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<u>**Review / Overview Paper**</u>

A CRITICAL STUDY ON TEST STANDARDS FOR EVALUATION OF JUTE GEOTEXTILES

S.K. Ghosh[1], T.Sanyal[2], M.M.Mondal[3] & R.Bhattacharyya[4]

ABSTRACT

Application of Geosynthetic material for road construction has become an established phenomenon worldwide where jute Geotextile material can play a significant role for the purpose of reinforcement providing dimensional stability as well as cushioning effect to the road surface thereby improving the life cycle of the road. With the increasing use of Jute Geotextile worldwide in combating geotechnical problems without hampering environment sustainability, and the confidence with which they are being used is also developing amongst engineers, manufacturers and end users is opening new avenues for potential Jute Geotextile. Hence, there is a dire need for quality control in terms of testing and evaluation of Jute Geotextile .demanding formulation of new standards for testing. The existing test standards for synthetic Geotextiles for evaluating different end use property parameters are not uniform globally i.e., these test standards vary from country to country. However, in the field of standardization for testing of different properties of Jute Geotextiles there is a paucity of data for formulation of specification and quality control guidelines. Test standards for synthetic Geotextiles understandably do not exactly apply to JGT. While study is on to develop exclusive test and design standard for JGT, There is need to adopt any of the existing standards for synthetic Geotextiles that cater to the majority of requirements in the interim period. The paper suggests adoption of ASTM standards for testing JGT because of the wide range of test standards available and their credibility.

Key words: Jute Geotextile, ASTM standards, Geotechnical Engineering, European Standards, CEN

1.0 INTRODUCTION

The potential of Jute Geotexitile (JGT) is complemented by the demand for these products in environmental protection and management, the Expert Committee on Textile Policy, constituted by Ministry of Textiles, Government of India, has in its report on August 1999 the potential of technical textiles in the country and has made strong recommendation for promoting its growth to enable India, Bangladesh, Nepal and all the others neighbouring jute growing countries to create a place as an entity in the International Technical Textile scenario. But for any application and supervision quality control tests are an essential part. Again, proper testing of technical textiles meant for geotechnical uses is critical to ensure their effective performance. The standards evolved for this purpose relate to synthetic

[1] Associate Prof.,DJFT, Institute of Jute Technology, C.U.,
[2] Chief Consultant, Nation Jute Board,
[3&4] Senior Research Fellow, DJFT, Institute of jute, Technology,C.U

Geotextiles only and are not uniform [1,2]. The design is based on rigorous empirical exercise carried out individually in each country. The site conditions are apt to vary and so also the approach to design. While some sort of uniformity in testing method could be achieved in case of synthetic Geotextiles after 'synthesizing` the standards available, no such standard have drawn up so far for Geotextiles made of different natural fibres such as Jute Geotextiles (JGT) [3]. In absence of testing standards for JGT, standards for Synthetic Geotextiles are presently adopted for Geotextiles made of natural fibres. In view of the growing demand of JGT in particular, it is felt necessary to evolve exclusive application-wise standards for JGT.

The selection of JGT for a particular application in geotechnical engineering areas necessarily depends on adequate and suitable fabric properties and specific functional characteristics in respect of end use requirements. If these properties are technically inadequate for a particular application considering the limited durability of JGT and others natural Geotextiles, distress/failure could be a distinct possibility. On the other hand, if these properties meet the desired specifications in excess of the actual requirement, the selection of the fabric will understandably prove uneconomical. As the physical features and mechanical properties of natural [4] and man-made fibres distinctly differ, we need to decide specification of JGT carefully.

2.0 INTERNATIONAL STANDRDS FOR GEOTEXTILES

There are reportedly as many as 293 different standards for the manufacture, testing, etc, of various types of Geotextiles all over the world. The International Organization for standardization (ISO) has been worked, on the harmonization of these standards for several years and has succeeded in reducing their numbers, in some instances basically by identifying identical standards carrying different names.

2.1 EUROPEAN STANDARDS

Most of the countries of Western Europe (e.g. Belgium, France, Germany, Italy, the Netherlands, Switzerland and the United Kingdom) have national standards [5] on the construction, testing and use of various types of synthetic Geotextiles. There is already a large volume of trade in Geotextiles among the countries of Western Europe but standard procedures for testing different parameters of Geotextiles of the produced Country may differ with that of the user country creating ambiguity about the conformity of the test result of the different parameters of the product in particular JGT.

European Economic Community (EEC) has a number of European Committees for Standardization (CENS) for various disciplines and product groups. The committee for Geotextiles and Geotextiles related products is CEN/TC 189, of which the Belgian Institute for Standardization (Institut Belge de Normalization) acts as the secretariat. CEN/ TC 189. has been functioning through five working groups (W. G. s) covering all areas in which standards need to be set. W. G. 1 deals with general and specific requirements and performance criteria for Geotextiles in various applications W.G2 deals with identification processes for Geotextiles on site, the sampling and preparation of that specimens, the determination of thikness at specified pressures, the determination of mass per unit area and the vocabulary to be used in connection with Geotextiles. It also deals with classification schemes for Geotextiles based on characteristics determined from index tests. The terms of reference of W.G.3 cover a large number of standards relating to determination of properties and performance tests for Geotextiles. W.G.4 deals with the determination of properties of, and test procedures for, Geotextiles and related product, such as Geogrids and Geonets. The terms of reference of W.G5 relate to measurement of different endurance properties, like the ageing of Geotextiles in wet and dry air. resistance to chemicals and microbiological degradation, etc. the decision to use a particuler Geotextile material in any construction process will depend, among others things, on whether it complies with the specification indicated for that material by the specialist engineer in the design of the project. As already stated different countries have developed their own standard for use of *A* Geotextiles which enable the specialist consulting engineers and other users to specify clearly the products they want; in addition, standardized make it possible to compare products and result.

2.2 ISSUES

The question is about the specification and testing methods to be adopted in the intervening period till such tine the application-wise specifications for JGT are finalized and testing methods specific for JGT are decided, Although an International `Organization for Standardization (ISO) exists, there are in fact very few ISO standard which apply to Geotextiles [2]. Whilst the national standards of different countries for test methods recommend a unified approach for testing, the way in which the test results are applied to specify a Geotextile for a particular application could hardly be uniform. As there is hardly is any different between JGT and any synthetic Geotextiles *functionally*, the standards available for synthetic Geotextiles are applied for JGT. In the United states, the ASTM [6] has a standard committee specially organized for Geosynthetics (D – 35) testing methodology, which is useful and convenient as well as accepted globally for different Geotextile applications. As the standard testing methods of Geotextiles are not uniform in developed countries and are somewhat sporadic in developing countries, ASTM standard testing methods for testing of different types of synthetic Geotextiles as well as JGT in most of the cases are being followed for the sake of uniformity. In India, BIS standards are followed where such standards exist for testing of JGT.

3.0 SPECIALITY OF JUTE FIBRE

Jute is one of most versatile natural fibres and is second only to cotton in availability and variety of uses among vegetable fibres. It is a long, soft, shiny vegetable fibre that can be spun into coarse, strong thereds. It falls into the bast fibre category (fibre collected from bast or skin of the plant) along with kenaf, industrial hemp, flax (linen), ramie. It is produced from plants in the Genus *Corchorus,* which has been classified in the family tiliaceae, or more resectly in malvaceae. Two species of jute [7] which are commonly cultivated are *Corchorus capsularis* (White jute) and *Corchorus olitorius* (Tossa jute). The fibres are off-white to brown, and 1-4 metres (3-12 feet) long. Jute fibre is grown abundantly in Bengal (India) and adjoining areas of Indian subcontinent. Retted jute fibres have three principal chemical constituents, namely ά cellulose, hemicelluloses, and lignin, The hemicelluloses consist of polysaccharides of comparatively low molecular weight built up from hexoses, pentoses, and uronic acid residues. In jute, *capsularis* and *olitorius* have similar analyses, although small differences occur among different fibre samples. In addition to the three principal constituents, jute contains minor constituents such as fats and waxes inorganic matter, nitrogenous matter and traces of pigments [8] The details of chemical composition [9,10] of the jute fibre is given in Table – 1 and the fibre properties of most widely used fibres for producing Geotextiles Like jute, poluester and polypropylene are depicted in Table-2.

Table- 1: Average chemical composition (in percent of bone dry weight of the fibre) of jute [10] *C.capsularis* (White), *C. olitorirs (Tossa)*

Constituent	*C. capsularis* (White) jute	*C.olitorius* (Tossa) Jute
Cellulose*	60.0-63.0	58.0-59.0
Lignin	12.0-13.0	13.0-14.0
Hemicellulose**	21.0-24.0	22.0-25.0
Fats and Waxes	0.4-1.0	0.4-0.9
Proteins or nitrogenous matter etc(% nitrogen x 6.25)	0.8-1.87	0.8-1.56
Pectins	0.2-0.5	0.2-0.5
Mineral matter (Ash)	0.7-1.2	0.5-1.2

* Major constituents of jute-cellulose include glucosan (55.0-59.0%), xylan (1.8-3.0%) polyuronide (0.8-1.4%)

** Major constituents of jute cellulose include xylan or pentosan (15.5-16.5%), hexosan (2.0-4.0%), polyuronide (3.0-5.0%) and acetyl content (3.0-3.8%).

Table-2: Properties of jute fibre [11-20] in contrast with manmade fibre

No.	Properties	Jute	Polyester	Polypropylene
01.	Specific gravity [21]	1.48	1.38	0.91
02	Tenacity, g/d	3 to 5	2 to 9.2	2.5 to 5.5
03.	Breaking Elongation,%	0.8 to 2.o	10 to 14.5	14 to 100
04.	Elastic recovery,%	75 to 85	57 to 99	75 to 95
05.	Moisture regain [22], At 65% R.H. and 27^0 C.	12.5 to 13.8	0.4 to 4.0	0.01
06	Effect of heat	It does not melt. Up to 180^0 C there is no major wt. loss and tenacity loss. However, hemicellulose degrades around 293^0C and other constituents at higher temperature.	Sticks at 180^0C and Melts at 23^0-240^0C	Softens at 143^0 – 154^0 c, melts at 160^0C & decomposes at 288^0C
07	Effect of acid/alkalis	Good resistant to dilute organic and mineral acids at room temperature but degrades in conc. mineral acids. Affected by hot alkali.	Good resistance at room temperature disintegrates in cone, hot alkali. Excellent resistance to acids.	Excellent resistance to conc. acid and alkalis.
08	Effect of bleaches & solvents	Resistant to H_2O_2 bleaching conditions. Excellent resistant to organic solvents . However. affected by strong oxidizing agents.	Excellent resistance to bleaches & oxidizing agents.	Resistance to bleaches & solvents. Chlorinated Hydrocarbon cause swelling & dissolves at 160F and higher.

4.0 ASTM STANDARDS AVALABLE

The following ASTM standards formulated for testing of synthetic Geotextiles are given in Table-3 below:

Table-3: ASTM Standards [6] followed for Geotexitile Testing

SI. No.	Test Parameters	ASTM No
0.1	Mass per unit area	D- 5261-92
0.2	Fabric Thickness	D- 5199-01
0.3	Tensile Properties of Geotextiles by the Wide-Width Strip Method	D- 4595-86
0.4	Strip Tensile Properties of Reinforced Geomembranes	D- 7003
0.5	Grab breaking load & elongation	D- 4632
0.6	Grave Tensile Properties of Reinforced Geomembranes.	D- 7004
0.7	Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method	D- 6637
0.8	Strength of Sewn or Thermally Bonded Seams of Geotextiles	D- 4884
0.9	Trapezoid Tearing Strength	D- 4533
10	Index Puncture Resistance	D- 4833 (96)
11	CBR Puncture Resistance	D- 6241
12	Determining Geonet Breaking Force	D- 7179
13	Pyramid Puncture Resistance of Unprotected and Protected Geomembranes.	D- 5494
14	Bursting Strength-Hydraulic / Mullen Bursting Strength	D- 3886/ D- 3786
15	Bursting Strength- Ball	D- 3887
16	Apparent Opening Size	D- 4751-99a
17	Water Permeability BY Permittivity	D- 4491
18	Permittivity of Geotextiles Under Load	D- 5493
19	Hydraulic Transmissivity of a Geosynthetic Using a Constant Head	D-4716
20	Hydraulic Transmissivity of a Geosynthetic by Radial Flow	D- 6574
21	Pore Size Characteristics of Geotextiles by Capillary Flow	D- 6767
22	Air Permeability	D- 6767-02
23	Abrasion Resistance of Geotextiles (Sand Pacer/Sliding Block Method)	D- 4886
24	Interface Friction between Soil & Geotextile by Direct Shear Method	D- 5321
25	Bond Strength (ply Adhesion) of Geocomposites	D- 7005
26	Biological Clogging of Geotextiles	D- 1987
27	Deterioration of Geotextile by Exposure to Light. Moisture & Heat	D- 4355
28	Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry	D- 5885
29	Effect of Temperature on stability of Geotextile	D- 4594
30	Ply Adhesion Strength of Reinforced Geomembranes	D- 6636
31	Filtering Efficiency and Flow Rate of a Geotextile for silt Fence Application Using Site Specific soil	D- 5141
32	Soil- Geotextile System Clogging Potential by the Gradient Ratio	D- 5101
33	Determination of tensile creep and creep rupture behaviour	D- 5262
34	Chemical Resistance of Geosynthetics / Geotextile to Liquids	D- 5322 D- 6389
35	Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics	D- 5596

Out of the 35 ASTM Standards available for testing of Geotextiles, 12 Testing Standards are being used for Jute Geotextiles at laboratories for assessing different property parameters before field trails. In this connection Table- 4 Shows the list of Jute Geotextiles Testing instruments with sample specifications along with other parameters which gives different basic concepts of testing and its applicability.

5.0 PROBLEM OF USING THE EXISTING TESTING STANDARDS FOR SYNTHETIC GEOTEXTILES IN JGT

Growing market offers new possibilities for jute in technical textile sector [23, 24]. In order to meet the challenges in this area, JGT should conform to the stringent quality specifications. This may be achieved only by following the standards established specifically for JGT [25]. But as these specific standards for JGT are yet to be formulated and published, exiting standards for manmade Geotextiles are adopted which could be sometimes misleading for JGT. Separate specific standards are required for JGT as the different property parameters of JGT like physical, mechanical, and hydraulic and endurance properties are not similar to synthetic Geotextiles. Apart From these, behaviour of JGT on imposition of extraneous load and its withdrawal are different from synthetic Geotextiles. JGT possess higher GSM than its counterpart which are lighter in weight. There are recommended norms for specifications of Geosynthetics for construction of roads - these commended norms have been published by Indian Roads Congress in " Guidelines for use of Geotextiles in Road Pavements and Associated Works" IRC:SP: 59-2002.

The recommended norms for Geosynthetics have considered properties for fabric strain more than 50% and less than 50%. It is also found that during straining elongation at break for synthetic Geotextile is much higher than that of JGT and these refractive behavior is defferent. In case of JGT properties for less than 50% are only applicable. The lower strain induces greater membrane effect necessary for ensuring larger CBR value in pavement design.

Behavioral differences between JGT and synthetics Geotextiles demand formulation of separate standards for JGT for assessing of different property parameters in the laboratory for its acceptance globally. This will not only meet the technical requirements for assessing the property of JGT but also make successful marketing of JGT globally.

BIS is working for finalizing two standards on JGT for its application in rural road construction and river bank erosion control which are expected to be published as BIS standards for JGT shortly.

6.0 SUITABILITY OF ASTM STAMDARDS AS AN INTERIM OPTION

There are different National / International standards available for synthetic Geotextiles. But among the available standards ASTM covers most of the property parameters of Geotextiles. As there is no unified standard [26,27,28] for JGT, ASTM testing standards are considered the most preferred option for JGT testing till such time exclusive JGT Standards are formulated and accepted. ASTM standards are accepted globally for its authenticity of all the existing standards for testing Geotextiles. Testing parameters of JGT which are measured for finding its potential applications in different geotechnical applications are given in Table-4.

Table -4: Testing parameters for jute Geotextiles (JGT)

SI. No	Testing Parameters ,	Woven JGT	Nonwoven JGT	Open Weave JGT
01.	Width (cm)	✓	✓	✓
02.	Construction: Design of Weave	✓	✓	X
03.	Converted Mass: GSM	✓	✓	✓
04.	Ends / dm & Picks / dm	✓	✓	✓
05.	Thickness (mm)	✓	✓	✓
06.	Wide – width Tensile strength (KN/m) (Warp x Weft)	✓	✓	✓
07.	Index Puncture Resistance (kN)	✓	✓	X
08.	Bursting Strength (kg)	✓	✓	X
09.	Flow Rate ($1/m^2$/sec) at 50mm.Constant Water Head Pressure.	✓	✓	X
10.	Permittivity (/sec) at 50 mm. Constant Water Head Pressure.	✓	✓	X
11.	Permeability (cm/sec) at 50 mm. Constant Water Head Pressure.	✓	✓	X
12.	Apparent Opening Size (micron), O_{95}	✓	✓	X
13.	Open Area (%)	X	x	✓

✓- applicable, X-not applicable

7.0 CONCLUSIONS

State - of – the Art has reached the point that Geotextile materials and technologies are accepted world wide as solutions to various geotechnical problems. The end-users and specifiers of Geotextiles are supposed to be aware of significance of technical parameters and their appropriate evaluation procedures through unified standard testing methods. Although an International Organization for Standardization (ISO) exists there are in fact very few ISO standards, which are applicable to jute Geotextiles. Hence for acceptance of JGT globally , the researchers, users and the producers should accept suitable standard testing methods approved by appropriate bodies for evaluating the different parameters of JGT to assess its performance and maintaining the quality of the same which is highly essential. Establishment of appropriate Jute Geotextile specifications and test procedures under recognized National / International standards – making bodies are of vital importance to achieve successful implementation and long term performance of JGT in the field of geotechnical engineering. Among the different standard methods of testing for geotextile adopted by different countries the ASTM standards is found to be suitable for evaluating all the properties of JGT until new standard methods of testings are designed keeping in mind the properties of jute.

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EFFECT OF SEED TREATMENT AND AGRONOMIC MANAGEMENT PRACTICES ON FIBRE YIELD AND YIELD ATTRIBUTES OF TOSSA JUTE VARIETY O-9897

A.K.M. Mahbubur Rahman[1], A.T.M. Morshed Alam[2], Md. Shafiqul Hasan[3] Md. Ferdausul Alom[4] and Izaz Ahmed[5]

ABSTRACT

An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymenaigh to evaluate the effect of seed treatment and agronomic management practices on fibre yield and yield attributes of tossa variety O-9897. The treatments included four seed treatments: T_1=No seed treatment (control), T_2= Treatment by Vitavex 200, T_3= Treatment by Dithane M-45 and T_4= Treatment by Bordeaux mixture and four agronomic management practices: M_1= Standard management practices, M_2=Recommended fertilizer application only, M_3=No fertilizer application but weeding and thinning and M_4= No management practice (control). The experiment was laid out in a split plot design with three replications. The highest fibre yield (2.76 t ha^{-1}) was produced when seeds were treated with Dithane M-45 and it was followed by Vitavax-200 (2.68 t ha^{-1}). The highest fibre yield (3.75 t ha^{-1}) was obtained when the crop was managed through standard management practices (M_1). The treatment combination of $T_3 \times M_1$ gave the highest fibre yield (4.86 t ha^{-1}) and yield attributes i.e. average diameter of stem, average thickness of bark and bark green weight.

Key words : Seed treatment, Agronomic management, jute

INTRODUCTION

Jute is an important cash crop of Bangladesh. Two species of jute i.e. *Corchorus capsularis* L. and *Corchorus olitorius* L. usually grown by our farmers which cover about 5 lac hectares of land. The national average yield of fibre is about 1.8 t ha^{-1} (3). About 80% of the total world jute is produced in Bangladesh and India. However, the major portion of the raw jute of international trade is yet supplied by Bangladesh. In Bangladesh *C. olitorius* L. jute covers about two third of the total area under jute and the remaining one-third is covered by the *C. capsularis* L.

Weeds are the natural enemies of crops, which reduces the yield to a great extent. Among the various factors responsible for low yield of jute, the contribution of weed is very significant. So, weeding is the most beneficial agronomic management practice for jute crops to take nutrients, moisture, light, space and some time controlling many diseases,

[1] Rural Development officer, LGED

[2&5] Principal Scientific Officer, Agronomy Division

[3] Scientific Officer, On Farm Research Division, BJRI and

[4] Deputy Manager, Bangladesh Sugar & Food Industries Corporation

organisms and insect pests. Weeding and thinning operation involved about 40% or more of the labour cost investment in jute cultivation (2).

The fibre and seed yield of jute is adversely affected without seed treatment and agronomic management. As the crop is grown during the summer season, a number of weed species are found to grow in the field causing deterioration of jute fibre quantitatively if these are not controlled timely. A disease free plant community is desirable to obtain maximum fibre yield and to create such condition weeding operations are to be performed timely.

The jute plant is very sensitive to disease infestation especially seed borne disease such as black band, root rot, yellow mosaic virus etc. The growth of plants may be checked totally at certain stage under the condition of severe infestation resulting poor yield. A number of agronomic management operations may be necessary to control weeds and diseases. These expensive operations should preferably be done to a minimum level by developing suitable cultural method and seed treatment to reduce the cost of production. The crop becomes stunted in growth if it is not thinned at proper time. As a result, the crowded and unhealthy crop ultimately produces poor fibre.

With this end in view, a study was, therefore, undertaken to evaluate the effect of seed treatment and agronomic management practices on the fibre yield of variety O-9897.

MATERIALS AND METHODS

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from April to September, 2002. The experimental site belongs to the Sonatola soil series of old Brahmaputra Floodplain AEZ (6). The land was medium high. The soil of the experimental field was non-calcareous loamy in texture with pH value ranging from 6.5 to 7.0 which is fairly suitable for jute cultivation.

Four seed treatments viz. T_1 (Control), T_2 (Treatment by Vitavax 200 @1/4 g/kg seed), T_3 (Treatment by Dythane M-45 @1/4 g/kg seed) and T_4 (Treatment by Bordeaux mixture @1/4 ml/kg seed) and four agronomic management practices viz., M_1= Standard management practices, M_2= Recommended fertilizer application only, M_3= No fertilizer application only weeding and thinning and M_4= No management practice.The experimental plot was laid out in a split plot design with three replications. The size of individual plot was 2.5m X 2.0 m. The seed treatments were placed in the main plots and the management practices in sub plots. Each main plot was divided into 4 (four) sub plots where the methods of management practices were placed randomly.

The tossa jute variety O-9897 was used as study material. The plots were fertilized with urea, TSP, MP, Gypsum and Zinc Sulphate @ 112, 55, 100, 50 and 11 kg ha^{-1}, respectively as recommended by Bangladesh Jute Research Institute (BJRI). Each plot received another 56 g urea as top dressing at 35 days after sowing (DAS). Seeds were sown on 20 April, 2002 at the rate of 6 kg ha^{-1} in 30 cm apart lines. Before sowing, the seeds were treated and the management practices were done according to the experimental requirement. Jute hairy caterpillars (*Spilarctia obliqua*) were found in some plots. The pest was effectively controlled by hand picking of leaves with eggs and larval masses. Crops were harvested at the field duration of 120 days. Before harvesting 10 sample plants were taken at random from each plot to study the yield contributing characters. After harvesting, the plants were made into small bundles and kept standing on the ground for 4 days for shedding of leaves prior to steeping for retting. Analyses of variances were worked out to find the statistical significance of the treatments. The differences in treatment means in question of significance were adjudged by the Duncan's New Multiple Range Test (7).

RESULTS

The fibre yield was significantly affected by seed treatment (Fig.1). The highest fibre yield (2.76 t ha^{-1}) was noticed under seed treatment with Dithane M-45 followed by Vitavax 200 (2.68 t ha^{-1}). The lowest fibre yield was obtained from the treatment with Bordeaux mixture (1.86 t ha^{-1}).

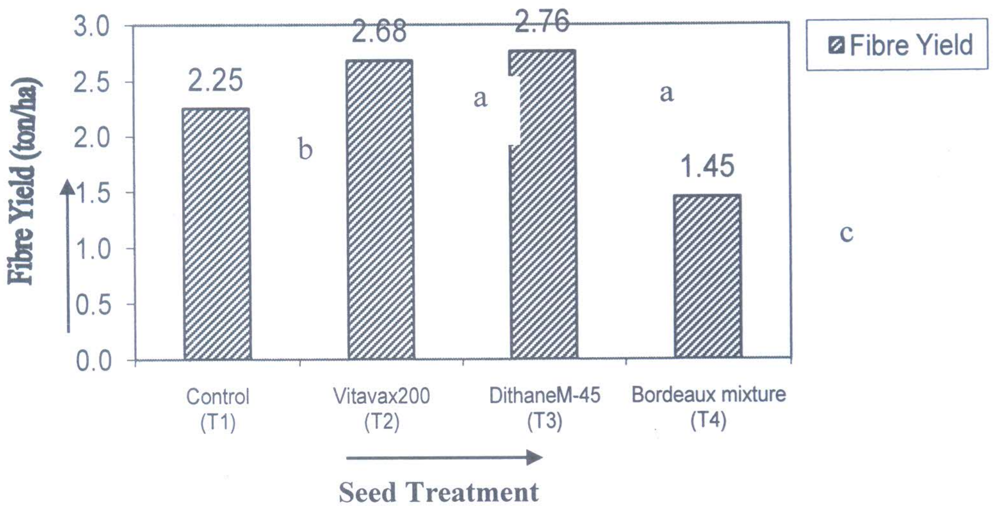

Fig. 1. Effect of seed treatment on the fibre yield of variety O-9897

Among the fibre yield attributes plant population, average thickness of bark and green weight of fibre were also significantly affected by seed treatment, which certainly contributed directly to fibre yield. However, other yield affecting factors like, plant height, branching, average diameter of stem and average stick diameter were remained unaffected (Table-1).

The plant population is one of the most important yield affecting factors. The highest plant population (90.58/m^2) was noted when the seeds were treated with Vitavax 200. It was identically followed by Bordeaux mixture (87.25/m^2) and the lowest number of plants was found under no seed treatment. Therefore, it is obvious that about 30.5% more plant population was observed due to treatment of seed with Vitavax 200 in comparison to no seed treatment (Table-1).

Thickness of bark was positively influenced by seed treatment. The highest thickness (0.24 cm) was noticed when it was treated with Dithane M-45. The second thickness (0.20 cm) was found in T_2 when seeds were treated with Vitavax 200. The lowest thickness was marked in case of no treatment of seeds (Table-1).

Table-1: Effect of seed treatment on yield contributing characters of variety O-9897

Treatment	Plant population at emerg. (no. m^{-2})	Plant height (m)	Branching $plant^{-1}$ (No.)	Average diameter of stem (cm)	Average stick diameter (cm)	Average thickness of bark (cm)	Bark green weight (kg $plot^{-1}$)
T_1	69.42 c	1.89	1.08	0.58	0.54	0.17 c	8.59 b
T_2	90.58 a	1.95	0.92	0.64	0.50	0.20 b	10.23 a
T_3	77.42 b	2.09	1.08	0.62	0.48	0.24 a	8.42 b
T_4	87.25 a	1.71	0.61	0.61	0.46	0.19 bc	7.65 b
Level of significance	0.01	NS	NS	NS	NS	0.01	0.05

T_1 =No seed treatment (control), T_2 =Seed treating with Vitavax-200, T_3 =Seed treating with Dithane M-45, T_4 =Seed treating with Bordeaux mixture and NS =Not significant

The fibre yield was significantly affected by the management practices (Fig.2). The highest fibre yield (3.75 t ha^{-1}) was found under the standard management practices (M_1) and the lowest fibre yield (0.45 t ha^{-1}) was found under no management practices (M_4).

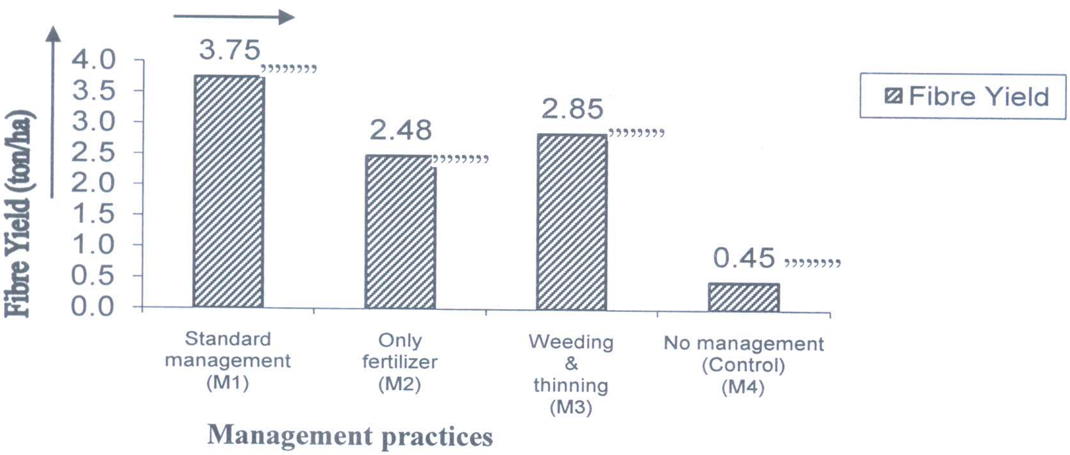

Fig. 2. Effect of management practices on the fibre yield of variety O-9897

Among the fibre yield attributes, plant population, plant height, average diameter of stem, average stick diameter, average thickness of bark and bark green weight were significantly affected due to management practices where as branching per plant was remained unaffected (Table-2). The tallest plant (2.19cm) was produced under the standard management practices and the shortest plant (1.55 cm) was found under no management practice. On an average, about 29% plant height was increased due to adoption of standard management practices including weeding and thinning, fertilizer application and insect pest control.

The highest average diameter of stem (0.74cm) was recorded under standard management practices (M_1) which was differentially followed by M_3 (0.61cm). The lowest average stem diameter (0.50cm) was noted under no management practices. Since the plants under the standard management practices (M_1) were spaced properly, it enhanced the growth and development of the plants (Table-2).

Table-2. Effect of management practices on yield contributing characters of variety O-9897

Management practices	Plant population at emerg. (No. m^{-2})	Plant height (m)	Branching (No plant^{-1})	Average diameter of stem (cm)	Average stick diameter (cm)	Average thickness of bark (cm)	Bark green weight (kg plot^{-1})
Standard management (M_1)	48.42 c	2.19 a	1.08	0.74 a	0.63 a	0.26 a	13.36 a
Only recommended fertilizer (M_2)	105.92 b	2.03 a	1.08	0.60 b	0.52 b	0.21 b	12.02 a
Only weeding & thinning but no fertilizer (M_3)	50.08 c	1.87 ab	0.50	0.61 b	0.45 bc	0.18 c	5.32 b
No management (M_4)	120.25 a	1.55 b	1.42	0.50 c	0.39 c	0.16 c	4.18 b
Level of significance	0.01	0.01	NS	0.01	0.01	0.01	0.01

M_1 = Application of recommended fertilizer + Weeding + Thinning at vegetative stage + Spray of pesticides (Standard management practice)
M_2 = Only recommended fertilizer application
M_3 = No fertilizer + Weeding + Thinning
M_4 = No management practice
NS= Not significant.

The interaction of seed treatment and management practices influenced the fibre yield and yield contributing characters of jute except plant height, branching and stick diameter (Table-3). The plant population was noted low under the treatment combination of vitavax 200 and standard management practices. Weeding and thinning operations in the package of standard management practices were only the reasons of differences in plant population. The highest fibre yield (4.86tha^{-1}) and stick yield (11.85 tha^{-1}) were observed under the treatment combination of Dithane M-45 and standard management practices (T_3M_1) i.e. weeding, thinning, fertilizer application and insect pest control. It was statistically identical with the interaction of T_2M_1 i.e the treatment combination of Vitavax 200 and standard management practices. The highest fibre yield (4.86 tha^{-1}) under this interaction was the cumulative result of the highest plant height (2.78cm), stem diameter (0.83cm) and thickness of bark (0.29cm). The lowest yield was found when the seeds were not treated with chemicals before sowing and no weeding, thinning and fertilizer application were done. From the above results, it might be concluded that before sowing, jute seeds should be treated with Vitavax 200 or Dithane M-45 and proper management operations i.e. weeding, thinning and fertilizer application must be done to achieve the higher fibre yield (Table-3).

Table-3. Effect of interaction of seed treatment and management practices on fibre yield and yield contributing characters of variety O-9897

Interaction	Plant population at erergence (no.$^{m-2}$)	Plant height (m)	Bronching (no. plant^{-1})	Average diameter of stem (cm)	Average stick diameter (cm)	Average thick-ness of bark (cm)	Bark green weight (kg plot^{-1})	Dry fibre yield (tha^{-1})	Dry stick yield (tha^{-1})
T_1 x M_1	53.67 c	1.87	0.67	0.55cde	0.66	0.22bc	14.08ab	3.11bc	10.02b
x M_2	77.33 d	2.13	1.33	0.57cde	0.59	0.16def	13.42b	2.35def	6.45e
x M_3	41.33 f	1.90	0.00	0.65bc	0.52	0.19cde	3.91ef	2.79cd	7.78d
x M_4	105.33 c	1.63	2.33	0.53cde	0.38	0.13f	2.96f	0.75g	1.71f
T_2 x M_1	51.00 ef	2.50	1.33	0.80a	0.63	0.26ab	13.54b	4.37a	11.6b
x M_2	122.33 b	2.34	0.67	0.74ab	0.57	0.27ab	16.62a	2.65cde	6.54e
x M_3	51.33 ef	1.56	0.67	0.52cde	0.42	0.14ef	4.00ef	3.43b	9.00c
x M_4	137.67 a	1.41	1.00	0.49dc	0.38	0.14ef	3.75cde	0.27g	1.00fg
T_3 x M_1	49.33 ef	2.78	1.33	0.83a	0.64	0.29a	16.29a	4.86a	11.85a
x M_2	115.00 bc	1.88	1.67	0.55cde	0.50	0.19cd	8.83c	2.90bcd	6.45e
x M_3	40.33 f	2.17	0.67	0.65bcd	0.43	0.25ab	5.71def	3.02bc	7.72d
x M_4	105.00 c	1.55	0.67	0.44c	0.36	0.23bc	2.83f	0.27g	0.90g
T_4 x M_1	39.67 f	1.60	1.00	0.75ab	0.59	0.25ab	9.54c	2.66cde	9.93b
x M_2	109.00 c	1.75	0.67	0.53cde	0.41	0.22bc	9.21c	2.05f	6.60e
x M_3	67.33 d	1.84	0.67	0.62bcd	0.44	0.15def	7.67cd	2.17ef	5.81e
x M_4	133.00 a	1.64	1.67	0.53cde	0.42	0.15def	4.17ef	0.53g	1.29fg
Level of significance	0.01	NS	NS	0.01	NS	0.01	0.01	0.01	0.01

T_1 = No seed treatment (control)

T_2 = Seed treating withVitavax-200

T_3 = Seed treating with Dithane M-45

T_4 = Seed treating with Bordeaux mixture

M_1 = Application of recommended fertilizer + Weeding + Thinning at vegetative stage + Spraying of pesticides (Standard management practice)

M_2 = Only recommended fertilizer application

M_3 = No fertilizer + Weeding + Thinning

M_4 = No management practice

NS = Not significant

DISCUSSION

The higher fibre yield due to seed treatment might be due to greater seedling emergence (higher plant population) and greater thickness of bark. It might be the fact that many young seedling of jute was damaged due to disease infection or seedling abnormality when seeds were not treated with the appropriate chemicals. Beneficial effect of seed treatment was also observed in rice when organomercurial seed dresser like Bavistin and Dithane M-45 were used (12). Inhibition of jute pathogens (77-100%) were found when the seeds were treated with Granosan-M, Vitavax 200 and B-8 in laboratory test in green house and in fields. In greenhouse, Granosan-M gave better results than Vitavax 200, while better results were obtained from Vitavax 200 compared to B-8 under field condition.

