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Genetic Analysis of Fiber Yield Associated Anatomical Traits in Tossa Jute (*Corchorus olitorius* L.)

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Abstract

Jute is known as Golden Fiber having significant contribution in the national economy of Bangladesh. The narrow genetic diversity in jute is due to its self-pollination habit and lack of exploration of available germplasm having genetic variability for yield associated traits. Tossa jute produces fibers with good strength, fineness and brightness compared to white jute. Five tossa jute accession (Acc.1354, Acc.1773, Acc.3705, Acc.3988, Acc.4481) and one control variety O-9897 were investigated from 2020 to 2021 in a completely randomized design for yield associated anatomical traits to find out the good genotype for breeding of new high yielding tossa jute variety. Among all genotypes, Acc. 1354 and Acc. 1773 showed good performance for yield contributing traits like stem diameter, bark thickness, number of trapezoid & total fiber bundle cell per section, and quality related traits i.e. length breadth ratio and fiber strength comparing with the control variety O-9897. These genotypes can be used in breeding programs to develop new high yielding tossa jute variety with quality fiber in future. The information obtained from this investigation is useful in planning further breeding program for tossa jute improvement.

Keywords: Anatomy, tossa jute, fibre strength, bast fibre and Xylem.

Introduction

Jute (*Corchorus olitorius* L.) is an important lingo-cellulosic natural, annual, herbaceous bast fibre crop bearing chromosome number 2n=2x=14 belongs to the Tiliaceae or Malvaceae family and Grewioideae subfamily (Basu et al., 2016) under the *Corchorus* genus (Sarkar et al., 2011; Zhang et al., 2019) and a few tetraploids (2n = 28) are also known (Bhaduri and Bairagi, 1968). Initially jute was classified in the family Tiliaceae (Steward, 1969). Recently the genus has been reclassified within the family Sparrmanniaceae (Heywood et al., 2007). Scientists identified approximately 100 jute species of this genus (Choudhary et al., 2017). Among these, only two species namely *Corchorus capsularis* L. (White or Bitter or Deshi jute) and *Corchorus olitorius* L. (Dark or Tossa or Bogi jute) which evolved through conventional breeding and pure line selection based on their yield and agronomic performances (Ghosh, 1983) are cultivated commercially (Maity et al., 2012).

It is biodegradable, eco-friendly long and fine fiber next to cotton (*Gossypium* spp. L.) that attracts diversified product manufacturing companies, including textile and paper (Majumdar et al., 2020; Mukul et al., 2020b). Pat, kosta, Nalita, Bimli or Mesta (kenaf) is also some local name of the jute. Jute crop is grown for commercial purposes in many south Asian countries (Rahman et al., 2021), predominately in India and Bangladesh (Ghosh et al., 2015). It is called the 'Golden Fibre' (Kundu, 1951; Ghosh et al., 2015) contributing about 4% GDP of the national economy and earns about 5% of the foreign exchange as well in Bangladesh (Islam and Ali, 2017).

The number of *Corchorus* species is probably around 50-60 but over 170 *Corchorus* names are given in the Index Kewensis (Edmonds, 1990). In the genus *Corchorus,* two species of jute, *C. capsularis* L. (Deshi jute) and *C. olitorius* L. (Tossa jute) are white and golden colour fiber respectively. In Bangladesh, tossa jute occupied 80%, white jute 10% and both Kenaf and Mesta 10% of total natural fiber crop cultivation. A part from Bangladesh and India the crop is now also grown in Myanmar, Nepal, Thailand, China, Taiwan, Vietnam, Cambodia, Brazil, Kenia, Tanzania and some other countries. However, Bangladesh, India, China, Myanmar, Nepal and Thailand are the major producers accounting for over 98% of the global output. The intra- and inter-specific differences existing at the base of all crop improvement programs. There is no crop improvement opportunity for various desirable traits if all the individuals within the species would have been similar genotypic and phenotypic basis. Information generated on the genetic diversity within and among closely related crop species is essential for crop improvement and to meet the diverse goals like producing cultivars with increased yield, wider adaptability, desirable quality, pest and disease resistance. For most of the *C. olitorius* landraces are yet to be extensively characterized, a lack of knowledge about their biological history and value restricts them to be utilized in breeding programs (Sarkar et al., 2019).

Tossa jute is high yielder than white jute, except under inundated conditions. Tossa jute is characterized by its delayed periderm formation, resulting in lesser periderm compared with white jute, which is a desirable trait that improves the retting quality of fibre. Average genetic diversity in the cultivars of *C. olitorius* and *C. capsularis* was 7.2% (range 2.8–12.3%) and 7.6% (range 2.2–13.1%), respectively (Rana et al., 2013). Moreover, a strong sexual incompatibility barrier exists between the two cultivated species preventing any genetic introgression through cross-breeding (Kundu et al., 1959; Patel and Datta,1960). The genetic diversity for improvement in jute crop is very narrow, and it is the major hurdle, which is a demand at priority for any crop improvement program (Ghosh et al., 2015). Now, tossa jute is highly demand crop in Bangladesh (Hossain, 2014). So, the genetic improvement as well as high yielding new variety development is a crying need for this species in Bangladesh (Mukul et al., 2020c).

