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Morphological Characterization of the Varietal Traits of Jute and Kenaf Seeds in Bangladesh

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A b s t r a c t

Jute (*Corchorus* spp.) and kenaf (*Hibiscus cannabinus* L.) are economically significant fiber crops with extensive industrial applications. Understanding of their genetic variability and agronomic traits is crucial for crop improvement and the development of value-added products. This study investigates the varietal characteristics of jute and kenaf seeds in Bangladesh, focusing on seed morphology. To conduct this study Deshi/ White jute (*C. capsularis*) varieties (11), Tossa jute (*C. olitorius*) varieties (6) and Kenaf (*H. cannabinus*) variety (3) were used. The results of this study demonstrate substantial diversity in the characteristics of seeds, including their size, seed volume, shape, color, % germination, thousand seed weight (WTS) and seed yield ha^{-1}. The seed color of white jute, tossa jute and kenaf varities are ash gray, greyish blue prussian and dark brown respectively but seed shape is diversified among different varieties. Varieties of kenaf seed showed higher seed length, seed width, WTS (g), % germination, seed yield ha^{-1} than that of tossa jute seed. Except, seed yield ha^{-1} for white jute seed, all tested parameter showed lower than tossa jute seed. Seed serface is 5, 6 and 5 for White jute, tossa jute and kenaf respectively. These findings have significant ramifications for varietal differentiation of seed, seed rate determination for fibre/seed cultivation purposes, determination of seed purity, potential seed yielder variety, breeding programs, and conservation activities for jute and kenaf genetic resources. This research adds to the current information on jute and kenaf seeds, establishing a foundation for future studies that will delve deeper into these crops to increase their economic worth, raise crop yields, and promote sustainable agriculture and economic growth.

Keywords: Characterization, Morphology, Kenaf and Jute.

Introduction

Jute and kenaf are two biodegradable natural fibers with different inherent advantages like high tensile strength, low extensibility, moderate heat, fire resistance, and long staple lengths. It outperforms synthetics in terms of environmental protection and ecological balance. *Corchorus capsularis* is called White Jute and *Corchorus olitorius* is named as Tossa jute, also known as "golden fiber" in Bangladesh, are an environmentally friendly vegetable fiber plant (IJSG, ITC and CFC, 2006). Kenaf (*Hibiscus cannabinus* L., Malvaceae) is a warm season annual fiber crop that is closely related to White Jute. It can be successfully produced in mainly in India and China, followed by Bangladesh. As the commercial use of kenaf expands from its traditional role as a cordage crop (rope, twine, and sackcloth) to new applications such as paper products, building materials, absorbents, and livestock feed, the number of options in the decision matrix will grow, encompassing issues ranging from basic agricultural production methods to kenaf marketing (Islam, 2019). The adoption of high-yielding varieties

and improved production technologies has caused the national average yield to rise from 1.59 to 1.98 tons per hectare (Islam and Ali, 2017). In Bangladesh, total 7,27,382 Hectors area was covered by jute crops in fiscal year 2021-22 which is 6.628% higher than that of fiscal year 2020-21 and yield rate has been estimated at 11.593 bales (2.09 ton /ha) per hector which is 2.375% higher than that of last year 2020-21 but 1.50 t/ha during 1970-80. Total jute production in 2021-22 was 84,32,395 bales, which is 9.156 % higher than that of 2020-21 (BBS, 2022). High yielding jute varieties and production technologies contributed toward higher yield (Bhattacharjee *et al.*, 2000). Quality of jute seeds ensures both the quantity and quality of jute fiber production. Bangladesh's government has prioritized the promotion of the jute seed industry, with the goal of strengthening both public and private sectors involved in jute seed production and reducing dependence on imported seeds. Bangladesh is a major exporter of raw jute and jute products, holding a significant share in the global market. Bangladesh requires approximately 5000 to 6000 metric tons of jute and kenaf seed annually based on its current jute production acreage. BADC supplied only 12-15% of the total seed for jute and allied fibers (Al-Mamun and Saha, 2017). A significant portion of the jute seed requirement is met by imports from India and unauthorized traders take advantage of high demand and enter the market with low-quality seeds. The findings indicate that an increase in seed size during planting influence plant growth and development. Large and medium seeds' superior performance in terms of plant growth, seed production, and quality can be attributed to the increased seed weight and the resulting higher initial capital of food reserves. This phenomenon resulted in a higher absolute growth rate for seedlings and plants (Bhattacharjee *et al.*, 2000). Quality seed is required for successful crop production and ensures high yields. These superior seeds have crucial traits like disease resistance, high germination rates, and optimal genetic characteristics. Investing in such seeds enhances crop resilience by providing improved resistance to environmental stressors, pest resistance, and promoting uniform growth.