The mean green weight per plot was significantly influenced by the seed treatments. The highest green weight (10.23 kg) was found in T_2 treatment (seed treated with Vitavax 200) and lower green weight was found in T_1 (no seed treatment) and it was statistically similar to T_3 (Dithane M-45) and T_4 (Bordeaux mixture). Therefore, it was clear that since, two important yield contributing characters, plant height and stem diameter did not improve due to seed treatment, the increase in green weight might be due to increase in plant population plot^{-1}, the thickness of bark. The higher fibre yield of jute under the treatments of different weed control method was noted (4, 5). Increased fibre yield was found due to application of nitrogen (10).

Treatment, M_1 and M_3 produced the lower number of plants (48.42 and 50.08 plants m^{-2}, respectively) and the highest number of plants were noted under M_4 (120 plants m^{-2}) where no management practice was adopted. In treatments M_1 and M_3, thinning and weeding were done as components of management practices, therefore these treatments automatically produced less number of plants per unit area.

Increased plant height was found with the adoption of weeding and raking treatment (4). Higher plant height of jute was observed when nitrogen was applied properly @ 45kg/ha, with good management (10).

Additional application of fertilizers improved the growth further. An increase of stem diameter of jute was also observed due to application of nitrogen (8, 10). Increased stem diameter was found due to removal of weeds from the jute fields (11). An increase of base diameter of jute was also found due to weed control in jute field (1).

The effect of management practices on the stem diameter and stick diameter were reflected on the thickness of bark. Therefore, the highest thickness (0.26cm) of bark was found in the treatment of M_1 where all the management practices were done properly. The lowest thickness of bark was noted in M_4 (0.16cm) where no management practice was done Therefore, good management practices provided the plants with better environment for nutrient absorption, which ultimately accumulated in jute bark and stick, of the crop. It was observed that nitrogen did not increase the thickness of bark of jute (10). However, significant increase of base diameter of jute was found due to nitrogen application (8).

The interaction effect of seed treatment and management practices influenced the fibre yield and yield contributing characters of jute except plant height, branching and stick diameter. Weeding and thinning operations in the package of standard management practices were the reasons of differences in plant population. The highest fibre and stick yield 4.86tha^{-1} and

11.85tha^{-1}, respectively were observed under the treatment combination of Dithane M-45 and standard management practices (T_3M_1) i.e. weeding, thinning, fertilizer application and insect pest control. It was statistically identical with the interaction of T_2M_1i.e the treatment combination of Vitavax 200 and standard management practices. The highest fibre yield (4.86 tha^{-1}) under this interaction was the cumulative result of the highest plant height (2.78cm), stem diameter (0.83cm) and thickness of bark (0.29cm). The highest base diameter (18.26 mm), fibre (3.02 t ha^{-1}) and stick (6.10 t ha^{-1}) yields were found at Faridpur location with the treatment combination of improved seed, line sowing, use of recommended dose of fertilizer and plant protection measures (9).

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DEVELOPMENT, DESCRIPTION AND SENSITIVITY ANALYSIS OF FIBGROW DYNAMIC SIMULATION MODEL FOR JUTE GROWTH AT IMPACTS OF CHANGING CLIMATE

Md. Mujibur Rahman
Bangladesh Jute Research Institute

ABSTRACT

The article presents the development process of jute growth model FIBGROW on jute production at changing climatic condition in Bangladesh with its detail description and sensitivity analysis. Solar radiation and ambient temperature are the most important variables and the model is solar driven. Incoming solar radiation is separated into diffuse and direct components. The leaves are distinguished as shaded leaf and sunlit leaf depending on the solar radiation availability. Assimilation rate per unit leaf is the sum of the average of assimilation rates of shaded leaves and sunlit leaves. The rate of assimilation or canopy photosynthesis is computed integrating the canopy assimilation at three positions in the canopy (top, middle and bottom) layer and at three times (morning, noon and afternoon) of the day using Gaussian integration method. The sensitivity analyses of the important parameters are examined and the initial light use efficiency, maximum rate of photosynthesis of single leaf, development stages were identified as the most sensitive parameters. Developed FIBGROW model shows excellent dynamic simulation performance for predicting potential yields and management strategies on jute crop at changing climate in Bangladesh.

Key words: Dynamic model FIBGROW, solar radiation, shaded and sunlit leaf, photosynthesis and sensitivity analysis.

INTRODUCTION

Jute is one of the major cash crops in Bangladesh and the important jute growing areas are Mymensingh, Faridpur, Dhaka, Rangpur, Rajshahi, Bogra, Pabna, Comilla, Jessore, Khustia, Khulna and Jamalpur. Recently vast coastal areas have shown promising potentiality for growing jute and allied fibre crops (BJRI, 2006). Total cultivated land for jute is 4.02×10^5 hectares and the total production is 4.62×10^6 tons (BBS, 2011).

The common items manufactured from jute are the gunny bags (Ghosh, 1983), jute carpet, suitcases, kitbags, rucksacks, mailbags and handbags. The jute wastes are used for manufacturing of insulation boards and the jute stick, another by-product, is used to make particleboard, hardboard, duplex board, kraft paper, newsprint and even rayon. Recently 3 largest car manufacturers of the world TOYOTA, MITSUBISHI MOTORS and GM MOTORS have shown interest to use jute in the internal decoration of their products (Haque, 2006). Jute fibre is environment friendly, biodegradable and is an excellent alternative of artificial fibre which creates environmental pollution and health hazards (Rahman and Bala, 2007).

Global climate change and its relevance to jute production in Bangladesh is an important issue which needs extensive research work. Direct measurement of the effect of changing climatic parameters and greenhouse gas concentration on the plant growth is very expensive and huge time consuming event and almost infeasible. Plant growth simulation models are the essential, less costly alternatives in this context, and provide us with the opportunity to build different scenarios of agricultural production in changing climatic impacts (Hussain *et al.*, 2005). Plant growth models offer excellent opportunity to keep boundary conditions related with other abiotic stress on growth and development of the field crops.

Sensitivity analysis tests how responsive the model is to change in certain variables and parameters (Willmott, 1982; Whisler *et al.*, 1986). The purpose is to study the sensitivity of the model (Jones *et al.*, 1987). Through the test, sensitive parameters are identified. A sensitive parameter is one which causes a major change in model output (Dent and Blackie, 1979). It also justifies the logic of consideration of the inputs and parameters in the study of the system. Sensitivity analysis depends on the objective of the study; in some cases there is little need to carry out the test if a given parameter is not important as far as the use of a given model is concerned (Dent and Blackie, 1979). When the analysis consists of examining the effect of uncertainty in model parameters it is called 'fine sensitivity analyses' and of uncertainty in the model structure then it is called 'coarse sensitivity analysis' (Rossing *et al.*, 1989). The process of the analysis starts with the selection of the model outputs that are considered to be crucial to the study (Jones *et al.*, 1987). Then an individual input variable or parameter is changed to a certain degree (range), holding the others constant (Whisler *et al.*, 1986). The model is then run and the results are obtained.

Many studies have been reported on crop growth modeling and climate change impacts on the yields of crops (Gabrielle and Kengni, 1996; Changnon and Winstanley, 2000; Saseendran *et al.*, 2000; Van Oosterom *et al.*, 2001a & 2001b; Shepherd *et al.*, 2002; Southworth *et al.*, 2002; Van Oosterom *et al.*, 2002; Aggarwal, 2003; Changnon and Hollinger, 2003; De Costa *et al.*, 2003a & 2003b; Yang *et al.*, 2003; Asseng *et al.*, 2004; Mall *et al.*, 2004; Saseendran *et al.*, 2005; Aggarwal *et al.*, 2006a & 2006b; De Costa *et al.*, 2006; Leakey *et al.*, 2006; Ludwig and Asseng, 2006; Anwar, *et al.*, 2007; Motha, 2007; and Meza *et al.*, 2008 etc.) and limited studies have been reported on modeling of fibre crops (Hasketh *et al.*, 1971 & 1972; Baker *et al.*,1972; Carberry *et al.*, 1992; Carberry and Muchow, 1992a & 1992b and Pannangpeth *et al.*, 1993, Wall *et al.*, 1994; Wu *et al.*, 2007). But, no study has been reported on jute crop growth modeling and fibre yield simulation. The objectives of this study is to present a growth model of jute crop, which can simulate the fibre yield successfully at changing climatic impacts on jute production in Bangladesh and performing the sensitivity analyses of the parameters used in the model development process.

MATERIALS AND METHODS

The model FIBGROW has been developed to simulate the FIBre GROWth (production) of two popular races of jute (*Corchorus capsularis* L. and *Corchorus olitorius* L.) in Bangladesh. FIBGROW simulates potential production of jute fibre. The simple representation of the model is shown in Fig. 1. Light and temperature are the driving variables, photosynthetic parameters are constants. Rectangles represent quantities (state variables), valve symbols for flows (rate variables), circles are auxiliary variables (converters), full lines are flows of material and dashed lines are flow of information (Fig. 1).

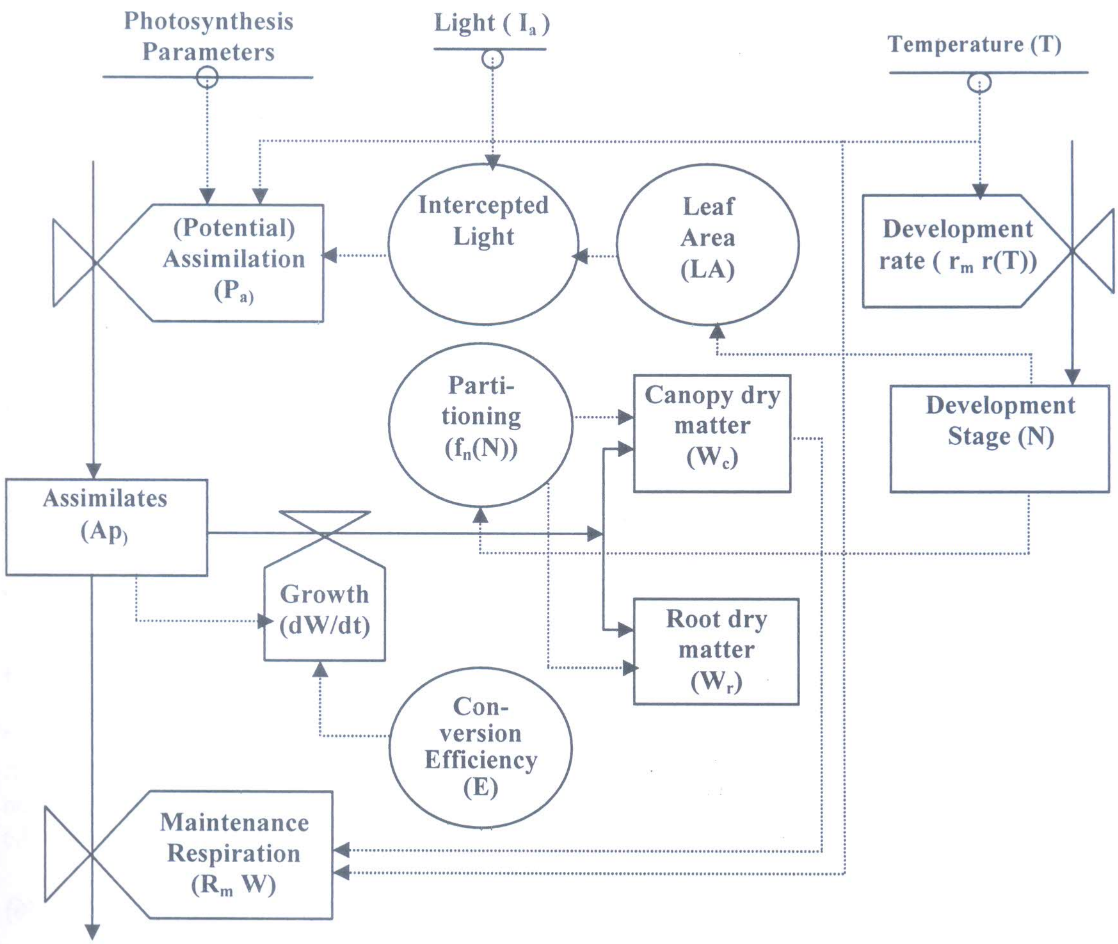


Fig. 1. Simple representation of FIBGROW model for jute production

Under favorable growth conditions, light, temperature, and the crop characteristics for phenological, morphological, and physiological processes are the main factors determining the growth rate of the crop on a specific day. The model follows a daily calculation scheme for the rates of dry matter production of the plant organs (leaf, root, bark and stick), the rate of leaf area development and the rate of phenological development (growth stages). By integrating these rates over time, dry-matter production of the crop is simulated throughout the crop growing season (120 days).

Computation of canopy photosynthesis from the incoming Photosynthetically Active Radiation (PAR) forms the central part of the crop growth models. Daily global irradiance is the input for the model and on the average, photosynthetically active radiation amounts 50% of the total radiation. Instantaneous values are derived from the daily totals applying a modified sinusoid over the day and the details are given in Rahman (2010).

Incoming radiation is separated into diffuse radiation and direct radiation and the leaf area classes are distinguished as shaded leaf area and sunlit leaf area. The shaded leaf area absorbs the diffuse flux and the diffused component of the direct flux and the sunlit area absorbs both diffuse and direct radiation (Spitters, 1986). The radiation absorbed by the shaded leaf area is:

$$I_{sh,a} = I_{df,a} + (I_{dr,a} - I_{dr,dr,a}) \quad (1)$$

and the radiation received by the sunlit area is:

$$I_{sl,a} = I_{sh,a} + (1-\sigma)\kappa_{bl} I_{0,dr} \quad (2)$$

The assimilation rate of a canopy layer is obtained by substituting the absorbed amount of light energy into the assimilation – light response curve of single leaves. The assimilation of the shaded leaves is thus described by:

$$A_{sh} = A_m (1 - e^{-\varepsilon I_{sh,a}/A_m}) \quad (3)$$

The direct flux absorbed by a leaf perpendicular to the direct beam (light) is:

$$I_{sl,dr,a} = (1-\sigma) I_{0,dr} / \sin\beta \quad (4)$$

For sunlit leaf area it is more accurate to account for the variation in leaf angle and thus in illumination intensity (Spitters, 1986). The integration over sine of incidence gives the assimilation rate of sunlit leaf as:

$$A_{sl} = A_m \left[1 - (A_m - A_{sh})(1 - e^{-\varepsilon I_{sl,dr,a}/A_m}) / (\varepsilon I_{sl,dr,a})\right] \quad (5)$$

The assimilation rate per unit leaf, averaged over a canopy layer, is the sum of the assimilation rates of sunlit and shaded leaves, each averaged to their share in that layer. Assimilation rates of sunlit and shaded leaf area are calculated in relation to vertical position within the canopy and time of the day using the method proposed by Spitters (1986). The assimilation rate per unit leaf can be expressed as:

$$A = f_{sl} A_{sl} + (1 - f_{sl}) A_{sh} \quad (6)$$

The rate of canopy photosynthesis i.e. the assimilation rate of the canopy can be computed from the photosynthesis – light response curve of individual leaves, the incoming radiation and the leaf area index. Goudriaan (1986) developed an excellent way to calculate the daily gross photosynthesis and it uses three-point Gaussian integration method. This method integrates the instantaneous rate of leaf photosynthesis in time (three points between noon to afternoon) and in space (three depths in canopy). Fig. 2 shows the flow diagram of the numerical integration over canopy layers over the day.

First, hourly canopy assimilation rate is calculated as a weighted average of the assimilation at three horizons within the canopy and the weighted average of these three assimilation rates is:

$$A_h = LAI(A_{-1} + 1.6A_0 + A_1)/3.6 \quad (7)$$

Second, daily canopy assimilation rate is computed as the weighted average of the assimilation rates at the three selected time points is:

$$A_d = D(A_{h,-1} + 1.6A_{h,0} + A_{h,1})/3.6 \quad \textbf{(8)}$$

Gross CO_2 assimilated through the assimilation process is partitioned in the different sinks (leaves, roots, barks and sticks) as structural dry matter (CH_2O) through a biochemical conversion process, after mitigating the requirement of plant respiration and maintenance need. The net canopy photosynthesis or assimilates are increased by gross photosynthesis and decreased by the use for maintenance and growth. Thus, the net photosynthesis can be expressed as:

$$\frac{dP}{dt} = A_d - R_m - R_g \quad \textbf{(9)}$$

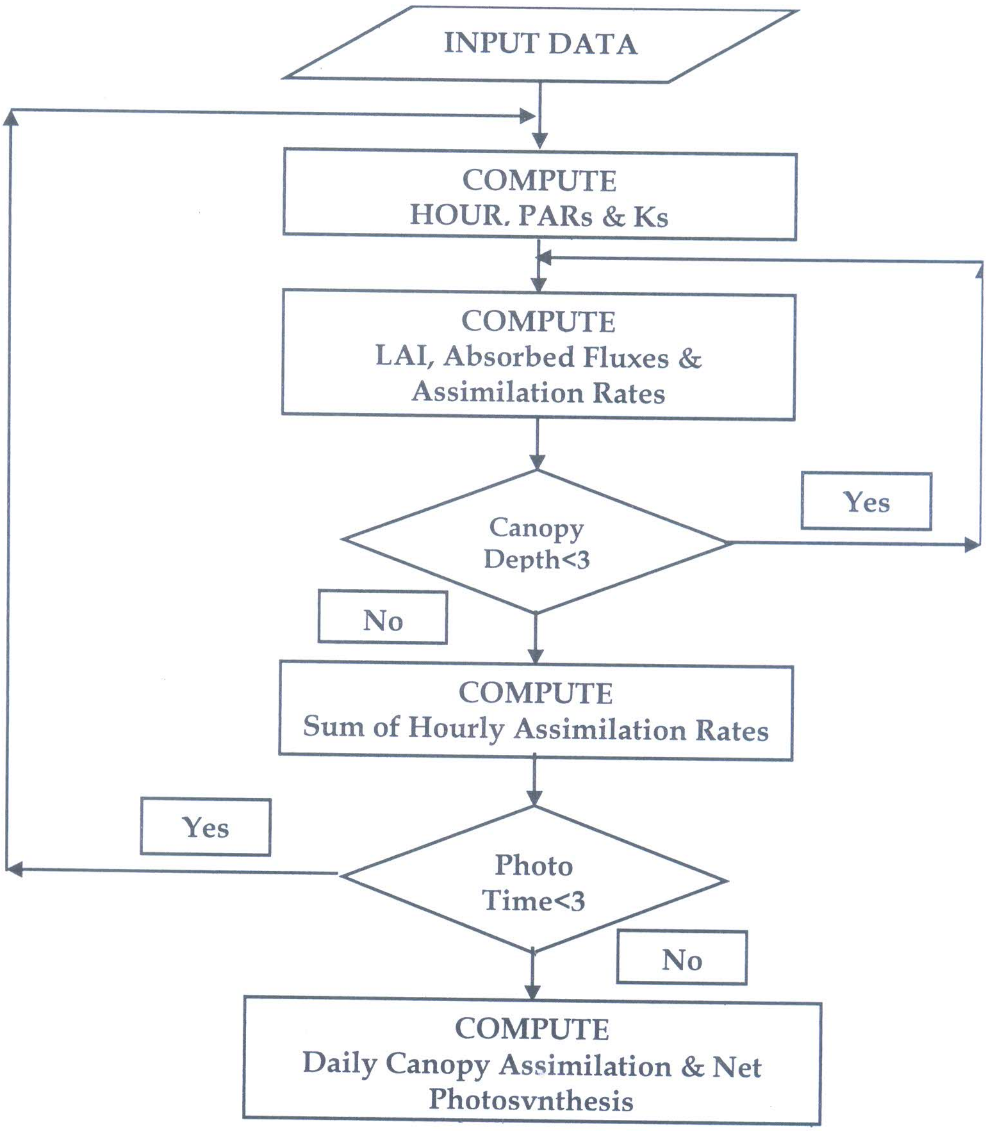


Fig. 2 Flow diagram of the numerical integration of gross photosynthesis

Maintenance respiration utilizes a part of the assimilates to support the metabolic activity of the plant organs (leaf, stem, root and movable reserves) and it depends on the temperature. Thus, it can be expressed as:

$$R_m = R_{ml} + R_{ms} + R_{mr} + R_{mm} \tag{10}$$

Simulation models using a one-day time period of integration it is assumed that any glucose that is produced in a day and the remaining after the day's maintenance processes is used for growth. Partitioned CH_2O in different organs of the plant then converted to structural dry matter and growth (dry weight increment) of that particular organ increased day by day. Physiological maturation (growth) of the crop is proportional to the growth of different plant parts as a whole.

$$R_g = R_{gl} + R_{gs} + R_{mr} \tag{11}$$

The development stage of a plant quantifies its physiological age and is related to its morphological appearance and it is a state variable in the plant growth modeling. The development stage has a value of 0.0 at emergence, 1.0 at anthesis and 2.0 at maturation. Since jute fibre crop development includes only vegetative growth (before flowering) and defined in the model as 1.0, rather than 2.0 for other cereal or legume crops (Penning de Vries, 1989). It thus can be expressed as:

$$\frac{dS}{dt} = S_r \tag{12}$$

Bark of jute plant is the ultimate source of jute fibre and its growth depends on development stage. Bark weight can expressed as:

$$\frac{dB}{dt} = B_r \tag{13}$$

Jute fibre is obtained from the bark after retting and processing. A fraction of the bark weight is the fibre of jute plant and fibre production can be expressed as:

$$F = B \times F_{fr} \tag{14}$$

RESULTS

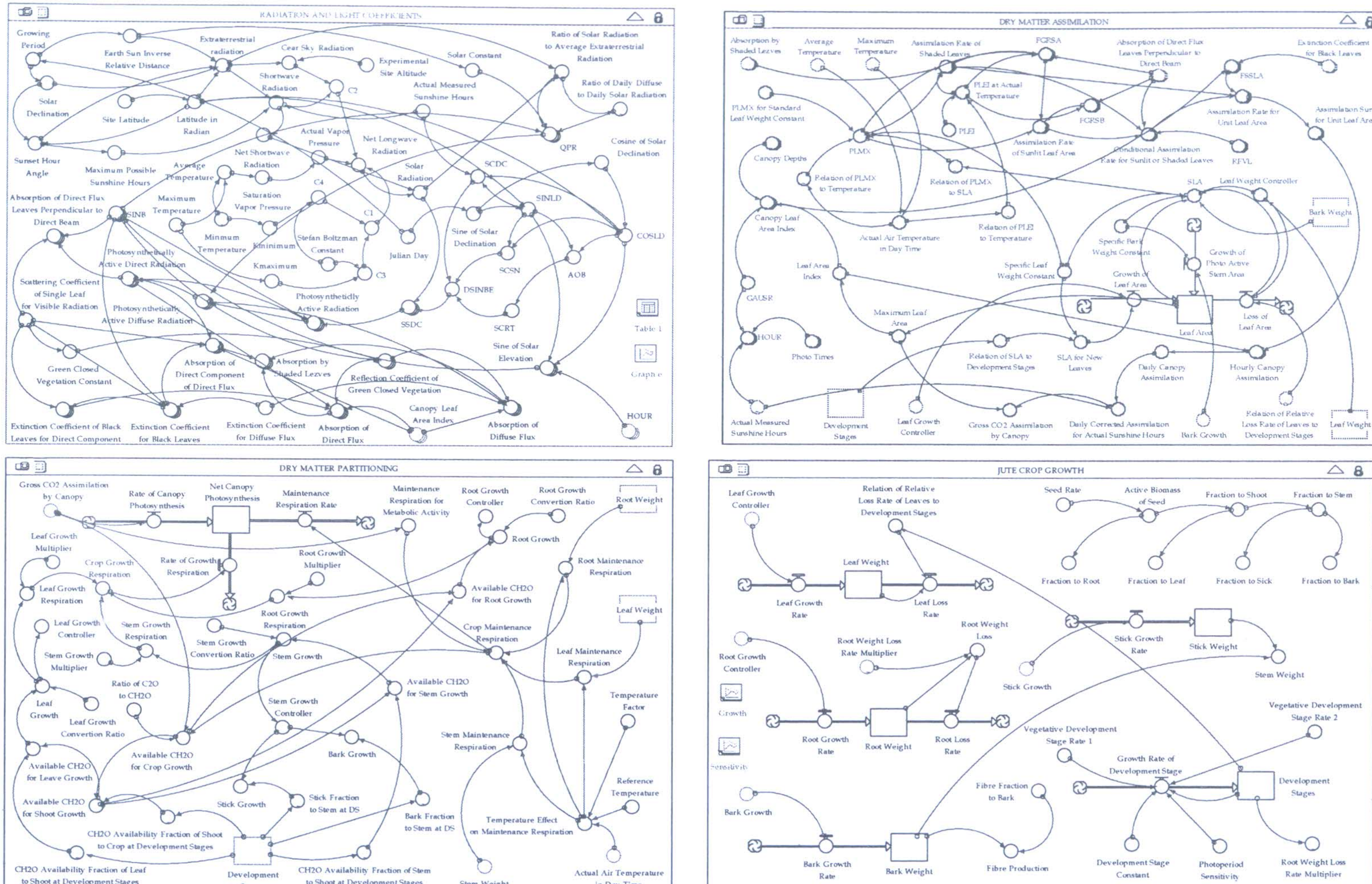
The model FIBGROW is developed on STELLA modeling software interface (Appendices). The simulation process in the model is executed in 4 sectors namely, Solar Radiation Sector, Dry Matter Assimilation Sector, Dry Matter Partitioning Sector and Crop Growth Sector. Following figures 3(a), 3(b), 3(c) and 3(d) show the main structures (Solar Radiation Sector, Dry Matter Assimilation Sector, Dry Matter Partitioning Sector and Crop Growth Sector respectively) of the FIBGROW model. The details of the computation process of the jute growth model are given in Rahman (2010).

Most of the parameters used in FIBGROW model are tested for sensitivity through running the model with different lower and higher values of the used one, and only six of them were showed sensitivity to the potential yield (kg/ha) of jute fibre. Parameters identified in the preliminary tests (initial light use efficiency of single leaf, PLMX for standard leaf weight constant, extinction coefficient (k) for diffuse flux, initial value of leaf area, development stage constant, and initial value of crop development stages) were further tested by reducing and increasing the values (-10 to +10%) from the base value.

Fibre yield changes due to the above mentioned 6 parameters are shown in table 1 for the changing values (-10% to +10%) of base values (PLEI, PLMX, k, LA, DS and Initial development stage). The percentages of the changes in simulated yields are presented in the table 1 for the six parameters under consideration.

Table 1 Fibre yield variations (%) for the changed values (-10% to +10%) of different sensitive parameters used in the FIBGROW model

No.	**Parameters**	**Yield variations (%) for changed (-10% to +10%) parameter values**				
		-10%	**-5%**	**Base**	**+5%**	**+10%**
1.	Initial light use efficiency (PLEI)	-13.20	-6.38	1959.	5.52	10.27
2.	PLMX for standard condition	-8.84	-4.18	38	3.52	6.40
3.	k for diffuse light flux	5.74	2.78	Do	-2.62	-5.08
4.	Initial LA value	-1.52	-0.72	Do	0.64	1.22
5.	DS constant value	-0.26	-0.12	Do	0.12	0.23
6.	Initial development stage	-0.04	-0.02	Do	0.01	0.02
				Do		



Figs.3(a) Solar Radiation, (b) Dry Matter Assimilation, (c) Dry Matter Partitioning and (d) Crop Growth Sector of the FIBGROW jute growth model at climate change impacts in Bangladesh (from top left to right).

DISCUSSION

Figure 4 shows the variations of yields (kg/ha) for the change in the base value (base value: 0.54) of initial light use efficiency for single leaf (PLEI) from –10% to +10%. As a result the fibre yield changes from 1700.74 kg/ha to 2160.61 kg/ha and this indicates that fibre yield is very much sensitive to initial light use efficiency for jute fibre production. This also indicates that the increase in initial light use efficiency increases the fibre yield production.

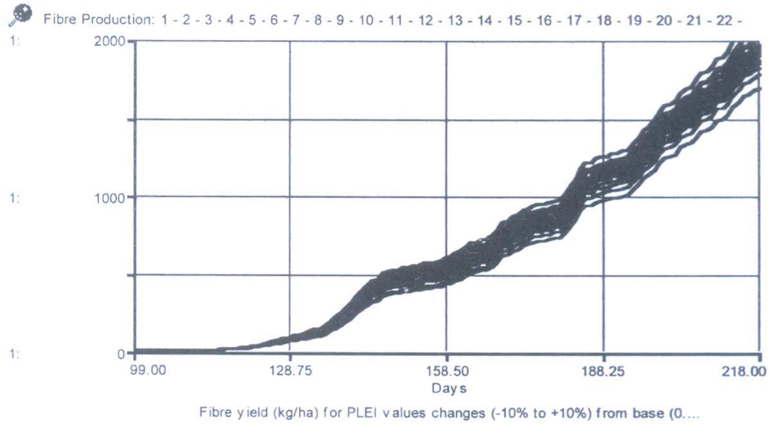


Fig. 4. Simulated fibre yields (kg/ha) for –10% to +10% changes in PLEI (Original value: 0.54)

Sensitivity analysis of fibre yield for maximum photosynthetic capacity for single leaf (PLMX) at standard leaf weight constant values are shown in Fig. 5. The pattern of changes of yields is similar to that of PLEI. But the yield changes within a narrow band (1786.17 kg/ha to 2084.78 kg/ha) compared to the changes in yield with the changes in initial light use efficiency.

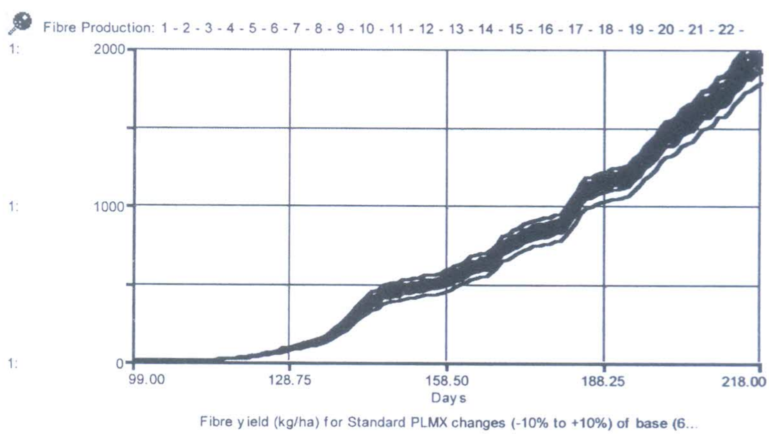


Fig. 5. Simulated fibre yields for –10% to +10% values of PLMX for standard leaf weight constant (Original value: 69.00)

Sensitivity of yield to the extinction coefficient of diffuses flux (k) changing the values of the extinction coefficient from –10% to +10% for a base value of 0.3015 are shown in Fig. 6 and it shows that the yield changes from 2071.85 kg/ha to 1859.84 kg/ha. Thus, the yield is not much sensitive to extinction coefficient.

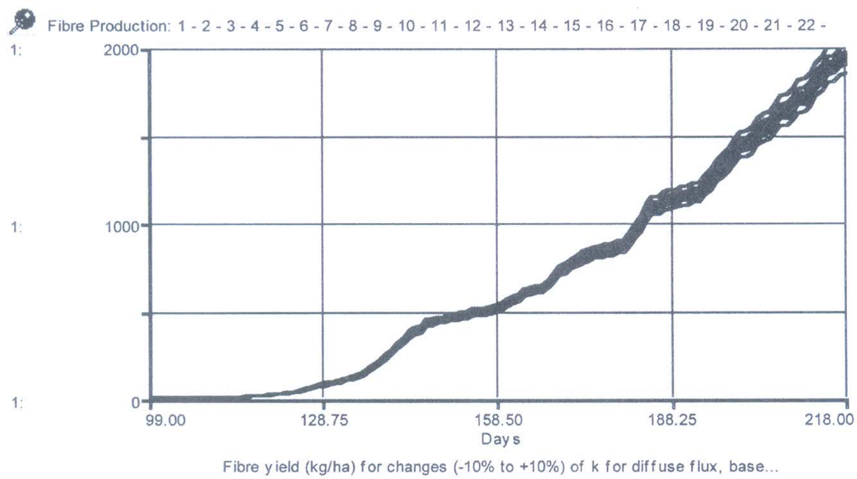


Fig. 6. Simulated fibre yields (kg/ha) for the –10% to +10% values of k for diffuse flux (Original value: 0.3015)

Figure 7 shows the sensitivity of fibre yield to the changes in crop development stage constant from -10% to +10%. Development Stage (DS) constant differentiate the whole crop development rate into two different development rates. It is seen from the Fig. 7 that the simulated yields (kg/ha) change very little due to the changes in crop development stage.

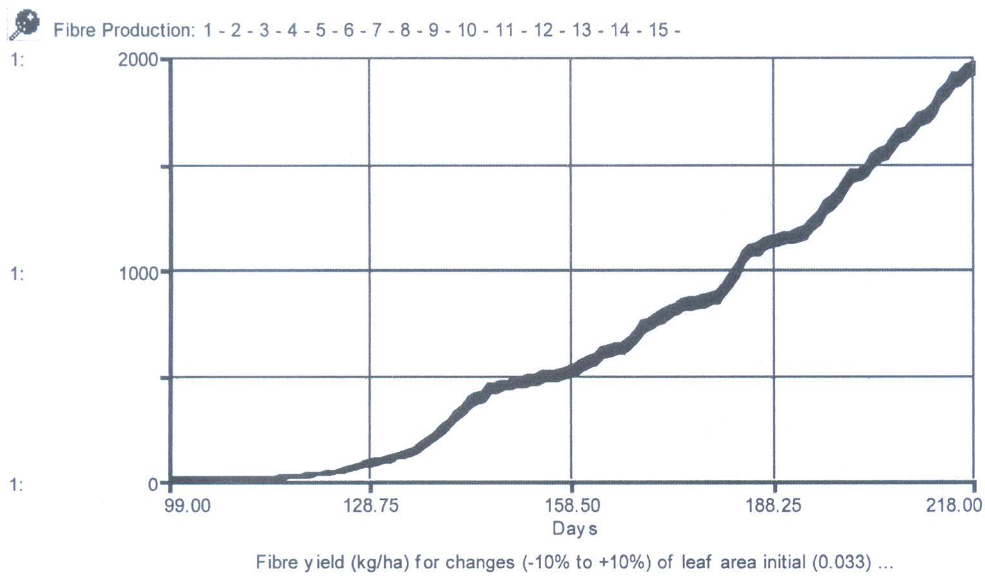


Fig. 7. Simulated fibre yield (kg/ha) for different values (-10% to +10%) of development stage constant (Original value: 0.45)

Figure 8 presents the simulated yield (kg/ha) variations due to the changes of initial Leaf Area (LA) value from -10% to +10% of initial value (0.033). Initial leaf area value is not a factor affecting the yield and thus the yield is insensitive to leaf area.