Both the cultivated jute species are mostly self-fertilized (Basu et al., 2016), however, as high as 15 % natural outcrossing occurs in *C. olitorius* (Mir et al., 2008a) and 5% in *C. capsularis* (Basak and Chaudhuri, 1966). Fibers are derived from the secondary phloem fibers from the bark of the stem (Kundu, 1951). A single jute fibre (i.e. ultimate fiber cell) which is 0.75–5.0 mm in length with an average of 2.3 mm and 15–25 µm in width (Rowell and Stout, 2007) is extracted from the bark of the jute stem by stepping and retting in water, usually 120 days after sowing, followed by stripping, washing, squeezing and drying and bailing (Palit et al., 2008).
Genetic diverse germplasm is important for the development of new variety with higher agronomic traits. Bangladesh Jute Research Institute has 6060 number of germplasms of jute, kenaf and mesta of both indigenous and exotic origin. Among them 1500 are *olitorius* species. These germplasms have wider gene pool with different types of biotic and abiotic tolerance. Study of diversity of these materials is important for searching variability and to isolate desirable genotypes, which can be used for developing a new variety of *olitorius* species. Genetic diversity lies in both agro-morphological and anatomical traits in jute crops. Hence, the fiber anatomical traits were studied in six tossa jute genotypes including one control variety to select superior genotype for further breeding of high yielding new variety in future.

Materials and Methods

Experimental site and time

Plants were grown in the field of Jute Agriculture Experimental Station (JAES) of BJRI, Manikganj District and the study was conducted from March, 2020 to July, 2021. The location of the site is 23^{0}53.95′ N latitude and 90^{0}04′ E longitude with an elevation of 8.8 m from the sea level. Soil type was loamy with 0.76% organic carbon, 6.85 soil pH, 12.7^o C–36^{o}C annual average temperatures, 2376 mm annual rainfall. Anatomical works were done in the molecular laboratory of Breeding Division, BJRI [23^{o}45′26″N, 90^{o}22′47″E].

Plant/Seed materials:

There are six tossa jute genotypes including one check variety were studied to observe their genetic variability for anatomical traits contributing to fibre production followed by identifying superior genotype(s) for further high yielding tossa jute variety development (Table 1).

Table 1. List of plant materials with source of collection and country of origin

Genotype No.	Plant Genotype	Plant type	Source of collection	Country of origin
G_1	Acc. 1354	Accession	Gene Bank, BJRI	India
G_2	Acc. 1773	Accession	Gene Bank, BJRI	Bangladesh
G_3	Acc. 3705	Accession	Gene Bank, BJRI	Kenia
G_4	Acc. 3988	Accession	Gene Bank, BJRI	Syria
G_5	Acc. 4481	Accession	Gene Bank, BJRI	USA
G_6	O-9897 (Check)	Variety	Breeding division, BJRI	Bangladesh

Growing of plants and anatomical study

Field was prepared by ploughing, harrowing and leveling 2-3 times. Fertilizers were applied as Urea-266kg, TSP-80kg, MoP-50kg, Gypsum-150kg per hectare of land. The half urea was applied during land preparation and the rest half was top dressed at 50 days after sowing in field. Seeds were sown in line at the rate of 5 kg per hectare and each genotype was grown in a single plot of 3×3 m^2 size having plant to plant distance 5-6 cm and line to line distance 30 cm. Plants were grown with standard agronomical practices (Figure 1). At physiological maturity for fiber after 110 days of sowing, 5 plants were selected randomly from the middle row of each genotype and harvested at base with the help of a jute harvesting sharpen knife without causing any injury for anatomical studies (Mahapatra et al., 2009). According to Kumar et al. (2014) and Atkinson (1965), a rapid and easy method was used for jute anatomy, 3–4cm long jute stem including fibre (Phloem) and stick (Xylem) were excised out with the help of sharp knife from 4-5cm above the base of each plant (Figure 2). Specimens were properly labelled and preserved in Formalin Acetic Alcohol (FAA) solution (10 ml of formalin, 5 ml of 85% glacial acetic acid and 85 ml of 70% alcohol) for further anatomical studies (Verma, 2008).

Figure 1. Growing of jute plants for anatomical studies

Figure 2. Anatomical sample (stem) collected for anatomical studies

According to Tolivia and Tolivia (1987) and Sadhukhan (2019), hands-free T.S.-transverse sections (0.3–0.5mm thin) were prepared using base sledge Microtome machine (WSL Lab Microtome-modified Reichert-type) (Figure 13) and the additional mucilage was removed by rinsing with clean water, and then T.S. were stained with 1% safranin (aqueous) solution followed by mounting with a drop of glycerine-water on clear glass slide with a cover slip (Figure 3). The collected samples were studied under electronic microscope (4 x10 magnification) (Figure 4) for anatomical parameters i.e., bark diameter, bark thickness, area of fiber cell containing trapezoid, average number of trapezoids per T. section, fiber bundle layer per trapezoid etc. at Breeding Division Laboratory of Bangladesh Jute Research Institute (BJRI).