Excessive moisture, combined with room temperature during storage, can negatively impact seed viability. Even in the absence of other conditions required for seed germination, seeds with high moisture content exhibit germination tendencies with rising storage temperatures. This germination tendency triggers physiological activities in the seeds, affecting seed vigor and ultimately leading to decreased viability (Hossen *et al.*, 2008)

In Bangladesh, the cultivation of jute and kenaf is deeply embedded in the agricultural tradition, yet challenges persist in achieving consistent yield and quality. Variations in seed characteristics significantly influence these outcomes, affecting fiber strength, length, and overall productivity. Identifying and understanding these varietal differences are essential for seed rate determination for fibre/seed cultivation purposes, determination of seed purity, potential seed yielder variety, fulfilment of seed demand, developing improved cultivars, enhancing crop resilience, and ensuring sustainable production. By examining factors such as germination rates, seedling vigor, and adaptability to different environmental conditions, this study seeks to contribute to the enhancement of jute and kenaf production. The findings will support the agricultural sector in making informed decisions to bolster the country's position in the global market for natural fibers. Hence the study was undertaken to evaluate morphological characteristics of white jute, tossa jute and kenaf seed. This study also investigated the seed production and germination capacity of different jute and kenaf varieties.

Materials and Methods

Study location

The experiment was conducted from January 2024 to April 2024 at the experimental institute of Bangladesh Jute Research Institute.

Study materials

Deshi/ White jute (C. capsularis) varieties (11)

CVL-1 (Late); Green Pat, CVE-3 (Early); Ashu Pat, CC-45; Joe Pat, BJRI Deshi Pat 5 (BJC-7370); Chaiti, BJRI Deshi Pat 6 (BJC-83); Bijli, BJRI Deshi Pat 8 (BJC-2197); Druti, BJRI Deshi Pat Shak-1 (BJC-390), BJRI Deshi Pat 9 (BJC-5003); Basumoti, BJRI Deshi Pat Shak-2 (Mehra Red), BJRI Deshi Pat Shak-3 (Mehra Green), BJRI Deshi Pat 10; Arnob.

Tossa jute (C. olitorius) varieties (06)

O-9897 (FalguniTossa; Popular variety), BJRI Tossa Pat 4 (O-72); Sonali Bangla, BJRI Tossa Pat 5 (O-795); Red Tossa, BJRI Tossa Pat 6 (O-3820); DurontaTossa, BJRI Tossa Pat 8 (Robi-1, Red variety) and BJRI Tossa Pat-9 ; Green Gold.

Kenaf (H. cannabinus) variety (3)

BJRI Kenaf −2 (HC- 95), BJRI Kenaf −3 (HC-3); Bot Kenaf and BJRI Kenaf −4 (KE-3); Red Kenaf

Seed Collection

To begin the assessment, representative samples of seeds or different varieties were collected from the Bangladesh Jute Research Institute to ensure the accuracy and reliability of the results. Random selection of seeds from each variety is crucial to avoid bias or favor in the assessment process. Bangladesh Jute Research Institute has released 56 jute and allied crops but 20 varieties had been used for this experiment.

Parameters of the study

Seed color

A standardized color chart was utilized for the assessment of seed color. The assessment was conducted under consistent lighting conditions to minimize variability. Human eye observation was employed to match the color of each seed with the closest color on the chart. The color of each seed was then recorded according to the chart for further analysis (Picture 1a, b and c).