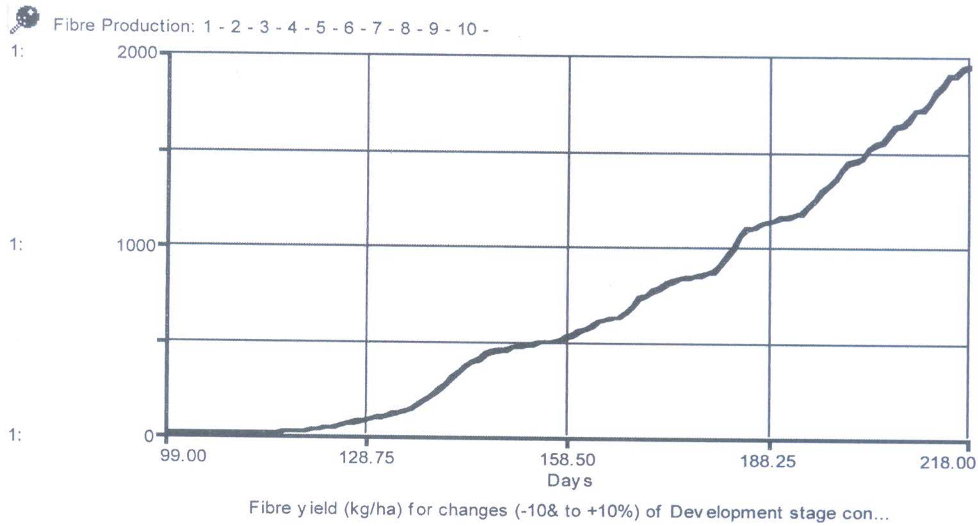
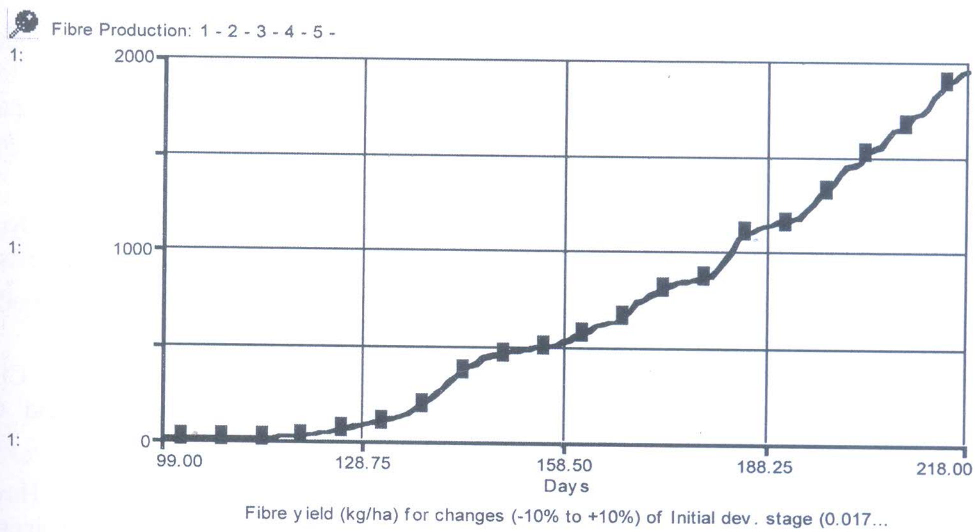


Fig. 8. Simulated yields (kg/ha) for initial values (-10% to +10%) of Leaf Area (LA) (Original value: 0.033)

Figure 9 shows the changes in fibre production with the changes (-10% to +10%) of the crop Development Stage



(DS), initial value of which is taken 0.017.

Fig. 9. Simulated fibre yield (kg/ha) for different values (-10% to +10%) of initial DS (Original value: 0.017)

It is seen from the Fig. 9 that almost no changes occurred in simulated fibre yield due to the changes (-10% to +10%) of the initial value for crop development stage. This indicates that the yield is insensitive to the changes in development stage.

It is seen from the table 1 that the yield changes (%) for the change in parameter values of PLEI, PLMX and k (-10% to +10%) are high and these parameters are highly sensitive, whereas initial leaf area value is less sensitive, and fifth and sixth parameters are not sensitive.

The development procedure of the model FIBGROW is well explained and showed competency in the procedure followed. The sensitivity analyses of the important parameters are examined and the initial light use efficiency, maximum rate of photosynthesis of single leaf, development stages were identified as the most sensitive parameters. Developed model FIBGROW of jute growth on impacts of climate change situation showed well competencies in respect of important parameter estimation. The model FIBGROW is an excellent tool for the potential production simulation of jute fibre crop. Predicted results of plant parts (leaf area, dry matter of leaf, root, bark and stick), fibre yield at the important AEZ, management strategies (plant population, sowing dates and their interactions) and climate change impacts on fibre production are presented in the articles "Validation and Performance Analysis of FIBGROW dynamic simulation model for jute growth at impacts of changing climate" and "Simulation and Application of FIBGROW dynamic growth model at impacts of climate change on jute production in Bangladesh" in this series.

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VALIDATION AND PERFORMANCE ANALYSIS OF FIBGROW DYNAMIC SIMULATION MODEL FOR JUTE GROWTH AT IMPACTS OF CHANGING CLIMATE

Md. Mujibur Rahman[1]
Bangladesh Jute Research Institute

ABSTRACT

The article presents the validation and performance analyses of the developed dynamic simulation model FIBGROW on jute production at changing climatic impacts. Threefold validation methods have deployed to compare the model simulated values with the experimentally observed data, model simulated values with the national statistics and management strategies with the reported values. The agreements between the simulated and observed or reported values showed reasonable good competencies. Simulated values of crop management strategies of plant density, sowing date, and their interactions and the predicted results agree well with the reported values which proved the performances of the model are good. Developed FIBGROW model is an excellent tool for predicting potential yields and management strategies on jute production at impacts of changing climate.

Key words: Dynamic model FIBGROW, performance analysis, model validation, management strategies.

INTRODUCTION

Climate change is a global issue and its relevance to jute production in Bangladesh is an important factor which needs extensive research work. Direct measurement of the effect of changing climatic parameters and greenhouse gas concentration on the plant growth is very expensive and huge time consuming event and almost infeasible. Plant growth simulation models are the essential, less costly alternatives in this case, and provide us with the opportunity to build different scenarios of agricultural production in the changed climatic conditions (Hussain *et al*., 2005). Plant growth models offer excellent opportunity to keep boundary conditions related with other abiotic stress on growth and development of the field crops.

Simulation models can assist in examining the effect of different scenarios of future development and climate change impacts on crop production. Several crop models are available such as CERES-Wheat, CROPGRO, SUCROS and APSIM. Jamieson *et al*. (1998) compared the predictions of five simulation models: AFRCWHEAT2, CERES-Wheat, Sirius, SUCROS2 and SWHEAT with measurements from wheat grown under drought. Four of the five models predicted the yield of the fully irrigated treatment to within 10%, and SWHEAT underestimated by more than 20%. However,

Wageningen Agricultural University crop growth model is also widely used. van Ittersum *et al*. (2003) reported a critical overview of Wageningen crop models and applications of the

[1] Chief Scientific Officer (cc), Jute Farming Systems Division, BJRI, Manik Mia Avenue, Dhaka-1207

Wageningen crop models. Aggarwal *et al.* (2006a & 2006b) developed InfoCrop: a dynamic simulation model for the assessment of crop yields, losses due to pests, and environmental impacts of agro-ecosystems in the tropical environments. Limited studies have been reported on plant growth modeling of fibre crops (Hasketh *et al.*, 1971&1972, Baker *et al.*, 1972, Carberry *et al.*, 1992a, 1992b & 1992c and Wall *et al.*, 1994) and most of them are on cotton. Carberry *et al.* (1992a, 1992b & 1992c) developed a computer simulation model NTKENAF (version 1.1) for kenaf (*Hibicus cannabinus* L) growth under rainfed conditions in tropical Australia. The model is based on CERES-Maize and it was used to assess the effect of sowing on phenology at different locations in tropical environment for biomass production.

Many studies have been reported on crop growth modeling and climate change impacts on the yields of crops (Changnon and Winstanley, 2000; Saseendran *et al.*, 2000; Van Oosterom *et al.*, 2001a & 2001b; Shepherd *et al.*, 2002; Southworth *et al.*, 2002; Van Oosterom *et al.*, 2002; Aggarwal, 2003; Changnon and Hollinger, 2003; De Costa *et al.*, 2003a & 2003b; Yang *et al.*, 2003; Asseng *et al.*, 2004; Mall *et al.*, 2004; Saseendran *et al.*, 2005; Aggarwal *et al.*, 2006a & 2006b; De Costa *et al.*, 2006; Leakey *et al.*, 2006; Ludwig and Asseng, 2006; Anwar, *et al.*, 2007; Motha, 2007; and Meza *et al.*, 2008 etc.) and limited studies have been reported on modeling of fibre crops (Wall *et al.*, 1994; Wu *et al.*, 2007; Carberry *et al.*, 1992; Carberry and Muchow, 1992a & 1992b and Pannangpeth *et al.*, 1993). But, no study has been reported on jute crop growth modeling and fibre yield simulation. The objectives of this study is to validate, performance and the management strategies analyses of jute growth FIBGROW model for production at impacts of climate change in Bangladesh.

MATERIALS AND METHODS

Threefold validation procedures have deployed to analyses the performances of the developed FIBGROW model (1) simulated dry matters are compared with the experimental values, (2) simulated fibre yield are compared with the national statistics and (3) simulated management options compared with the reported results which are described briefly in following section.

Field experiments were conducted in the Central Research Station (CRS) of Bangladesh Jute Research Institute (BJRI), Jagir, Manikgonj (56 km north-west of Dhaka metropolitan city), Bangladesh to determine biomass of the different components of jute plant during its growth. Data on plant height (cm), plant base diameter (mm), leaf area development (cm^2), leaf area index (LAI), plant total green weight (g/plant), green and dry matter weights (g/plant) for root, bark, stick and leaves as well as the plant total dry matter weights (g/plant) were collected at an interval of 10 days starting from the plant age of 20 days after emergence and continued until 120 days of plant age. Also final weights of jute fibre (kg/plot) and jute sticks (kg/plot) were recorded. The green components of the jute plants were dried in an electric oven at a temperature of 90 ^{o}C for 24 h and weights of the components measured with an electronic balance (Model XL-6100, accuracy ±0.01g, Denver Instruments, Bohemia, NY, USA). The leaf area of the jute plant was measured with an electronic leaf area meter (Model L1-COR, Inc., Lincoln, NB, USA). Daily weather data obtained from a weather station at the experimental site. Two sets of field experiments were conducted in each jute growing season in 2006 and 2007. Experimental data for two varieties of jute (*Corchorus capsularis* (cv. CVL-1) and *Corchorus olitorius* (cv. O-9897)) were collected based on split plot experimental design. Details of the experiments are given in Rahman (2010).

RESULTS

Plant leaf is the factory for CO_2 assimilation and plays the most important role for growth and development of the jute plants. Fig. 1 shows the predicted (simulated) and experimental dry matter of the leaves of jute plants. The leaf dry matter increases till 90^{th} days after emergence and approaches a value of 2800 kg/ha. The simulated results follow the patterns of the observed values and the agreement is very good.

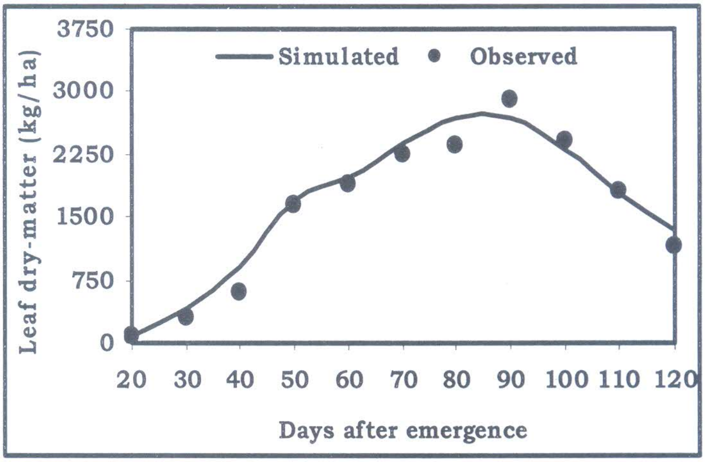

Fig. 1 Simulated and observed leaf dry matter of jute plants

Jute stick is an important commercial product used for fuel and fencing at farmer's level as well as production of building materials such as jutex. Fig. 2 shows the experimental and predicted results of stick dry matter of jute plants. The agreement between the predicted and experimental results is very good. The model prediction of the stick dry matter after 120 days of the development stage is excellent and it reaches a value of 6000 kg/ha.

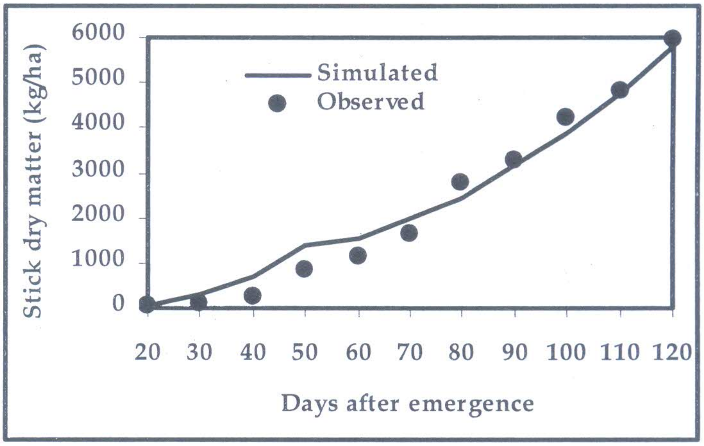

Fig. 2 Simulation and experimental values of stick (wood) dry matter of jute plants

Fig. 3 shows the simulated and observed root dry matter of jute plants. Root is important for jute plant and serves the purposes of anchorage and collection of nutrients (including water) from soil strata. The predicted (simulated) values agree well with the observed data and showed the good performance of the model FIBGROW developed for the purposes of simulating the yield of jute at changing climatic impacts.

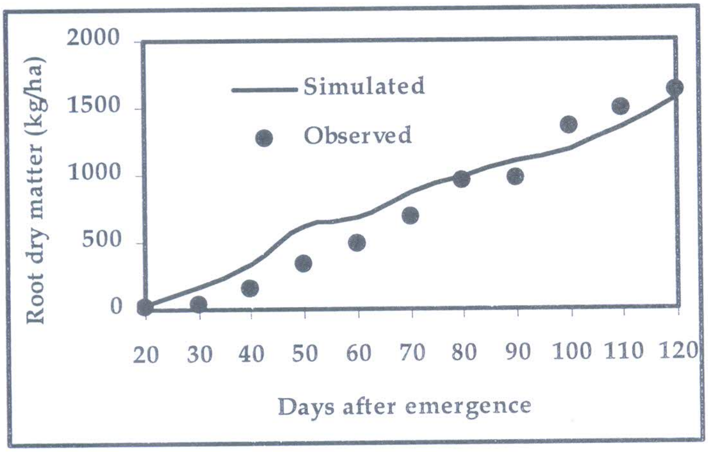

Fig. 3 Simulated and observed values of roots dry-matter of jute plants

Bark is the ultimate source of jute fibre. Fig. 4 shows the experimental and predicted results of bark dry matter of jute plants. The agreement between the predicted and experimental results is very good and the model predicts the dry matter of bark very well for all stages of the development. FIBGROW model can simulate jute growth very well.

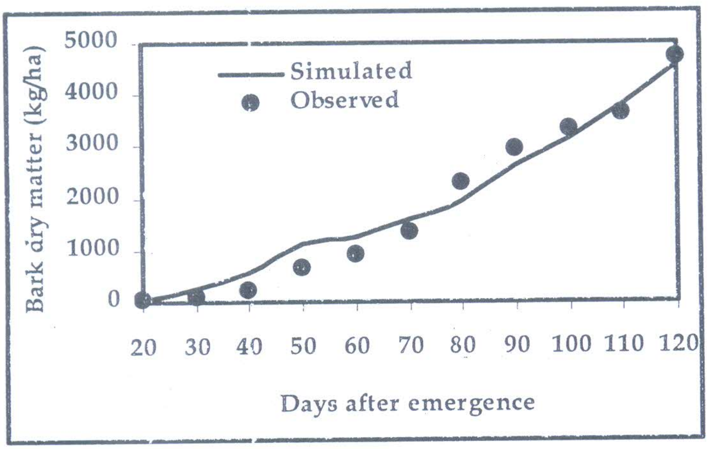

Fig. 4 Simulated and experimental values of the bark dry of jute plants

Mean Bias (Retta *et al.*, 1996; Willmott, 1982), Mean Absolute Bias or Error (Fox, 1981), Root Mean Square Error (Gabrielle and Kengni, 1996; Quemada and Cabrera, 1995), Relative Error (Loague and Green, 1991), and Index of Agreement (Willmott, 1982; Lecina *et al.*, 2003) with correlation of these two series of outputs are computed to indicate the overall model performance (Table 1).

Table -1: Indicators of the model performances

Performance indicator	**Dry matter (kg/ha)**			
	Bark	**Stick**	**Leaves**	**Root**
Mean Bias (MB, kg/ha)	71.35	53.77	76.99	10.30
Mean Absolute Bias (MAB, kg/ha)	249.87	321.08	144.53	198.85
Root Mean Square Error (RMSE, kg/ha)	275.89	383.99	175.01	241.21
Relative Error (RE, %)	15.10	16.62	11.07	30.31
Index of Agreement (IA)	0.9913	0.9914	0.9898	0.9532
Correlation Coefficient (R^2)	0.9889	0.9884	0.9800	0.9595
Rank	1 (17)	2 (14)	1 (17)	3 (13)

Note: Numbers inside the parentheses indicate the grading points.

DISCUSSION

Predictions for the different components of the jute plant were graded (Table 1) using a 4 point system in terms of six criteria (MB, MAB, RMSE, RE, IA and R^2). The cumulative grades for the six criteria then determined the rank. The purpose of this grading and ranking was to identify which component of the jute plant shows the best agreement between the simulated and observed results. Predictions of jute bark and leaves were jointly ranked first while the prediction of stick ranked second. The predictions of the model had the lowest MAB (144.53) with a high correlation coefficient (R^2=0.98) for leaves while the model predicted largest RE (30.31%) with a correlation coefficient of R^2=0.96 for root. This implies that leaf was predicted well than root. The IA and R^2 are close to 1 (0.96-0.99) for bark, stick leaves and root indicating FIBGROW model can explain well the dynamics of plant growth for all the components of the jute plants. The error terms were also small for all the components of the jute plant implying that the differences between the predicted (simulated) and observed values were also small. Thus, it may be concluded that the model predictions are good.

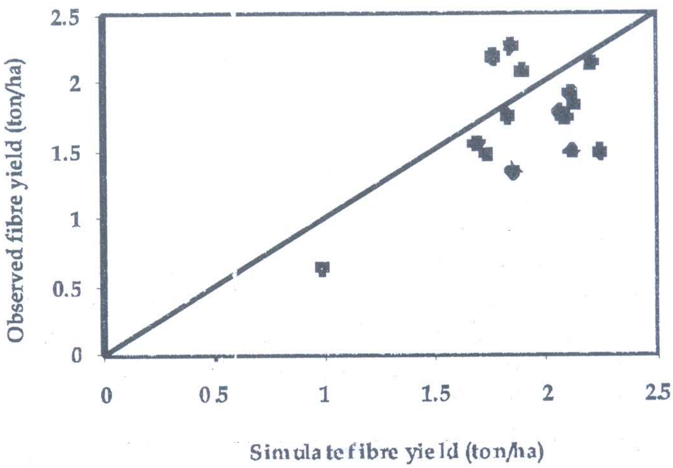

Fig. 5 Comparison of the simulated and locally observed fibre yields at different locations of Bangladesh

Figure 5 shows the comparisons between the simulated and observed fibre yields for the important jute growing areas of Bangladesh (Dhaka, Mymensingh, Faridpur, Tangail, Comilla, Sylhet, Rangamati, Jessore, Khulna, Barisal, Patuakhali, Rangpur, Dinajpur, Rajshahi and Bogra). It is evident from the Fig. 5 that the simulated fibre yields are close to the observed yields at different locations. This comparison demonstrates the good performance of the model FIBGROW.

Table 2 shows the model performance for simulated yields for 15 different important jute growing areas of Bangladesh to those of the national reported averages of 2001 to 2005 (BBS, 2006). Statistical indicators of the model performance for the simulated yields at the different agro-ecological important locations of Bangladesh to those of the reported (Average of 2001-2005) yields showed closeness with Mean Bias: 0.1893 (t/ha), Mean Absolute Error: 0.3277 (t/ha), Root Mean Square Error: 0.3794 (t/ha), Relative Error: 22.14%, and overall with a good agreement to the observed values (0.7244). But the value of their correlation coefficient is fare (0.5898). Statistical analysis of the model simulated fibre yield potential to the field observation (BBS, 2006) yields for the 15 different locations of Bangladesh were showed acceptable accuracy and precision (Loague and Green, 1991) indicated the model, to be a good representation of the reality in fulfilling the pre-defined objectives.

Table 2 Indicator of the model performance for the fibre yields (Simulated and Reported)

Sl. No.	Performance Indicators	Values
1.	Mean Bias (ton/ha)	0.1893
2.	Mean Absolute Bias or Error (ton/ha)	0.3277
3.	Root Mean Square Error (ton/ha)	0.3794
4.	Relative Error (%)	22.142
5.	Index of Agreement	0.7244
6.	Correlation between observed and simulated values	0.5898

Management strategies

Management strategies are very important for crop production processes to obtain a reasonable good yield by overcoming the multidimensional vulnerabilities (Hussein *et al.*, 1988). Since the model is developed for the potential yield of jute fibre, some important crop management options were considered. Among the crop management strategies (i) date of sowing, (ii) plant densities and (iii) interaction effect of these two strategies were studied using model FIBGROW and these are described in the following sub-sections.

Plant density

Density of jute plant in the field plays an important role (competition for light) in fibre yield (Hussein *et al.*, 1988). Optimum numbers of plants should be in the crop field for increased fibre yield, which is also cultivar specific (Ahmed *et al.*, 1996; Rahman *et al.*, 2000-2003). The simulated fibre yields for different plant density along with experimental data are presented in Fig. 6. It is evident from the Fig. 6 that the yields (kg/ha) increases with the increase of plant density and the trend follow a logarithmic relationship:

$$F = 808.06Ln(x) - 2261.80 \qquad r^2 = 0.9867 \qquad (1)$$

where x is the plant density ('000 plant/ha).

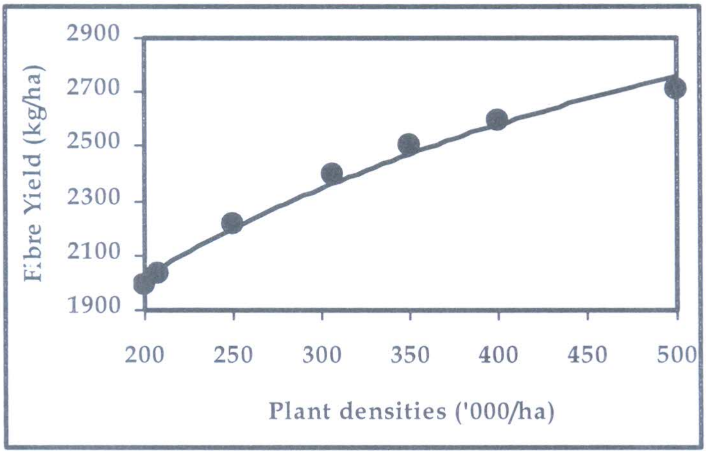

Fig. 6 Simulated fibre yield for different plant densities and experimental data

In fact, the high density of plant in the crop field accelerates competition for light among the plants. As a result the yield is reduced (Damgaard, 2004). Simulated fibre yields (kg/ha) for higher plant densities are presented in the Fig. 7.

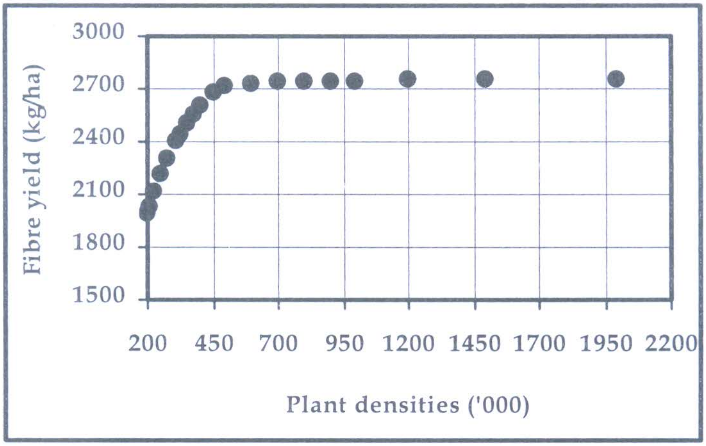

Fig. 7 Simulated fibre yield for different plant densities

It is seen from the Fig. 7 that the simulated fibre yield increases up to the density of 500,000 plants/ha and the yield becomes independent (yield not increase) for further increase in plant density (Equation 1).

Date of Sowing

Date of sowing (timely sowing) for jute seed is another important crop management strategy in the jute fibre production process. Being a photosensitive crop, yield of jute fibre is highly dependent on day light hours and associated maximum and minimum temperatures (Husain, 1977). Prolonged day light hours and high temperature differences causes early flowering of jute crop, which reduces the yield seriously (Husain, 1977; Khandakar *et al.*, 1998-1999; Rahman, 1988). Fig. 8 shows the simulated fibre production (kg/ha) for different sowing date of jute seed.

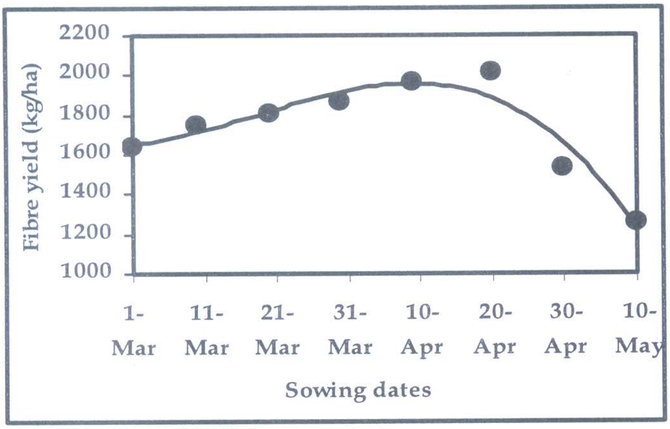

Fig. 8 Simulated potential fibre yields for different sowing dates

It is evident from the Fig. 8 that the optimum time of sowing is from March 31 to April 20 and these finding agree with the optimum sowing time suggested by different researchers (Husain, 1977; Khandakar *et al.*, 1998-1999; Rahman, 1988; Hussein *et al.*, 1988). The trend of fibre yield dependency on sowing date follows the relationship:

$$F = -0.001x^3 + 948.79x^2 - 3.75\times10^7 x + 4.94\times10^{11} \quad r^2 = 0.9117 \qquad \textbf{(2)}$$

where x stands for sowing date.

Effects of plant density and sowing date

It is important to know the combined effects of sowing date and the density of plant on fibre yield. Simulated combined effects of plant density and sowing date on fibre yield are shown in Fig. 9.

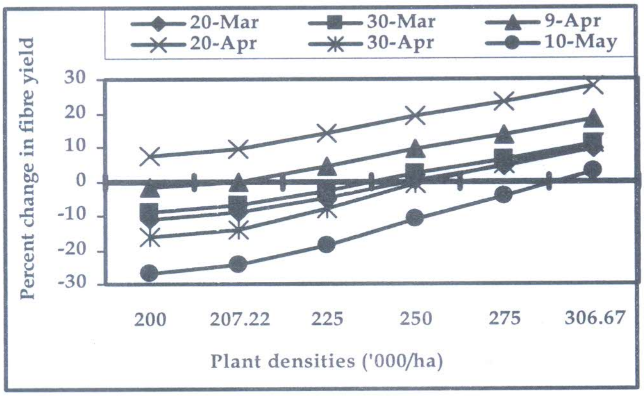

Fig. 9 Fibre yield dependency on sowing dates and plant densities

It is seen from the Fig. 9 that the overall tendency is that the fibre yield increases with the increase in plant density for all the sowing dates. But the yields for sowing date on 10^{th} May are lower than the yield on the base year for all the plant densities except the plant density of 306,670 per ha, for which the yield is slightly higher. This suggests that for late sowing in May 10 the plant density must be higher (≥306670 plants/ha). However, it is evident that the optimum sowing time is April 09 to April 20.

The performance analyses of the important aspects are examined and compared the model simulated values with the experimented, observed and national statistics available. The model was validated using threefold simulation process of dry-matter, potential fibre yield for important jute growing areas and important management strategies of jute production systems. Developed model FIBGROW of jute growth simulated the dry-matters, fibre production and jute production management strategies very well. The model FIBGROW is an excellent tool for the potential production simulation of jute fibre crop in the changing climatic condition. The development procedure of the model FIBGROW is well explained in the articles "Development, Description and Sensitivity Analysis of FIBGROW dynamic simulation model for jute growth at impacts of changing climate" and showed competency in the procedure followed. Predicted climate change impacts on fibre production are presented in the article "Simulation and Application of FIBGROW dynamic growth model at impacts of climate change on jute production in Bangladesh" in this series.

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SIMULATION AND APPLICATION OF FIBGROW DYNAMIC GROWTH MODEL AT IMPACTS OF CLIMATE CHANGE ON JUTE PRODUCTION IN BANGLADESH

Md. Mujibur Rahman[1]

ABSTRACT

The article presents the impacts of climate change on the jute production in Bangladesh. Jute growth model FIBGROW is used for the simulation of the fibre yield in climate changes scenarios. Sole effects as well as the interaction effects of prime climatic parameters, solar radiation, maximum-minimum temperatures and concentration of CO_2 are considered in the study. Sixteen treatment combinations of temperature increases (0°C, +1°C, +2°C, and +3°C) and solar radiation changes (0%, +5%, +10%, and -5%) and twenty treatment combinations of CO_2 concentrations (390, 440, 490, 540 and 640 ppm) with the increase in average temperatures (0°C, +1°C, +2°C and +3°C) were considered for fibre yield simulation. Increased fibre yield was simulated for the higher solar radiation and elevated CO_2 concentrations for 1°C increase in temperature but fibre yield decreased for the temperature rise of 2°C and 3°C. Fibre yields were also simulated decadewise climatic variabilities up to 2100 AD using the climate change prediction scenarios of IPCC and different GCMs. Fibre yields of jute are more or less same up to 2030. Simulated fibre yields for the predicted climate change scenarios showed a clear tendency of decreasing yield after 2030, which eventually falls down to 57.54% at the end of this century.

Key words : Climate change, jute production, simulation and reduction of fibre yield.

INTRODUCTION

Bangladesh lies between the latitude 20° 34'-26° 38' north and longitude 88° 01'-92° 41' east with an average altitude of 12 m MSL and it is classified as the humid-tropical zone of the world climate. The climate of Bangladesh is dominated by southwest and northeast monsoons. Here temperature variations are relatively small, but important (Warrick *et al.*, 1996). If, as expected, the population of Bangladesh doubles in the next 30 years, enormous pressure will be hoisted on the already limited land resources; this can only exacerbate existing vulnerability to climate variability (Rahman and Bala, 2007). Small changes in climate, therefore, could potentially have a much greater relative impact in Bangladesh. Since solar radiation is the prime driving factor to the crop growth and productivity, decrease of it will significantly reduce agricultural productivity (Aggarwal, 2003). The accompanied increase in minimum temperature will increase maintenance respiration requirement of the crops and thus further reduction of net growth and productivity will be committed (Rahman, 2010). The bottom-line conclusion of the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) is that the average global surface temperature will increase by between 1.4°C and 3.0°C above 1990 levels by 2100 AD for

[1] CSO, JFSD, Bangladesh Jute Research Institute.

low emission scenarios and between 2.5°C and 5.8°C for higher emission scenarios of greenhouse gasses and aerosols in the atmosphere. The concentration of CO_2, [CO_2] was in the steady state at 280 volume parts per million (ppm) till the pre-industrial period (1850). It is rising since then at the rate of 1.5 to 1.8 ppm per year. The [CO_2] is likely to be doubled by the end of this century. The increasing [CO_2] in the atmosphere and intercepted climate change due to global warming are likely to affect future global agricultural production through changes in rate of plant growth.

Because crop growth and development respond dynamically to daily weather conditions and exhibit threshold responses to extreme events, these changes are likely to produce significant impacts on agricultural productivity and global food and fibre production. For this reason the assessment of the impacts that future climatic conditions may have on agricultural productivity, and the information for agricultural scientists and policy makers. Jute is one of the main cash crops for most of the farmers and also agriculture still stands as the largest economic as well as the biggest labor employing sector in Bangladesh. Jute is cultivated in almost every districts of Bangladesh with a limited option for the northeast hilly and southern coastal areas. Jute cultivation needs both humid and temperate weather in conjuncture which prevails in March to September at *Kharif-1* and *Kharif-2* (summer) seasons all over the country. Hence, the best quality of jute fibre is produced in Bangladesh. Jute is biodegradable and environment friendly hence, further opportunity for jute is knocking at the door of replacing artificial fibre because, artificial fibres creates environmental pollution and human health hazards (Rahman and Bala, 2009).

Global climate change and its relevance to jute production in Bangladesh is an important issue which needs extensive research work. Direct measurement of the effect of changing climatic parameters and greenhouse gas concentrations on the crop growth is very expensive and huge time consuming as well, which even may not be feasible (Hussain *et al.*, 2005). Crop growth simulation models are the inexpensive and less time consuming best alternative (Bala, 1999) and also provide us with the opportunity to construct different scenarios of agricultural production for changing climatic conditions. Several studies have been reported on climate change impacts on rice (Karim *et al.*, 1996; Aggarwal, *et al.*, 1997; Saseendrain *et al.*, 2005 and De Silva *et al.*, 2007), wheat (Aggarwal *et al.*, 2006a and 2006b; Ludwig and Asseng, 2006; Anwar, *et al.*, 2007; Sultana *et al.*, 2009; and Wang *et al.*, 2009) and maize (Xiong *et al.*, 2007 and Meza *et al*, 2008). Many studies have been reported on crop growth modeling and climate change impacts on the yields of crops (Changnon and Winstanley, 2000; Saseendran *et al.*, 2000; Van Oosterom *et al.*, 2001a & 2001b; Shepherd *et al.*, 2002; Southworth *et al.*, 2002; Van Oosterom *et al.*, 2002; Aggarwal, 2003; Changnon and Hollinger, 2003; De Costa *et al.*, 2003a & 2003b; Yang *et al.*, 2003; Asseng *et al.*, 2004; Mall *et al.*, 2004; Saseendran *et al.*, 2005; Aggarwal *et al.*, 2006a & 2006b; De Costa *et al.*, 2006; Leakey *et al.*, 2006; Ludwig and Asseng, 2006; Anwar, *et al.*, 2007; Motha, 2007; Ludwig *et al.*, 2008 and Meza *et al.*, 2008 etc.). Several studies have been reported on cotton (Wall *et al.*, 1994; Wu *et al.*, 2007), and bast fibre crop kenaf and roselle (Carberry *et al.*, 1992; Carberry and Muchow, 1992a & 1992b and Pannangpeth *et al.*, 1993). But, no study has been reported on climate change impacts on jute. FIBGROW model is the only study conducted so far on jute yield simulation on climate change impact scenarios (Rahman, 2010). The objective of the present study is to predict the future climate change impacts on jute production in Bangladesh using the model FIBGROW.

MATERIALS AND METHODS

The model FIBGROW is a process based system dynamics model developed for simulation of fibre production. Detail description of the model FIBGROW is given in the paper of model development and performance analyses in this series. The model FIBGROW takes into account the changes in solar radiation, maximum, minimum and average temperatures by default. The changes in [CO_2] are incorporated in the model FIBGROW as a growth multiplier of [CO_2] i.e., growth rate multiplier of jute plant as a function of [CO_2]. Relationship between PLMX and the [CO_2] growth multiplier is (Goudriaan *et al.*, 1985):

$$PLMX_x = PLMX_0 \{1 + \beta \times Ln(C_x \div C_0)\} \qquad \textbf{(1)}$$

where C stands for [CO_2], subscript 0 for base (2006 value: 390 ppm), PLMX is the maximum rate of photosynthesis for single leaf, 0 for base and x for new (changed) values and β is about 0.8 for C_3 crops.

Temperature is one of the important driving climatic parameters and it affects each and every step of crop growth and development (crop physiology and phenology) process (Palit and Bhattacharyya, 1987). Current national average maximum, minimum and day time temperatures (°C) at jute growing seasons are shown in table 1.

Table-1. National average current temperature for jute growing season

Parameter	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Maximum Temperature (°C)	31.76	33.20	32.86	31.68	31.04	31.26	31.53	31.33
Minimum Temperature (°C)	19.65	23.20	24.55	25.51	25.60	25.69	25.38	23.65
Day time Temperature (°C)	28.73	30.70	30.78	30.14	29.68	29.87	29.99	29.41

Source: BARC, 2006.

Temperature rise

Fussel *et al.* (2003) reported Annual Global Mean Temperature (AGMT) in 21 steps from the baseline value up to a $1.6 \times \Delta T_{2 \times CO_2}$ warmer climate. This range corresponds to 4.5°C for both the GCMs (CIRF: Fussel *et al.*, 2003 and HadCM3: Meza *et al.*, 2008). The simulated future temperatures and differences with reference to the present condition at nearest sea level to Bangladesh were presented by Biswas (2000). Average, maximum and minimum temperatures considered for the climate change impacts on jute production are shown in table 2.

