, if the basal parts of the defoliated plants are soaked for 3-4 days by keeping the bundles standing under water and then retted, because of the soaking action at the base the retting becomes uniform and the cuttings are reduced.

In case of malleting, if the basal parts are malleted with the help of a wooden hammer and then the plants are retted, the bacteria get more access and the fibres become soft and cuttings are reduced. In case of special method of extraction, if the basal parts of the plants are scrapped off with the help of fingers, the decomposed matters go off easily and thus the cuttings are greatly reduced.

Jute plants are about 10-12 feet in height. If the plants are cut in the middle and the lower and upper parts are retted separately, the cuttings are greatly reduced. The marketing of such fibres has, however, yet to be organized. But this method certainly appears to be very promising (Islam, 2010; Islam and Rahman, 2008; Ann. Report, 1971).

Improvement of fibre strength

Among all the characteristics determining the quality of fibre, strength is the most important one. Although this

Table 4. Effect of retting period on fibre strength, fibre yield and quality of *C.capsularis* Jute (44 gms green weight).

Retting period(days)	Fibre strength	Fibre yield (gms)	Fibre quality
14	+++	2.08	BW - A
16	+++	1.78	BW - A
18	++	1.80	BW - B
20	++	1.65	BW - B
22	++	1.40	BW - B
24	++	1.70	BW - B

+ Indicates degree of strength.

strength could be a varietal character, actually it is influenced by retting. A little over-retting greatly weakens the fibre. It has been observed that the determination of end point of retting is a very important step in this regard. Growers determine the end point only by mere guess. They think that retting is usually completed in about 15-20 days and after this period they normally extract the fibre from the ret. But it has been seen that by this practice fibres are usually over retted and therefore weak (Table 4). It appeared that by three methods, the end point of retting can be easily determined, namely (i) by determining the pH value of the retting liquor with the help of universal indicator. At the end of retting, if this value is around neutrality, the end point is expected to be reached, (ii) by carrying out an epidermis test. The test is done by soaking a piece of retted bark taken from the middle portion of the plant in clear water in test tubes and looking for the separation of the fibre strands. If the fibres are found separated then the end point is expected to be reached and (iii) by examining the fibre separation of the fibres extracted from 1 to 2 whole plants taken out of a ret from time to time. Among the three methods, the latter two are practicable by the jute growers and they may be encouraged to practice the same (Ann. Reports, 1967, 1968, 1969, 1970).

Improvement of fibre colour, lustre, and texture

Fibre colour, lustre and texture also have great role in the quality of fibre. The best natural colour of white jute is creamy white and that of tossa is golden. Any deviation from this natural colour is considered abnormal. Past studies have revealed that this colour is greatly influenced by retting water and covering or weighting materials used on the rets. Jute plant contains tannin. If the retting water contains iron, the colour of the fibre is turned dark grey (commonly called 'shamla' colour) formed by the reaction between iron and tannin. Most turbid water contains iron and the fibres obtained from retting in such water are invariably dark in colour. Furthermore, for submerging the bundles of jute plants under water weights such as

muds, earth chunks, banana stems, mango logs etc. are frequently used. These materials leach out tannin and iron into the retting water making the resulting fibre 'shamla' coloured. Instead of these materials if stone boulders or concrete slabs are used, this problem is greatly solved. Generally if retting is conducted in clear transparent water, the colour, lustre and texture of the fibres are greatly improved.

Research have been carried out to evolve methods for the removal of dark grey colour from the fibres. It was observed that 'shamla' colour of jute is easily soluble in weak acid solution or 2.5% tamarind solution or extracts of sour fruits like Kot bell, Batapi, Lemon etc. If the 'shamla' fibres are immersed in any of the solutions in earthen vats, within a few minutes the dark-grey colour is removed. Of course the fibres then need to be washed with clear water and dried. Weak acid solution is a mixture of 0.06 the oxalic acid, 0.25% sulphuric acid and 0.25% hydrochloric acid (Islam, 2010; Islam and Rahman, 2008; Ali and Choudhury, 1963; Eshaque and Asaduzzaman, 1980).

In another study very low grade (SMR) and dark fibres produced at Rangpur were brought to Central station of Bangladesh Jute Research Institute. Attempts were made to improve the quality of those fibres by chemical methods. Fibres were re-retted in earthen vats with 0.1% urea, washed, treated with weak acid solution and washed again and dried. There was sharp improvement of fibre colour and grade. The percentage of cuttings was also reduced to a great extent (Ann. Report, 1980).

Retting methods for water scarce areas

In some areas of Bangladesh jute grows well especially in the northern part of the country, but for want of sufficient retting water the fibres produced in these areas are very inferior in quality. Attempts have been made to solve this problem by evolving methods of retting the ribbons (green bark of the plant) instead of retting the whole plant and by providing retting water facilities by excavating roadside canals, new retting tanks and re-excavating the available derelict tanks in

Table 5. Comparative data of traditional methods of retting and ribbon retting of Jute grown in 1 acre (100 decimal) of land.

Operations:	Traditional method of retting	Ribbon retting
Labour requirement (Man days @ 8 hours a day):		
a) Harvesting	7	7
b) Bundling	4	4
c) Defoliating	10	15
d) Malleting	-	4
e) Ribboning	-	19
f) Making ribbons	-	3
g) Making rets	8	2
h) Extracting of fibre	18	-
i) Washing of fibre	6	6
j) Drying and storing of fibre	2	2
Retting time (days)	16-20	8-10
Cuttings (%)	20-30%	0%
Fibre grade	B-bottom to SMR	Top to Middle
Fibre yield (kg)	900	880
Stick yield (kg)	1800	1920
Labour cost @ 80% (Tk.)	4400	4960
Inputs (Bamboo, Polythene etc.)	300	400
Total cost (7+8) (Tk.)	4700	5360
*Fibre price (Tk.)	9000	11000
**Price of Jute stick (Tk.)	14400	15360
Total income (10+11) (Tk.)	23400	26360
Net income (12-9) (Tk.)	18700	21000
Benefit-cost ratio (12/9)	4.98	4.92

*Fibre price: Tk. 10.00 and Tk. 12.50 per kg of fibre obtained from traditional retting and Ribbon retting practices, respectively.**
Price of stick: Tk. 8.00 per kg of stick obtained from both the practices.

the strategic jute growing areas.

It is observed that if the barks of the green jute plants called ribbons, are retted instead of the whole plants, retting problem of the water scarce areas can be greatly solved in which the advantages are achieved, namely (i) it requires much less water, (ii) retting time is reduced to almost half, (iii) cuttings are almost eliminated, (iv) fibre quality is greatly improved.

Attempts were made to extract ribbons from the plants using two types of machines called decorticators or ribboners. One was Japanese type and other was an American type. The main disadvantage with these ribboners was that they broke the jute sticks of the plants into small pieces which could not be used as fence, fuels, etc. The other disadvantage with machine ribboners is that the machines were very costly. Bangladeshi jute growers will not be able to purchase those (Ali et al., 1976).

In view of the disadvantages of the machine ribboners, efforts were made to produce a short of hand ribboners which would produce ribbons without breaking the stick and also be very cheap. Box method, sandle method, cylinder method, roller

method, bamboo hook method etc. were tried. Finally the bamboo hook method was evolved by BJRI followed by Single Roller Ribboner and Double Roller Ribboner for ribboning green Jute plants. The ribbons thus obtained were made into ring form and allowed to ret in earthen vats, polythene lined artificial ditches, low deep shallow water etc. If 0.01% urea or 1% retting effluent was used in the ret the retting speed was much accelerated. Good quality fibres were obtained when the plants were harvested a few days earlier than the average flowering time and immediately ribboned. Although the rather younger plants gave lower fibre yield, it was likely that the quality of the fibres would compensate the loss of yield (Table 5).

The hand ribboning and ribbon retting method has been taken to the growers of water scarce areas and are gaining much popularity. It has been observed that although a few more labourers are involved in the hand ribboning method of retting, its other advantages such as good quality fibre, quicker retting etc. more than compensate for these additional labours (Table 5) (Islam, 2010; Islam and Rahman, 2008; Ann. Reports, 1968, 1969, 1970, 1971; Ali et al., 1976).

Dry ribbon retting

In order to continue retting throughout the whole year avoiding cold season of 3 months only, attempts were made to dry the green ribbons and kept in store and retted in the convenient time other than jute retting season. Thus the pressure on retting water and time could be greatly reduced.

It was found that dry ribbon retting took longer time than green ribbon retting. Addition of 0.01% urea to the retting liquor accelerated the retting speed. The fibre quality from such dry ribbons was not good enough. It was observed that the fibres obtained from hand made dry ribbons were better in quality than those of machine made dry ribbons. It was also observed that fibres obtained from old dry ribbons were comparatively inferior to those of freshly dried ribbons (Islam, 2010; Islam and Rahman, 2008; Ann. Reports, 1968, 1969, 1970, 1971, 1973, 1988).

Retting of Jute seed plants

When jute plants are harvested for seed, the plants become so mature that fibres obtained from those plants are very poor in quality. Attempts were made to find out a proper stage of harvest of jute seed plants for getting mature seeds as well as quality fibres from the same plants. In a study it was found that if the seed plants were harvested at one third brown pod stage and malleted 2 feet from the bottom and retted, yielded better fibre as well as quality seed with optimum germination (Ann. Report, 1983). The fibre quality was greatly improved and the retting speed was also found to be accelerated if the rets (jaks) of seed plants were covered with rice straw. This finding was demonstrated to the selected registered growers of Jute Seed Division J.S.D at Rajshahi, BJRI (Ann. Reports, 1972, 1980, 1981, 1983).

Fertilizer value (NPK-content) of retting effluent

The water in which retting has already been completed is known as retting effluent. Since retting effluent contains various organic and inorganic matters, which are originated from the decomposition of no-fibrous matters of jute plants kept under water for retting by the action of microorganisms, it was interesting to find out the chemical composition of retting effluent. It was found that retting effluent contains 0.47 g of Nitrogen, 0.044 g of Phosphorus and 8.71 g of Potassium per litre. Since jute requires a lot of nitrogen, phosphorus and potassium for its growth, retting effluent considered as good potential source of NPK which can also be used in different crops as fertilizer

and as such the use of chemical fertilizer will be reduced (Ann. Reports, 1969, 1972, 1992).

Production of biogas from Jute retting effluent

Since retting effluent contains a large amount of organic substances of jute plants, a study was, therefore, undertaken to explore the possibility of utilizing the retting effluent as a substrate for the production of biogas. The flammable gas containing about 62% methane could be recovered during jute retting at laboratory condition. The gas production is optimum at pH range 7.0-8.0 and at temperature 28 - 37°C. Beyond 40°C, there was no production of flammable gas. Attempts are on progress to design a container with empty kerosene can for retting and Jerry can for collection of methane gas (Ann. Reports, 1982, 1983, 1992; Begum et al., 1988).

Effect of jute retting on fish farming

There is a common belief that jute retting hampers the fish cultivation. So, a study was undertaken to find out the feasibility of using the fish farming tank as jute retting tanks without disturbing the fish cultivation. It was found that if jute can be retted in fish farming tanks in control condition, the growth and population of the existing fishes, especially cat fishes of the tank are not affected (Ann. Reports, 1981, 1982, 1983, 1985).

Retting technique in Rice field

Since jute retting effluent is rich in N, P and K, a study was undertaken to explore the possibility of retting jute in the rice field and increasing the rice production through using the retting effluent. It was observed that jute retting could be effectively conducted in the selected plot of rice cultivation by augmenting retting water through making artificial embankment surrounding the land and then rice plants could be sown after the retting is over by spreading the retting effluent through breaking the embankment. In the approach good quality fibre was obtained and yield of rice was found to be increased significantly (Ann. Reports, 1993, 1994).

Up-gradation of SMR and low grade barky jute fibre through the application of fungi

Due to improper retting a large quantity of jute fibres produced in the water scarce areas of the country are of very inferior in quality having 20 - 40% cuttings in

the basal portions of the fibre, which have no demand both in the local and foreign markets. As a result farmers in particular and the country as a whole are being deprived of getting proper price out of these produce. So attempts were made to up-grade these low grade barky jute fibres through the application of promising fungi, previously isolated and preserved in the laboratory of Bangladesh Jute Research Institute (Agriculture).

It was observed that SMR low grade barky jute fibres could be up-graded by wet-piling of the barky areas with the culture of *Aspergillus* sp., *Sclerotium* sp. and *Sporotrichum* sp. blended with wheat bran media separately at 27 - 30°C covered with hessians. It was found that the barky areas were softened within 10-12 days after piling, upgrading the fibres by two grades (Islam, 2010; Islam and Rahman, 2008; and Haque et al., 1989).

STATUS OF IMPLEMENTATION OR ADOPTION OF IMPROVED JUTE RETTING TECHNOLOGIES AT FARMER'S LEVEL

Most of the evolved technologies are being disseminated to the jute growers through Dept. of Agriculture Extension (DAE) by organising workshops, training programmes, booklets, leaflets, various mass media etc. and are being practised by many jute growers of Bangladesh. Among these, (i) preparation of 'rets', (ii) acceleration of retting speed, (iii) reduction of fibre cuttings, (iv) improvement of fibre strength, (v) improvement of fibre colour, lustre and texture, (vi) retting methods for the water scarce areas etc. are worth mentioning. At present poor logistic supports are provided to strengthen the dissemination and motivational activities of the evolved technologies to the jute growers for the production of good quality fibres.

FACTORS INFLUENCING JUTE RETTING

The major factors affecting Jute retting are as follows:

- (a) Types of bast fibre plant, b) age of the plant, c) fertilization of crop, d) retting methods,
- e) retting water, f) temperature and pH of retting water,
- g) depth of retting water, h) Type of weighting material, and i) activators.

FARMER'S LEVEL PROBLEM IN JUTE RETTING PRACTICES

Mostly, the following problems are being observed in

Jute retting practices at farmer's level:

- 1) Slow speed of retting taking very long time (15-20 days even longer).
- 2) Excessive bulk requiring lot of labour to transport and lot of water to ret.
- 3) Quantitative and qualitative loss of fibre due to erroneous determination of end point of retting.
- 4) Darker fibre due to retting in muddy water and using earth chunks, banana stems etc. as weighting materials in the ret (lack of awareness and non-availability of quality retting water).
- 5) Low quality barky fibre (with more cuttings in the basal parts) production due to improper retting practices.
- 6) Scarcity of retting water (inadequate rain, siltation of tanks or canals).
- 7) Delayed harvest resulting in poor quality fibre (quality not duly rewarded, therefore tendency to obtain more quantity).
- 8) Lack of awareness about fibre quality and grading.
- 9) Unwillingness to accept improved location specific technologies.
- 10) Prices are often non-remunerative and fluctuating.
- 11) Not willing to invest, have capital constraint, not sure of the future of the commodity to get full benefit of the investments.
- 12) Comparative non-profitability with other crops.

CONSTRAINTS IN THE ADOPTION OF EVOLVED JUTE RETTING TECHNOLOGIES

The main constraints in the adoption of the new technologies include (i) lack of publicity, (ii) ignorance about different grades, (iii) absence of incentive price for good quality fibre, and (iv) very low and unremunerative price of jute fibre. Since the country is somehow deficient in food, whole extension network for field demonstration, farmers training or extension of research recommendations is geared to food crops only. As a result, the evolved jute retting technologies do not receive the priority, as it deserves for national economy. Furthermore, the growers are not familiar with the grades of the fibres. The buyers in the primary market always take advantage of this situation and do not pay according to the grades. Again the price differentials between the grades are so small and unstable that the growers do not feel encouraged to produce quality fibre. They rather go for quantity rather than quality.

The flow of improved Jute retting technologies developed at BJRI to farmers proceeds as: (i) through leaflets, booklets, posters published by BJRI and distributed smoothly through Department of Agriculture Extension, (ii) Training of extension personnels

(Subject Matter Specialist, Subject Matter Officer) through Field-days and Workshops etc. The trained extension personnels in turn train up the farmers through the extension personnels at grass-root level so that the fruits of the valuable research reach the door-steps of the farmers speedily with prompt feed back. However, the rate of diffusion is much slower since the linkage between the researchers and extension personnels is poor. The linkage should be further strengthened.

FUTURE THRUST

It is evident that water is the key and dominant factor for retting of jute. Major jute growing areas of Bangladesh face retting water scarcity problem as a result of which poor quality fibres are being produced. So it is feared that if water requirement of jute retting could not be minimised then in future both yield and quality of jute production will be hampered. On the other hand, the location specific retting methods evolved for the water scarce areas like ribbon retting need to be disseminated. However, the ribboning technology available now is somehow labour intensive. More Research and Development R&D efforts are needed to develop cost effective and easily affordable ribboning methods. Ribboning process should be semi-mechanised. Fair price for the good quality fibre is a pre-requisite for the production of quality fibres by the jute growers. To motivate the growers to produce quality jute fibre, assurance of grade wise price is of prime importance. Jute acreage is diminishing day by day. Jute is pushed to the marginal lands in Bangladesh. To save jute going indigo way, development of high yielding varieties, development of more location specific retting technologies, production of cuttings free good quality fibres through improved location specific jute retting technologies suited to changing agro-ecological condition and assurance of grade-wise price for the Jute fibre are the future thrust areas.

However future programmes of Jute retting for the improvement of fibre quality that need to be emphasised are as follows:

- 1) Development of environmentally safe improved technologies for retting, fibre extraction and drying for Jute and Kenaf.
- 2) To verify the performance of available Jute and Kenaf retting methods through research trials and recommend the most suitable ones for specific production environments.
- 3) To verify the performance of available Jute and

Kenaf ribboners or decorticators and in case of necessity develop semi-mechanised low cost Jute ribboners and recommend the most efficient and cost effective ones for farmer's use.

- 4) To undertake studies to develop techniques for minimizing retting water requirements.
- 5) Evaluation of the efficiency of existing Jute and Kenaf fibre extraction and drying methods.
- 6) To develop improved extraction and drying methods for Jute and Kenaf fibres through trials.
- 7) To identify suitable fish species for culturing in Jute retting ponds and to undertake studies to develop successful environmentally safe fish culture techniques in Jute and Allied Fibre JAF retting ponds.
- 8) To disseminate location specific Improved Jute retting and Post harvest technologies, Ribbon retting, Pisciculture in Jute retting ponds and Fibre grading techniques to the Jute growers and Block supervisors of Agriculture Extension Department.
- 9) Study of the possible factors influencing the quality of jute fibre and location wise manipulation to get best possible grade.
- 10) Collection of different existing retting methods and facilities from different Jute and Allied fibre growing countries.
- 11) Study of the relative economics of various methods of retting in relation to various locations.
- 12) Exchange of ideas, Information and Expertise on Environmentally Safe Primary Processing Technologies for Jute and Kenaf among the participating member countries.

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Seed quality of two *Corchorus* spp. collected from different sources in Bangladesh

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ABSTRACT

Bangladesh annually requires about five thousand metric tons of jute seeds to grow in about 0.81 million hectares of land. About 10-12% of jute seeds are produced under the supervision of the Bangladesh Agricultural Development Corporation (BADC) and the rest of the seeds are produced and managed by the farmers themselves. Due to prolonged stay in the field, this jute seed crop is affected by the traumatic events including drought, hailstorm, heavy shower, flood, diseases and insect pest infestation. This crop can become physiologically weak, leading to production of low yield of poor quality seeds. The study aimed to determine the quality of jute seeds collected from five different sources in Bangladesh. Two jute varieties, CVL-1 of *Corchorus capsularis* L. and O-9897 of *C. olitorius* L. were used as study materials. For both varieties, treatments were comprised from five different seed sources: Bangladesh Jute Research Institute (BJRI), Bangladesh Agricultural Development Corporation (BADC), farmers' of two jute growing areas, and a local market. The experiments were laid out using completely randomized design with four replications. Results revealed that seeds from BJRI and BADC of both the jute varieties showed better quality in terms of vigor and pathogen incidence compared to seeds from farmers' and local markets. BJRI and BADC seeds showed lower moisture content and inert matter whereas these two variables were high in farmers' seed. Higher moisture content was associated with low germination and vigor index of farmers' and market seeds for both jute varieties. Lower moisture content of BJRI and BADC seeds showed higher germination and vigor index. Seeds of both the varieties started to germinate within one day and more than 70 percent was recorded on the second day. The relationship among germination, vigor index and purity were significant and positive. Based on seed quality attributes observed, BJRI seeds seem to be the best than all other seeds tested.

KEYWORDS: *Corchorus* Spp., seed quality, source, germination, vigor index

1 INTRODUCTION

Jute is a cash crop of Bangladesh. It is grown in the summer season (Kharif-I). In 2010-2011, 0.803 million ha land cultivated for jute. Production of raw jute was 1.5 million MT by volume in 2010-2011. Jute cultivation area was 6% of total land area of 13 million ha, of which 8.44 million ha belongs to agricultural land. Jute cultivation area was 10% of agricultural land area. Jute production was 26% as of all agricultural crops (IJSG, 2012).

Quality seed of high yielding variety is the key for better crop establishment and yield. Seed quality is a multiple concept comprising several components that include. Physical purity, species purity, freedom from weed seed, cultivars' purity, germination capacity, viability, vigor, seed size, seed health and moisture content (Thomson, 1979). Unless the seeds are good quality the use of other inputs and technologies of crop production would become meaningless.

Bangladesh requires about 5,000 metric tons of jute seeds of which only 12-15% is produced and distributed by Bangladesh Agricultural Development Corporation (Salim et al., 1998). The rest of seeds is solely produced and utilized by the farmers'. The quality of farmers' seed is not maintained during production, processing and storage. In many cases, farmers' collect their seeds from their friends or neighbors and thus, there is no specific system to control the quality of seeds. Hence, it is conceived that the quality of seeds produced by majority of the farmers' is of low standard. Also, there is very little information regarding the level of farmers' knowledge on the production of jute seed and method of quality testing before sowing. Farmers' sometimes get good germination and good crop, but in most cases they get poor germination and a poor crop, and occasionally seeds do not germinate which results in total crop failure (Hossain et al., 1994a; Islam, 2009).

The quality status of jute seed at farm level is very poor and farmers' are normally ignorant of seed quality and quality evaluating tests. Farmers' are not aware of the germination percentage, vigor value, pathogens associated with seeds and percentage of moisture in their seeds. Although, there are many researches on the quality of the seed, no effort has yet been made to evaluate the quality of seed at farm level despite 75% of the total requirements of the jute seed are solely produced and distributed by the farmers'. If it is possible to address and appreciate the seed growers

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about their seed problems and help understand them to assess quality of jute seeds, they could establish it as a profitable enterprise.

Kenaf seed germination percentage and vigor index were affected significantly due to seed moisture content at different month of testing during the period of storage. Aluminum foil bag, plastic pot, polythene bag and tin container at 8% and 10% moisture maintained more than 80% germination after 12 months of storage while those stored at 12% maintained above 80% germination for up to 6 months. On the other hand, seeds stored in aluminum foil bag, plastic pot, polythene bag and tin container at 14% SMC reached below 80% germination after 8 months of storage. Germination percentage and seed vigor index and moisture content of kenaf seed at different months of testing during storage period varied significantly (Mollah et al., 2015).

Farmers' conventionally sow seeds in the month of March-April for fiber production and a part of the crop is kept for seed production. The seeds of the remnant part of fiber crop get matured in the month of October. Due to prolonged stay in the field, this seed crop is affected by the traumatic events like drought, hailstorm, heavy shower, flood, diseases and insect pest infestation and it becomes physiologically weak and produces low yield of poor quality seeds (Ali, 1984; Hossain et al., 1994a). Subsistent jute farmers' sometimes cannot afford the public-sector seeds. In Bangladesh, there are many jute seed sources, and it is important to determine their quality. Therefore, the present study was designed to assess the quality attributes and vigor of jute seeds collected from different seed sources in Bangladesh.

2 MATERIALS AND METHODS

The study was conducted at the Agronomy laboratory, Crop Management Department, Agronomy Division of Bangladesh Jute Research Institute (BJRI), Dhaka. The seeds of jute varieties CVL-1 of *Corchorus capsularis* L. species and O-9897 of *Corchorus olitorius* L. species were used as study materials. The treatments consisted of five sources of seeds CVL-1 and that of O-9897. They were obtained from the BJRI, BADC, farmers' of two jute growing areas and local market. The farmers' and local market seeds of CVL-1 were collected from Manikganj and Kishoreganj and that of O-9897 from Faridpur and Rangpur jute growing areas.

At least 250 g of farmers' seed samples were collected from 20 farmers' of each jute growing areas. The local market seed samples were collected from local markets of the same areas as farmers'. Primary seed samples of farmers' and local market were mixed thoroughly to make a composite sample for both the species. About 500 g of each composite samples were taken as submitted samples. The submitted seed samples were kept in brown paper bags. All the seed samples collected from different seed sources were labeled properly and preserved in Gene Bank of BJRI at 20o-C

until the samples were used for conducting experiments. Working seed samples were taken time to time from the preserved seed samples as per requirement. The experiment was designed by Completely Randomized Design with five replications. Total procedure was maintained following the rules of ISTA (ISTA, 1999). The seeds were collected immediately after the harvest of jute seed crop. All seed quality attributes data were collected and analyzed statistically. Percentage data of seed germination, seed moisture content, and presence of pathogens were analyzed after square root transformation. Treatment mean differences were adjudged following level of significance (0.05 and 0.01%) (Gomez and Gomez, 1984).

Determination of Moisture content: Moisture content of the seeds of different sources was tested for both CVL-1 and O-9897. The collected seed samples were tested in the laboratory for moisture content following the oven-dry method (Khandakar, 1980). About 2 g seeds of each sample were weighed and kept in the oven for 24 hours at 100°C.

$$\text{Moisture content (\%)} = \frac{(m_2 - m_3)}{(m_2 - m_1)} \times 100$$

Where,

m_1 = weight of crucible + lid

m_2 = weight of crucible + lid + fresh seed and

m_3 = weight of crucible + lid + dried seed

Determination of seed purity: Fifteen grams of each working sample was measured with an analytical balance and carefully examined and separated on purity board into the following: i) Pure seed, ii) Other seeds, and iii) Inert matter (SCA, 2000). After separation, the component parts were separately weighed and percentage of each component was worked out and recorded. All the three components were weighed together to verify any loss due to handling.

Determination of seed germination: Germination test was carried out in an incubator at 30±1o-C. One hundred seeds with four replications were evenly distributed on the top of four filter papers placed in four glass petri dishes. The seeds and filter papers were kept moist throughout the test period by adding water. Seeds that germinated were counted and recorded daily until the fifth day. A seed was considered to have germinated if the seed coat ruptured and radicle came out up to 0.2 cm or length. Germination percentage was calculated using the following formula (Krishnasamy and Seshu, 1990; Islam, 2009).

$$\text{Germination (\%)} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds tested}} \times 100$$

Determination of 1000- seeds weight: For 1000 seed weight determination, one thousand seeds of jute were randomly counted from each pure seed sample and weighted in an electronic balance (Model-PC-180). Thousand seeds weight was also calculated at specific moisture content by following Seed Testing Manual (SCA, 2000).

$$1000 - \text{seed weight} = \frac{\text{Weight of 1000 - seeds (100 - moisture content at counting)}}{100 - \text{Weight at which moisture content is required}}$$

Determination of seed Vigor: This test was conducted in the laboratory with same procedure as that of laboratory standard germination test. Vigor (Vigor value) was calculated by following the method of Jain and Saha (1971).

$$V = \frac{a}{1} + \frac{b}{2} + \frac{c}{3} + \dots$$

Where, V= Vigor value, and a, b and c are the number of seeds that germinated after 1st, 2nd and 3rd days from the start of germination test. The final count was made at the end of 5th day. Co-efficient of germination was calculated from above recorded data using the formula of Copeland (1976 Islam, 2009).

$$\text{Co - efficient germination} = \frac{100 (A_1 + A_2 + \dots + A_x)}{A_1 T_1 + A_2 T_2 + \dots + A_x T_x}$$

Where, A = number of seed germinated, T = time corresponding to A and x = number of days to final count.

Evaluation of seedling growth: Seedlings obtained from standard germination test were used for seedling growth. Normal and abnormal seedlings were classified according to the rules of the Association of Official Seed Analysts (AOSA, 1981). Seedling shoot and root lengths (cm) were measured on 5th day of the germination test. Ten seedling samples from each petri dish were collected randomly. Shoot and root lengths (cm) of individual seedling were recorded. Ten seedlings were counted to form one replication and three replications were formed in this way for each treatment. The shoot and roots were dried at 70°C for 72 hours for dry matter yield. Length and weight basis root-shoot ratio was calculated by following the method of Khandakar (1994) to estimate root efficiency to support production.

$$\text{Root - shoot ratio (length)} = \frac{\text{Root length (cm)}}{\text{Shoot length (cm)}}$$

$$\text{Root - shoot ratio (weight)} = \frac{\text{Root weight (g)}}{\text{Shoot length (g)}}$$

Assessment of seed pathogen: Pure seed samples were examined in the Pathological Laboratory of the BJRI to observe the association of pathogen with the seeds. After germination, seeds were examined with the microscope and the following pathogens were recorded. i) *Macrophomina phaseolina* (Stem rot), ii) *Botryodiplodia theobromae* (Black band) and ii) *Colletotrichum corchori* (Anthracnose).

3 RESULTS AND DISCUSSION

Moisture content

Seed sources showed significant difference in seed moisture content (Table 1). The highest moisture

of 14% was obtained in market seeds of CVL-1 and 13% in farmers' seed of Rangpur of O-9897. In CVL-1, farmers' seed of Kishoregonj location and market seed's moisture content were insignificant ($p > 0.05$). However, in O-9897 farmer seed of Rangpur was statistically identical to local market seed. Jute seed collected from farms of different locations contained higher moisture than BJRI and BADC sources. Jute seed of BJRI and BADC of CVL-1 and O-9897 contained 9.3% and 10.8%; 9.4% and 10% moisture respectively, whereas, farmers' and local market seed contained much higher moisture content of 13.6, 13.9 and 13.9% in CVL-1 and 11.9, 12.9 and 12.1 in O-9897 (Table 1). Low moisture content in BJRI and BADC seeds might be due to proper sun drying and storage. Lower moisture content of BJRI and BADC seeds had better planting value as Sobhan and Khatun (1986) reported that jute seed with a moisture content of 4 to 7% maintained more than 85% viability up to twelve months even at room temperature. The above results are in partial conformity with those of Islam *et al.* (1999) and Islam *et al.* (2002) who reported variations in moisture content of jute, kenaf and reselle seeds and it is in full agreement with that of Hossain *et al.* (1994b) who observed all categories of farmers' (ranged 5-10 per cent).

Germination

Rate of germination of different seeds varied widely due to sources for both the species (Fig. 1 and 2). It was found that jute seed started to germinate within a day and most seeds germinated (>70%) on the second day. However, all the seeds of different sources of both species required four to five days to complete germination. Seeds of CVL-1 germinated faster than O-9897 within the first day. BJRI and BADC seeds of both species germinated faster than all other seed sources. The highest germination of 95% was found for O-9897 and 89% for CVL-1 with BJRI sources, followed by BADC 92% for O-9897 and 87% for CVL-1.

The germination percentage differed significantly ($P < 0.05$) due to different seed sources. Lower but above 80% germination was observed in farmers' seeds of different locations and local market sources for both the varieties. The standard percentage of germination was 80% for both the jute species. Lower germination rates were observed in case of seeds of CVL-1 seeds. The lowest germination (81%) was observed in CVL-1 seed of farmers' in Manikgonj while 82% in local market sources and 85% in Kishoreganj. The highest (89%) germination was observed in BJRI seeds for CVL-1 seed followed by BADC seed (87%) (Table 1). Verma and Arora (1978) observed jute variety CVL-1 seeds required eight days while O-9897 five days to complete germination at 30°C. Germination percentage was however enhanced with increased temperature. Jain and Saha (1971) reported that more than 90% seeds of both the species germinated within the first day at 30°C.

Irrespective of seed sources, germination in O-9897 was lower (ranged from 25 to 35%) than CVL-1 (about 42 to 68%). Hossain *et al.* (1994) observed that seed samples collected from different survey sites gave mean germination rate ranging from 31-66% when applied to all categories of farmers', which was far below the expected or recommended minimum rate of 80 per cent. It was very unfortunate that about 50 per cent seed samples contained moisture above 10.22 to 13.38 per cent. So, those samples were very uncertain to retain proper seed viability. Lower germination of farmers' seed may be due to higher infestation of pathogen which have negative relationship between pathogen per cent and germination of jute seeds. Islam *et al.* (1999) and Islam *et al.* (2002) reported that germination percentage differed significantly among the jute, kenaf and reselle.

Thousand seeds weight

The seeds of CVL-1 have higher weight than that of O-9897 (Table 1). Thousand seed weight of CVL-1 species varied from 3.14 to 3.38g and that of O-9897 ranged from 1.76 to 2.11g. Farmers' and local market seed weights were statistically identical. The lowest seed weights was observed in BJRI seed (3.14g) for CVL-1 variety. Lower seed weight was observed in BJRI and BADC in O-9897, whereas higher seed weights were found in farmers' seeds of two locations and local market seeds. As seed size differs for location of pod in the plant and location of seeds in the pod, seed grading may help in collecting better seed weight for future use. Lack of knowledge about seed grading might be the possible

cause of lower size of farmers' and local market seed. At 9% moisture status, the highest 1000-seed weight or seed size of CVL-1 was observed in farmers' seed of Manikgonj and the lowest in Kishoreganj. On the other hand, in O-9897, the highest seed size was found in BJRI seed followed by BADC. The lowest (2.11g) was observed in farmers' jute seed of Rangpur (Table 1). Talukder and Ali (1977) reported that *C. capsularis* L. fruits are 1.0 to 1.5 cm in diameter, and round. Seeds, 7 to 10 in number are arranged in two rows without transverse partition in each of 5 chambers. There are 35 to 50 seeds in each fruit. On the other hand, in *C. olitorius* L. the fruit contained 25 to 40 seeds arranged in a single row having transverse partition between the seeds. There are 125 to 200 seeds in each fruit of *C. olitorius* L. Jute seed are not round. They are pyramidal in shape having 4-5 faces. The *C. olitorius* L. seeds are smaller than *C. capsularis* L. Talukder and Akanda (1994) reported that among the pre-harvest factors, the effect of photoperiod is presumably very high on the quality of jute seed because, jute crop planted under exorbitant short photoperiodic condition gives lower 1000-seed weight and lower seed viability. Islam *et al.* (1999) revealed that number of seed per litter, volume per kg seeds, germination percentage, vigor value and moisture percentage differed significantly among the crops jute, kenaf and reselle. Choudhury (1994) reported that germination capacity of jute seeds correlated with seed weight. The seed weight factor influenced total germination as well as speed of germination.

Table 1. Quality attributes of CVL-1 and O-9897 seed as affected by seed sources

Treatments (Seed sources)	Moisture Content (%)	1000- seed weight (g)	Germination (%)	1000- seed weight at 9% moisture (g)
CVL-1				
BJRI	9.26 d (3.13d)	3.14b	89a (9.44a)	3.13
BADC	10.78 c (3.36c)	3.24b	87ab (9.37ab)	3.18
Farmer (Manikganj)	13.02 b (3.68b)	3.36a	81d (9.01d)	3.27
Farmer (Kishoreganj)	13.87 a (3.79a)	3.38a	85bc (9.22bc)	3.20
Local market	13.93 a (3.80a)	3.36a	82cd (9.09cd)	3.21
Level of significance	0.01	0.05	0.01	-
O-9897				
BJRI	9.44c (3.15c)	1.76b	95a (9.75a)	1.75
BADC	9.96c (3.23c)	1.87b	92a (9.64a)	1.85
Farmer (Faridpur)	11.85b (3.51b)	2.17a	82b (9.10b)	2.10
Farmer (Rangpur)	12.84a (3.65a)	2.11a	84b (9.19b)	2.02
Local market	12.13b (3.55b)	2.05a	83b (9.15b)	1.98
Level of significance	0.01	0.01	0.01	-

In a column data having common letter(s) do not differ significantly by DMRTat 5% and 1% level of probability. Transformed data in the parenthesis.

Seed purity

Percentage of pure seeds was higher for both the species in BJRI sources followed by BADC. In CVL-1 the highest percentage of pure seed (99.68%) was found in BJRI seeds, which was followed by BADC (97.7%). In contrast, the lowest (80.4%) purity was observed in farmers' seeds of Manikgonj (Table 2). In O-9897 species the highest purity of 99.4% was found in BJRI seed, which was statistically identical with BADC (98.0%). The highest 85.0% purity was found in Rangpur farmers' seed. However, local market seeds showed much better (94.3%) purity than that of CVL-1 (85.7%) (Table 2). The percentage of inert matter also varied significantly ($p < 0.05$) due to different seed sources. Inert matter was the highest (19.57%) in farmers' seed source of Mankigonj followed by farmers' of Kishoregonj (18.0%) and local market sources (14.2%) in CVL-1 seeds. However, lowest inert matter (0.36 per cent) was found in BJRI sources with second lowest (2.2%) in BADC (Table 2). On the other hand, Table 1.4 shows that the lowest percent inert matter (0.47%) was present in BJRI followed by BADC (1.91%). The highest percent of inert matter (15.34%) was observed in farmers' seed of Rangpur. Second highest inert matter (13.41%) was found in farmers' seed collected from Faridpur (Table 2). Higher purity of seed in BJRI and BADC sources were due to processing of seeds on cemented threshing floor. The use of kacha floor during seed processing at farm level resulted in higher accumulation of inert matter in the farmers' seeds. The study showed that the purity percentage of farmers' seeds, however, was better in case of O-9897 seeds. O-9897 seed is produced in the high land of Faridpur and Rangpur area. Farmers' of those areas were more careful during jute seed processing and avoid mixture of inert matter in the jute seeds (Table 2). Islam *et al.* (2002) studied different categories (breeder seed, foundation seed, certified seed and farmers' seed) of jute seeds for purity, viability, vigor, green yield and dry fiber yield of varieties O-9897 and CVL-1. Purity of breeder seed was found the best in all respects and of farmers' seed were the poorest.

Presence of pathogen

The presence of pathogens in the farmers' seed sources was higher in both the jute species (Table 2). BJRI seed showed no pathogen in both CVL-1 and O-9897 seeds. BADC seed source of O-9897 showed only *Macrophomina phaseolina* and *Botrydiploidia theobromae* (Table 2) while only saprophyte observed in trace amount (0.40%) in BADC source for CVL-1 seeds. *Botrydiploidia theobromae* was absent in all the seed sources of CVL-1 although a higher amount was present in all the seed sources except BJRI for O-9897. The higher *Macrophomina phasiolina* was present in farmers' and local market seed sources of CVL-1, while it was lower in O-9897 (Table 2). *Colletotrichum*

corchori was present in farmers' and local market seed sources in CVL-1 although it was the highest (7.6%) in farmers' seeds of Manikgonj. The lower per cent (0.99%) of *C. corchori* was present in O-9897 seeds of local market source and 1.24% in farmers' source of Faridpur. Saprophytes were higher in O-9897 seeds. The highest (15.40%) appeared in farmers' seed of Rangpur and the lowest (7%) in local market sources for O-9897 seeds (Table 2). On the other hand, 0.4% saprophyte was observed in BADC seed for CVL-1. The highest amount (7.8%) appeared in Kishoregonj seeds. For both the species, seed sources differed significantly for the pathogens presence (Table 2).

The pathogens invaded seeds in the field during seed development while steel in fruits apart from during processing on the threshing floor. However, these pathogens may be destroyed if well sun dried (Khandakar and Bradbeer, 1983). Khandakar (1983) observed very negligible percentage of those pathogens at Baiderbazar (Narayanganj) and Kalampur (Manikgonj) jute seed growing areas. Sultana and Biswas (1992) studied the percentage of infection and viability of seeds from healthy and diseased pods of stem-rot and anthracnose affected jute plants along with disease free plants of D-154. They observed germination below the standard of National Seed Board, Bangladesh from diseased pods. Furthermore, seeds from healthy pods of both healthy and diseased plants gave 98% and 95% germination respectively.