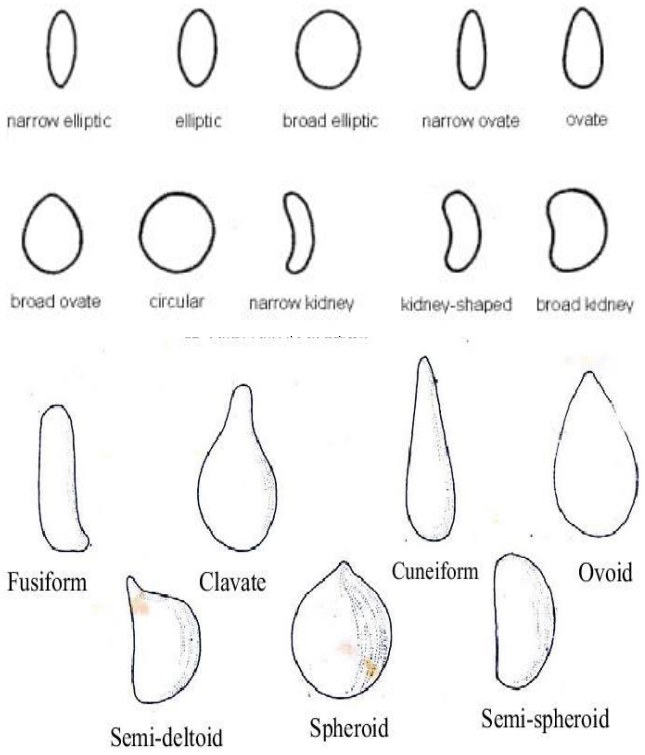
Picture-1.a. Color Shade for identifying the color of White Jute seed; b. Color Shade for identifying the color of Jute and Kenaf seed, and c. Color Shade for identifying the color of White Jute seed

Seed Size (Length & Width)

Seed size was measured using slide calipers to obtain accurate length and width measurements. Five seeds were measured from each sample to ensure the representatives of the data. Proper calibration of the slide calipers is needed for obtaining precise measurements. Utilizing a millimeter scale and the keen observation of our eyes, aided by a magnifying glass for enhanced precision, we carefully measured the length and width of each seed.

Seed Volume
The seed volume (mm3 × 10−3) was calculated using the following formula (Arditti *et al.*, 1980)
$SV= [(L/2) (W/2)^2 (\pi/3)]$
Where SV= seed volume, L = length, W = width, and π = 22/7,

Seed Shape
The seed shape determination process involved utilizing various seed shapes as references. A range of seed shapes, such as round, oval, elongated, or irregular, were compared to the seeds under assessment. Observers examined the seeds closely, comparing them to the reference shapes to determine the closest match. This data was then compiled into a summary, which likely included the frequency of each shape observed and any notable variations or outliers. Overall, the goal of this process was to categorize the seeds based on their shape characteristics in a standardized and reproducible manner, allowing for further analysis and comparison across different samples or experiments.



Picture 2. Measuring indicator (A&B) of Seed Shape for identifying the shape of Jute and Kenaf seed (www.pinterest.com).

Seed Surface
Seeds from each sample were carefully chosen, once selected, these seeds were subjected to rotation to facilitate observation of their surfaces from multiple angles. To ensure adequate lighting and utilize appropriate magnification tools such as microscopes or magnifying glasses had been used when observing seed surfaces from multiple angles.

Thousand seed weight (WTS)
Typically at least 1000 seeds were counted at least three times with the help of counter machine after that sample were counted one by one again by us and the total count was recorded. The sample is then weighed using electronic balance which was capable of measuring to at least three decimal places. This experiment was tested three times for each variety to reduce error and ensure reliability.