Table-2. Temperature change scenario for climate change

Parameter	Base year (2006)	Future Temperature						
Average Temperature (°C)	29.02	29.5	30.5	31.5	32.5	33.5	34.5	35.5
Minimum Temperature (°C)	24.79	25	26	27	28	29	30	31
Maximum Temperature (°C)	33.26	34	35	36	37	38	39	40

Solar radiation is another driving climatic parameter for crop growth and development process. Carbon dioxide assimilated by the plant leaves is synthesized to the plant structural tissues with the help of solar energy (Photosynthetically Active Radiation, PAR). National average solar radiation of Bangladesh ($MJm^{-2}d^{-1}$) for the jute growing season is shown in Fig. 1.

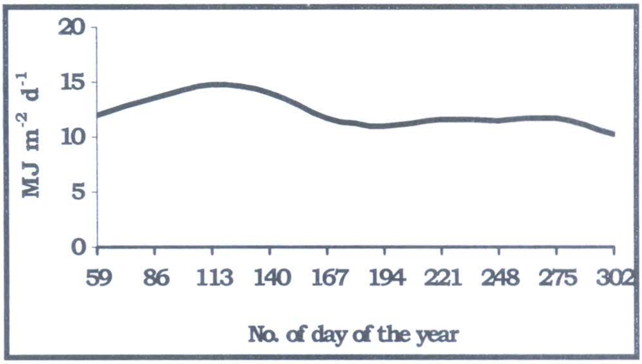

Fig. 1. National average seasonal solar radiation (BARC, 2006)

Solar radiation change

Solar radiation reaching the earth are changed by aerosols, dust etc. Salam (1992) expressed it as the bright sunshine hours. Future change of solar radiation is considered for simulation of jute production as presented in the table 3.

Table-3. Solar radiation change scenario for climate change

Parameter	Base year (2006)	Future solar radiation							
Solar radiation ($MJm^{-2}d^{-1}$)	12.74	13	14	15	16	17	18	19	20

CO_2 concentration: Carbon is the main component of the plant structural tissue, which derived through a complex biochemical process from CO_2 absorbed by plant leaves from ambient air. Hence [CO_2] in the ambient air is very important for crop production system. Concentration of CO_2 in the ambient air is in general optimum condition, and the present value of it is 390 ppm.

CO_2 concentration increase

Several studies have been conducted throughout western and northern Europe and all of them reported significant increases in plant growth and productivity for the increase in [CO_2] (Wittwer, 1995; Allen *et al.*, 1987). However, plant species differ in their response to CO_2 fertilization, C_3 plants will be benefited from increased atmospheric CO_2 concentration. The primary reason is that the increased atmospheric [CO_2] will reduce photo respiratory loss of carbon in the C_3 plant, thus enhancing plant growth and productivity (Aggarwal, 2003). The [CO_2] are considered in 23 steps from 325 (the average concentration of the year 1970 used as the reference value) up to 1200 ppm at the end of this century (Fussel *et al.*, 2003).

As the [CO_2] is increasing 1.5 to 1.8 ppm per year, it is likely to be doubled in 2100. In the present study 390 ppm is the concentration of CO_2 for the base year (2006) and future increments are considered up to 640 ppm. The consequences of high [CO_2] on crops are simulated by incorporating PLMX as a function of the ratio of new [CO_2] and [CO_2] level in 2006. PLMX values along with the increase of [CO_2] are presented in the table 4.

Table-4. Carbon dioxide concentration and PLMX values

Base year (2006)		**Future CO_2 concentration**				
CO_2 concentration (ppm)	*390*	440	490	540	590	640
PLMX (kg CO_2 $ha^{-1}h^{-1}$)	69	77	83	89	94	103.92

Interaction of temperature with solar radiation: As both temperature and solar radiation are simultaneously affected by the climate change and both of these are important for fibre yield prediction, the interaction of these two parameters is studied taking 1, 2 and 3°C increment of temperature with –5, 5, and 10% increment of solar radiation.

Interaction of temperature with [CO_2]: Increased temperature reduces the fibre yield, but [CO_2] increment is beneficiary to the C_3 plant like jute, hence the interaction effect of these two is important. For 1, 2 and 3°C rise of temperature and 440, 490, 540, and 640 ppm of [CO_2], the interaction effects on jute fibre production are simulated.

Climate change impacts up to 2100 AD

Fibre yield prediction for decade wise climate change scenarios of temperature, solar radiation and [CO_2] up to the end of this century (2100 AD) have also conducted using FIBGROW model. Table 5 shows the temperatures, solar radiation and [CO_2] changes for climate changes based on recent publication of International Panel of Climate Change (IPCC, 2007), different GCMs and available literatures. Then, the fibre yields are simulated for these changes.

Table-5. Decade wise temperature, solar radiation and concentration of CO_2 changes for climate change

Climate Change	Year									
Parameters	2006	2020	2030	2040	2050	2060	2070	2080	2090	2100
Maximum Temperature (°C)	33.26	34.01	34.76	35.51	36.26	37.00	37.76	38.50	39.25	40.00
Minimum Temperature (°C)	24.79	25.48	26.17	26.86	27.55	28.24	28.93	29.62	30.31	31.00
Solar Radiation ($MJm^{-2}d^{-1}$)	12.74	13.55	14.35	15.16	15.97	16.77	16.97	17.77	19.19	20
CO_2 concentration (ppm)	390	406.67	423.33	440	456.67	473.33	490	506.67	523.33	540

RESULTS

Individual effects as well as interactions among the prime climatic variables i.e. solar radiation, temperature and [CO_2] with the different combinations as treatments on fibre yields were evaluated using FIBGROW model. There were 16 treatment combinations of temperature increase (0°C, +1°C, +2°C, and +3°C) and solar radiation change (0%, +5%, +10%, and -5%) and 20 combinations of [CO_2] (390, 440, 490, 540 and 640 ppm) and temperature increase (0°C, +1°C, +2°C, and +3°C). Results of these climate changes can be well linked to any climate change scenario to evaluate the impacts of climate change on the fibre productivity in Bangladesh. Being a photoperiod sensitive short-day crop, the temperature would play a decisive role in altering the jute growth physiology (Khandakar *et al*., 1998-99).

Seasonal average temperature of the year 2006 at the field experimentation site at CRS, Manikgonj was 29.02 °C, and the simulated fibre yield for this average base temperature was 1958.60 kg/ha. The simulated results shows that the fibre yield increases by 3.37% for an increase of average temperature to 29.5 °C, but the yields decrease by 8.08, 21.71, 36.37, 53.61, 70.83 and 84.94% respectively for further every 1°C increase in the average temperature up to 35.5 °C. Thus, the influence of average temperature rise due to climate change is negative and it would significantly affect the jute production in Bangladesh. This reduction of fibre yield with the rise in average temperature is shown in Fig. 2, and the trend of yield reduction can be expressed by the equation 2.

$$Fibre\_yield = -16.59x^2 + 793.27x - 7007.60 \qquad (2)$$

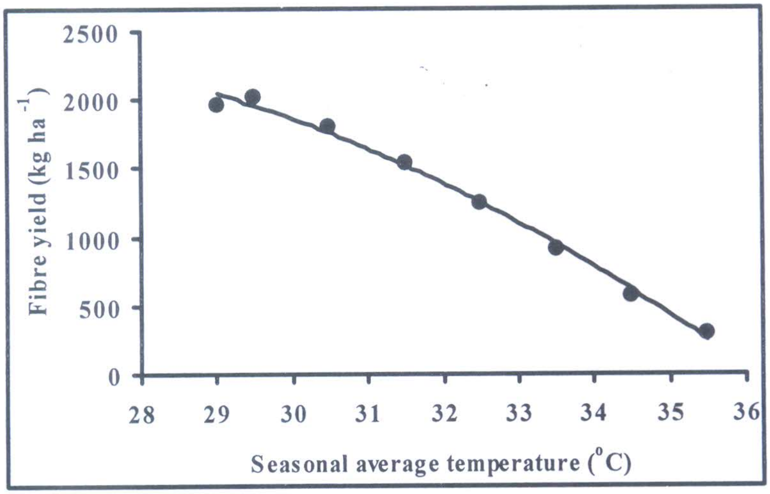

Fig.2. Fibre productivity with seasonal average temperature

Fibre yield reductions are also simulated for maximum and minimum temperature changes. Maximum temperature (average of the entire jute growing season) for the base year (2006) was 33.26°C and the fibre yield simulated for this temperature was 2097 kg/ha. Fibre yield decreases by 5.19% for an increase of maximum temperature to 34°C and this decreasing trend continues (Fig. 3). Fibre yields decreased by 13.06, 22.47, 32.45, 43.07, 54.86 and

66.74% for every 1°C rise in the maximum temperature up to 40°C according to the yield decreasing pattern of equation 3.

$$Fibre\_yield = -8.87x^2 + 440.87x - 2745.90 \quad (3)$$

Thus the influence of maximum temperature due to climate change is also negative and the increase of maximum temperature due to the future climate change would significantly affect the jute production in Bangladesh.

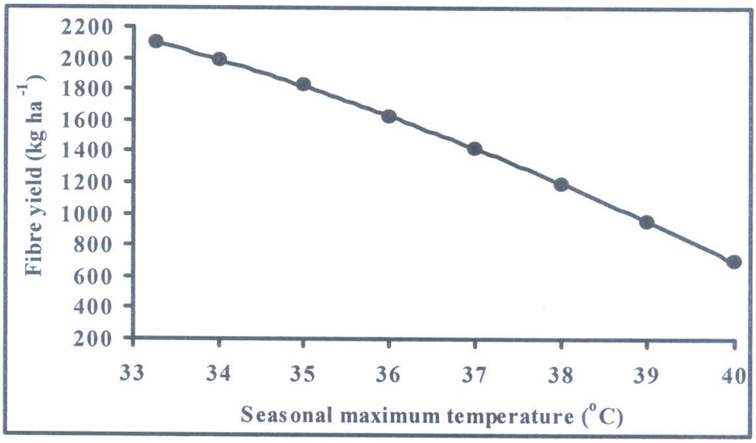

Fig. 3. Seasonal maximum temperature dependence on fibre productivity

Seasonal (average) minimum temperature for the base year (2006) at the experimental site was 24.79°C. Model simulated fibre yield for this minimum temperature was 2004.16 kg/ha (base yield). Decreasing trend is simulated in the fibre yield for increase in minimum temperature to 25°C, and it was 1993.57 kg/ha (0.53% less from the base yield of 2006). Fibre yield decreases by 3.14, 5.96, 8.94, 11.96, 15.14 and 18.43% for further every 1°C rise of the seasonal minimum temperature up to 31°C (Fig. 4).

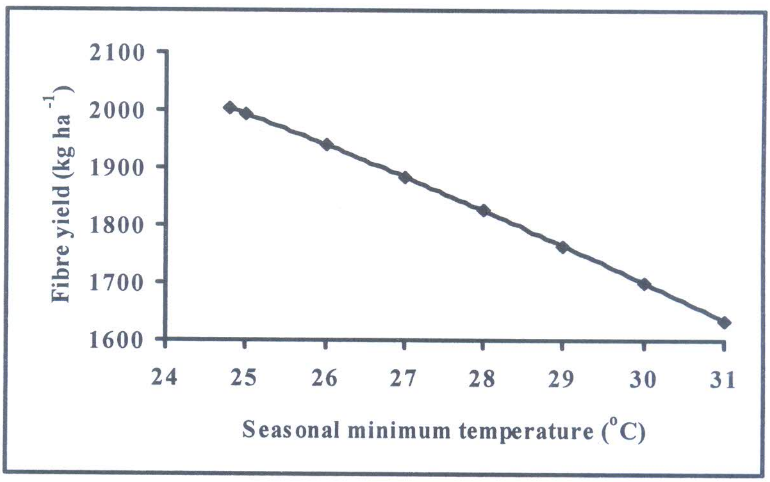

Fig. 4. Seasonal minimum temperature dependence on fibre yield

This gradual rises of minimum temperatures with the climate change scenario would significantly affect the jute production system in Bangladesh. The trend of decrease of fibre yield with minimum temperature rise can be expressed by the equation 4.

$$Fibre\_yield = -1.29x^2 + 12.16x + 2493.30 \quad (4)$$

The average solar radiation for the jute growing season in 2006 (base year) was 12.74 MJ $m^{-2}d^{-1}$, and simulated fibre yield for this average solar radiation was 1685.38 kg/ha. Fibre yield increases for 1 $MJm^{-2}d^{-1}$ increase in solar radiation up to 20 $MJm^{-2}d^{-1}$ were simulated. Simulated fibre yield increments are 3.43% to 63.70% for 13 to 20 $MJm^{-2}d^{-1}$ solar radiations as shown in Fig. 5. The trend of fibre yield increment with the increase of solar radiation follows a logarithmic pattern of equation 5.

$$Fibre\_yield = 2383.70 \times Ln(x) - 4349.70 \quad (5)$$

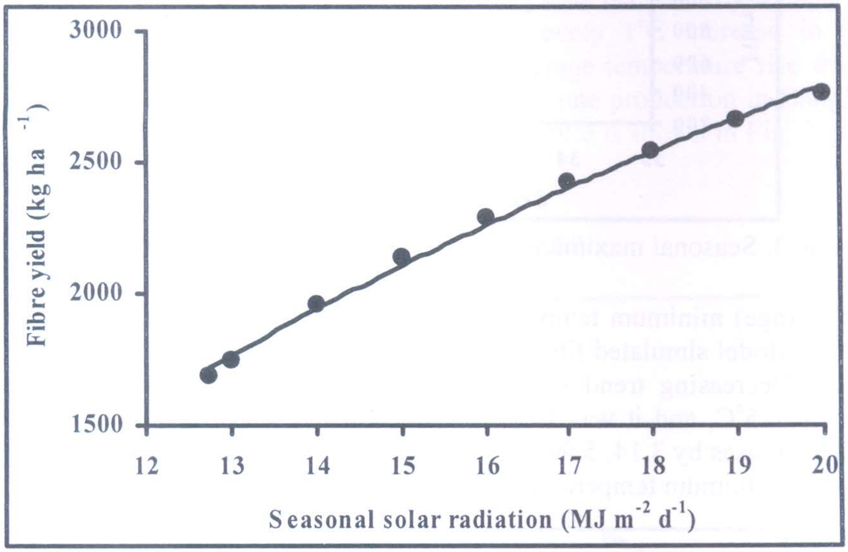

Fig. 5. Solar radiation increase impact on fibre yield

The concentration of carbon dioxide, [CO_2] is increasing day by day. The effects of [CO_2] on fibre yield were simulated for elevated [CO_2] and the simulated results are presented in Fig. 6. Increase in fibre yield by 3.84% was simulated for the increase in [CO_2] from the base value (2006) of 390 ppm to the 440 ppm. Fibre yield increases of 7.09, 9.47, 13.50 and 16.25% for the increase in [CO_2] of 490, 540, 640 and 740 ppm respectively were simulated. The increase in fibre yield with the increasing [CO_2] follows a logarithmic trend of equation 6.

$$Fibre\_yield = 531.29 \times Ln(x) - 1053 \quad (6)$$

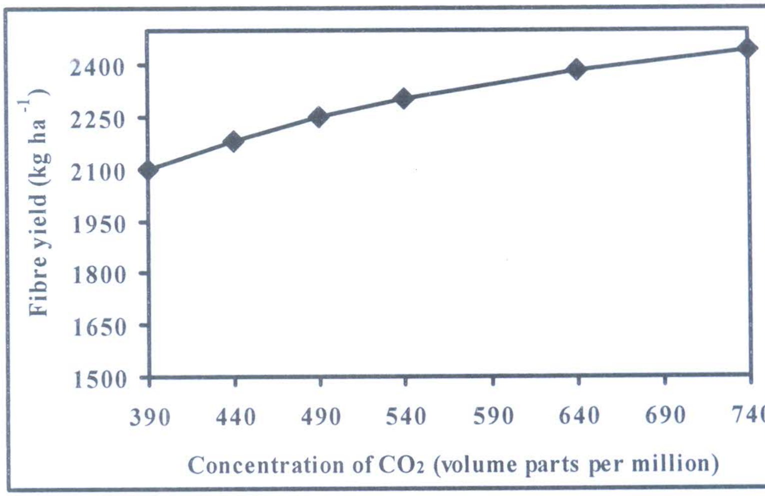

Fig. 6. CO_2 concentration rise impact on fibre productivity

DISCUSSION

The interactions of the climatic variables (temperatures, solar radiation and [CO_2]) are important. Sixteen treatment combinations of temperature increase (0°C, +1°C, +2°C, and +3°C) and solar radiation changed (0%, +5%, +10%, and -5%) were considered for fibre yield simulations. Fibre yields simulated by FIBGROW model for the interaction effect of temperature and solar radiation are shown in Fig. 7.

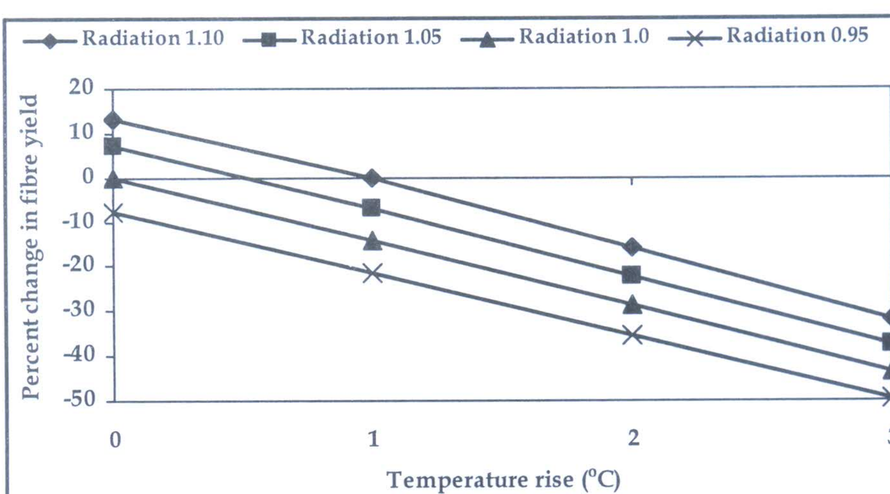

Fig. 7. Temperature rise in changing solar radiation effect on fibre yield

Simulated fibre yields increases by 7.05% and 12.98% for +5% and +10% solar radiation respectively, but decreases by 7.88% for -5% solar radiation and at 0°C rise (i.e., no rise) in temperature. Fibre yields are reduced by 0.14%, 6.93%, 14.1% and 21.56% for increase in solar radiation by +10%, +5%, 0% and -5% respectively for further temperature rise of 1°C.

Fibre yield reduced by 15.68%, 22.05%, 28.73% and 35.58% for +10%, +5%, 0% and -5% solar radiation levels respectively for 2°C rise in temperature and for 3°C rise of temperature yields are reduced by 31.91%, 37.66%, 43.60% and 49.60% for +10%, +5%, 0% and -5% solar radiation respectively. Fig. 7 indicates that the higher radiation levels with the rise in temperature (+1°C, +2°C, and +3°C) have reduction effects on jute production in Bangladesh.

Elevated [CO_2] increases the yield but the average temperature increases reduces the yield. Twenty combinations of CO_2 concentration (390, 440, 490, 540 and 640 ppm) and average temperature rise (+0, +1, +2 and +3°C) were considered to simulate the yields of jute and the simulated yields are shown in Fig. 8. Fibre yields increases by 5.23%, 8.49%, 11.34% and 13.43% for the elevated [CO_2] of 440, 490, 540 and 640 ppm respectively at the base temperature of 29.02 °C (zero increase in temperature). Fibre yields also increases by 2.72% and 4.93% in the elevated [CO_2] of 540 and 640 ppm for 1°C rise of temperature. But, the fibre yield reduces by 9.74% for 390 ppm [CO_2], by 3.78% for 440 ppm [CO_2] and 0.27% for 490 ppm. Fibre yields again decreases by 22.22%, 14.48%, 10.04%, 6.61% and 4.20% for CO_2 concentrations of 390, 440, 490, 540 and 640 ppm levels respectively for a 2°C rise of temperature. Decreased fibre yields were also simulated for the temperature rise of 3°C by 36.05%, 27.88%, 22.67%, 18.12% and 14.83% for [CO_2] of 390, 440, 490, 540 and 640 ppm respectively. From the Fig. 8 it is evident that the higher [CO_2] levels with the rise in temperature (+1°C, +2°C, and +3°C) has reduction effects on jute fibre production in Bangladesh.

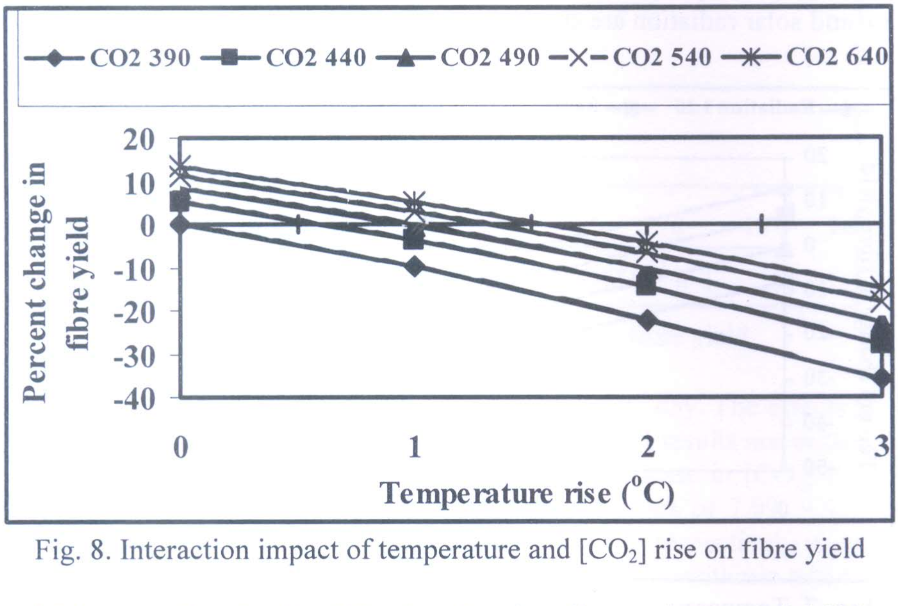

Fig. 8. Interaction impact of temperature and [CO_2] rise on fibre yield

Jute fibre yields were also simulated for decade wise climate change variabilities up to the 2100 AD for the climate change prediction scenarios (Table 5) using the model FIBGROW and the simulated results are presented in the Fig. 9. Fibre yields are almost same up to 2030 (Fig. 9), which indicates that jute as a C_3 crop utilizes the benefits of elevated [CO_2] at 423 ppm and solar radiation of 14.35 MJ $m^{-2}d^{-1}$ compensating the high maintenance respiration at maximum temperature rise of 1.50 °C and minimum temperature rise of 1.38 °C. But, fibre yield decreases rapidly starting from 2040 and falls 811.15 kg/ha at the end of this century (2100 AD) according to the trend of following equation 7.

$$Fibre\_yield = -0.205x^2 + 831.63x - 840584 \quad (7)$$

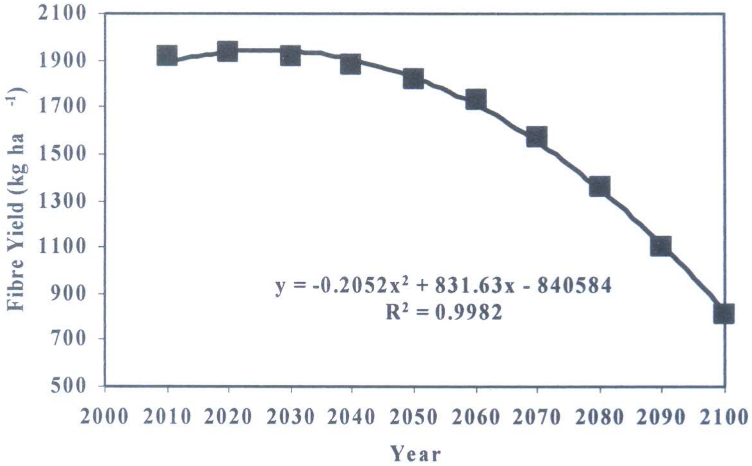

Fig. 9. Fibre yield simulated for the decade wise predicted climate change

Sole effects as well as interactions among the prime climatic parameters of solar radiation, temperature and CO_2 concentration at different combinations were evaluated using FIBGROW model. Temperature affects the fibre yield while concentrations of CO_2 and solar radiation have positive impacts. Elevated concentrations of CO_2 and increase in solar radiation level are dominant for low level of temperature rise (up to 1°C) and the reverse is true for high level of temperature rise (more than 1°C). For the climate change scenario from 2000 to 2100, the effect of temperature increase (1.5 °C maximum and 1.38 °C minimum) on yield is compensated by the effects of CO_2 concentration increase (33.33 volume parts per million) and solar radiation increase (1.61 $MJm^{-2}d^{-1}$) up to 2030. Later period from 2030 to 2100, the effect of temperature increase becomes dominant and the yield drops from 1910.35 kg ha^{-1} in 2030 to 811.15 kg ha^{-1} in 2100. This model can be used to assess the climate change impacts on jute production systems for different climate change scenarios.

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GENETIC VARIABILITY AND PATH ANALYSIS OF YIELD COMPONENTS IN KENAF *(HIBISCUS CANNABINUS L.)*

M. M. Hussain, Md. Nazrul Islam, S. M. Mahbub Ali and C. K. Saha

Bangladesh Jute Research Institute, Manik Mia Avenue, Dhaka-1207, Bangladesh

ABSTRACT

Variability, correlation and path coefficient analysis were studied for twelve yield and yield components in twelve diverse genotypes of Kenaf (*Hibiscus cannabinus* L.). The genotypes differed significantly in respect of all the characters studied. The difference between phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) was narrow for the characters dry fibre weight, dry stick weight, green weight with and without leaves and days to flower indicated low environmental influences on the expression of these characters. High heritability coupled with high genetic advance as percentage of mean for important fibre yield components indicated low selection pressure for fibre yield is effective as they are governed by additive gene action. Green weight with and without leaves and dry stick weight showed highly significant positive association with dry fibre weight. Green weight with leaves had the highest direct effect on dry fibre weight. Results indicated that the most important character for selection was green weight with leaves.

Key words: Kenaf (*Hibiscus cannabinus* L.), genetic variability, heritability, path analysis

INTRODUCTION

Kenaf (*H. cannabinus* L.) and mesta (*H. sabdariffa* L.) are the most important bast fibre yielding cultivated species. The fibre quality of these two species is next to jute (*Corchorus* spp.) and hence gained importance as substitute of jute. The traditional use of Kenaf focuses on its fibre production, such as making ropes having greater tensile strength, sacs, canvases, and carpets (11). However, new applications of Kenaf have recently been developed such as pulping and papermaking, board making, absorbents and potting media, filtration, textiles especially as raw materials for geotextile and livestock feed.

Yield is a character which is governed by several factors and is thus very complex. Fibre yield is dependent on various component characters such as plant height, basal diameter, number of nodes, fibre weight, stick weight, days to flower, etc. (3,14). So, any improvement in fibre yield should be sought for through improvement in these component characters. The effectiveness of increasing fibre yield depends on the extent to which the variability in fibre yield is dependent on genetic factor. It is essential to separate the total phenotypic variation into its heritable and non-heritable components with the help of certain genetic parameters such as genetic co-efficient of variation, heritability and genetic advance. Information on correlation coefficient between fibre yield and its contributing characters has always been helpful as a basis for selection for fibre yield in a breeding program. Thus, determination of correlation (both phenotypic and genotypic) between the characters are a matter of considerable importance in selection practices since it helps in construction of selection indices and also permit the prediction of correlated response. Path coefficient analysis provides a true picture of genetic association between different traits. It specifies the cause and effect, and measures their relative importance. Therefore, correlation in combination with the path coefficient analysis quantifies the direct and indirect contribution of one character upon another. Considering these facts, the present study was conducted with 12 diverse genotypes of kenaf with a view to study the variability among genotypes and to find out the relationship among fibre yield and yield attributes and their contribution to fibre yield.

MATERIALS AND METHODS

Twelve genotypes of Kenaf collected from the Gene Bank of Bangladesh Jute Research Institute (BJRI) namely, HC-2, HC-95, DS/024H, DS/028H, PI-270104, PI-329192, PI-343144, PI-365441, CPI-61000, CPI-72117, FJ/017H and KAI/SUC/044 were grown at the experimental field of BJRI, Dhaka in 2005. The experiment was laid out in the Randomized complete Block Design (RCBD) with three replications. Seeds were sown on 02-04-2012 in single row of 3 meter long with spacing of 30, 60 and 10 cm between rows, replications and plants respectively. Standard production technology was adopted to raise a good crop under optimum management. Ten competitive plants of each genotype from each replication were selected randomly and harvested at 120 days of crop age. Observations were recorded on days to flower, plant height (m), basal diameter (mm), node number, green weight with leaves (g./pl), green weight without leaves (g./pl), dry stick weight (g./pl), number of flowers per plant, number of capsules per plant, number of seeds per capsule, 1000 seed weight (g.) and dry fibre weight (g./pl) following the descriptor published by the then International Jute Organization (1). The data were analysed to estimate the genotypic and phenotypic variances using the formula of Burton and De Vane (5). Genotypic (GCV) and Phenotypic (PCV) coefficients of variation were measured in accordance with the formula given by Burton and De Vane (4). Heritability (h^2b) and genetic advance (GA) were determined using the method suggested by Singh and Chowdhury (15). Phenotypic and genotypic correlation coefficient were measured using the formula of Al-Jibouri *et al.* (2). Path analysis was done following the formula by Dewey and Lu (7).

RESULTS

The highly significant differences were observed among the genotypes for all the characters studied. The estimates of genetic parameters for twelve characters are given in Table 1. High range of variation was found in green weight with and without leaves, while narrow range was found in plant height. The genotypic variances for the characters days to flower, green weight with and without leaves, dry fibre weight, dry stick weight and number of seeds per capsule were more or less close to their phenotypic variances. The phenotypic coefficient of variation (PCV) was higher than that of the corresponding genotypic coefficient of variation (GCV) in all the characters. The highest GCV was observed for green weight without leaves (30.62) followed by dry stick weight (29.33), green weight with leaves (28.23) and dry fibre weight (26.03); it was lowest for 1000 seed weight (5.43). The highest PCV value was found in green weight without leaves (32.99) followed by dry stick weight (31.75), green weight with leaves (30.16) and dry fibre weight (27.74) and the lowest value was in 1000 seed weight (6.55). The heritability was high for all the characters except number of capsules per plant (21.04%). The highest (92.46%) and lowest (21.04%) heritability were observed in days to flower and number of capsules per plant respectively. Genetic advance as percentage of mean was high for green weight with (54.44) and without (58.57) leaves, dry stick weight (55.81) and dry fibre weight (50.54). High heritability associated with high genetic advance as percentage of mean was obtained in green weight with and without leaves, dry stick weight and dry fibre weight.

Though twelve characters were taken into consideration for variability study, correlation and path coefficient were analyzed with eight direct yield contributing characters for fibre. Correlation coefficients (genotypic and phenotypic) between different pairs of characters (Table 2) revealed that fibre yield was positively and significantly correlated with dry stick weight, green weight with and without leaves both at phenotypic and genotypic level at 1% level of significance and with basal diameter only at phenotypic level at 5% level. Negative correlation of dry fibre weight was found with days to flower both at phenotypic and genotypic level. Dry stick weight was positively and significantly correlated with green weight with and without leaves and basal diameter both at phenotypic and genotypic level. Significant and negative correlation was observed for node number with days to flower both at genotypic and phenotypic level and with plant height at genotypic level.

Path coefficient analysis showed that green weight with leaves had the maximum direct effect on dry fibre weight both at genotypic and phenotypic level (Table 3). Green weight without leaves had the considerable direct effect next to green weight with leaves on dry fibre weight at genotypic level followed by days to flower, plant height, node number and dry stick weight. The basal diameter had lowest and negative direct effect on dry fibre weight both at genotypic and phenotypic level.

DISCUSSION

Highly significant mean square due to genotypes indicated inherent genetic differences among the genotypes with respect to the characters studied. Genotypic differences were reported by Mostofa *et al.* (13) for different yield components in *H. cannabinus*. The genotypic variances were more or less close to their phenotypic variances for the characters days to flower, green weight with and without leaves, dry fibre weight, dry stick weight and number of seeds per capsule. Similar findings were reported by Heliyanto *et al.* (8) in kenaf; and Chaudhury (6) in *olitorius* jute. The PCV value was higher for all the twelve characters studied than the corresponding GCV indicating the presence of environmental influence in the phenotypic expression of the characters. Similar findings were reported by khatun (10) in kenaf. The highest GCV was observed for green weight without leaves followed by dry stick weight, green weight with leaves and dry fibre weight; whereas, the lowest was observed for the character 1000 seed weight. The highest PCV value was found in green weight without leaves followed by dry stick weight, green weight with leaves and dry fibre weight and the lowest was in 1000 seed weight. Manjunatha and Sheriff (12) reported high PCV for plant height, fibre weight, green weight, number of capsules, seed weight and high GCV for days to flower, plant height, green weight, fibre weight and seed weight in *H. cannabinus*. The coefficient of variation, both at genotypic and phenotypic level, was low for 1000-seed weight, number of capsules per plant and days to flower which indicated that the scope for genetic improvement of these three characters in and amongst the population was poor. This might be due to less variability for these characters in the materials tested. The difference between phenotypic and genotypic coefficient of variation for characters dry fibre weight, dry stick weight, green weight with and without leaves, and days to flower was reasonably narrow which suggested that the environmental influence on phenotypic expression of these characters was not worth consideration and the phenotypic expression of these characters was the true representation of their genetic makeup. Hence, selection of desired characters simply on phenotypic value may be effective. On the other hand, the magnitude of differences between phenotypic and genotypic coefficient of variation for number of capsules, number of flowers and plant height were relatively high which suggested the existence of considerable effect of environment on expression of these characters. Therefore, simple breeding technique such as pure line would not be much effective for the genetic improvement of these characters in the present materials. Similar findings were observed by Mostofa *et al.* (13) for green weight without leaves, dry fibre weight and dry stick weight. The heritability was high for all the characters except number of capsules per plant. High heritability for plant height, fibre weight/plant, nodes/plant, capsules/plant and seed yield/plant were observed in kenaf by Khatun (10). Manjunatha and Sheriff (12) observed high heritability for days to flower and 1000 seed weight in *H. cannabinus*. High genetic advance as percentage of mean was observed for green weight with and without leaves, dry stick weight and dry fibre weight. Genetic advance as per cent of mean was observed high for days to flower, green weight without leaves, dry fibre weight and dry stick weight in *H. cannabinus* by Mostofa *et al.* (13). They also reported high heritability coupled with high genetic advance for days to flower and green weight without leaves in *H. cannabinus*. Khatun (10) reported high heritability coupled with high genetic advance as percent of mean for fibre yield/plant, nodes/plant, capsules/plant and seed yield/plant in kenaf. Thus, above results suggest substantial contributions of additive genes for expression of these characters. Therefore, direct selection of these traits would be effective. Interesting results of high heritability coupled with high genetic advance as percent of mean for most important character dry fibre weight per plant indicated that direct selection for yield was remunerative for materials studied in respect of dry fibre yield.

The character fibre yield was positively and significantly correlated with dry stick weight, green weight with and without leaves both at phenotypic and genotypic level at 1% level of significance, but only at phenotypic level with basal diameter at 5% level. This is in accordance with the findings of Mostofa *et al.* (13), who observed that plant height, basal diameter, green weight without leaves and dry stick weight showed positive and significant correlation with dry fibre weight both at genotypic and phenotypic levels. Sobhan and khatun (16) reported that fibre yield was positively associated with plant height, base diameter, green weight, stick weight and number of nodes/plant in kenaf. They also observed positive association among the yield components. Khatun and Sobhan (9) observed that plant height and base diameter showed a significant positive association with fibre yield and also with each other in kenaf. Dry fibre weight was negatively correlated with days to flower both at phenotypic and genotypic level. These findings are in agreement with the findings of Subramanyan *et al.* (17) in Kenaf. Dry stick weight was positively and significantly correlated with green weight with and without leaves and basal diameter both at phenotypic and genotypic level. Significant and negative correlation was observed for node number with days to flower at genotypic and phenotypic level and with plant height at genotypic level. Mostofa *et al.* (13) reported in *H. cannabinus* that dry stick weight had positive and significant genotypic and phenotypic correlation with plant height, basal diameter, green weight without leaves and dry fibre weight. He also observed positive and significant phenotypic but non-significant genotypic correlation between dry stick weight and node number. The correlation study suggested that selection for fibre yield through basal diameter, green weight with and without leaves and dry stick weight would be effective.