Khandaker (1994) stated that most of the fungal pathogens and a good number of saprophytes of bast fiber crops are seed borne. Infected seeds are primary source of seed borne diseases. The highest percentage of *Macrophomina* (51%), *Botrydiploidia* (79%), *Colletotrichum* (66%) infections were observed in Dhabdhabey (JAES) with CVE-3 and CVL-1 (Chandina), although above 15% *Macrophomina* and *Colletotrichum* infected seeds were found and not recommended for sowing. Hossain *et al.* (1994) conducted a survey on six different jute-growing areas of Bangladesh. With the seed samples of all the survey sites, the occurrence of pathogenic fungi mainly *M. phaseolina*, *B. theobromae* and *C. corchori*, which cause stem rot, black band and seedling blight diseases respectively, were frequently found at the rate of total 2.33 to 6.47 percent. Besides, saprophytic fungi observed at the rate of 0.64 to 32.55 percent. Seeds of Chandina and Kishoregonj (desi jute growing area) carried enormous saprophytes and those from Jessore, Faridpur, and Manikgonj (Tossa and Deshi jute seed growing areas, respectively) also carried saprophytes at a harmful rate. They also reported higher percentage of pathogens (above 6%) with seed samples collected from Manikgonj, Kishoregonj and Chandina (Deshi, jute growing area) sites and in contrast at a lower rate (2.33-3.70%) in Faridpur, Rangpur and Jessore sites.

Table 2. Purity and seed health of CVL-1 and O-9897 seeds as affected by seed sources

Treatments (Seed sources)	Pure Seed (%)	Other seed (%)	Inert Matter (%)	Pathogen (%)			Sap.
				M.P.	B.T.	C.C.	
CVL-1							
BJRI	99.58	0	0.36	-	-	-	-
BADC	97.70	0	2.17	-	-	-	0.40c (0.88c)
Farmer (Manikganj)	80.36	0	19.57	3.80a (2.05a)	-	7.60a (2.84a)	5.00b (2.32b)
Farmer (Kishoreganj)	82.08	0	17.88	3.40ab (1.96ab)	-	4.00b (2.12b)	7.80a (2.88a)
Local market	85.71	0	14.23	2.00b (1.57b)	-	4.00b (2.11b)	3.20b (1.90b)
Level of significance	-	-	-	0.05	-	0.01	0.05
O-9897							
BJRI	99.44	0	0.47	-	-	-	-
BADC	97.98	0	1.91	1.60b (1.44b)	0.80c (1.09c)	-	-
Farmer (Faridpur)	86.48	0	13.41	1.85b (1.53b)	4.60a (2.26a)	1.24	15.40a (3.97a)
Farmer (Rangpur)	85.04	0	15.34	1.40b (1.37b)	3.20b (1.91b)	0.00	12.00a (3.53a)
Local market	94.34	0	5.65	2.60a (1.76a)	1.40c (1.37c)	0.99	7.00b (2.72b)
Level of significance	-	-	-	0.01	0.01	NS	0.01

M.P.=*Macrophomina phaseolina*, B.T.=*Botrydipodia theobromaeae*, C.C.=*Coletroticum corchori* and Sap.= Saprophyte. In a column data having common letter(s) do not differ significantly by DMRT at 1% level of probability. Transformed data in the parenthesis.

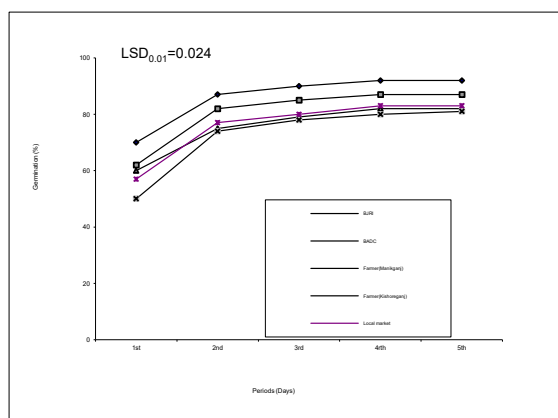


Fig. 1. Germination rate of CVL-1 seeds as affected by seed sources

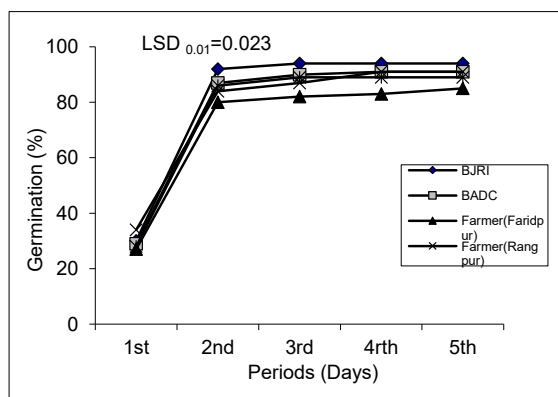


Fig. 2. Germination rate of O-9897 seeds as affected by seed sources

Seed vigor

Two sets of experiments were conducted for CVL-1 and O-9897 seed obtained from different sources. The index of different sources of seeds of CVL-1 and O-9897 varied significantly (Tables 3). The highest vigor index (76.35) was observed at farmers' seed sources of Kishoregonj in CVL-1. On the other hand, in O-9897 the highest vigor index (63.63) was found in BJRI sources and the lowest (46.59) in farmers' of Faridpur. In O-9897, in terms of vigor index there was no significant difference between the two sources of BJRI and BADC. However, local market source and farmers' sources of different locations differed statistically in respect of vigor index. Vigor index in local market seed was higher than that of farmers' seed of Rangpur and Faridpur. On the contrary, the vigor index differences were significant in case of BJRI and BADC seed sources of CVL-1 BJRI seed was superior than BADC in this respect (Table 3).

From this vigor evaluation test, germination percentage after one day and coefficient of germination were calculated and evaluated. Speed of germination test after one day it was observed that the trend of germination of CVL-1 seeds was higher than O-9897 seeds. After one day about 50-65% seeds germinated in CVL-1, however in case of O-9897 seeds only 25-35% seeds germinated. From this test, it was further observed that after two days maximum number of seeds of CVL-1 and O-9897 completed their germination. Even after two days a few number of seeds took five days to germinate. Usually jute seed lots need five days to complete germination (ISTA, 1985). In case of CVL-1

and O-9897 seeds germination percentage after 48 hours differed significantly due to different seed sources (Tables 3). In case of CVL-1 the highest germination (86.60%) was found in BJRI seed. Similar result was observed in O-9897. About 87% BJRI seeds germinated

followed by BADC and farmers' seed of Mankigonj for CVL-1 and Faridpur for O-9897. The lowest germination (75.80) after two days in CVL-1 was found in farmers' seeds of Kishoregonj and in O-9897 it was 71% in farmers' seeds from Rangpur.

Table 3. Vigor index and coefficient of germination of CVL-1 and O-9897 seed as affected by seed sources

Treatments (Seed sources)	Vigor Index	Germination after 48 hours (%)	Coefficient of germination
CVL-1			
BJRI	76.35a	86.60a (9.33a)	80.86a
BADC	73.52b	83.80b (9.18b)	78.60a
Farmer (Manikganj)	71.03c	82.40c (9.10c)	79.24a
Farmer (Kishoregonj)	64.02e	75.80e (8.73e)	67.40c
Local market	68.56d	78.40d (8.88d)	75.38b
Level of significance	0.01	0.01	0.01
O-9897			
BJRI	63.63a	87.00a (9.35a)	60.53
BADC	61.75a	82.60b (9.12b)	59.11a
Farmer (Faridpur)	46.59d	71.00c (8.45c)	56.55b
Farmer (Rangpur)	53.00c	82.60b (9.11b)	58.88a
Local market	56.68b	79.00b (8.92b)	58.32a
Level of significance	0.01	0.01	0.01

In a column data having common letter(s) do not differ significantly by DMRT at 1% level of probability. Data at the parenthesis are square root transformed.

Coefficient of germination (%) of CVL-1 and O-9897 seeds differed significantly due to seed sources (Table 3). The higher coefficient of germination was found in CVL-1 than those of O-9897 seed sources. The highest value (80.86) was found in CVL-1 seeds of BJRI source and 60.53 in O-9897 seeds collected from farmers' of Faridpur. Coefficient of germination was statistically similar in BJRI, BADC and farmers' seed for CVL-1. However, except BADC seeds, there were no significant variation among other seed sources of O-9897 (Table 3).

Haque and Khandakar (1992) reported that the *C. olitorius* L. seed remained dormant when it contained high level of moisture after harvest and germination percentage increased rapidly with drying of seeds. The germination percentage increased from 18 to 92% when the moisture decreased from 40 to 8% due to drying. Islam (1996) found that the germination of jute seed after 48 hours was a good guide to vigour and the laboratory germination was 15-20% higher than field emergence. Islam *et al.* (2002) reported in their seed potentiality assessment that the seed lot of *C. capsularis* L. differed significantly in pot culture, speed of germination, coldtest and germination after 48 hours tests. In *C.*

olitorius L. seed lot differed significantly in laboratory standard germination, pot-culture, hot temperature test and cold tests. The highest germination of 92% in *C. capsularis* L. and 96% in *C. olitorius* L., respectively for cold temperature treatment germination tests. *C. capsularis* L. differed due to vigour and other potentiality tests.

Yamauchi and Tun (1996) reported positive correlation between vigour index and germination and they suggested that the faster germination indicate the success of plant establishment under field condition. Hossain *et al.* (1994b) reported that the correlation coefficient (r) values varied among sites 0.75 to -0.96, where seed moisture content ranged 5 to 20% and seed germination ranged 00-98%. The authors also estimated regression equation of seed moisture content and seed germination. The mean regression equation appeared at $Y = 98.67 - 3.34x$. From this equation, they estimated seed viability of 80% with the adjustment of seed moisture content of 5.62%. In the same report, they further stated that seed moisture content had very high and positive correlation with the association of fungal pathogen. The correlation coefficient (r) values ranged 0.33 to 0.86 at six sites. Islam *et al.* (2002) reported that the highest correlation ($r = 98^{**}$) was found in pot culture with hot

temperature treatment germination test of *C. capsularis* L. and in laboratory standard germination with pot-culture of *C. olitorius* L. ($r=97^{**}$). Rate of germination showed negative but significant correlation with all other tests.

Vigor index was positively correlated with coefficient of germination in CVL-1 jute seed sources (Fig. 3). The relationship was significant in O-9897 also (Fig. 4).

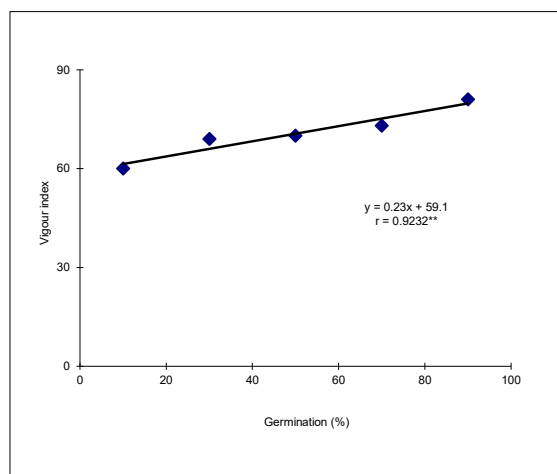


Fig. 3. Relationship between vigor index and germination percentage of CVL-1 seed as affected by seed sources.

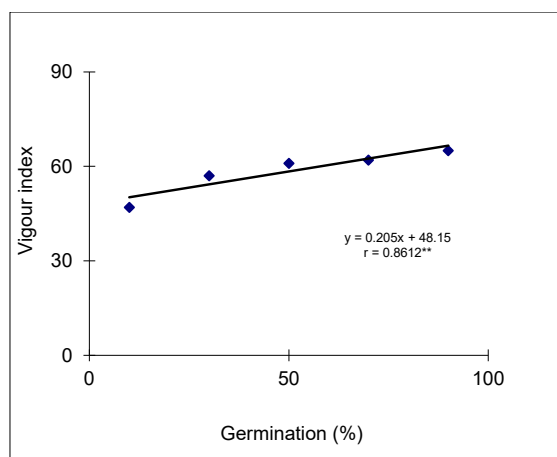


Fig. 4. Relationship between vigor index and germination percentage of O-9897 seed as affected by seed sources

Seedling growth and dry matter

Seedling growth and dry matter were assessed for both CVL-1 and O-9897 seeds collected from different sources. In case of CVL-1 seed, shoot length and root length differed significantly due to different seed sources (Table 4). The highest shoot length (6.10 cm) was found in BJRI and the lowest (5.08cm) in farmers' of Kishoregonj in CVL-1. In CVL-1 jute, shoot length was like BJRI, BADC, farmers' seed of Manikgonj and local market seed (Table 4). In case of root length, all sources showed statistically similar results except farmers' seed of Manikgonj. A root length of 3.94 cm was observed in CVL-1 of BJRI seeds and the lowest (2.90 cm) in farmers' seed of Mankigonj.

Root-shoot ratios were same in BJRI and BADC seed. However, the highest root-shoot ratio was found for farmer seed of Kishoregonj and the lowest (0.53cm cm⁻¹) in Manikgonj. However, this ratio was 18.46 percent in farmers' seed of Manikgonj and 12.31 per cent in farmers' seed of Kishoregonj and 3.08 percent in local market seed sources against BJRI seed. The increase or decrease of the root-shoot ratios against BADC was same as BJRI seed (Table 4). Development of a normal seedling from the seed is an essential requirement in the maintenance of seed viability. A normal seedling essentially should have a well-developed root system, some intact hypocotyls, two cotyledonary leaves and plumule with developing green leaves (Islam, 2009).

In O-9897, the highest shoot length (4.90cm) was recorded in BJRI seed, which was similar to BADC (4.64cm). The lowest shoot length (3.72cm) was recorded in farmers' seed of Faridpur. BJRI and BADC sources had similar yet the highest root length (3.40cm). The lowest root length (2.40cm) in contrast was recorded in farmers' seed of Faridpur (Table 4). The highest root shoot ratio (0.73%) was observed in BADC seed and the lowest (0.65%) in farmers' seed of Faridpur. Root-shoot ratio increase or decrease against BJRI sources showed 5.8% increase in BADC and 4.35% in local market seeds. Although 1.45% decrease in farmers' seed of Rangpur and 5.80% in farmers' seed of Faridpur were observed (Table 4). The ratios were found to have decreased (10.96%) in farmers' seed of Faridpur, 6.85% in farmers' seed of Rangpur and 1.37% in local market seed against BADC sources (Table 4). Similar results were reported by Islam (2009).

As regard CVL-1 shoot dry weight of BJRI and BADC seeds were similar. However, BJRI seed gave the highest shoot dry weight. On the other hand, farmers' of two locations and local market seed sources showed statistically similar shoot dry weight (Table 5). In terms of root dry weight, the highest was observed in BJRI source but it was similar to BADC. Farmers' and local market seeds showed no statistical differences in root dry weight. Root-shoot ratio and seedling dry weight was insignificant due to different seed sources (Table 5). In O-9897 jute the highest shoot dry weight (0.67mg) was obtained in BJRI followed by BADC seed (0.64mg). The lowest (0.51mg) in contrast was found in farmers' seed of Faridpur. The highest root dry weight (0.26mg) was in BJRI followed by (0.24) in BADC. The lowest (0.15mg) was found in farmers' seed of Rangpur. Root-shoot ratio was highest 0.39mg mg⁻¹ in BJRI and the lowest 0.28mg mg⁻¹ was observed in farmers' seed of Rangpur. The ratio was similar (0.35mg mg⁻¹) for farmers' seed of Faridpur together with local market (Table 5). The total seedling dry weight differed significantly due to different seed sources. The seedling weights of BJRI (0.94mg) and BARC (0.89mg) were statistically alike and the highest than those of reminder sources. In contrast, the lowest seedling dry weight (0.69mg) was observed in farmers' seed of Rangpur. In terms of total seedling dry weight, farmers' of two locations and local market sources were statistically similar (Table 5). Delouche and Baskin (1973) reported that loss of storage potential was one of the specific

consequences of seed deterioration, which decreased germination rate and increased incidence of seedling abnormalities.

Table 4. Shoot length, root length and root-shoot ratio of CVL-1 and O-9897 seed as affected by seed sources

Treatments (Seed sources)	Shoot length (cm)	Root length (cm)	Root- shoot ratio	Increase/decrease of root-shoot ratio against	
				BJRI (%)	BADC (%)
CVL-1					
BJRI	6.10	3.94a	0.65	-	-
BADC	5.70	3.72a	0.65	0	-
Farmer (Manikganj)	5.50	2.90b	0.53	-18.46	-18.46
Farmer (Kishoreganj)	5.08	3.72a	0.73	12.31	12.31
Local market	5.40	3.64a	0.67	3.08	3.08
Level of significance	NS	0.05	-	-	-
O-9897					
BJRI	4.90a	3.40a	0.69	-	-
BADC	4.64ab	3.40a	0.73	5.80	-
Farmer (Faridpur)	3.72c	2.40b	0.65	-5.80	-10.96
Farmer (Rangpur)	3.82c	2.60b	0.68	-1.45	-6.85
Local market	3.88cb	2.80ab	0.72	4.35	-1.37
Level of significance	0.05	0.05	-	-	-

In a column data having common letter(s) do not differ significantly by DMRT at 5% level of probability. NS= Not significant.

Table 5. Shoot and root dry weight, root-shoot ratio and seedling dry weight of CVL-1 seed as affected by seed sources

Treatments (Seed sources)	Shoot dry wt. (mg)	Root dry wt. (mg)	Root- shoot Ratio	Seedling dry weight (mg)
CVL-1				
BJRI	1.28a	0.34a	0.27	1.64a
BADC	1.27a	0.32a	0.25	1.58a
Farmer (Manikganj)	1.17b	0.28b	0.23	1.47b
Farmer (Kishoreganj)	1.18b	0.27b	0.23	1.46b
Local market	1.18b	0.28b	0.24	1.47b
Level of significance	0.01	0.01	-	0.05
O-9897				
BJRI	0.67a	0.26a	0.39	0.94a
BADC	0.64a	0.24a	0.38	0.89a
Farmer (Faridpur)	0.51b	0.18bc	0.35	0.71b
Farmer (Rangpur)	0.53b	0.15c	0.28	0.69b
Local market	0.54b	0.19b	0.35	0.74b
Level of significance	0.01	0.01	-	0.01

In a column column having common letter(s) do not differ significantly by DMRT at 1% and 5% level of probability.

In CVL-1, seed sources positive correlation was observed in between shoot length and root length, shoot dry weight and root dry weight, shoot length and shoot dry weight and root length and root dry weight (Table 6). Of the correlations, statistically significant relationships were found between shoot dry weight and root dry weight, and shoot length and shoot dry weight. The relationship between the root and shoot length, and the root length and root dry weight were non-significant. In O-9897, relationship between shoot length and root length, shoot dry weight and root dry weight, shoot length and shoot dry weight; and root length and root dry weight were significant and positive (Table 6). In the present study, CVL-1 had shown better and higher seedling growth and seedling dry weight than O-9897. The seedling from large seeds of *C. capsularis* L. (var. D-154) had much vigour than small and wrinkled seeds. It

may have contributed for higher seed size and higher seedling dry matter (DM) similar to Talukder and Ali (1977). The differences in root length of different sources were also remarkable. It varied from 2.09 cm of farmers' to 3.94 cm of BJRI in CVL-1 and 2.4 cm of farmer to 3.4 cm of BJRI in case of O-9897. However, root dry weights and shoot dry weights contributed maximum towards the seedling growth of different sources and attended the highest shoot length and root lengths in CVL-1 compared to O-9897 of farmers' seeds. As regards shoot and root length, similar trend was observed in *C. capsularis* L. and *C. olitorius* L. The highest shoot length in *C. capsularis* L. and in *C. olitorius* L. were found in BJRI seeds, however the BADC seeds occupied in the second position and the farmers' jute seed showed the lowest values in terms of shoot length of the seedlings (Islam, 2009).

Table 6. Different relationships of root length and root dry weight, shoot dry weight and root dry weight, shoot length and shoot dry weight and root length and root dry weight of CVL-1 and O-9897 seed as affected by seed sources

Jute species	Shoot length and root length	Shoot dry weight and root dry weight	Shoot length and shoot dry weight	Root length and root dry weight
CVL-1	Y=0.312x +1.8504 r= 0.4959*	Y=0.5427x - 0.3819 r= 0.9684**	Y=0.119x +0.5548 r= 0.8305**	Y=0.401x +0.1544 r= 0.5264*
O-9897	Y=0.8245x-0.5362 r= 0.9645**	Y=0.587x -0.1353 r= 0.9369**	Y=0.333x +0.0191 r= 0.9987**	Y=0.0892x-0.0563 r= 0.9110**

4 CONCLUSION

Seeds from BJRI and BADC of both the jute varieties showed better performances in terms of seed quality concern compared to seeds from farmers' and local markets. BJRI and BADC seeds showed lower moisture content and inert matter whereas these two variables were high in farmers' seed. Lower moisture content of BJRI and BADC seeds showed higher germination and vigor index. Seeds of both the varieties started to germinate within one day and more than 70 percent was recorded on the second day. The relationship among germination, vigor index and purity were highly significant and positive. Based on seed quality results observed, BJRI seeds sources of both the jute species are the best than all other seeds tested.

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Research and Development Advances of Jute Seed in Bangladesh: A Review

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Abstract

Jute seed production season, methods and related practices for yield and their economics were selected for its being large concentration point in relation to production methods, yield and cost in Bangladesh. The technical review paper provides crucial insights regarding the past, present status and future prospects of jute seed scenarios of the country. The whole contents of the article covering all aspects of jute seed including strategies in overcoming the acute jute seed shortage of the country. Data were collected from different print media like different annual reports and journals during the year 2018 at Agronomy Division, Bangladesh Jute Research Institute (BJRI), Dhaka. Jute is grown in about 0.8 million hectares of land by about 3.5-4.0 million farmers. To cultivate that amount of land, it requires about 5000 to 5500 tons of seed. One of the most important problems for jute production in Bangladesh is the non-availability of quality seed at proper time of sowing. Only about 15%-20% quality jute seeds are supplied by institutional sources however the rest amount of quality seeds yet to be managed to supply. Bangladesh Jute Research Institute (BJRI) produces nucleus seed to produce "Breeder seed" duly certified by Seed Certification Agency (SCA). Bangladesh Agricultural Development Corporation (BADC) collects Breeder seeds from BJRI for producing Foundation seeds at its own multiplication farms. BADC produces certified seeds through its contract growers. Besides, BJRI also produces 8-10 tons of Truthfully Leveled Seed (TLS) and distributed to the farmers. Since its inception BJRI has developed 42 varieties of jute fibre crops. Jute seed could be produced by direct seeding, plant top/stem cutting and seedling transplanting methods, called improved methods. In traditional method it took 240 to 270 days of field duration for seed production. In contrast 120 to 160 days of field duration required for any improved method. Seed sowing generally done during March-April for jute fibre, a part of matured plant's of the same land kept for seed production in traditional system. However, in off-season, June-July was proved appropriate sowing time for *Corchorus capsularis* L. and August-September for *C. olitorius* L. for quality and higher seed production. The average flowering days, pod maturation days and total field duration also varied significantly due to the planting dates in *C. olitorius* L. and *C. capsularis* L. *C. capsularis* L. yielded 100-150 kg/ha; however, *C. olitorius* L. 200-300 kg/ha of lower quality seed in traditional system. On the other hand, in improved method *C. capsularis* L. and *C. olitorius* L. yielded 500-700 kg/ha and 600-1000 kg/ha of good quality seed, respectively. Pest and diseases infestation recorded higher in traditional method. In contrast lower infestation observed in improved method. Net return and as well as BCR found higher in improved direct seeding method (1.25%), which followed by top/stem cutting (1.16%) and seedling transplanting method (1.07%). The future thrust are development of HYV, short day and stress tolerant jute varieties. Meet up the seed shortage in Bangladesh searching of suitable seed growing areas. Seed production in nontraditional areas. Location specific seed production technologies research. In spite of its success there has some constraints for producing quality jute seed like-Manpower shortage in seed management and research. Lands of different stations of BJRI are not suitable for seed production specially tossa jute. Lack of modern laboratory facilities in different regional and sub-stations.

Keywords: Jute (*C. olitorius* L. and *C. capsularis* L.), research, seed, constraints, future thrust, BJRI, BADC, SCA, BCR.

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INTRODUCTION

Jute (*Corchorus* spp.) is one of the main cash crops of Bangladesh. It plays an important role earning about 5-6% foreign exchange through exporting jute and jute goods. Jute covers about 2.86% of total cropped area. In Bangladesh, annually covering 0.461

millions ha of land with the production of 0.912 million tons of fibre. The farmers require about 4,000 tons of seed to cultivate the said area [1]. Jute accounts for about 4% of the foreign currency earnings from export. It is a common term used both for plant and the fibre obtained from the bark of the plants, *Corchorus*

capsularis L. and *Corchorus olitorius* L. These two species are annual and short day plants belonging to the family *Tiliaceae*. Bangladesh is not only the second largest producer of jute but also produces the best quality jute fibre and leads the export market. In Bangladesh, jute is grown in about 0.7 - 0.8 million hectares of land by about 3.0-3.5 million out of 10 million farm families. It is a rapid growing renewable biomass and photo-reactive crop with only 100-120 days harvesting period. It is mainly grown for fibre rather than the seed. It is a photo-period sensitive and short day plant. The critical photo-period is being 12 hours for *C. capsularis* L. and 12.5 hours for *C. olitorius* L. plants [2, 3]. Due to photo-sensitivity, jute plants sown or planted subjected to short days (less than the critical photo-period) giving stunted growth and premature flowers [4, 5]. Its fibre is primarily used for making hessian, sack and carpet backing clothes. It has versatile uses for making mats, blankets, furnishing fabrics, packaging materials & other diversified jute products in the jute mills.

The demand of seed of departmental seed was higher but there was no seed production farm and registered farmers under the then established. Chitla jute seed farm in Kustia was established to produce pedigree jute seeds and to supply the Department. Later on another farm of 833 acres was established in Nasipur, Dinajpur in 1960. In 1976 a Seed Wing was established in BJRI as per recommendation of FAO/ADB. Since then BJRI plays a vital role for production and supplying quality jute seeds in the country. But, this Seed Wing of BJRI was merged with the BADC in 1988 [6]. Jute is predominantly grown for fibre rather than seed production. Farmers usually grow seeds by keeping a part of their fibre crops planted in March-April. Remnant part of the fibre crop due to prolonged stay in the field is usually affected by natural calamities, becomes physiologically weak and produces low yield of poor quality seeds. Besides, fibre quality on seed maturity becomes degraded and sells at a low price. This results in a chronic problem in the cultivation practice of jute crop. Besides the use of jute fibre, jute sticks are traditionally used as fuel and fencing in the rural areas. Recent uses of jute sticks are in making activated charcoal. Moreover, the sticks are used as house construction materials either directly or with mill processed hardboard while the leaves continue to be used as a favorite vegetable. In addition, jute plants improve soil productivity because of its huge leaf defoliation and root proliferation in the field [7-9].

Predominantly jute is grown for fibre and thus little attention is given to its seed production. Earlier, farmers of Bangladesh grow jute seed along with the fibre crop. Jute crop requires 7-8 months for producing seeds and farmers keep a piece of land for this purpose at the corner of the field during harvesting of the crop for fibre. After harvesting fibre crop, the crop for seed remains almost uncared for a long period. Due to weathering, diseases and insects affect the seed crop

and as such, poor quality seed is produced. For lower seed yield and poor quality of jute seed, the farmers become more interested to procure seeds from government sources. Sometimes, farmers cannot grow good crop for using poor quality seeds obtained from markets. To overcome the problem the scientists of BJRI evolved improved technique for quality seed of jute crop [7].

To cultivate about 0.80 million hectares of land, the farmers require about 5000 to 5500 tons of seed. Some jute farmers use to produce jute crops by their own seeds but such seeds are inadequate and sometimes poor in quality. One of the most important problems for jute production in Bangladesh is the non-availability of quality seed at optimum time of sowing. Only about 15% - 20% quality jute seeds are supplied by institutional sources the Bangladesh Agricultural Development Corporation (BADC) but the rest of the seeds are produced and managed by the farmers themselves [7].

The most disappointing situation persists in the processing and preservation methods of jute seeds at farm level. Early sowing of jute seed crops are normally planted in the month of March-April, harvested in October-November, preserved at the storage from November through February and again sown in the following season in the months of March and April. The late seed crop is planted in the month of August and September, harvested in December and preserved from January through February. During this preservation period, cool and dry weather of the winter season does not cause any adverse effect on deterioration of seed quality. However, the real problem arises with the carry-over seeds and the seeds that are preserved for late season seed production programme to be sown in the month of August-September. Almost every year, there are enough unsold seeds remain with the seeds men and growers. As there is no other way of utilizing jute seeds but to destroy the entire quantity of unsold seeds, the country faces a huge wastage of national resources for want of a suitable method of long-term seed preservation. This problem warrants emphasis for the development of a suitable technology with the available materials to the farmers, which would help preserve seed viability and vigour at least for one year [3].

There evolved some less photo-sensitive varieties of both *C. capsularis* L. and *C. olitorius* L. species which have flexibility in sowing time and can easily be accommodated in three cropping patterns. Among the less photo-sensitive varieties, O-9897 of *C. olitorius* L., ranks at the top for its higher yield and better quality fibre. Farmers also prefer this variety for its early sowing characteristics. This variety exclusively produces better fibre yield but produces very poor seed yield when planted in March-April as fibre crop [6]. During the devastating flood of 1988 almost all of the jute seed crops were damaged. To recover that cataclysmic effect, jute seeds were planted in the month

of September where, O-9897 provided excellent results. Earlier evidences also offered favourable opinions that late planting technique produce higher seed yield [6, 10]. Choudhuri and Ali [11] suggestively stated that one of the devices to increase seed yield of jute was to check vegetative growth by late sowing. They further stated that jute crop should be planted in June or later so that plants remain stunted, induce early flowers and produce higher seed yield. Evidences also indicated that jute seeds could be sown even in the month of December for producing seeds of the following crop season [12, 13].

Above facts and findings thus indicated that photo-periodic effect rather brought beneficial effect to late-planted jute seed crop. Appropriate methods have been developed to produce jute seeds. Therefore, present review has evaluated the production methods, phenology, yield and cost of production of the off-season jute seed.

MATERIALS AND METHODS

The study was based on secondary data. The secondary data used were collected from different studies of the Library of Bangladesh Jute Research Institute, Dhaka during from August 2018 to till March, 2019. These secondary data were in BJRI annual reports, different thesis, Bangladesh Journal of Jute and Fibre Research of BJRI and other international journals.

FINDINGS

PRESENT STATUS: RESEARCH AND DEVELOPMENT ACTIVITIES

i. Jute and Allied Fibre Production in Bangladesh

Jute is the second most important vegetable fibre crop after cotton. In Bangladesh, last decade jute and allied fibres were cultivated about 0.70 to 0.80 millions hectares and total fibre production around 70-80 lac bales. The acreage and production of jute largely depends on market price of jute fibre at previous year and environment. The acreage and production of jute and allied fibre during last 10 years presented below.

Table-1: Acreage, production and yield of jute during last 10 years from 2008-09 to 2018-19

Year	Acreage (Lac ha.)	Production (Lac metric ton)	Production (Lac bales)	Yield (ton/ha)	Yield (bales/ha)
2009-10	4.56	8.89	48.99	1.95	10.74
2010-11	8.03	15.23	83.93	1.90	10.45
2011-12	7.60	14.41	79.41	1.90	10.45
2012-13	6.81	13.71	75.54	2.01	11.09
2013-14	6.66	13.57	74.78	2.04	11.23
2014-15	6.73	13.52	74.50	2.01	11.07
2015-16	7.25	13.74	75.71	1.90	10.44
2016-17	7.37	14.96	82.43	2.03	11.18
2017-18	7.90	14.54	80.10	1.84	10.14
2018-19	6.50	13.50	74.39	2.08	11.44

Source: BBS & DAE

ii. Status of Jute seed in Bangladesh

In BJRI, jute and allied fibre seed research activities is the main responsibility of breeder seed department of Genetic Resources and Seed Division. Besides breeder seed department other divisions like agronomy, pest management and jute faming systems division done some research work on jute and allied fibre seeds. At present, BADC is the major public sector of the country produce and distributes Jute and Allied Fibers (JAF) seeds to the growers. Generally BADC produces 700- 800 tons of seed both of deshi (*C. capsularis* L.) and tossa (*C. olitorius* L.) meeting only 8-10% of the total jute and allied fibers (JAF) seed requirements.

It is to be noted that the total need of deshi (*C. capsularis* L.) seeds is being met by the country itself through domestic source. In case of tossa (*C. olitorius* L.) seed, out of total requirement of 4500 tons, BADC is supplying only 450 tons. It appears that the remaining quantities of *C. olitorius* L. seeds are coming from the farmers own production (very little) and from both official and unofficial trade from a neighboring country.

The unofficial source of jute seed has no guarantee of its quality and is often causes of lower yield. Due to lack of sufficient quantity of quality seed from the public sector farmers always opt for unofficial source of jute seeds.

With a view to overcoming this critical situation, Ministry of Agriculture (MOA), Bangladesh has directed to increase the production of quality seed both in the public and private sectors and for making best quality seeds available to the farmers on time with competitive price.

A look in to the public sector jute seed production reveals that Bangladesh Jute Research Institute (BJRI) produce nucleus seed to produce "Breeder seed" duly certified by Seed Certification Agency (SCA) with tag level. BJRI generally supplied 1000-1600kg Breeders Seed to BADC & NGOs every year for multiplication as Foundation and finally certified seed. Besides, BJRI also produces 8-10 tons of Truthfully Leveled Seed (TLS) in its different stations and supply to the farmers. Bangladesh Agricultural

Development Corporation (BADC) collects Breeder seeds from BJRI for producing Foundation seeds at its own seed multiplication farms. BADC then produces certified seeds through its contract growers. After collection, necessary processing and marketing of jute seed were done accordingly to reach to the hands of the farmers.

For production of certified jute seeds, there are six-contract growers zone under the management of BADC. The seeds are procured, processed and preserved in the seed processing centers and after packing, it is transported to distribution centers for selling to the farmers. Seeds are then distributed through private seed dealers with the consultation of DAE. In case of imported jute seed, distribution programme is taken themselves as of demand.

Recently, BJRI has taken up a programme of “Nizer beez nize kore” at farmers level to make the farmers self sufficient by providing seed and practical training. This programme has expanded widely with 2500 farmers training annually under “Develop & Dissemination of Agricultural Technologies of Jute & Allied Fibre Crops” project. Arrangement of fund through agricultural subsidy can help to overcome this situation of seed to a large extent. It may be mentioned here that jute seed crop alone is not profitable to the farmers. As jute is a short day plant, its production period covers Rabi season where lots of high value crops are there. So farmers of Bangladesh are reluctant to grow jute seed.

Table-2: Variety wise Breeder seed production in BJRI during 2013-2014 to 2017-2018

Name of varieties/ Year	2013-14	2014-15	2015-16	2016-17	2017-18
Desi pat					
CVL-1	260	245	530	385	545
CVE-3	8	12	0	0	0
CC-45	0	30	0	0	0
BJRI Deshi Pat -5 (BJC-7370)	30	0	50	95	85
BJRI Deshi Pat -6 (BJC-83)	20	0	0	0	0
BJRI Deshi Pat -6 (BJC-2147)	8	0	0	0	0
BJRI Deshi Pat -8 (BJC-2197)	0	0	5	25	12
BJRI Deshi Pat Sak-1	0	0	0	13	6
Sub -total	326	287	585	518	648
Tossa pat					
O-9897	540	500	670	761	618
OM-1	3	0	0	0	0
BJRI Tossa Pat-4 (O-72)	51	30	55	60	26
BJRI Tossa Pat-5 (O-795)	46	90	40	99	75
BJRI Tossa Pat-6 (O-3820)	0	0	20	20	10
Sub -total	640	620	785	940	729
Kenaf					
HC-95	250	110	115	339	280
BJRI kenaf-3	0	0	0	18	15
Sub -total	250	110	115	357	295
Total amount of seed (kg)	1216	1017	1485	1815	1672

The Government of Bangladesh has given more thrust to promote the seed industry particularly by helping the private sector and Non Government Organizations (NGOs). About 50 companies are now in active seed business for different crops and different seed associations have grown up. It is the prime time to

bring the private company to produce quality jute seed domestically to reduce the dependence on imported jute seed as well as to curb the unauthorized jute seed trade. BJRI has HYV jute varieties for the Bangladeshi farmers to get fibre and as well as jute seed profitably.

Table-3: Demand and supply of jute seed (*C. capsularis* L. & *C. olitorius* L.) and kenaf seed in Bangladesh during last seven years from 2011-12 to 2017-18

Year	Demand (M.T)				Supply (M.T)			
	Desi	Tossa	Kenaf	Total	Desi	Tossa	Kenaf	Total
2011-12	465	4125	555	5145	446	4733	440	5619
2012-13	352	3770	465	4587	277	3723	498	4478
2013-14	345	3675	480	4500	447	4613	425	5285
2014-15	360	3690	510	4560	493	4049	448	4991
2015-16	337	4030	525	4892	500	4292	757	5549
2016-17	292	4223	707	5222	368	4899	1097	6364
2017-18	220	3463	627	4310	227	4102	909	5238

Source: DAE and BADC

Organizations (public) Involved in Jute Seed Sector of Bangladesh

Four components of jute seed industry in Bangladesh are controlled by several public and private sector organizations. These are:-

- *Variety/Seed Improvement:* The Bangladesh Jute Research Institute (BJRI) and The Bangladesh Institute of Nuclear Agriculture (BINA).
- *Seed production:* Bangladesh Agriculture Development Corporation (BADC), and Bangladesh Jute Research institute (BJRI)
- *Seed Marketing and Distribution:* BADC, BJRI, Department of Agriculture Extension (DAE), Department of Jute, Ministry of

Textile and Jute, BINA and Private Seed Importers.

- *Controlling Institution:* Seed certification Agency (SCA) and seed Wing of Ministry of Agriculture.

iii. Bangladesh Jute Research Institute (BJRI)

Since its inception BJRI has developed 49 varieties of jute and allied fibre crops. Of which 20 are now cultivated at farmers level. Under Agriculture Research on Jute, BJRI produces breeder seeds of released varieties to supply to BADC for their Foundation as well as certified Seed production program. Besides BJRI also produces truthfully labeled seeds (TLS) in order to supply quality jute seeds at farmers level. Seed production programme of BJRI are as follows.

Table-4: Seed production programme of BJRI during last 5 years

Year	Breeder Seed (kg)	TLS (ton)
2013-14	1216	62.675
2014-15	1017	61.827
2015-16	1485	3.203
2016-17	1815	7.678
2017-18	1672	10.365

iv. Bangladesh Institute of Nuclear Agriculture (BINA)

Using radiation techniques the institute has already developed 97 improved mutant varieties of different crops and accordingly released by the National Seed Board (NSB) for large scale cultivation in the farmer’s field. Of the 97 varieties three were of jute out of which two for fibre production and one for vegetable purposes. Besides BJRI, they are the only Institute for variety development on jute. BINA supplies about 20 kg of breeder’s seed of these varieties to BADC for foundation and subsequently certified seed production.

The Department of Agriculture Extension is the largest public sector extension service provider in Bangladesh. Its mission is providing needs based extension services to all categories of farmers and enabling them to optimize their use of resources in order to promote sustainable Agriculture and socioeconomic development. The core functions of DAE include increasing agricultural productivity, human resources development and technology transfer. Of different Projects of DAE “Production, Storage and Distribution of quality Rice, Wheat and Jute Seed at Farmers Level” is one of the important, projects through which quality jute seeds are produced. Jute seed production and distribution of DAE are as follows.

v. Department of Agricultural Extension (DAE)

Table-5: Jute seed production and distribution of DAE

Year	Seed production (M.T)
2013-14	15.0
2014-15	10.0
2015-16	33.0
2016-17	26.0
2017-18	11.0

Source: DAE

vi. Department of Jute, Ministry of Textile and Jute

Due to heavy shortage of jute seed in the country intrusion of inferior quality or non certified jute seed occurs causing deterioration in the quality o jute fibre and consequently has an adverse affect on the jute product. To save the country’s jute industries from unwanted critical situation, it has been strongly recommended to go for distribution of quality seeds to the jute growers. As a pilot project named “Integrated

jute production and Marketing” was launched funded by EC in 1994 and continued up to 1997. From 1997 another project was launched entitled “Production and Exchange Programme of HYV Jute Seeds at Farmers” and continued up to 2002. Later on “Integrated HYV Jute and Jute Seed production” project was undertaken in order to continue the programme of supporting quality jute seed distribution to the growers. Through this project jute growers are getting input programme.