% Germination
Fifty to one hundred seeds of each of the jute varieties were placed in the petri dishes with wet blotting paper for germination on 20 April, 2024 in the Laboratory of the BJRI. After 2 days the seeds began to germinate. After 72 hours germinated seeds were counted and recorded. Consistent temperature and moisture levels were maintained throughout the germination period to facilitate optimal seedling emergence. The germination progress was monitored regularly, checking for signs of seedling emergence. The germination percentage was calculated by dividing the number of germinated seeds by the total number of seeds tested and multiplying by 100 (Orchard, 1977)

$$\% \text{ Germination} = \frac{\text{Number of Germinated Seeds}}{\text{Number of Seeds Tested}} \times 100$$

Seed Yield (ha^{-1})
Seed production data was collected from Bangladesh Jute Research Institute as a secondary data.

Measuring indicators validation for identifying
Assign indicators or parameters were selected for seed distinguish characters based on its importance in the segregation at seed farmers and seed industries level. This was done through expert consultation with Scientists of Bangladesh Jute Research Institute.

Results and Discussions

Seed Color, Shape and Surface
Different jute varieties exhibit distinct colors, as observed on a color chart, with white jute seeds being brown in color. The shape of white jute seeds was observed to vary, some being ovoid or ovate, while others were conical or triangular when viewed from multiple angles. Tossa jute seeds closely resembled steel gray and Prussian blue in color, while kenaf seed varieties were closer to gray. Tossa jute seeds were small, with some being spheroid and others being broad ovate when observed from multiple angles. Kenaf seeds were of intermediate size, gray in color, and had a conical or broad kidney shape from various perspectives. These observations align with the findings of Islam, (2019) regarding seed color and shape. Additionally, the surfaces of white jute seeds and kenaf seeds were observed with a number of 5, whereas tossa jute seeds had a surface count of 6 based on observations (Table 1, 2 and 3).

Table 1. Characterization of White Jute varieties: (*Corchorus capsularis* L.) in regard to color, shape and surface

Sl	Variety Name	*RY	Characteristics	Photo
1	CVL-1 (Late); Green Pat	1977	Seed Color: Dark brown Seed Shape: Small, Conical and Triangular Surface: 5	
2	CVE-3 (Early); Ashu Pat	1977	Seed Color: Dark Brown Seed Shape: Small, Conical and Ovate Surface:5	

3	CC-45; Joe Pat	1979	Seed Color: Dark Brown Seed Shape: Small, Triangular and Ovate Surface: 5	
4	BJRI Deshi Pat 5 (BJC-7370); Chaiti	1995	Seed Color: Dark Brown Seed Shape: Small, Ovoid and Ovate Surface: 5	
5	BJRI Deshi Pat 6 (BJC-83); Bijli	1995	Seed Color: Dark Brown Seed Shape: Small, Ovoid and Ovate Surface: 5	
6	BJRI Deshi Pat 8 (BJC-2197); Druti	2013	Seed Color: Dark Brown Seed Shape: Small, Ovoid and Ovate Surface: 5	
7	BJRI Deshi Pat Shak-1 (BJC-390)	2014	Seed Color: Dark Brown Seed Shape: Small, Ovoid and Ovate Surface: 5	
8	BJRI Deshi Pat 9 (BJC-5003); Basumoti	2017	Seed Color: Dark Brown Seed Shape: Small, Ovoid and Ovate Surface: 5	
9	Deshi Pat-10	2021	Seed Color: Dark Brown Seed Shape: Small, Ovoid and Ovate Surface: 5	
10	BJRI Deshi Pat Shak-2 (Mehra Red)	2020	Seed Color: Dark Brown Seed Shape: Small, Ovoid and Ovate Surface: 5	
11	BJRI Deshi Pat Shak-3 (Mehra Green)	2020	Seed Color: Dark Brown Seed Shape: Small, Ovoid and Ovate Surface: 5	

Table 2. Characterization of Tossa Jute varieties: (*Corchorus olitorius* L.) in regard to color, shape and surface