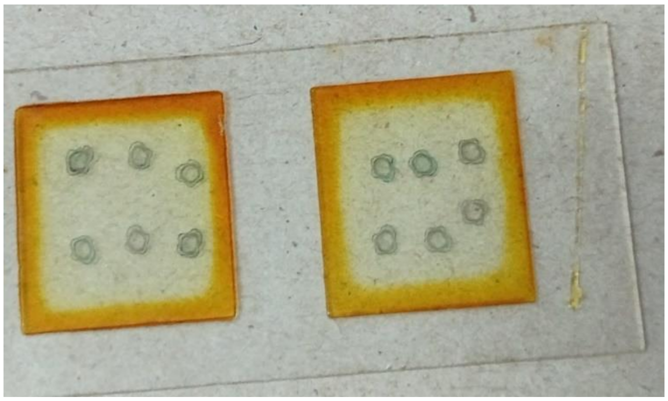

Figure 3. T.S. Specimen stained & prepared with slide-coverslip for anatomical studies

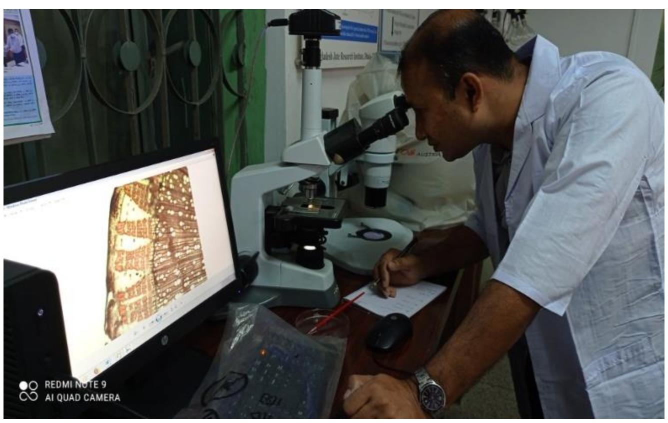

Figure 4. Specimen observation under compound microscope

Data recording

Eleven following parameters were considered in the study.
The details of the data recording are given below:

a. Stem diameter (mm) was measured by using scale. The average diameter from the six different peripheral locations with equal distance was measured.
b. Bark thickness (mm) was measured by six different peripheral locations with equal distance under microscope.
c. Number of trapezoids per section was counted under microscope from each section.
d. Area of trapezoid per section (sq.mm) was measured by the following formula: Area of trapezoid= 1/2(upper length + Lower length) x perpendicular length of trapezoid x conversion factor. [Conversion factor = 39.4 in 4 x 10 magnification].
e. Number of layers per trapezoid was counted under electronic microscope from randomly selected trapezoid.
f. Number of bundles per trapezoid was estimated under electronic microscope from each of fibre layer.
g. Average length (µ) of 10 randomly selected ultimate fibre was measured from one end of the fibre to the other end by using Oculometer under microscope (Figure 5).
h. Average breadth (µ) of 10 randomly selected fibre cells was measured by using Oculometer under microscope (Figure 6).
i. Length/breadth ratio: It is the ratio of average fibre length and average fibre breadth.
j. Fibre strength (lb/mg) was determined by Pressley Bundle Strength Tester using zero-gauge length.

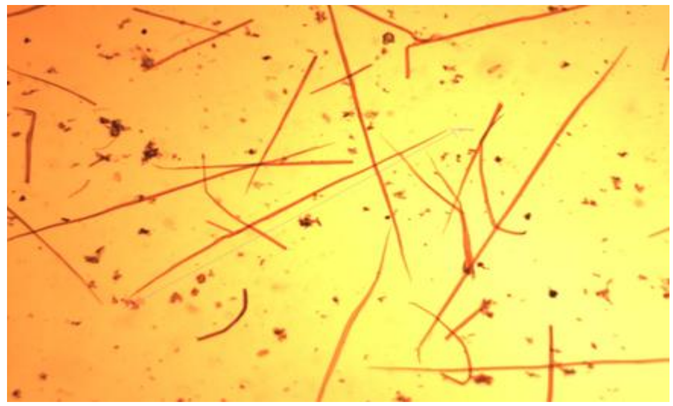

Figure 5. Observation of fiber cell length under electronic microscope

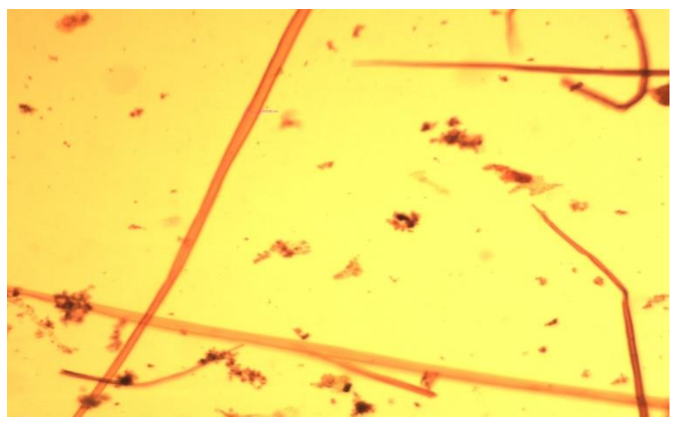

Figure 6. Observation of fiber cell breadth under electronic microscope

Data analysis

The collected data on different anatomical parameters were statistically analyzed using MSTAT-C software.

Results and Discussions

Performance of the genotypes

Genotypes mean performance of jute genotypes for ten anatomical parameters such as stem diameter (mm), bark thickness (mm), number of trapezoid, area of trapezoid (mm^2), number of layers, number of bundles, length of fibre cell (µ), breadth of fibre cell (µ), length: breadth ratio and fibre strength (lb/mg) were studied [(Table 2) and Figure 7(a-f)]. Transverse sections of anatomical pictures (microscopic) of six genotypes are also presented in figure 8(a-f). Stem diameter, bark thickness, number of trapezoid and area of trapezoid are the important role-playing parameters for fibre compactness that actually shows the higher fibre yield of jute.