The seed production programme (last 5 years) under these projects was as follows.

Table-6: Jute seed production and distribution of MoTJ

Year	Seed Production (m. ton)
2012-13	1150.00
2013-14	1095.00
2014-15	971.19
2015-16	1016.00
2016-17	1180.48

vii. Bangladesh Agricultural Development Corporation (BADC)

It is an autonomous corporate body under the Ministry of Agriculture serves to the whole of Bangladesh and has a nationwide network of outlying field offices down to the upazila/Farm level and at some places even below that level. The primary functions of BADC are: to make suitable arrangements throughout

Bangladesh for the production, procurement, transport storage and distribution of essential agricultural inputs such as seed and fertilizers through utilization of surface and underground water to the farmers. It is the largest public institution for production and distribution of jute seeds in the country. Seed production and distribution of last five years are projected below.

Table-7: Jute seed production and distribution of BADC during last 5 years

Year	Production (M.T)			Distribution (M.T)		
	Deshi	Tossa	Total	Deshi	Tossa	Total
2013-14	317.5	473.1	790.6	315.7	454.5+199.6*	969.8
2014-15	564.8	479.0	1043.8	500.9	459.8	960.7
2015-16	521.8	371.2	893.0	520.0	297.5	817.5
2016-17	470.9	363.0	833.9	368.7	341.0	709.7
2017-18	234.2	545.0	779.2	227.3	0.3	227.6

Source: BADC *Imported seed (JRO-524)

viii. Seed Wing

The seed wing is the administrative authority of the seed sector in Bangladesh. The Wing plays an important role in monitoring seed production, import,

distribution and utilization. It is responsible on testing breeder seed, certified seed, seed market, monitoring including an analysis on the demand and supply of seed in Bangladesh. Jute seed import situation are as follows.

Table-8: Jute seed import situation

Year	Tossa Jute (m.ton)	Kenaf (m.ton)	Total
2017-18	4102	909	5011
2016-17	4598	1097	5695
2015-16	4005	757	4762
2014-15	3598	640	4238
2013-14	3964	928	4891
2012-13	3980	550	4530
2011-12	4361	656	5017
2010-11	3617	772	4389
2009-10	3141	186	3327

ix. Seed Certification Agency (SCA)

The SCA is a regulatory agency of the ministry of Agriculture, responsible to certify and control the quality of all agriculture seeds of the recommended varieties since its establishment in 1974, SCA has been playing a vital role in quality seed production under an expanding seed industry development program in the country. The agency

certifies and maintains seed quality through Field inspection, Seed Testing and Variety Testing as per decision of the NSB and regulations provided by the National Seed policy 1993. At present there are three classes of seeds (breeder, Foundation and Certified) under the Seed certification program in our country. SCA also monitored TLS through market monitoring system.

Table-9: List of varieties of jute and allied crops of Bangladesh

SI No	Varieties	Released year	Pedigree
White jute (<i>C. capsularis</i> L.)			
1.	Oocarpus	1910	PLS
2.	Kakya Bombai	1910	PLS
3.	R-85	1916	PLS
4.	D-154	1919	PLS
5.	D-386	1931	PLS
6.	Funduk	1939	PLS
7.	C-212	1939	PLS
8.	C-13	1941	PLS
9.	C-412	1942	PLS
10.	C-1	1952	PLS
11.	C-2	1952	PLS
12.	C-3	1952	PLS
13.	C-4 (C-320)	1955	PLS
14.	C-5 (C-321)	1955	PLS
15.	D-154-2	1961	PLS
16.	C-6 (C-322)	1967	PLS
17.	CVL-1	1977	PLS
18.	CVE-3	1977	PLS
19.	CC-45	1979	PLS
20.	BJRI Deshi Pat-5 (BJC-7370)	1995	D-154 x CC-45
21.	BJRI Deshi Pat-6 (BJC-83)	1995	CVL-1 x Fuleshwari
22.	BJRI Deshi Pat-7 (BJC-2142)	2008	CC-45 x BJC-718
23.	BJRI Deshi Pat-8 (BJC-2197)	2013	CC-45 x FDR
24.	BJRI Deshi Pat Shak-1 (BJC-390)	2014	Cap dwarf red x BINA Pat Shak-1
25.	BJRI Deshi Pat-9 (BJC-5003)	2017	CVL-1 x Acc.1831
Tossa jute (<i>C. oclotarius</i> L.)			
26.	Chinsura green (D-38)	1915	PLS
27.	R-26	1929	PLS
28.	R-27	1929	PLS
29.	O-620	1939	PLS
30.	O-632	1939	PLS
31.	O-753	1939	PLS
32.	O-1	1955	PLS
33.	O-2	1955	PLS
34.	O-3	1955	PLS
35.	O-4	1967	PLS
36.	O-5	1964	PLS
37.	O-9897	1987	O-5 x BZ-5
38.	OM-1	1995	PLS
39.	BJRI Tossa Pat-4 (O-72)	2002	O-9897 x O-2021 x O-9897
40.	BJRI Tossa Pat-5 (O-795)	2008	O-4 x Uganda Red
41.	BJRI Tossa Pat-6 (O-3820)	2013	PLS
42.	BJRI Tossa Pat-7 (MG-10)	2017	PLS

Source: Islam [7].

Table-10: Variety wise Breeder seed distribution to BADC and private seed companies in last 5 years

Name of varieties	2013-14	2014-15	2015-16	2016-17	2017-18
Deshi pat					
CVL-1	180.00	219.00	219.00	232.50	232.50
BJRI Deshi Pat -5 (BJC-7370)	12.00	21.00	21.00	27.00	12.00
BJRI Deshi Pat Sak-1	-	-	-	3.00	3.00
Sub -total	192.00	240.00	240.00	262.50	247.50
Tossa pat					
O-9897	350.00	365.00	531.00	509.34	266.25
BJRI Tossa Pat-4 (O-72)	12.00	23.00	28.00	25.83	13.18
BJRI Tossa Pat-5 (O-795)	12.00	19.00	14.00	42.92	-
BJRI Tossa Pat-6 (O-3820)	-	-	-	2.33	2.32
Sub -total	374.00	407.00	573.00	580.42	281.75
Kenaf					
HC-95	5.00	25.00	25.00	325	140.00
Total amount of seed (kg)	571.00	672.00	838.00	1167.92	669.25

STRATEGIES OF POPULARIZATION NEW VARIETIES AND TECHNOLOGIES

i. Supply of quality jute seed in time at doorstep of farmers

Due to short span of sowing time for jute, it is necessary to supply the jute seed well ahead of sowing time to the doorstep of farmers. Supply of jute seed should be distributed on the basis of demand and sowing time of the zone (early, late). Besides, jute seed marketing of public organizations need to be strengthened/modernized/competitive as well as private sectors need to be encouraged to produce seed in the country.

ii. Development of High Yielding Varieties (HYV) of jute

A single variety of tossa jute is mostly cultivated (80% of world jute area) over the jute growing areas of India and Bangladesh which is not desirable. Though productivity of jute has been increased to some extent but lot more need to be addressed to minimize cost of production with quality fiber and to withstand the competition thrown by cheaper synthetic fibers. Moreover, cultivation of jute is increasingly shifting to less productive land, thus creating challenges in dealing with new emerging production constraints. As an eco-friendly crop the demand of jute is increasing day by day. To meet up this demand variety development program should be strengthened to evolve HYV, having drought/flood/salinity tolerance and early maturity.

iii. Judicious import of jute seed

Different public organizations in Bangladesh are producing and distributing jute seed. Import quantity of jute seed is to be determined by considering the carryover seed and the production and marketing of the existing organizations on the corresponding year. It may be mentioned here that, to reduce the dependency on imported seed, gradual increase in seed production and distribution of public sector is necessary.

iv. Extension services need to be strengthened

Extension machinery needs to be activated for popularization of different varieties along with their potentialities. This will minimize the risk of dependence on single variety as well as will increase the production and productivity of jute through exploitation of newly developed varieties. It is noticed that even the results of research and development so far achieved have not been fully utilized for want of adequate extension facilities. This situation needs to be corrected by strengthening jute-specific extension services. Besides, BJRI developed “jute seed production technology” as well as “Nijer beez nije kori” programme should be disseminated with immediate priority.

v. Identification of new areas for production of jute seeds

Exclusive dependence on a few conventional jute seed production areas may affect the entire jute production in case of any large scale damage. Besides, developments of HYV of jute, identification of ideal seed production zones nearer to the marketing areas deserve much attention. If the jute growing areas produce at least some quantity of jute seed in the identified areas of their own, farmers may be benefited by availing the seed at an appropriate time and a moderate price.

vi. Kenaf-Mesta seed production and distribution should be undertaken by Public sectors

Kenaf varieties released by CRIJAF (India) are having the yield potentialities of 2.7-3.0 q/ha, whereas our farmers are getting 1.5-1.6 ton/ha. One of the major reasons for this yield gap is non-availability of seeds of improved varieties to the farmers. The kenaf production of Bangladesh is entirely dependent on Indian seeds. Organized/certified system of production of mesta-kenaf seed has to be taken up and this needs immediate attention.

vii. Following of seed multiplication chain in the production system of jute and kenaf-mesta seeds

After formal release and notification of a variety, the process of seed production and distribution is followed. Breeder, Foundation and Certified seed production is done for all notified varieties of jute in order to get quality seeds. The regeneration process from breeder to certified seed stage takes three years in jute and kenaf. This production cycle has to be ensured specially in India from where seeds are producing and distributing.

viii. Strengthening of monitoring system of Seed certification agency (SCA) of Bangladesh

Due to huge demand of jute seed, sometimes dishonest traders are taking the opportunity of introducing poor quality seeds in the market. They are mixing the new seed with old seed. India is the producer of 80% of jute seed of the world. In India only 30% seeds of the requirement is producing under public sector, the rests are under private sectors. Certification of kenaf seed in India is very limited. But the imported all kenaf seeds in Bangladesh are certified. In this context, certified seed production of jute and kenaf has to be increased and to be made available in time, and in adequate quantity at reasonable price.

ix. Buffer stock of jute and kenaf seeds

Natural calamities are a common phenomenon in Bangladesh. Excessive and continuous dependence on a few major production areas may affect seed availability and jute production due to any unforeseen large-scale damage. A conditioned seed storage facility with capacity of at least 25% of the requirement in jute growing areas is necessary.

x. R and D activities for alternate uses of jute and mesta-kenaf seeds along with their biomass

Jute and kenaf-mesta seeds' have no alternated uses other than as propagating materials. On the other hand reasonable quantities of these seeds remain unsold every year. Through value addition jute and mesta seeds may be marketed as important commodity other than propagating materials. Jute and mesta-kenaf seeds are reasonably rich in oil content and these oils may be used industrially. Profitable utilization of left over biomass especially fibrous stems of jute seed crops may be explored. Research interventions may yield useful result.

JUTE SEED PRODUCTION

Quality seed is the prerequisite to successful crop production. Yield of jute can be increased by 15-20% through good quality seeds alone. Generally jute seed crop is raised in two different methods. 1) Traditional method and 2) Improved method.

Methods of jute seed production

A portion of the fibre crop is kept at a corner of the main field for seed harvest. In traditional method, the most important intercultural operation was to rogue out off-type variety, diseased and insect infested plants.

Other cultural operations are same as that followed in fibre crops. However, seed yield and quality were found to be very low in this method. On the contrary improved was found to be appropriate technology of jute seed production under varied conditions as it could be practiced through late planting to avoid flooding during monsoon as well as precipitation during seed maturation. Crop grown under improved method could also be harvested in dry months ensuring the high seed quality. In improved method, jute seed could be produced through three different methods i.e. i) Direct seeding method, ii) Stem/top cutting method and iii) Seedling transplanting method.

Direct seeding method

Studies revealed that the direct seeding method was observed to be the easiest and most profitable among the three methods of jute seed production technology. In this method seeds needed to be sown in July-August on medium high to high land with well drained soil where rain water or flood water did not accumulate or inundated the seed crop. The appropriate soil texture were sandy loam with pH value ranging 5.5-6.0 and the soil rich with organic matter was reported suitable for direct seeded jute seed crop. Cleaning weeds during land preparation was found to be effective to keep the land being less infested with more weeds during the subsequent period. Seeds sown on mid July to mid September were found to be productive. However, tossa jute seeds could be sown up to the last week of September.

Studies on seed rate showed that the rate depended on the soil condition, species and planting methods. In case of Deshi jute under line sowing it ranged 4.0-4.5 while under broadcast sowing 5.0-5.5 kg/ha. But in case of Tossa jute under line sowing 3.0-3.5 and broadcast sowing 4.0-4.5 were found to be optimum. Treatment of 1 kg of jute seed with 4-5 gm of Provex-200 for 10 minutes in a tin/plastic pot prevent jute plants from soil pests.

Top/Stem cutting method

Top/Stem cuttings were to be transplanted during July-August, where strong and healthy stems, preferably of 120 days old were proved to be best. The optimum length of each cutting ranged 20-25 cm having 2-3 nodes which needed to plant in line with a spacing of 30 cm between the lines and 10 cm between the transplanted cuttings maintaining 5 cm depth at 45° angles inclined towards north-south direction.

Seedling transplanting method

On seedling transplanting method, sowing 50-100 gm seeds in a seed bed measuring 3m×1m using 50-100 g seed within mid July to mid August were proved to produce vigorous seedlings. 25-30 days old seedlings transplanted from mid August to last week of September in lines with a spacing of 30×10 cm and fertilizer with 60 Kg/ha Urea, 50 Kg/ha TSP, 20 Kg/ha

MP and 50 Kg/ha Gypsum were found to be produced higher seed yield. Besides this, two splits of urea for top dress in first split (60 Kg/ha) on 30-35 days after transplanting and second split (60 Kg/ha) before flowering were needed.

Studies on jute seed crop harvest data suggested being between mid-October to mid-December when 60-70% capsules/fruit of deshi jute became brown in color. However, in case of O-9897 the optimum harvest time was identified when 80% fruits turned brown in colour. Over maturity mainly in *C. olitorius* L. promoted shattering. Moist plant due to rain should be avoided for harvesting.

Traditional method

In traditional method the seed crop yielded about 150 to 250 kg/ha of seed. However, in improved direct seeding method it was observed to yielded 600 to

1000 kg/ha. Seed yield of 600 to 900 and 600 to 800 kg/ha were obtained in top/stem cutting and seedling transplanting method, respectively.

Studies revealed that the sowing time was very early in conventional and very late in improved method. Seed rate was recorded very high in conventional, on the other hand, in improved method the rate was very low and other types. A wide field duration of about 240 days was required in conventional, while in improved it was to be as low as 120 days (Table-12). As usually the pest and disease infestation was also found very high in conventional, but in improved method it was recorded to be very low among the seed production methods. In terms of survivability it was observed that probability was higher in direct seeding method, while medium in traditional and seedling transplanting methods (Table-12).

Table-12: Agronomic suitability of different methods of jute seed production

<i>Agronomic parameters</i>	Traditional method	Direct seeding	Top / stem cutting method	Transplanting Method
<i>Land requirements</i>	Land with fine tillage	Land with fine tillage	Land with fine tillage having available moisture	Land with fine tillage having high moisture
<i>Optimum sowing time</i>	April to May	Mid August to 1 st week of September	Throughout the July	Mid August to September
<i>Optimum seed rate</i>	6-8 Kg/ ha	4-5 Kg/ha	It requires mother plants to collect top/stems	50-100 gm seed for a seed bed of (3x1)m ² area
<i>Field duration</i>	About 240 days	About 120days	About 135 days	About 150 days
<i>Infestation of pests and diseases</i>	Very high	Very low	Very low	Low
<i>Survivability</i>	Medium	Higher	High	Medium

Source: Islam [7]



C. capsularis L. fruits



C. olitorius L. fruits

Response studies of *C. capsularis* L. in terms of pod/plant, seed pod, seed wt/ plant and 1000-seeds weight towards different seed production methods were also made. Results revealed that direct seeding was found to be superior over all other methods (Table-13). The highest seed yield (500-700 kg/ha) was recorded in direct seeding. In contrast the lowest (200-300 kg/ha) in

conventional method of seed production (Table-13). Similar results were also observed in seed yield attributes of *C. olitorius* L. where the improved method, seed yield, were recorded to be as high as about 600-1000 kg/ha. Whereas, in conventional it was the lowest (150-250 kg/ha) (Table-14).

Table-13: Jute seed yield and yield attributing characters of *C. capsularis* L. under different production methods

Production methods	Branch /plant	Pod /plant	Seed /pod	Seed weight /plant (g)	1000 seed weight (g)	Seed yield (kg/ha)
Conventional	3-4	10-15	20-25	2.50-2.70	2.50-2.99	200-300
Improved method						
• Direct seeding	3-4	30-45	35-50	3.75-4.50	2.85-3.24	500-700
• Top/stem cutting transplantation	-	-	-	-	-	-
• Seedling transplantation	3-4	25-30	30-40	3.25-4.00	2.50-3.00	400-600

Source: Islam [7].

Table-14: Jute seed yield and yield attributing characters of *Corchorus olitorius* L. under different production methods

Production methods	Branch /plant	Pod /plant	Seed /pod	Seed weight /plant (g)	1000 seed weight (g)	Seed yield (kg/ha)
Conventional	4-5	20-25	50-120	3.00-3.15	1.80-2.00	150-250
Improved method						
• Direct seeding	4-5	45-50	150-220	3.40-3.70	2.00-2.35	600-1000
• Top/stem cutting transplantation	3-5	50-60	170-230	3.45-3.75	2.00-2.35	600-900
• Seedling transplantation	3-4	45-55	160-220	3.35-3.65	2.00-2.35	600-800

Source: Islam [7].

Different parameters in jute seed production

Average days to flowering

The attainment of average flowering ranged from first week of September in sowing from May15 to July15 in *C. capsularis* L., (D-154 and CVL-1). In September30 sowing in *C. capsularis* L., the average flowering ranged from first week of November. In *C. olitorius* L., (O-9897) it ranged from first week of September in sowing from May15 to June30 and in mid

November in sowing of September30. It extended in O-4 up to last week of November in September30 sowing. In *C. capsularis* L. the average flowering days, pod maturation days and total field duration varied significantly due to planting dates. May15 and May30 sowing took longer period of 113 to 108.5 days, respectively for attainment of average flowering. It decreased gradually in latter dates of sowing. It was 44.5 days in September 15 sowing. In *C. olitorius* L. the

average flowering days, pod maturation days and total field duration also varied significantly due to the planting dates. The average flowering days consistently decreased from May15 sowing (123.5 days) to September 30 (41 days) in O-4 and O-9897.

Pod maturation

Pod maturation in all experimental materials was attained within 50 to 67 days. It was shorter in July to August sowing. But longer in earlier and latter

planting as compared to July and August sowing. In *C. capsularis* L. pod maturation days gradually decreased from May15 to September30. The duration was 65.5 days in May15 sowing and 60 days in September 30 sowing. In *C. olitorius* L. pod maturation days also decreased consistently from May15 to July15 and it increased from July 30 to September 30 sowing. Field duration also showed a consistent decrease from May15 to September 30.



Seed washing and drying

Field duration

Field duration ranged from first week of November to first week of January in D-154, CVL-1 and O-9897. Whereas it ranged from first week of November to last week of December in O-4. May15 to July15 sowing required more than 6 to 8 months field duration in D-154, CVL-1 and O-4. July30 to September30 sowing required less than 4 months of field duration in D-154, CVL-1 and O-4. *C. olitorius* L. O-9897 required 5.6 months to 4 months field duration in May15 sowing through August30 sowing. It was less than 4 months in two September sowings. The days from sowing to flowering, sowing to pod maturation and sowing to harvest were counted and expressed in calendar days. In *C. capsularis* L. field duration decreased gradually from May15 to August30 sowing whereas, increased in September15 to September30 sowing. It was 178 days in May15, 102.5 days in August30 and 106.5 days in September30 sowing. In *C. olitorius* L. the field duration ranged from 103-201 days in O-9897 and from 93-182 days in O-4 from May15 to September 30 sowing. The marked difference in total field duration between O-9897 and O-4 supports the

earlier report that O-9897 was less photosensitive (Figure 1, 2 & 3) [5].

Being less photosensitive O-9897 took longer field duration to get the pod matured than the D-154, CVL-1 and O-4. It may be postulated that the late varieties started flowering at day length of 12.30 hours. This might have happened due to decrease in sunshine hours from June to September (5.0 to 5.9 hours). The variety O-9897 responded to a low temperature, shorter sunshine hours and day length below 12 hours. Kar [14] indicated that a critical day length for both jute was 12 hours and suggested that low temperatures hastened the photoperiodic effect in *C. olitorius* L. and delayed the reproductive phase in *C. capsularis* L. He also reported days to flowering of both jute to be progressively shortened with the delayed planting from April to October. Plant height also decreased significantly in all the jute varieties from May15 to September30 sowing. It was taller in May15 and shorter in September30 sowing. *C. olitorius* L. attained higher plant height than *C. capsularis* L. [15, 16].

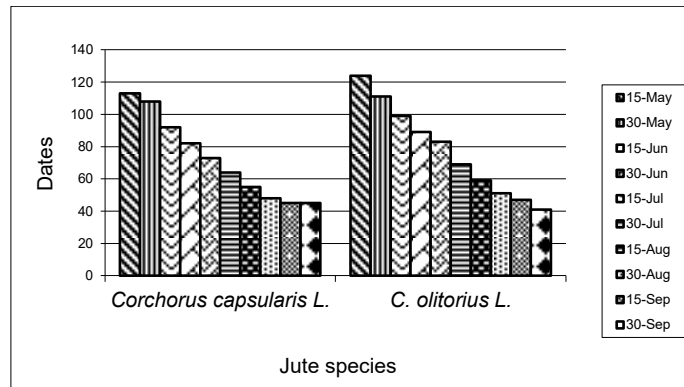


Fig-1: Average days to flowering of jute seed plants as affected by different dates of sowing
(Source: Islam [7])

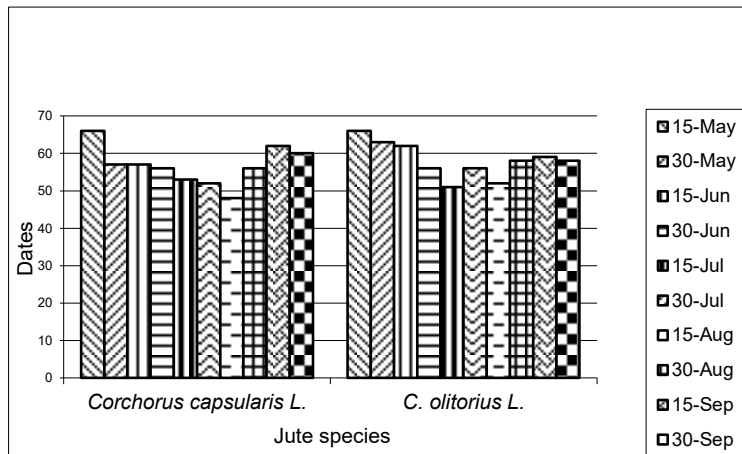


Fig-2: Days to pod maturation of jute seed plants as affected by different dates of sowing
(Source: Islam [7])

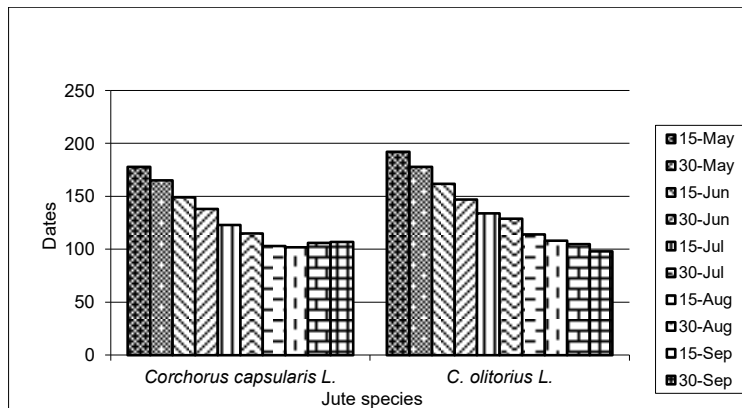


Fig-3: Field duration for jute seed production as affected by different dates of sowing
(Source: Islam [7])



C. oltorius L. and *C. capsularis* L. seeds and fruits

SEED TECHNOLOGY

i. Appropriate time of jute seed crop harvest

The crop becomes ready to harvest between mid October-mid December when 60-70% capsules become brown in color. This is the optimum time of harvesting the crop. Over maturity mainly in *C. oltorius* L. promotes shattering. Wetted plant due to rain should be avoided to harvest. Jute seeds are to be harvested in sunny day so that it can be dried immediately after harvest. It is also found that harvesting jute seed in sunny days before noon. As some fruits are burst due to over maturity and these fruits receive moisture from night dews and seeds get wet. If these seeds are harvested at an early hour before drying of seeds, this moisture certainly affects seed quality [9].

ii. Physiological maturity of jute seed

Maturity of a seed at the time of harvest is one of the important factor that contribute to quality seed production. The harvest stage of 194 days in *C. capsularis* L. and 178 days in *C. oltorius* L. coincide with 60% browning of fruits in *C. capsularis* L. and 70% browning of fruits in *C. oltorius* L. Such stage of fruit browning confirm to physiological maturity i.e. optimum germinability, lowest moisture content, optimum seed dry weight for both the species and at the same time it appears maximum fruit bearing and highest seed yield. Seed should be collected at harvest stage of 194 and 178 days which coincide with 60% and 70% browning of fruits for *C. capsularis* L. and *C. oltorius* L., respectively [9]. Seed crop will be harvest when physiological maturity will come up.

iii. Suitable floor for jute seed drying at farmers level

Initial seed moisture content plays a vital role in the maintenance of seed quality in storage. The effect of floor types on the reduction of moisture during seed drying is very important. Seed drying on gunny bag or sacking was found very effective to reduce seed moisture without any damage of its embryo. Seeds will be dried just after harvest on gunny bag or sacking [9].

Gunny bag or sacking is more suitable for seed drying at farmers level then those of polythene sheet, cowdung plated floor and cemented floor.

iv. Easy viability test of jute seed at farm level

We know quality seed increase the production about 15 to 20 percent. We are facing the scares of quality seed at the sowing time of every crop in every year in our country. So is very important to test the viability of jute seed for quality before sowing. It is very easy and cost effective to test the viability of jute, kenaf or mesta seeds. Firstly one hundred seeds with four replications will be evenly distributed on the top of four bloating papers or news paper or old cloths placed in four soil made plates. The seeds and bloating or news paper or old clothes are kept moist through out the test period by adding water. Seeds that germinated will be counted and recorded daily till fifth day. A seed will be considered to be germinated as seed coat ruptured and radicle come out up to 0.2 cm or more length. Germination test will be carried out in room temperature. Above 80% of germinated seeds are considered as good quality seed. However below 70% viability are considered as bad as not to sow in the field for production purpose [9].

v. Seed treatment method of jute seed at farm level

In jute field the incidence of many diseases are found to occur from seedling stage to late stages. These are seedling die, seedling wilt, stem rot, black band, anthracnose and yellow mosaic. Any severe incidence may affect yield by 50%. As we all know prevention is better than cure. For this purpose, we can treat seeds before sowing. Seeds should be treated before sowing to prevent seed and soil born diseases and insect- pests infestations. For this, 1 kg of jute seed is to be treated mixing with 4-5 gm of Vitavex-200 for 10 minutes in a soil pot [9].

vi. Jute seed storage at small farm Level

Jute seeds are very delicate and it is slightly difficult to maintain its viability in storage condition. Before storing seed, it must be dried through 6-7 sundry. The dried seed then is stored in airtight tin or

plastic container. The sealed lamofoil is the best of all. If the quantity is more, it can be stored in airtight drum. Seeds will be dried through 6-7 sun dry, and then dried seed must be stored in air tight tin or plastic container or sealed lamofoil. If the quantity is more, airtight drum may be used for storing [9]. Sealed lamofoil is the best for seed storing followed by airtight plastic container, tin can and drum.

Cost of production per hectare of jute seed

Real differences were recorded in terms of comparative cost of production per hectare of jute seed

production in direct seeding, top cutting and seedling transplanting methods. Results revealed that the highest variable cost was found in seedling transplanting (Tk. 84400/-) and the lowest (Tk. 75400/-) in direct seeding method of seed production (Table-15). Similar and higher gross return of Tk. 100000/- were observed in top cutting and direct seeding, however lower of Tk. 90000/- in seedling transplanting methods. The highest net return of Tk. 19600/- (BCR=1.25) obtained by calculating the data recorded from the method of direct seeding and the lowest in seedling transplanting (Tk. 5600/-, BCR=1.07) (Table-15) [5, 6].

Table-15: Comparative cost of seed production (Tk/ha) of jute in direct seeding, top cutting and seedling transplanting methods

Different operations	Unit cost	Direct seeding		Top/stem cutting		Seedling transplanting	
		No. of labour/ Amount required	Total cost	No. of labour/ amount required	Total cost	No. of labour/ amount required	Total cost
Land preparation (Ploughing and laddering)	450/-	25person	11250/-	25person	11250/-	25 person	11250/-
Seed	150/-	6 kg	900/-	-	-	3 kg	450/-
Seed sowing	450/-	4 person	1800/-	-	-	-	-
Seed bed preparation	450/-	-	-	-	-	5 person	2250/-
Seedling uprooted & transplanting	-	-	-	-	-	20 person	9000/-
Plant cut from mother plant	450/-	-	-	5 person	2250/-	-	-
Cutting making & transplanting	-	-	-	25person	11250/-	-	-
Fertilizer	-	-	-	-	-	-	-
Urea	25/-	180 kg	4500/-	180 kg	4500/-	180 kg	4500/-
TSP	20/-	50 kg	1000/-	50 kg	1000/-	50 kg	1000/-
MP	30/-	20 kg	600/-	20 kg	600/-	20 kg	600/-
Other fertilizers (Gypsum)	10/-	50 kg	500/-	50 kg	500/-	50 kg	500/-
Fertilizer and manuring	450/-	3 person	1350/-	3 person	1350/-	3 person	1350/-
Intercultural operations (Weeding & thinning)	450/-	40person	18000/-	40person	18000/-	40person	18000/-
Fruit harvest & carrying	450/-	25person	11250/-	25person	11250/-	25person	11250/-
Seed processing	450/-	35person	15250/-	35person	15250/-	35person	15250/-
Seed drying & storing	450/-	20person	9000/-	20person	9000/-	20person	9000/-
Total no. of Labour (Person)	-	157	-	183	-	173	-
Total variable cost	-	-	75400/-	-	86200/-	-	84400/-
Seed yield (kg/ha)	-	-	450	-	500	-	450
By product yield (kg/ha)	-	-	5500	-	5000	-	4500
Gross Return (Tk)	-	-	95000/-	-	100000/-	-	90000/-
Sale price (Tk) Product/Byproduct	-	-	150/5(Tk/kg)	-	150/5(Tk/kg)	-	150/5(Tk/kg)
Net Return (Tk)	-	-	19600/-	-	13800/-	-	5600/-
BCR (%)	-	-	1.25	-	1.16	-	1.07

Source: Islam [7]

CONSTRAINTS

With limited resources the agriculture research of BJRI has many successes. In spite of its success BJRI has some constraints for producing quality jute and kenaf seed.

- Manpower shortage in seed management and research.
- Lands of different stations of BJRI are not suitable for seed production specially tossa jute.
- Lack of modern laboratory facilities in different regional and sub-stations.
- Storage facilities are very poor in different regional and sub-stations of BJRI.
- Inadequate training facilities.
- Unauthorized institution of inferior quality seeds from neighboring country.
- Sometimes traders take illegal opportunity due to high demand of jute seed in the market.

FUTURE RESEARCH THRUST

Bangladesh jute research institute is trying to meet up the national requirement of jute seed by producing breeder seed, Truthfully Labeled Seed (TLS) and technology transfer at farmers as well as different seed producing organizations. There are some future thrust of BJRI is given below:

- Development of HYV jute and kenaf.
- Development of short day and stress tolerant varieties.
- To meet up the seed shortage in Bangladesh identification of suitable seed growing areas.
- Seed production research in nontraditional areas.
- Location specific seed production technologies research.
- Alternate uses of jute seed.
- Fibre extraction from late jute seed plants.

CONCLUSION AND RECOMMENDATIONS

Bangladesh produces world's best quality jute. The agriculture climate of Bangladesh is very much suitable for quality fibre production. As a result supply of quality jute seed will ensure the fibre quality as well as quantity to a great extent. The government of Bangladesh has given more thrust to promote the jute seed industry by strengthening public sectors dealing with jute seed and also by sensitizing private sectors to reduce the dependence on imported jute seed. The activities of private sectors regarding jute seed are limited on seed import only. Bangladesh and India jointly produced 92% of total raw jute of the world and Bangladesh exports about 90% raw jute and 70% jute products in the world market. The major portion of the jute seed requirement of Bangladesh is meeting up through import from India. It was also observed that some of the introduced seed lots do not have the desired quality as required. Due to heavy demand of jute seed sometimes few unauthorized traders are taking

the opportunity of introducing poor quality seeds in our country. From the above review, it may be concluded that among three improved methods of seed production, stem/top cutting and the seedling transplanting methods were found relatively complex, labour intensive and costly. On the other hand, direct seeding method was observed easier and less costly. The average flowering days, pod maturation days and total field duration also varied significantly due to the planting dates in *C. olitorius* L. and *C. capsularis* L. Pest and diseases infestation found higher in traditional method for its long field duration. Lower infestation was observed in improved method as this was practiced in dry and comparatively cool season. Net return as well as BCR was found to be higher in improved direct seeding method (1.25%), which was then followed by top/stem cutting (1.16%) and seedling transplanting method (1.07%). Therefore, it could be recommended that at farm level, the direct seeding method showed safer and appropriate for jute seed production in Bangladesh. On the other hand a strong and active coordination among public and private jute seed sectors of the country is necessary for a sound supply of quality jute seed in Bangladesh. An appropriate policy in this respect can mitigate the jute seed problem of the country.

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JUTE FIBRE YIELD AND ECONOMICS IN CHARLAND AREAS OF BANGLADESH

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Abstract. The area of charland due to alluvium is more than two thousand square kilometers in Bangladesh. About 70 to 75 lakh people dwell on different chars. The aim of jute cultivation in charlands was to disseminate of improved jute cultivation and retting technologies on chars for facilitating market systems that enhance opportunities for employment, income generation and improvement of livelihood of vulnerable charland households. The jute production programmes were conducted with plots size of 20 decimal per farmes in charlands of Jamuna river located in Kazipur and Sirajgonj Sadar of Sirajgonj, Sariaikandi of Bogra, Fulchori and Shaghata of Gaibandha and Sorisabari and Islampur of Jamalpur districts of Bangladesh during 2013-14. Results revealed that the highest fibre yield 305 kg was recorded at demo plots of Jamalpur charland area and however the lowest 276 kg was at charland of Bogra. In case of non-demo farmers, the highest fibre yield was recorded 243 kg from Gaibandha charland and the lowest 213 kg was recorded at Bogra. The average production cost was Tk. 6451 and Tk. 5544 per 20 decimal for demo and non-demo plots, respectively. The gross return, gross margin and benefit cost ratio were Tk. 10,358, Tk. 3907 and 1.61, respectively for demo farmer. In case of non-demo farmers, the gross return, gross margin and benefit cost ratio were Tk. 7379, Tk. 1832 and 1.33, respectively per 20 decimal. The benefit cost ratio (BCR) was the higher (1.61) in demo plot than that of non-demo plot (1.33).

Keywords: Charland, jute, gross return, gross margin, benefit cost ratio.

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1. Introduction

Jute is a cash crop of Bangladesh. It is grown in the summer season (Kharif-I). In 2010-2011, 0.803 million ha land cultivated for jute. Production of raw jute was 1.5 million MT by volume in 2010-2011. Jute cultivation area was 6% of total land area of 13 million ha, of which 8.44 million ha belongs to agricultural land. Jute cultivation area was 10% of agricultural land area. Jute production was 26% as of all agricultural crops (IJSG, 2012). Among the jute growing countries of the world, Bangladesh ranked second in respect of fibre production. Jute alone contributes about 1.58% to GDP without involving any foreign investment. In 2011-2012, 1523 thousand tones of jute fibre were produced from 7 lakh hectares of land (BBS, 2010). Charland in Bangladesh are landmasses formed through the sedimentation of huge amount of sand, silt and clay over time carried by the Padma, the Meghna, the Jamuna and the Brahmapurtra with their numerous tributaries. Bangladesh has about 0.83 million hectares charland of

which about 0.52 - 0.79 million hectares are cultivable. Generally charland farmers cultivate local variety of different crops following indigenous crop production practices. As a result crop yield in charland areas is low. Increase in crop yield as well as production in mainland is somewhat difficult due to higher cost of inputs and shrinkage of land resource. The diversified ecosystems of Bangladesh are prone to various environmental hazards. Climate change is added threat to the Bangladesh agriculture and vulnerable to ecosystem. Moreover, cultivable land of Bangladesh is decreasing by 1% in every year but population is increasing at an alarming rate. So, to feed the ever increasing population, crop production measures in unfavourable eco-systems like charland areas under the context of changing climate should be strengthened for ensuring food security. Cultivated soils of chars are mostly sandy loam to silty loam with slightly acidic to slightly alkaline in reaction and deficient in plant nutrients as well as organic matter content. Generally farmers in char lands cultivate local variety of different crops. Moreover, they follow their own crop production techniques which are the main causes of low yield in char areas (Aziz *et al.*, 2016).

The lands in the rivers left behind after floods are called charlands. These charlands are formed through the sedimentation, over time, of huge amounts of sand, silt, and clay carried by different rivers. The people who build temporary houses in charland are known as charland dwellers. Charlands in Bangladesh is a unique asset. This extensive stretch of resource can play an extraordinary role in reducing poverty as well as increasing income generation of a huge number landless people of the country. According to different sources, the area of charland due to alluvium is more than two thousand square kilometers in the country. At present about 70 to 75 lakh people dwell on different chars in Bangladesh. Sixty percent of these people are absolutely landless having neither agricultural nor homestead land.

The charland was a medium low to low land with sandy to silty alluvium soils and it belongs to non-calcareous alluvium predominate and organic matter is very low [8]. The alluvial charlands are most suitable for crop cultivation. A huge quantity of paddy, jute, groundnut, maize, rabi and different vegetables grow well in the charland. Jute grows in *Kharif* season (April to September). A jute cultivation programme was done in the charlands areas of Jamuna, Padma and Teesta rivers which cover four districts viz. Jamalpur, Sirajganj, Bogra and Gaibandha of northern Bangladesh to disseminate the improved jute cultivation and retting technologies on chars for facilitating market systems that enhance opportunities for employment, income generation and improvement of livelihood of vulnerable charland households.

2. Materials and methods

The aim of jute cultivation in charlands was to disseminate of improved jute cultivation and retting techniques on the char for facilitating market systems that enhance opportunities for employment, income generation and improvement of livelihood of poor and vulnerable charland households. The jute production programmes were conducted in the charlands of Jamuna river located in Kazipur and Sirajgonj Sadar of Sirajgonj, Sariakandi of Bogra, Fulchori and Shaghata of Gaibandha and Sorisabari and Islampur of Jamalpur districts during the period from April to September in 2013-14. At the beginning of the programme, high officials of BJRI visited the charlands of the said four districts for the possibility of jute cultivation. On the basis of their visit and discussion with the farmers of charlands, 20 farmers of each

site were selected through random selected method. Demo farmers' plots were selected with considering fertile land, easily visible, road side etc. for developing awareness to the different group farmers with the help of local NGOs personnel. The farmers prepared their land finely with 3-4 ploughing and cross ploughing and laddering by power tiller. They cleaned the residues of the previous crop properly. Farmers' sown jute seeds after application of recommended doses of different fertilizers. Finally drainage channels were made around the plot to remove the excess rain water.