Sl	Variety Name	RY	Color	Photo
12	O-9897 (FalguniTossa; Popular variety)	1987	Seed Color: Greyish Blue Prussian Seed Shape: Small, Spheroid and Broad ovate Surface: 6	
13	BJRI Tossa Pat 4 (O-72); Sonali Bangla	2002	Seed Color: Greyish Blue Prussian Seed Shape: Small, Spheroid and Broad ovate Surface: 6	
14	BJRI Tossa Pat 5 (O-795); Red Tossa	2008	Seed Color: Greyish Blue Prussian Seed Shape: Small, Spheroid and Broad ovate Surface: 6	
15	BJRI Tossa Pat 6 (O-3820); DurontaTossa	2013	Seed Color: Greyish Blue Prussian Seed Shape: Small, Spheroid and	

			Broad ovate Surface: 6	
16	BJRI Tossa Pat 8 (Robi-1, Red variety)	2019	Seed Color: Greyish Blue Prussian Seed Shape: Small, Spheroid and Broad ovate Surface: 6	
17	BJRI Tossa Pat-9 (Green Gold, green variety)	2020	Seed Color: Greyish Blue Prussian Seed Shape: Small, Spheroid and Broad ovate Surface: 6	

Table 3. Characterization of Kenaf varieties: (*Hibiscus cannabinus* L.) in regards to color, shape and surface

Sl	Variety Name	RY	Color	Photo
18	BJRI Kenaf −2 (HC-95)	1995	Seed Color: Ash Gray Seed Shape: Intermediate Size, Conical and Broad kidney shape Surface: 5	
19	BJRI Kenaf −3 (HC-3); Bot Kenaf	2010	Seed Color: Ash Gray Seed Shape: Intermediate Size, Conical and Broad kidney shape Surface: 5	
20	BJRI Kenaf −4 (KE-3); Red Kenaf	2017	Seed Color: Ash Gray Seed Shape: Intermediate Size, Conical and Broad kidney shape Surface: 5	

*RY= Release Year

Seed Size (length & Width)

The highest seed length was observed 5.84 mm, which belonged to BJRI Kenaf -2 (HC-95). Following closely were lengths of 5.74 mm and 5.72 mm, which were also varieties of BJRI Kenaf -4 and BJRI Kenaf -3, respectively. As mentioned earlier, Kenaf seeds tend to have intermediate sizes. The lowest seed length was recorded 2.38 mm, observed in Rabi 1. Both Tossa jute and White jute seeds length were comparatively shorter than Kenaf seeds, as they are smaller in size. Islam (2019) also found that exact size and shape may vary among different jute varieties. Based on the observations, it is evident that BJRI Kenaf -3 (HC-3) had the widest seed width at 4.88 mm, while BJRI Deshi Pat Shak-2 had the narrowest at 1.54 mm. Consequently, both white and tossa jute seed dimensions, including length and width, were smaller compared to Kenaf seed varieties (Fig. 1 and 2).

