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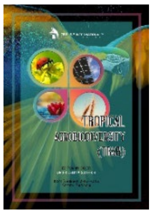

RESEARCH ARTICLE

ASSESSMENT OF FIBER QUALITY OF KENAF ON DIFFERENT HARVESTING AGES AT KISHOREGANJ DISTRICT IN BANGLADESH

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ABSTRACT

This research investigates the mechanical and physical qualities of kenaf fibers (variety HC-95) harvested at various intervals—specifically at 90, 100, 110, and 120 days after sowing (DAS)—at the Jute Research Regional Station in Kishoreganj. Two factors were considered: green and yellow fiber samples. The study assessed four key physico-mechanical attributes: bundle strength, whiteness, fineness, and texture. Results indicate that green fibers harvested at 110 DAS exhibited superior bundle strength, whiteness, fineness, and texture compared to fibers from other harvesting intervals. For yellow fibers, both 100 DAS and 110 DAS showed similar performance, although 100 DAS fibers demonstrated higher attributes, except for texture. Additionally, whiteness levels in both green and yellow fibers were highest at 90 DAS and 100 DAS. Overall, green kenaf fiber plants were found to be more favorable for spinning quality compared to yellow plants, highlighting the importance of harvest timing in optimizing fiber quality.

KEYWORDS

Jute; variety; Das; investigate; fiber quality; fiber strength; fineness; brightness and texture

1. INTRODUCTION

Jute is classified as a lingo cellulosic bast fiber, primarily comprising phloem tissue. The composition features a significant lignin content of 12-13%, accompanied by cellulose levels ranging from 61% to 71.5% and hemicellulose content between 13.6% and 20.4%. Bangladesh significantly contributes to its economy through the export of raw jute and a variety of jute-based products. Similar to other fibers, the quality of raw jute is assessed by producers and consumers based on its strength, fineness, and color which are essential for its effectiveness in creating various types of yarns and its performance during the fabrication workflow (Mollah et al., 2008). Kenaf (Hibiscus cannabinus L.) is an annual, short-day herbaceous fiber crop classified within the Malvaceae family (H'ng et al., 2009). This family is acknowledged for its economic and horticultural significance (Akinrotimi and Okocha, 2018). As part of the Hibiscus genus, which comprises more than 200 species, kenaf is distinguished by the presence of both annual and perennial varieties (Hassan et al., 2018). It shares close relations with other notable plants such as cotton (Gossypium hirsutum L.), jute (Corchorus spp.), and okra (Abelmoschus esculentus L.) (Webber et al., 2003).

Kenaf is recognized as a significant global fiber crop and provides a range of valuable components, such as stalks, leaves, and seeds (Akinrotimi and Okocha, 2018). These components can be processed into fibers, fiber strands, proteins, oils, and allelopathic compounds (Akinrotimi and Okocha, 2018). These properties enable the production of a wide range of products, facilitating ongoing use and innovation (Mostafa et al., 2013). Kenaf can thrive in diverse climatic conditions, reaching heights of 2.5 to 4.5 meters with a woody base (Rowell et al., 1999). Traditionally, it has been cultivated for cordage, including rope, twine, and sackcloth, but its commercial applications have expanded to include absorbents, paper products, building materials, and animal feed. The plant comprises quadruple key elements —grains, stalks, greens, and petals—each with distinct uses. Kenaf stems can reach lengths of 1 to 2 meters, while the foliages measure 10 to 15 cm and the petals, which can be white, yellow, or purple, have diameters of 8 to 15 cm, typically featuring a dark purple center. The fruit, a capsule measuring 2 cm in diameter, contains numerous seeds. Additionally, Kenaf leaves are abundant in antioxidants and polyphenolic compounds, making them suitable for consumption as vegetables (Ryu et al., 2017).

The quality of allied fibers is influenced by various factors, including climate, soil conditions, and cultivation practices. The environmental conditions, soil types, cultivation techniques, water availability, retting methods, and drying processes across the Observation centers of the Bangladesh Jute Research Institute (BJRI) are not uniform. Currently, white jute is less widely cultivated than tossa and kenaf for several reasons, resulting in its limited availability in the Trading post. Nevertheless, it remains a significant variety in certain regions, maintaining a high demand following kenaf and tossa jute. Both tossa and kenaf jute are categorized into six grades by graders based on consumer preferences (Saha et al., 1994). The assessment of jute quality is crucial for Profit-oriented objectives, and accurate evaluation of fiber quality is essential to minimize confusion in trade and to produce appropriate products at effective costs (Karim and Kabir, 1976). Physical and mechanical characteristics, such as bundle strength, fineness, brightness, whiteness, and texture, are key factors in characterizing kenaf and jute fibers, with bundle strength and fineness being particularly emphasized.