A total of 100 jute farmers were trained up on jute cultivation following the title "Improved jute production technology and retting practices in the charland" discussing on different lessons like land selection and preparation, fertilizer management, seed treatment, seed germination test, seed sowing, intercultural operations, pest management, location specific improved jute retting practices etc. Forty jute demonstration plots in four districts (10 plots per district) was set-up and sixty farmers' field days were conducted in those locations participating nearly 1,500 farmers. Sampling of 10 grouped and 10 non-demo farmers were selected by adopting simple random sampling method. Tabular method was used for analyzing the data.



Way to char land by local boat

Farmer's home area of char land

3. Results and discussion

Results revealed that the highest fibre yield 305 kg per 20 decimal was recorded at demo farmers plots of Jamalpur charland area and the 2nd highest was 300 kg per 20 decimal was observed at Gaibandha, however the lowest 276 kg per 20 decimal was at the charland of Bogra. On the other hand, in case of non-demo farmers, the highest fibre yield was found 243 kg per 20 decimal at Gaibandha charland and the lowest 213 kg per 20 decimal was recorded at Bogra. Total production cost for both demo and non-demo farmers were Tk. 6646 and Tk. 5832 per 20 decimal, respectively were the highest at Gaibandha and both the costs were lowest at Bogra. The highest gross return Tk. 11227 was found at Jamalpur and the lowest was Tk. 9333 at Sirajgonj for the demo farmer. Gross Return Tk. 8290 was found at Gaibandha and the lowest was Tk. 7020 at Bogra for non-demo farmers. The highest gross margin for demo was found Tk. 4631 at Jamalpur and non-demo was Tk. 2458 at the charland of Gaibandha but the lowest Tk. 2937 for demo and non demo Tk. 1396 were calculated at Sirajgonj. The highest

Benefit Cost Ratio 1.70 for demo was found at the charland of Jamalpur due to the higher market price of both fibre and stick. However, BCR was the lowest 1.53 for demo at Sirajgonj. In case of non-demo plots, the highest BCR (1.42) for demo was found at Gaibandha and the lowest 1.24 was at Sirajgonj for the lower market price of both fibre and stick (Table 1). It was observed that demo and non-demo farmer, the average production costs were Tk. 6451 and Tk. 5544 per 20 decimal, respectively (Table 2).

In case of demo farmers, the average fibre yield was 291 kg per 20 decimal. The average fibre and stick price was Tk. 31.85 per kg and Tk.1.88 per kg, respectively. In case of non-demo farmers, the average fibre yield was 222 kg per 20 decimal based on the survey results. The average fibre and stick price was Tk. 30.47 per kg and Tk.1.50 per kg, respectively (Table 3). The variation in yield between demo and non-demo farmers might be the lack of quality seed, different types of management practices, lack of balanced fertilizer uses, irrigation facility, lack of knowledge about jute cultivation procedure and uncertain market price. In case of demo farmer, it was also found that, the gross return, gross margin and benefit cost ratio were Tk. 10,358, Tk. 3907 and 1.61, respectively per 20 decimal. In case of non-demo farmers, the gross return, gross margin and benefit cost ratio were Tk. 7379, Tk. 1832 and 1.33, respectively per 20 decimal. The benefit cost ratio (BCR) was the higher (1.61) in demo plot than that of non-demo plot (1.33) (Table-3). It might be due to the advantages of timely ensuring inputs and improved technologies for demo plot compared to non-demo plots in the charlands of four districts.

Table 1. Comparison between demo and non demo farmers of charlands under 4 districts on fibre yield, Total Production Cost (TPC), Gross Return (GR), Gross Margin (GM) and Benefit Cost Ratio (BCR)

Name of charland	Fibre Yield (Kg per 20 decimal)		TPC (Tk. per 20 decimal)		GR (Tk. per 20 decimal) (Include stick price)		GM (Tk. per 20 decimal)		BCR	
	Demo farmer	Non demo farmer	Demo farmer	Non demo farmer	Demo farmer	Non demo farmer	Demo farmer	Non demo farmer	Demo farmer	Non demo farmer
Sirajgonj	281	217	6396	5727	9333	7123	2937	1396	1.53	1.24
Bogra	276	213	6161	5364	9654	7020	3493	1706	1.60	1.32
Gaibandha	300	243	6646	5832	10359	8290	3713	2458	1.58	1.42
Jamalpur	305	215	6596	5252	11227	7146	4631	1894	1.70	1.36



Jute plants are harvesting



Jute plants are staked

Table 2. Cost of jute cultivation in average of Demo farmer and Non demo farmer at charland of Sirajgonj, Bogra, Gaibandha and Jamalpur districts

Items	Cost (Tk. per 20 decimal)	
	Demo farmer	Non demo farmer
Human labour: Family	1344	1460
Hired	3048	2833
Land preparation:		
Own Draft animal/tractor/tiller	149	153
Draft animal/tractor/tiller	269	260
Seed: Owned	-	-
Purchased	72	90
Fertilizer:		
Urea	307	470
TSP/DAP	84	-
MoP	72	-
Gypsum	77	-
Furadan	79	-
Pesticides:	197	40
Irrigation:	265	238
Jak covering materials (Hessian)	488	-
Total Production Cost (Tk.)	6451	5544

Table 3. Return of jute cultivation in the char land of Sirajgonj, Bogra, Gaibandha and Jamalpur districts

Item	Return (For 20 decimal)	
	Demo farmer	Non demo farmer
Production (Kg/20 decimal): Fibre and Stick	291	222
Price of Fibre (Tk/kg)	31.85	30.47
Price of Stick (Tk/kg)	1.88	1.50
Gross Return :(Tk/20 decimal)		
	Value of fibre	9268
	Value of stick	1090
Total:	10,358	7,379
Total cost (TC)/TVC:	6451	5547
Gross Margin (Tk):	3907	1832
Benefit Cost Ratio:	1.61	1.33



Jute plants are staked before retting



Preparing of jute retted fibre extraction

The average production cost was Tk. 6451 and Tk. 5544 per 20 decimal for demo and non-demo farmers, respectively. The gross return, gross margin and benefit cost ratio were Tk. 10,358, Tk. 3907 and 1.61, respectively per 20 decimal for demo farmer. In case of non-demo farmers, the gross return, gross margin and benefit cost ratio were Tk. 7379, Tk. 1832 and 1.33, respectively per 20 decimal. The benefit cost ratio (BCR) was the higher (1.61) in demo plot than that of non-demo plot (1.33).



Jute fibre drying

Processed jute fibre

Local jute market near char land

4. Conclusion

From the above results it could be concluded that specially ensuring the timely seed sowing, proper management, irrigation at drought condition and harvesting made at 110 to 120 days of jute crop age, the charland jute farmers of Bangladesh could get higher yield of good quality fibre with high BCR. Presently, it already proved that charland farmers cultivating jute at a lower cost and getting benefit by selling their produced quality fibre at higher price.

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STUDY THE IMPACT OF CLIMATIC CHANGES ON JUTE PRODUCTION IN BANGLADESH

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Abstract

The present study was an attempt to assess the jute crop status of Bangladesh as regard to its production, cultivation areas, cultivation ratio, sowing and harvesting time etc. due to global climatic changes. The study was based on secondary data. Data were collected during May to June, 2008. The secondary data were accumulated from different records of BBS, BJRI, FAO, IJSG reports etc. Results revealed that in Bangladesh there was pre-monsoon shower during the month of March and April thereby offering optimum condition for land preparation and sowing. Following that there were moderate and intermittent rain and shower during May and June providing enough moisture in the soil needed for growth of jute plants. Both species of jute were of photo-periodic-short day plant, the critical light period seems to be near about 12.50 hours. The jute crop was grown in a wide range of temperature. It can thrive well with a minimum temperature of 15°C to maximum temperature of 38°C and may increase up to 46°C. Due to global warming the increasing temperature and rainfall were observed during the jute growing season. Moreover, the crop sweep out the excess load of carbon-dioxide from the atmosphere and released a bulk amount of oxygen in the air. The total jute acreage in 1972-73 was 2214.70 thousand acre and the production was 1181 thousand tones. It was 1908 thousand acres in 1986-87 and the area gone down to 500.00 thousand acres in 2006-07 from where producing 1221 and 990 thousand tones of jute fibre, respectively. The seed sowing time of different released varieties changed over the time due to changing behaviors of temperature and rainfall. At present cultivation ratio of white and tossa jute was also reversed.

Key words: Jute, climate (temperature, rainfall), area, production

Introduction

Emission of green house gases into the atmosphere has lead to Global warming. That caused glaciers melting, raising sea levels, cyclones, tornados, flood, drought Tsunami etc. Incremental raising of the temperature these calamities intensified many folds and causing havoc to life and properties. Bangladesh is facing the reality of climate change due to global warming. It will impact on the composition of atmosphere, hydrology, geomorphology, ecology, soil, land use, biodiversity, vegetation etc. As a result many natural ecosystems may be changed. Emergence of climate change would affect Bangladesh in two ways in two major contrasting regions. First one, the southern region would be in drainage congestion with rise of sea level and intrusion of saline water. Secondly the north-western part will be subjected to scarcity of water leading to drought condition, both will impaired the agro-ecosystem of the country. Agriculture is the main concern due to changes in climatic factors such as temperature, humidity, precipitation, wind flow, solar radiation; evaporation etc has direct effect on the production of crop.

Jute is a fibre crop belongs to genus *Chorchorus* of the Tiliaceae family with two cultivated species—*C. capsularis* L. *C. olitorius* L. Fibre is extracted from the bark of the plants. It grows under an abundant range of climatic factors. Among the climatic factors, temperature, humidity rainfall, sunshine are the dominating component for the growth of jute plant. In 1970-80 decades about 15-16 lac hectare of the total cultivable land was occupied by jute has now been reduced to 4.50 to 5.0 lac hectare. Still jute is contributing to national economy. Its present contribution to GDP is about 5.5% (Sikder *et al.*, 2008). Jute is a versatile and environment friendly

biodegradable natural fibre widely grown in Asia, particularly in Bangladesh, India and China. It is rapid growing renewable biomass and photo-reactive crop with only 120 days harvesting period. Bangladesh is the drainage basin of big rivers and being bestowed with alluvial soil and availability of non-stagnant water for jute retting has a distinct agro-ecological comparative advantage in production of best quality fibre. Though market for traditional jute products has been declining continuously in the recent past, now with the increasing environmental awareness, eco-friendly and biodegradable products are gaining popularity both in developed and developing countries for combating retardation of ecological degradation due to green house effect. Jute and jute products not only retard ecological degradation but conserve environment and atmosphere as a whole.

Materials and Methods

The study was based on secondary data. Data were collected during May to June, 2008. The secondary data were accumulated from different records of BBS, BJRI, IJSG (IJO) etc. Climatic data temperature, rainfall, day length etc. were selected for its being large concentration point of relation with jute production of Bangladesh. On the basis of concentration on the changes of production, growing area, growing behaviors i.e. seed sowing time, harvesting time, plant protection measures etc. were selected as study areas for collecting information on jute fibre production aspects. The year wise data of climatic factors during 1987-90 and 2007; and 1972 to 2005 of cultivated jute area and production were collected from different sources.

Results and Discussions

Temperature

Temperature directly affects photosynthesis, respiration, and cell wall permeability, absorption of water and nutrient, transpiration, enzyme activity and protein coagulation. Jute is grown in a wide range of temperature. It can thrive well with a minimum temperature 15°C to maximum temperature 38°C and may increase up to 46°C. Generally the temperature of Bangladesh remains between 7°C to 12°C during winter and maximum range of 23.88°C to 31.55°C during summer season. The IPCC-WG-I Third Assessment report (IPCC, 2001) mentioned the global average surface air temperature has increased by 0.6°C over the 20th century, which has been mainly attributed due to atmospheric causes of green house gases. The trend of global temperature increase during the last two decade was 0.15°C/decade. IPCC (2001) has also projected the rise of temperature by 1.4-5.8°C over the period 1991-2100. During the last decade there was increase of temperature due to climate change (Table 1 & 2). But the fall of humidity will cause wilting of jute plant with nutritional disorders. Some diseases may be uncounted as to the raise of temperature specially originated from thermophilic organism. The limit of survival of living organism has generally been reported to be between -35°C and +75°C but for plant the range is much narrower, which may be 15°C to 40°C (Nelson, 1997). So under the predicted temperature due to climate change crop will suffer from disease infestation.

Rainfall

The annual rainfall varies from 1419 mm to 4338 mm, which is more intensive in the eastern and southern region with less in the north and western part of Bangladesh. Climate change will cause more intensive rainfall pattern in eastern and southern region and scarcity of rainfall in the northern-western part of the country. Average precipitations are projected to increase in June – August up to 12.5 percent by 2020s and about 20 percent by 2050s. Jute is sown between March to April, and remains in the field up to July i.e. occupied by pre-

monsoon to Monsoon season. Early precipitation exceeding 750 mm will delay sowing period of jute and ultimately crop yield (Table 1). Maximum and minimum temperature increased highly during jute growing season March-April to July-August. The highest temperature 2.77°C increased in the month of July. In contrast the highest minimum temperature of 2.17°C increased in the month of April. Within 17 years of age the maximum temperature increasing range was 0.83°C – 2.77°C and that of minimum was 0.08°C– 2.17°C. Month wise increasing temperature was higher during the jute growing season (Table 2). On the other hand, rainfall increased vigorously within this study period of 17 years. The highest increased rainfall of 3377.8 mm was observed in the month of July. From the result it seems that increase of temperature increase the rainfall. The increasing range was - 3.0mm to 3377.8 mm Monthly increasing rainfall were higher in the jute growing season also (Table 2).

Solar radiation

Solar radiation is a significant factor in plant growth and developed specially the intensity and duration of light is most important for the physiological process in plant. Both species of jute are of photo-periodic-short day plant, the critical light period seems to be near about 12.50 hours. White jute is a highly photosensitive plant of which tossa is more sensitive than white; the crops fall victim of short day length when sown early. Jute exhibits short-day flowering behaviour with critical day lengths generally being about 12 h for *Corchorus capsularis* L. varieties and 12.5 h for *C. olitorius* L. (Kundu, 1959). Temperature and soil moisture are the other factors which affect flowering and stunted or limit the growth. Photoperiod is the dominant factor controlling flowering, and hence growth habit. There was relatively little effect of temperature on flowering even though night temperatures below 20°C markedly delayed emergence and initial growth. Thus effect of light intensity or quality may be involved (Johansen et al., 1985).

Table 1. Change in monthly average temperature and rainfall of Bangladesh

Months	Average of 1987-1990			Year 2007		
	Temperature (°C)		Rainfall (mm)	Temperature (°C)		Rainfall (mm)
	Mean daily Maximum	Mean daily Minimum		Mean daily Maximum	Mean daily Minimum	
January	23.29	11.22	1.41	24.19	12.00	103.98
February	24.47	13.21	19.64	25.79	15.09	297.39
March	28.79	17.16	59.59	31.00	18.24	182.88
April	30.93	21.05	196.65	33.04	23.22	852.18
May	30.66	22.09	217.10	32.43	23.82	1248.09
June	30.90	23.75	349.29	32.35	25.69	1548.42
July	29.94	24.69	578.43	32.71	25.82	3956.28
August	30.65	24.71	325.12	32.29	26.10	1762.17
September	30.43	23.99	292.07	31.70	25.61	2346.09
October	29.66	23.50	281.14	31.30	24.40	1942.71
November	27.81	18.94	61.48	28.64	19.02	137.40
December	24.47	14.15	3.00	26.48	14.26	0.00

Source: Khandaker (1991).

Table 2. Increased in monthly average temperature and rainfall after 17 years of Bangladesh

Months	After 17 Years		Rainfall (mm)
	Temperature (°C)		
	Mean daily Maximum	Mean daily Minimum	
January	0.90	1.22	102.5
February	1.32	1.88	277.7
March	2.21	1.08	123.2
April	2.74	2.17	655.5
May	1.77	1.73	1030.9
June	1.45	1.94	1199.1
July	2.77	1.13	3377.8
August	1.64	1.39	1437.0
September	1.27	1.62	2054.0
October	1.64	0.90	1661.3
November	0.83	0.08	75.92
December	2.01	0.11	-3.00

Relationship between climatic factors and jute production

Result revealed that jute production is so nicely matched with the ecological attributes of Bangladesh that there is pre-monsoon shower during the month of March and April thereby offering optimum condition for land preparation and sowing. Following that there were moderate and intermittent rain and shower during May and June providing enough moisture in the soil needed for growth of jute plants. Heavier rains follow during July and August, which fill the ditches and ponds with sufficient water needed for retting of jute plants after harvest.

Jute is mainly cultivated in kharif-1 season (March-June). Tossa jute (*Corchorus olitorius* L.) fibre and seed are commercially superior to those of white jute (*C. capsularis* L.) in both national and international market. Tossa jute shows premature flowering resulting in yield with low quality fibre when seeded in relatively low temperature in early March. Tossa jute seed generally used to collect from the normal fibre-yielding crop seeded during April-May.¹ This seed-yielding crop is severely affected by natural calamities like flood, water, cyclone, heavy rainfall, insect pest infestation etc. during July-August almost every year and as a result there is acute shortage of seed for sowing in the next season. Hence, it becomes necessary to grow tossa jute and under late sowing condition in off-season during July-August for white and August-September for tossa jute. Bangladesh Jute Research Institute released so many tossa jute varieties O-9897, OM-1 and O-72 that are more or less similarly tolerant to comparatively short day and low temperature. Now the varieties do not initiate premature flower even when sown in early March and also grown well under temperature of October-November for seed production.

Year wise area and production of jute

Recently, Jute is facing a hard competition Jute sector is crossing a miserable situation in the economy of Bangladesh. This is due to the fact that

jute land is equally suited for growing rice, and rice is commanding a record high price in the local market. Moreover, the different hybrid varieties of rice have further increased the possibilities of increasing cultivation of rice over jute.

Table 3. Total area and production of jute in Bangladesh

Years	Area (000 acres)	Decade average (000 acres)	Production (000 tones)	Decade average (000 tones)
1972-73	2214.70		1181.00	
1973-74	2196.40		1088.00	
1974-75	1416.55		630.00	
1975-76	1277.34		714.00	
1976-77	1603.45		873.00	
1977-78	1805.27		973.00	
1978-79	2051.58		1150.00	
1979-80	1874.31		1065.00	
1980-81	1568.77	1778.71	897.00	952.33
1981-82	1411.85		842.00	
1982-83	1425.44		886.00	
1983-84	1435.12		946.00	
1984-85	1484.20		928.00	
1985-86	2614.00		1571.00	
1986-87	1908.00		1221.00	
1987-88	1244.88		780.80	
1988-89	1269.58		799.40	
1989-90	1338.49		835.00	
1990-91	1461.50	1559.31	914.10	972.33
1991-92	1449.39		945.10	
1992-93	1235.49		885.60	
1993-94	1287.61		782.30	
1994-95	1402.47		929.50	
1995-96	1355.55		910.35	
1996-97	1253.00		883.00	
1997-98	1427.00		1057.00	
1998-99	1181.00		821.00	
1999-00	1008.00		711.00	
2000-01	1107.00	1270.65	821.00	874.59
2001-02	1128.00		859.00	
2002-03	1079.00		800.00	
2003-04	1008.00		794.00	
2004-05	965.00		1035.00	
2005-06	500.00		990.00	
2006-07	500.00	863.33	990.00	911.33

Source: BBS 1991, 1998, 2004 & 2006 and Choudhury, 1998

The area and production situations of jute in Bangladesh were between 1972-73 and 2006-2007. There have been considerable variations in jute areas and production over the years. However there is a clear downward trend (Table 3). The area of jute production reduced to 965 thousand acres in 2004-05 from 2214.7 thousand acres in 1972-73. Table 3 also shows that the production of jute reduced to 1035 thousand tones in 2004-05 from 1181 thousand tones in 1972-73. The production of jute were 794 thousand tones and 800 thousand tones in 2003-04 and 2002-03 respectively while the areas of jute production were 1008 thousand acres and 1079 thousand acres in 2003-04 and 2002-03, respectively. The total jute acreage in 1972-73 was 2214.7 thousand acre and the production was 1181 thousand tones. It was 1908.00 thousand acres in 1986-87 and the area gone down to 500 thousand acres in 2006-07 from

where producing 1221 and 990 thousand tones of jute fibre, respectively (Table 3). The jute production area decreased gradually during the decades from 70s to 2000s. It was observed the average cultivation areas (1778.7 thousand acres) in 70s. In contrast it was decreased up to 863.3 thousand acres in 2000s decade. On the other hand, the average production was found 952.3 thousand tons in 70s decade was increased up to 972.3 thousand tons in 80s, however, it was decreased 874.59 thousand tons in 90s and 911.3 thousand tons in 2000s (Table 3). It might be happened for day by day getting pressure of food crop production, change of jute cultivation zones, cultivation ratio of tossa and white jute etc.

Jute cultivation affected by air quality

Jute is the fast growing field crop. Its carbon dioxide consumption is $0.23 \text{ mg CO}_2 \text{ m}^{-2} \text{ S}^{-1}$ on an average to a maximum of $0.44 \text{ mg CO}_2 \text{ m}^{-2} \text{ S}^{-1}$ (Palit and Bhattacharyya, 1988).

In a theoretical calculation one ha of jute plants can consume to about 14.66 tons of CO_2 at the rate of $0.34 \text{ mg m}^{-2} \text{ S}^{-1}$ in life span of about 100 days. Therefore, it can be said that the jute crop is a good environmental cleaner that reduces the pressure of CO_2 in the atmosphere and thus lowers the rise of temperature of the atmosphere and reducing possible green house effect. On the contrary, it also refreshes the atmosphere with release of fresh oxygen at the rate of $10.66 \text{ tons ha}^{-1}$. To a theoretical calculation the total jute crop in Bangladesh removes/sweeps to about million tons of carbon dioxide in one jute season. In the same process it freshens the air with the release of 10 tons oxygen ha^{-1} and in total 5.90million tons of oxygen is released to Bangladesh atmosphere. (Calculation based on the basic equation of photosynthesis to produced the required dry weight in total. This calculation also agrees with the finding of Palit and Bhattacharyya, 1988). A picture (figure-2) drawn in relation with jute and environment.

Jute cultivation affected by water quality

One of the most important natural resource is water. The most important environmental issues that has been identified for Bangladesh in the Rio Earth Summit (1992), is too much water, too little water and polluted water. The adverse situation like flood and drought which frequently occur in Bangladesh causes crop destruction including jute and jute seeds that brings immense miseries to the people in the form of food shortage, cash shortage and last of all seed shortage. Flood and drought also pose a threat in the conservation of biodiversities of crop species.

Planting time

To concern *Corchorus capsularis* L. varieties planting around 30 March register optimum fibre yield and it provides room for other crops to fit into 3 cropping patterns. However, some recently developed high yielding varieties can be sown on about one month ahead. To concern *C. olitorius* L.

varieties, the conventional variety like O-4, planting should be done after 14 April, but less photoperiod sensitive varieties are to be planted starting from 15 March (Islam and Rahman, 2008).

Jute sowing is dependent either on residual moisture or on natural rainfall. From this aspect jute growing areas fall into two main categories: (i) early sowing areas namely, greater Rangpur, part of greater Dhaka, Comilla and Mymensingh district; and (ii) late sowing areas namely, Faridpur, Jessore, Kushtia, Rajshahi, Pabna, Bogra and part of Dhaka, Comilla and Mymensingh. Jute varieties bred previously could not sow usually earlier than late March with *C. capsularis* and before mid-April with *C. olitorius* L. varieties for their sensitivity to flowering. For the same reason the varieties could not be adjusted to a 3-crop pattern. But now a days the scenario of jute based cropping pattern got a great change.

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Marketing of Raw Jute in Bangladesh: A Review

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Abstract : *The study was based on both primary and secondary data. The secondary data were accumulated from different records of Department of Agricultural Marketing (DAM) and Bangladesh Jute Association (BJA). The study uses both analytical and descriptive techniques. Five marketing channels are: Farmer→ Faria→ Kutcha baler→ Pucca baler/exporter→ Mill/foreign buyer, Farmer→ Bepari→ kutcha baler→ pucca baler/exporter→ Mill/foreign buyer, Farmer→ kutcha baler→ pucca baler/exporter→ mill/foreign buyer, Farmer→ Faria→ pucca baler/exporter→ Mill/foreign buyer and Farmer→ Bepari→ Mill/pucca baler→ Foreign buyer were identified. A large number of people were involved in the marketing of raw jute. At best it can be said that the present marketing system is not inefficient. Proper and adequate steps to develop this sector are required to making the business more profitable to the entrepreneurs. There is a great possibility to expand the jute marketing all over the country. Irregular marketing practices should be checked and better marketing facilities ought to be provided in order to improve the performance of jute market.*

Keywords: *Raw jute, jute marketing, marketing channels*

I. Introduction

Jute the 'Golden fibre' of Bangladesh has been considered as the major source of foreign exchange earnings of the country. It provides livelihood for the millions of farmers and industrial workers in the country. Cultivation of jute in the country has been drastically reduced from 25.42 lakh acres of land with production of 13.44 lakh tonnes jute fibre and 30.91 lakh tonnes of jute sticks in 1969-70 to 9.6 lakh acres of land with production of 10.35 lakh tonnes jute fibre and 16.72 tonnes jute stick in the year 2004-05 [1]. On average, jute was cultivated between 10.00 to 11.85 lakh acres producing almost 53 to 57.5 lakh bales of raw jute in the country. The export market tried to sustain a steady trend showing positive and promising signal for jute. Jute sector could contribute to creation of huge employment opportunities, wide scale income generation and poverty alleviation, and ultimately higher contribution to GDP [2 and 3]. In 2004-05, the total production of jute was 1035 thousand tonnes and the cultivation area was 965 thousand acres. The total export earnings from jute and jute goods were 3019 crore taka in 2005-06 which was 4.82 percent of the total export earnings [1]. The highest percentage of fibre (93%) was bought by Aratdar from farmers followed by Faria/Bapari [4].

Cultivation and marketing of jute as well as the manufacturing of jute goods provide employment for lakhs of people. Bangladesh government earns revenue both from raw jute and jute goods. The welfare of the rural people which depends directly on agriculture is intimately bound up with the production and trade of jute. Import of various goods and services is a prime necessity for the economic development of Bangladesh. All the imports depend on the quantity and value of exportable surplus to which jute is the main contributor. In fact, jute is foreign trade and the financial barometer of the country [5]. Firms and traders involved in jute trading may utilize the information of this study in formulating their marketing plans judiciously. The findings of this survey would help them ascertain their economic status in the business. Jute is equally important both as agricultural product and industrial raw material in the economy. In spite of great importance of jute as a commercial crop, research studies on jute marketing in Bangladesh remains scanty.

The study on marketing costs and margins is useful for all persons involved in performing marketing functions. It has a great significance because referring to the marketing cost and margin one can judge whether or not the services of the intermediaries are provided at reasonable costs. The cost incurred to move the product from

producers to consumers is ordinarily known as marketing cost. In other words, the cost of marketing represents the cost of performing various marketing functions [6]. Marketing costs are incurred when commodities move from the farm to the final market, whether they are moved by farmers, traders, cooperatives, marketing boards and exporters. On the basis of collected data, marketing cost and marketing margin have been computed and discussed. The variations were observed among the intermediaries and study areas for cost and price of jute fibre. In that investigation the authors reported more, jute farmers reportedly did not received fair price of jute fibre as per quintal due to grade fixation by the buyers and they faced a number of problems [4].

Prices observed through time are the result of a complex mixture of changes associated with seasonal, cyclical, trend and irregular factors. The most common in agricultural prices is seasonal pattern of change. Seasonal price behavior is regularly repeating price pattern that is completed once in every twelve months. Such a regular pattern might arise from seasonality in demand and supply; and in marketing or a combination of both. Most agricultural products are characterized by some seasonality in production arises from climatic factors and the biological growth of the plants [6, 3].

The measurement of seasonal price variation is required to measure the short time fluctuation in the time series data. Because, seasonal variations are short time fluctuation that occur within a year, which are present in the data recorded on daily, weekly, monthly or quarterly basis. It is usually seen in business and economic data. Their measurements are necessary to isolate them to determine the effect of seasons on the size of variable. It helps a business or sales manager or farmer for planning future production and scheduling purchase, inventory control, selling and advertising programmes. In the absence of any knowledge of seasonal variations, a seasonal upswing may be mistaken as indicator of slump may be misinterpreted as deteriorating business conditions. Thus to understand the behavior of the phenomenon in time series properly, the time series data must be adjusted for seasonal variation. The seasonal variation in prices arises from the seasonal production, poor storage facilities and lack of retention power of the producers. Firms and traders involved in jute trading may utilize the results of this study in formulating their marketing plans judiciously.

In recent years, the use of synthetic fibre products, because of their preferential price over jute goods, dominated jute goods and had adverse affects on jute market. At present jute cultivation is facing many problems. As a result, the future of the golden fibre has become uncertain. These problems are (i) the cost of cultivation of jute is higher than paddy (ii) the financial condition of the farmers is not good enough to procure agricultural inputs like seeds, fertilizer and insecticides and (iii) due to shortage of water, in some areas retting can not be done in a proper way. Firms and traders involved in jute trading may utilize the results of this study in formulating their marketing plans judiciously. Therefore, considering the importance of jute and jute goods in the context of Bangladesh economy the present review was undertaken to analyze the existing marketing system of raw jute in important growing areas, to estimate the marketing costs and margins of intermediaries and to assess the seasonal price variation and the problems faced by the growers and different intermediaries of raw jute market.

II. Materials and Methods

The review study was worked to examine the seasonal price variations in different raw jute markets and problems faced by the growers and traders in terms of production and marketing of raw jute. The experiment was conducted at some selected areas of Faridpur and Narayangonj district of Bangladesh during March to April, 2012. The study was based on secondary data. Fourteen jute farmers, 15 *Farias*, 10 *Beparis*, 12 *Aratders*, 7 *Kutch* balers, 6 *Pucca* balers and 6 exporters were selected from Kanaipur bazaar, Talma bazaar, Krisnapur bazaar, and Narayangonj terminal market. The secondary data were accumulated from different records of Department of Agricultural Marketing (DAM) and Bangladesh Jute Association (BJA). The study uses both analytical and descriptive techniques.

III. Results and Discussions

Marketing channels, participant's characteristics and functions of intermediaries of raw jute marketing from farmer to foreign buyer: The survey reveals marketing channels or routes in the study area through which raw jute moved from the point of initial production to milling or exporting. Bulk of the output enters into the markets. The jute farmers sell their produce at their homes or in the nearest village markets to the *Farias* and *Beparis*. *Farias* purchase loose jute in small quantities from farmers and other small dealers who may not possess any license. They sell unsorted jute to the *Beparis* who usually handle a large volume. The *Beparis* sold loose jute to the *Kutch* balers, *Pucca* balers and to the mills. *Kutch* balers purchased loose jute from farmers, *Farias* and *Beparis* and processed it into *Kutch* bales. They mainly operate in the secondary markets. The

The *Farias* purchased their entire volume of jute from farmers. The *Beparis* on the other hand purchased 77.25 percent of jute from farmers and the rest 22.75 percent from *Farias*. *Kutch*a balers purchased 9.05 percent of jute from farmers, 18.32 percent from *Farias*, 60.46 percent from *Beparis* and 12.17 percent from other *Kutch*a balers. The *Pucca* balers who were also exporters purchased most of their jute (76.94 percent) from *Beparis*. They also purchased 5.46 percent, 12.33 percent and 5.27 percent of their jute from *Farias*, *Kutch*a balers and *Pucca* balers respectively. The millers purchased 24.12 percent jute from *Beparis* through *Aratdars*, 34.69 percent and 41.19 percent from *Kutch*a balers and *Pucca* balers respectively. Foreign buyers purchased baled jute and jute goods from mills and *Pucca* balers with the help of international brokers (Table 1).

Table 1. Purchasing of jute by different intermediaries (Sources Moniruzzaman *et al.*, [9], Moniruzzaman *et al.*, [8] and Moniruzzaman *et al.*, [4])

Intermediaries	Purchased from (%)						
	Farmer	<i>Faria</i>	<i>Beparis</i>	<i>Kutch</i> a baler	<i>Pucca</i> baler	Exporters	Mills
<i>Faria</i>	100.00	-	-	-	-	-	-
<i>Beparis</i>	77.25	22.75	-	-	-	-	-
<i>Kutch</i> a baler	9.05	18.32	60.46	12.17	-	-	-
<i>Pucca</i> baler/Exporter	-	5.46	76.94	12.33	5.27	-	-
Mills	-	-	24.12	34.69	41.19	-	-
Foreign buyer	-	-	-	-	29.97	52.32	17.71

The farmers sold 58.40 percent, 29.74 percent and 10.16 percent of their jute to the *Farias*, *Beparis* and *Kutch*a balers respectively. The table also shows that *Farias* under survey sold their jute 36.23 percent, 47.55 percent and 16.22 percent of jute *Beparis*, *Kutch*a balers and *Pucca* balers, respectively (Table 2). The *Beparis* sold their jute 42.72 percent and 34.63 percent of their jute to the *Kutch*a baler and *Pucca* balers respectively. They also sold 22.65 percent of their jute to the mill through *Aratdar*. The *Kutch*a balers sold 58.59 percent of their jute to the *Pucca* balers and 29.78 percent to the mills. They also sold 9.07 percent to the exporter. The *Pucca* balers who were also exporters sold a major portion of their jute to the foreign buyers (39.83 percent). The also sold 23.52 percent to the exporters and 35.12 percent to the mills. Jute mills sold their processed jute to the foreign buyers (Table 2).

Table 2. Selling of jute by different intermediaries (Sources Moniruzzaman *et al.*, [9], Moniruzzaman *et al.*, [8] and Moniruzzaman *et al.*, [4])

Farmer and Intermediaries	Sold to (%)						
	<i>Faria</i>	<i>Beparis</i>	<i>Kutch</i> a baler	<i>Pucca</i> baler	Exporters	Mills	Foreign buyers
Farmers	58.40	29.74	10.16	-	-	-	-
<i>Farias</i>	--	36.23	47.55	16.22	-	-	-
<i>Beparis</i>	-	-	42.72	34.63	-	22.65	-
<i>Kutch</i> a baler	-	-	2.56	58.59	9.07	29.78	-
<i>Pucca</i> baler/Exporter	-	-	-	1.53	23.52	35.12	39.83
Mills	-	-	-	-	-	-	91.48

Table 3. Modes of transportation used by farmers and jute traders(Sources Moniruzzaman *et al.*, [9], Moniruzzaman *et al.*, [8] and Moniruzzaman *et al.*, [4])

Mode of Transportation	Farmers and Traders				
	Farmers (%)	<i>Farias</i> (%)	<i>Beparis</i> (%)	<i>Kutcha</i> baler (%)	<i>Pucca</i> balers (%)
Head load	85.72	-	-	-	-
Carts/push carts	35.71	20	40	20	-
Rickshaw/van	28.57	70	40	-	10
Boats/mechanica l boats	42.86	90	80	100	100
Truck	-	20	40	30	30
Rail	-	-	10	30	40
Vessel	-	-	-	-	20

Storage plays a crucial role in maintaining the quality of fibre. Average storage period for farmers was 2.5 months and traders were 3.5 months. Most producer (85.72 percent) carried jute, 35.71 percent used carts/push carts, 28.57 percent used rickshaw/van and 42.86 percent used boats by head loaded. In the study areas, 90 percent *Farias* used boats/ mechanical boats, 70 percent used van/rickshaw and 20 percent used carts and truck to transfer their products. On an average, 80 percent *Beparis* used boats/ mechanical boats, 40 percent used carts/push carts van/rickshaw and truck to transfer their products while 10 percent *Beparis* used rail to transfer their products. All the *Kutcha* balers and *pucca* balers used boats/ mechanical boats while 30 percent and 20 percent used Truck, rail and carts/push carts to transfer their products respectively. Forty percent of *Pucca* balers used rail, 30% of them used truck, 20% used vessel and 10% used van/rickshaws (Table 3).

The farmers were self-financed. Own money constituted about 81.27 percent of the investment in jute trade for *Farias* and 7.30 percent, 3.55 percent and 7.88 percent invested money provide by friends and relatives, banks and *Aratdars* respectively (Table 4). Own money and borrowed money of the *Beparis* were about 62.94 percent and 37.06 percent, respectively. Out of the borrowed money the *Beparis* received 11.65 percent from friends and relatives, 16.37 percent from bank and rest of the money from *Aratdars*. The table 4 also shows that for the *Kutcha* balers 45 percent of investment came from their own money, 3.82 percent came from friends and relatives and 51.18 percent was borrowed from commercial banks. In the case of *Pucca* balers or exporters about 83.29 percent of the business money was borrowed from bank (BRAC bank, Sonali bank) and rest of the investment was self financed. BRAC bank provided interest rate 13 percent and Sonali bank provides interest rate 15 percent. The duration of loan was one year (Table 4).

Table 4. Sources of finance of jute producers and traders (Sources Moniruzzaman *et al.*, [9], Moniruzzaman *et al.*, [8] and Moniruzzaman *et al.*, [4])

Farmers and traders	Sources			
	Own (%)	Friends and relatives (%)	Banks (%)	<i>Aratdars</i> (%)
Farmers	94.72	5.28	-	-
<i>Farias</i>	81.27	7.30	3.55	7.88
<i>Beparis</i>	62.94	11.65	15.37	10.04
<i>Kutcha</i> balers	45.0	3.82	51.18	-
<i>Pucca</i> balers/exporters	16.71	-	83.29	-

The farmers got their market information through market visit and personal observation (43 percent). Other sources of market information for farmers were fellow traders (36 percent) and telephone/ mobile (57 percent). All *Farias*, 70 percent *Beparis*, 90 percent *Kutcha* balers and 80 percent *Pucca* balers/exporters stated that visit to markets and personal observation were the sources of their market information. Sixty percent *Farias*, 65 percent *Beparis*, 70 percent *Kutcha* balers and 40 percent *Pucca* balers/exporters also reported that they received information about jute market from their fellow traders respectively. Eighty five percent *Farias* and all *Beparis*,

Kutcha balers and *Pucca* balers/exporters got market information with the help of telephone or mobile. All *Pucca* balers/exporters and 30 percent *Kutcha* balers got market information from BJA/BJEA marketing reports (Table 5).

Table 5. Sources of market information (Sources Moniruzzaman *et al.*, [9], Moniruzzaman *et al.*, [8] and Moniruzzaman *et al.*, [4])

Farmers and traders	Sources			
	Visit to market and personal observation (%)	Fellow trader (%)	Telephone/ Mobile	BJA and BJEA marketing report
Farmers	43	36	57	-
<i>Farias</i>	100	60	85	-
<i>Beparis</i>	70	65	100	-
<i>Kutcha</i> balers	90	70	100	30
<i>Pucca</i> balers / exporters	80	40	100	100

Only a small amount of jute was retained on the form for domestic and cottage industry purposes, e.g. making rope, mats etc. The rest enters into a circuitous marketing channel and eventually reaches the end users i.e. the jute mills of home and abroad. In the marketing process the raw jute moves through different levels of markets such as primary, secondary and terminal. In the study areas apart from farmer-sellers, different categories of intermediaries participated in the marketing system of raw jute. The market participants included *Farias*, *Beparis*, *Aratdars*, *Kutcha* balers, *Pucca* balers, exporters, millers, dalals, international brokers and foreign buyers. The jute producers were the primary link in the raw jute-marketing channel. Raw jute marketing channels started from the jute farmers. The jute farmers sell their produce at their homes or in the nearest village markets to the *Farias* and *Beparis*. Large farmers also sell their raw jute to *Kutcha* balers and sometimes they sold mills through *Aratdars* in the study areas. No jute producers were found in the study areas to sell their jute directly to the mills or *Pucca* balers. *Farias* purchase loose jute in small quantities from farmers and other small dealers who may not possess any license. They sell unsorted jute to the *Beparis* who usually handle a large volume. Generally, *Farias* do not have adequate storage facilities and they sell their unassorted raw jute in kanaipur, Krisnapur and Talma bazaar immediately. If needed, they store jute for a short period either at their dwelling houses or in the godowns. Two types of risks were involved such as physical risk and market risk. Physical risk occurred due to accident, wastage, damage etc. Market risk occurred due to fall of market price. All the *Kutcha* and *Pucca* balers protected themselves against risks that were inherent in jute business, through insurance. Some *Pucca* balers had insurance policies against their godowns.