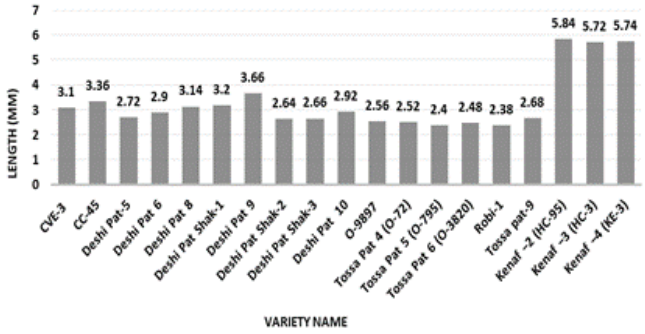


Fig 1. Variety wise seed length (mm) of Jute and Kenaf seed

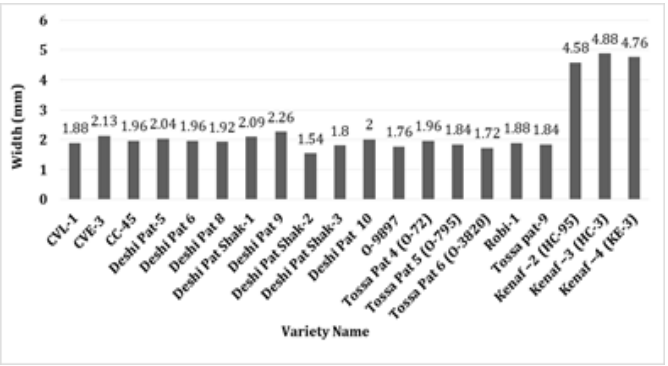


Fig 2. Variety wise seed length (mm) of Jute and Kenaf seed

Seed volume

BJRI Kenaf -3 (HC-3) showed the highest seed volume (17.84 $mm^3 \times 10^{-3}$) followed by BJRI Kenaf −4 and BJRI Kenaf −2 (HC-95). The lowest seed volume was recorded BJRI Deshi Pat Shak-2 (0.82 $mm^3 \times 10^{-3}$). Within the jute variety, tossa seed volume is lower than white jute except BJRI Deshi Pat Shak-2 and BJRI Deshi Pat Shak-3 but the volume of kenaf seed is larger than jute seed. (Table 4).

Table 4. Characterization of Jute and Kenaf varieties in regards on seed surface volume ($mm^3 \times 10^{-3}$)

Sl. No.	Variety Name	*R-1	*R-2	*R-3	*R-4	*R-5	Average seed volume
01	CVL-1	1.03	1.57	1.56	1.57	1.68	1.48
02	CVE-3	1.68	1.73	1.90	1.62	2.27	1.84
03	CC-45	1.83	2.09	1.57	1.65	1.32	1.69

04	BJRI Deshi Pat-5	1.28	1.47	1.50	1.47	1.71	1.48
05	BJRI Deshi Pat 6	1.41	1.47	1.37	1.57	1.47	1.46
06	BJRI Deshi Pat 8	1.79	1.65	1.32	1.37	1.47	1.52
07	BJRI Deshi Pat Shak-1	1.57	2.02	1.90	1.57	2.08	1.83
08	BJRI Deshi Pat 9	2.49	2.19	2.64	2.49	2.41	2.45
09	BJRI Deshi Pat Shak-2	0.84	0.84	0.77	0.80	0.85	0.82
10	BJRI Deshi Pat Shak-3	1.14	0.84	0.98	1.32	1.41	1.13
11	BJRI Deshi Pat 10	1.47	1.62	1.47	1.57	1.52	1.53
12	O-9897	1.36	0.87	0.95	1.10	0.95	1.04
13	BJRI Tossa Pat 4 (O-72)	1.31	1.36	1.18	1.13	1.36	1.27
14	BJRI Tossa Pat 5	1.06	1.13	1.26	0.87	1.02	1.06
15	BJRI Tossa Pat 6 (O-3820)	1.06	0.98	1.02	1.09	0.68	0.96
16	BJRI Tossa Pat 8 (Robi-1)	1.18	1.36	1.02	0.85	1.13	1.10
17	BJRI Tossa pat-9	1.23	1.15	1.15	1.19	1.23	1.19
18	BJRI Kenaf −2 (HC-95)	19.64	11.10	15.91	18.87	15.65	16.04
19	BJRI Kenaf −3 (HC-3)	21.12	19.32	18.55	13.26	17.61	17.84
20	BJRI Kenaf −4	17.61	15.38	18.24	14.58	19.64	17.03

Foot Note: *R= Replication

Thousand Seed Weight (WTS)

The average thousand seed weights of the varieties ranges from 1.778 to 28.534 g. BJRI Kenaf −4 (KE-3) variety had the highest average WTS among all varieties, with 28.534 grams. BJRI Tossa Pat 9 had the lowest average weight among all varieties, with 1.778 grams. Result shows that the WTS of Tossa Pat is lower than White jute. BJRI Deshi Pat Shak-2 and BJRI Deshi Pat Shak-3 had the lowest average weights among Deshi Pat varieties, with 2.480 grams and 2.588 grams respectively. The average weights of different varieties vary significantly, indicating diversity in seed characteristics (Fig. 3).