In this study, the kenaf variety HC-95, released by BJRI, was chosen for quality mapping. Bundle strength is regarded as the most critical mechanical property for producing durable jute products. Numerous studies have illustrated how fiber dimensions impact processing and the properties of final fabrics and garments. Consequently, the pricing of

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natural fibers is often closely linked to one or more of their dimensional attributes (Anderson, 1976). The material characteristics of natural fibers, including jute, kenaf, and ramie, are directly related to their structural forms (Fidelis et al., 2013). Fineness, defined as the ratio of fiber width-to-length comparison area, is a key criterion for jute fibers used in the production of fine and consistent yarns, as only fine fibers can yield fine yarns. Historically, jute was utilized primarily for traditional products like bags, carpet support material, and coarse woven fabric. However, the range of applications for jute and kenaf has significantly expanded, leading to their use in producing fine yarns for lightweight fabrics. Furthermore, natural fibers, including jute, kenaf, flax, and sisal, are increasingly employed as strengthening agents in lightweight composite materials (Wambua et al., 2003; Defoirdt et al., 2010; Prasad et al., 2013; Bisaria et al., 2015; Sayeed and Paharia, 2019; Senthilkumar et al., 2018; Asumani et al., 2020). To create high-quality products, fine yarn is essential, and strong fibers are necessary to produce robust yarn; conversely, weak fibers cannot yield strong yarn. It is vital for individual fibers to possess sufficient strength to endure the mechanical strains encountered during subsequent processing (Wilson, 2011). This research seeks to contrast various Tangible and structural properties, including fiber durability, whiteness, smoothness, and texture, of kenaf varieties cultivated in the Kishoreganj region of Bangladesh.

2. Materials and Method

2.1 Plant Materials

Various aged samples of green and dry fiber from the widely used kenaf variety HC-95, developed by the Bangladesh Jute Research Institute (BJRI), were sourced from the Jute Research Regional Station in Kishoreganj

2.2 Methods

To standardize the quality of jute fibers, several parameters were assessed, including bundle strength, whiteness (%), fineness, and texture (%). All samples were tested under controlled atmospheric conditions of 21±2 °C and 65±5% moisture content. The specific testing approaches are detailed below.

2.3 Bundle Strength Test

The fiber aggregate strength was measured using a Pressley Fiber Strength Tester with a zero-gauge length. A flat collection, approximately 6.35 mm (1/4 inch) wide, was secured between a pair of clamps (Booth, 1968). Any protruding ends were evenly sheared off before tension was applied to separate the clamps and break the fibers. The weight of the damaged bundle was then measured using a analytical balance. The bundle power was calculated using the following equation:

$$\text{Bundle Strength (gm/tex)} = \frac{\text{Breaking Load (Ib)} \times 5.36}{\text{Bundle Weight (mg)}}$$

2.4 Fineness Test

Fineness was assessed using the fineness testing apparatus developed by the British Jute Trade Research Association (BJTRA), which operates on the principle of airflow. In this apparatus, air is drawn through a cylindrical bundle of fibers measuring 7.62 cm in length and 3.3 cm in diameter. The resistance to airflow is recorded on a flow meter, which is calibrated to indicate fiber diameter in microns (1 micron = 10^-3 mm). Upon activating the device, the location of the float is read to determine the fiber diameter in microns.

2.5 Texture

Texture was assessed using the cut-middle method. In this case evaluation, 50 to 60 reeds were arbitrarily selected from each sample and then fastened at a length of 36 cm. From the central section of the reeds, one hundred strands were extracted to trim the jute fibers into 10 cm lengths. These lengths were weighed on a precision balance to determine their linear density in surface quality (Lyons, 1963).

2.6 Whiteness (Color)

The color and luster of the fibers were measured using a Photo Voltmeter (Leukometer) with a sensitivity of 4×10^-9 A, employing emerald and azure filters, Sequentially. The photograph Voltmeter operated in conjunction with a search unit that included multiple filters, such as amber, green, and blue (Booth, 1968). Assessments were compared to a standard of magnesium oxide (MgO), which has a reflectance of 100%.

2.7 Data Analysis

The collected data were subjected to statistical analysis using The Analysis of Variance (ANOVA) method, and mean differences among the treatments were later refined using Duncan's New Multiple Range Test.