Table 1. Estimates of genetic parameters for different morphological characters of 12 genotypes of *H. cannabinus*

Characters	Range	Mean ± SE	Genotypic variance	Phenotypic variance	GCV	PCV	h^2b (%)	GA (% of mean)
Days to Flower	191.00 – 131.67	178.69 ± 3.55	231.96	250.87	8.52	8.86	92.46	0.17
Plant height (m)	3.10 – 2.17	2.60 ± 0.21	0.05	0.12	8.61	13.33	41.66	11.17
Base diameter(mm)	20.47 – 14.27	18.24 ± 0.89	3.25	4.43	9.88	11.54	73.36	17.38
Node number	83.21 – 55.30	67.18 ± 4.40	83.13	112.17	13.57	15.77	74.07	24.05
Green wt. with leaves(g/pl)	424.79 – 145.61	294.89 ± 25.56	6932.70	7912.58	28.23	30.16	87.62	54.44
Green wt. without leaves(g/pl)	390.26 – 134.17	246.98 ± 24.71	5720.88	6636.96	30.62	32.99	86.20	58.57
Dry stick wt. (g/pl)	60.18 – 19.67	39.96 ± 3.97	137.35	160.976	29.33	31.75	85.32	55.81
No. of Flowers/pl	53.58 – 38.19	43.27 ± 3.27	11.79	27.78	7.93	12.18	42.44	10.64
No. of capsules/pl	34.27 – 26.83	30.90 ± 2.69	2.90	13.73	5.51	11.99	21.04	5.19
No. of seed/capsule	22.13 – 15.10	18.49 ± 0.77	4.40	5.29	11.35	12.44	83.28	21.34
1000 Seed wt. (g.)	27.20 – 22.90	24.89 ± 0.74	1.83	2.66	5.43	6.55	68.80	9.28
Dry fibre wt. (g/pl)	25.06 – 10.17	17.55 ± 1.37	20.88	23.70	26.03	27.74	88.07	50.54

SE: Standard error; GCV: Genotypic coefficient of variation; PCV: Phenotypic coefficient of variation; h^2b: Heritability; GA: Genetic advance

Table 2. Genotypic and phenotypic correlation coefficients of eight morphological characters of 12 genotypes in *H. cannabinus*

Characters		Plant height (m)	Base diameter (mm)	Node number	Green wt. with leaves (g/pl)	Green wt. without leaves(g/pl)	Dry stick wt. (g/pl)	Dry fibre wt.(g/pl)
Days to Flower	G	0.180	-0.231	-0.451*	-0.354	-0.322	-0.304	-0.197
	P	0.183	-0.228	-0.459*	-0.348	-0.310	-0.303	-0.195
Plant height (m)	G		-0.237	-0.430*	-0.056	0.054	0.042	0.129
	P		-0.091	-0.347	0.049	0.162	0.136	0.211
Basal diameter (mm)	G			0.200	0.452*	0.333	0.477*	0.366
	P			0.243	0.490*	0.375	0.527**	0.420*
Node number	G				0.021	-0.070	0.099	-0.028
	P				0.032	-0.061	0.129	0.001
Green wt. with leaves (g/pl)	G					0.936**	0.864**	0.915**
	P					0.967**	0.890**	0.939**
Green wt. without leaves(g/pl)	G						0.809**	0.904**
	P						0.834**	0.927**
Dry stick wt. (g/pl)	G							0.838**
	P							0.869**

* = Significant at 5% level, ** = Significant at 1% level

Highest direct effect both at genotypic and phenotypic level on dry fibre weight were exerted by green weight with leaves among the characters studied. The highly positive correlation of dry fibre weight with green weight with leaves was owing to its indirect contribution via green weight without leaves and dry stick weight. Green weight without leaves exerted the considerable direct effect next to Green weight with leaves on dry fibre weight at genotypic level followed by days to flower, plant height and node number. In agreement with these findings Manjunatha and Sheriff (12) reported maximum direct effect of green weight on dry fibre yield at both genotypic and phenotypic leaves in *H. cannabinus*. The lowest and negative direct effect was exerted by basal diameter on dry fibre weight, but its positive correlation with fibre weight may be due to positive indirect effect of green weight with leaves. Manjunatha and Shariff (12) reported positive direct effect of basal diameter on fibre yield in *H. cannabinus*. Considering the direct and indirect effects on dry fibre weight, the important characters were green weight with leaves. Both genotypic and phenotypic residual effects (0.0978 and 0.0694) indicated that almost all the contributors on dry fibre weight (yield) have been considered in the present investigation.

The results of the present study indicated high heritability coupled with high genetic advance as percentage of mean for green weight with and without leaves, dry stick weight and dry fibre weight in *H. cannabinus* which suggested that these traits are least influenced by the environmental factors and they may require low selection intensity for improvement as they are governed by additive gene action. Correlation and path coefficient analysis suggested that during selection more emphasis should be given on green weight with leaves since this character has high positive correlation and high direct effect on dry fibre yield.

Table 3. Genotypic and phenotypic path co-efficient analysis showing direct (bold) and indirect effect of different yield attributes toward fibre yield in *H. cannabinus*

Characters		Days to Flower	Plant height (m)	Base diameter (mm)	Node number	Green wt. with leaves (g/pl)	Green wt. without leaves (g/pl)	Dry stick wt. (g/pl)	Correlation with dry fibre wt. (g/pl)
Days to Flower	G	**0.1727**	0.0292	0.0988	-0.0545	-0.2163	-0.1016	-0.0275	-0.197
	P	**0.1650**	0.0277	0.0113	-0.0496	-0.3101	-0.0195	-0.0197	-0.195
Plant height (m)	G	0.0311	**0.1622**	0.0010	-0.0519	-0.0342	0.0170	0.0038	0.129
	P	-0.0301	**0.1511**	0.0045	-0.0375	0.0437	0.0102	0.0088	0.211
Base diameter (mm)	G	-.0399	-0.0384	**-0.0428**	0.0242	0.2762	0.1051	0.0432	0.366
	P	-0.0376	-0.0138	**-0.0494**	0.0263	0.4366	0.0236	0.0343	0.420*
Node number	G	-0.0779	-0.0697	-0.0009	**0.1208**	0.0128	-0.0221	0.0097	-0.028
	P	-0.0757	-0.0524	-0.0120	**0.1081**	0.0285	-0.0038	0.0084	0.001
Green wt. with leaves (g/pl)	G	-0.0611	-0.0091	-0.0019	0.0025	**0.6110**	0.2954	0.0783	0.915**
	P	-0.0574	0.0074	-0.0242	0.0035	**0.8911**	0.0608	0.0578	0.939**
Green wt. without leaves(g/pl)	G	-0.0556	0.0088	-0.0014	-0.0085	0.5719	**0.3156**	0.0733	0.904**
	P	-0.0511	0.0244	-0.0185	-0.0066	0.8617	**0.0629**	0.0542	0.927**
Dry stick wt. (g/pl)	G	-0.0525	0.0068	-0.0020	0.0120	0.5279	0.2553	**0.0906**	0.838**
	P	-0.0499	0.0206	-0.0260	0.0139	0.7931	0.0524	**0.0650**	0.869**

Residual effect: Genotypic: 0.0978 and
Phenotypic: 0.0694

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BIOCHEMICAL, PHYSICAL AND SENSORY EVALUATION OF JUTE (*CORCHORUS* SPP.) LEAVES AS AFFECTED BY STORAGE PERIODS AFTER DIRECT SUNDRY AND HOT WATER TREATMENTS

Md. Mahabub Ali[1], Aleya Nasreen[2], S. C. Sarkar[3] and Md. Assaduzzaman[4]

ABSTRACT

The experiment was conducted at The Laboratory of Biochemistry Department, Bangladesh Jute Research Institute, Dhaka, during January to December 2012 to evaluate the biochemical components of different varieties jute (*Corchorus* Spp.) leaves as affected by four months storage after direct sundry and hot water treatments (HWT) applied. The jute varieties were BINA Pat Shak1, O-9897, O-4, OM-1 and O-72 of *C. olitorius* L. and CVL-1, CVE-3 and CC-45 of *C. capsularis* L. Moisture, protein, fat, fibre, mineral and pigment factor were analyzed. The results revealed that the products produced by the HWT better than direct sundry treatment, which were similar to fresh condition. The hot water treated leaves gave substantially higher solid content due to higher protein, fat, fiber, mineral, pigment factors and found greenish up to the storage period. The green colour disappeared in direct sundried leaves after 2 months periods to final stage of storage. Hot water treated dried leaves showed better results in terms of degree of acceptability through sensory evaluation.

Key words: Jute leaf, drying, biochemistry, sensory evaluation.

INTRODUCTION

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 (*Corchours 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 (4 and 9).

Jute leaves are used as vegetable, frozen foods and medicinal purpose. The people use it to produce mucilaginous soup or sauce, stews, curries vegetable dishes or boil the leaves and mix it with others (groundnut, fish, dal etc.). Depending on the region of the world in which one is cooking. It has an antioxidant activity with a significant alpha-tocopherol equivalent vitamin E. The nutritive value of 100gm leaves of 81.75% moisture, protein 3.5 %, fat 1%, calcium 488 mg, vitamin A 1221μg, ascorbic acid (Vitamin C) 95mg, riboflavin 28mg and niacin 1.5mg (5 and 9). Young jute leaves are flavourful and tender, older leaves tend to be more woody and fibrous making them less ideal for consumption. The jute leaves are picked

[1] Senior Scientific Officer(cc) and [2]Principal Scientific Officer(cc) of Biochemistry Department, [3]Publication Officer, PTC Division [4]Directot (Technology), Bangladesh Jute Research Institute, Manik Mia Avenue, Dhaka-1207.

several times during the growing phase as also during the thinning of the jute plant for use as vegetables. It has been reported the green leaves were defoliated 3-4 ton/ha during the jute cultivation. During the time of harvesting jute leaves remain unutilized.

A huge quantity of resources is lost every year. On the other hand, the people suffer from malnutrition (6). The farmers produce jute commercial for fibre production. But they do not get direct economic value from the jute leaves. Drying is one of the oldest and most widely used methods/technique of food preservation (3) and its success largely depend on the reconstitution properties of the dried products. Islam *et al.*, (8) reported protein, lipid, calcium, iron, carotene, vitamins, folic acid and some enzymes have been reported from the leaves. A large number of phytoconstituents with their structures including flavonoids, saponins, tannins, steroids, glycosides, sugars and triterpenes and their applications have also been reported from the leaf, bark, root and seeds of the species.

It has been established that jute is one of the popular vegetable in the most jute growing areas of Bangladesh. Jute can not survive with its traditional uses. Sometimes, Farmers of Bangladesh got into problem for it's reasonable price. So, to promote the diversification of jute such as preserve of jute leaves in green condition will give create scope of use. Jute leaves of selected variety can be stored for further use. Therefore, the present experiment was under taken to find out the optimum technique to preserve of jute leaf.

MATERIALS AND METHODS

The experiment was conducted at the Laboratory of Biochemistry Department, Bangladesh Jute Research Institute (BJRI), Dhaka, during January to December 2012 to evaluate the biochemical constituents of different varieties jute (*Corchorus* Spp.) leaves as affected by four months storage after direct sundry and hot water treatments (HWT) applied. Eight White and Tossa jute varieties such as BINA patshak-1 (Developed by Bangladesh Institute of Nuclear Agriculture), O-4, O-9897, OM-1, O-72 (Tossa pat) (*Corchorus olitorius* L.), and; CVL-1, CVL-3 and CC-45 (White/Deshi pat) (*Corchorus capsularis* L.) were used as experimental materials, grown in simple plots at Green house of BJRI. Fresh leaves of 35 days age were collected from those plots.

Two drying methods were used-

a) Direct Sun drying method: The collected jute leaves were dried directly in the sunlight by keeping on polyethylene sheet for 4 days of 8 hours daily and then preserved in air tight glass container and store in the cool and dry place for 4 months.

b) Hot water treatment (HWT) drying method:

- Used 3 liters of water per 450g/1lb of fresh jute leaves. Enough water to allowed the leaves cook quickly (Less water might causes the leaves stew and would became limp, losing colour, texture and nutrition also).
- The boiling of the fresh leaves should be done without lid (If used, volatile acids would be trapped which was release from the leaves during cooking and could became limp and deteriorated in color).

- The leaves should be cooked as quickly as possible with high heat level.
- To know when the jute leaves were cooked, using a slotted spoon to removed a piece from the boiling water and will taste.
- The proper condition for cook are: **a)** Leaves-removed and drained as soon as those stoped being stiff. **b)** Tough greens or strong tasting greens-cook for up to 5 minutes, long enough to soften their texture and improve the flavour.
- Drained the hot water immediately to retain freshness. Then plunge those cooked into ice water to reheated or cold.
- A table spoon of salt per litre/quart of boiling water could help boiled jute leaves to retain greenish colour. After 5 minutes most of the salt had to remove with the water.

The treated jute leaves dry in shade spread on polyethylene sheet and then preserved in air tight glass container and stored in the cool and dry place for 4 Months.

Chemical analysis: The fresh and dried samples were analyzed for their moisture, protein, fat, fibre, mineral and pigment factors contents followed by adopting AOAC (2004) method and Jayaraman (10). All the results reported by mean of triple analysis.

Sensory evaluation: A testing panel evaluated the consumers acceptability of developed products. The 10 member panelists were selected from BJRI, Dhaka. The panelists were requested to assign score for characteristics i.e. colour, flavour, texture and over all acceptability of different varieties dried jute leaves. The scale was arranged such as that 9=Like extremely, 8=like very much, 7=like moderately, 6=like slightly, 5=Neither like/dislike, 4=Dislike slightly, 3=Dislike moderately, 2=Dislike very much and 1=dislike extremely. The results were evaluated by analysis of mean score procedures of statistical analysis system.

Storage studies: The processed dried jute leaf packaged in low density polyethylene was assessed at room temperature. Each pack contained 20g dried jute leaf. Total storage time was 4 months. The different parameters used for assessing the quality of products were colour, flavour, texture and moisture content. The observations were made at an interval of 0 day up to 120days.

RESULTS

The biochemical components viz. moisture(water), protein, fat, fibre, mineral and pigment factors content's mean values of different varieties jute leaves were differed due to direct sundried and hot water treated dried (Table 1). However the contents were found similar in fresh and hot water treated leaves. The hot treated leave's contents gave substantially higher solid content due to higher protein, fat, fiber, mineral, pigment factors than direct sun dried (Table 1).

Table-1. Biochemical constituents of different varieties fresh, direct sundried and hot water treated and then dried jute leaves

Composition	BINA pat shak1	OM-1	O-72	O-4	O-9897	CVL-1	CVL-3	CC-45
Fresh leaves								
% Moisture	80.40	81.24	82.20	83.45	82.45	82.00	83.66	82.45
% Protein	3.61	3.65	3.65	3.75	3.70	3.86	3.78	3.76
% Fat	0.22	0.25	0.25	0.24	0.23	0.25	0.23	0.23
% Fibre	1.80	1.82	1.82	1.83	1.80	1.76	1.72	1.75
% Mineral	2.45	2.42	2.43	2.44	2.46	2.52	2.48	2.49
Pigment factor	1.153	1.162	1.560	1.154	1.156	1.153	1.166	1.154
Direct sundried leaves (Analysis made after 4 months storage)								
% Moisture	10.45	11.23	11.96	11.44	12.00	11.54	11.87	11.23
% Protein	3.55	3.45	3.45	3.64	3.53	3.60	3.56	3.54
% Fat	0.22	0.25	0.24	0.23	0.25	0.23	0.23	0.25
% Fibre	1.75	1.75	1.80	1.78	1.68	1.80	1.62	1.65
% Mineral	2.46	2.45	2.47	2.54	3.48	2.56	2.52	2.50
Pigment factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Hot water treated and dried leaves (Analysis made after 4 months storage)								
% Moisture	10.75	10.76	11.40	11.22	11.27	11.34	11.50	11.80
% Protein	3.60	3.63	3.57	3.65	3.65	3.72	3.65	3.56
% Fat	0.20	0.22	0.25	0.24	0.23	0.25	0.23	0.23
% Fibre	1.80	1.82	1.82	1.83	1.80	1.76	1.72	1.75
% Mineral	2.45	2.42	2.43	2.44	2.46	2.52	2.48	2.49
Pigment factor	1.145	1.152	1.140	1.145	1.178	1.145	1.156	1.146

Colour, flavour, texture and moisture content of different dried leaves were differed due to different treatments applied (Table 2). The natural colour greenish was intact in hot water treated leaves for the whole storage period. However in direct sundried leaves were off green. Flavour and texture also showed better results in hot water treatment than direct sun dry. The moisture contents were higher in direct sun dried jute leaves which was a bad sign for long time preservation (Table 2).

Table-2. Effect of storage period on colour, flavour, texture and moisture content of different dried jute leaves

Sample	Storage time (month)	Parameters			
		Colour	Flavour	Texture	% Moisture
Sun dried	0	Greenish	Natural	Fine	9.33
	1	Light greenish	Less natural	Less fine	9.70
	2	Off greenish	Less natural	Not fine	10.00
	3	Off greenish	Not natural	Not fine	10.20
	4	Off greenish	Not natural	Not fine	10.50
Hot water treated dried	0	Greenish	Natural	Fine	8.11
	1	Greenish	Natural	Fine	8.24
	2	Greenish	Natural	Fine	8.27
	3	Greenish	Natural	Fine	8.30
	4	Greenish	Natural	Fine	8.35

The sensory evaluation in order to assess degree of acceptability (mean score) in terms of colour, flavour, texture and over all acceptability after four months storage with one month interval, HWT showed better results than sun dried one (Table 3).

Table -3. Mean score for colour, flavour, texture and overall acceptability of dried jute leaf product

Sample	Sensory attributes			
	Colour	Flavour	Texture	Overall acceptability
Sun dried	4.20	6.70	5.8	6.4
HWT dried	8.30	8.00	8.4	8.3

DISCUSSION

The nutritional values of fresh, sun dried and hot water treated jute leaves were almost similar to those reported by Akindahunsi and Salawu (1). The variation in the composition of jute leaf might be due to difference in variety, soil property, growing condition, harvesting period, maturity stage and other agronomical practices. Pigment factor (Chlorophil and xanthophil) in hot water treated sample retained long time and nutrient level more than one and similar as fresh. However, the sun dried samples pigment unfortunately were absent within few (2-5) days. The nutritional values, flavour texture and colour of both sample (Fresh leaves and hot water treated dry leaves) were same.

Storage effect showed that only the colour of sun dried sample was changed from greenish to off greenish after one month of storage. These might be due to enzymatic or non enzymatic initiated during drying (7). The texture became fine to less fine after few days of storage. The sun dried sample might not be stored for more than one month due to higher moisture uptake and slow enzymatic activities. But hot water treated dried sample was fine during 4 months of storage period.

The results of sensory evaluation showed that for overall acceptability hot water treated dry sample the highest score could be ranked as “like very much”. From the above, it was clearly found that from all considerations, the hot water treated dried jute leaf was the most acceptable product with a ranking of “like very much”.

CONCLUSIONS

Every year a huge amount of jute leaves fallen on the jute field after emergence to harvest time. Jute growers usually do not get the proper price of that amount jute leaf. However, if the farmer could preserve their product by effective and economic way, they would able to get proper price and get encourage to maximize production. This study indicated that there was a good prospect of dried jute leaf for production of diversified value added jute products. Through processing the market values of dried jute leaves products might increase and production could be maximized. Dried jute leaves could be successfully and economically preserved by hot water drying process.

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GENETIC VARIATION AND CHARACTER ASSOCIATION IN MESTA *(HIBISCUS SABDARIFFA* L.)

M. M. Hussain[2], S. M. Mahbub Ali[3], Md. Nazrul Islam[1] and C. K. Saha[3]

ABSTRACT

Twelve diverse genotypes of mesta (*Hibiscus safdariffa* L.) were studied to find out the genetic variability, character association and path coefficient for fibre yield and its component traits. Significant variations were observed in respect of all the characters studied. The difference between phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) was narrow for the characters, days to flower, plant height, number of flowers per plant, number of capsules per plant and number of seeds per capsule indicated low environmental influences on the expression of these characters. High heritability coupled with high genetic advance as percentage of mean for number of capsules per plant, number of flowers per plant, dry fibre weight and green weight without leaves suggested effective selection for the improvement of these characters as they are governed by additive gene action. Green weight with and without leaves and dry stick weight showed highly significant positive association with dry fibre weight. Green weight without leaves had the highest direct effect on dry fibre weight. Thus selection on fibre yield in mesta through green weight without leaves will be effective.

Key words: Variability, character association, path coefficient, mesta (*Hibiscus safdariffa* L.)

INTRODUCTION

Mesta (*H. sabdariffa* L.) is now widely cultivated throughout the tropics as fibre crop. Two botanical varieties are recognized in this species namely, variety *sabdariffa* (edible type) and variety *altissima* (fibre type). The edible variety is a short bushy plant bearing profuse smooth fruits having large fleshy calyx and epicalyx. This type is used for culinary purposes. The fleshy calyx and epicalyx are used for jelly making and in other confectionery preparation. The fibre producing variety is a tall unbranched plant with smaller inedible hairy fruits. This variety is being cultivated throughtout the tropical and subtropical countries for fibre and paper pulp. The fibre quality of this species is next to jute (*Corchorus* spp.) and hence gained importance as substitute of jute. It produces more biomass in poor soil where even jute cannot be grown (10). Little attention has been paid for improving the fibre yield of this crop.Yield is a complex character which is governed by several factors. Fibre yield is dependent on various component characters such as plant height, basal diameter, number of nodes, fibre weight, stick weight, days to flower, etc. (4, 14). The understanding of association of characters is of prime importance in developing an efficient breeding programme. The correlation studies provide information about the mere association between any two characters. The path coefficient analyses provide the partitioning of correlation coefficient into direct and indirect effects giving the relative importance of each of the causal factors. Therefore, the present study was undertaken with

[1] Director (A&F), [2]CSO, Genetic Resources and Seed Division, [3] PSO, PTC Division & [4] CSO PTC Division
Bangladesh Jute Research Institute Manik Mia Avenue, Dhaka-1207,Bangladesh

twelve diverse genotypes of mesta in order to find out the genetic variability, interrelationship among different characters and the direct and indirect contributions of these characters toward fibre yield.

MATERIALS AND METHODS

Twelve diverse genotypes of mesta were grown in a Randomized complete Block Design (RCBD) with three replications in 2005 at the experimental field of Bangladesh Jute Research Institute (BJRI), Dhaka. The genotypes were HS-24, PI-468410, PI-468413, Acc. 3574, PI-SSRH/006, Y/146H, JRC/617H, 300M, Acc.2932, Acc. 2065, Acc.2934 and Raikhali. The genotypes were sown on 16 April in single row of 3 meter long with spacing of 30, 60 and 10 cm between rows, replications and plants respectively. Standard production technology was adopted to raise a good crop under optimum management. Intercultural operations (weeding, thinning, irrigation and drainage, plant protection measures etc.) were done at proper time for ensuring proper growth of the crop. Ten competitive plants of each genotype from each replication were randomly selected and harvested at 120 days crop age. Observations were recorded on days to flower, plant height (m), base diameter (mm), node number, green weight with leaves (g./pl), green weight without leaves (g./pl), dry stick weight (g./pl), number of flowers per plant, number of capsules per plant, number of seed per capsule, 1000 seed weight (g.) and dry fibre weight (g./pl) by using the descriptor published by the then International Jute Organization (1). Mean values for each character were subjected to statistical analysis. Genotypic (GCV) and Phenotypic (PCV) coefficient of variation were measured in accordance with the formula given by Burton and De Vane (6). Heritability (h^2b) and genetic advance (GA) were determined using the method, suggested by Singh and Chowdhury (15). Phenotypic and genotypic correlation coefficient were measured using the formula of Al-Jibouri *et al.* (2). Path analysis was done following the formula by Dewey and Lu (8).

RESULTS

The analysis of variance revealed that the genotypes differed significantly in respect of all the characters studied. The estimates of mean, range, genotypic (GCV) and phenotypic coefficient of variation (PCV), heritability (h^2b) and genetic advance (GA) as percentage of mean for twelve characters are given in Table 1.The genotypic variance was close to their respective phenotypic variances for plant height, basal diameter, number of flowers per plant, number of capsules per plant, number of seeds per capsule and dry fibre weight. Similar findings were reported by Heliyanto *et al.* (9) in kenaf and Chaudhury (7) in *olitorius* jute. The phenotypic coefficient of variation (PCV) was higher for all the twelve characters studied than corresponding genotypic coefficient of variation (GCV). The highest GCV was found in number of capsules per plant (91.34) followed by number of flowers per plant (58.65) and dry fibre weight (46.54); and the lowest GCV value was in 1000-seed weight (1.79). In case of PCV, the highest value was found in number of capsules (91.66) followed by number of flowers (59.25), dry fibre weight (49.43), green weight without leaves (47.46) and dry stick weight (44.55). The lowest PCV value was observed in 1000 seed weight which was 5.24. Thirthamallappa and Sheriff (17) observed maximum PCV and GCV for fibre weight and number of capsules in *H. sabdariffa*. In the present study, heritability was high for all the characters except 1000-seed weight (28.20%). The highest (99.20%) and lowest (28.20%) heritability were in number of capsules per plant and 1000 seed weight respectively. Ibrahim and Hussein (11) reported high heritability for plant height, number of capsules per plant and seed weight per plant in *H. sabdariffa*. Genetic advance as percentage of mean ranged from 3.04 (1000 seed weight) to 187.31 (number of capsules per plant). High genetic advance as percentage of mean was observed for number of capsules per plant, number of flowers per plant, dry fibre weight, green weight with and without leaves, dry stick weight and plant height

Table-1. Estimates of genetic parameters for different morphological characters of 12 genotypes of. *H. sabdariffa*

Characters	Range	Mean ± SE	Genotypic variance	Phenotypic variance	GCV	PCV	h^2b (%)	GA (% of mean)
Days to Flower	240.67 – 120.67	199.83 ± 3.59	1370.71	1390.015	18.53	18.68	98.6	37.89
Plant height (m)	3.20 – 1.20	2.20 ± 0.18	0.372	0.48	27.77	29.44	88.9	53.87
Basal diameter(mm)	19.37 – 11.72	15.81 ± 1.21	6.64	8.85	14.13	16.31	75.1	29.10
Node number	70.18 – 40.13	57.83 ± 5.78	51.86	101.91	12.45	17.46	50.8	18.27
Green wt. with leaves(g/pl)	382.59 – 101.17	241.70 ± 31.93	9206.27	10735.81	39.70	42.87	85.7	75.68
Green wt. without leaves(g/pl)	312.76 – 54.29	177.70 ± 28.72	5874.64	7111.894	43.13	47.46	82.6	80.75
Dry stick wt. (g/pl)	55.31 – 10.24	34.09 ± 6.34	170.27	230.58	38.28	44.55	73.8	67.72
No. of Flowers/pl	73.50 – 12.58	31.08 ± 2.13	332.29	339.13	58.65	59.25	97.9	119.48
No. of capsules/pl	65.62 – 5.94	20.81 ± 1.31	361.41	363.98	91.34	91.66	99.2	187.31
No. of seed/capsule	26.02 – 15.34	21.88 ± 0.68	10.78	11.47	15.00	15.47	93.5	29.80
1000 Seed wt. (g.)	24.27 – 22.03	23.08 ± 0.84	0.41	1.47	1.79	5.24	28.2	3.04
Dry fibre wt. (g/pl)	24.00 – 4.57	12.84 ± 1.75	35.69	40.28	46.54	49.43	88.6	90.21

SE: Standard error; GCV: Genotypic coefficient of variation; PCV: Phenotypic coefficient of variation; h^2b: Heritability; GA: Genetic advance

Though twelve characters were taken into consideration for variability study, correlation and path coefficient were analyzed with eight direct yield contributing characters for fibre. The genotypic and phenotypic correlation coefficients between different pairs of characters are presented in Table 2. Dry fibre weight was positively and significantly correlated for all the characters studied except days to flower. Dry stick weight was positive and significantly correlated for all the characters except days to flowers. No negative correlation for any character was observed both at phenotypic and genotypic level.

In the present investigation, fibre yield per plant was considered as the dependent variable, and the genotypic and phenotypic correlation of the character with other seven quantitative characters, respectively was partitioned into their corresponding direct and indirect effects (Table 3). Highest direct effect on fibre yield both at phenotypic and genotypic level was exerted by green weight without leaves followed by dry stick weight. Banerjee *et al.* (5) reported positive direct effect of green weight on dry fibre yield in *H. sabdariffa.* Basal diameter had also negative direct effect on dry fibre weight. But its positive effect on dry fibre yield was via green weight without leaves. The direct effect of other characters on dry fibre weight was of little consequences.

DISCUSSION

The difference between phenotypic and genotypic coefficient of variation for characters days to flower, plant height, number of flowers per plant, number of capsules per plant and number of seeds per capsule was narrow which suggested that the environmental influence on phenotypic expression of these characters was not worth consideration and the phenotypic expression of these characters was the true representation of their genetic makeup. Hence, selection of desired characters simply on phenotypic value may be effective. On the other hand, the magnitude of differences between phenotypic and genotypic coefficient of variation for 1000 seed weight, node number and dry stick weight were relatively high which suggested the existence of considerable effect of environment on expression of these characters. Therefore, simple breeding technique such as pure line would not be much effective for the genetic improvement of these characters in the present materials. Similar findings were observed by Mostofa *et al.* (13) for green weight without leaves, dry fibre weight and dry stick weight. High genetic advance as percentage of mean was observed for number of capsules per plant, number of flowers per plant, dry fibre weight, green weight with and without leaves, dry stick weight and plant height suggested substantial contributions of additive genes for expression of these characters. Therefore, direct selection of these traits would be effective. High heritability coupled with high genetic advance as percent of mean for most important character dry fibre weight per plant indicated that direct selection for yield was remunerative for the materials studied in respect of dry fibre yield. Ibrahim and Hussein (11) observed high heritability coupled with high genetic advance for plant height and seed weight.

Dry fibre weight was positively and significantly correlated for all the characters studied except days to flower (Table 2). Aruna *et al.* (4) observed that fibre yield had positive and significant genotypic and phenotypic correlation with days to flower, plant height, basal diameter, number of nodes, fibre weight and stick weight in *H. sabdariffa.* Khatun and Sobhan (12) reported that fibre yield had significant positive correlation with plant height and base diameter. They also found strong positive association between plant height and base diameter. Dry stick weight was positive and significantly correlated for all the characters except days to flowers. No negative correlation for any character was observed both at phenotypic and genotypic level. Aruna *et al.* (3) observed positive and significant genotypic and phenotypic correlations of plant height with basal diameter, node number, stick weight but negative association between plant height and green weight in *H. sabdariffa*. Sinha *et al.* (16) observed significant positive correlation of plant height only with green weight.

Considering the direct and indirect effects on dry fibre weight, the important characters was green weight without leaves. Both genotypic and phenotypic residual effects (0.0384 and 0.0143) indicated that almost all the contributors on dry fibre weight (yield) were considered in the present investigation.

The results of the present study indicated high heritability coupled with high genetic advance as percentage of mean for number of capsules per plant, number of flowers per plant, dry fibre weight and green weight without leaves which suggested that these traits are least influenced by the environmental factors and they may require low selection intensity for improvement as they are governed by additive gene action. Correlation and path coefficient analysis suggested that during selection more emphasis should be given on green weight without leaves since this character has high positive correlation and high direct effect on dry fibre yield.

Table-2. Genotypic and phenotypic correlation coefficients of morphological characters of 12 genotypes in *H. sabdariffa*

Characters		Plant height (m)	Base diameter (mm)	Node number	Green wt. with leaves (g/pl)	Green wt. without leaves (g/pl)	Dry stick wt. (g/pl)	Dry fibre wt.(g/pl)
Days to Flower	G	0.287	0.512*	0.155	0.427*	0.337	0.145	0.250
	P	0.288	0.506*	0.165	0.426*	0.337	0.148	0.253
Plant height (m)	G		0.672**	0.705**	0.865**	0.815**	0.822**	0.854**
	P		0.663**	0.662**	0.859**	0.812**	0.823**	0.852**
Base diameter (mm)	G			0.468*	0.800**	0.796**	0.537**	0.670**
	P			0.448*	0.810**	0.803**	0.584**	0.690**
Node number	G				0.623**	0.611**	0.501*	0.639**
	P				0.620**	0.599**	0.492*	0.641**
Green wt. with leaves (g/pl)	G					0.944**	0.821**	0.929**
	P					0.977**	0.854**	0.949**
Green wt. without leaves(g/pl)	G						0.880**	0.956**
	P						0.902**	0.973**
Dry stick wt. (g/pl)	G							0.915**
	P							0.943**

* = Significant at 5% level, ** = Significant at 1% level

Table-3. Genotypic and phenotypic path co-efficient analysis showing direct (bold) and indirect effect of different yield attributes toward fibre yield in *H. sabdariffa*

Characters		Days to Flower	Plant height (m)	Base diameter (mm)	Node number	Green wt. with leaves (g/pl)	Green wt. without leaves (g/pl)	Dry stick wt. (g/pl)	Correlation with dry fibre wt.(g/pl)
Days to Flower	G	**-0.0372**	0.0302	-0.1103	0.0045	0.1205	0.2258	0.0165	0.250
	P	**0.0022**	0.0398	-0.0990	0.0096	-0.0391	0.3187	0.0207	0.253
Plant height (m)	G	-0.0107	**0.1053**	-0.0145	0.0206	0.2442	0.5450	0.0934	0.854**
	P	0.0006	**0.1385**	-0.1298	0.0386	-0.0788	0.7680	0.1148	0.852**
Base diameter (mm)	G	-0.0190	0.0708	**-0.2155**	0.0137	0.2258	0.5332	0.0610	0.670**
	P	0.0011	0.0918	**-0.1957**	0.0261	-0.0744	0.7595	0.0815	0.690**
Node number	G	-0.0058	0.0743	-0.1009	**0.0293**	0.1759	0.4093	0.0569	0.639**
	P	0.0004	0.0917	-0.0877	**0.0583**	-0.0569	0.5665	0.0687	0.641**
Green wt. with leaves (g/pl)	G	-0.0159	0.0911	-0.1724	0.0182	**0.2823**	0.6324	0.0933	0.929**
	P	0.0010	0.1190	-0.1585	0.0362	**-0.0918**	0.9241	0.1192	0.949**
Green wt. without leaves(g/pl)	G	-0.0125	0.0858	-0.1716	0.0179	0.2665	**0.6699**	0.0999	0.956**
	P	0.0075	0.1125	-0.1572	0.0349	-0.0897	**0.9458**	0.1259	0.973**
Dry stick wt. (g/pl)	G	-0.0054	0.0866	-0.1157	0.0147	0.2318	0.5895	**0.1136**	0.915**
	P	0.0003	0.1140	-0.1143	0.0287	-0.0784	0.8531	**0.1395**	0.943**

Residual effect: Genotypic: 0.0384 and Phenotypic:0.0143

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EFFECT OF CHEMICAL ON THE IMPROVEMENT OF JUTE FIBRE

M.A. Alam[1], M.A.K. Mollah[2], Mohammad Hussain[3], A.K.M. Maqsudul Alam[4] and M.S.H. Bhuyan[5]

ABSTRACT

An experiment was conducted in Bangladesh Jute Research Institute (BJRI), Regional Station, Kishoreganj to observe the effect of Triple Super Phosphate powder (TSP) on the improvement of low grade fibre of tossa jute (*Corchorus olitorius*), Variety tossa pat-4. The study was carried out by applying Triple Super Phosphate powder in different rates and for different times. A total of twenty six treatment combinations including a control were used in the experiment. From the study it was revealed that all the treatment combinations were found effective in the improvement of jute fibre. However, the best quality jute fibre was found with the combination of P_3T_2 whose brightness was 34.44 %, fineness was 36.04μ, and bundle strength was 8.93. So the treatment P_3T_2 may be considered for the improvement of low grade fibre to an up grade quality fibre.