Additional fibre length, fibre breadth, length: breadth ratio and fibre strength are accountable to the fineness of fibre for making jute fabrics. The results of anatomical characters of tossa jute genotypes are discussed below.

Stem diameter (mm)

Stem diameter is an important yield component of jute. Stem diameter ranged from 9.476 mm to 13.500m m in genotypes. Three genotypes (Acc. 1354, Acc. 1773 and Acc. 3705) had higher stem diameter compared to the control (Figure 7, Figure 14, 15, 16, 19). Stem diameter is significantly associated with the fiber yield in jute crops (Mukul et al., 2021). The genotype with higher results of stem diameter can be studied for bark thickness to select high-yielding one.

Bark thickness (mm)

Bark thickness ranged from 0.877mm to 1.293mm in genotypes. The genotype Acc. 1354 and Acc. 3705 showed higher bark thickness than control variety (Figure 8). The jute genotype with higher bark thickness can be used as parents in breeding programs for high yielding variety development (Mukul, 2020).

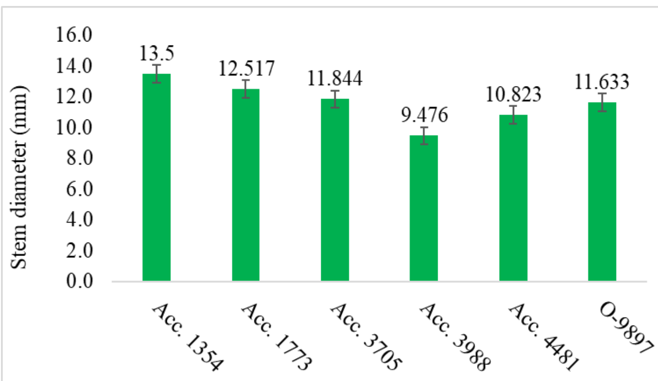

Figure 7. Stem diameter of 6 jute genotypes

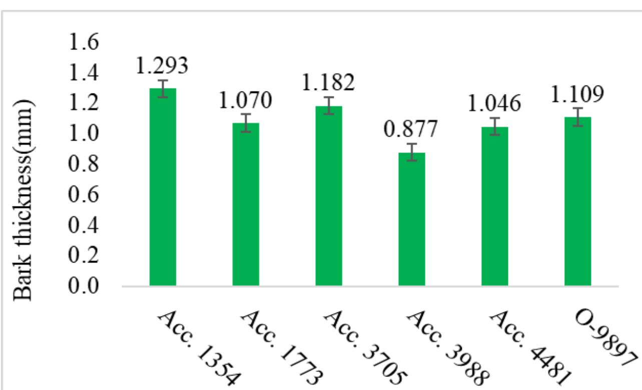

Figure 8. Bark thickness of 6 jute genotypes

Length and breadth of fiber cell

The fiber cell length was ranged between 1.518µm to 2.067µm where higher cell length (2.067µm) was found in Acc. 3988 followed by Acc. 3705(1.786µm), Acc. 1773 (1.566µm), Acc. 1354 (1.518µm) compared to control variety O-9897 (1.811µm) (Figure 9, 17). The fiber cell length was ranged from 0.038µm to 0.051µm where the highest value was found in the Acc. 3705 (0.051µm) followed by Acc. 3988 (0.049µm) compared to control O-9897 (0.046µm) (Figure 10). Jute genotype with higher cell length but lower cell breadth can lead to produce quality fiber for industrial uses (Kumar et al., 2014).