Beparis are the professional jute traders. *Beparis* were big merchant and licensed trades having fixed business premises in the wholesale market (kanaipur, Krisnapur and Talma market) and they did business with large volume of product. The *Beparis* buy jute in loose from both *Farias* and farmers. The *Beparis* sold loose jute to the *Kutcha* balers, *Pucca* balers and to the mills. Most of them sold jute through *Aratdars* and some *Beparis* sold jute directly to the balers.

Kutcha balers purchased loose jute from farmers, *Farias* and *Beparis* and processed it into *Kutcha* bales. They sometimes purchased jute in *Kutcha* bale from other kuthca balers. They mainly operate in the secondary markets. Recognized commercial grades and trade standards are practiced by the *Kutcha* balers who employ permanent and temporary staff as well as labour. They also have storage facilities. The processed jute is sold to the *Pucca* balers or exporters and jute mills through Dalals/brokers.

Aratdars play a significant role in jute marketing. *Aratdars* are commission agents who had fixed establishments in the secondary market at upazila level and terminal market. They are the biggest traders in the marketing channel but are limited number. The *Aratdars* are commission agents having fixed establishment who operated between traders of jute on the one hand and balers and mills on the other hand, and charge a fixed commission. They often serve as a source of financing and provide storage facilities. The survey shows that the *Aratdars* or commission agents having Arat-Office and they do the function of negotiation between buyers and sellers. In the study area, the *Aratdar* of Kanaipur bazaar received commission at the rate of Tk. 15 per quintal from the *Beparis*. They also received a commission of Tk. 6.50 per quintal from balers and exporters. In Talma bazaar

and Krisnapur bazaar under Nagar Kanda upazila and Sadarpur upazila the *Aratdar* received commission at the rate of Tk 12.50 per quintal from the *Beparis* respectively. They also received a commission of Tk 2.50 per quintal from balers and exporters. Similar results were reported by [12 and; 9]. The highest percentage of fibre (93%) was bought by *Aratdar* from farmers followed by *Faria/Bapari* [4].

Pucca balers buy jute in loose form from *Faria* and also in the form of *Kutch*a bales from *Kutch*a balers. They also procured loose jute from *Beparis* with the help of *Aratdars*. In the *Pucca* baling press the raw jute is pressed and packed according to export grades. They some times purchased *Pucca* bales from other *Pucca* balers and sold them to the exporters and millers with the help of Dalals. Basically there was no difference between *Pucca* balers and exporters because some *Pucca* balers operate as exporters. Exporters operate in the terminal market and procure loose jute from dealers of jute and baled jute from *Kutch*a balers and *Pucca* balers. They also purchased baled jute from the Bangladesh Jute Corporation (BJC). They export raw jute after processing and baling it in their own presses or in other presses on payment of baling charges. They sell baled jute to the mills through Dalals, while selling *Pucca* bales to the foreign buyers; they sought the help of international brokers. It may be mentioned here that all the exporters interviewed also acted as *Pucca* balers. So, we can say that all exporters are *Pucca* balers but all *Pucca* balers are not exporters.

In the study areas, jute mills procured loose jute from *Beparis* with the help of *Aratdars*. They also bought baled jute from *Kutch*a balers and *Pucca* balers through Dalals. After processing of jute the millers sell their product to foreign buyers. Before, 1947, there was no jute mill in Bangladesh. In 1970, there were 70 jute mills in government sector in Bangladesh. In 2006 there were 24 jute mills in government sector (BJMC).

Foreign buyers purchased *Pucca* bales of jute from exporters and purchased processed jute from mills with the help of international brokers. The Dalals are commission agents who have no fixed establishments in the market. They negotiated sales between buyers and sellers. They got commission at the rate of Tk 2.50 and Tk 5.0 per quintal for *Kutch*a bales and *Pucca* bales respectively from the sellers. The International brokers helped in negotiating sales of *Pucca* bales between exporters and foreign buyers. They received a fixed rate of commission of Tk 12.00 per *Pucca* bales from the exporters.

The study revealed that, the whole marketing of jute has been broken down into various functions such as buying and selling, transportation, grading storage, weighing, financing, market information and pricing. Buying and selling are the major exchange functions of marketing. Marketing includes the commercial transactions of buying and selling as well as physical distribution. The activities involved in the transfer of goods were completed through buying and selling functions. Marketing functions may be defined as a specialized business activities performed in accomplishing the marketing processes of concentration, equalization and dispersion [6].

Transportation plays an important role in jute marketing system. Transportation enables the movement of products between places. This creates place utility and facilitates availability of goods at the right time, in right condition and at the right place. Jute was transported from primary market to secondary market and secondary to terminal market by push carts, boats, mechanical boats, trucks, cargo- vessels rail wagons etc. Farmers used country boat and head load. Inadequate transportation system and high transportation cost was the major problem for the intermediaries Adequate and efficient transportation is the corner stone of modern marketing system.

The market intermediaries are mostly self financed. Besides own capital other sources of financing of the *Farias* and *Beparis* are *Aratdar*, friends and relatives and Bank. They usually did not get institutional credit. But the big traders as well as exporters had access to institutional credit. Commercial banks issued loan to them. Marketing mechanism depends on market information for effective working. Market information is a facilitative marketing function required for an efficiently operating marketing system. Accurate and timely market information facilitates the farmers in deciding about price, time and place of sale of their produce. Visits to markets, personal observation, fellow traders, land telephone or mobile, BJA and BJE A marketing reports were the main sources of market information.

Raw jute marketing systems in Bangladesh

Marketing cost of Farmer: Major cost items of farmers were transportation, loading and unloading, market tolls, tips & donations, subscriptions, losses and personal expenses etc. The total marketing cost of farmers was Tk. 27.91 per quintal for tossa jute. The highest cost item was transportation, which accounted for 62.70 percent of total cost. The second highest cost was due to personal expenses (14.90 percent). The other cost items of

farmers in descending order were tips and donation (4.48 percent) and market toll and losses (8.96 percent) (Table 6).

Table 6. Marketing cost of farmers for Tossa jute (Sources Moniruzzaman *et al.*, [9], Moniruzzaman *et al.*, [8] and Moniruzzaman *et al.*, [4])

Cost items	Cost (Tk/ quintal)	Percentage of total cost
Transportation	17.50	62.70
Market tolls	2.50	8.96
Tips and donations, subscriptions	1.25	4.48
Losses	2.50	8.96
Personal expenses	4.16	14.90
Total	27.91	100.00

Note: Personal expenses included entertainment and meals

Marketing cost of *Farias* and *Beparis*

The cost items were transportation, loading unloading, storage, commission, tolls, subscription, shortage, assortment and weighment, packaging, telephone bill, electricity bill and personal expenses. The *Farias* purchased raw jute from farmers and sold those to *Bepari* and *Kutcha* balers. The average total marketing cost of *Farias* per quintal of jute was estimated at Tk. 117. The transportation cost was the highest of Tk. 38.00 which represents 32 percent of the total cost. The other major cost items were storage (15 percent), commission paid (13 percent), Assortment and weighment (6 percent), salary and wage (10 percent) and loading and unloading (5.33 percent). The lowest cost item was electricity bill which represents only 1 percent of the total cost (Table 7).

Marketing cost includes transportation, loading and unloading, storage, assortment and weighment, packaging, telephone bill, electricity bill, salary and wages and personal expenses. The total marketing cost of *Beparis* per quintal of jute was estimated at Tk. 143. The highest cost item of *Beparis* was transportation as the price of fuel is high which represented 31 percent of the total marketing cost. The other major cost items were storage (16 percent), commission paid (10 percent) salary and wages (11 percent), assortment and weighment (5 percent), loading and unloading (4 percent) and personal expenses (6 percent) (Table 7).

Table 7. Marketing cost of *Farias* for Tossa jute (Sources Moniruzzaman *et al.*, [9], Moniruzzaman *et al.*, [8] and Moniruzzaman *et al.*, [4])

Cost items	<i>Farias</i>		<i>Beparis</i>	
	Costs of tossa jute (Tk/ quintal)	Percentage of total cost	Costs of tossa jute (Tk/ quintal)	Percentage of total cost
Transportation	37.50	31.95	45.00	31.37
Loading and unloading	6.25	5.33	6.25	4.36
Storage	17.50	14.91	22.50	15.69
Commission paid	15.00	12.78	15.00	10.46
Market toll	3.75	3.20	3.75	2.61
Tips and donation, subscription	1.88	1.60	3.75	2.61
Shortage	3.05	2.60	5.56	3.88
Assortment & weighment	7.50	6.39	7.50	5.23
Packaging cost	4.75	4.05	4.75	3.31
Telephone bill	2.50	2.13	3.75	2.61
Electricity bill	1.25	1.07	1.25	0.87
Salary and wages	11.25	9.59	15.75	10.98
Personal expenses	5.19	4.42	8.62	6.01
Total	117.37	100.00	143.43	100.00

Note: Personal expenses included entertainment and meals

Marketing costs of balers and exporters

The marketing costs for tossa jute of *Kutch*a balers, *Pucca* balers and exporters are presented in Tables 8, 9 and 10, respectively. The marketing cost elements have been broadly classified into four segments namely buying, processing, selling and others. Since the *Pucca* balers were also exporters their marketing costs for buying and processing jute were the same. The shipping and related costs for exporting jute to different countries had not were included as these expenses were not usually borne by the exporters.

Buying Costs: The cost items for buying were loading and unloading, transportation, weighing, commission paid and stacking. Total buying cost per quintal of jute for *Kutch*a balers was Tk. 20.00 while that of *Pucca* balers and exporters was Tk. 14.00, which represents 13.05 percent, 7.02 percent and 6.34 percent of total marketing costs respectively. The most important cost item in this category for all traders was transportation, which was the highest cost item for buying (Table 8).

Processing costs: The jute processing costs included the cost of assortment, rope making, hessian/bale ticket, pressing charge and stacking. Total processing cost per quintal of jute for *Kutch*a balers and *Pucca* balers/exporters were Tk. 27.00 and Tk. 78.00 respectively. The processing costs represent 17.33 percent, 38.33 percent and 35.15 percent of the total marketing costs for *Kutch*a balers, *Pucca* balers and exporters respectively. The highest cost item was assortment for *Kutch*a balers and pressing charge for the *Pucca* balers/exporters. It represents 11.13 percent and 18.23 percent respectively of their total marketing cost (Table 8).

Selling costs: Selling cost was incurred for dispatch, transportation and internal brokerage by the *Kutch*a balers and *Pucca* balers. For the exporters, the selling costs included the cost of dispatch, transportation, export brokerage, commission to clearing and forwarding (C & F) agents, Bangladesh Jute Corporation (BJC) and bill of lading and stamp. Selling cost of tossa jute for the *Kutch*a balers, *Pucca* balers and exporters were estimated at Tk. 17, Tk. 11 and Tk. 30 per quintal respectively. The selling cost constituted roughly 10.59 percent, 5.38 percent and 13.34 percent of the total marketing cost for *Kutch*a balers, *Pucca* balers and exporters respectively. The most important cost items in this category for *Kutch*a balers as well as *Pucca* balers/exporters were transportation and export brokerage (Table 9).

Table 8. Marketing cost of *Kutch*a balers for tossa jute (Sources Moniruzzaman *et al.*, [9], Moniruzzaman *et al.*, [8] and Moniruzzaman *et al.*, [4])

Marketing cost segments/items	Costs of tossa jute (Tk/ <i>Kutch</i> a bale)	Costs of tossa jute (Tk/ quintal)	Percentage of total cost
A. Buying Costs	30.50	20.33	13.05
Loading and unloading	5.00	3.33	2.14
Transportation	18.00	12.00	7.70
Commission paid	3.75	2.50	1.60
Weighment	3.75	2.50	1.60
B. Processing costs	40.50	27.00	17.33
Assortment	26.00	17.33	11.13
Rope making	2.00	1.33	0.85
Bale ticket	0.50	0.33	0.21
Pressing and stacking	12.00	8.00	5.14
C. Selling costs	24.75	16.50	10.59
Dispatch	6.00	4.00	2.57
Transportation	15.00	10.00	6.42
Internal brokerage	3.75	2.50	1.60
D. Other costs	137.94	91.96	59.03
Bank interest	38.88	25.92	16.64
Insurance premium	31.62	21.08	13.53
Salary and establishment	18.84	12.56	8.08
Godown rent	15.75	10.50	6.74
Shortage/ wastage	15.48	10.32	6.62
Telephone bill	4.50	3.00	1.93
Electricity bill	3.50	2.33	1.50
Personal expenses	9.37	6.25	4.01

Total	233.69	155.79	100.00
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Note: 1 *Kutch*a bale = 150 Kg. Personal expenses included entertainment and meals

Other costs: Other costs included the cost of bank interest, insurance premium, salary and establishment, godown rent, shortage, telephone bill, electricity bill and personal expenses. Total other cost was estimated at Tk. 92, Tk. 98 and Tk. 101 per quintal of jute for the *Kutch*a balers, *Pucca* balers and exporters respectively. Other cost constituted roughly 59.03 percent, 48.67 percent and 45.17 percent of the total costs for *Kutch*a balers, *Pucca* balers and exporters respectively. Bank interest and insurance was the most important cost item in this category and they represent 16.64 percent and 13.53 percent for *Kutch*a balers, 12.11 percent and 10.37 percent for *Pucca* balers and 12.17 percent and 9.36 percent for the exporters of total marketing costs respectively. To sum up the marketing costs incurred by the *Kutch*a balers, *Pucca* balers and exporters were Tk. 156, Tk. 201 and Tk. 223 per quintal of jute respectively. Among the different types of costs item, the other cost was the highest for *kutch*a balers, *Pucca* balers and exporters because the bank interest, insurance cost and godown rent was the highest cost item of these intermediaries (Table 9).

Total marketing cost of jute

The costs for performing various marketing functions up to the shipping point by different participants constitute the total marketing cost. On an average the total marketing cost of all intermediaries was Tk. 869 per quintal of jute. The costs incurred by the farmers, *Farias*, *Beparis*, *Kutch*a balers, *Pucca* balers and exporters were 3.21 percent, 13.51 percent, 16.51 percent, 17.94 percent, 23.17 percent and 25.66 percent of the total marketing cost. It is evident that the marketing cost gradually increased with the passage of the product through successive stage in the marketing system due to increasing complexity and greater multiplicity of functions performed (Table 10). Marketing cost of *faria* / *baparis* was Tk. 39.92 which was 136.96 per quintal of *Katch*a balers [9]. Another study revealed that during 1999 the marketing cost of intermediaries (*Faria*/*baparis*) was Tk. 63 per quintal [10].

Table 9. Marketing cost of *Pucca* balers for *tossa* jute (Sources Moniruzzaman *et al.*, [9], Moniruzzaman *et al.*, [8] and Moniruzzaman *et al.*, [4])

Marketing cost segments/items	Costs of <i>tossa</i> jute (Tk/ <i>Pucca</i> bale)	Costs of <i>tossa</i> jute (Tk/ quintal)	Percentage of total cost
A. Buying Costs	25.42	14.12	7.02
Loading and unloading	7.00	3.89	1.93
Stacking <i>Kutch</i> a bale	2.00	1.11	0.55
Transportation	8.92	4.96	2.47
Commission paid	3.75	2.08	1.03
Weighment	3.75	2.08	1.03
B. Processing costs	141.00	78.33	38.93
Assortment	65.00	36.11	17.95
Rope making	4.00	2.22	1.10
Bale ticket	2.00	1.11	0.55
Pressing and stacking	66.00	36.67	18.23
Stacking <i>Pucca</i> bale	4.00	2.22	1.10
C. Selling costs	19.50	10.82	5.38
Dispatch	4.00	2.22	1.10
Transportation	10.50	5.83	2.90
Internal brokerage	5.00	2.78	1.38
D. Other costs	176.27	97.93	48.67
Bank interest	43.86	24.37	12.11
Insurance premium	37.54	20.86	10.37
Salary and establishment	22.50	12.50	6.21
Godown rent	23.72	13.18	6.55
Shortage/ wastage	19.92	11.07	5.50
Telephone bill	8.55	4.75	2.36
Electricity bill	6.72	3.73	1.85
Personal expenses	13.45	7.47	3.71
Total	362.18	201.20	100.00

Note: 1 *Pucca* bale = 180 Kg. Personal expenses included entertainment and meals

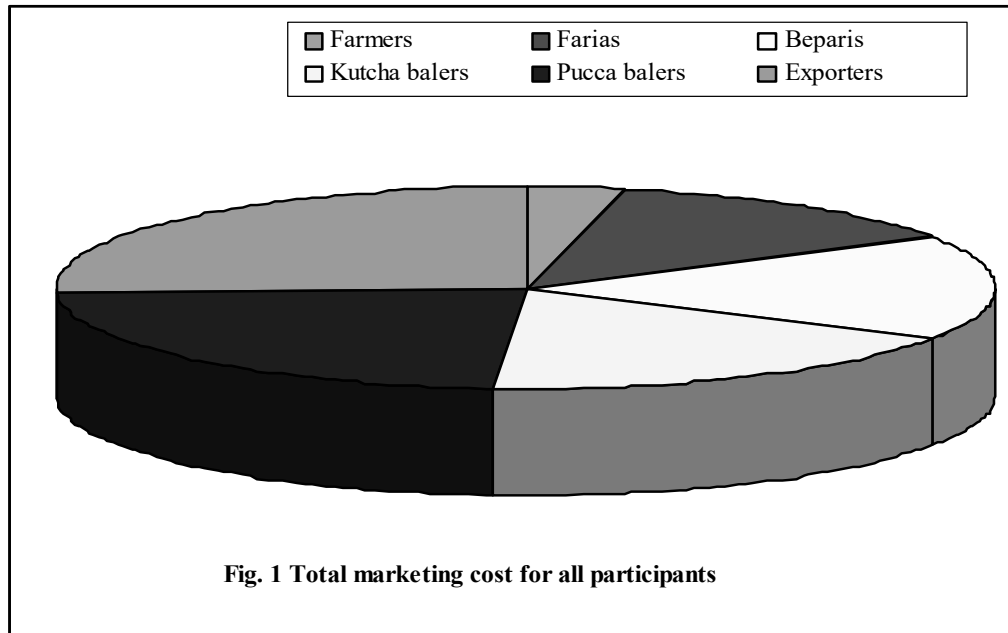
Table 10. Marketing cost of exporters for tossa jute (Sources Moniruzzaman et al., [9], Moniruzzaman et al., [8] and Moniruzzaman et al., [4])

Marketing cost segments/items	Costs of tossa jute (Tk/ Pucca bale)	Costs of tossa jute (Tk/ quintal)	Percentage of total cost
A. Buying costs	25.42	14.12	6.34
Loading and unloading	7.00	3.89	1.75
Stacking <i>Kutcha</i> bale	2.00	1.11	0.50
Transportation	8.92	4.96	2.23
Commission paid	3.75	2.08	0.93
Weighment	3.75	2.08	0.93
B. Processing costs	141.00	78.33	35.15
Assortment	65.00	36.11	16.20
Rope making	4.00	2.22	1.00
Bale ticket	2.00	1.11	0.50
Pressing and stacking	66.00	36.67	16.45
Stacking <i>Pucca</i> bale	4.00	2.22	1.00
C. Selling costs	53.50	29.72	13.34
Dispatch	4.00	2.22	1.00
Transportation	10.50	5.83	2.62
Export brokerage	12.00	6.67	2.99
Commission to C & F agent	11.00	6.11	2.74
Commission to BJC	11.00	6.11	2.74
Bill of loading & stamp	5.00	2.78	1.25
D. Other costs	181.21	100.68	45.17
Bank interest	48.81	27.12	12.17
Insurance premium	37.54	20.86	9.36
Salary and establishment	22.50	12.50	5.67
Godown rent	23.72	13.18	5.91
Shortage/ wastage	19.92	11.07	4.97
Telephone bill	8.55	4.75	2.13
Electricity bill	6.72	3.73	1.67
Personal expenses	13.45	7.47	3.35
Total	401.13	222.85	100.00

Note: 1 *Pucca* bale = 180 Kg. Personal expenses included entertainment and meals

Table 11. Total marketing cost of jute incurred by market participants (Sources Moniruzzaman et al., [9], Moniruzzaman et al., [8] and Moniruzzaman et al., [4])

Market participants	Cost (Tk./quintal)	Percentage of total cost
Farmers	27.91	3.21
<i>Farias</i>	117.37	13.51
<i>Beparis</i>	143.43	16.51
<i>Kutcha</i> balers	155.79	17.94
<i>Pucca</i> balers	201.20	23.17
Exporters	222.85	25.66
Total	868.55	100.00



Marketing margins per quintal of jute for intermediaries

The *Farias* who purchased loose jute from farmers and sold to different types of buyers had a gross margin of Tk. 150.00 per quintal. They incurred a marketing cost of Tk. 117 per quintal and therefore, the net profit earned by them was only Tk. 33 per quintal. The gross margins of the *Beparis*, *Kutcha balers*, *Pucca balers* and exporter were respectively Tk. 192, Tk. 175, Tk. 338 and Tk. 650 per quintal of jute. The net margins of the *Beparis*, *Kutcha balers*, *Pucca balers* and exporters were estimated at Tk. 49, Tk. 19, Tk. 136 and Tk. 240 per quintal of jute respectively. Thus in terms of profit making, the performance of the exporters and *Pucca balers* was relatively because of the fact that return over investment for exporters and *Pucca balers* was 9.09 percent and 5.21 percent respectively which was higher compared to other traders (Table 12).

Marketing margin at a particular stage of transaction may be defined as the difference between purchase price and sales price of commodity. Total marketing margin is obtained by deducting the price received by the producers from the price paid by the consumers. According to [6], marketing margin in a sense, is the price of all utility adding activities and functions that are performed by the intermediaries. A marketing margin is the percentage of the final weighted average selling price taken by each stage of the marketing chain. The margin must cover the costs involved in transferring produce from one stage to the next and provide a reasonable return to those doing the marketing activities [11]. Marketing margins of jute were calculated separately for different intermediaries. Gross marketing margin of each type of intermediaries was calculated by deducting the purchase price of jute from their sale prices whereas net margin or profit component was calculated by deducting the marketing cost from gross marketing margins. Marketing margins, it may be mentioned has two elements such as marketing costs and profit.

Table 12. Marketing margins of all intermediaries (Tk./quintal) (Sources Moniruzzaman *et al.*, [9], Moniruzzaman *et al.*, [8] and Moniruzzaman *et al.*, [4])

Intermediaries	Purchase price	Sales price	Gross margin	Marketing cost	Net margin	Return over total investment (%)
<i>Farias</i>	2000.00	2150.00	150.00	117.37	32.63	1.54
<i>Beparis</i>	2055.00	2247.50	192.00	143.43	48.57	2.21
<i>Kutcha balers</i>	2237.50	2412.50	175.00	155.79	19.21	0.80
<i>Pucca balers</i>	2412.50	2750.00	337.50	201.20	136.30	5.21
Exporters	2412.50	2875.00	462.50	222.85	239.65	9.09
Total	-	-	1317.00	868.55	476.36	-

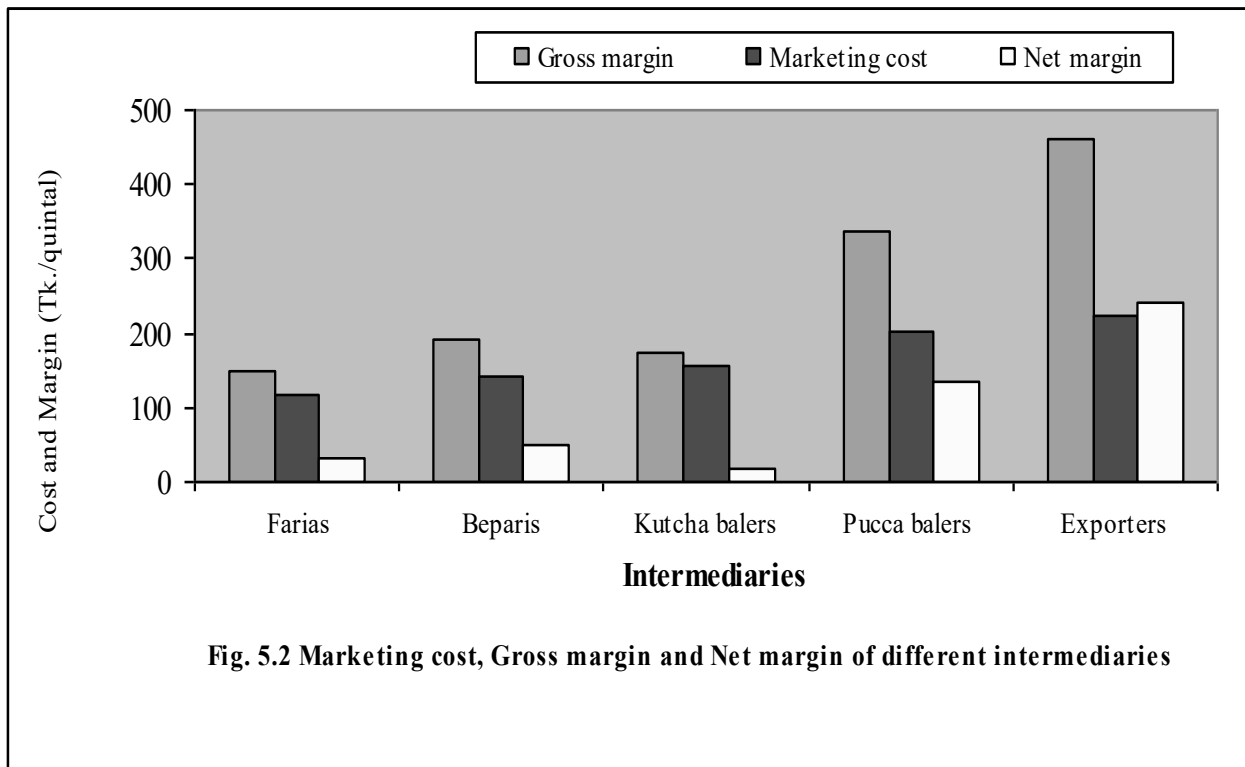


Fig. 5.2 Marketing cost, Gross margin and Net margin of different intermediaries

Seasonal price variation and problem faces by the growers and traders of raw jute production and marketing in Bangladesh: Result revealed that during the period 1997 to 2006, the maximum price indices of raw jute in Krisnapur market was 104.44 in the month of June and the minimum of 96.09 in the month of October for raw jute because of the fact that June was the short supply month and the of raw jute was high in the month of October. The important feature of raw jute prices was that their prices were more or less the same during August to December. This implied that during this period the supply matched the demand for raw jute. The price reached the maximum level in June after slight decrease in July, began to decline from August and reached minimum level in October. The range of seasonal price variation was 8.34. The co-efficient of variation of monthly price indices was 2.79 for raw jute.

The prices were more or less same during October to December because of matching the supply and demand during this period. The maximum price index of Talma market was 104.54 in the month of June and the minimum was 96.11 in the month of December for raw jute because of the supply of raw jute was the lowest in the month of June and supply of raw jute was high in the month of December. The range of seasonal price variation was 8.43 and the co-efficient of variation was 2.89 for raw jute (Table 13). The range of seasonal price variation of Kanaipur market was 8.85 for raw jute. The co-efficient of variation of monthly price indices was 3.01 for raw jute. The price is above average during April to July and below average during August to December because during April to July was lean period and August to December was peak period of raw jute. Change in supply was the main cause of this seasonal price variation (Table 1). The seasonal price variation of raw jute was found highest in Kanaipur market compared with all selected markets and lowest in Krisnapur market in Faridpur district. Raw jute price indices revealed seasonal variation on account of variation in demand and supply in the markets (Table 13).

Table 13. Seasonal price variation of tossa jute of different secondary markets of faridpur district during 1997 to 2006(Sources Moniruzzaman *et al.*, [9], Moniruzzaman *et al.*, [8] and Moniruzzaman *et al.*, [4])

Months	Seasonal indices of different secondary markets of Faridpur district		
	Krisnapur	Talma	Kanaipur
January	97.25	97.30	97.706
February	100.37	100.30	100.750
March	100.43	100.63	100.906
April	102.68	102.61	102.788
May	102.12	102.03	102.263
June	104.47	104.54	104.337
July	104.14	104.36	104.454
August	99.65	99.33	99.328
September	99.34	99.76	99.681
October	96.09	96.17	95.722
November	96.99	96.84	96.459
December	96.54	96.11	95.607
Maximum	104.44	104.54	104.454
Minimum	96.09	96.11	95.607
Range	8.34	8.43	8.847
SD	2.79	2.87	3.012
Mean	100.00	100.00	100.00
CV%	2.79	2.87	3.012

Note: $CV = Sd / Mean * 100$

Range = Maximum – Minimum

Source: Department of Agricultural Marketing (DAM), Bangladesh Jute Association (BJA).

In Narayangonj terminal market, the maximum price indices was 104.27 in the month of June and the minimum was 95.80 in the month of December for raw jute because of the supply of raw jute was the lowest in the month of June and supply of raw jute was high in the month of December. The range of seasonal price variation was 8.47 for raw jute. The co-efficient of variation of monthly price indices in Narayangonj terminal market was 2.95 for raw jute. The price variation of raw jute was more or less same during April to July. This imply that during this period, the supply matched the demand for raw jute. After slight decrease in July began to decline from August and reached minimum level in December (Table 14).

Table 14. Seasonal price variation of tossa jute of Narayangonj terminal market during 1997 to 2006 (Sources Moniruzzaman *et al.*, [9], Moniruzzaman *et al.*, [8] and Moniruzzaman *et al.*, [4])

Months	Seasonal indices of Narayangonj terminal markets
January	97.55
February	100.75
March	101.11
April	102.66
May	103.31
June	104.27
July	103.80
August	98.47
September	99.39

October	96.27
November	96.62
December	95.80
Maximum	104.27
Minimum	95.80
Range	8.47
SD	2.95
Mean	100.00
CV%	2.95

Note: $CV = Sd / Mean * 100$

Range = Maximum – Minimum

Source: Department of Agricultural Marketing (DAM)
Bangladesh Jute Association (BJA).

The average seasonal price indices of raw jute in the selected markets during the period of 1997 to 2006 was observed the highest price index of raw jute was 104.41 in the month of June and lowest price index was 96.01 in the month of December. The difference between highest and lowest average indices was 8.40. The coefficient of variation of monthly price indices of raw jute was 2.90. In all markets raw jute price indices reveal seasonal variation on account of variation in demand and supply in the market (Figure 2).

The causes of such price variation might be –

- i) The cause of a decline in the price of raw jute during August to December was highest might be due to the highest supply in harvest period and correspondingly, the price of jute remained lowest. On the other hand during April to June, the supply of jute was the lowest (lean period) and for this reason the price remained higher in this period.
- ii) The jute production depends on temperature, humidity, rainfall, sowing and harvesting time. The impact of weather disturbances is reflected in yield and harvested acreage. Several other factors such as availability of seeds, fertilizers, pesticides, credit, government policy etc. also influence the instability of supply of jute which effect price of jute.

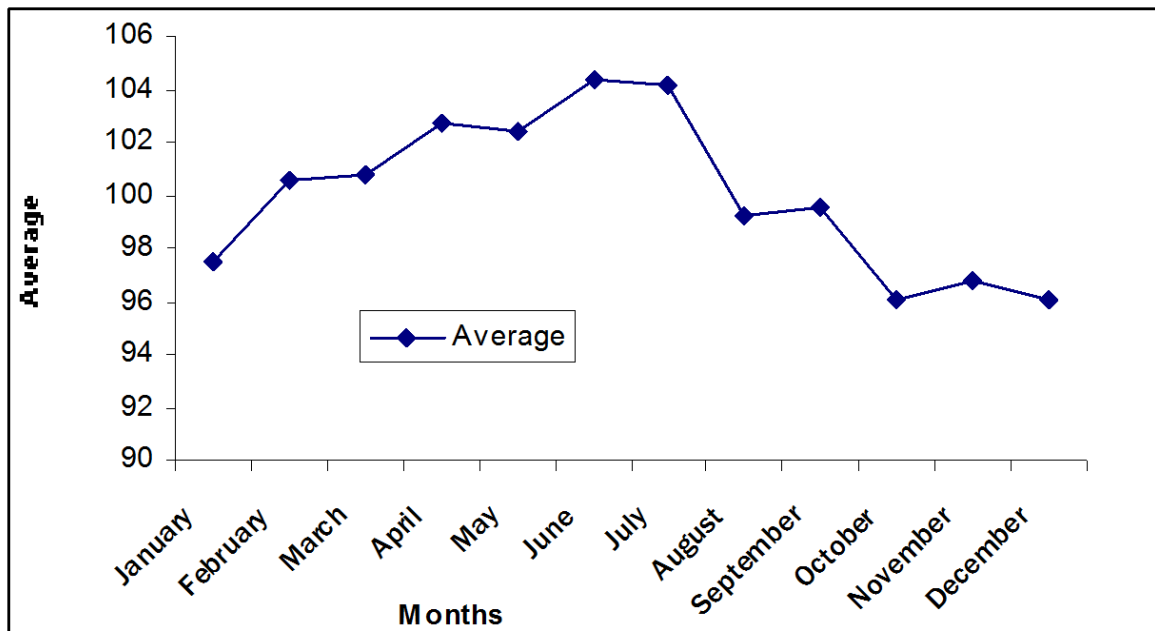


Figure 2. Average seasonal price variations of tossa jute of different secondary and terminal markets during 1997 to 2006 (Sources Moniruzzaman *et al.*, [9], Moniruzzaman *et al.*, [8] and Moniruzzaman *et al.*, [4])

Problems Faced by Raw Jute Growers

Farmers produce jute for selling in the market. They sell their crop at their homes and in the nearest rural market. For production and marketing of jute, farmers faced various problems in the study area which are discussed below:

Lack of availability, supply and distribution of good quality jute seeds: Jute production depends largely upon availability of good quality seeds. Bangladesh Agricultural Development Corporation (BADC) cannot supply sufficient good quality seed according to the demand of the farmers. So farmers bought low quality seeds from open markets. Low quality seed was a pertinent problem for the farmers.

Lack of scientific knowledge and technical support: Lack of scientific knowledge and technical support was one of the major problems for better jute production. In the study areas, farmers were not aware of the latest scientific knowledge such as seed drill used in broadcast sowing, retting in insufficient water in dry season etc.

Pest attacks on the plants: Pest attack on the plants was a serious problem in the study areas. Farmers cannot buy pesticide because of high price. As a result, they do not get good quality of fiber.

Scarcity of retting water at harvest time: Scarcity of retting water at harvest time was the major problem in the study areas. A certain depth of water is needed for retting. When the farmers harvest their jute, they do not get sufficient water for retting because rivers, beels, etc. are becoming dry day by day.

Low bargaining power: Low bargaining power was also major problems for farmers. Farmers does not have cooperatives, so they cannot bargain with buyers. For instability in prices and low bargaining power at the local markets, the farmers remained uncertain to get fair price. On the other hands, farmers compelled to sell their jute at low price just after harvest in order to pay the credit to the lenders.

Lack of marketing facilities: Lack of marketing facilities like storage facilities and transportation were mentioned as problems in jute marketing which are essential for jute. The prices of jute fluctuate in local markets. The farmers who wanted to get higher prices, they could not store their products for want of storage facilities.

Lack of sufficient fund and complexity of getting credit from institutional sources: Most of the producers in the study area could not cultivate their lands due to lack of sufficient funds. Non-availability of credit and complex procedures of getting institutional credit was a limiting factor in production. In the study areas, some of the farmers mentioned that it was very much complicated to get the credit from institutional sources. On the other hand, interest rate of NGO's credit was very high.

Lack of market information: Market information influenced the farmers to make their decisions regarding the production, sales and the price of the product. The right market information helps the farmers operate their business smoothly. In the present study, the farmers could not collect the market information about jute production from reliable sources. In the study areas, farmers considered lack of market information as a problem in marketing their jute which adversely affected the profitability of the jute cultivation.

Solutions to the Problems Faced by the Farmers

To overcome the problems of jute production and make the production more profitable, some suggestions are mentioned below:

Coordination of different organizations: Coordination of different organizations could solve the problem of non-availability of good quality seeds. The relationship of different organization such as BADC, DAE and BJRI, should be developed because BADC along is not able to supply the good quality and HYV variety seeds. Government should come forward to supply the good quality seeds in reasonable price to the farmers through the above organizations.

Providing scientific education and training: Scientific education and training can upgrade the farmers knowledge about the improved method of jute cultivation. The use of different technologies and scientific use of chemicals should be ensured in the farmers fields. Government and non-government agencies should take necessary steps to provide scientific education and training facility to the farmers.

Availability of water for retting: Insufficient water for retting was a major problem in the study areas because a certain depth of water is needed for retting. To overcome this problem, supplementary supply of water, digging of ponds, khal etc. in proper time may be arranged by government. Technology can be developed so that retting can be done using small amount of water. Department of Agriculture Extension (DAE) should arrange training for the progressive farmers in the jute growing areas on scientific retting of green jute.

Formation of farmers association: Farmers association should be formed which might improve bargaining power of farmers, enabling them to face the traders and ensuring them better prices from jute production.

Availability of credit as easy terms: Government may enact a new law in banking sector so that farmers can get credit from any government and private bank at a low interest rate and on easy terms and conditions.

Improvement of communication system and market information: Transport and communication system should be improved. To reduce transportation cost, government should take proper steps. Government may forecast or publish regularly market information through different mass media such as radio, TV and newspaper etc.

Problem Faced by Jute Intermediaries

In the study areas, jute intermediaries faced various problems and these are discussed below:

High transportation cost: A good transportation system is essential for trading any product. But in the study areas, inadequate and inappropriate transportation system created problem in jute marketing. Due to inadequate transportation facilities and increased price of fuel, the transportation cost in the study areas was very high.

Irregular payment by buyers: Irregular payment was a great problem in the study areas. When *farias* and *beparis* purchased the products of farmers, they paid in cash to the farmers but in case of selling to *pucca* balers/exporters, BJMC and mills, they sold in credit.

Inadequate storage facilities: Inadequate storage facility increased marketing cost due to high preservation charge. They usually stored their product in rented warehouse which increased the cost.

Lack of technical knowledge of grading: For the purpose of export, grading according to specific standard is sine quo non. But in our country, *farias* and *beparis* could not grade their raw jute. Grading is done by *pucca* balers but due to lack of expert hands, grading are not always done efficiently. As a result, the demand of jute in foreign market is decreasing.

Price and demand fluctuation: Price and demand fluctuation were the major problem in jute marketing. In this situation, the traders remain uncertain on profit and the possibility of loss is a common phenomenon.

Lack of credit facilities: Non-availability of credit from institutional sources at easy terms and condition was a major problem in the study area. In the absence of insurance knowledge, the *farias* and *beparis* are afraid of taking any risk, thus causing an unbalanced fluctuation of price. Sometimes they did not get enough money for purchasing jute and whole of the marketing system was hampered.

Lack of proper market information: Although market information was available to some extent to the intermediaries but the information was not accurate and up to date. So, in the study are lack of proper market information was important problem to the trades.

Lack of government purchase center: Lack of government purchase centre was also a major problem because there was no government purchase centre near the jute producing areas. As a result, farmers could not sell their products at fair prices.

Mixing/adulteration and watering: Mixing/adulteration and watering problem were great problems in the study areas. Poor quality products are sometimes mixed with the good quality in order to make big volume and to get higher prices. On the other hand, the unscrupulous traders often mix water with loose jute to increase the weight, thereby to increase the profits. Most of the times this problem was created by the *farias* and *beparis*.

High shipment cost: It is the major problem of exporters. Shipment cost is estimated on the basis of product weight but weight of many jute products is higher than the value of product. They have to pay on the basis of weight which was high.

Lack of quality jute: Lack of quality fiber was important problem of *pucca* balers and exporters. The foreign buyers want good quality fiber. But exporters could not supply good quality jute because of adulteration made by the middlemen.

Political instability: Political instability like strike, hartal etc. are a great problem, to run any kind of business efficiently. Transportation of jute was very much hampered by strike and for that reason the total marketing cost increased. In the case of political unstable situation, the auction market cannot perform its function properly.