INTRODUCTION

Jute is the internationally recognized name of bast fibre obtained from stalks of plants of genus Corchorus of Tiliaceae family (1). Jute is the main industrial crop in Bangladesh. The principal uses of jute are bagging, wrappings, manufacturing carpets, carpet backing cloth etc. A fibre of high tenacity and small uniform diameter welcome in the field of textile, which produce yarns of high strength (2).

Fineness is one of the very important property of jute fibre in terms of fibre grading of each variety. The grades of jute can be distinguished from one another by this value of fineness along with other attributes of fibre like luster and strength (3).

Jute was the golden fibre of erstwhile East Pakistan (now Bangladesh) in early sixties for its demand in international markets and earning revenues. Subsequently, the local and international markets collapsed drastically due to the development of synthetic fibre in the early seventies. However jute, once golden fibre is still one of the important cash crops in Bangladesh and annual production of jute is 25.46 million bales (1 bale=0.18 ton) (4).

Jute industry is facing serious challenges and competitions from other industries, which are producing packaging materials from synthetic fibre. As a result, the consumption of jute in the production of traditional packaging and carpet backing materials is declining day by day. In the wake of this declining trend, the jute industries have now begun to diversify its product range to sustain operations. However, these effects cannot totally stop the downward trend for jute.

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[1]SSO, Kishoregonj RA, [2] Director (Agri.), [3] CSO, JFSD, [4] SSO, HQ, Bangladesh Jute Research Institute.

Therefore, there is an urgent need to find truly diversified end uses for jute. One way of diversification is the blending of jute with cotton and other fibres and the production of value added apparel and furnishing fabrics from such blends (5).

The golden fibre, jute is the most imperative cash crop of great socio-economic importance in Bangladesh as it provides subsistence to millions of farmers for their livelihood and earns foreign exchange for the national economy. Quality is apprehended psychological terms. In case of industrial textiles made of jute, quality should be assessed through functional and nonfunctional properties. The functional properties, expressed as strength, fineness, defects and root content, are very important for manufacturing system (6). Fibre quality i.e. functional suitability, plays a far bigger part in case of processing than the processing variables themselves. The intangible effect of appearance is also important and customers may require a golden yarn because it looks shinning, clean and beautiful. So more importance is given to determine bundle strength, brightness, whiteness, fineness, density and defects to develop a scorecard system of scientific grading for jute. Strength of jute fibre is of extremely important commercial characteristic as because weak fibers cannot produce a strong yarn (7). Brightness and whiteness is also imperative commercial characteristic for same products making allowance for aesthetic aspects (8,9 and 10).

Food and Agricultural Organization (FAO) has declared 2009 as the International Year for Natural Fibre which reflects the importance of this group of commodities to many countries. Considering all these facts, improvement of fibre quality of jute is the prime need of farmers of Bangladesh. In this aspect, research regarding development of quality jute fibre is very important. There are records of fibre quality improvement by applying different indigenous materials such as Tamarind (tatul), Dhancha etc. Anos. (2008) narrated that light black to gray colored (Shamla) low grade fibre may be improved to higher grade by immersing these low grade fibre in a 2.5% Tamarind (tatul) solution for 5-10 minutes with subsequent washing and drying. Effort was also made by Kamruzzaman et.al. (2010) to upgrade and accelerate retting with the application of Dhanicha at 100:1, 100:10 & 100:20 of green jute weight. They observed that 100:20 was better interns of color and quality of jute fibre. But application of non-indigenous materials such as chemicals like mono calcium phosphate or triple super phosphate for fibre quality improvement has less or no evidence. It is also evident that lack of retting water and improper process of retting produces poor quality fibre, resulting poor market price. Therefore, much attention should be given towards the improvement of quality of jute fibre through use of indigenous and non- indigenous materials to bring back the past glory of Bangladesh jute. Considering the above facts the present study has been undertaken to observe the effects of Triple Super Phosphate powder on the quality of jute fibre of the variety O-72.

MATERIALS AND METHODS

The experiment was conducted at the Jute Research Regional Station, Kishoreganj during March 2012 to December 2012. Tossa jute variety O-72 was used for this experiment. Five doses of Triple Super Phosphate powder (2,4,6,8,and 10 gm per liter pond water) and five different application times (2,4,6,8 and 10 minute) were used as experimental variables which constituted twenty five treatment combinations (Table-1) with another control (Where triple super phosphate powder was not used) and replicated thrice in RCBD. After 120 days of sowing the plants were harvested and put to retting (a process of partial rotting) by natural microbes present in the water bodies of the retting tank (Ghosh 1983) (11) and the quality of fibre was determined by methods described by Paliet, et. al. 2006 (12). Extracted wet jute fibre were treated with chemical agent (Triple Super Phosphate powder). Two kilogram wet jute fibre was used in two liter pond water for each treatment. Solutions of the above chemical agent were prepared separately in pond water at varying concentrations (2,4,6,8 and 10 gm l^{-1} pond water) and different times (2,4,6,8 and 10 minutes) respectively. Each two kilograms wet jute fibre was put in two liter pond water prepared solution according to the treatment combinations. Finally treated jute fibre was pulled out from the solution. The treated jute was not washed in normal water. After that treated fibre were dried in direct sunlight. The physical properties of treated fibre were tested in the Testing and Standardization Department of BJRI. The treatments combination are as follows Table- 1.

Table-1: Description of different Treatment combinations :

Treatments
T_1- No triple super phosphate powder used (P_o T_o)
T_2- Triple super phosphate powder @ 2g/l with 2 minutes submergence in pond water (P_1 T_1)
T_3- Triple super phosphate powder @ 2 g/l with 4 minutes submergence in pond water (P_1 T_2)
T_4- Triple super phosphate powder @ 2 g/l with 6 minutes submergence in pond water (P_1 T_3)
T_5- Triple super phosphate powder @ 2g/l with 8 minutes submergence in pond water (P_1 T_4)
T_6- Triple super phosphate powder @ 2g/l with 10 minutes submergence in pond water (P_1 T_5)
T_7- Triple super phosphate powder @ 4g/l with 2 minutes submergence in pond water (P_2 T_1)
T_8- Triple super phosphate powder @ 4g/l with 4 minutes submergence in pond water (P_2 T_2)
T_9- Triple super phosphate powder @ 4g/l with 6 minutes submergence in pond water (P_2 T_3)
T_{10}- Triple super phosphate powder @ 4g/l with 8 minutes submergence in pond water (P_2 T_4)
T_{11}- Triple super phosphate powder @ 4g/l with 10 minutes submergence in pond water (P_2 T_5)
T_{12}- Triple super phosphate powder @ 6 g/l with 2 minutes submergence in pond water (P_3 T_1)
T_{13}- Triple super phosphate powder @ 6 g/l with 4 minutes submergence in pond water (P_3 T_2)
T_{14}- Triple super phosphate powder @ 6 g/l with 6 minutes submergence in pond water (P_3 T_3)
T_{15}- Triple super phosphate powder @ 6 g/l with 8 minutes submergence in pond water (P_3 T_4)
T_{16}- Triple super phosphate powder @ 6 g/l with 10 minutes submergence in pond water (P_3 T_5)
T_{17}- Triple super phosphate powder @ 8 g/l with 2 minutes submergence in pond water (P_4 T_1)
T_{18}- Triple super phosphate powder @ 8 g/l with 4 minutes submergence in pond water (P_4 T_2)
T_{19}- Triple super phosphate powder @ 8 g/l with 6 minutes submergence in pond water (P_4 T_3)
T_{20}- Triple super phosphate powder @ 8 g/l with 8 minutes submergence in pond water (P_4 T_4)
T_{21}- Triple super phosphate powder @ 8 g/l with 10 minutes submergence in pond water (P_4 T_5)
T_{22}- Triple super phosphate powder @ 10 g/l with 2 minutes submergence in pond water (P_5 T_1)
T_{23}- Triple super phosphate powder @ 10 g/l with 4 minutes submergence in pond water (P_5 T_2)
T_{24}- Triple super phosphate powder @ 10 g/l with 6 minutes submergence in pond water (P_5 T_3)
T_{25}- Triple super phosphate powder @ 10 g/l with 8 minutes submergence in pond water (P_5 T_4)
T_{26}- Triple super phosphate powder @ 10 g/l with 10 minutes submergence in pond water (P_5 T_5)

Bundle strength:

Pressley Fibre Strength Tester using zero gauge length was used to measure bundle strength of the samples (13, 14). Bundle strength was calculated from breaking load and weight of the sample using the formula given below:

$$\text{Pressley index (lbs/mg)} = \frac{\text{Breaking load(Ibs}}{\text{Bundle weight(mg)}}$$

Fineness:

WIRA Airflow Fineness Tester was used to measure the fineness of fibres. The samples were prepared accordingly for the measurement of each sample. The airflow method is the single most widely used commercial method and has achieved international standardization for wool, cotton and jute (15).

Brightness:

Brightness was measured using a digital photo-volt meter. The photo-volt meter was used in conjunction with a search unit containing blue filter. Brightness was measured in reflectance value using blue filter. These reflectance values of the samples are the percentage of brightness of a comparative standard of Magnesium Oxide (MGO) of 100% reflectance. In the way for blue filter 70.9 standard values was used for the measurement of brightness of the sample under test.

RESULTS

The results of the experiment has been presented Table- 2. Application of triple super phosphate powder with different times showed positive effect on the physical parameters such as bundle strength, fineness and brightness of jute fibre. A change has been observed in the value of these parameters (Table-2).

DISCUSSION

Comparing the rate of application i.e 2,4,,6,8,10 gl^{-1}, it was observed that application of 6 g/l resulted better quality in respect of brightness and fineness. On the other hand submergence time (i.e 2, 4, 6, 8, 10 minutes) of fibre in the solution showed better improvement of fibre quality with 4 minutes. Bundle strength, Fineness and Brightness of the non treated fibre (control) was 9.17, 34.60 and 29.34 respectably. Whereas the applications of treatments (Triple super phosphate) at different rates improved the fibre quality much higher (average value) compared to control. Since the higher value of brightness and bundle strength and lower value fineness resembles good quality fiber. Study reveals that higher bundle strength and brightness was with T_{13} (P_3 T_2-6 g/l and 4 minutes submergence) i e the value were 8.93 and 34.44 respectively.

But the value for fineness was 36.04 which is slightly higher than the average value of all the five rates of application. As the value of bundle strength and brightness are much lower than the said, treatment T_{13}; Therefore it can be concluded that among the applied treatment better improvement of fibre quality could be obtained with T_{13} (i.e 6 g/l Triple Super Phosphate powder with four (4) minutes submergence) for the fibre of variety BJRI tossa pat-4.

Table-2: Effects of different combination treatments on fibre quality of jute

Treatment	**Bundle strength**			**Fineness(μ)**	**Brightness(%)**
	Mean	S.D	CV%		
T_1	9.17	0.57	6.29	34.60	29.34
T_2	7.99	0.87	10.35	33.81	31.83
T_3	8.28	0.86	10.13	34.48	32.13
T_4	8.38	0.93	11.06	34.24	31.21
T_5	8.34	0.93	10.88	33.67	30.10
T_6	8.30	0.91	11.23	34.09	30.65
T_7	8.38	0.65	7.62	34.09	33.04
T_8	8.67	0.64	7.41	34.77	33.34
T_9	8.77	0.71	11.06	34.53	32.42
T_{10}	8.73	0.69	8.15	33.95	31.31
T_{11}	8.79	0.72	8.51	34.37	31.86
T_{12}	8.33	0.93	10.83	35.36	34.14
T_{13}	8.93	0.91	10.62	36.04	34.44
T_{14}	8.72	0.99	11.54	35.79	33.52
T_{15}	8.69	0.97	11.36	35.22	32.41
T_{16}	8.65	0.99	11.72	35.64	32.96
T_{17}	8.18	0.82	9.72	35.10	33.83
T_{18}	8.48	0.81	9.51	35.78	34.13
T_{19}	8.57	0.88	10.43	35.54	32.22
T_{20}	8.54	0.86	10.25	34.96	32.10
T_{21}	8.50	0.89	10.47	35.38	32.66
T_{22}	8.46	0.74	8.33	34.79	31.23
T_{23}	8.75	0.72	8.12	35.47	31.53
T_{24}	8.85	0.80	9.04	35.23	30.62
T_{25}	8.81	0.78	8.86	34.65	29.50
T_{26}	8.77	0.80	9.22	35.07	30.06

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EFFECT OF DIFFERENT CONTAINERS AND STORAGE DURATION ON THE OIL AND PROTEIN CONTENT OF JUTE SEEDS AT TWO LEVELS OF MOISTURE CONTENT

S. M. A. Haque[1], M. A. Rahman[2], Niharika Dasgupta[3] and I. Hossain[4]

ABSTRACT

The experiments were conducted in the laboratory laboratory of Plant Pathology Department, Bangladesh Jute Research Institute (BJRI), Manik Mia Avenue, Dhaka; Seed Pathology Center, Bangladesh Agricultural University (BAU), Mymensingh and Oil Seed Division, Bangladesh Agricultural Research Institute (BARI), Gazipur. The experiments were conducted during the period of 15 January 2010 to 5th March 2012. Nine different types of containers viz. tin pot, plastic pot, poly bag, gunny bag, gunny bag lined with polythene, earthen pot, cloth bag, brown paper and IRRI poly bag were used at two level of moisture contents viz. farmers' practice (16%) and recommended (9.5%) by Bangladesh Gazette (2010) for the present study. Seeds were stored for 12 months and examined after every 4. 8 and 12 months of storage. Among the nine containers, tin pot was found better and brown paper was found the poorest in performance in respect of seed oil and protein content. The findings of the present study also revealed that the recommended moisture content (9.5% moisture content in seed) was better than that of at farmers' condition. Thus, better quality can be insured by storing the jute seeds in tin pot at the recommended moisture content (9.5%) level.

Key word: Effect, storage container, moisture content, oil and protein, jute seed

INTRODUCTION

Jute is one of the main cash crops of Bangladesh. It is accounted that 6% of the country's total foreign exchange came from the jute and foreign currency earnings from exports (12). Bangladesh is the second largest producer of jute in the world (11), with its production of about 9.9 lakh tons of jute fibre, of which, 51% is used as mill consumption, 44% is used as raw jute export, and 5% is used domestically. Millions of people earn their livelihood from agricultural and industrial activities based on jute and allied fibres crops. Moreover, beyond the farmland and factory, jute and jute goods keep alive the transport sector, the service sector like banks and insurance and the agro-industrial job market. The jute crop greatly improves 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 through its long taproots. Also, jute and jute goods have been recognized as being friendly to the environment. Jute is mostly grown in Indo-Bangladesh region and in some countries of Southeast Asia. Two species of jute (*Corchorus capsularis* and *Corchorus olitorius*) are

[1] Senior Scientific Officer, Plant Pathology Department, Pest Management Division, Bangladesh Jute Research Institute, Dhaka-1207, [2&4] Professor, Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh. [3] Executive, krishi call centre, AIS, MoA.

cultivated in Bangladesh. The land and climatic conditions of Bangladesh are congenial for the production of high quality jute.

In Bangladesh, about 0.709 million hectares of land was under jute cultivation and the total yield was 8.40 million bales (4, 10). Bangladesh annually needs about 4000 metric tons of jute seeds of which only 12-15% is produced and supplied by the Bangladesh Agricultural Development Corporation (BADC) (14). The rest of the seeds about 85% or more of the requirement, are produced and managed by farmers' (8). BADC produces 300 tons of seed through contact growers and distributes them to the farmers. Deterioration of jute seed occurs during storage. Because different physiological and biochemical changes occur naturally in aged seeds during the process of deterioration. Ageing of seed in storage was enhanced due to lipid peroxidation and ultimately lost viability of seed (21). This loss of viability was most pronounced in oil rich seeds because the presence of polyunsaturated fatty acids in the seeds which is highly susceptible to peroxidation (17). Lipid peroxidation is associated with depletion of lipid reserves resulting in production of free fatty acids that finally results in the loss of seed viability (3). Seed is the most important and vital input for crop production. Quality seeds itself provide 20% additional yield of the crop (9). One of the major constrains responsible for low yield of jute in our country is mainly due to sowing of diseased or unhealthy seeds. Considering the above facts, the present study was carried out with the objective was to maintain the oil and protein content for producing quality jute seeds in storage condition.

MATERIALS AND METHODS

Experimental sites and period

The experiments were conducted in the laboratory laboratory of Plant Pathology Department, Bangladesh Jute Research Institute (BJRI), Manik Mia Avenue, Dhaka; Seed Pathology Center, Bangladesh Agricultural University (BAU), Mymensingh, Oil Seed Division, Bangladesh Agricultural Research Institute (BARI), Gazipur. The experiments were conducted during the period of 15 January 2010 to 5 March 2012.

Varieties used

Seeds of CVL-1 were used in the experiment. 110 kg of farmer's seeds were collected from Savar, Dhaka.

Containers used

Nine different types of storage containers were used, viz. T_1= Tin pot, T_2= Plastic pot, T_3= Poly bag having 25 μm thickness, T_4= Gunny bag, T_5= Gunny bag lined with polythene, T_6= Earthen pot, T_7 = Cloth bag, T_8= Brown paper and T_9= IRRI Poly bag (Super Grain bag II Z) having 78 μm thickness.

Moisture content of seeds

Seeds having two level of moisture content were used, viz.

i) Recommended moisture content (9.5%) (15 and 2).
ii) Farmers' condition

Determination of seed moisture content

Jute seed moisture was determined by constant temperature oven dry method (Khandakar, 1983; ISTA, 1999). The amounts of working samples depended on the diameter of the container which was used for determination of the moisture of the seed samples. The diameter of the container was less than 8 cm and the amount of seed samples were 4-5g. The working sample was evenly distributed over the surface of the container. The weight of the container and its lid were recorded before and after filling the container with the seed samples. The container was placed rapidly on the tops of its lid, and placed in an oven maintaining the temperature of 103± 2^0 C and dried for 17±1 hrs. At the end of the prescribed period, the containers were covered with lids and placed in the desiccators to make it cool for 30-40 minutes. After cooling, weight of the container with its lid and contents were recorded. The relative humidity of the ambient air in the laboratory at the time of moisture determination was less than 70%. The moisture content of the seed samples were calculated by means of the following formula (ISTA, 1999) and expressed as percentage.

$MC (\%) = (M_2 - M_3) X 100 / (M_2 - M_1)$

MC = Moisture Content

M_1 = Weight in grams of container and its cover/lid

M_2 =Weight in grams of the container, its cover and its contents before drying

M_3 = Weight in grams of the container, cover and contents after drying.

Bio-chemical analysis (protein and oil %)
Steps involving bio-chemical analysis
Procedure of protein analysis

Total soluble protein estimation

Seed extracts were prepared according to (13) and the total soluble proteins were estimated as described (13, 16) below:

Reagents used

i) 0.2 M phosphate buffer solution of p^H 7.5: a) K_2HPO_4 (17.418 g) was dissolved in distilled water and was made the volume up to 500 ml with distilled water and b) KH_2PO_4 (13.609 g) was dissolved in distilled water and was made the volume up to 500 ml with distilled water. Then solution (b) was slowly added to 500 ml of solution (a) until the p^H reach to 7.5.

ii) Lowry solution: Reagent (a) NaOH (4 g) + Na_2CO_3 (20 g) dissolved in distilled water and was made up to 1 L with distilled water. Reagent (b) $CuSO_4$ (0.25 g) + Na-K tertarate (0.5 g) dissolved in distilled water and was made the volume 50 ml with distilled water. Then by dissolving 1 ml of reagent (a) was into 50 ml dissolved of reagent (b) and the solution was kept for one day in ambient temperature. After discarding the solution, and the Lowry solution was prepared.

iii) Phenolfolin reagent: Phenolfolin solution was made by dissolving 1 ml phenolfolin to 1 ml of distilled water.

Procedure

Jute seeds (100 mg) were grounded with 5 ml of phosphate buffer using a pestle and mortar and centrifuged. The precipitates were washed twice with 5 ml of phosphate buffer, and made up to volumes of 20 ml with distilled water. This extract solution was used to estimate protein content. 0.5 ml extract was taken in a test tube and 2.5 ml Lowry solution was added, and incubated for 20 minutes. Then 0.25 ml phenolfolin reagent was added and shaken by hand. After developing colour, the optical density was measured within 20 minutes at 660 nm wave length by a double beam spectrophotometer (Model: HITACHI 200-20, Japan), and the total soluble protein was estimated as mg g^{-1} fresh weight by using the standard curve.

Procedure of oil analysis (Soxhlet extraction)

The method described by (1) was used with slight modification. The seed kernels (3g) were grounded using a mechanical method and defatted in a soxhlet apparatus. The extraction was carried out by using three different solvents such as hexane, isopropanol, and petroleum ether. The process continued for 6 hours. Solvent was removed by vacuum evaporation and exposure to heat in a drying oven at 50°C. The amount of oil recovered was calculated as percentage of total oil present in jute seed kernels. Each extraction was run thrice and the final value is the average of all.

Statistical analysis

Data were analysed statistically and treatments effects were compared by Duncan's Multiple Range Test (DMRT) (7).

RESULTS

Effect different containers and storage periods on the oil content and rate of oil decrease of jute seed at the moisture content level of farmers' practice

Oil percentage of farmers' seeds belonging to CVL-1 variety obtained from different storage containers varied significantly from 11.83 to 14.12% (Table 1). Rate of oil decreased depending upon storage period and storage containers and varied from 3.75 to 19.36%. Before storage, oil was 14.67% in CVL-1. In storage condition, oil content was decreased continually depending on the storage containers and storage duration. After 12 months of storage condition the lowest oil was 11.83% in the seeds stored in tin pot and the highest oil was 13.16% in the seeds stored in brown paper (Table 1). The rate of oil decrease was the highest (19.36%) in tin pot stored seeds which was statistically similar to gunny bag stored seeds (18.34%) and the lowest (10.29%) oil content was recorded in the seeds stored in brown paper.

Table 1. Effect different containers and storage periods on the oil content and rate of oil decrease of jute seed at the moisture content level of farmers' practice

Container	Oil content (%)				Rate of oil decreases (%)		
	Storing period (in months)				Storing period (in months)		
	0	4	8	12	4	8	12
T_1		12.83 c	12.21 f	11.83 d	12.54 a	16.77 a	19.36 a
T_2		13.45 b	13.05 b	12.60 b	8.32 b	11.04 cd	14.11 bc
T_3		13.45 b	12.41 ef	12.27 c	8.32 b	15.41 ab	16.36 b
sT_4		12.85 c	12.28 f	11.98 cd	12.41 a	16.29 a	18.34 ab
T_5		13.17 bc	12.72 cd	12.62 b	10.22 ab	13.29 bc	13.97 bc
T_6	14.67	13.36 b	13.31 a	12.24 c	8.93 b	9.27 d	16.56 b
T_7		13.55 b	13.05 b	12.85 ab	7.63 c	11.04 cd	12.41 cd
T_8		13.17 bc	12.57 de	13.16 a	10.22 ab	14.31 b	10.29 d
T_9		14.12 a	12.85 bc	12.76 b	3.75 d	12.41 c	13.02 c
Level of significance		0.01	0.01	0.01	0.01	0.01	0.01

T_1= Tin pot; T_2= Plastic pot; T_3= Poly bag; T_4= Gunny bag; T_5= Gunny bag lined with polythene; T_6= Earthen pot; T_7= Cloth bag; T_8= Brown paper and T_9= IRRI poly bag

Data in column having common letter(s) do not differ significantly at 1% level of significance

Effect of different containers and storage periods on the oil content and rate of oil decrease of jute seed at the moisture content level recommended by Bangladesh Gazette

Average differences of oil in the seeds having recommended moisture content seeds varied significantly depending on the storage containers and time. Oil varied from 11.76 to 13.12% in CVL- 1 and (Table 2). Oil continuously decreased with increased duration of storage period and varied from 3.17 to 13.21%. Oil content was 13.55% at the initial stage. After 12 months of storage the lowest oil

was 11.76% in the seeds in tin pot which was statistically similar to IRRI poly bag stored seeds (11.79%) and the highest (12.68%) oil was observed in the stored seeds in brown paper which was statistically similar to cloth bag (12.37%), poly bag (12.35%), gunny bag (12.28%), gunny bag lined with polythene (12.14%), plastic pot (12.12%) and earthen pot (12.06%), respectively (Table 2). The rate of oil decrease was the highest (13.21%) in seeds stored in tin pot and the lowest (6.42%) was observed in brown paper stored seeds.

Table 2. Effect different containers and storage periods on the oil content and rate of oil decrease of jute seed at the moisture content level recommended by Bangladesh Gazette

Container	Oil content (%)				Rate of oil decrease (%)		
	Storing period (in months)				Storing period (in months)		
	0	4	8	12	4	8	12
T_1		12.16 b	11.83 c	11.76 b	10.26 a	12.69 a	13.21 a
T_2		12.78 ab	12.50 ab	12.12 ab	5.68 e	7.75 d	10.55 bc
T_3		12.79 ab	12.02 bc	12.35 ab	5.61 e	11.29 b	8.86 e
T_4		12.50 ab	12.30 abc	12.28 ab	7.75 d	9.23 c	9.37 d
T_5	13.55	12.50 ab	12.17 bc	12.14 ab	7.75 d	10.18 bc	10.41 c
T_6		12.29 b	12.24 abc	12.06 ab	9.30 c	9.67 c	11.00 b
T_7		12.88 ab	12.50 ab	12.37 ab	4.94 f	7.75 d	8.71 e
T_8		13.12 a	12.76 a	12.68 a	3.17 g	5.83 e	6.42 f
T_9		12.18 b	11.86 c	11.79 b	10.11 b	12.47 a	12.99 ab
Level of significance		0.01	0.01	0.01	0.01	0.01	0.01

T_1= Tin pot; T_2= Plastic pot; T_3= Poly bag; T_4= Gunny bag; T_5= Gunny bag lined with polythene; T_6= Earthen pot; T_7= Cloth bag; T_8= Brown paper and T_9= IRRI poly bag
Data in column having common letter(s) do not differ significantly at 1% level of significance

Effect of different containers and storage periods on the protein content and rate of protein decrease of jute seed at the moisture content level of farmers' practice

In farmers' seed, protein content varied from 17.35 to 19.40% (Table 3) and the rate of decrease was varied from 3.43 to 13.64% in the variety CVL-1. The rate of protein decrease depended upon the duration of storage period and different types of containers. After 12 months of storage, the highest protein was 18.96% in the stored seeds in tin pot followed by IRRI poly bag (18.01%) and the lowest was (17.35%) in plastic pot and earthen pot stored seeds preceded by gunny bag lined with polythene stored seeds (17.44%) (Table 3). The highest protein decreased rate (13.64%) was recorded in the seeds stored in plastic pot and earthen pot which were statistically similar to the gunny bag lined with polythene (13.19%), gunny bag (13.14%) and brown paper (13.09%) stored seeds. The lowest decrease rate (5.62%) was found in the seeds in tin pot followed by IRRI poly bag stored seeds (10.35%).

Table 3. Effect of different containers and storage periods on the protein content and rate of protein decrease of jute seed at the moisture content level of farmers' practice

Container	Proteinl content (%)				Rate of protein decrease (%)		
	Storing period (in months)				Storing period (in months)		
	0	4	8	12	4	8	12
T_1		19.40	19.18	18.96	3.43 d	4.53 d	5.62 d
T_2		17.85	17.60	17.35	11.15 a	12.39 a	13.64 a
T_3		17.86	17.69	17.52	11.10 a	11.95 ab	12.79ab
T_4		17.91	17.68	17.45	10.85 b	12.00 a	13.14 a
T_5	20.09	17.86	17.65	17.44	11.10 a	12.15 a	13.19 a
T_6		17.81	17.56	17.35	11.35 a	12.59 a	13.64 a
T_7		18.01	17.83	17.68	10.35 b	11.25 b	12.00 b
T_8		18.00	17.73	17.46	10.40 b	11.75 ab	13.09 a
T_9		18.40	18.14	18.01	8.41 c	9.71 c	10.35 c
Level of significance		NS	NS	NS	0.01	0.01	0.01

T_1= Tin pot; T_2= Plastic pot; T_3= Poly bag; T_4= Gunny bag; T_5= Gunny bag lined with polythene; T_6= Earthen pot; T_7 = Cloth bag; T_8= Brown paper and T_9= IRRI poly bag
Data in column having common letter(s) do not differ significantly at 1% level of significance
NS = Not Significant

Effect different containers and storage periods on the protein content and rate of protein decrease of jute seed at the moisture content level recommended by Bangladesh Gazette

In the recommended moisture containers seeds protein percentage varied from 18.06 to 20.13% in the variety CVL-1 (Table 4). At the initial stage, protein was 21.63%. But after 12 months of storage the highest protein was 19.61% in the stored seeds in tin pot and IRRI poly bag which were statistically similar to other stored seeds (Table 4). The highest protein decrease rate (17.85%) was recorded in poly bag stored seeds which was statistically similar to the gunny bag lined with polythene stored seeds (16.50%) and the lowest decrease rate (9.34%) was in tin pot stored seeds preceded by IRRI poly bag (13.85%) stored seeds.

Table 4. Effect different containers and storage periods on the protein content and rate of protein decrease of jute seed at the moisture content level recommended by Bangladesh Gazette

Container	Protein content (%) Storing period (in months)				Rate of protein decrease (%) Storing period (in months)		
	0	4	8	12	4	8	12
T_1		20.13	19.89	19.61	6.93 d	8.04 d	9.34 d
T_2		18.69	18.50	18.39	13.59 b	14.47 b	14.98 bc
T_3		18.50	18.26	17.77	14.47 a	15.58 a	17.85 a
T_4		18.50	18.50	18.39	14.47 a	14.47 b	14.98 bc
T_5	21.63	18.50	18.31	18.06	14.47 a	15.35 a	16.50 ab
T_6		18.50	18.50	18.29	14.47 a	14.47 b	15.44 b
T_7		18.69	18.59	18.37	13.59 b	14.05 b	15.07 b
T_8		18.50	18. 42	18.28	14.47 a	14.84 b	15.49 b
T_9		19.13	18.99	18.63	11.56 c	12.21 c	13.85 c
Level of significance		NS	NS	NS	0.01	0.01	0.01

T_1= Tin pot; T_2= Plastic pot; T_3= Poly bag; T_4= Gunny bag; T_5= Gunny bag lined with polythene; T_6= Earthen pot; T_7 = Cloth bag; T_8= Brown paper and T_9= IRRI poly bag
Data in column having common letter(s) do not differ significantly at 1% level of significance
NS = Not Significant

DISCUSSION

From the above study tin pot was found better and brown paper was found poorest performance in respect of seed oil and protein content. The other containers in order of prevalence were IRRI poly bag, poly bag, plastic pot, gunny bag lined with polythene, cloth bag, gunny bag and earthen pot. Oil and protein content of seeds depended on the storage longevity. In storage condition, oil and protein content decreased with the influence of storage condition on oil content of maize, soybean and sunflower (5). The storage longevity was negatively associated with the oil content under storage conditions at 12°C/60%, decrease of seed oil content was less by 0.55% (maize), 1.30% (soybean) and 1.75% (sunflower) than in storage condition at 25°C/75%. During a period of three months of storage the percentage of seed oil gradually decreased with the increase of storage duration (19 and 20). The declining rate in total soluble protein of jute seed was observed with the progress of storage period (6 and 18).

Therefore, it may be summarized that during storage oil and protein contents of jute seeds depend upon the storage containers, duration and environmental condition and the quality can be ensured by storing the seeds in tin pot by maintaining the moisture content at 9.5%.

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EFFECT OF BATCH COMPOSITION ON JUTE YARN IN RELATION TO ITS PHYSICO-MECHANICAL PROPERTIES.

A. K. Mollah[1], Md. Abdul Majid Molla[2], Md Assaduzzaman[3], M. A. Salam Khan[4] and M. A. M. Khan[5]

ABSTRACT

The study was conducted for the assessment of yarn quality produced from different batch compositions in jute mills in relation to its physico-mechanical & properties. Jute yarns of different counts 8lbs/spy, 10.25 lbs/spy, and 30 lbs/spy were collected from different jute mills of Chittagong zone in the year of 2008 & 2010. The samples were examined to determine Actual Count, Tensile Strength, Twist Per Inch (TPI), Tenacity and Quality Ratio in the laboratory of Testing and Standardization Department of Textile Physics Division of BJRI maintaining standard test condition. It was found that best quality yarn, possessing 97.61% quality ratio was produced in Amin Jute Mills Ltd (AJM) for 8 lbs/spy and the yarn of Gull Ahmed Jute Mills Ltd (GAJM) possessed the lowest quality ratio 88.98% for the same count. In case of 10.25 lbs/spy yarn which was produced in Amin Jute Mills possessed the highest quality ratio 93.07% with highest Tensile Strength and Tenacity and the yarn of same count produced in Hafiz Jute Mills (HJM) possessed the lowest quality ratio 88.81% with the lowest Tensile Strength and Tenacity. Yarn of 30lbs/spy of Bangladesh Carpet Finishing Jute Mills Ltd (BDCF) obtained highest quality ratio 92.21% and yarn of Gull Ahmed Jute Mills Ltd (GAJM) possessed the lowest quality ratio 79.58%. It was found from this study that yarn quality varies with the variation of batch composition.

INTRODUCTION

Jute is the leading cash crop and second foreign exchange earner of Bangladesh. A great advantage of jute fibre is that, it is an environment friendly natural fibre. At present jute is facing tough competition from the convenient and competitive synthetic counter parts in the world market. There are various potential diversified usages through which jute fibre could be saved. Hence, the quality batch must be prepared with standard fibre to make yarn of best quality. After producing the yarns of various count, their various physical properties must be observed & standardized (1) .Here in this study physical properties like Tensile Strength, Actual Count, Linear Density(tex), Tenacity, Quality Ratio (QR%) and Moisture Regain(MR%) were observed.

In jute industry the required physico-mechanical properties of jute fibres are determined by the responses to the applied forces and deformations. The physico-mechanical properties of jute fibre play a very important role for producing quality yarn and largely influence the cost of yarn (7). The properties of jute products such as jute yarns or fabrics depend on some

[1] SSO, Textile physics, 2 PSO, PPP Division, 3 Director (Tech.), 4 SSO, PPP Division, 5 SSO, Textile physics, Division, BJRI.

complex interrelation between fibre arrangement and fibre properties, so that, knowledge of fibre properties is essential to understand the properties of the products. There will be some effects that are due to internal properties of the micro structural arrangement, and the fibre properties may be modified by the presence of neighbouring fibres. Only fine fibres can produce fine yarn.

The morphological structure of jute fibre is by no means regular and perfect. If the strength of the yarn is much above the required value, the resultant fabric may be too strong for its intended use. The yarn Tensile Strength (TS) depends on the quality of fibre as well as on the processing parameters. Irregular sliver will produce an irregular yarn due to which the average strength of yarn may be affected. Batch composition has an impact on yarn qualities, because it is prepared by different types of fibre having different properties. Determined by the batch, quality and the required strength of the yarn could be managed (5). Good yarn cannot be produced without good fibres. In this case, low standard of fabrics need low quality yarns.

Different amount of emulsion is necessary for different types of raw jute. In order to soften the fibres, in other words, to make jute more pliable for spinning before its use jute fibres are treated with emulsion. Oil and water in emulsion is used to remove the hardness of the fibre. This is normally prepared using mineral oil, water, and emulsifier (soft soap). The composition varies with products and also mill for different. The general composition for emulsion is as follows: (i) Mineral oil-25.4 %(ii) Water-73% (iii) Emulsifier-1.6% for ordinary Hessian (8).

For the production of jute yarns always a batch is made with different types of fibres at specific compositions according to the need of the right type of product. That is the fibres are mixed in different percentages. The batch composition becomes an important phenomenon for yarn production. The present work was under taken to identify the effect of batch composition of jute yarn objectively.

Jute is a kind of natural fibre extracted from the state of jute plant. Two major types of jute are Tossa and White, grown abundantly in Bangladesh. It is an agricultural crop as well as an industrial crop. End usages of jute are almost entirely dependent on mechanical processing. In some cases chemical processing is needed to develop and improve the quality of jute products for diversification. Spinning and weaving are the primary mechanical processes to build up the products. In that case top manufacturing of quality yarn of different counts, these processes are the important factors. Only yarn of better quality can make better quality fabrics. From the very beginning, jute has been used to make Hessian, Sacking and Carpet backing cloth. But now a days jute fibre is used in various types of diversified products also like home textiles, shopping bags, school bags, ladies bag, sweater, brief case etc. Above all, only experience can show the correct way that is best suited to individual mills (9).