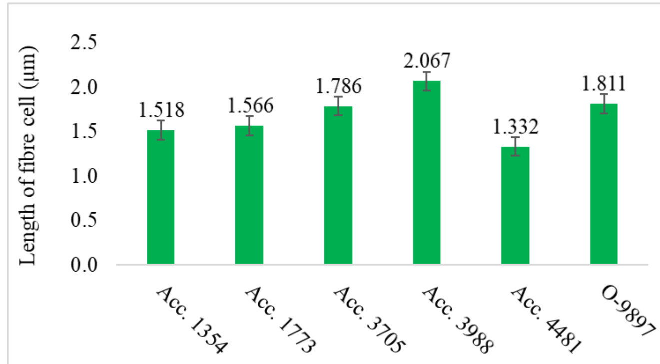

Figure 9. Length of fiber cell of 6 jute genotypes

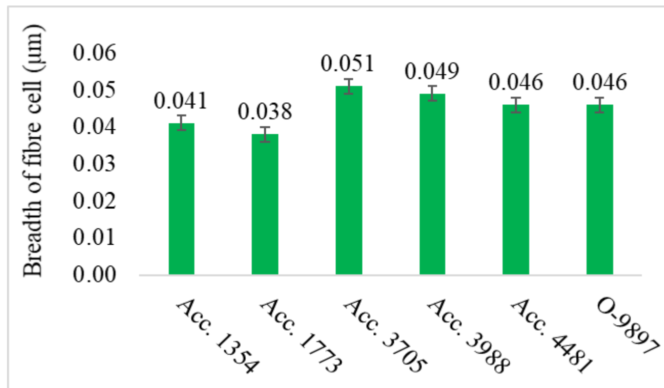

Figure 10. Breadth of fiber cell of 6 jute genotypes

Area of trapezoid and fiber strength

Higher results for area of trapezoid were recorded in Acc. 1773 (24.68mm^2) followed by Acc. 1354 (22.85 mm^2) and Acc. 3705 (21.35 mm^2) against the control variety (20.73 mm^2) (Figure 11). Fiber strength was found higher in Acc. 3988 (6.586lb/mg) followed by Acc. 1773 (6.564lb/mg), Acc. 3705 (6.153lb/mg), Acc. 1354 (5.996lb/mg) than control variety (5.426lb/mg) (Figure 12). The area of trapezoid leads to increase the number of fiber bundle cells as well as fiber yield in jute crops (Mukul et al., 2021). The fiber cell strength is an essential quality of jute fiber for industrial application (Alagirusamy and Das, 2011). The jute genotype(s) having good fiber strength can be used to produce quality fiber of industrial uses (Mukul et al., 2021).

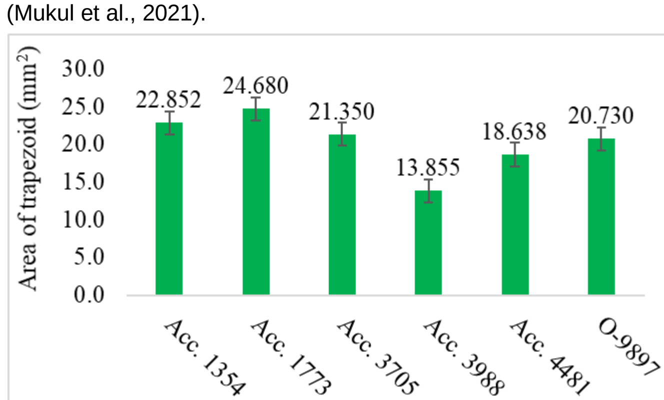

Figure 11. Area of trapezoid of 6 jute genotypes

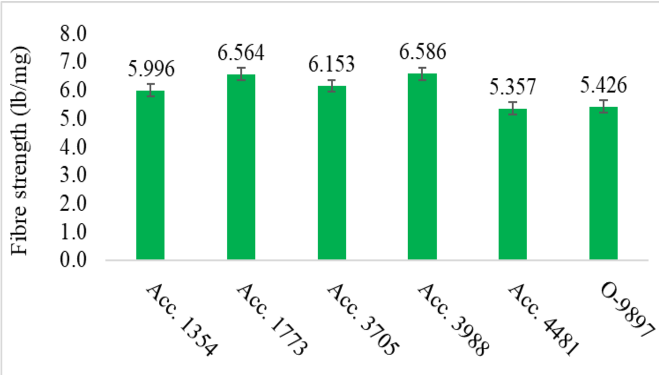

Figure 12. Fiber strength performance of 6 jute genotypes

Higher number of trapezoids were found in Acc. 1354 (74.957) and Acc. 1773 (72.558) than control O-9897 (60.050). The control variety O-9897 gave maximum number of fiber bundle layer (9.962) per trapezoid than the tested materials. The Acc. 4481 gave higher number of fiber bundles (65.031) per T.S. and the Acc. 1773 recorded maximum ratio (43.466) between length and breadth of fiber cell than control (Table 2; Figure 18, 19). The number of trapezoids per transverse section, number of fiber bundle layer per trapezoid and number of bundles per trapezoid are strongly correlated and leading to fiber yield in jute crops (Mukul et al., 2021). Higher ratio between fiber cell length and breadth indicates more quality (fineness) of fiber for varieties of textile product development (Ramey, 1982; Kumar et al., 2014).

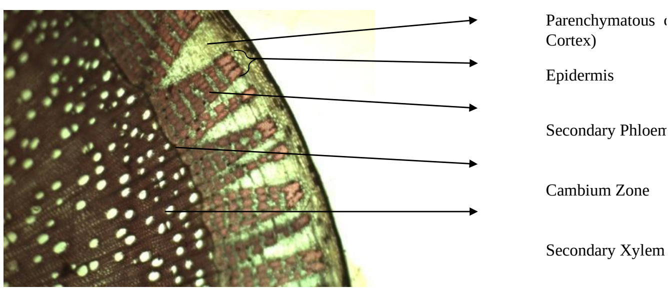

Figure 13. Cross section of trapezoid (area of 2^0phloem fibre) of tossa jute stem under microscope