Solutions to the Problems Faced by the Intermediaries

Ensure stable price: Stable price is a very important criterion for running business smoothly. Government should take some feasible actions (fixing the price, monitoring market etc) so that the traders can buy jute from the producers at a reasonable price and price may remain stable throughout the year.

Open purchase center: A large number of Govt. purchasing centres may be opened in different locations so that the farmers and traders can buy and sell their jute products easily at fair prices.

Availability of credit on easy terms: Government may enact a new law in banking sector and start special insurance programme so that traders can get credit from any Govt. and private bank at a easy terms and conditions and can face any risk

Adequate market information and storage facilities: Market information and storage facilities should be ensured for getting fair prices of jute products.

Provide technical knowledge of grading: Grading is very important for jute products. If traders grade jute properly, they can get suitable price for their products and can earn more profits. Government and Non-government organization can provide proper trainings for traders.

Reduction of shipment cost: To reduce the shipment cost as well as marketing cost, government should take proper steps to reduce shipment costs. Government can provide subsidy on value of jute exporters.

Stable political situation: The government and the opposition parties can play an important role to stabilize political situation. Stable political situation can ensure the development activities of the country, so the jute industry and its marketing functions. The government and opposite parties can take effective steps to stop hartals and other political hazards. The marketing system can run smoothly if political situation in the country is stable.

IV. Conclusion

It can be concluded that the jute farmers sell their jute to the Farias and Beparis. Farias sold unsorted jute to the Beparis who usually handle a large volume. The Beparis sold loose jute to the Kutcha balers, Pucca balers and to the mills. Kutcha balers purchased loose jute from farmers, Farias and Beparis and processed it into Kutcha bales. The processed jute sold to the Pucca balers or exporters and jute mills through Dalals/brokers. The Aratdars are commission agents having fixed establishment who operated between traders of jute on the one hand and balers and mills on the other hand, and charge a fixed commission. Pucca balers bought jute in loose form from Faria and also form of Kutcha bales from Kutcha balers. Aratdar sold to the exporters and millers with the help of Dalals. Exporters operated the terminal market and procured loose jute from dealers of jute and baled jute from Kutcha balers and Pucca balers. They sold baled jute to the mills through Dalals and Pucca bales to the foreign buyers. Foreign buyers purchased Pucca bales from exporters and processed jute from mills with the help of international brokers. The findings of the study reveal that total marketing costs per quintal of jute for farmers, Farias, Beparis, kutcha balers, Pucca balers and exporters were calculated at Tk. 28, Tk. 117, Tk. 143, Tk. 156, Tk. 201 and Tk. 223 respectively. The average net marketing margins per quintal of jute for Farias, Beparis, kutcha balers, pucca balers and exporters were Tk. 33, Tk. 49, Tk. 19, Tk. 136 and Tk. 240 respectively. Among all intermediaries the profit of exporter was the highest. The results revealed that the seasonal price variation in all raw markets were more or less similar. The price variation arises from lack of storage facility, high transportation cost, change in supply and demand and economic condition of the producers as well as traders. The price was above average during April to July and below average during August to December because during April to July was lean period and August to December was peak period of raw jute. Jute farmers and traders faced a number of problems such as lack of availability, supply and distribution of good quality jute seeds, lack of scientific knowledge and technical support, pest attacks on plant, scarcity of retting water, low bargaining power, lack of credit, high transportation and shipment cost, irregular payment by buyers, price

fluctuation, adulteration, lack of market information, political instability etc. On the other hand, ensure stable price, opening of open purchasing centres, availability of bank credit on easy terms, adequate market information and storage facilities, updating technical knowledge of grading, reduction of shipment cost and stable political situation etc. were assessed as points of solutions of above mentioned problems.

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Kenaf (*Hibiscus cannabinus* L., Malvaceae) Research and Development Advances in Bangladesh: A Review

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Abstract

Kenaf [1] originated in India and Africa the plant is best grown in tropics and to some extent in sub-tropics. In Bangladesh, Kenaf is now a promising new fibre crop. Around 0.08-0.09million tons of kenaf produced in the country from 0.04 million hectares of land. The secondary data of kenaf used here were collected from different studies like national and international annual reports, thesis, books and journals during from January to July 2019. The plants are herbaceous annuals; growing to a height of even 5 m. There are some Kenaf varieties of bnagladesh, HC-2, HC-95, BJRI Kenaf-3(Bot Kenaf) and BJRI Kenaf -4 (KE-3). The commercial success of kenaf has important potential economic and environmental benefits in the areas of soil remediation, toxic waste cleanup, removal of oil spills on water, reduced chemical and energy use for paper production, greater recycled paper quality, reduced soil erosion due to wind and water, replacement or reduced use of fiberglass in industrial products, and the increased use of recycled plastics. In Bangladesh day by day demand of kenaf fibre is increasing. Kenaf uses in fibre, forage, paper pulp and also where kenaf is grown in home gardens, the more tender upper leaves and shoots are sometimes eaten either raw or cooked. Kenaf fruits have significant medicinal properties, very high in vitamin-C, antioxidants and phytochemicals. It's seeds are a good source of fat slouble antioxidants. In future research to be continued for searching kenaf varieties tolerance to problem soil; tolerance to diseases and pests; having small seed size with long duration of seed viability and smoothness and indehiscence type of kenaf fruits.

Key Words: kenaf, history;botany; cultivation; research and development, uses, future approach

Introduction

Kenaf (*Hibiscus cannabinus* L., Malvaceae) is a warm season annual fiber crop closely related to White Jute (*Corchorus capsularis* L.) that can be successfully produced in mainly in India and China, followed by Bangladesh. As the commercial use of kenaf continues to diversify from its historical role as a cordage crop (rope, twine, and sackcloth) to its various new applications including paper products, building materials, absorbents, and livestock feed, choices within the decision matrix will continue to increase and involve issues ranging from basic agricultural production methods to marketing of kenaf products. These management decisions will require an understanding of the many different facets of kenaf production as a fiber, feed, and seed crop. It is an annual, non-wood fiber plant indigenous to central Africa. Akin to okra and cotton, kenaf grows to heights of 12 to 18 feet in a six-month growing season. Kenaf produces 5 to 10 tons of dry fiber per acre, consisting of external bast fibers (about 1/3 of the plant) and internal core fibers (the remaining 2/3 of the plant). Uses of the fiber range from paper, grass mats, fiberglass substitutes, animal bedding, oil-absorbent materials, chicken and cat litter, animal forage, particle board, and potting soil, to name a few. At present, in Bangladesh, so many areas are covered by Kenaf like, Bhrambaria, Voirab, Netrokona, vast areas of Kishoregonj; Laksmipur, Noakhali, Shriatpur, Madaripur, some sporadic areas of Tangail, Mymensingh and Jamalpur.

In Bangladesh, Kenaf [1] is a promising new fibre crop. Around 0.08-0.09

million tons of kenaf produced in the country from 0.04 million hectares of land [1]. The name kenaf is of Persian origin and is most generally used to describe the plant *Hibiscus cannabinus* L. and the fibre. Miyake and Suzuta [2] compiled a list of 129 world wide names that have been given this plant. In India the common name in Bengal is Mesta; in Madras it is called palungi; in Western India and Taiwan it is known as ambari; in Bombay, decean hemp; in Andhra Pradesh it is known as Bimli jute or Bimlipatam jute; in Egypt and northern Africa it is variously called til, teel, or teal; in Indonesia it is known as Java jute; in Brazil as papoula de sao Francisco; in South Africa, stokroor ("wild stock rose); in Wesdt Africa it is known as dah, gambo, and rama. Kenaf, (species *Hibiscus cannabinus*), fast-growing plant of the hibiscus, or mallow, family (Malvaceae) and its fibre, one of the bast fibre group. It is used mainly as a jute substitute. The plant grows wild in Africa, where the fibre is sometimes known as Guinea hemp, and has been cultivated on the Indian subcontinent, where it is usually known as mesta, or ambari, since prehistoric times.

Kenaf was unknown in the West until late in the 18th century, when cordage and sacking made from the fibre were brought to Europe. It remained one of the less important bagging materials until World War II, when shortages of jute and other bagging fibres led to a new interest that continued after the war, as supplies of established materials remained insufficient and prices increased. In Cuba, the United States, and similarly affected countries, governments encouraged cultivation of kenaf, and production became increasingly mechanized. The plant is an herbaceous annual with stalks growing to about 18 feet (5.5 metres) in height and fibre concentrated mainly in the lower portion. The leaves are composed of five

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lance-shaped lobes occurring mainly near the stalk top; the flowers, pale yellow with purple centres, are borne on short stalks growing from the upper angles between leaf stalks and stems.

Kenaf, although adaptable to various soils, grows best in well-drained, sandy loam and requires a warm, moist climate, tropical or subtropical, without excessively heavy rains or strong winds. Some varieties need at least 12 hours of light each day throughout the growing season. Kenaf is less demanding on the soil than jute and may be grown in rotation with other crops. Dense sowing is common, except when cultivation is for seed production. Crops are hand-harvested, yielding the best fibre at the flowering stage. Fibres are usually separated from the stalks mechanically, although in some areas retting, followed by hand stripping, is still practiced. The fibre strands, about 3 feet (0.9 metre) long, are pale in colour and lustrous, with strength comparable to that of jute. Leading producers include India, Thailand, and China. Kenaf, still fairly new to international trade, is used mainly for cordage, canvas, and sacking but is receiving increased consideration for other products, such as newsprint and carpet-backing yarn. Studies begun in the 1950s demonstrated that kenaf, which reaches its mature height in less than six months, is easier to process, produces a higher yield, and has stronger fibres than plants grown for wood chips.

History of Kenaf

Kenaf has been used as a cordage crop to produce twine, rope, and sackcloth for over six millennia. Kenaf was first domesticated and used in northern Africa. India has produced and used kenaf for the last 200 years, while Russia started producing kenaf in 1902 and introduced the crop to China in [3]. In the United States, kenaf research and production began during World War II to supply cordage material for the war effort [4]. The war not only interrupted the foreign fiber supplies from countries such as the Philippines, but the US involvement in the war also increased the use of these fibers by the US. Once it was determined that kenaf was a suitable crop for US production, research was initiated to maximize US kenaf yields. As a result, scientists successfully developed high-yielding anthracnose-resistant cultivars, cultural practices, and harvesting

machinery that increased fiber yields [5; 6].

Then in the 1950s and early 1960s, as USDA researchers were evaluating various plant species to fulfill future fiber demands in the US, it was determined that kenaf was an excellent cellulose fiber source for a large range of paper products (newsprint, bond paper, and corrugated liner board). It was also determined that pulping kenaf required less energy and chemical inputs for processing than standard wood sources [7]. More recent research and development work in the 1990s has demonstrated the plant's suitability for use in building materials (particle boards of various densities, thicknesses, with fire and insect resistance), adsorbents, textiles, livestock feed, and fibers in new and recycled plastics (injected molded and extruded) [8].

Habitat and Distribution

Originated in India and Africa the plant is best grown in tropics and to some extent in sub-tropics. Kenaf grows almost throughout the world both in tropical and temperate areas it is sensitive to frost. In India, kenaf is grown often as a border crop in garden areas where the soil is loamy and affords good drainage. It is grown mixed with most cereals in dry lands or as a pure crop. Kenaf is an important fibre crop in South India. It is cultivated as a rainfed crop in large areas in Madhya Pradesh, Andhra Pradesh and Tamil Nadu. It is sown on the bunds of irrigation channels and in small patches in garden lands.

Kenaf Cultivation in Bangladesh

Geographical localization of the agricultural production area for Kenaf-varieties used in the Kenaf-based fiber composites value chain (Kenaf with sufficient quality for the fibre properties of tenacity, elongation and cleanness- please confer with NFC for the specific quality requirements). Agricultural production areas of Kenaf-varieties in Bangladesh are Brammanbaria, Voirab, vast areas of Kishoregonj; Lakkhipur, Shariatpur, Madaripur, some sporadic areas of Tangail, Mymensingh and Jamalpur.

Districts	2012	2011	2010	2009	2008	2007
Greater Dhaka	4165	5084	7157	0	0	0
Kishoreganj, Netrokona, Sherpur, Jamalpur	10016	11626	7502	1206	628 Jamalpur	507
Brammanbaria	485	537	488	75	269	364
Lakshmpur	107	55	36	30	0	0
Shariatpur	4369	4436	4412	2485	2450	2140

Table 1: Area under Kenaf in different growing location of Bangladesh (Hectare)

Source: Dept. of Agril. Extension

[=]Total	2012	2011	2010	2009	2008	2007
Bangladesh	19144	21795	19595	3769	3347	6530

Table 2: Total area under Kenaf in Bangladesh in different year (Hectare)

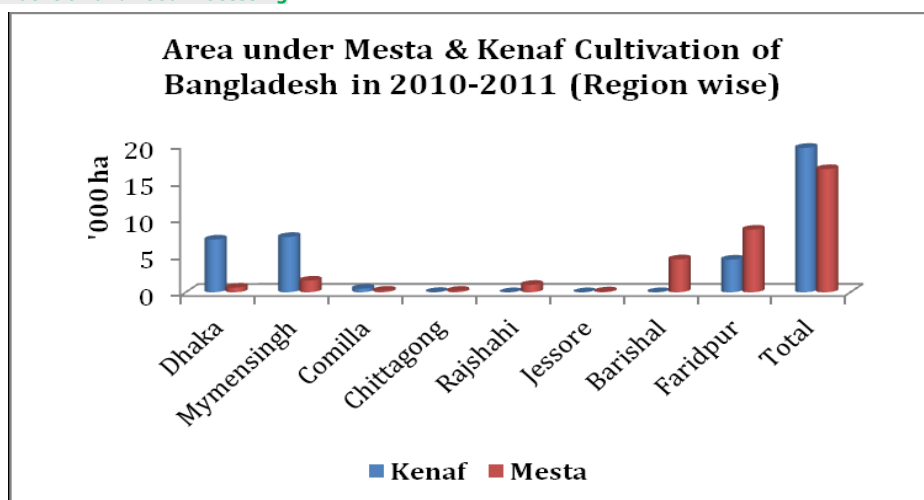


Figure 1: Area under Mesta and Kenaf cultivation of Bangladesh in 2010-2011 (Region wise)

Materials and Methods

The study was based on secondary information. The secondary data used were collected from different studies of the Library of Bangladesh Jute Research Institute, Dhaka during from January to June 2019. These secondary data were BJRI annual reports, different thesis, Books, Bangladesh Journal of Jute and Fiber Research, Jute and Jute Fabrics, Bangladesh (News letter) of BJRI and other national and international journals.

Results and Discussion

Taxonomy

Scientific classification	
Kingdom:	Plantae
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Rosids
Order:	Malvales
Family:	Malvaceae
Genus:	<i>Hibiscus</i>
Species:	<i>H. cannabinus</i>
Binomial name	
<i>Hibiscus cannabinus</i> L.	
Synonyms	
<ul style="list-style-type: none"> • <i>Abelmoschus congener</i> Walp. • <i>Abelmoschus verrucosus</i> Walp. • <i>Furcaria cannabina</i> Ulbr. • <i>Furcaria cavanillesii</i> Kostel. • <i>Hibiscus malangensis</i> Baker f. • <i>Hibiscus vanderystii</i> De Wild. • <i>Hibiscus vitifolius</i> Mill. no. illeg. 	

Source: <http://www.britannica.com/EBchecked/topic/314686/kenaf>

Botany of Kenaf

The plants are herbaceous annuals; growing to a height of even 5 m. the stems are straight, with small prickles: leaves alternate, stipulate, lobed and with serrated margins, stipules long and pointed: flowers solitary, with short pedicels and axillary, epicalyx stiff, consisting of seven to

eight bracteoles: corolla larger, spreading pale yellow or yellow with crimson or purplish centre: stamens numerous on a staminal column: ovary superior, five carpelled: style passes through staminal column and terminate in five stigmatic branches: fruit capsule, five loculed each containing four to five seeds. It is mainly as self-pollinated crop. Kenaf is a short day, annual, herbaceous plant cultivated for the soft bast fibre in the stem. It belongs to the Malvaceae, a family notable for both its economic and horticultural importance [9]. The genus *Hibiscus* is widespread, comprising some 200 annual and perennial species [10]. Kenaf is closely related to cotton and the holly hocks (*Althea* sp.). A modified morphological description of the species from Bates [9] follows.

Stem: Erect, prickly, cylindrical, branched or un-branched reaching a height of 1 to 4m, either entirely green green with pinkish or raddish pigmentation, or red.

Leaves: Eigher entirely cordated and very shallowly lobed with serrated margins or 3-5-7 deeply palmate, alternate, stipulate, stipulates free lateral, pubescent 0.5 to 0.8 cm long. Petiole 3.0 to 18.0 cm long, finely pubescent on the adaxial surface and bristled on the abaxial surface, green to red, scabrous.

Lamina: Lobed or unlobed, when unlobed ovagte margin serrated, apex acuminagte, 5-7 nerved palmately reticulate, when lobed palmately 5-7 deep, each lobe lanceolate, margin serrated, apex acute, one green gland present on the mid-vein on the under surface, upper surface glabrous, lower surface hairy along with veins, scaberulous.

Flowers: Salitary, axillary, pedunculate, pednecl 0.2 to 0.4 cm long, bristled, pentamerous, 8.0 to 10.0 cm in diameter when open, yellow with red center or completely yellow, showy, bracteoles (epicalyx) 7-9, segmented, linear, bristled, 1.0 to 1.5 cm long, green attached to the base of the calyx.

Calyx: Cepals 5, lanceolate, cornate below the middle into a cap, green bristled and tormentosed with a large green gland on the back of each sepal, persistent.

Corolla: Large, spreading, bell shaped, full yellow with or without deep enter, petals 5, free, very slightly united at the base twisted outer side pubescent, 7-9 cm long.

Stamens: Many monadelphous, stamined coluran epipetatous truncate, 2.5 cm long with glandular hairs, yellow or light red, filaments 0.1 to 0.2 cm long, red yellow anthers semiform, pollen spiny .

Carpels: 5, ovary ovoid, 0.7 to 0.8 cm long. Densely covered with white silky adpressed hairs, 5, chambered with many ovules in each chamber arranged in 2 vertical rows stigma-5, hairy, capitate, red or yellow, exerted.

Capsule: Ovoid, pointed, villose, half of the length of the calyx with about 20 to 26 seeds.

Seed: Traiangular, angles more or less acute, ash gray with pointed light yellowish warty spots. Hilum brown, relatively small. Most of the better known kenaf varieties produce seed that range from 36000 to 40000 per kg.; however some Africand types from Sadan, Uganda abnd Central African Republic produce small seed that range from 100,000 to 110,000 per kg. Small seeded kenaf types have also been noted in Iran [11].

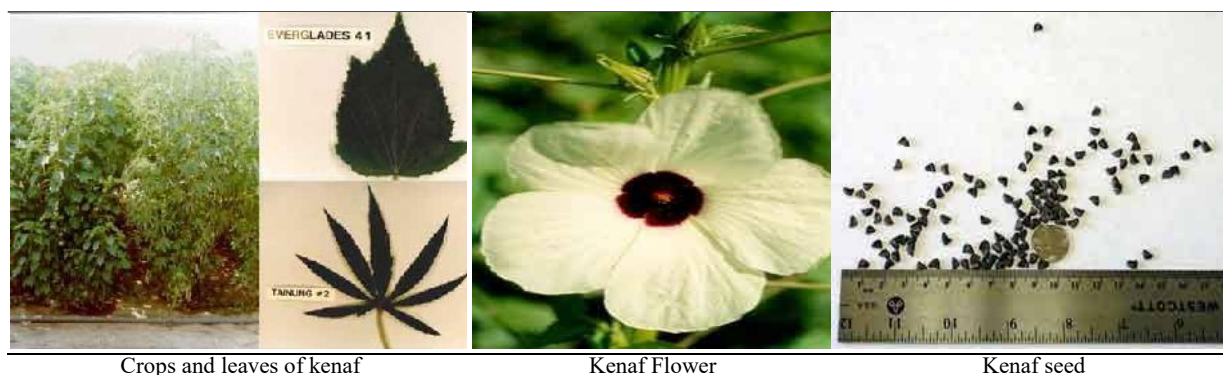




Figure 2. Crops and leaves, flower and seed of Kenaf

Climate

Kenaf cultivation requires specific climate and land. It requires early rains in March, May and June and intermittent rain and sunlight thereafter till August, temperature between 28°C and 35°C and humidity between 70% and 90%. This type of climate is available in areas between 30° Latitude North and South of the earth.

Soil



One of kenaf’s advantages as a crop, is it can be successfully grown in a wide range of soil types, from high organic peat soils to sandy desert soils. Although kenaf grows better on well-drained, fertile soils with a neutral pH, the crop can withstand late season flooding, low soil fertility, and a wide range of soil pH values. Kenaf also has shown excellent tolerance to drought conditions.

Characteristics	Kenaf	White Jute
		
	Figure 3. Kenaf plant	Figure 4. White jute
Stem	Erect, prickly, cylindrical, branched or un-branched reaching a height of 1 to 4m, either entirely green green with pinkish or raddish pigmentation, or red.	It is generally 1.5 to 3.7m tall, can withstand water logging in later stages, herbaceous annual, 3-5 month duration for fibre yield depending upon sowing time. It’s stem cytindrical, green to dull coppery red to pink, periderm in the basal portions in later stages.
Leaves	Eigher entirely cordated and very shallowly	Leaves are glabrous, 5-13 cm by 2.5-8.2 cm length and

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	lobed with serrated margins or 3-5-7 deeply palmate, alternate, stipulate, stipulates free lateral, pubescent 0.5 to 0.8 cm long. Petiole 3.0 to 18.0 cm long, finely pubescent on the adaxial surface and bristled on the abaxial surface, green to red, scabrous.	bright. Ovate oblong, acuminate, coarsely toothed, lower most pair of serrations enlarged and end in hairy appendages. Petiole 4-8 cm, various from green to pink in different varieties, stipules 0.5-2.0 cm or more, foliaceous in some varieties, tip coloured or green.
Flowers	Salitary, axillary, pedunculate, peduncle 0.2 to 0.4 cm long, bristled, pentamerous, 8.0 to 10.0 cm in diameter when open, yellow with red center or completely yellow, showy, bractoles (epicalyx) 7-9, segmented, linear, bristled, 1.0 to 1.5 cm long, green attached to the base of the calyx.	Flowers are small generally in extra axillary cymes in groups of 2-5 or more; 0.3-0.5 cm long and 0.5-0.6 cm wide; sepals 5, coloured or green, petals 5, yellow or pale yellow, stamens 20-30; anther yellow to pale yellow, ovary rounded, 5-carpelled, syncarpous, ovals axile, usually 10 in each locale in 2 rows, giving about 50 ovules in each ovary; style 2-4 mm; stigma pubescent. Anthesis one or two hours after sun rise.
Capsul	Ovoid, pointed, villose, half of the length of the calyx with about 20 to 26 seeds.	sules rounded, 1.0-1.5 cm in diameter, wrinkled, rarely smooth, muricate, 5-locular, seed- 7-10 in 2 rows in each ocular, without transverse partitions, 30-50 in each fruited.
Seed	Traiangular, angles more or less acute, ash gray with pointed light yellowish warty spots. Hilum brown, relatively small. Most of the better known kenaf varieties produce seed that range from 36000 to 40000 per kg.; however some African types from Sadan, Uganda and Central African Republic produce small seed that range from 100,000 to 110,000 per kg.	Seeds are small, chocolate brown, 4-5 faced about 300 per gm.
Fibre	Fine fibre with lower weight than Kenaf	rose fibre higher weight than white Jute
Growing areas	Brammanbaria, Voirab, vast areas of Kishoregonj; Lakkhipur, Shriatpur, Madaripur, some sporadic areas of Tangail, Mymensingh and Jamalpur.	over Bangladesh except Sylhet, Chattagram Hill Tracts, Southern areas like Barishal, Borguna, Volla, Ptiouakhali, etc
Processing (Post harvest)	Similar processing as jute	ilar processing as Kenaf
Rules and regulations	Not at all	es are maintained

Table 3. A morphological differences between Kenaf and White Jute

Kenaf	Roselle/Mesta
	
Figure 5. Kenaf plant	Figure 6. Mesta plant
[Sour Leaf, Decan Hemp, Java Jute, Kenaf, Jamaica(English); Hanf (Persian); Gongura, Pulicha, Keerai, Ambaadi, Mesta,	[Sour Leaf, Red Sorrel (English); Rosella (Australia, Indonesia); Belchanda (Nepal); Tengamora, Mwitha (Assam, India); Chukor,

<p>Shougri (India); Teel, Til, Teal (North Africa); Dah, Gambo, Rama (West Africa); Papoula-de-são-francisco, Cãhãmo-brasileiro, Quenafe (Brazil); Cãñamo de la India, Cãñamo de gambo, Cãñamo Rosella, Pavona encendida, Yute de Java, Yute de Siam de gambo, (Spanish); and many, many more; [<i>Hibiscus cannabinus</i>]</p> <p>This plant, probably originating in South Asia, is cultivated worldwide for many uses: rope fiber, paper, edible leaves, oil, animal feed and bedding, fiberboard, engineered wood and thread for fabrics. The ancient Egyptians used it to make the ropes and sails for their ships. It can grow to about 11 feet tall with stems up to 1 inch diameter. Currently small crops are grown in California, Texas and Louisiana, mostly for animal feed and bedding, but you can expect it to expand as more of its uses are exploited, particularly if hemp remains illegal in the US (hemp has similar fibrous properties but is not related).</p> <p>The leaves are widely eaten in India, and preferred to the leaves of Roselle, but I haven't seen this plant here in Southern California. The seeds are pressed for cooking oil, which has a very similar fatty acid profile to Cottonseed Oil, but with more Omega 3. It is commonly called Gongura for culinary uses and Kenaf for industrial and fiber uses. This plant is closely related to the smaller, red stemmed Roselle/Gongura (<i>Hibiscus sabdariffa</i>), but has green stems and much different fruit pods. Roselle has wider culinary and medicinal useage.</p>	<p>Gongura, Pulicha, Keerai, Pundi, Ambadi, LalChatni, Kutrum, Mathipuli (India); Chin baung (Burma); KraJiabDaeng (Thailand); Chaye-Torosh (Iran), Karkade (Arabic); Sorrel (Caribbean & Latin America); Flor de Jamaica (Mexico); Guragod, Labug, Labog (Philippines); Bissap (Africa); <i>Hibiscus sabdariffa</i>]</p> <p>This plant is closely related to the taller, green stemmed Gongura / Kenaf (<i>Hibiscus cannabinus</i>) but Kenaf fruit pods are very different in structure. Like Kenaf, Roselle is primarily a fiber crop, growing to 8 feet tall, but also has a wide variety of culinary and medicinal uses.</p> <p>The leaves are a very important herb or vegetable in a good part of India (Andhra, Karala, Karnataka, Assam and others), and valued for their iron content. They are used in a wide variety of pickles, dals and curries, particularly goat and mutton curries, but also with chicken and pork. They are also much used in Burma, especially with fish and shellfish, and in Africa, particularly Senegal, where they flavor a recipe for fish and rice.</p> <p>This plant fruits prolifically. The fruit pod, similar to a short stubby okra pod, is surrounded by a calyx of dark red petal like sepals. There are two styles, the short one (photo) and the long one where the points around the base are also long.</p> <p>The sepals could be used in salads as a color accent, but the pod is not particularly edible due to the many stiff fibers it contains. It is almost edible raw, but cooking hardens the sharp fibers while softening the pod, and the seeds remain quite stiff, quite unpleasant. They are, however, used by the Shan people in Burma as a souring agent in stews.</p> <p>Simmering the whole calyces in water produces a brilliant crimson broth that is just a little sour and quite pleasant enough to serve as the basis for herb teas. It is best to remove the pod, which can make the broth a bit mucilaginous - it's related to okra, after all. The calyces contains enough pectin that jam can be made from them using only sugar and calyces.</p>
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Table 4: Differences between Kenaf and Roselle/Mesta

	Kenaf	White Jute
Green Plants	36019 kg (100%)	34 mt/ha (100%)
Green leaves	Attached 5155 kg (14.2%)	5304 kg (15.6%)
Green Ribbons	12246 kg (34.0%)	13688 kg (40.2%)
Green Wood	18658 kg (51.8%)	15028 (44.2%)
Dry leaves	1176 kg (3.26%)	1326 kg (2.9%)
Dry Ribbons	3429 kg (9.51%)	3788 kg (11.2%)
Dry wood	5747 kg (15.95%)	4250 kg (12.5%)
Dry retted fibre	1742 kg (4.83%)	2006 kg (5/9%)



Table 5: Comperison of Kenaf and White jute in different characters



	Whole kenaf	Kenaf bast	Kenaf core
Fibre length (mm)	1.28	2.6	0.6
Diameter (microns)		20	30
Lignin (%)	13.2	7.7	17.4

Table 6: Kenaf Fibre Characteristics

SI No	Varieties	Released year	Pedigree
Kenaf (<i>Hibiscus cannabinus</i>)			
1.	HC-2	1977	PLS
2.	HC-95	1995	PLS
3.	HC-3 (Bot kenaf)	2010	PLS
4.	BJRI Kenaf-4 (KE-3)	2017	PLS

Table 7: List of varieties of Kenaf crop of Bangladesh

Identifying characters of different Kenaf varieties developed by BJRI in Bangladesh	
Kenaf varieties (<i>Hibiscus cannabinus</i> L.)	
<p>HC-2 (Joly kenaf): HC-2 was released in 1977. Its stem green pigmented and petiole green, leaves simple cordated, petiole is longer than lamina. Fruit capsule ovoid, indehiscent, seeds subreniform grayish brown. Bright fibre. Medium to medium low land is suitable for cultivation. Seed sowing time mid March to mid April. Seed rate 12-15 kg/ha. Plant height 4.00 to 5.50 meter. Fibre recovery 7.3%. Time of flowering 150-165 days after sowing. Time of harvest 120 days after harvest or as per need. Yield 2.50-2.70 t/ha at Research station. The variety suitable for medium low, less fertile and flood affected land. Fibre is bright and shiny. Green plants are excellent raw materials for paper pulp. Tolerant to water logging [12].</p>	
	HC-2 (Joly kenaf)
<p>BJRI Kenaf-2 (HC-95): BJRI Kenaf-2 was released in 1995. Its stem tall cylindrical, unbranched, whole plant deep green, Fibre bright. leaves lobed, the petal is light cream colour with very light pink tinge on the inner basal part of the petals. Fruit capsule ovoid, indehiscent, seeds subreniform grayish brown. Medium to medium low land. Loom or slightly clay to sandy loam are suitable for cultivation. Seed sowing time Mid March to Mid April. Seed rate 12-15 kg/ha. Plant height 3.50 to 4.00 meter. Fibre recovery 6.23%. Time of flowering 150-170 days after sowing. Time of harvest 120 days after harvest or as per need. Yield 2.80-3.30 t/ha at Research station. This variety is suitable for medium low, less fertile and flood affected land. Fibre is bright and shiny. Green plants are excellent raw materials for paper pulp, seeds contain about 20% edible oil. Tolerant to water logging [12].</p>	
	BJRI Kenaf-2 (HC-95)

<p>BJRI Kenaf-3 (Bot Kenaf): BJRI Kenaf-3 was released in 2010. Its stem tall cylindrical, unbranched, whole plant deep green, Fibre bright. leaves cordated, the petal is light cream colour with very light pink tinge on the inner basal part of the petals. Fruit capsule ovoid, indehiscent, seeds subreniform grayish brown. Medium to medium low land. Loom or slightly clay to sandy loam are suitable for cultivation. Seed sowing time 15 March to 30 April. Seed rate 12-15 kg/ha. Plant height 3.50 to 4.00 meter. Fibre recovery 6.53%. Time of flowering 150-170 days after sowing. Time of harvest 120 days after harvest or as per need. Yield 2.60-3.00 t/ha at Research station. This variety is suitable for medium low, less fertile and flood affected land. Fibre is bright and shiny. Green plants are excellent raw materials for paper pulp, Tolerant to water logging [12].</p>	
<p>BJRI Kenaf-4 (KE-3): BJRI Kenaf-4 was released in 2017. Its stem tall cylindrical, unbranched, whole plant deep green, Fibre bright. leaves lobed, the petal is light cream colour with very light pink tinge on the inner basal part of the petals. Fruit capsule ovoid, indehiscent, seeds subreniform grayish brown. Medium to medium low land. Loom or slightly clay to sandy loam are suitable for cultivation. Seed sowing time 15 March to 15 May. Seed rate 12-15 kg/ha. Plant height 3.50 to 4.00 meter. Fibre recovery 6.75%. Time of flowering 140-160 days after sowing. Time of harvest 120 days after harvest or as per need. Yield 2.80-3.30 t/ha at Research station. This variety is suitable for medium low, less fertile and flood affected land. Fibre is bright and shiny. Green plants are excellent raw materials for paper pulp, Tolerant to water logging [12].</p>	
	<p>BJRI Kenaf-4 (KE-3)</p>

Research and Development works at BJRI

Mamun *et al.*, [13] reported that among the 94 Acc., twenty seven genotypes viz. Acc. 4410, Acc. 5080, Acc. 4380, Acc. 5016, Acc. 4197, Acc. 1612, Acc. 4383, Acc. 1571, Acc. 5114, Acc. 4897, Acc. 1595, Acc. 1600, Acc. 1601, Acc. 1611, Acc. 1823, Acc. 1824, Acc. 1983, Acc. 1986, Acc. 3746, Acc. 4115, Acc. 4345, Acc. 4443, Acc. 4447, Acc. 4461, Acc. 4623, Acc. 5006 and Acc. 5018 showed better performance than the control varieties HC-95 and BJRI Kenaf-3 in respect of plant height, base diameter and green weight per plant.

Mostafa *et al.*, [14] reported that seventeen genotypes of Kenaf including three cultivated varieties; and fourteen genotypes of Mesta including one advanced line and one cultivated variety. A total of 272 crosses of Kenaf and 130 crosses of Mesta were made. Among them, 262 and 110 successful crosses were obtained from different cross combinations of Kenaf and Mesta respectively.

Mostafa *et al.*, [15] reported that analysis of variance revealed significant differences among the treatments for all the traits studied at three locations except Manikganj for plant population and base diameter. All the tested lines showed lower yield than the check varieties HC-95 (3.63 t/ha) and BJRI Kenaf-3 (3.42 t/ha).

Ali *et al.*, [16] reported that significant effect of different NPKS levels on BJRI Kenaf-4 yield and yield contributing characters over control. The highest fibre (3.14t/ha) and stick (7.65t/ha) yield were obtained by the

combination dose of N100 Kg/ha with PKS 10-60-20 kg/ha at Kishoreganj. The plant height (3.14m), base diameter (19.47mm) also found highest with the same fertilizer treatment combination. By the same treatment produced higher fibre yield and yield contributing characters at Manikganj though that yield was slightly lower than Kishoreganj. Economic analysis suggested the best combination is N100-P10-K60-S20 kg/ha. The findings of the present experiment clearly indicated a great prospect of nutrient combination of N100-P10-K60-S20 kg/ha on the growth and yield of fibre production on the variety BJRI kenaf-4.

Islam [17] reported in a review article that Jute, kenaf and mesta fibre cultivation, trade and industry provide sustenance to over 4 million people of Bangladesh. The productivity of jute had doubled from 1.50 t/ha during 1970-80 to about 2.04 t/ha during 2015-16. Development of high-yielding varieties were the one of the main specific technologies which made this possible. Nearly 8 lack hectares of land cultivated by jute and allied crops per year in Bangladesh, which produced 80-90 lack bales of fibre. Over all 49 jute and allied varieties (White jute 25, Tossa jute 17, Kenaf 4 and Mesta 3 varieties) developed by BJRI. CVL-1, BJRI Deshi Pat-5, BJRI Deshi Pat-6, BJRI Deshi Pat-7, BJRI Deshi Pat-8, BJRI Deshi Pat Shak-1 and BJRI Deshi Pat-9 of *C. capsularis* L., O-9897, BJRI Tossa Pat-4, BJRI Tossa Pat-5, BJRI Tossa Pat-6, BJRI Tossa Pat-7 of *C. olitorius* L., HC-2, HC-95, HC-3 and BJRI Kenaf-4 of *Hibiscus cannabinus* and HS-24, BJRI Mesrta-2 and BJRI Mesta-3 of *H. subdariffa*. found important could cultivated in farmers field.

Ali *et al.* [18] was conducted an experiment to determine the effects of

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inorganic fertilizer on growth, yield and economic potential yield contributing characters over control. The highest fibre (3.10t/ha) and stick (7.20t/ha) yield were obtained by the combination dose of N100 Kg/ha with PKS 10-60-20 kg/ha at Manikganj. The plant height (3.08m), base diameter (20.10mm) also found highest with the same treatment of fertilizer combination. By the same treatment produced higher fibre yield and yield contributing characters at Kishoreganj though that yield was slightly lower than that of Manikganj location. Economic analysis favored the use of 100-10-60-20 kg/ha NPKS for yield of 3.10 t/ha Mesta fibre.

Mollah *et al.* [19] reported that seed germination percentage, seed vigor index (SVI), germination (%) after AA and EC values were found highly significant due to planting time, method and their interaction. It was found in interaction that the best quality seeds with germination (95.75% and 90.25%), seed vigor index (54.72 and 49.37), Electro-Conductivity value (13.21 and 14.19 μ scm-1g-1) and Accelerated Ageing (AA) germination percentage (76.0% and 72.75%) were recorded when the seeds were sown on 30 July at transplanting method in both the years.

Mollah *et al.* [20] found that seed vigour through accelerated ageing, electro-conductivity and field emergence were affected significantly due to seed moisture content at different month of testing during the period of storage. At each of the observation period it was found that the accelerated ageing and field emergence decreased and electro-conductivity value increased with increasing initial seed moisture content. The highest values were found with seed having 8% initial seed moisture content (SMC) in both 2011 and 2012. Seed vigour values through accelerated ageing, electro-conductivity and field emergence of kenaf seed at different months of testing during storage period varied significantly. The accelerated ageing, field emergence percentage decreased and electro-conductivity increased with time of storage. Seed vigour by accelerated ageing, electro-conductivity and field emergence differed significantly due to interaction

of initial seed moisture content and storage container. The present study concludes that kenaf seeds could be stored in aluminum foil bag, plastic pot, polythene bag and tin container at 8 and 10% moisture content for up to 12 months of harvesting.

Mollah *et al.* [21] reported that seed germination percentage and vigour index were affected significantly due to seed moisture content at different month of testing during the period of storage. Aluminum foil bag, plastic pot, polythene bag and tin container at 8% and 10% moisture maintained more than 80% germination after 12 months of storage while those stored at 12% maintained above 80% germination for up to 6 month. On the other hand, seeds stored in aluminum foil bag, plastic pot, polythene bag and tin container at 14% SMC reached below 80% germination after 8 months of storage. Germination percentage and seed vigour index and moisture content of kenaf seed at different months of testing during storage period varied significantly. The seed stored in earthen pots at 8 and 10% SMC maintained above 80% germination for 2 months while those stored at 12 and 14% were failed. The present study concludes that kenaf seeds could be stored in aluminum foil bag, plastic pot, polythene bag and tin container at 8 and 10% moisture content for up to 12 months after completing post-harvest processing.

Mollah *et al.* [22] conducted experiment and reported that the yield and yield attributes differed significantly due to planting date and methods. The highest seed yield (144.90 and 143.50gm⁻²) were recorded when the seeds were sown on 30 July at transplanting method in both the years. The lowest seed yield (47.30 and 57.01gm⁻²) was observed from the plants of 30 September sowing with top cutting method. Plant height, base diameter, number of pod plant⁻¹, number of seed pod⁻¹ and 1000-seed weight had positive significant correlation with seed yield. Gross return, gross margin and BCR were calculated higher in transplanting method.