3. Results and Discussion

The physical and mechanical properties of kenaf fibers, categorized by the age of the green growing plants, are summarized in Table 1. Analysis of the table indicates that the bundle strength of kenaf fibers ranges from 43.87 to 51.24 gm/texture, with significant values observed in plants at 90, 100, and 110 days after sowing (DAS) compared to those at 120 DAS. Notably, the plants at 110 DAS exhibited the highest bundle strength. Variations in jute fiber properties are influenced by the harvesting age, which is essential for producing diverse products with specific quality attributes. Research aims to assess fiber yield and characterize the physico-chemical, thermal, and mechanical properties of jute at different harvesting times, revealing significant findings related to harvesting days (Dayan et al., 2022).

A group researchers conducted a study examining how bundle strength affects the tensile properties of jute fibers, noting that factors such as chemical makeup, cellular structure dimensions, flaws and single distance significantly influence these tensile properties (Rahman and Hossain, 2021; Das et al., 2019). The stretching characteristics of jute fibers, particularly bundle strength, immediately impact the performance of composite substances (Hasan, 2013). Stronger bundle fibers facilitate the production of durable yarns necessary for heavy-duty jute products.

According to a study, chemically and bacterially retted decorticated kenaf stems (variety E41) yield fibers with a bundle strength of 22-30 g/texture (Ramaswamy et al., 2016). The fineness of textile fibers, which refers to size, diameter, linear density, or weight per unit length, varies widely among natural fibers compared to synthetic counterparts. This fineness is crucial for producing uniform yarn with minimal breakage, with values ranging from 33.39 to 36.38 μm, averaging 35.62 μm. Except for the 90 DAS plants, significant results were obtained for all other ages, with the highest fineness recorded at 100 DAS (36.36 μm), potentially enhancing spinning and weaving performance. The fineness values remained relatively stable at 110 DAS (35.35 μm) and 120 DAS (36.38 μm), suggesting that optimal spinning quality may occur at earlier growth stages (Mandal and Karmakar, 2019).

The whiteness and texture percentages of the samples ranged from 46.85% to 53.08% and from 2.41% to 2.79%, respectively, with the 110 DAS plants showing the highest texture value. The highest texture value of 2.79 indicates coarse surface fibers with strong strength, while the supplementary textures were fine, smooth, and conducive to fine yarn formation. The texture of fibers was optimal at 110 DAS (2.79%), making this age particularly suitable for textile applications, while lower texture percentages in other ages may affect overall quality. Whiteness values were significant at 90 and 110 DAS, with the highest whiteness recorded at 90 DAS and the lowest at 100 DAS. These results align with previous studies, indicating that brightness and whiteness are key aesthetic properties important for producing visually appealing products, allowing consumers to select fibers that meet their requirements (Mollah et al., 2021; Molla et al., 2011; Molla et al., 2010). Whiteness serves as a critical criterion for assessing fiber quality in industry, research, and grading systems (Roy et al., 2016). Furthermore, the quality of jute yarn is significantly influenced by fiber whiteness, which is essential for both aesthetic and functional properties (Mandal and Karmakar, 2019). This study investigates the relationship between whiteness levels and various mechanical characteristics of jute yarn, including tensile strength and elongation.

Table 1: Ages effect on bundle strength, whiteness (%), fineness & texture of green kenaf plants.

Plant age	Bundle strength	Whiteness (%)	Fineness	Texture (%)
90	50.17a	53.08a	33.39b	2.50b
100	49.43a	46.85b	36.36a	2.47b
110	51.24a	51.22a	35.35a	2.79a
120	43.87b	47.45	36.38a	2.41b
Mean	48.68	49.67	35.62	2.54
CV (%)	4.47	6.35	1.39	5.70

Table 2: Ages effect on bundle strength, whiteness (%), fineness & texture of yellow kenaf plants.				
Plant age	**Bundle strength**	**Whiteness (%)**	**Fineness**	**Texture (%)**
90	43.67 b	47.79 b	33.87 a	2.37 c
100	49.51 a	50.70 a	35.33 a	2.50 b
110	47.90 a	48.09 b	36.55 a	2.63 a
120	44.85 b	47.18 b	36.18 a	2.44 a
Mean	46.48	48.44	35.48	2.48
CV (%)	3.07	5.73	5.15	4.50

The physical and mechanical properties of yellow kenaf plants, categorized by days after sowing (DAS), are detailed in Table 2. This table illustrates the impact of plant age on the physico-mechanical characteristics of yellow kenaf, focusing on bundle strength, whiteness percentage, fineness, and texture. The highest bundle strength was observed at 100 DAS, measuring 49.51 gm/tex, indicating that this stage is optimal for harvesting stronger fibers. Conversely, the lowest bundle strength was recorded at 90 DAS (43.67 gm/tex) and 120 DAS (44.85 gm/tex), suggesting a decline in fiber quality at both ends of the harvesting spectrum.