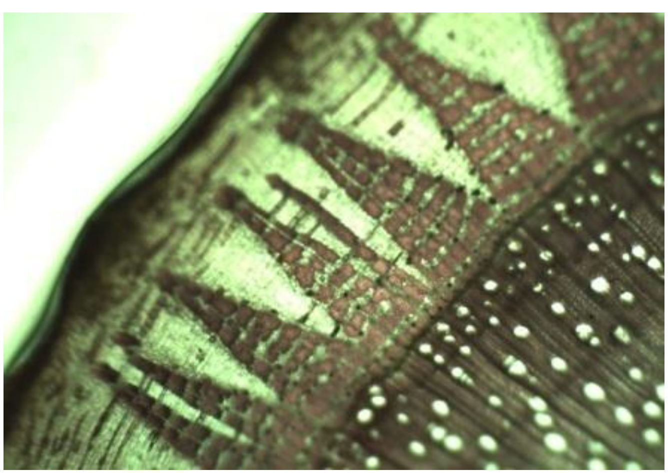

Figure 14. Anatomical sectioning of Acc. 1354

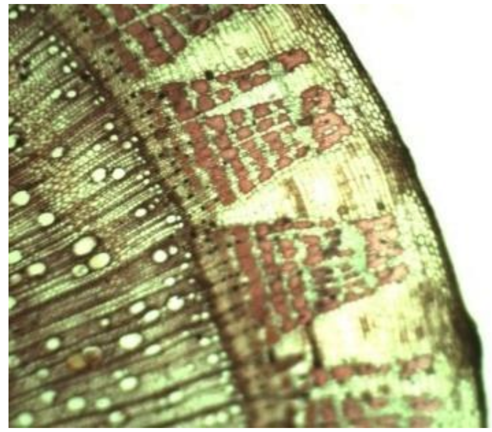

Figure 15. Anatomical sectioning of Acc. 1773

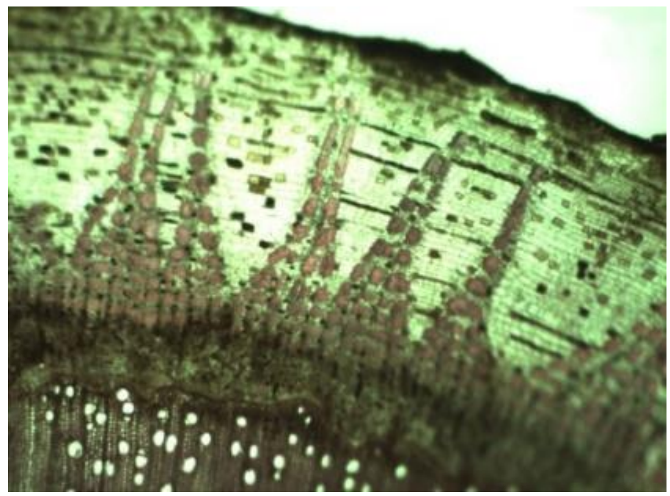

Figure 16. Anatomical sectioning of Acc. 3705

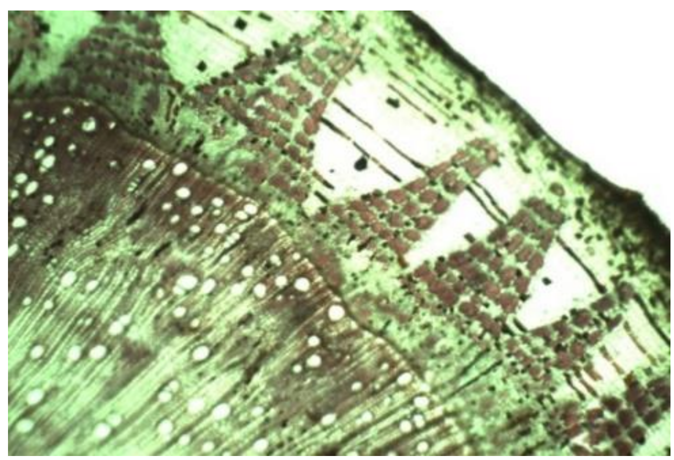

Figure 17. Anatomical sectioning of Acc. 3988

Conclusions

The studied tossa jute genotypes showed a large magnitude of variation in their fiber yield and quality associated anatomical traits. Among the five tested tossa jute accession, the Acc. 1354 and Acc. 1773 showed good performance in respect of yield attributing anatomical traits i.e. stem diameter, bark thickness, number of fiber bundle pyramid (trapezoid) & total fiber bundle cell per section, and quality attributing anatomical traits i.e. length breadth ratio and fiber strength comparing with the control variety O-9897.