Properties	Hemp	Jute	Ramie	Coir	Sisal	Flax	Cotton	Kenaf
Density g/cm ³	1.48	1.46	1.5	1.25	1.33	1.4	1.51	1.4
Tensile Strength, MPa	550-900	400-800	500	220	600-700	800-1500	400	283-800
Modulus, GPa	70	10-30	44	6	38	60-80	12	21-60
Specific (E/d)	47	7-21	29	5	29	26-46	8	-
Elongation at failure, %	1.6	1.8	2	15-25	2-3	1.2-1.6	3-10	1.6
Moisture absorption, %	8	12	12-17	10	11	7	8-25	18

Table 8: Properties of Hemp, Jute, Ramie, Coir, Sisal, Flax, Cotton and Kenaf

Uses

i. Fiber Uses

Kenaf has a unique combination of long bast and short core fibers which makes it suitable for a range of paper and cardboard products. Scientists at the ARS have tested several kenaf pulping techniques, with the pulps being used to make several grades of paper including newsprint, bond, coating raw stock and surfaced sized. Results have been positive, particularly in terms of paper quality, durability, print quality and ink absorption. Commercialization of kenaf for newsprint manufacturing is in its final stages. Commercial scale newsprint runs were conducted by the private sector in California, Texas and Florida. Newspapers made from kenaf pulp have been shown to be brighter and better looking, with better ink laydown, reduced ruboff, richer color photo reproduction and good print contrast. Quality analyses showed kenaf newsprint to have superior tear, tensile and burst ratings. Additionally, kenaf newsprint manufacturing requires less energy and chemicals for processing, an

important advantage, both economically and environmentally.

ii. Forage Uses

The top leafy portion of the kenaf plant is not useful for pulping. Therefore, this part of the plant would be useful as forage if harvest equipment could be practically adapted to a dual collection operation. Florida researchers found that immature plants at a height of 6 ft contained up to 20% protein. The kenaf ensiled successfully, both alone and with corn, and the silage was acceptable to heifers. They also found that kenaf leaf, dried and ground into a meal, had a greater crude protein digestibility than that of alfalfa meal. The amino acid composition of kenaf leaves is similar to that of alfalfa. Oklahoma research showed that kenaf leaf and petiole (non-stalk) portions of the plant were readily consumed by lambs and contained low fiber and high N concentrations. Analysis of the leafy kenaf material showed values of 8.7% NDF, 3.5% ADF and 34.0% CP. Contrasted to this, total plant composition levels were 42.9%, 32.6% and

17.1% respectively. Clearly, the leaf and petiole

portion of the plant contains the majority of the digestible nutrients.

iii. Kenaf paper

The most common process to make kenaf paper is using soda pulping before processing the obtained pulp in a paper machine.

The use of kenaf in paper production offers various environmental advantages over producing paper from trees. In 1960, the USDA surveyed more than 500 plants and selected kenaf as the most promising source of tree-free newsprint. In 1970, kenaf newsprint produced in the International Paper Company's mill in Pine Bluff, Arkansas, was successfully used by six U.S. newspapers. Printing and writing paper made from the fibrous kenaf plant has been offered in the United States since 1992. Again in 1987, a Canadian mill produced 13 rolls of kenaf newsprint which were used by four U.S. newspapers to print experimental issues. They found that kenaf newsprint made for stronger, brighter and cleaner pages than standard pine paper with less detriment to the environment. Due partly to kenaf fibres being naturally whiter than tree pulp, less bleaching is required to create a brighter sheet of paper. Hydrogen peroxide, an environmentally-safe bleaching agent that does not create dioxin, has been used with much success in the bleaching of kenaf.

An area of 1-acre (4,000 m²) of kenaf produces 5 to 8 tons of raw plant bast and core fibre in a single growing season. In contrast, 1-acre (4,000 m²) of forest (in the US) produces approximately 1.5 to 3.5 tons of usable fibre per year. It is estimated that growing kenaf on 5,000 acres (20 km²) can produce enough pulp to supply a paper plant having a capacity of 200 tons per day. Over 20 years, 1-acre (4,000 m²) of farmland can produce 10 to 20 times the amount of fiber that 1-acre (4,000 m²) of Southern pine can produce.

As one of the world's important natural fibres, kenaf is covered by the International Year of Natural Fibres 2009. The first novel to be published using 100% kenaf paper was *The Land of Debris and the Home of Alfredo* by Kenn Amdahl (1997, Clearwater Publishing Company). David Brower, former Executive Director of the Sierra Club, in chapter 8 of his semi-autobiographical environmental book *Let the Mountains Talk, Let the Rivers Run: A Call to Save the Earth* (1995, Harper Collins), titled "Forest Revolution," advocated for kenaf paper use and explained its many advantages over wood pulp. The first edition of the book was printed on kenaf paper.

iv. Food and Medicinal Uses

Where kenaf is grown in home gardens for fiber, the more tender upper leaves and shoots are sometimes eaten either raw or cooked. Kenaf fruits have significant medicinal properties, particularly for lowering blood pressure by helping increase nitric oxide and reducing oxidized lipids in the blood. They are very high in vitamin-C, antioxidants and phytochemicals, and have been found useful in treating metabolic diseases such as atherosclerosis, liver disease, cancer and diabetes. The seeds are a good source of fat soluble antioxidants [23].

Future Approach

Development and searching to be continued for-

- Less thermo and photo-sensitivity, especially allowing more flexibility of sowing and harvesting time with optimum biomass formation of Kenaf,
- Tolerance to problem soil (e.g. salinity, soil toxicity, wet foot condition etc.),
- Tolerance to diseases and pests;
- Having small seed size with long duration of seed viability of Kenaf,
- Smoothness and indehiscence type of kenaf fruits and

- Superior quality of kenaf fibre producing characteristics for diversified end uses.

Conclusion

There are so many kenaf crop varieties developed, released and used at farmer's level for commercial cultivation. All those varieties have high fibre and biomass yielding values. The kenaf fibre is snow white in colour same as white jute. In Bangladesh day by day demand of kenaf fibre is increasing. Kenaf uses in fibre, forage, paper pulp and also where kenaf is grown in home gardens, the more tender upper leaves and shoots are sometimes eaten either raw or cooked. Kenaf fruits have significant medicinal properties, very high in vitamin-C, antioxidants and phytochemicals. It's seeds are a good source of fat soluble antioxidants. In future research to be continued for searching kenaf varieties tolerance to problem soil; tolerance to diseases and pests; having small seed size with long duration of seed viability and smoothness and indehiscence type of kenaf fruits.

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Review Article

Food and Medicinal Values of Roselle (*Hibiscus sabdariffa* L. Linne Malvaceae) Plant Parts: A Review

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Abstract

Roselle/Mesta plant (*Hibiscus sabdariffa* L. Linne Malvaceae) was selected for its being large concentration point in relation to research advances on food and medicinal values. Data were collected from different print media like different annual reports and national and international journals during the year 2018 at Agronomy Division, Bangladesh Jute Research Institute (BJRI), Dhaka. So many Roselle crop varieties developed, released and used at farm level for commercial cultivation. All those varieties leaves and calyces have both vegetable and medicinal values. These are used fresh for making wine, juice, jam, jelly, syrup, gelatin, pudding, cakes, ice cream and flavors and also dried and brewed into tea, spice, and used for butter, pies, sauces, tarts, and other desserts. The roasted seeds can be used as a coffee substitute. The young root is edible, but very fibrous. The leaves are antiscorbutic, emollient, diuretic, refrigerant, and sedative. The fruits are antiscorbutic. The flowers contain gossypetin, anthocyanin, and the glycoside hibiscin. The ripe calyces are diuretic and antiscorbutic. The plant is also reported to be antiseptic, aphrodisiac, astringent, cholagogue, demulcent, digestive, purgative and resolvent. Medicinal plants as natural antimicrobial agents are gaining popularity. Roselle plant has been used in folk medicine as a diuretic, mild laxative, and treatment for cardiac and nerve diseases. In future, controlled studies are required to prove the effectiveness of different parts of Roselle under the various conditions.

Keywords: Roselle/Mesta; Leaf; Flower; Calices; Seed; Root; Food (Jam, Jelly, Syrup, Tea); Medicine (Antioxidant, Antihypertensive, Antimicrobial, Anticancer properties)

Introduction

Roselle is the most common name used specifically for *Hibiscus sabdariffa* var. Altissimo Hort, both for plant and fiber, although the edible *Hibiscus sabdariffa* L. is called Roselle. Other common names for the plant and fiber include: Kenaf in most countries; Mesta, Roselle, hemp, and pusa or pusa hemp in India; Kasi gogu in Andhra Pradesh, India; Roselle in Indonesia; Siam jute and paw keo in Thailand; voam bombazaha in Madagascar; azedinha, Curura-de-guine, and quiaboroseo in Brazil; and Oiselle-de-Guinee in West Africa. Roselle is a short day, annual herbaceous, bast fiber-bearing plant belonging to the Malvaceae family. The subspecies is the most economically important member of the genus *Hibiscus* in terms of fiber production. It is closely related to Kenaf (*Hibiscus cannabinus* L.) and okra (*Hibiscus esculentus* L.), young seed pods of the latter being widely used for food in many temperate, subtropical and tropical continuous. The plant reaches to about two meters in height, has beautiful bright white to pale yellow flowers and a stout fleshy and bright red as the fruit matures. Roselle is famous for producing edible calyx that can be used in beverages. The calyx is the red colored pointed pods found on the hibiscus that protect and support the hibiscus plant. It tastes sweet

and should be picked 10 to 15 days after they lose its blooms, or else it will taste more tart [1,2].

Roselle plant, with an attractive flower believed to be native to Africa, is cultivated in Sudan, India, Malaysia and Taiwan. It is an annual or perennial herb or woody-based sub-shrub, growing to 2 m to 2.5 m tall. The leaves are deeply 3 to 5 lobed, 8 cm to 15 cm long, arranged alternately on the stems. The flowers are 8 cm to 10 cm in diameter, white to pale yellow with a dark red spot at the base of each petal, and have a stout fleshy calyx at the base, 1 cm to 2 cm wide, enlarging to 3 cm to 3.5 cm, fleshy and bright red as the fruit matures. It takes about six months to mature. In some places, the plant is primarily cultivated for the production of bast fiber from the stem of the plant. The fiber may be used as a substitute for jute in making burlap. The red calyces of the plant are used as food colorings and dyes [3]. Today, Roselle is attracting the attention of food and beverage manufacturers and pharmaceutical concerns who feel it may have exploitable possibilities as a natural food product for herbal medicine and as a colorant to replace some synthetic dyes.

The most scientifically studied claim is the use of Roselle tea to positively affect blood pressures and cholesterol and prevent cardiovascular disease. Some of the other less-researched health benefits of Roselle tea include assisting in digestion, strengthening immunity, working as an anti-inflammatory agent, and reducing the risk of cancer. Roselle tea is also rich in vitamin-C, minerals and various antioxidants, while also helping in the treatment of hypertension and anxiety. Roselle tea can be made by steeping parts of the hibiscus plant in boiling water, particularly the calyx. It has distinct maroon color along with sweet and tart flavor similar to that of cranberries. It can be enjoyed both hot and cold depending on your preferences like most other teas [4].

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Kenaf/Mesta Cultivation: Area under Mesta & Kenaf in Bangladesh: 34,000 ha (Kenaf - 19,611 ha & Mesta - 14,489 ha) (Figure 1).

Origin of *Hibiscus sabdariffa*

There is a big argument about the origin of Roselle among different scholars. Cogley [1], suggested Roselle is a native plant of West Africa and from there it was carried to other parts of the world such as Asia and America, whereas in others opinion, Roselle was originated from India [5].

Description of *Hibiscus sabdariffa*

Hibiscus has more than three hundred species distributed in tropical and subtropical regions around the world and are used as ornamental plants. Research on have shown that some species of *Hibiscus* possess certain medicinal properties of which *Hibiscus sabdariffa* is one [6]. *H. sabdariffa* is commonly named as “red sorrel” or “Roselle”. Even though permeable soil is the best, Roselle can adapt to a variety of soil in a warmer and more humid climate [7,8].

H. sabdariffa, a member of Malvaceae family, is a known medicinal plant with a worldwide fame [9] and the plant can be found in almost all warm countries such as India, Saudi Arabia, Malaysia, Indonesia, Thailand, Philippines, Vietnam, Sudan, Egypt and Mexico [3,7,10]. Roselle is mainly cultivated to be consumed and the main producers of Roselle blossoms are Egypt, Sudan, Mexico, Thailand and China. Other hibiscus varieties are planted for their fibers they produce [11]. With the above information a review was undertaken to assess the nutritional and medicinal importance of Roselle crop.

Materials and Methods

The study was based on secondary information. The secondary data used were collected from different studies of the Library of Bangladesh Jute Research Institute, Dhaka during from January to November 2018. These secondary data were BJRI annual reports, different thesis, Books, Bangladesh Journal of Jute and Fiber Research, Jute and Jute Fabrics, Bangladesh (News letter) of BJRI and other national and international journals.

Results and Discussion

Taxonomy

A morphological description of the Roselle/Mesta is as follows: Stems are erect, solid, cylindrical, unbranched, mostly bristled, rarely glabrous, green, red, or regimented in various shades, reaching a height of 1 m to 5 m.

Leaves are simple on young plants, later becoming lobed alternate, stipulate, stipules free lateral, 0.5 cm to 1.0 cm long, green or red. Petiole 4 cm to 14 cm long, green to red, pubescent on the abaxial surface and densely bristled or sparsely hairy on the abaxial surface, green to deep and red, scabrous or smooth. Lamina are mostly 3 to 5, deeply palmately lobed, each lose ovate to oblong lanceolate, margin serrulose, apex-acute, pubescent and bristled along the veins on both the surface, scabrous or scaberulous, green to red, one green gland present in the mid vein on the undersurface. Flowers solitary, axillary, pedunculate, peduncle 0.2 cm to 0.4 cm long, bristled, pentamerous, completely yellow or yellow with red center, when open 3.0 cm to 5.0 cm in diameter, bracteoles (epicalyx) 8 to 10, short ovate, bristled, 0.5 cm to 0.7 cm long, green or red, persistent, attached to the base of the calyx [4].

Calyx, sepals 5, lanceolate, connate bellow the middle in to a cup,

1.5 cm to 2.0 cm lobes 1.5, 1.5 to 2.0 times the lengthy of the cup, bristled slightly tomentose, gland not prominent, persistent.

Corolla large, preading, bell-shaped, full-yellow or yellow with deep red center, petals 5, free, twisted, outside pubescent and with glandular hairs in the inner portion, 3 cm to 5 cm long.

Stamens many, monadelphous, staminal column epipetros, truncate, 1.0 cm long, with glandular hairs, yellow or red, filaments 0.1 cm to 0.2 cm long, yellow to red, anthers reinform, pollen spiny. Corpels 5, ovary ovoid 0.3 cm to 0.4 cm long, broadly globular ovoid, weith dense silky hairs, 5 chambered with many ovules in each chamber arranged in 2 to 3 rows, stigma 5, hairy, capitate, red or yellow exerted.

Capsule ovoid, pointed densely villose with about 30 to 40 seeds. Seeds reinform, smaller than those of Kenaf reddish brown with many small yellowish brown warty spots. Hilum reddish brown, relatively long seed average, 60000 per kg (Figure 2) [4].

Propagation of Roselle

Seed sow early spring in a warm greenhouse. Germination is usually fairly rapid. Prick out the seedlings into individual pots when they are large enough to handle. If growing them as annuals, plant them out into their permanent positions in early summer and protect them with a frame or cloche until they are growing away well. If hoping to grow them as perennials, then it is better to grow them on in the greenhouse for their first year and to plant them out in early summer of the following year. Cuttings of half-ripe wood, July/August in a frame. Overwinter them in a warm greenhouse and plant out after the last expected frosts (Figure 3).

Identifying characters of different Mesta varieties developed by BJRI

Mesta variety (*Hibiscus sabdariffa* L.):

Variety HS-24 (Tani mesta): Variety HS-24 was released

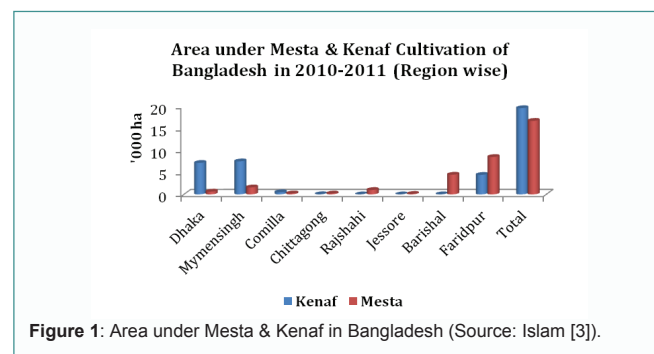


Figure 1: Area under Mesta & Kenaf in Bangladesh (Source: Islam [3]).

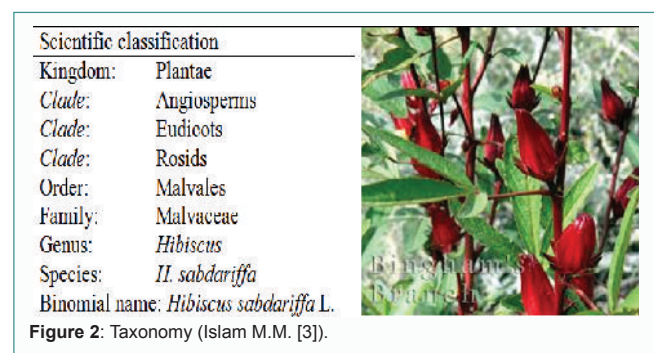


Figure 2: Taxonomy (Islam M.M. [3]).

in 1977 developed by pure line selection. Its stem green with nodes purple, pigmented leaves fine lobed, petiole is smaller than lamina. Leaves 5 lobed with lanceolate segments which are serrated, central lobe longest, leaf lobed dark green with veins and margins purple, rough, sepals light green with purple spots at maturity, petals yellow with crimson red at the inner basal portion, fruits capsule ovoid hairy, dehiscent seeds dull brown reniform. High land (Less fertile) is suitable for cultivation. Seed sowing time mid February to mid May. Seed rate 12 to 18 kg/ha. Plant height 4.00 m to 6.00 m. Fiber recovery 6.23%. Time of flowering 190 to 210 days after sowing. Time of harvest 120 to 130 days after harvest or as per need. Yield 2.00 to 2.70 t/ha at Research station. This variety is suitable for high, less fertile and drought affected land. After harvest T. aman can be grown. Resistant to root-knot nematodes (Figure 4) [4].

BJRI Mesta-2 (VM-1): BJRI Mesta-2 (VM-1) was released in 2010 developed by pure line selection. Its stem red with nodes purple, pigmented leaves fine lobed, Long petiole similar as lamina. Leaves 3 lobed with lanceolate segments which are serrated, central lobe longest, leaf lobed dark green with veins and margins purple, rough, sepals light green with purple spots at maturity, petals yellow with crimson red at the inner basal portion, fruits red and cone type. Plants are bushy in type. High land (Less fertile) is suitable for cultivation. Seed sowing time 15th April to 30th June. Seed rate 12 to 18 kg/ha. Plant height 1.00 m to 1.50 m. Time of flowering 180 to 200 days after sowing. Time of harvest from 60 days to onward for fruit or as per need. Red colored fruit yield 2.00 to 2.50 t/ha and leaf 6.0 to 7.0 t/ha at Research station. This variety is suitable for high, less fertile and drought affected land. Could produce 20% edible oil from seeds, Resistant to drought and root-knot nematodes (Figure 5) [4].

BJRI Mesta-3 (SAMU'93): BJRI Mesta-3 (SAMU'93) was released in 2017 developed by pure line selection. Its stem green with nodes purple, leaves green and fine lobed, long petiole than lamina. Leaves 5 lobed with lanceolate segments which are serrated, central lobe longest, leaf lobed dark green with veins, fine, sepals light green with purple spots at maturity, petals yellow with crimson red at the inner basal portion, fruits capsule ovoid hairy, dehiscent seeds dull brown reniform. High land (Less fertile) is suitable for cultivation. Seed sowing time 15th March to 15th May. Seed rate 12 to 18 kg/ha. Plant height 4.00 m to 5.00 m. Time of flowering 180 to 210 days after sowing. Time of flowering 190 to 210 days after sowing. Time of harvest 120 to 130 days after harvest or as per need. Yield 2.50 to 2.80 t/ha at Research station. This variety is suitable for high, less fertile and drought affected land. Quick growing and resistant to root-knot nematodes (Figure 6) [4].



Figure 3: Mesta plant with leaf, flower and fruits.



Figure 4: Variety HS-24 (Tani mesta).



Figure 5: BJRI Mesta-2 (VM-1).



Figure 6: BJRI Mesta-3 (SAMU-93).



Figure 7: A Roselle drink.

Different uses of Mesta/Roselle

Nutritional uses of Roselle: The fresh calyx (the outer whorl of the flower) is eaten raw in salads, is cooked and used as a flavoring in cakes etc and is also used in making jellies, soups, sauces, pickles, puddings etc. The calyx is rich in citric acid and pectin and so is useful for making jams, jellies etc. It is also used to add a red color and to flavor to herb teas, and can be roasted and used as a coffee substitute. A refreshing and very popular beverage can be made by boiling the calyx, sweetening it with sugar and adding ginger. Tender young leaves and stems - raw or cooked. Used in salads, as a potherb and as a seasoning in curries, they have an acid, rhubarb-like flavor. Seed - the dried and make into a powder then can use in oily soups and sauces. The oven dried seeds have been used as a coffee substitute as aphrodisiac properties. Root- also edible however very fibrous. Mucilaginous, without flavor. The seed has 20% oil content [12].

Nutritional value: Many parts of Roselle including seeds, leaves, fruits and roots are used in various foods. Among them, the fleshy red calyces are the most popular. They are used fresh for making wine, juice, jam, jelly, syrup, gelatin, pudding, cakes, ice cream and flavors and also dried and brewed into tea, spice, and used for butter, pies, sauces, tarts, and other desserts. The calyces possess pectin that makes a firm jelly. The young leaves and tender stems of Roselle are eaten raw in salads or cooked as greens alone or in combination with other vegetables and/or with meat. They are also added to curries as seasoning. They have an acid, rhubarb-like flavor. The seeds, are high in protein, can be roasted and ground into a powder then used in soups and sauces. The roasted seeds can be used as a coffee substitute. The young root is edible, but very fibrous (Table 1) [12].

The nutritional analysis of Roselle plant by proximate method found the carbohydrate content (68.7%) was highest followed by crude fiber (14.6%) and ash content (12.2%) and others [13]. The plant is also found to be rich in minerals especially potassium and magnesium. Vitamins (ascorbic acid, niacin and pyridoxine) were also present in appreciable amounts. Various workers reported variable content suggesting that the type of soil influences its ash and mineral content causing variations within the same species [14-18]. It has long been used in herbal tea to treat hypertension, pyrexia and liver damage although the pharmaceutical components are poorly defined [19]. Choi and Mason [20], reported that nutritional studies have indicated that low consumption of fruits and vegetables is consistently related to an increased incidence of cancer reflecting dietary habits (Figure 7).

Medicinal use of Roselle: Roselle is an aromatic, astringent, cooling herb that is much used in the Tropics. It is said to have diuretic effects, to help lower fevers and is antiscorbutic. The leaves showed antiscorbutic, diuretic, emollient, sedative and refrigerant. The leaves tastes very mucilaginous and used as emollient and use to cough remedy. The fruits showed antiscorbutic effect. The flowers contain gossypetin, glycoside hibiscin and anthocyanin. These might have choleric and diuretic effects, decreasing blood viscosity, stimulating intestinal peristalsis and reducing blood pressure. The Roselle leaves and flowers are used as a tonic for internal digestive and kidney functions. The seeds are also diuretic, laxative and tonic. Those are used in treatment of debility. The plant is also reported to be antiseptic, astringent, aphrodisiac, cholagogue, digestive, demulcent, purgative and resolvent. Roselle plant is used as folk remedy in treatment of abscesses, bilious conditions, cancer, cough, debility, dyspepsia, dysuria, fever, heart ailments, scurvy, hypertension, hangover, neurosis, and strangury [14]. The fruits and vegetables

components *viz.* polyphenol and anthocyanin might be responsible for the reduced risk of cancer [21-26]. Plants have the capacity of producing secondary metabolites *viz.* proteins, steroids, alkaloids, etc that enhanced its nutritive value [27].

Biochemical values are responsible for the medicinal properties of Roselle: Roselle calyx, which are of three types: dark red, red and green. The red calyces are the most used are characterized by their concentration anthocyanin. Delphinidin 3-Sambubioside and Cyanidin 3-Sambubioside are the major anthocyanin. Roselle is also rich in minerals, amino acids, organic acids, carotene, vitamin C and total sugar in its calyx, seeds and leaves at different levels depending on the variety and geographical area. Roselle has flavonoids, anthocyanidins, triterpenoids, steroids and alkaloids. Nutrient contents of different part of *H. sabdariffa* per 100 g are as follows in Table 2.

Different medicinal properties:

Antimicrobial properties: Roselle is widely used for the treatment of diseases. Olaleye [28] used the aqueousmethanolic extract of Roselle and reported that the extract contained cardiac glycosides, flavonoids, saponins and alkaloids. It exhibited antibacterial activities against *Staphylococcus aureus*, *Bacillus stearothermophilus*, *Micrococcus luteus*, *Serratia marsecences*, *Clostridium sporogenes*, *Escherichia coli*, *Klebsiella pneumoniae*, *Bacillus cereus*, *Pseudomonas fluorescence*. The results agreed the use of Roselle plant in the treatment of abscesses, bilious conditions, cancer and coughs in traditional medicine, and also suggested for possibility of isolating antibacterial and anticancer agents while the antimicrobial activity on *Escherichia coli* O157:H7, *Salmonella enterica* and *Listeria monocytogenes* isolates from food, veterinary, and clinical samples by Fullerton [29] indicated that Roselle extract was effective and suggested for application of extracts as potential antimicrobials in foods. The antibacterial effects of

Table 1: Nutritional value per 100 g of Roselle.

Roselle/Mesta (raw)	
Nutritional value per 100 g (3.5 oz)	
Energy	205 kJ (49 kcal)
Carbohydrates	11.31 g
Fat	0.64 g
Protein	0.96 g
Vitamins	
Vitamin A equiv.	14 µg (2%)
Thiamine (B ₁)	0.011 mg (1%)
Riboflavin (B ₂)	0.028 mg (2%)
Niacin (B ₃)	0.31 mg (2%)
Vitamin C	12 mg (14%)
Trace metals	
Calcium	215 mg (22%)
Iron	1.48 mg (11%)
Magnesium	51 mg (14%)
Phosphorus	37 mg (5%)
Potassium	208 mg (4%)
Sodium	6 mg (0%)

Units: µg: Micrograms; mg: Milligrams; IU: International

Table 2: Biochemical values of different parts of Roselle plant [10].

Nutrients	Calyxes	Seeds	Leaves
Protein (g)	2	28.9	3.5
Carbohydrates (g)	10.2	25.5	8.7
Fat (g)	0.1	21.4	0.3
Vitamin A (I.E.)	-	-	1000
Thiamine (mg)	0.05	0.1	0.2
Riboflavin (mg)	0.07	0.15	0.4
Niacin (mg)	0.06	1.5	1.4
Vitamin C (mg)	17	9	2.3
Calcium (mg)	150	350	240
Iron (mg)	3	9	5

Roselle calyx aqueous and ethanol extracts and protocatechuic acid against food spoilage bacteria *Salmonella Typhimurium* DT104, *E. coli* O157:H7, *Listeria monocytogenes*, *Staphylococcus aureus* and *Bacillus cereus* were estimated by Chau et al. [30], and shown that the inhibitory activity in dose-dependent behavior against test bacteria in ground beef and apple juice and suggested that it might be potent agents as food additives for preventing contamination from those bacteria.

Antioxidant properties: Roselle-*Hibiscus anthocyanins* (HAs) which are a group of natural pigments existing in the dried calyx exhibited antioxidant activity and liver protection manner. HA antioxidant bioactivity in rat primary hepatocytes and hepatotoxicity was studied by [31]. The results revealed that HA's, at the concentrations of 0.10 mg/ml and 0.20 mg/ml, significantly decreased the leakage of lactate dehydrogenase and the formation of malondialdehyde and the serum levels of hepatic enzyme markers (alanine and aspartate aminotransferase) significantly decreased and reduced oxidative liver damage. An antioxidative activity was also reported in cancerous cell lines [32]. McKay et al. [33], reported in his animal models that extracts of Roselle's calyces have demonstrated hypocholesterolemic and antihypertensive properties. The antioxidant potential of three fractions of the ethanol crude extract (HS-C: chloroform soluble fraction; HS-E: ethyl acetate soluble fraction; HS-R: residual fraction) found from the dried flowers were evaluated for their capacity to quench free radicals and inhibiting xanthine oxidase (XO) activity [34]. HS-E showed the greatest capacity of scavenging free radical, and HS-C showed the strongest inhibitory effect on XO activity. Furthermore, antioxidant bioactivities of these crude extracts were investigated on rat primary hepatocytes. All fractions were found to inhibit significantly the Unscheduled DNA Synthesis (UDS). These results revealed that the dried flower extracts (HS-C and HS-E) protect rat hepatocytes from t-BHP-induced cytotoxicity and genotoxicity. The study on hepatoprotective and antioxidant effects on the Carbon Tetrachloride (CCl_4)-induced hepatocyte damage in fish provided evidence of potential use as a medicine for curing liver diseases in aquaculture as Roselle extract significantly elevated levels of Lactate Dehydrogenase (LDH), Glutamate Oxalate Transaminase (GOT), Glutamate Pyruvate transaminase (GPT), and Malondialdehyde (MDA) and significantly reduced levels of Superoxide Dismutase (SOD) and Glutathione Peroxidase (GSH-Px) [35].

Anticancerous properties: Akim et al. [32], evaluated the antiproliferative activities of Roselle juice by using different cell lines like ovarian (Caov-3), breast (MCF-7, MDA-MB-231) and cervical (HeLa) cancer cell lines and found that it exhibited the strongest anti-proliferative potentiality towards the MCF-7 cancer cells. Using Roselle-anthocyanins (HA), the effects on human cancer cells (HL-60) studied and showed apoptosis of cells in a dose and time-dependent manner [36]. Hou et al. [19], reported the apoptosis of leukemia cells induced by anthocyanin was through reactive oxygen species mediated mitochondrial pathways. Protocatechuic Acid (PCA), a phenolic compound isolated from the dried flower, was found to inhibit the survival of human promyelocytic leukemia (HL-60) in a concentration and time dependent manner [34], and apoptosis was induced via reduction of retinoblastoma phosphorylation and down regulation of Bcl-2 protein expression [37]. The study revealed that cells underwent intranucleosomal DNA fragmentation and morphological changes characteristics of apoptosis while the action against gastric carcinoma cells by inducing apoptosis was through JNK/MAPK signaling pathways [38]. The methanolic extract of

Roselle on seven cancer lines implied the AGS cancer cells being most susceptible in concentration-dependant form affecting both the intrinsic and extrinsic apoptotic routes [39].

Mohamed et al. [40], reported that the antioxidant potential of Roselle (*Hibiscus sabdariffa* L.) extracts was studied. Different plant organs, including seeds, stems, leaves, and sepals, were analyzed with respect to their water-soluble antioxidant capacity, lipid-soluble antioxidant capacity, and tocopherol content. The Roselle seeds are a good source of lipidsoluble antioxidants, particularly γ -tocopherol. Its seed oil was extracted and characterized, and its physicochemical parameters were reported: acidity, 2.24%; peroxide index, 8.63 meq/kg; extinction coefficients at 232 (k232) and 270 nm (k270), 3.19 and 1.46, respectively. Oxidative stability, 15.53 h; refractive index, 1.477; density, 0.92 kg/L; and viscosity, 15.9 cP. Roselle seed oil belongs to linoleic/oleic category, most abundant fatty acids being C18:2 (40.1%), C18:1 (28%), C16:0 (20%), C18:0 (5.3%), and C19:1 (1.7%). Sterols include β -sitosterol (71.9%), campesterol (13.6%), Δ -5-avenasterol (5.9%), cholesterol (1.35%), and clerosterol (0.6%). Total tocopherols were detected as an average concentration of 2000 mg/kg, including α -tocopherol (25%), γ -tocopherol (74.5%), and δ -tocopherol (0.5%). The global characteristics of Roselle seed oil suggest that it could have important industrial applications, adding to the traditional use of Roselle sepals in the elaboration of karkade drink.

Different physiological effect:

Effect on lipid metabolism: In a studied on hypertensive patients, the effect of Roselle on lipid profile, creatinine and serum electrolytes reported that the upward trend of total cholesterol and High Density Lipid (HDL) which is significant since HDL-Cholesterol is a protective factor for coronary heart diseases [41]. After consuming Roselle juice in different concentrations and durations, the changes of urine in normal patients which may help the treatment and prevention of renal stone disease, reported that a decrease of creatinine, uric acid, citrate, tartrate, sodium, calcium, phosphate and potassium however not oxalate in urinary excretion [42].

Antihypertensive effect: The consequence of hypertension is implicated in the development of cerebrovascular diseases, cardiac ischemia as well as cardiac and renal failure, and is now considered a global health problem. Faraji et al. [43], reported that the efficacy of aqueous extract in hypertensive human showed significant reduced pressure difference in both systolic and diastolic compared to control group. In another report found the decrease in systolic pressure significant, the diastolic pressure remained unchanged [33]. Studies were also conducted on rats and findings were supported the popular belief that Roselle extract contains antihypertensive constituents [44,45]. The anthocyanins extract investigated for its therapeutic efficacy, safety and tolerability along with antihypertensive drug captopril [46], lisinopril in humans found the results were comparable and suggested that the synergistic mechanism of diuretic and ACE inhibition results in exerting hypotensive effects [47,48].

Other uses of Roselle/Mesta: A strong fiber obtained from the stem (called rosella hemp) is used for various household purposes including making sackcloth, twine and cord. A yellow dye obtained from the petals of the flowers. The Roselle seed has 20% oil content.

Use as domestic animal's food for medicinal effect: A few studies were found in animals. In post weaning pig, Roselle extract as acidifiers has been found the ability to increase trypsin activity, improve feed conversion ratio (FCR) and fat digestibility [49]. The

effect of Roselle calyx in layer diets on egg production performance in the poultry, egg quality and Thiobarbituric Acid Reactive Substances (TBARS) value in plasma and yolk was studied to check the lipid peroxidation as a result of degradation of fats. Storage time of extract was found as an important factor to decrease egg quality and increase TBARS value in yolk. [50].

Roselle's Drink

Roselle drink is caffeine free herbal drink from a special type of hibiscus, called *H. sabdariffa*. Specifically, the drink is made out of the dried fruit part, called calyx. Its color is red and tastes like berries [51].

Steps in preparation of Calyx Drink:

- a. First, collect the fruits and wash those clean, and then dry in air or dry in an oven with 70°C for 3 days.
- b. Then peel off the calyx and store those in air-tight containers.
- c. To make drink, simply take 2 g of the dried calyx, and crash them into small pieces using a wooden roller.
- d. Then put those in a bag like tea bag or a net, bring out mug and then add 8 oz of boiling water and steep it for 2 to 4 min, if desired add sugar, or add other flavors of choice such as few drops of lemon juice.
- e. We can also refrigerate the dried calyx and make Roselle iced drink.

Future Approach

Among the properties reported to date, its effect on lipid metabolism, antihypertensive action and apoptosis are largely studied. Some studies on its antimicrobial effects were also documented. The calyx of Roselle is rich in citric acid and pectin and so is useful for making jams, jellies etc. It is also used to add a red color and to flavor to herb drinks, and could be roasted and used as a coffee substitute. It is found aromatic, astringent, cooling herb that much used in the Tropics. The leaves found antiscorbutic, emollient, diuretic, refrigerant, and sedative. The plant also reported to be antiseptic, aphrodisiac, astringent, cholagogue, demulcent, digestive, purgative and resolvent. It used as a folk remedy in the treatment of abscesses, bilious conditions, cancer, cough, debility, dyspepsia, dysuria, fever, hangover, heart ailments, hypertension, neurosis, scurvy, and strangury. Therefore, with many enriching chemical-biological knowledge from animal and human models using plant extracts, future studies with greater scientific robustness in terms of standardization of dose for its effectiveness, safety and tolerability will permit the formulation of safe, effective therapeutic herbal formulations which can be used as an acceptable source for curing many food and health issues and restoring general health.

Conclusion

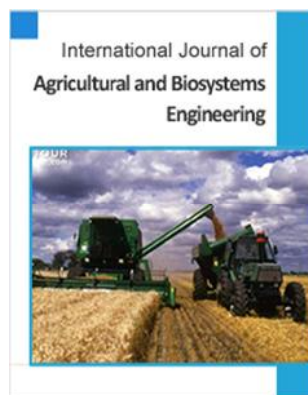
There are so many Roselle crops varieties developed, released and used at farmer's level for commercial cultivation. All those varieties leaves and calyces have both vegetable and medicinal values. The fleshy red calyces are the most popular. They are used fresh for making wine, juice, jam, jelly, syrup, gelatin, pudding, cakes, ice cream and flavors and also dried and brewed into tea, spice, and used for butter, pies, sauces, tarts, and other desserts. The roasted seeds can be used as a coffee substitute. The young root is edible, but very fibrous. Roselle is an aromatic, astringent, cooling herb that is much used in the Tropics. The leaves are antiscorbutic, emollient, diuretic, refrigerant, and sedative. The fruits are antiscorbutic. The flowers contain gossypetin,

anthocyanin, and the glycoside hibiscin. These may have diuretic and choleric effects, decreasing the viscosity of the blood, reducing blood pressure and stimulating intestinal peristalsis. The ripe calyces are diuretic and antiscorbutic. The plant is also reported to be antiseptic, aphrodisiac, astringent, cholagogue, demulcent, digestive, purgative and resolvent. It may reduce risk of cancer. Therefore Roselle leaves, fleshy red calyces, roots have great importance in terms of human nutrition and health care. In future, controlled studies are required to prove the effectiveness of different parts of Roselle under the various conditions.

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Industrial Research Advances of Jute in Bangladesh

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Abstract

The secondary information was collected from different sources of the Library of Bangladesh Jute Research Institute, Dhaka during the period from April to till December, 2015. The data sources were IJSG reports, BJRI reports, Bangladesh Journal of Jute and Fibre Research; Jute and Jute fabrics, Bangladesh, News letter of BJMA, BJMC and BJSa, DAE, FAO statistics, different books, direct communications with related office and persons. Total labour force in agriculture 32 million in 2011 of which 4 million farmers are engaged in jute cultivation. There are 219 jute mills in Bangladesh. Among them 86 are under BJSa, 106 are under BJMA of which 88 are running and 27 are under BJMC. There are approximately 1,65,501 workers employed in the jute mills of Bangladesh. The average production of BJSa mills, BJMA mills and BJMC mills are 422,000, 160,000 and 172,923 MT of jute products, respectively. The long staple fiber has high tensile strength and low extensibility. Its luster determines quality. It also has some heat and fire resistance. Jute is a biodegradable features. Jute includes good insulating and antistatic properties, as well as having low thermal conductivity and moderate moisture regain. 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. Jute can also be blended with wool. If proper research and development works in the different stages of manufacture of jute fibre/yarn/fabrics with special emphasis on the developments in the mechanical and chemical machinery sides are carried out, jute will get a good place in the textile world along with cotton, wool and such fibres.

1. Introduction

Jute is the main cash crop of Bangladesh, is a natural fiber popularly known as the golden fiber. It is known that jute occupied a world market for quite a long time because of its unique properties like high strength, rough handling, easily degradable, environment friendly advantages. It is one of the cheapest and the strongest of all natural fibers and considered as fiber of the future. Jute is second only to cotton in world's production of textile fibers. India, Bangladesh, China and Thailand are the leading producers of Jute. It is also produced in southwest Asia and Brazil. The jute fiber is also known as Pat, kosta, Nalita. Once it was only the single biggest foreign exchange earner of the country. Despite, the conventional uses of this commodity is being reduced and has been facing severe challenge from the products made of synthetics and allied fibres for the last few decades. So, non-conventional jute products are sought in the wider textile fields at present. Such attempts need improvement of the associated drawbacks of jute fibre / fabric in various directions. Amongst the fibres of commerce jute is next to cotton. It is a lignocellulosic multi- cellular fibre composed of cellulose, lignin,

hemi-cellulose, waxes, pectin, protein and mineral matters. Jute is physically coarse, harsh, irregular and short in length and diameter. On account of these characteristics jute is used mainly for making conventional products like carpet backing cloth (CBC), Hessian, sacking, twines and ropes. If proper attention is given in the field of research and development it could, however be used for many other uses in specific areas as well as sophisticated textile products like blanket, furnishing fabrics, wearing apparel, knitting yarns, jute-geo-textile, light weight shopping bags, sanitary napkins etc.