MATERIALS AND METHODS

Jute yarns of different counts 8,10,25 and 30 lbs/spy were collected from Gull Ahmed Jute Mill Ltd (GAJM), Hafiz Jute Mill Ltd (HJM), Amin Jute Mill Ltd (AJM) and Bangladesh Carpet Finishing Jute Mill Ltd (BDCF) of Chittagong zone to assess the different quality parameters of yarn namely Counts, Tensile Strength, Twist Per Inch, Tenacity, Quality Ratio % and Moisture Regain%. Using the following methods, physical properties were determined in standard atmospheric condition.A number indicates the mass per unit length or the length per unit mass of yarn. It indicates the coarseness or fineness of a yarn. Jute count system is determined by lbs/spy i.e. the weight in pound of 14,400 yds (1spyndle). The count of a yarn is a numerical expression which defines its fineness. The count of the weight in pound of 14400 yards of jute yarn was determined by making hanks of 100 yards from four different bobbins, selected from the spinning section, for each quality randomly. The weight of each hank was taken with the help of a precision balance. Precision balance is a special yarn balance used in the determination of count as it is essential to have accurate weight of the hanks. The count i.e. weight/spindle (lbs per 14,400) of each quality of yarn was calculated by

$$count\,(Grist) = \frac{weight\ in\ (g) \times 14400}{453.6 \times measured\ length\,(yards)}$$

Tensile Strength:

Tensile Strength is the average breaking load of a number of standard test lengths expressed in pounds of the yarns, determined through Good brand Single Yarn Tester. The gauge length is 50 cm and rate of traverse of the actuated jaw is 30 cm per minute.

Quality Ratio:

Quality ratio (QR%) is the average yarn Tensile Strength expressed in pounds, divided by count of the jute yarn and multiplied by hundred. The Quality Ratio values of yarns of different counts and collected from different jute mills were calculated and average value of this quality ratio was calculated for each type of yarn(6).

$$QualityRatio = \frac{\text{Tensile Strengh (lb)} \times 100}{\text{weight in pound per 14400 yards of yarn}}$$

The quality ratio value of yarns of different jute mills were calculated and average value of this quality ratio was calculated for each type of yarn (2).

Some of the most important properties of textile fibre and behaviour are closely related to the atmospheric condition. Most cellulosic fibres are hygroscopic, which means they are able to absorb water vapors from a moist atmosphere.

Moisture Regain and Moisture Content:

The amount of moisture in a sample of material may be expressed in terms of Regain or Moisture content. Regain is defined as the weight of water in a material, expressed as a percentage of the over dry weight (Over dry weight will be defined shortly). Moisture Content is the weight of water in a material expressed as present (%) of the total weight (7).

Twist Per Inch (TPI):

TPI is measured by Twist tester using 10 gauge lengths (4). The total number of turns registered on the revolution counter when divided by length of the sample in inch is define as twist per inch.

Tenacity:

The tenacity value is ratio of Tensile Strength (g) of single yarn and linear density (tex), Tenacity value was calculated by using the following formula,

$$\text{Tenacity (g/tex)} = \frac{\text{Tensile Strength (g)}}{\text{liner density (tex)}}$$

Where linear density is the mass of materials in some standard length (3). It was observed that the Jute Mills produce particular yarns for specific purpose keeping only their nominal counts fixed or same but in reality actual counts vary. Thus Actual yarn Counts, Tensile Strength, Twist Per Inch, Tenacity, Moisture Regain% and Quality Ratio% were determined to assess the yarn quality of these three counts. In Tex system, it is the weight of one kilometer length of materials in gramme. Averages of Twist Per Inch (TPI), Tensile Strength (TS), Standard Deviation and Co-efficient of Variation were calculated. The experiment was conducted in the laboratory of Textile Physics Division Bangladesh Jute Research Institute (BJRI) during the year of 2008 to 2010.

RESULTS

Jute yarns having count 8.00 lbs/spy, 10.25 lbs/spy and 30.00 lbs/spy were collected from four jute mills of Chittagong zone. The samples were tested and the obtained results are shown in the following tables.

Table 1. Results of different Yarn Properties of 8.00 lbs/spy.

Name of Jute Mill	Batch Composition	Count (lb/spy)	Tensile Strength (lbs)	Twist per inch(TPI)	Tenacity g/tex	MR%	QR%
GAJM	T.X.Bottom-60% W.X.Bottom-20% BWC-20%	Actual count=7.81 Nominal count=8.00	Mean=6.93 SD=0.72 CV%=10.29	Mean=3.9 SD=0.62 CV%=13.87	11.68	8.7	88.98
HJM	BWD-40.5% TC-Bottom-29.5% WC-Bottom-20% T.X-Bottom-10%	Actual count=7.81 Nominal count=8.00	Mean=7.41 SD=0.66 CV%=8.89	Mean=4.0 SD=0.49 CV%=11.53	11.97	8.11	90.92
AJM	T.C.Bottom-30% W.C .Bottom-20% BWC-30% T.X-Bottom-20%	Actual count=7.81 Nominal count=8.00	Mean=7.76 SD=0.67 CV%=8.66	Mean=4.49 SD=0.68 CV%=8.93	12.85	7.53	97.61
BDCF	T.X.Bottom-30% W.X.Bottom-30% BWB-40%	Actual count=7.81 Nominal count=8.00	Mean=7.5 SD=0.69 CV%=9.23	Mean=3.1 SD=0.27 CV%=6.94	12.45	8.11	94.58

Table 2. Results of different Yarn Properties of 10.25 lbs/spy.

Name of Jute mill	Batch Composition	Count (lb/spy)	TS (lbs)	TPI	Tenacity g/tex	MR %	QR%
GAJM	BWD-30.5% TCutting-39.5% WCutting-19.5% TSMR-10%	Actual count=10.35 Nominal count=10.25	Mean=9.40 SD=0.78 CV%=8.23	Mean=3.9 SD=0.50 CV%=12.61	11.98	9.29	91.01
HJM	WSMR-2 32.28% Thread waste-67.82	Actual count=8.89 Nominal count=10.25	Mean=8.78 SD=0.90 CV%=10.16	Mean=3.75 SD=0.44 CV%=11.607	11.69	8.40	88.81
AJM	BWD-30.5% WC Bottom-29.5% T cutting-20% T.X-Bottom-20%	Actual count=10.10 Nominal count=10.25	Mean=9.42 SD=0.76 CV%=8.13	Mean=4.22 SD=0.41 CV%=9.62	12.25	8.70	93.07
BDCF	BWD-30. % WX-Bottom-30% Thread waste-40.00	Actual count=10.13 Nominal count=10.25	Mean=8.89 SD=0.54 CV%=6.02	Mean=3.8 SD=0.51 CV%=12.05	12.17	8.10	92.44

Table 3. Results of different Yarn Properties of 30.00 lbs/spy.

Name of Jute mill	Batch Composition	Count (lb/spy)	TS (lbs)	TPI	Tenacity g/tex	MR %	QR%
GAJM	TSMR-10% WSMR-20% Habijabi-30% T.cutting40%	Actual count=29.63 Nominal count=30.00	Mean=23.58 SD=1.01 CV%=4.29	Mean=2.53 SD=3.42 CV%=13.55	10.48	9.89	79.58
HJM	WSMR-10% Habijabi-40% T.cutting50%	Actual count=29.30 Nominal count=30.00	Mean=23.97 SD=0.76 CV%=7.85	Mean=2.86 SD=0.47 CV%=16.54	10.77	10.4 9	81.81
AJM	BWD-30% W.X.Bottom-30% WSMR-20% Habijabi-20%	Actual count=29.75 Nominal count=30.00	Mean=26.85 SD=1.45 CV%=5.41	Mean=3.11 SD=0.53 CV%=16.92	11.88	9.29	90.25
BDCF	BWD-50.23% TC-Bottom-20% BC-Bottom-29.77%	Actual count=29.77 Nominal count=30.00	Mean=27.45 SD=0.97 CV%=3.52	Mean=3.6 SD=0.47 CV%=16.55	12.14	9.56	92.21

DISCUSSION

Results obtained from this study was shown in three different tables above viz. Table-1, Table-2 and Table-3 were tabulated against 8.0 lbs/spy, 10.25lbs/spy and 30.00 lbs/spy yarns respectively. It was found that for yarns of 8.0 lbs/spy actual counts of the entire samples were same. The sample collected from AJM attained the highest tensile strength value than those of others because of its better batch composition and highest twist per inch. The batch was prepared as T.C. Bottom-30% +W.C. Bottom-20% +WBC-30%+ T.X-Bottom-20% which were the batch composition of higher quality fibres. It was found that fibre of grade C and B were used in maximum percentage in that batch. Its tenacity and quality ratio were found higher than those of others. The sample of GAJM possessed the lowest tensile strength, tenacity and quality ratio amongst all. Because of its batch composition yarn quality was found lower. In that case GAJM used fibre of low quality as X-Bottom in maximum percentage. Hence quality of yarn became lower. The sample of BDCF obtained a result very close to the sample of AJM. The batch composition of BDCF was also found better than those of GAJM & HJM. It was found from Table-2 that yarns of AJM and BDCF possessed almost same values for the measuring properties. But the yarn of AJM obtained slightly higher values than those of BDCF samples because of its better batch composition. Among those two batches AJM used 20% T.Cutting & BDCF used 40% thread waste as mentioned in previous page. The yarn of HJM obtained the lowest values for almost all parameters. It was mentioned that HJM used very low quality fibres in preparing the batch. So quality of yarn became very poor. The yarn of GAJM also attained a good result very close to the samples of BDCF. Comparing between the batches of GAJM and BDCF, it was found that the batch of GAJM was prepared by using cutting fibres in maximum percentage. On the other hand, BDCF used thread waste in a noticeable percentage. It was found from Table-3 that the yarn of BDCF possessed the highest tensile strength among the all because of its better batch composition. In that case BDCF did not use either any cutting fibre waste. It was prepared with better fibres and thus the yarn possessed better results. The yarn properties of AJM obtained slightly lower values than that of BDCF yarn. In this study it was found that the yarns of GAJM obtained the lowest values in almost all parameters. As because the batch of GAJM was prepared with a composition of TSMR-10%+ WSMR-20%+ Habijabi-30% + T.Cutting -30%, the yarn quality became lower than those of others. But the yarn of HJM displayed very good result in Tensile strength values which are very close to the tensile strength of GAJM. From this study it was observed that batch compositions perform a significant role in determining the yarn quality.

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GENETIC VARIABILITY, HERITABILITY AND GENETIC ADVANCE IN TOSSA JUTE *(CORCHORUS OLITORIUS* L.)

M. M. Hussain[2], S. M. Mahbub Ali[3], Md. Nazrul Islam[1] and C.K. Saha[4]

ABSTRACT

Genetic variability, heritability and genetic advance were studied for eight yield and yield attributes of fourteen elite genotypes of tossa jute and their ninety one F_1 hybrids. The genotypes differed significantly for all the characters. Higher genotypic coefficient of variation was observed for dry stick weight, dry fibre weight, plant height, petiole length and green weight. The difference between the corresponding phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) was narrow for plant height, internodal length, petiole length and dry stick weight suggesting that the environment had little influence on the phenotypic expression of these characters. Heritability was high for all the characters. High heritability coupled with high genetic advance was observed for green weight indicates additive nature of the genes for this character. Green weight had comparatively higher values of genotypic coefficient of variation, heritability estimate and highest genetic advance. Thus selection based on this character could be considered more fruitful for making effective selection.

Key words: Tossa jute (*Corchorus olitorius* L.), variability, heritability, genetic advance

INTRODUCTION

Jute fibre is obtained from two cultivated species of the genus *Corchorus* namely, *Corchorus capsularis* L. and *C. olitorius* L. It is the most important bast fibre crop next to cotton (7, 13). Jute, not only constitutes a major foreign currency earner, but is also a major source of employment, which is of prime importance to the rural economy of the regions in which it is grown. In Bangladesh jute assumes high socio-economic significance because millions of small farmers and industrial laborers depend on jute production and utilization for their livelihood. To run the industries economically and profitably a steady supply of raw jute all the year round is therefore, most vital. Thus to sustain economic growth of the country, increase in raw jute yield per unit of land with improved quality and modification in its structure and properties is urgently needed. To date, no major break through has been made in yield improvement through varietal development as has been achieved in the case of major crops like rice, wheat, cotton etc. This necessitates the improvement of yield potentiality through breeding programme. For a successful breeding programme knowledge about the genetic parameters of the characters is essential as it provides not only a basis for selection but also some valuable indication relating selection of parents to be hybridized. Information on the nature and magnitude of variation in the populations, the extent of

[1] Director (A&F), [2] CSO, Genetic Resources and Seed Division, [3] PSO, PTC Division & [4] CSO, PTC Division, Bangladesh Jute Research Institute Manik Mia Avenue, Dhaka-1207,Bangladesh

environmental influence on the expression of characters is necessary for fruitful gain in breeding programme. The genetic parameters also help in the prediction of possible genetic advance through selection based on phenotypic value. Dudley and Moll (3) suggested to partition the available variability in a population into its heritable and non-heritable components with the help of genetic parameters such as genotypic coefficient of variation, heritability estimates and genetic advance for selecting superior genotypes. Therefore, the present study was undertaken to find out suitable selection criteria through genetic estimates in tossa jute.

MATERIALS AND METHODS

Fourteen parents and their ninety one F_1s were grown in a randomized complete block design with 3 replications in 1995 at the experimental field of Bangladesh Jute Research Institute (BJRI), Dhaka. The parents were Syria-155, Syria-154, YPY-026C, YPY-009C, O-4, O-9897, SM/024C, DS/060C, SU/034C, SU/017C, Y/074C, Nonsoong 1, JRO-7835 and JRO-524. Each entry consisted of three rows of 3.0 m long, spaced 30 cm between the rows and 5-6 cm within the rows. All necessary cultural operations were employed as and when necessary during the whole growing period. Data were recorded for eight quantitative characters namely, plant height (m), base diameter (mm), internodal length (cm), leaf area (sq. cm), petiole length (cm), green weight per plant (g.), dry fibre yield per plant (g.) and dry stick weight per plant (g.). Ten competitive plants from middle row of each plot were randomly selected and harvested at 120 days crop age. Data were recorded for each entry over replication. Analysis of variance, coefficient of variation (genotypic and phenotypic), broad sense heritability and genetic advance were determined using the formula suggested by Panse (9), Burton and Devane(1), Lush (8) and Johnson and Robinson (5) respectively.

RESULTS

Analysis of variance for yield and yield attributes showed significant variation among the genotypes for all the characters studied (Table 1). The genotypic variances were partitioned into the variances of parent, crosses and parents versus crosses. Variances of both parents and crosses were significant for all the characters except base diameter, leaf area and green weight for parents. The variances of parents versus crosses were significant for all the characters except internodal length.

The mean values, genotypic and phenotypic variances, genotypic and phenotypic coefficient of variation, heritability and genetic advance are shown in Table 2. The phenotypic variance was higher than the corresponding genotypic variance for all the characters studied. The genotypic variances were more or less close to their corresponding phenotypic variances for the characters plant height, internodal length and petiole length. The highest genotypic variance was found in green weight (948.84) followed by dry stick weight (119.56), leaf area (9.11) and dry fibre yield (7.70) and the lowest was in internodal length (0.12). The phenotypic coefficient of variation (PCV) was higher than their corresponding genotypic coefficient of variation (GCV) for all the characters. The highest PCV was found for dry stick weight (31.89) followed by dry fibre yield (24.24), green weight (18.00), plant height (15.86), petiole length (15.24), internodal length (9.56) and base diameter (8.04). On the other hand, highest GCV was observed in dry stick weight (26.90) followed by dry fibre yield (17.54), plant height (15.46), petiole length (14.42), green weight (11.90), internodal length (8.55), and base diameter (4.99).

Table 1. Analysis of variance of eight yield contributing characters in tossa jute.

Sources of variation	Degrees of freedom	Plant height	Base diameter	Internodal length	Leaf area	Petiole length	Green weight	Dry fibre yield	Dry stick weight
Blocks	2	0.27**	44.70**	0.29*	773.95**	9.40**	34686.54**	39.63	225.06
Genotypes	104	0.51**	4.96**	0.39**	69.47**	1.75**	6115.01**	40.82**	447.95**
Parents	13	0.15**	2.93	0.20**	57.44	0.78**	4214.60	38.57*	285.02*
Crosses	90	0.44**	4.51**	0.42**	68.07**	1.81**	5747.63**	35.57**	449.37**
Parents Vs Crosses	1	11.09**	71.33**	0.01	351.48**	8.79**	63885.22**	542.17**	2438.31**
Error	208	0.03	3.19	0.07	45.64	0.19	3663.87	21.01	145.49

**,* Significant at p=0.01 and 0.05, respectively.

Heritability estimates were high for all the characters. The characters in descending order are plant height (95.0%), petiole length (89.5%), internodal length (80.0%), dry stick weight (71.15%), dry fibre yield (52.38%), green weight (43.72%), base diameter (38.5 1%) and leaf area (37.43%).The estimates of genetic advance recorded for eight characters, ranged from 41.96 (green weight) to 0.88 (plant height). The highest value of genetic advance was observed for the character green weight (41.96) at 5 percent selection intensity whereas dry stick weight (19.00) recorded medium value. Comparative low genetic advance was observed in plant height (0.88), base diameter (1.05), internodal length (0.64), leaf area (3.80), petiole length (1.50) and dry fibre yield (4.14). On the other hand, the genetic advance as percent of mean ranged from 46.74 (dry stick weight) to 5.63 (leaf area). The highest value (46.74) was observed for dry stick weight followed by plant height (31.21), petiole length (28.12), dry fibre yield (26.17), green weight (16.21) and internodal length (15.80). Lower values of genetic advance as per cent of mean were observed for base diameter (6.40) and leaf area (5.63). In the present investigation, green weight had high heritability value coupled with high genetic advance. High heritability coupled with moderate genetic advance was observed for dry stick weight. The high heritability coupled with low genetic advance was observed for plant height, base diameter, internodal length, leaf area, petiole length and dry fibre yield.

Table 2. Genetic parameters of eight different characters of tossa jute.

Genetic Parameters	Plant height (m)	Base diameter (mm)	Internodal length (cm)	leaf area (cm^2)	Petiole length (cm)	Green weight per plant (g)	Dry fibre yield per plant (g)	Dry Stick weight per plant (g)
Mean	2.82	16.41	4.05	67.46	5.37	258.84	15.82	40.65
Genotypic variance	0.19	0.67	0.12	9.11	0.60	948.84	7.70	119.56
Phenotypic variance	0.20	1.74	0.15	24.34	0.67	2170.10	14.70	168.05
Genotypic coefficient of variation (%)	15.46	4.99	8.55	4.47	14.42	11.90	17.54	26.90
Phenotypic coefficient of variation (%)	15.86	8.04	9.56	7.31	15.24	18.00	24.24	31.89
Heritability (%)	95.00	38.51	80.00	37.43	89.55	43.72	52.38	71.15
Genetic advance	0.88	1.05	0.64	3.80	1.51	41.96	4.14	19.00
Genetic advance as percentage of mean	31.21	6.40	15.80	5.63	28.12	16.21	26.17	46.74

DISCUSSION

Significant variation was observed among the genotypes in respect of all the characters studied. Variances of both parents and crosses were significant for all the characters except base diameter, leaf area and green weight for parents indicates the presence of genetic variation within the parents. The variances of parents versus crosses were significant for all the characters except internodal length. The significant variances for these characters suggest manifestation of heterosis in the F_1s.

The phenotypic variance was higher than the corresponding genotypic variance for all the characters studied. The extent of variability for any character is very important to use in breeding programme for crop improvement. The genotypic variances were more or less close to their corresponding phenotypic variances for the characters plant height, internodal length and petiole length indicating that these characters are influenced by the environment. Similar findings were reported by Chaudhury (2) in tossa jute. On the other hand, comparatively higher environmental influence was observed on base diameter, leaf area, green weight, dry fibre yield and dry stick weight.

The phenotypic coefficient of variation was higher than their corresponding genotypic coefficient of variation in all the characters. The highest genotypic coefficient of variation was observed in dry stick weight followed by dry fibre yield, plant height, petiole length, green weight, internodal length, and base diameter and it was lowest for leaf area. The difference between phenotypic and genotypic coefficient of variation for plant height, internodal length, petiole length and dry stick weight was reasonably narrow suggesting that the environmental influence on the phenotypic expression of these characters was not worth for consideration and the phenotypic expression of these characters were the true representation of their genetic make-up. Hence, selection of desired character simply on the phenotypic value may be effective. Shukla and Singh (11) reported higher genetic coefficient of variation for green weight, dry stick weight and dry fibre yield in white jute. Similar results were also reported by Joseph (6) for green weight and dry fibre yield in white jute and Ghoshdastidar and Das (4) for dry fibre yield in tossa jute. The magnitude of differences between phenotypic and genotypic coefficient of variation for the characters base diameter, leaf area, green weight and dry fibre yield were relatively high suggesting the considerable effect of environment on these characters.

All the characters had high heritability values. Singh (12) reported high heritability estimates for plant height, base diameter, dry fibre yield and stick weight in tossa jute. High magnitude of heritability for plant height, base diameter and fibre yield were reported by Ghoshdastidar and Das (4) in white jute. Sardana *et al.* (10) reported high heritability value for plant height, base diameter and dry fibre yield in jute germplasm.

The highest value of genetic advance was observed for green weight whereas dry stick weight recorded medium value. Comparative low genetic advance was observed in plant height, base diameter, internodal length, leaf area, petiole length and dry fibre yield. On the other hand, genetic advance as per cent of mean depicted some alteration in the relative ranking of different characters. The highest value was observed for dry stick weight followed by plant height, petiole length, dry fibre yield, green weight and internodal length. Lower values of genetic advance as per cent of mean were observed for base diameter and leaf area.

Green weight had high heritability value coupled with high genetic advance indicating the predominance of additive gene effects and hence the selection for this character would be more effective. This is in accordance with Shukla and Singh (11) who observed high heritability with high genetic advance for green weight in white jute. Similar observations were also reported by Joseph (6). High heritability coupled with moderate genetic advance was observed for dry stick weight. Singh (12) observed similar findings for dry stick weight in tossa jute which is in confirmation to the present investigation. The phenotypic selection for making genetic improvement is expected to be more effective for this trail.

High heritability coupled with low genetic advance was observed for plant height, base diameter, internodal length, leaf area, petiole length and dry fibre yield suggests that these characters are controlled by non-additive gene action and selection for these characters will not give good response. Similar findings were reported by Sobhan (14) in tossa jute for the characters plant height and fibre yield. He observed moderate heritability with low genetic advance for base diameter.

Genetic advance as percent of mean was high for dry stick weight, plant height, petiole length, dry fibre yield and green weight and low for the rest of the characters. Ghoshdastidar and Das (4) observed high genetic advance as per cent of mean for plant height and fibre yield in tossa jute. Sobhan (14) reported similar findings for fibre yield and stick yield in tossa jute. He also observed low genetic advance as percent of mean for plant height and base diameter which provide support to present findings.

Among the different characters studied, green weight had comparatively high values of genetic coefficient of variation, heritability and highest genetic advance. Therefore, green weight could be considered as one of the most important character for making effective selection.

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STATUS OF QUALITY AND HEALTH OF O-9897 JUTE VARIETY IN BANGLADESH

S. M. A. Haque[1], I Hossain[2], M. A. Rahman[3], M. A. Alam[4]
Sultan Ahmmed[5], and Niharika Dasgupta[6]

ABSTRACT

The experiments was conducted in the laboratory of Plant Pathology Department, Bangladesh Jute Research Institute (BJRI), Dhaka. during the period from 15 January 2010 to 5 March 2010. A survey was conducted to determine the status of farmers' seed management practices, seed quality and prevalence of seed borne pathogens in jute seeds. It was observed that 58% jute farmers' used O-9897 variety and two third of the farmers' used BADC seed and stored their seeds in earthen pot, gunny bag, tin pot, plastic pot, gunny bag lined with polythene, poly bag and cloth bag. Among five tiers, breeder seed showed best performance and farmers' and NGO's seeds showed the poorest performance in respect of moisture content, germination, vigour index, purity, 1000- seed weight and seed borne infection by fungal pathogens.

Key words: Status, seed quality and health, O-9897

INTRODUCTION

Jute (*Corchorus capsularis* L. and *Corchorus olitorius* L.) is one of the main cash crops of Bangladesh. Jute earns 6% of the foreign currency from exports (12). Millions of people earn their livelihood from industrial activities based on jute and allied fibres crops. Jute and jute goods keep alive the transport sector, the service sector and the agro-industrial job market. The jute crop improves the soil fertility by iproviding organic matter to the soil through decomposition of shaded leave, plant residues and helps in breaking plough-pans through its long taproots. Jute and jute goods have been recognized as being friendly to the environment. Among the jute growing countries of the world, Bangladesh ranks second in respect of production (11). Two species of jute (*Corchorus capsularis* and *Corchorus olitorius*) are cultivated in Bangladesh. The land and climatic conditions of Bangladesh are congenial for the production of quality jute. In Bangladesh, about 0.709 million hectares of land was under jute cultivation and the total yield was 8.40 million bales (3, 10). Bangladesh annually needs about 4000 metric tons of jute seeds of which only 12-15% is produced and provided by Bangladesh Agricultural Development Corporation (BADC) (16). The rest about 85% or more of the requirement, are produced and provided by farmers' (9). BADC produces 300 tons of seed (Olitorius =125 tons and Capsularis = 175 tons) for the farmers. BADC produces jute seeds through contact growers. The farmers of the country often have to depend on market seeds having poor quality. Hence, the production of quality seed and its quality storage is essential to ensure the higher yield of quality fibre to meet the challenging

[1] SSO, Pest Management Division, [2] Professor, Department of Plant Pathology, BAU., [3] SSO, Farm Management Unit, BJRI, [4] SO, Entomology Department, BJRI, [5] Executive, Krish call Centre, AIS, MoA

demand for natural fibre in Bangladesh. Thus the present study was carried i) to evaluate existing storage conditions of jute seeds in Bangladesh. ii) to determine the health and quality status of jute seeds of different sources of Bangladesh.

MATERIALS AND METHODS

The experiments were conducted in the laboratory of Plant Pathology Department, Bangladesh Jute Research Institute (BJRI), Manik Mia Avenue, Dhaka. The experiments were conducted during the period 15 January 2010 to 5 March 2010. The status of quality, health and storage methods of jute seeds at the farmers' level was assessed in different regions of Bangladesh was done through the use of questionnaire. Altogether 107 seed samples representing five tiers – breeders, foundation, certified, farmers' and NGOs seed were collected from fourteen different locations (Dhaka, Manikgonj, Faridpur, Jessore, Pakhimara, Rangpur, Dinajpur, Bogra, Rajshahi, Kustia, Tangail, Comilla, Kishoregonj and Mymensingh) of Bangladesh. The number of seed samples were 5, 2, 6, 90 and 4 under breeder, foundation, certified, farmers' and NGOs seed tiers, respectively.

Corchorus olitorius (O-9897) seed was selected for the study. Primary seed sample of 30 g were randomly taken from 10 different positions of the seed lot. All the primary seed samples were mixed thoroughly to make a composite sample. All the seed samples were labelled properly and preserved properly until the samples were used for the study. Working seed samples were taken from the preserved seed samples as per requirement. Seed collection procedure seed quality and health status were conducted following the International Rules for Seed Testing (13). Seed vigour index was determined following the rules of Jain and Saha (14).

Jute seed moisture was determined by constant temperature oven dry method (15, 13). The working sample 4.5g was evenly distributed over the surface of the container. The weight of the container and its lid were recorded before and after filling the container with the seed samples. The container was placed rapidly on the tops of its lid, and placed in an oven maintaining the temperature of 103 ± 2^0 C and dried for 17 ± 1 hrs. After cooling, weight of the container with its lid and contents were recorded. The relative humidity of the ambient air in the laboratory at the time of moisture determination was maintained less 70%. The moisture content of the seed samples were calculated by means of the following formula (13) and expressed as percentage.

$MC (\%) = (M_2 - M_3) X 100/ (M_2 - M_1)$

MC = Moisture Content

M_1 = Weight in grams of container and its cover/lid

M_2 =Weight in grams of the container, its cover and its contents before drying

M_3 = Weight in grams of the container, cover and contents after drying.

Seed germination and seed vigour

Seed germination test was done by blotter method (13). Seed vigour index was assessed through speed of germination of seeds. Speed of germination was derived from the germinated seedlings at an interval of 24 hours for five days using the following formula (4).

$$\text{Vigour Index} = \frac{\text{Number of germinating seedlings (First count)}}{\text{Number of day to first count}} + \frac{\text{Number of germinating seedlings (Second count)}}{\text{Number of day to second count}} + \ldots\ldots\ldots + \frac{\text{Number of germinating seedlings (last count)}}{\text{Number of day to last count}}$$

Seed purity

The seed purity regarding i) Pure seed, ii) other crop seed, iii) weed seed and iv) inert matter was calculated using the following formula (20,13):

$$\text{Pure seed, } W_1 = \frac{W_1 \text{ X}100}{W}$$

$$\text{Other crop seed, } W_2 = \frac{W_2 \text{ X}100}{W}$$

$$\text{Weed seed, } W_3 = \frac{W_3 \text{ X}100}{W}$$

$$\text{Inert matter, } W_4 = \frac{W_4 \text{ X}100}{W}$$

(W = Total seed, W_1 = Pure seed, W_2 = Other crop seed, W_3 = Weed seed and W_4 = Inert matter)

Seed Health Test

Seed health analysis was conducted by blotter method following the International Rules for Seed Health Testing (13). The presence of seed borne fungal pathogens was identified by observing their growth characteristics under stereomicroscope at 25X magnification. In some cases, pathogens were identified by preparing temporary slides and observed under compound microscope. The fungi were identified according to the keys characteristic (21, 5, 18, 17 and 19). Results were expressed as percentage of seeds infected by the pathogens. Data were analysed statistically and treatments effects were compared by Duncan's Multiple Range Test (DMRT). Relation between seed borne fungal pathogens and germination was expressed by regression equations (6).

RESULTS

Status of farmers' seed management practices

Farmers' used seven types of containers viz., Earthen pot, Plastic pot, Tin pot, Gunny bag lined with polythene, cloth bag, poly bag and gunny bag for their seed storage. Out of 100 farmers' 58.0% farmers' used O-9897, 52% farmers brought seed from BADC and 30.0% from local market. Only 18.0% farmers' produced their own seed for cultivation. For seed production, 88.0% farmers' followed broadcasting method. All the farmers' sowed seed in August for seed production. They harvested their crop seed production in November to December. They harvested crop for fibre and seed production in July to August and November to December, respectively. All the farmers' followed stem cutting method for fibre production and fruit collection method for seed production. For threshing 98.0% farmers' followed beating method and used 'Kula' for cleaning seed and dried their seed under sun. Seven types of containers were used by the farmers' viz. Earthen pot, Gunny bag, Tin pot, Plastic pot, Gunny bag lined with polythene, Poly bag and Cloth bag for seed storage.

Table 2. Some basic information about farmers' seed management practices

Management practices	Time/Method	No. of Sample	Percentage
Variety use			
O-9897		87	58.0
Source of seed			
Own		27	18.0
BADC		78	52.0
Market		45	30.0
Methods of cultivation			
For seed	Broadcasting	132	88.0
	Line sowing	18	12.0
Sowing time (O-9897)			
For seed	August	150	100.0
Harvesting time (O-9897)			
For seed	November to December	150	100.0
Harvesting method			
For seed	Fruit collection	150	100.0
Threshing method	Beating	147	98.0
	Hand	3	2.0
Threshing place	Yard	150	100.0
Cleaning method	Winnowing by 'Kula'	150	100.0
Cleaning after drying	Sun drying	150	100.0
Drying after storage		150	100.0
Storage container	Earthen pot	39	26.0
	Gunny bag	29	19.3
	Tin pot	46	30.7
	Plastic pot	22	14.7
	Gunny bag lined with polythene	3	2.0
	Poly bag	6	4.0
	Cloth bag	5	3.3

Data representent the information of seeds collected from 150 farmers'.

Status of seed quality

Moisture content of seeds from different souces belonging to O-9897 variety varied significantly from 10.32 to 11.59% in respect to seed tiers and locations (Table 3). The lowest moisture content 10.32% was recorded in breeder seed and the highest (11.59%) was recorded in foundation seed tier (Table 3). Germination of seeds varied from 71.67 to 89.33% depending on different seed tiers, jute varieities and seed sources (Table 3). Significantly the highest germination (89.33%) was recorded in breeder seed and the lowest germination (68.00%) was in farmers' seed. Vigour index of jute seeds varied significantly depending on different seed tiers and seed sources. Vigour index varied from 58.29 to 80.30. The highest vigour index (80.30) was recorded in breeder seed and the lowest (58.29) in NGO's seeds (Table 3). Purity of seeds varied significantly from 91.21 to 99.85% with respect to variety and different seed tiers. The purity of seed was the highest (99.85%) in breeder seed and the lowest (91.21%) in farmers' seeds (Table 3). Means of 1000- seed weights (g) belonging to different seeds tiers collected from different sources were not significantly different. However, 1000- seed weight varied from 1.60 to 1.90 g. the highest 1000-seed weight was 1.90 gm recorded in Farmers' and NGO's seeds.

Table 3. Quality status of jute seeds O-9897 belonging to five tiers collected from different sources in Bangladesh

Seed tier	**Moisture content (%)**	**Germination (%)**	**Vigour index**	**Purity index (%)**	**1000-seed weight (gm)**
Breeder seed	10.32 d	89.33 a	80.30 a	99.85 a	1.87
Foundation seed	11.59 a	79.67 b	67.80 b	99.65 a	1.60
Certified seed	10.79 c	74.33 c	65.37 c	98.33 b	1.87
Farmers' seed	10.43 d	68.00 d	62.50 d	91.21 d	1.90
NGO's seed	11.30 b	71.67 c	58.29 e	92.46 c	1.90
Level of significance	0.01	0.01	0.01	0.01	NS

Data in column having common letter(s) do not differ significantly at 1% level of significance.
MGT = Mean Germination Time (Hours)
NS = Not significant

Seed health status

Total seed borne fungal infections was detected in breeder, foundation, certified, farmers' and NGO's seeds collected from different locations. A total number of 3216 seed borne fungal infections were recorded in the blotter from 21400 seeds, The average seed borne fungal infections recorded in the survey study varied from 4.60 – 32.78%. The highest percent seed borne fungal infections (32.78%) was recorded under farmers' seed and the lowest percent seed borne infection (4.60%) was recorded under breeder seed (Table 4).

Table 4. Fungal infections recorded in five tiers of O-9897 seeds collected from different sources in Bangladesh

Seeds tier	Total number of seed samples tested	Number of seed borne fungal infection	% seed borne fungal infections[1]
Breeder seed	5	23	4.60
Foundation seed	2	22	11.00
Certified seed	6	175	29.17
Farmers' seed	90	2950	32.78
NGO's seed	4	46	11.50
Total	107	3216	

[1]Seed borne fungal infection was calculated on the basis of number of collected seed sample
Data represent the means of 200 seeds/sample

Occurrence of seed borne fungal pathogens in O-9897

The jute seeds of O-9897 was predominantly infected by were found infected by *Aspergillus* Spp., *Fusarium* spp. and *Penicillium* spp. and that were (90.65%, 88.79% and 79.44 %) seed samples respectively. Among the fungal infection 3.70% seeds yielded *Aspergillus* spp., followed by *Penicillium* spp. (3.02%) and *Fusarium* spp. (2.82%). In order of prevalence, the total infection of *Aspergillus* spp., *Penicillium* spp. and *Fusarium* spp. respectively were 31.91%, 26.06% and 24.32%.