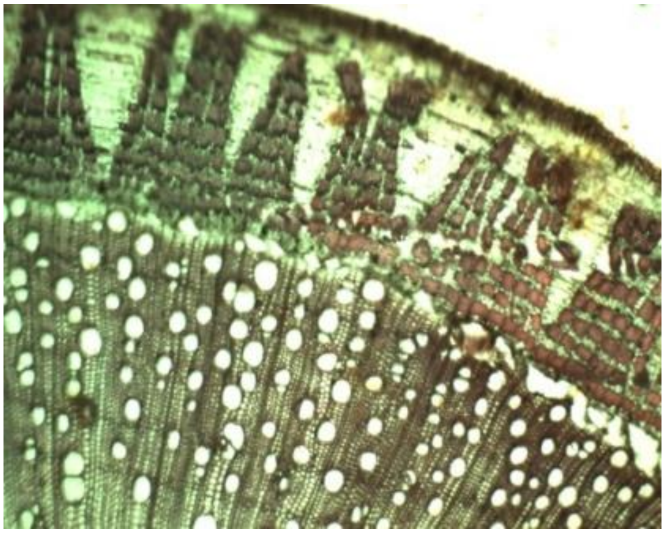

Figure 18. Anatomical sectioning of Acc. 4481

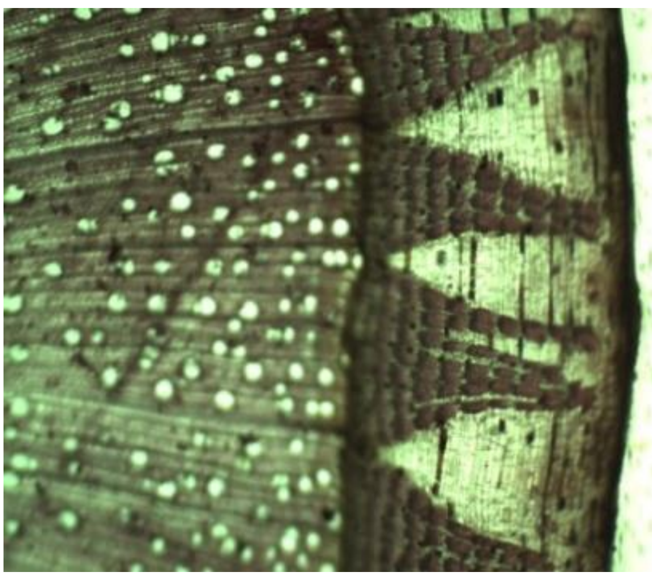

Figure 19. Anatomical sectioning of O-9897

Table 2: Mean performance for stem anatomical traits of 6 tossa jute genotypes

Genotypes	Number of trapezoids	Number of layers	Number of bundles	Length/Breadth ratio
Acc. 1354	**74.957**	9.275	58.720	39.217
Acc. 1773	**72.558**	9.188	54.422	**43.466**
Acc. 3705	58.300	9.114	56.327	36.128
Acc. 3988	58.505	8.352	47.398	42.632
Acc. 4481	54.050	9.435	**65.031**	33.672
O-9897(Check)	60.050	**9.962**	62.661	41.659
Mean	63.070	9.221	57.426	39.462

Recommendations

The Acc. 1354 and Acc. 1773 can be studied furthermore for fiber yield and associated morphological traits to use them as genetic source material for breeding of new high yielding tossa jute variety in future.

Author's' Contribution

M. J. Alam has designed and conducted the research work. M.M. Mukul has helped in data analysis, writing of article, submission to journal and publication of the manuscript. A.S.M. Yahiya and A. Miah had helped in conducting research work like data collection, reporting to the authority of BJRI.

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References

Atkinson, R.R., 1965. Jute, Fibre to Yarn. B. I. Publications. Naoroji Road, Bombay, India. http://www.bestjute.com/JUTE-Fibre-to-Yarn.pdf.

Mukul, M.M., Akter, N., Islam, M.M., *et al*., 2021. Morpho-phenetical study of high yielding tossa jute variety BJRI Tossa Pat 7 (MG-1) for bast fibre yield and qualities. Heliyon, Elsevier; 7 (10); 1-17, e07042.

Mukul, M.M., 2020. Elucidation of Genotypic Variability, Character Association, and Genetic Diversity for Stem Anatomy of Twelve Tossa Jute (*Corchorus olitorius* L.) Genotypes. BioMed Research International (Hindawi), Volume 2020; Article ID. 9424725, 16 p. https://sci-hub.st/10.1155/2020/9424725 https://doi.org/10.1016/j.heliyon.2021.e08129.

Mukul, M.M., Akter, N., Mostofa, M.G., Ahmed, S.S.U., Nur, I.J., Al-Mamun, M., Rashid, M.H., 2020c. Analyses of genetic variability, character association, heritability and genetic advance of tossa jute (*Corchorus olitorius* L.) genotypes for morphology & stem anatomy. Am. J. Biosci. 8 (4), 99–112.

Mukul, M. M., Akter, N., Mostofa, M. G., Rahman, M. S., Hossain, M. A., ROY, D. C., Jui, S. A., Karim, M. M., Ferdush, J., Hoque, M. M., Mollah, M. A. F., 2020b.Analysis of variability, Euclidean clustering and principal components for genetic diversity of eight Tossa Jute (*Corchorus olitorius* L.) genotypes. Plant Sci. Today 7 (4), 564-576.

Alagirusamy, R., & Das, A. (2011). Yarns: Production, processability and properties. Fibrous and Composite Materials for Civil Engineering Applications, 29–61. doi:10.1533/9780857095583.1.29.

Basak, S. L., Chaudhuri, B.B.,1966. Extentandnature ofnatural crosspollination in 'tossa' jute (*Corchorus olitorius* L.). Indian J. Agric. Sci. 36, 267–272.

Basu, T., Satya, P., Sarkar, D., Kar, C.S., Mitra, J., Karmakar, P.G., 2016. Organelle genetic diversity in a global collection of Jute (*Corchorus capsularis* and *C. olitorius*, Malvaceae). South Afr. J. Bot. 103, 54–60.

Bhaduri, P.N., Bairagi, P., 1968. Interspecific hybridization in jute (*Corchorus capsularis* x *C. olitorius*). Sci. Cult. 34, 355–357.

Edmonds, I. M. (1990). Herbarium Survey of African Corc/tortls Species. Systematic and ecogeographic studies on crop genepools 4. International Board for Plant Genetic Resources, Rome, Italy. 284p.

Ghosh, T., 1983. Handbook on Jute. FAO, Rome, p. 219. https://catalogue.nla.go v.au/Record/2026173.

Ghosh, s., Meena, K., Sinha, M. K., et al. 2015. Genetic diversity in Corchorus olitorius genotypes using jute SSRs. Proc. Natl. Acad. Sci. India B Biol. Sci.87, 917-926(2017).

Heywood, V.H., Brummitt, R.K., Culham, A., Seberg, O., 2007. Flowering Plant Families of the World. R Bot Gard, Kew. https://www.researchgate.net/%20publication/23 6111232_Flowering_Plant_Families_of_the_World.