A brief of jute agriculture in Bangladesh

Total land area of Bangladesh is 13 million ha of which 8.44 million ha belongs to agricultural land. In 2010-11, 0.803 million ha land cultivated for jute. Jute cultivation area was 6% of total land area. Jute cultivation area was 10% of agricultural land area. Jute production was 26% as of all agricultural crops. Annual jute seed requirement was 5,000-5,500 MT. Seed average sowing rate 7-8 kg/ha for fibre. Jute seed supply was from i) Public: 2,187 MT and from ii) Import 3,617 MT in 2010-2011 (IJSG, 2012). Below the image 1 showed the jute growing areas of Bangladesh (Source: Islam, 2013). Production of raw jute was 1.5 million MT by volume in 2010-11 and USD261 million by value in 2009-10. Share of raw jute production in agriculture was 1.401% by value in 2010. Average yield of fibre was 1.9 ton/ha in 2009-10 (Figure 2 &

3). Total labour force in agriculture 32 million in 2011 of which 4 million farmers are engaged in jute cultivation. Total labor force was 75.42 million. Share of labour force in jute agriculture was 12.5%. Male: Female ratio of labour force in jute agriculture was 3:1 (IJSG, 2012). Bangladesh, the drainage basin of big rivers being bestowed with alluvial soil and availability of non-stagnant water for jute retting has a distinct agro-ecological comparative advantage in production of jute. With the increasing environmental awareness, eco-friendly and bio-degradable products are gaining popularity both in developed and developing countries for retardation of ecological balances and degradation due to green house effects. Jute and jute products not only retard ecological degradation but conserve environment and atmosphere as a whole. All these propelling factors have created a new scope of reinventing jute and jute products leading towards their effective exploitation. At present many technologies and process are available for commercialization of jute diversified products (JDPs). To capitalize this competitive edge, it is essential to achieve general improvements starting from increasing the yield and improving quality. Adoption of newly developed and improved technologies and processes for production of high value jute diversified products and alternative use of jute (Annon, 2009).

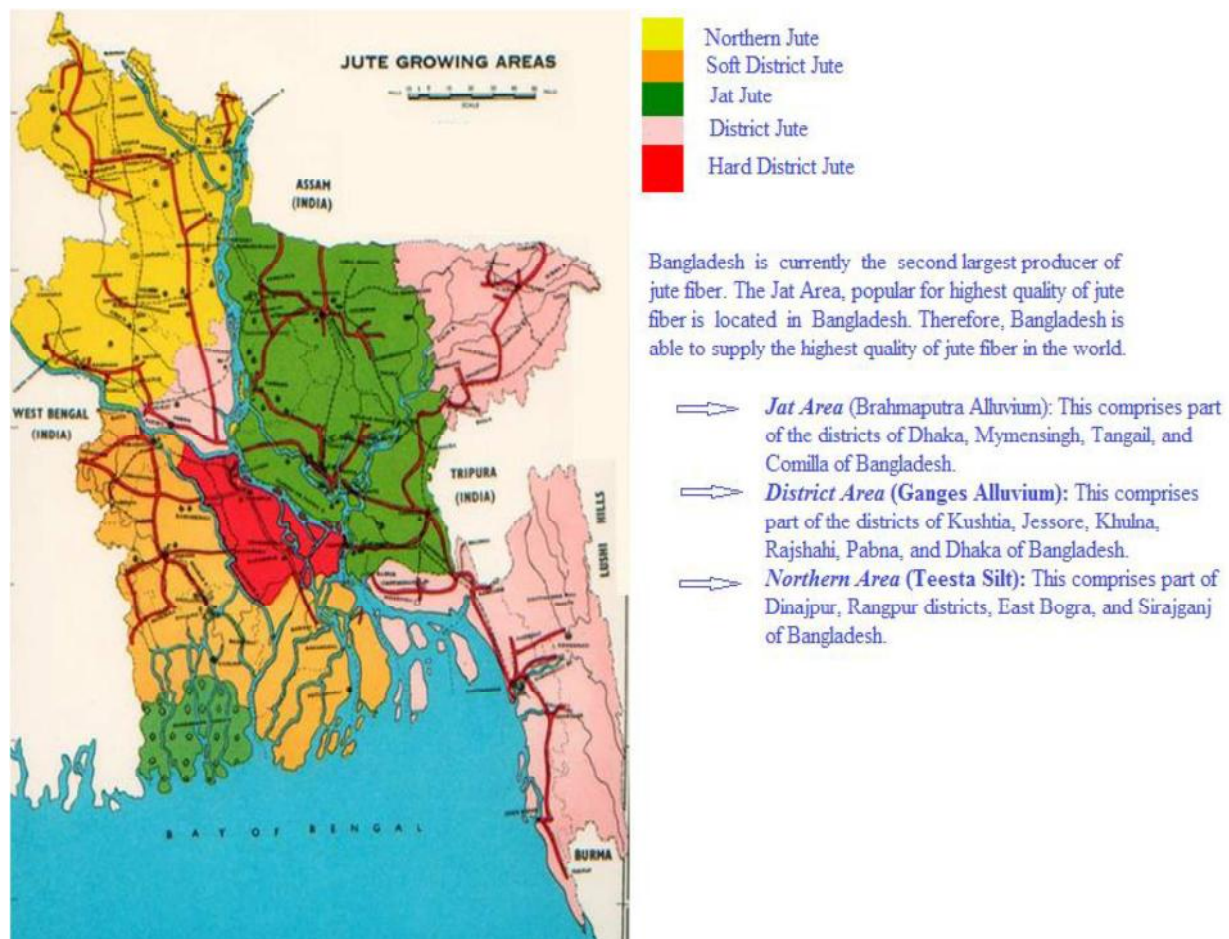


Figure 1. Jute growing areas of Bangladesh (Source: Islam, 2013).

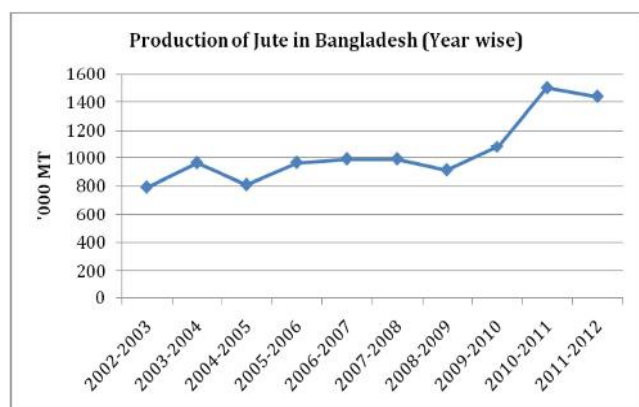


Figure 2. Production of jute fibre in Bangladesh from 2002-03 to 2011-12.

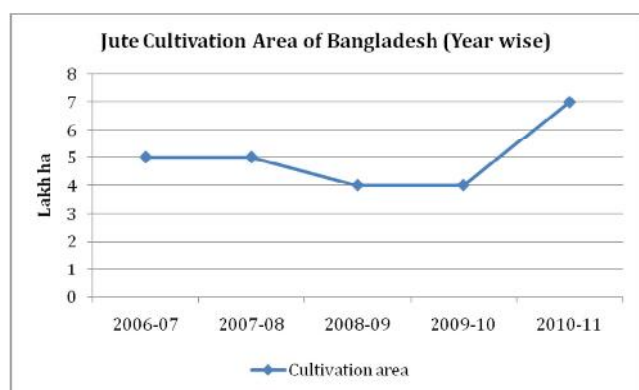


Figure 3. Jute cultivation areas of Bangladesh from 2006-07 to 2010-11.

There are 219 jute mills in Bangladesh. Among them 86 are under Bangladesh Jute Spinners Association (BJSa), 106 are under Bangladesh Jute Mills Association (BJMA) of which 88 are running and 27 are under Bangladesh Jute Mills Corporation (BJMC). While in India there are 83 mills most of which are composite mills. There are 1,65,501 (approximately) workers employed in the jute mills of Bangladesh. The average production of BJSa mills, BJMA mills and BJMC mills are 422,000, 160,000 and 172,923 MT of jute products, respectively. Among these the BJSa mills export 3,42,195 MT of yarns/twines while BJMA and BJMC export 48,000 MT and 21,000 MT of hessian and sackings mainly to Middle East countries, Europe, USA, etc. Yarn sector in Bangladesh has flourished tremendously over the last decade compared to the composite mills. The closed mills of various countries (Algeria, Italy, France, Belgium, UK, Bulgaria, Brazil, Thailand, etc.) have been relocated in Bangladesh which started production of jute yarns of various counts to meet the requirement of foreign consumers. In 2011 Bangladesh exported about 3,93,000 MT of jute yarn to various countries, Turkey being the lead importer with 37% of the total yarn export. Composite mills, however, could not fare so well because of shrinkage of export market for hessian, carpet backing cloth, etc.

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 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 favorable for successful cultivation. Jute requires 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. This paper reviews jute (*Corchorus* spp.) industrial research and product diversification advances in Bangladesh and other most related important affairs.

2. Materials and Methods

The study was based on secondary data. The secondary information used was collected from different sources of the Library of Bangladesh Jute Research Institute, Dhaka during the period from April to till September, 2015. The data sources were International Jute Study Group (IJSG) reports, IJSG website, BJRI reports, Bangladesh Journal of Jute and Fibre Research; Jute and Jute fabrics, Bangladesh, News letter of Bangladesh Jute Mills Association (BJMA), Bangladesh Jute Mills Corporation (BJMC) and Bangladesh Jute Spinners Association (BJSa). Department of Agricultural Extension, Food and Agriculture Organization statistics, different books, direct communications with related office and persons, accessing internet and using different national and international journals.

3. Results and Discussions

Important 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).

- g. 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).
- h. 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 flame proofing agents (Basu *et al.*, 2005, Pan *et al.*, 2000).
- i. 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.
- j. 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.
- k. 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).

Jute being natural is biodegradable

- a. It does not plug the natural pore of the earth soil and surface.

- b. It has no adverse effect on human body and the Mother Nature as a whole. Protecting environment is one of the major activities it does for all our tomorrows.
- c. When burned, it emits the same fume as a burning wood as we know, is nothing dangerous.
- d. The ignition temperature of jute is 193°C. It thus remains very stable up to near ignition point. Even at boiling temperature, its intact physical properties guard it from undergoing possible distortion.

Industrial Research Advances

a) Properties of Jute

Jute is one of the strongest natural fibers. The long staple fiber has high tensile strength and low extensibility. Its luster determines quality; the more it shines, the better the quality. It also has some heat and fire resistance. Jute is a biodegradable features. Jute includes good insulating and antistatic properties, as well as having low thermal conductivity and a moderate moisture regain. It include acoustic insulating properties and manufacture with no skin irritations. 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. 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 flame proofing agents (Annon, 1962; Pan *et al.*, 2000).

Table 1. Average Values of the Main Properties of jute Fibre.

Properties	Amount
Ultimate:	
Length	2.5mm
Diameter	18μ
Single Fibre:	
Diameter	40μ
Tensile Strength	105kg/mm ²
Extension at Break	2.6%
Helix angle	8°
Moisture Regain (65%R.H.):	
Absorption	12.8%
Desorption	14.6%
Specific Gravity	1.48
Refractive Index	1.536
Birefringence	+0.041

(Source: Annon, 1962; Pan *et al.*, 2000)

a1) Physical Properties of Jute fibres

The major physical properties of jute fibre briefly presented in the following table.

Table 2. Physical Properties of jute fibre.

Macro & Micro Structure		
Ultimate Cell Length (L)	Average	2.50mm
	Range	0.8-6.0mm
Ultimate Cell Breadth (B)	Average	18µm
	Range	10-25µm
L/B Ratio	Average	110
Fibre Fineness		1.3-4.0tex
Fibre Length (after Carding)		2-50cm
Density	True	1.46g/cc
	Apparent	1.10-1.34g/cc
Bulk Density		0.4-0.5g/cc
Degree of Crystallinity (X-ray)		55- 60%
Moisture Regain	Moisture Absorption	
	At 65% RH	13.8%
	-at 100% RH	36.0%
Transverse Swelling in water	Diameter-wise	20%
	Cross-sectional area-wise	45%
Water holding Capacity		500%
Thermal Properties		
Specific Heat		1.36x10 ³ Jkg ⁻¹ K ⁻¹
Thermal Conductivity		427.3mWm ⁻¹ K ⁻¹
Heat of Combustion		17.5J/g
Ignition Temperature		193°C
Heat of Wetting		18.2calories

(Source: Pan *et al.*, 2000; IJSG)

a2) Chemical Properties of Jute Fibre and Stick

The chemical composition of jute fibres and sticks are given in the following tables

Table 3. Chemical composition of jute fibre.

Constituents (in % of Bone Dry Weight of the Fibre)	Jute	
	<i>C. capsularis</i> L.	<i>C. olitorius</i> L.
Alphacellulose	60.0–63.0	58.0-59.0
Hemicellulose	21.0–24.0	22.0–25.0
Lignin	12.0–13.0	13.0–14.0
Fats &Waxes	0.4–1.0	0.4–0.9
Pectin	0.2–1.5	0.2–0.5
Proteins / Nitrogenous matter, etc.	0.80–1.9	0.8–1.6
Ash	0.7–1.2	0.5–1.2

(Source: Surand Amin, 2010; Pan *et al.*, 2000)

Table 4. Chemical composition of jute sticks.

Constituents	Jute Stick (in % of Bone Dry Weight of the Fibre)
Alphacellulose	40.8-47.5
Hemicellulose	23.0-23.6
AcetylContent	3.6-4.7
Lignin	22.2-23.5
Fats &Waxes	1.7-2.4
Pectin	0.5-0.7
Ash	0.6-0.8

(Source: Surand Amin, 2010; Pan *et al.*, 2000)

Chemical composition of fibres of different pipeline varieties of jute (*C. capsularis* and *C. olitorius*) has been studied for the selected promising varieties (C-718, C-2005, C-2193, C-2035 and OM-1). The varieties moisture content (%), cellulose content (%), hemicellulose content (%), lignin content (%), ash content (%) and fat content (%) were

studied in three different parts of the plant -top, middle and bottom. Moisture content was found the highest (12.68%) 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. The hemicellulose was found the 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 5. Klason lignin, Kappa Number and Kappa lignin of different jute samples.

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

(Source: Hussain *et al.*, 2002)

Choudhury (2010) reported that natural technical textile in the name of Jute Agrotextile (JAT) is highly effective in agri-horticulture and forestry for higher agricultural yield. Extensive R&D work and field study have been conducted by IJIRA with the support of IJMA & JMDC in collaboration with reputed organizations in this field with encouraging results. Efficacy of the products have been established and documented. Application areas of JAT covered under the study are conservation of surface soil, weed management, afforestation in semiarid zone, growth of sapling in nurseries, air layering, plant wrapping etc. This paper discusses the effect of application of Jute Agrotextile for higher agricultural output. Faster and better growth of seedlings due to better aeration of roots of seedlings, evening out of temperature extremes, non-formation of ice within the sleeves and spread of roots through fine openings of the jute sleeves. High survival rate (90%). No extraction at the post-plantation stage was necessary, Unlike in the case of poly sleeves. Jute sleeves are evidently superior to poly sleeves in performance, installation and after care. The cost of jute sleeves is, of course, higher than poly sleeves.

Jute Agrotextile is a kind of natural technical textile, usually either in woven or non-woven form, made from 100% natural eco-friendly bast fibre of jute plant used on soil to achieve higher agricultural productivity by improving agronomical characteristics of soil and by reducing growth of unwanted vegetation. Constituents of jute fibre are alpha and hemi cellulose-85%, lignin-11.5%, ash-1.6%, nitrogenous compound-1% and others- 0.9%. Jute Agrotextile provides the natural answer to ensure faster crop-and-plant growth. JAT helps retain soil humidity at conducive levels, arrests desiccation of soil and attenuates extremes of temperature due to the inherent characteristics jute. It absorbs water / moisture up to about 5 times of its dry weight. On biodegradation, jute coalesces with soil, increasing its permeability and supplementing its nutrient level. JAT fosters growth of vegetation even in arid and semi-arid zones much faster than under control conditions without use of manures. On top of it, the non-woven variety of JAT can suppress weed-growth effectively without use of chemical herbicides. JAT provides all these advantages without affecting eco-ambience adversely at affordable and competitive cost.

Development and Modernization of Processing Machinery

As recognized by most studies, modernization would include development and adoption of new generation machinery as jute needs to be processed at a technological level equivalent to that used by other fibres for its survival against the competition from competing alternative fibres. New machinery need to be designed to process greater volumes, process faster with higher standards, consume less power and be cheaper and easy to maintain. Electronic retrofits need to be introduced in these machines for effective quality control and continuous monitoring.

A number of jute mill machinery manufacturers like Lagan

Engineering Company Ltd, Milltex Engineering (P) Ltd, GSL, India and Zhejiang Golden Eagle Co., Ltd, China manufacture and supply jute processing machinery to the jute industry of Bangladesh and India.

Modern machinery which can be adapted to work successfully with jute are high output spreaders, new design high output Breaker and Finisher cards, high speed & high output drawing frames, ring twistors, shuttle less looms, precision winders, etc. Installation of shuttle less looms like Sulzer, STB, Dornier, ATPR, etc would improve the productivity and quality as well. Ring spinning may be adopted to produce fine yarns which will be subsequently used in making light weight fabrics to be used for making various products like shopping bags, decorative, household items, handicrafts, etc. Establishment of an automatic jute bag sewing unit would increase the productivity to a great extent (IJSG, 2012).

Wet processing of jute and jute materials

Jute fibre is neither a staple fibre like cotton nor a true filament fibre like silk or viscose filament, but a composite fibre of alpha-cellulose molecules and cementing materials being lignin and hemicelluloses. This gives rise to complications in wet processing of jute. Jute fibre and its products for sophisticated textile uses have to undergo some chemical processing in wet stage. On gradual removal of these constituents of jute there is slight loss of strength and a stage comes when the constituents are disintegrated with complete loss of fibre quality. So, in the chemical processing of jute fibre materials, this aspects is to be taken care of. The wet processing of fibre and its products are of recent origin, as the conventional jute products do not need chemical processing in the wet stage. Some methods have been developed in the chemical process for jute materials which are given below-

Woolenisation and slack mercerization

Weelenisation or slack mercerization of jute fibre and products is an important wet process. At different stages from fibre to fabric when the material is treated with caustic soda at certain concentration and lower temperature some interesting changes are observed. The fibre becomes more circular with increased fineness i.e. it becomes lustrous, crimp with reduction in length, when the crimp is fully produced the resultant fibre is termed as modified jute or woolenised jute, as it appears like wool, the process is known as woolenisation.

The percentage composition of the fibre also changes with the materials loss (10-20%), the loss are mainly due to the removal of hemicelluloses. There is loss of strength but with increase in extensibility. The crimp property, reduction in diameter and length, loss of weight and strength are all dependent on concentration of alkali, time and temperature of the treatment.

A process of hot woolenisation of jute fabrics with less loss of strength, more softness and greater economic value has been developed. Desizing and scouring processes are not required to be done in the case of hot woolenisation of jute fabrics

Scouring: Before prior to bleaching and dyeing jute materials some pretreatments are necessary. Raw Jute contains impurities consisting mainly of natural waxes, peptic substance which are insoluble in water but can be removed by treatment with hot alkalis. The impurities prevent the easy wetting out of jute in the dye bath and consequently prevent easy penetration of the dye solution in the fibre.

Secondly, the warp threads of jute fabrics often contain sizing materials (starch) in addition to natural impurities for facilitating weaving the fabrics. If it is not removed, it makes very difficult to obtain solid well penetrated even dyeing. It is therefore, necessary to remove them by impregnating with some desizing agents followed by scouring with soda ash, caustic soda and wetting agent at 90-100°C for 1 hour. The natural coloring matters must be removed by bleaching before dyeing.

Bleaching: This is another chemical process for whitening and preparation of jute materials prior to dyeing. Oxidizing bleaching agents like hypochlorite, chlorite and hydrogen peroxide are employed here. Jute materials are generally bleached in one stage and mostly in two stages. BJRI has developed economic standard bleaching methods for jute materials. It has been observed that instead of bleaching the jute materials in one stage with higher concentration of a bleaching agent if it is done in two stages with lower concentration of two active components better whiteness and uniform products are obtained with less loss of strength. In this type of combination bleaching in two stages it is better to use hypochlorite in the first stage and hydrogen peroxide in the second stage. The total loss in weight and strength in the above process of woollenisation and bleaching are 15-18% and 30-40% respectively. These losses of weight and strength do not have any adverse effect for production of end uses of jute products.

Dyeing: Some standard and economic dyeing methods have been developed for jute materials in order to obtain satisfactory washing light and rubbing fastness.

Dyeing is done by using selected dyes suitable for jute. Direct, Reactive, Sulfur, Vat and Basic dyestuffs are used for dyeing jute. Methods/recipes are now available for dyeing of jute with these dyestuffs. Selections of dyes are dependent on the end uses of the products.

Jute fabrics and jute cotton union fabrics are generally dyed in jig-ger machine and yarns in open vat or in hank dyeing machine.

Printing: Printing is essential and popular for jute fabrics. It has got positive impacts on diversified jute products. Screen printing methods for furnishing fabrics have been developed with Reactive and Pigment dyestuffs. Methods are ready to transfer the technology to the concerned industries for commercial production.

Finishing: Jute and Jute materials are generally harsh and hard in feel. After dyeing/printing jute and jute materials are treated with some silicon based non-ionic softener, such as Siligen, Basosoft EUK (BASF) to make them soft. Some

cross-linking agents like Fixapret CPN, Fixapret Ecos, Kaurit-W etc. melamineformaldehyde type of resin finishing agents are also used for impurities of jute fabrics. Besides these fibre retardant, rot proofing, water repellent finishing treatment etc. have been developed for jute for diversified uses of jute products.

Improvement of low quality jute

Low quality jute like SMR and jute cuttings may be improved by enhancing the growth of micro organism in the fibre or by the application of microbial enzymes. The technology provides opportunity for improving and using low grade jute for manufacturing different products while reducing the cost of raw materials.

Jute Furnishing

Jute is a plant fiber that is used to create a vast assortment of household furnishing items such as carpets, chair coverings, curtain, cloths, sacks, and more. There are two types of jute fiber namely White Jute and Tossa Jute. White Jute has a little coarse texture whereas Tossa Jute is much softer, silkier, and lustrous. To manufacture Jute Furnishing Items, mostly Tossa Jute is used with classic textile traditions. Jute fibers are then dyed in almost any color to get the desired color-combination such as vibrant red, gold, gray, and more. Jute furnishings are trendy and thus a perfect accessory to decorate a lifeless interior by adding some products made from natural fiber.

Jute Furnishing gives a homey and cozy look to the interiors with the impressive texture, lively appeal, and unique color-combination. As the jute fiber is incredibly tough and fibrous, the products made from it, is durable. Yet, jute is capable of looking delicate and being soft which make it completely unique. So now, attractive range of Jute Furnishing Items can be made in a completely delicate form such as flowers, flower pots, leaves, soft table mats, and more. Jute fiber can be easily dyed as well in any color; as a result, customer can conveniently get a product in a color of their choice.

Availability of a variety of designs, shapes, sizes, and colors make Jute Furnishing Items appealing for all and one. These are ideal to give a natural look to the house and augment the touch of culture and ethnic appeal. Moreover, jute products are lively, bio-degradable, and Eco-friendly that also keep the interiors healthy and prevent the usage of harmful plastics. Besides, Jute Furnishing Items are much cheaper and are available at competitive rates in almost anywhere in India.

4. Conclusion

In conclusion it may be pointed out that any fibre can make better place in the tomorrow's world fibre market if it is backed by proper research and development works. It is equally applicable to jute also. If proper research and development works in the different stages of manufacture of jute fibre/yarn/fabrics with special emphasis on the developments in the mechanical and chemical machinery sides are carried out, jute will get a good place in the

textile world along with cotton, wool, and such fibres. We shall have to open the future possibility through coordinated efforts for a new vision for jute in this direction.

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Biography

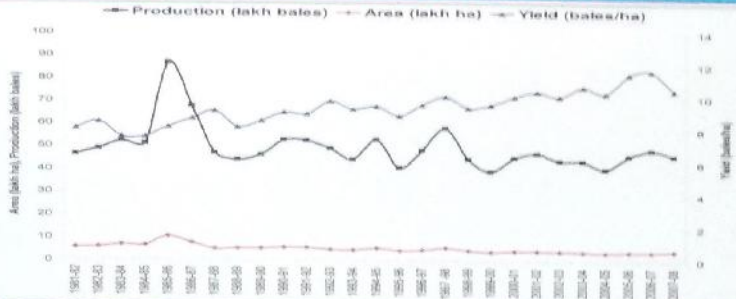


Md. Mahbubul Islam (Corresponding Author) awarded PhD in 2008 from the Department of Agronomy of Bangladesh Agricultural University especially on Jute seed quality, plant establishment and yield. He had done his M.Sc. (Agriculture) in Agronomy and B.Sc. Agriculture (Hons.) from the same University. He is working at Bangladesh Jute Research Institute (BJRI) since 1989. At present he is serving as Chief Scientific Officer & Head of Agronomy Division. He has 6 books, 67 scientific papers and more than 70 popular articles published in international and national journals, newsletters etc. He visited United Kingdom, Malaysia, India for training, seminar, workshop purpose.

JUTE PRODUCTION, AREA AND YIELD SITUATION OF BANGLADESH

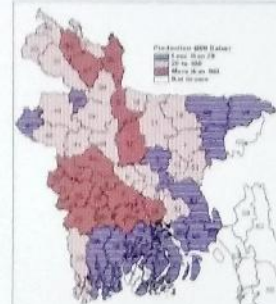
Jute Production Situation

Trends in area, production and yield of jute: 1981/82-2007/08



In 2007/08, jute production (46.22 lakh bales) was 0.5% lower than that of 1981/82 (46.46 lakh bales). Jute area has decreased from 5.72 lac hectare to 4.40 lakh hectare (23.1% decrease). Jute yield increased from 8.1 lakh bales per hectare to 10.5 lakh bales per hectare (29.6% increase).

Jute Production: 2007/08



Four categories of districts:
Not grown: 7 districts

Low (up to 20 thousand bales): 18 districts (Bagerhat, Barisal, Bhola, Bogra, Comilla, Feni, Gazipur, Gaibanda, Jalakathi, Joypurhat, Khulna, Lakshmipur, Narayanganj, Nawabgonj, Noakhali, Patuakhali, Pirojpur, Sunamgonj and Sylhet)

Medium (20 to 100 thousand bales): 21 districts (Bogra, Brahmanbaria, Chandpur, Dhaka, Dinajpur, Gaibanda, Kishoregonj, Lalmonirhat, Manikgonj, Munsigonj, Mymensingh, Narsingdi, Natore, Netrokona, Noagaon, Panchagar, Rajshahi, Sathkhira, Sherpur, Sirajgonj and Thakurgaon)

High (more than 100 thousand bales): 18 districts (Chuadanga, Faridpur, Gopalganj, Jamalpur, Jessore, Jhenaidah, Kurigram, Kustia, Madaripur, Magura, Meherpur, Narail, Nilphamari, Pabna, Rajbari, Rangpur, Shariatpur and Tangail)

Jute Area: 2007/08



Five categories of districts (jute area basis):

Not grown: 7 districts

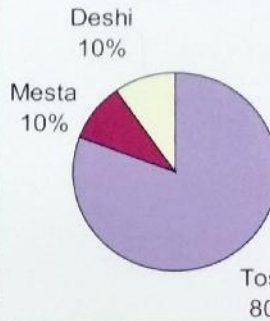
Low (<5 thousand ha): 30 districts (Bagerhat, Barisal, Bhola, Bogra, Brahmanbaria, Chandpur, Comilla, Dhaka, Feni, Gazipur, Hobigonj, Jalakathi, Joypurhat, Khulna, Lakshmipur, Manikgonj, Narayanganj, Narsingdi, Natore, Nawabgonj, Netrokona, Noagaon, Noakhali, Patuakhali, Pirojpur, Rajshahi, Sherpur, Sunamgonj, Sylhet and Thakurgaon)

Medium (5-15 thousand ha): 17 districts (Chuadanga, Dinajpur, Gaibanda, Gopalganj, Jamalpur, Jhenaidah, Kishoregonj, Lalmonirhat, Meherpur, Munsigonj, Mymensingh, Narail, Nilphamari, Panchagar, Rangpur, Sathkhira and Sirajgonj)

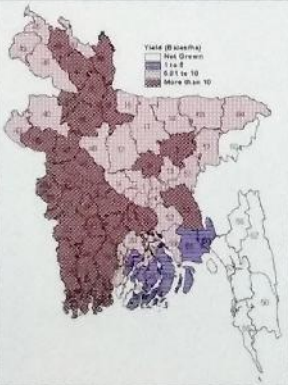
High (15-20 thousand ha): 7 districts (Jessore, Kurigram, Kustia, Magura, Pabna, Shariatpur and Tangail)

Very High (>20 thousand ha): 3 districts (Faridpur, Madaripur and Rajbari)

- Among the sample farmers, Jute covered about 90% of the area under fiber crops and Mesta covered about 10% area
- Share of Deshi jute was about 10% of total area under fiber crops while Tossa jute was cultivated in 80% of total area under fiber crops



Jute Yield: 2007/08



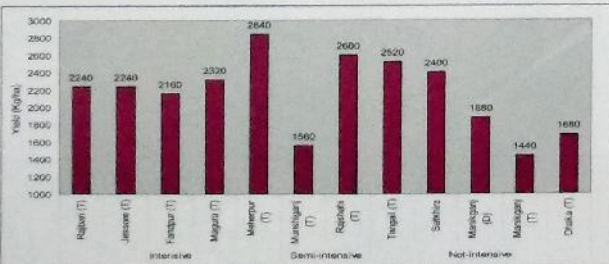
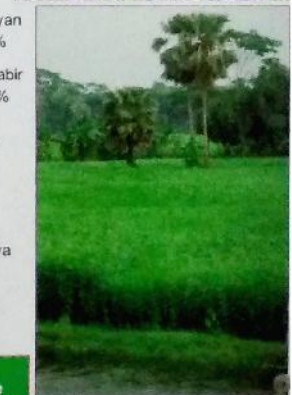
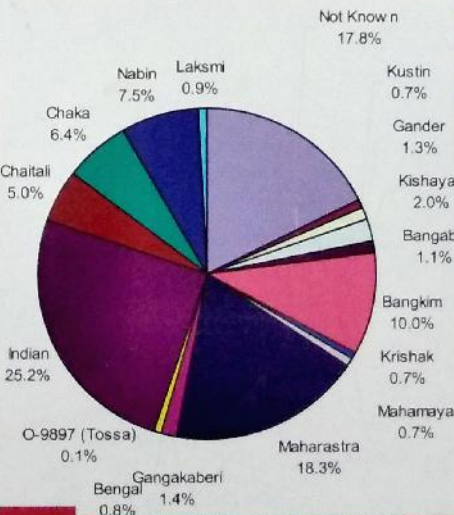
Four categories of districts:
Not grown: 7 districts

Low (1 to 5 bales/ha): 5 districts (Bagerhat, Barisal, Bhola, Comilla, Feni, Gazipur, (Bhola, Feni, Jalakathi, Noakhali and Patuakhali)

Medium (5.01-10.0 bales/ha): 24 districts (Barisal, Brahmanbaria, Chandpur, Dhaka, Dinajpur, Hobigonj, Lakshmipur, Lalmonirhat, Manikgonj, Munsigonj, Mymensingh, Narayanganj, Narsingdi, Nawabgonj, Netrokona, Noagaon, Panchagar, Pirojpur, Sherpur, Sirajgonj, Sunamgonj, Sylhet, Tangail and Thakurgaon)

High (10.01 to 15.0 bales/ha): 28 districts (Bagerhat, Bogra, Chuadanga, Comilla, Faridpur, Gaibanda, Gazipur, Gopalganj, Jamalpur, Jessore, Jhenaidah, Joypurhat, Khulna, Kishoregonj, Kurigram, Kustia, Madaripur, Magura, Meherpur, Narail, Natore, Nilphamari, Pabna, Rajbari, Rajshahi, Rangpur, Sathkhira, Shariatpur)

- Farmers did not know the name of variety grown in case of 18% of area under Tossa jute
- In case of about 25% of tossa area farmers only knew that the variety was Indian but they did not know the name
- 64% of the area under Tossa jute was under Indian varieties
- Among the known varieties, highest share was for Maharashtra (18.3%) followed by Bangkim (10.0%), Nabin (7.5%), Chaka (6.4%), Chaitali (5.0%), Kishayan (2.0%), Gangakaberi (1.4%), Gander (1.3%), Bangabir (1.1%), Laksmi (0.9%), Bengal (0.8%), Kustin (0.7%), Mahamaya (0.7%), Krishak (0.7%) and O-9897 (Tossa) (0.1%)



Highest jute yield (2.84 t/ha) was in Meherpur and lowest jute yield (1.44t/ha) was in Rangpur

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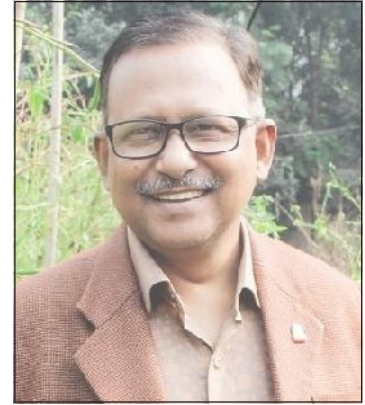


Agronomy Division
Bangladesh Jute Research Institute



Jute seed production through stem cutting method

About Dr. Md. Mahbubul Islam



Md. Mahbubul Islam awarded PhD in 2008 from the Department of Agronomy of Bangladesh Agricultural University especially on Jute seed quality, plant establishment and yield. He had done his M.Sc. (Agriculture) in Agronomy and B.Sc. Agriculture (Hons.) from the same university.

He is working at Bangladesh Jute Research Institute (BJRI) since 1989. At present he is holding the position of Director (Planning, Training & Communication) of BJRI with the responsibilities of institutional all sorts of Planning, Training and Communication affairs from 24 December 2019. Before this position he hold the chair of Chief Scientific Officer & Head of Planning, Training & Communication Division from June 13, 2019 to December 23, 2019 and Chief Scientific Officer & Head of Agronomy Division with the responsibilities of research, training and administration of three core departments (Crop Management Department, Physiology Department and Soil Science Department) of the Division from December 01, 2011 to June 12, 2019. Before that he also holds the Director (Administration & Finance) position of BJRI from June 2009 to November 2011 with institutional administrative and financial management responsibilities.

Above 30 years of working experiences, he developed and implemented a good number of research projects/works/experiments on jute and allied crop's fibre and seed technological affairs like production, post-harvest processing and quality control/maintenance, storage etc.

Dr. Islam received in-country training on Agriculture Research Project Proposal Preparation, Sponsored Public Goods Research Project Proposal Preparation, Project Development and Management, Monitoring & Evaluation of Research Programs/Projects, Research Planning and Evaluation, Farming System Research Methodology, Role of Anthropology in Agricultural Research, Cost and Return Analysis in Agriculture, Computer Simulation for Crop Growth and Resource Management, Applied Statistics, Jute Quality & Grading, Administrative and Financial Management, Development Communication, Computer Training on Package of MS Office, SPSS and Email, Data Management, Windows⁹⁵, MS-Word, MS-Excel and PC Trouble shooting, English Language for Communication and Study Skills Development etc. He also attended a foreign training on "Seed Research Methodology" at Edinburgh University, Scotland, UK.

Dr. Islam Syndicate Member of Khulna Agricultural University, Khulna and Academic Council Member of Sher-e-bangla Agricultural University; and He also Registered Graduate and an Alumni of Sher-E-Bangla Agricultural University. He associated with Professionals Institutions like Krishibid Institution, Bangladesh; Agronomy Society of Bangladesh; Seed Science Society of Bangladesh; Bangladesh Society of Seed Science & Technology; Weed Science Society of Bangladesh as Life Member.

He is acting as Research Supervisor for MS/PhD student of Sher-e-bangla Agricultural University, Dhaka, and Islamic University, Kushtia, Bangladesh. Editor and Editorial Board Member of Journal of Experimental Bioscience, Bangladesh Journal of Agronomy, Bangladesh journal of Weed Science, Bangladesh and Journal of Subtropical Agricultural Research and Development, g-Science Implementation & Publication, Bangladesh Journal of Jute and Fibre Research and Jute & Jute Fabrics, Bangladesh (News letter) of BJRI.

He has 8 books (in English and Bangali) on different issues of jute and allied crops published in home and abroad. Moreover he has 82 scientific articles and more than 70 other publications like popular articles, proceedings, project reports, abstracts and posters published in different international and national print media like journals, newsletters, magazines etc. His books “About Jute seed Research, Handbook on agricultural technologies of Jute, Kenaf and Mesta crops, Jute Seed Technology, and Pat (Jute)” etc. are frequently referring for basic information of different proposal preparation. His Book “Seed Quality, Plant Establishment and Yield of Jute” Published in General Natural Sciences, LAP LAMBERT Academic Publishing (2017-10-16) - ISBN-13: 978-620-2-06015-8. He also has Book Chapters i) “*Corchorus Species: The Jute: An Over-Utilized Crop*” (Chapter). Published in Crop Production Technologies for Sustainable Use and Conservation Physiological and Molecular Advances (Book), 6. Apple Academic Press. Canadian office: 3333 Mistwell Crescent Oakville, Ontario L6L 0A2 Canada; and US office: 1265 Goldenrod Circle NE Palm Bay, FL 32905 USA, and ii) *Advanced Production Technology and Processing of Jute* (Chapter), Published in Agronomic Crops, Volume 1: Production Technologies, Mirza Hasanuzzaman, Editor, (ISBN 978-981-32-9150-8 ISBN 978-981-32-9151-5 (eBook), © Springer Nature Singapore Pte Ltd. 2019. <https://doi.org/10.1007/978-981-32-9151-5>),

Dr. Islam took part in a series of workshops related to agricultural research where he got opportunity to know about the opportunities of Bangladesh in International research and development from the International experts. He took part in some important workshops like “International Conference on Kenaf and Allied Fibres 2009” (ICKAF2009), Viable Bio-fibres for future, Organized by Institute of Tropical Forestry and Forest Products (INTROP), Universiti Putra Malaysia, held at The Legend Hotel, Kuala Lumpur, Malaysia in 1-3 December 2009; “International Conference on Crop Production under Changing Climate in Bangladesh: Agronomic Options”, Held on 6-7 October 2010 and 12th Conference on “Agronomic Research for Enhancing Sustainable Crop Production” Held on 20 September, 2013 at Bangladesh Agricultural Research Council, Dhaka, Organized by Bangladesh Society of Agronomy and “International Seminar on Strengthening of collaboration for jute, Kenaf and Allied Fibres research and development”, Held in 8-9 June 2011, Organized by International Jute Study Group (IJSJG). Dhaka. Bangladesh and “International Conference on Natural Fibres” held on August 1-3, 2014. Organized by The Indian Natural Fibre Society, C/o National Institute of Research on Jute & Allied Fibre Technology, Kolkata, India.

Dr. Islam visited United Kingdom (Scotland [Edinburgh], England [London, Birmingham, Kent]), Malaysia and India for attending training, international conference purpose.

Dr. Islam is son of Md. Abul Fazal Sarker (Late) and Motia Begum (Late). He comes from a noble Muslim family of Sirajgonj District of Bangladesh. His wife Nighat Sultana a Government Officer serving as Deputy General Manager (DGM) of Bangladesh Sugar and Food Industries Corporation (BSFIC), Dhaka. He has two sons, Md. Alvee Islam Navid presently enrolled for PhD programme on CSE in Japan and Tahmid Yeazdan Nabil reading in Class X in Dhaka, Bangladesh.

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- Industrial research advances of jute

Dr. M. Mahbubul Islam



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