Table 5. Frequency of occurrence of pathogenic fungi identified in O-9897

Fungi	% number of infected seed sample[a]	% Pathogenic fungi	% Total infection
Macrophomina phaseolina	37.38 d	0.73 b	6.33 d
Botryodiplodia theobromae	53.27 c	0.63 b	5.45 d
Aspergillus spp.[1]	90.65 a	3.70 a	31.91 a
Penicillium spp.	79.44 b	3.02 a	26.06 b
Fusarium spp.[2]	88.79 ab	2.82 a	24.32 c
Other[3]	25.23 e	0.69 b	5.93 d
Level of significance	0.01	0.01	0.01

[1] *Aspergillus* spp. (*Aspergillus flavus* & *A. candidus*)
[2] *Fusarium* spp. (*Fusarium moniliforme* & *F. semitectum*),
[3] Other fungi (*Chaetomium* spp.; *Curvuluria lunata; Cladosporium cladosporioides; Myothecium* sp.; *Alternaria tenuies;* Mycelium and *Rhizoctonia solani*) Data represent the means of 200 seeds/sample

Seed germination and seed borne pathogens recorded in five tier seeds of O-9897 variety

Seed germination of the different tiers varied significantly. The highest germination (89.33%) was recorded in breeder seeds followed by foundation seeds (79.67%), certified seeds (74.33%), NGO's seeds (71.67%) and farmers' seeds (68.00%). The highest total seed borne fungal pathogens (49.64%) was recorded in farmers' seeds followed by NGO's seeds (37.27%), certified seeds (15.66%), foundation seeds (11.82%) and breeder seeds (7.49%). Individual seed borne pathogens were also highest in farmers' seed and the lowest in breeder seeds.

Table 6. Seed germination and seed borne fungi recorded in five tiers of O-9897 collected from different sources of Bangladesh

Seeds tier	% Germination	% seed borne fungal pathogens						
		Mp.	*Bt.*	*Asp.* spp.[1]	*Pen.* spp.	*Fusa.* spp.[2]	Other fungi[3]	Total pathogens
Breeder seed	89.33 a	1.34 d	1.17 c	1.46 b	1.17 b	1.00 b	1.34 d	7.49 e
Foundation seed	79.67 b	1.58 d	1.29 c	3.01 b	2.41 b	1.79 b	1.74 d	11.82 d
Certified seed	74.33 c	2.03 c	1.81 bc	3.32 b	3.11 b	3.05 b	2.35 c	15.66 c
Farmers' seed	68.00 d	5.31 a	5.15 a	12.52 a	11.24 a	10.35 a	5.07 a	49.64 a
NGO's seed	71.67 c	3.79 ab	3.56 ab	8.90 a	8.39 a	8.88 a	3.75 ab	37.27 b
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Mp.=Macrophomina phaseolina;, Bt= Botryodiplodia theobromae; Pen= Penicillium spp.
[1] *Aspergillus* spp. (*Aspergillus flavus & A. candidus*)
[2] *Fusarium* spp. (*Fusarium moniliforme & F. semitectum*),
[3]Other fungi (*Chaetomium* spp.; *Curvuluria lunata; Cladosporium cladosporioides; Myothecium* sp.; *Alternaria tenuies;* Mycelium and *Rhizoctonia solani*)

Regression analysis

Negative correlation was found between *Macrophomina phaseolina* and seed germination where regression co-efficient (β) was -4.09 and regression equation who Y=-4.0939X+88.104 (r^2 = 8.37). Negative correlation was also found between *Botryodiplodia theobromae* and seed germination where regression co-efficient (β) was -3.99 and regression equation who Y= -3.988X+86.953 (r^2 = 8.27) (Fig. 1)

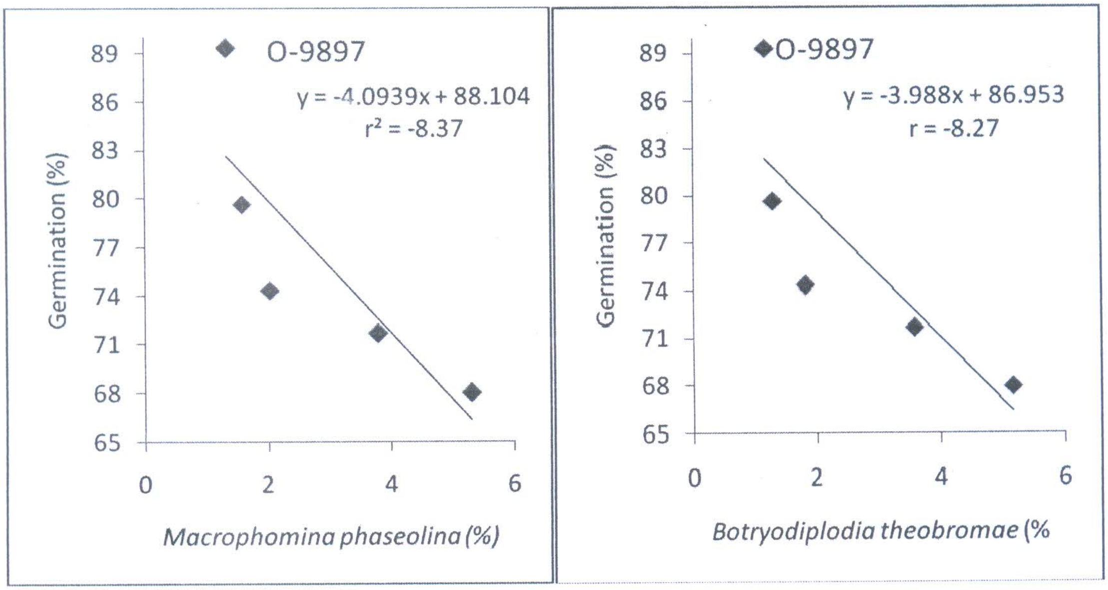

Fig 1. Relationship between *Macrophomina phaseolina* (%), *Botryodiplodia theobromae* and germination (%) in O-9897 seeds of five seed tiers

DISCUSSION

Jute in Bangladesh is considered as one of the important cash crops that accounts as much as 6% of foreign exchange (12). The present study was undertaken with an aim to evaluate existing storage conditions and the health and quality status of jute seeds of different sources. It was observed that 58% farmers' of jute growing areas used O-9897 variety, two third of the farmers' bought their seeds from BADC. Majority of farmers' followed broadcasting method for seed production. They stored their seeds in earthen pot, gunny bag, tin pot, plastic pot, gunny bag lined with polythene, poly bag and cloth bag. Hossain *et. al.* (8) reported that a significant portion of farmers (45%) used the earthen pot, 30% used metal container of different kinds, 19% used polyethylene bag with or without combination with earthen pot or gunny sack and only 6% farmers used gunny sack. Among the five tiers of jute seeds, breeder seed showed the best performance in respect of moisture content,

germination, mean germination time, vigour index, purity and 1000- seed weight. Health condition of breeders seeds was better due to adequate care taken by the jute seed breeder during selection of quality good seeds for sowing, good management of seed crop as well as seed processing and storage. The poorest performance was observed in farmers' and NGO's seeds in respect of moisture content, germination, mean germination time, vigour index, purity and 1000- seed weight. The finding of the present study is in accordance with the finding of Haque, *et al.* (7). The identified fungal pathogens were *Macrophomina phaseolina* (Tassi. Goid), *Botryodiplodia theobromae* Pat., *Colletotrichum corchori* Ikata, *Aspergillus flavus*, *A. candidus*, *Penicillium* spp., *Fusarium moniliforme*, *F. semitectum* Berk. and Rave., *Chaetomium* spp., *Curvuluria lunata* (Wakker), *Cladosporium cladosporioides*, *Myothecium* sp., *Alternaria tenuies* and *Rhizoctonia solani*. *Aspergillus flavus* and *A. candida.* Negative relationship has been observed between fungal pathogens and percent seed germination in five seed tiers that indicated the seed germination lowered with the increase of seed borne infections. Regression coefficients (β) were -4.09 and -3.99 in *Macrophomina phaseolina* and *Botryodiplodia theobromae,* respectively which mean that for every 1% increase of seed borne infection there were corresponding decrease of 4.09% and 3.99% germination in O-9897. Akanda and Fakir (1) reported similarly that the fungi associated with the jute seeds reduced the germination of seeds. In the present study 32.78% seed borne fungal infections were observed in O-9897 belonging to farmers' seeds. Breeder seeds had the lowest seed borne infections of 4.60%. Akanda (2) studied the health status of farmers' jute seeds of Mymensingh district and observed that rarely a seed sample was free from *Macrophomina phaseolina*, *Botryodiodiplodia theobromae*, and *Colletotrichum corchori* where 50.0 %, 75.0% and 85.5% seed-borne infection was recorded, respectively. Haque *et al.* (7) recorded least prevalence of seed borne infection of fungal pathogens in breeder seeds and the highest in farmers' seeds.

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CORRELATION AND PATH ANALYSIS IN TOSSA JUTE (*CORCHORUS OLITORIUS* L.)

M. M. Hussain[1], Md. Nazrul Islam[2], S. M. Mahbub Ali[3], M. G. Mostofa[4] and C. K. Saha[5]

ABSTRACT

Correlation and path coefficients were studied in ninety one F_1 and fourteen parent populations for eight characters in tossa jute (*Corchorus olitorius* L.). In most of the cases genotypic correlations were higher than their corresponding phenotypic correlations. Dry fibre yield was positively and significantly correlated with all the characters both at genotypic and phenotypic level except leaf area at phenotypic level and internodal length at both levels. Path analysis revealed that green weight and dry stick weight had highest direct and indirect effect on dry fibre yield. This indicates that these two characters were the major contributors to dry fibre yield and they should be taken into consideration for yield improvement in tossa jute.

Key words: Tossa jute (*Corchorus olitorius* L.), correlation coefficient, path analysis

INTRODUCTION

The improvement of yield potential has always been of prime importance in jute breeding programmes. Little attention has been paid for yield improvement of this crop. Yield being a complex character and is the multiplicative end product of many factors called yield components, such components are interlinked by virtue of pleiotropy, linkage, multiple alleles etc. Thus the understanding of association of characters is important in developing an efficient breeding programme. The correlation studies provide information about mere association between any two characters. The path coefficient analyses provide the partitioning of correlation coefficients into direct and indirect effects, giving the relative importance of each of the causal factors. The present study was undertaken to find out the interrelationships between yield and its components and to understand the extent of direct and indirect contributions of yield components toward yield in tossa jute.

MATERIALS AND METHODS

Fourteen parents of tossa jute and their ninety one F_1s derived from a diallel cross without reciprocals were grown in a randomized complete block design with 3 replications in 1995 at the experimental field of Bangladesh Jute Research Institute (BJRI), Dhaka. The fourteen parents namely, Syria-155, Syria-154, YPY-026C, YPY-009C, O-4, O-9897, SM/024C, DS/060C, SU/034C, SU/017C, Y/074C, Nonsoong 1, JRO-7835 and JRO-524 were collected from the gene bank of BJRI, Dhaka. The parents and F_1s were sown on 15/04/2011

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[1]CSO, Genetic Resources and Seed Division, [2] Director (A&F), [3] PSO, PTC Division, [4] PSO,GRSD & [5]CSO PTC Division Bangladesh Jute Research Institute Manik Mia Avenue, Dhaka-1207, Bangladesh

in three rows of 3.0 m long in each block. The row to row and plant to plant distance was 30 and 5-6 cm respectively. Normal cultural practices were followed as and when necessary during the whole growing period. Data were recorded for eight quantitative characters namely, plant height (m), base diameter (mm), internodal length (cm), leaf area (sq. cm), petiole length (cm), green weight per plant (g.), dry fibre yield per plant (g.) and dry stick weight per plant (g.). Ten competitive plants from middle row of each plot were randomly selected and harvested on 13/08/2011. Data were recorded for each entry over replication. Genotypic and phenotypic correlation coefficient were determined using the formula suggested by Miller *et al.*(9). Direct and indirect effects were estimated using the genotypic and phenotypic correlation coefficient as suggested by Dewey and Lu (5).

RESULTS

The genotypic and phenotypic correlation coefficients between different pairs of characters are presented in Table 1. Plant height showed significant positive correlations with base diameter, leaf area, petiole length, green weight, dry stick weight and dry fibre yield both at genotypic and phenotypic levels. Plant height also showed insignificant positive association with internodal length both at both levels. Base diameter had high and positive correlations with petiole length, green weight, dry stick weight and dry fibre yield at both levels, and also with internodal length and leaf area but only at genotypic level. Leaf area showed significant positive correlations with petiole length and green weight at both levels, and with dry stick weight and dry fibre yield at genotypic level only. Petiole length was significantly and positively correlated with green weight, dry stick weight and dry fibre yield both at genotypic and phenotypic levels. Positive and significant genotypic and phenotypic correlation was also observed between green weight and dry stick weight, dry fibre yield; and between dry stick weight and dry fibre yield.

Table 1. Genotypic (G) and Phenotypic (P) correlation coefficients among different pairs of characters

Characters		Base diameter	Internodal length	Leaf area	Petiole length	Green weight	Dry stick weight	Dry fibre yield
Plant height	G	0.904**	0.138	0.706**	0.532**	0.972**	0.703**	0.963**
	P	0.509**	0.130	0.303**	0.396**	0.577**	0.515**	0.608**
Base diameter	G		0.197*	0.714**	0.858**	0.830**	0.666**	0.794**
	P		0.004	0.114	0.238**	0.687**	0.547**	0.660**
Internodal length	G			-0.205	0.144	0.069	0.118	0.117
	P			0.026	0.098	0.003	0.008	-0.081
Leaf area	G				0.532**	0.956**	0.339**	0.931**
	P				0.257**	0.225*	0.078	0.149
hPetiole lengt	G					0.927**	0.957**	0.959**
	P					0.300**	0.490**	0.350**
Green weight	G						0.821**	0.981**
	P						0.619**	0.730**
Dry stick weight	G							0.862**
	P							0.798**

**,* Significant at p = 0.01 and 0.05, respectively.

Direct and indirect effects were worked out using path analysis both at genotypice and phenotypic level in order to find out a clear picture of the inter-relationship between dry fibre yield and other yield components in tossa jute (Table 2). Path analysis revealed that direct effect of plant height on dry fibre yield was negative and negligible (-0.0463) at genotypic level while at phenotypic level the direct effect was positive and small (0.1714). At genotypic level the indirect effect of plant height on dry fibre yield via green weight was 1.1519 and other indirect effects were negligible. At phenotypic level, the indirect effect of plant height on fibre yield via dry stick weight and green weight were 0.27 and 0.1292 respectively and other indirect effects were negligible. The direct effect of base diameter on dry fibre yield was negligible and negative (-0.0953) and small and positive (0.1480) at genotypic and phenotypic levels respectively. Base diameter has contributed indirectly through green weight (0.9836) at genotypic level whereas at phenotypic level the indirect effect was through dry stick weight (0.2868) and green weight (0.1538). The association between internodal length and fibre yield was not remarkable both at genotypic and phenotypic level. The direct effect of internodal length was positive and negligible (0.0379) at genotypic level and negative and small (-0.1021) at phenotypic level. Other indirect effects were very negligible at both levels. The direct effect of leaf area on dry fibre yield was negative and small (-0.1001) at genotypic level whereas very small and positive (0.0095) at phenotypic level. The strong association between leaf area and dry fibre yield (0.9310) was due to indirect effect of green weight (1.1329) at genotypic level. Petiole length had very negligible positive direct effect on dry fibre yield (0.0085) but it contributed strongly to the later (0.9591) indirectly via green weight (1.0986) at genotypic level.

Table 2. Genotypic (G) and Phenotypic (P) path co-efficients of different yield contributing characters on dry fibre yield.

Characters		Plant height	Base diameter	Internodal length	Leaf area	Petiole length	Green weight	Dry stick weight	Correlation coefficent with dry fibre yield
Plant height	G	**-0.0463**	-0.0861	0.0052	-0.0707	0.045	1.1519	0.0045	0.9630**
	P	**0.1714**	0.0753	-0.0133	0.0029	-0.0276	0.1292	0.2700	0.6079**
Base diameter	G	-0.0419	**-0.0953**	0.0075	-0.0715	0.0073	0.9836	0.0043	0.7940**
	P	0.0873	**0.1480**	-0.004	0.0011	-0.0166	0.1538	0.2868	0.6600**
Internodal length	G	-0.0064	-0.0188	**0.0379**	0.0205	0.0012	0.0818	0.0008	0.1170
	P	0.0223	0.0006	**-0.1021**	0.0002	-0.0068	0.0007	0.0042	-0.0809
Leaf area	G	-0.0327	-0.0680	-0.0078	**-0.1001**	0.0045	1.1329	0.0022	0.9310**
	P	0.0519	0.0169	-0.0027	**0.0095**	-0.0179	0.0504	0.0409	0.1490
Petiole length	G	-0.0246	-0.0817	0.0055	-0.0533	**0.0085**	1.0986	0.0061	0.9591**
	P	0.0679	0.0352	-0.0100	0.0024	**-0.0696**	0.0672	0.2559	0.3500**
Green weight	G	-0.0450	-0.0791	0.0026	-0.0957	0.0079	**1.1851**	0.0052	0.9810**
	P	0.0989	0.1017	-0.0003	0.0021	-0.0209	**0.2239**	0.3246	0.7300**
Dry stick weight	G	-0.0326	-0.0634	0.0045	-0.0339	0.0082	0.9729	**0.0064**	0.8621**
	P	0.0883	0.0810	-0.0008	0.0007	-0.0341	0.1386	**0.5244**	0.7981**
Residual effect	G	0.1811							
	P	0.4805							

**,* Significant at p = 0.01 and 0.05, respectively.

Whereas at phenotypic level, the direct effect was negligible and negative (-0.0696) but it contributed on fibre yield indirectly via dry stick weight (0.2569). Other indirect effects were very small. Green weight contributed the highest direct positive effect (1.1851) at genotypic level and second highest direct positive effect (0.2239) at phenotypic level on dry fibre yield among the characters studied. But strong association of ***M.*** green weight with dry fibre yield (0.7300) was due to considerable and positive indirect effect of dry stick weight (0.3246) and small and positive indirect effect of base diameter (0.1017) at phenotypic level. The direct effect of dry stick weight on dry fibre yield was positive at both levels but at phenotypic level its direct effect was highest among the characters studied (0.5244). Though the direct effect at genotypic level was negligible but dry stick weight contributed indirectly via green weight (0.9729) on fibre yield.

Other indirect effects were negligible at genotypic level. But at phenotypic level a small indirect effect was shown by green weight (0.1386).

DISCUSSION

Correlation Coefficient:

The genotypic correlation coefficients obtained between pairs of characters in all possible combinations were higher than their corresponding phenotypic correlation coefficient except between leaf area and internodal length. This indicates fairly strong inherent association between yield and the characters studied and among the characters themselves except between leaf area and internodal length. Similar results were also reported by several workers in tossa jute (12, 13, 2). Higher phenotypic correlation coefficients than genotypic correlation coefficient in the above combination indicated that theexpression of these characters was appreciably enhanced by environmental influence. Similar results in relation to these findings were reported by Sardana *et al.* (10).

Plant height showed strong positive genotypic and phenotypic correlations with base diameter, leaf area, petiole length, green weight, dry stick weight and dry fibre yield indicating with the increase in plant height, base diameter, leaf area, petiole length, green weight, dry stick weight and dry fibre yield would increase. Shukla *et al.* (11) reported that plant height and base diameter were highly correlated with each other as well as with the dry fibre yield in tossa jute. The character also showed insignificant positive association with internodal length both genotypically and phenotypically. But Sardana *et al.* (10) found significant positive association between plant height and internodal length in the study of jute germplasm.

Base diameter showed high and positive genotypic and phenotypic correlations with petiole length, green weight, dry stick weight and dry fibre yield. Therefore, with the increase in base diameter it might be considered that petiole length, green weight, dry stick weight and dry fibre yield would increase. Similar results of correlation were found between base diameter and dry fibre by Eunus (6) in jute, Shukla *et al.* (11) in tossa jute, Das (3) in white and tossa jute, Sardana *et al.* (10) in jute germplasm. Singh (12) found that base diameter had significant and positive correlation with dry stick weight in tossa jute. Base diameter also showed only high and positive genotypic, but low phenotypic correlations with internodal length and leaf area. So, there were high association of additive genes controlling these pairs of characters but environmental factors may be together with epistatic and dominant genes created low association in phenotypes.

Internodal length showed positive and insignificant genotypic and phenotypic correlations with petiole length, green weight and dry stick weight. The character internodal length associated with other characters, leaf area and dry fibre yield were positive and insignificant at phenotypic and genotypic levels respectively. Leaf area and dry fibre yield were negatively and insignificantly associated with internodal length at genotypic and phenotypic levels respectively. Chaudhury *et al.* (2) observed negative genotypic and phenotypic association of internodal length with fibre yield in tossa jute. But positive genotypic and phenotypic correlations were observed by Sinhamahapatra and Rakshit (13) in tossa jute.

Leaf area showed high positive genotypic and phenotypic correlations with petiole length and green weight. So, the results indicated that if the leaf area increased, petiole length and green weight increased. The character also showed high and positive genotypic but low phenotypic correlations with dry stick weight and dry fibre yield. It indicated that there were high association of additive genes controlling the pairs of characters but environmental effects may be together with epistatic and dominant genes created low phenotypic association. Das (3) found significant correlations of leaf area with petiole length and fibre yield in *C. capsularis* L. and *C. olitorius* L. Das and Rakshit (4) observed highly significant correlations of leaf area with fibre yield in tossa jute.

Petiole length showed strong positive phenotypic and genotypic correlations with green weight, dry stick weight and dry fibre yield. Therefore, it could be concluded that with the increase in petiole length, green weight, dry stick weight and dry fibre yield would increase. But Das and Rakshit (4) reported insignificant correlation between petiole length and fibre yield in tossa jute.

Green weight showed strong and positive phenotypic and genotypic correlations with dry stick weight and dry fibre yield indicating with the increase in green weight, dry stick weight and dry fibre yield increased. Similar findings were observed by Maiti *et al.* (7).

Finally dry stick weight showed strong and positive genotypic and phenotypic correlations with dry fibre yield. Similar results were found by Shukla *et. al*. (11) and Singh (12) in tossa jute.

The result suggested no single component trait could be effectively used as guiding index for making selection for yield in breeding programme. Multiple selection criteria for yield through simultaneous improvement in the component trait might prove more fruitful.

Path Analysis:

Green weight had the highest positive direct effect (1.1851) at genotypic level and second highest positive direct effect (0.2239) at phenotypic level on dry fibre yield among the characters studied. The highest positive correlation between green weight and dry fibre yield (0.9810) was due to highest direct effect at genotypic level. Strong association of green weight with dry fibre yield (0.7300) was due to considerable and positive indirect effect of dry stick weight (0.3246) and small positive indirect effect of base diameter (0.1017) at phenotypic level. Manjunatha and Sheriff (8) reported that green weight had direct effect on fibre yield at both the levels which is conformed by the present findings. The result of the present investigation on maximum direct effect of green weight on fibre yield might be on the assumption that the genotypes which were used in the present investigation might be selected knowingly or unknowingly on the basis of their green weight.

The dry stick weight had positive direct effect on fibre yield at both levels but at phenotypic level its direct effect was highest (0.5244) among the characters studied. The positive correlation between dry stick weight and dry fibre yield (0.8621) may be explained by the positive direct effect of dry stick weight on dry fibre yield (0.0064) and indirect effect via green weight (0.9729), petiole length (0.0082) and internodal length (0.0045) at genotypic level. The positive correlation between dry stick weight and dry fibre yield (0.7981) reflects the positive direct effect of dry stick weight (0.5244) on dry fibre yield and indirect effect via green weight (0.1386), plant height (0.0883), base diameter (0.0810) and leaf area (0.0007) at phenotypic level. On the contrary to this findings negative direct effect of dry stick weight on dry fibre yield was reported by Banerjee et al. (1).Residual effects (genotypic 0.1811 and phenotypic 0.4805) made a low contribution in determining the dry fibre yield suggested that some other components not included here may have little influence in determining the total fibre yield.

Path analysis indicated that green weight was the most important character which had maximum contribution to fibre yield as it exhibited highest direct effect and via effects on fibre yield. The second most important character was dry stick weight. Indirect effects of this character were also considerable. Correlation coefficients also indicated the highest association between green weight and dry fibre yield. So, selection for higher green weight per plant and dry stick weight per plant would give better response for yield improvement in tossa jute.

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Short communication

STUDY OF GENETIC PARAMETERS OF SOME QUANTITATIVE CHARACTERS IN TOSSA JUTE (*CORCHORUS OLITORIUS* L.)

R.K.Ghosh[1], M.A.Newaz[2], M.G.Mostofa[3], A.T.M.Morshed[4], M. Moksuder Rahman[5], M.Muktadir Hussain[6] and S. C. Sarkar[7]

ABSTRACT

Eight yield and yield contributing characters of 10 tossa jute genotypes were evaluated to estimate genetic parameters and to identify superior genotype for using jute breeding program for the improvement of tossa jute. Significant differences were observed among the genotypes, dates of sowing and their interaction for all the studied characters. Phenotypic coefficient of variations (PCV) was higher than genotypic coefficient of variations (GCV) for all the studied characters and the differences between PCV and their corresponding GCV were very close. The PCV and GCV were high for dry stick yield and lowest for plant height. The highest heritability value (90.16) was found in internodal length followed by dry stick yield (87.19) and the lowest was fresh weight with leaves (80.76). Genetic advance (GA) in percent of mean was the maximum for dry stick yield (28.92) followed by fresh weight without leaves (27.84). The lowest GA in percent of mean (13.63) was found in plant height. On the basis of yield and yield contributing characters, the genotype PL-7/95 was identified as the most promising genotype for improvement of tossa jute.

Key words: Genotypic coefficient of variation, phenotypic coefficient of variation heritability, genetic advance, tossa jute

INTRODUCTION

Jute is a natural fiber crop and has commercial significance in the world after cotton. It is a completely biodegradable, recyclable and enveromentally friendly fiber (Mir *et al*., 2008). Comparing the two cultivated species of jute, the fibers of tossa jute (*Corchorus olitorius*) are stronger with brown or golden in color than deshi jute (*Corchorus capsularis).* Yield potentiality of jute is mainly dependent on plant height, base diameter, internondal length, green weight of plant etc. Roy (1967) suggested that plant height and base diameter should be considered in selecting jute plants for better fiber yield. Eunus (1969) reported that base diameter of jute plant is a good indicator of its fiber yield potentiality. The magnitude of genetic variability existing in genotypes is an index of its genetic dynamism and the improvement of crop is mainly dependent on it. Dudley and Moli (1969) suggested partitioning the available variability in a population into its heritable and non-heritable components with the help of genetic parameters such as genotypic coefficient of variation, heritability estimates and genetic advance for selecting superior genotypes. Swarup and

[1] SSO, Monirampur Substation, [2] Professor, SAU, [3] PSO, GRSD, [4] PSO, [5] PSO, [6] SO,FQID,[7] Publication Officer, PTC, BJRI.

Chaugale (1962) suggested studying the heritability along with the genetic gain to obtain better estimate of heritable variation. Johnson and Robinson (1953) reported that high heritability does not always mean greater genetic gain. Chawdhury *et.al.* (1985) observed that appreciable variability for plant height, base diameter, internodal length and fiber yield in tossa jute. Therefore, study of genetic parameters of jute or other crops is essential for its improvement. In the past, little work had been done in tossa jute for its improvement. Hence, the present study was under taken with the following objectives i) to estimate genetic parameters and performance in respect of yield and yield contributing characters of tossa jute and ii) to identify superior genotype (if any) for using jute breeding program for the improvement of tossa jute.

MATERIALS AND METHODS:

The experiment was conducted at Bangladesh Agricultural University experimental field in 2002. Ten genotypes of tossa jute as listed in Table 1 were sown at four different dates of sowing (1 March, 22 March, 12 April and 3 May of 2002). Seeds of all the genotypes were collected from Bangladesh Jute Research Institute.

Table 1. List of the genotypes used in the experiment with their origin

Sl. No.	Genotype	Status	Origin
1	O-9897	Variety	Bangladesh
2	O-4	Variety	Bangladesh
3	OM-1	Variety	Bangladesh
4	JRO-524	Variety	India
5	P-11/95-2	Pedigree selection	Bangladesh
6	Acc-4311	Accession	Tanzania
7	PL-7/95	Pure line selection	South Africa
8	Acc-3724	Accession	Kenya
9	Acc-4575	Accession	Nepal
10	P-3/96	Pedigree selection	Bangladesh

The experiment was laid out in a Randomized complete Block Design (RCBD) with three replications. Each plot had three rows of 3m length. Space between rows, plants and blocks were 30 cm 8 cm and 1m, respectively. The seeds of the genotypes were randomly assigned to each plot within each block for every date of sowing. The recommended cultural practices were followed for proper growth of the plants. Ten plants were randomly selected from each row of every replication and every date of sowing after 130 days of sowing. Data were recorded for eight selected characters viz. plant height (m), base diameter (mm), number of nodes per plant, internodal length (cm), fresh weight with leaves per plant (g), fresh weight without leaves per plant (g), dry fiber yield per plant (g) and dry stick yield per plant (g).

Data were analyzed statistically according to Zaman *et al.* (1982). Broad sense heritability (H_b) and genetic advance (GA) were estimated by using the formula of Hanson *et al.* (1956). Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were estimated followings the formula of Johnson *et al.* (1955).

RESULTS

Analysis of variance revealed that significant difference existed for dates of sowing, genotypes and their interaction for all the studied characters (Table 2).

Table 2: Pooled analysis of variance for different plant characters over four dates of sowing in tossa jute.

Items	df	Values of mean square of different characters							
		Plant height (m)	Base diameter (mm)	No. of Nodes plant^{-1}	Internodal length (cm)	Fresh weight with leaves plant^{-1} (g)	Fresh weight without leaves plant^{-1} (g)	Dry fiber yield plant^{-1} (g)	Dry stick yield plant^{-1} (g)
Sowing dates (S)	3	8.77**	167.83**	3414.09**	12.22**	61824.19**	71035.06**	204.13	1320.61**
Rep. in S	8	0.02	0.34	15.90	0.02	60.28	17.11	0.07	6.75
Genotypes (G)	9	0.50**	15.96**	396.60**	1.90**	7694.80**	8173.54**	27.54	324.62**
S×G interaction	27	0.06**	2.26**	67.68**	0.19**	1480.31**	1471.93**	4.73**	41.59**
Error	72	0.02	0.39	10.74	0.02	37.14	44.95	0.36	4.88

**P<0.01

Among the 10 genotypes, the genotype PL-7/95 produced the highest plant height (3.03m), base diameter (16.01mm), fresh weight with leaves (238.61 g plant^{-1}), fresh weight without leaves (194.03 g plant^{-1}), dry fiber yield (15 g plant$^{-1)}$ and dry stick yield (39.88 g plant^{-1}). The genotype 0-4 gave the lowest plant height (2.32m), base diameter (12.25 mm), number of nodes per plant (42.83), fresh weight with leaves (153.76 g plant^{-1}), fresh weight without leaves (114.93 g plant^{-1}), dry fiber yield (9.92 g plant^{-1}) and dry stick yield (25.27 g plant^{-1}) (Table-3).

Table 3.Mean of different plant characters in ten tossa jute genotypes over four dates of sowing.

Genotype	**Plant height (m)**	**Base diameter (mm)**	**No. of nodes plant^{-1}**	**Internodal length (cm)**	**Fresh weight with leaves plant^{-1} (g)**	**Fresh weight without leaves plant^{-1} (g)**	**Dry fiber yield plant^{-1} (g)**	**Dry stick yield plant^{-1} (g)**
O-9897	2.91	15.51	61.50	4.61	229.23	190.06	14.86	39.31
O-4	2.32	12.25	42.83	3.66	153.76	114.93	9.92	25.27
OM-1	2.66	14.30	57.67	4.15	207.55	162.35	12.93	33.52
JRO-524	2.65	14.10	55.42	4.12	210.87	169.82	12.87	34.51
P-11/95-2	2.58	13.24	53.75	3.95	190.58	144.12	12.39	27.60
Acc-4311	2.52	13.01	51.58	3.62	185.27	136.49	12.08	30.28
PL-7/95	3.03	16.01	62.83	4.69	238.61	194.03	15.00	39.88
Acc-3724	2.85	15.09	60.17	4.80	223.74	184.62	13.96	36.49
Acc-4575	2.62	14.19	54.33	3.79	185.65	143.53	11.80	28.89
P-3/96	2.62	14.16	54.50	3.98	191.84	143.22	12.34	27.22
SE (±)	0.04	0.18	0.95	0.04	1.76	1.94	0.17	0.64
CV%	5.15	4.43	5.91	3.27	3.02	4.23	4.70	6.84

Range, mean, standard error, heritability (broad sense), genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), genetic advance (GA), genetic advance in percent of mean are presented in Table-4.

Wide range of variation was observed for the characters fresh weight with leaves (153.76-238.61 g plant^{-1}) followed by fresh weight without leaves (114.93-194.03 g plant^{-1}), while narrow range of variation was found for plant height (2.32-3.03 m) followed by internodal length (3.66-4.80 cm).The highest mean value was recorded for fresh weight with leaves(202.00 g plant^{-1}) followed by fresh weight without leaves (158.31 g plant^{-1}), number of nodes per plant (55.49) and dry stick yield (32.30 g plant^{-1}). Similar results were also observed by Ghosh and Das (1982).

PCV was higher than their corresponding GCV for all the studied characters. But the different between PCV and GCV were very close (Table-4). These results agreed with the results of Sukla and Singh (1967), Joseph (1974) and Dahal (1991). The highest GCV (15.04) was observed in dry stick yield followed by fresh weight without leaves (14.93), the highest PCV (16.49) was recorded in fresh weight without leaves followed by dry stick yield (16.10).While the lowest GCV (7.09) and PCV (7.61) was recorded in plant height. Heritability estimate was the highest (90.16) for internodal length followed by dry stick yield (87.19). The highest GA (44.08) was found for fresh weight without leaves followed by fresh weight with leaves (42.13). GA in percent of mean was the maximum for dry stick yield (28.92) followed by fresh weight without leaves (27.84). The lowest GA (0.36) was found in plant height (Table-4).

Table 2: Pooled analysis

Table 4. Estimates of genetic parameters for eight important characters in tossa jute.

Characters	Range	Mean ± SE	Heritability (H_b)	GCV (%)	PCV (%)	GA	GA in percent of mean
Plant height (m)	2.32-3.03	2.68 ± 0.04	86.95	7.09	7.61	0.36	13.63
Base diameter (mm)	12.25-16.01	14.19 ± 0.18	85.85	7.53	8.13	2.04	14.37
No. of nodes plant^{-1}	42.83-62.83	55.49 ± 0.95	82.93	9.44	10.37	9.82	17.71
Internodal length (cm)	3.66-4.80	4.16 ± 0.04	90.16	9.07	9.55	0.74	17.74
Fresh weight with leaves plant^{-1} (g)	153.76-238.61	202.00 ± 76	80.76	11.28	12.55	42.13	20.89
Fresh weight without leaves plant^{-1} (g)	114.93-194.03	158.31 ± 1.94	81.99	14.93	16.49	44.08	27.84
Dry fiber yield plant^{-1} (g)	9.92-15.00	12.81 ± 0.17	82.83	10.76	11.82	2.58	20.17
Dry stick yield plant^{-1} (g)	25.27-39.88	32.30 ± 0.64	87.19	15.04	16.10	9.34	28.92

DISCUSSION

The results of the present study showed significant genetic variation in tossa jute under studied traits. Usually, the success of any breeding program depends on genetic variation availability in the breeding materials. The significant genetic variation in this study could be useful for widening the genetic base of the crop. The genotype PL-7/95 exhibited superior performance compare to others for all the studied characters except internodal length indicated most promising genotype in tossa jute.

Heritability estimate is important for selecting superior genotype for breeding program. In this study, high heritability coupled with high GCV, PCV and GA as percent of mean were observed for dry stick yield and fresh weight without leaves indicating these two characters were greatly controlled by additive gene. According to Johnson *et al*. (1955), heritability estimate coupled with genetic advance should be concurrently considered for predicting yield under phenotypic selection. Similar results were found Islam *et al*. (2002) in tossa jute. We observed less difference between PCV and GCV for most of the studied characters suggesting these characters were of less influence by different dates of sowing. It can be concluded from the results that the studied characters were reliable and heritable, and the genotype PL-7/95 is the most promising genotype for improvement of tossa jute.

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