Hossain, M., 2014. Jute and Jute Industry. College Gate Binding and Printing, 1/7, College gate, Mohammadpur, Dhaka, Bangladesh.

Ramey, H.H., 1982. The meaning and Assessment of Cotton Fibre Fineness.

Sarkar, D., Kundu, A., Das, D., Chakraborty, A., Mandal, N.A., Satya, P., Karmakar, P.G., Kar, C.S., Mitra, J., Singh, N.K., 2019. Resolving population structure and genetic differentiation associated with RAD-SNP loci under selection in tossa jute (Corchorus olitorius L.). Mol. Genet. Genom. 294 (2), 479–492.

Sarkar, D., Kundu, A., Saha, A., Mondal, N.A., Sinha, M.K., Mahapatra, B.S., 2011. First nuclear DNA amounts in diploid (2n¼2x¼14) Corchorus spp. by flow cytometry: genome sizes in the cultivated jute species (C. capsularis L. and C. olitorius L.) are ~300% smaller than the reported estimate of 1100–1350 Mb. Caryologia 64 (2), 147–153.

Steward, F.C., 1969. Tropical Crops: Dicotyledons, 2. J. W. Purseglove. Wiley, New York, p. 719, 1968 Science 163(3871), 1050–1051.

Islam, M. M., Ali, M. S., 2017. Economic importance of jute in Bangladesh: production, research achievements and diversification. Int. J. Bcon. Theory April. 4(6), 45-47. ttp://article.aasit/org/file/pdf/9180778.pdf.

Kumar, V., Singh, P. K., Dudhane, A. S., De D. K. and Satya, P., 2014. Anatomical and morphological characteristics of nine jute genotypes. Journal of Crop and Weed, 10(2):334-339(2014).

Kundu, B.C., Basak, K.C., Sarkar, P.B., 1959. Jute in India. Indian Central Jute Committee Publ, Calcutta. https://catalogue.nla.gov.au/Record/883397.

Kundu, B. C., 1951. Origin of jute. Indian J. Plant Breed. 1 (1), 95-99. http://www.isg pb.org/documents/archieve/vol.-11-number-1.1951.pdf.

Maity, S., Chowdhury, S., Datta, A.K., 2012. Jute biology, diversity, cultivation, pest control, fibre production and genetics. Organic Fertilisation Soil Qual. Human Health 227–262.

Majumder, S., Saha, P., Datta, K., Datta, S. K., 2020. Fibre crop, jute improvement by using genomics and genetic engineering. Adv. Crop Improv. Tech. 363-383.

Patel, G.I., Datta, R.M., 1960. Interspecific hybridization between Corchorus olitorius Linn. and C. capsularis Linn. and the cytogenetical basis of incompatibility between them. Euphytica 9, 89–110.

Palit, P., Meshram, J.H., 2008. Physiology of jute yield and quality. In: Karmakar, P.G., Hazra, S.K., Ramasubramanian, T., Mandal, R.K., Sinha, M.K., Sen, H.S. (Eds.), Jute and Allied Fibre Updates. Central Research Institute for Jute and Allied Fibres (CRIJAF), Kolkata, pp. 112–124.

Rahman, M. S., Islam, M. N., Polan, M. S., Talukder, F. U., Mukul, M.M. 2021. Relative toxicity of some chemical pesticides against jute hairy caterpillar (*Spilosoma obliqua* W.) in tossa jute (*Corchorus olitorius* L.). Malaysian J. Sustain, Agric. 5 (2), 115-122.

Rana, M. K., Arora, K., Singh,S.,Singh, A, K.,2013. Multi-locus DNA figure printing and genetic diversity in jute (*Corchorus* spp.) based on sequence-related amplified polymorphism. J. Plant Biotechnol. 22(1), 1-8.

Rowell, R.M., Stout, H.P., 2007. Jute and kenaf. In: Lewin, M. (Ed.), Handbook of Fibre Chemistry, third ed. CRC Press, Boca Raton, pp. 405–452 https://www.routledge .com/%20Handbook-of-Fibre-Chemistry/Lewin/p/book/9780824725655.

Sadhukhan, S., 2019. Histobiochemical and physicochemical characterization of mutant jute Corchorus capsularis CMU 013 with poorly developed fibre. Biosci. Biotech. Res. Comm. 12 (1), 90–98.

Tolivia, D., Tolivia, J., 1987. Fasga: a new polychromatic method for simultaneous and differential staining of plant tissues. J. Microsc. 48 (1), 113–117.

Verma, P.K., 2008. Preservation of botanical specimens retaining the natural colour pigments. J. Histotechnol. 30, 173–190. http://ir.amu.ac.in/1594/1/T%207090.pdf.

Zhang, L., Ibrahim, A.K., Niyitanga, S., Zhang, L., Qi, J., 2019. Jute (*Corchorus* spp.) breeding. In: Al-Khayri, J., Jain, S., Johnson, D. (Eds.), Advances in Plant Breeding Strategies: Industrial and Food Crops. Springer, Cham, pp. 85–113.

Choudhary, S.B., Sharma, H.K., Kumar, A.A., et al., 2017. The genus Corchorus L. (Malvaceae) in India: species distribution and ethnobotany. Genet. Resour. Crop Evol. 64, 1675–1686.

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