Whiteness percentages peaked at 100 DAS (50.70%), highlighting that this stage not only optimizes fiber strength but also enhances aesthetic appeal. In contrast, the whiteness values at 90 DAS (47.79%) and 110 DAS (48.09%) suggest that harvesting too early or too late may negatively impact the visual quality of the fibers. Fineness remained consistently high across all ages, reaching its maximum at 110 DAS (36.55), which is beneficial for spinning processes. Additionally, texture values significantly improved at 110 DAS (2.63%), indicating that this age also contributes to superior quality for textile applications.

Similar findings have been reported (Kaysar et al., 2022). Overall, the results suggest that harvesting yellow kenaf plants at 100 DAS achieves an optimal balance between bundle strength and whiteness, while 110 DAS is preferable for enhanced texture. These findings underscore the importance of selecting the appropriate harvesting age to improve the quality and marketability of yellow kenaf fibers (Mandal and Karmakar, 2019).

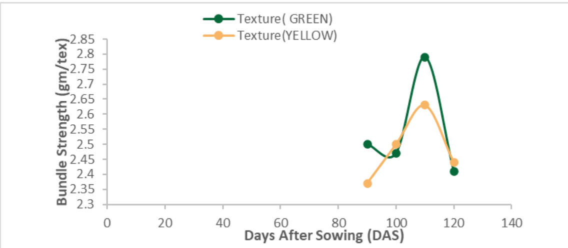

Figure 1: Combine effects of Bundle strength of green & yellow plants

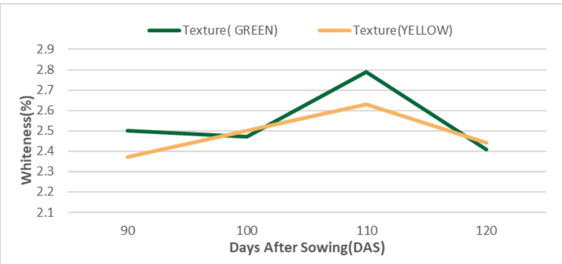

Figure 2: Combine effects of whiteness (%) of green & yellow plants.

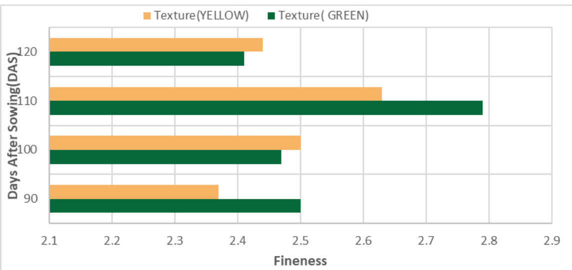

Figure 3: Combine effects of Fineness of green & yellow plants.

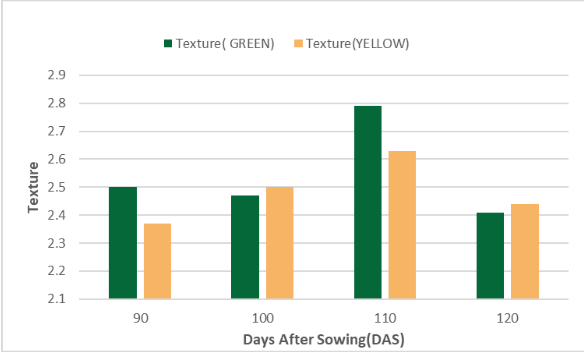

Figure 4: Combine effects of Texture of green & yellow plants.

4. Conclusion

The current study has focused on the physico-mechanical properties of various segments of kenaf fiber. The findings indicate that bundle fiber strength (gm/tex) is optimal in green plants at 90 to 110 days after sowing (DAS). The differences in bundle strength between green and yellow plants are minimal. Therefore, it is recommended to harvest yellow plants at specific ages, namely 100 DAS and 110 DAS, for effective fiber production. This flexibility in harvesting schedules facilitates strategic planning in fiber production, enabling growers to maximize yield while maintaining quality.

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