Seed germination (%)

The germination rates vary among the different varieties tested. BJRI Kenaf −4 (KE-3) achieved high germination rates of 98% and 94 % germination rate recorded at CVL-1, BJRI Deshi Pat Shak-3 indicating favorable conditions for seed growth. On the other hand, varieties like BJRI Deshi Pat Shak-1 exhibited lower germination rates at 72% where 75% at CC-45 and BJRI Deshi Pat Shak-2. Several varieties demonstrated consistent germination rates around the 90% mark (Fig. 4).

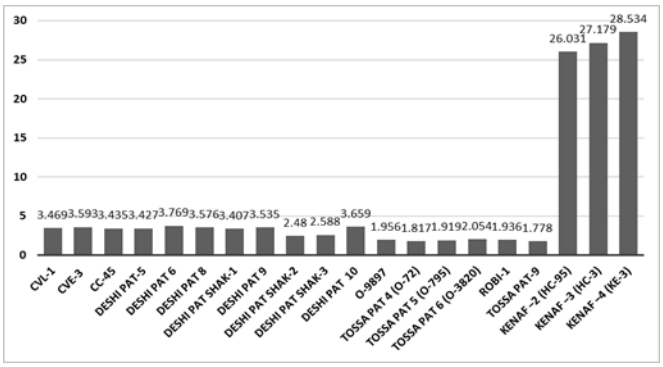


Fig 3. Variety wise 1000 seed weight (gm) of Jute and Kenaf seed

This consistency suggests stable seed quality across multiple batches. The Kenaf varieties tested (BJRI Kenaf −2, BJRI Kenaf −3, and BJRI Kenaf −4) exhibited high germination rates ranging from 86 to 98%. This suggests good seed viability and suitability for cultivation. Most varieties demonstrated relatively high germination rates, with the majority falling within the range of 85% to 94%. This indicates overall good seed quality across the tested varieties (Fig. 4).

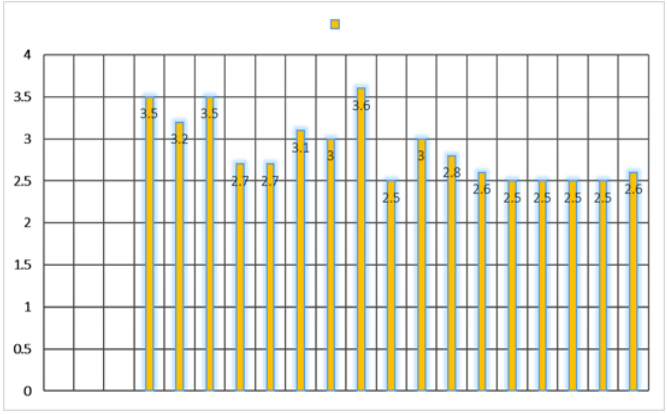


Fig 4. Variety wise Seed germination (%) of Jute and Kenaf

Seed yield

The top three varieties in terms of seed production are BJRI Kenaf−3 (HC-3) with 1208 Kg/ha and BJRI Kenaf−2 and BJRI Kenaf −4 with 1186 and 1161 kg/ha respectively. Other high-producing seed white jute varieties are BJRI Deshi Pat 9 with 741 kg/ha and tossa jute varieties are BJRI Tossa Pat-9 with 753 kg/ha. Kenaf varieties generally have a significantly higher production per acre compared to jute varieties. The lowest seed producing Kenaf variety BJRI Kenaf −4 with 1161 Kg/ha still outperforms the highest producing jute variety This suggests that for higher seed production, cultivating Kenaf could be more advantageous compared to white and tossa jute varieties. However, the choice between Kenaf and Jute may also depend on other factors such as

market demand, climatic conditions, and specific use cases of the crop (Table-5).

Tabe 5. Variety wise Seed Production

Sl. No.	Variety Name	Production (Kg /ha)
1.	CVL-1	482
2.	CVE-3	489
3.	CC-45	511
4.	BJRI Deshi Pat-5	605
5.	BJRI Deshi Pat 6	615
6.	BJRI Deshi Pat 8	660
7.	BJRI Deshi Pat Shak-1	632
8.	BJRI Deshi Pat 9	741
9.	BJRI Deshi Pat Shak-2	645
10.	BJRI Deshi Pat Shak-3	670
11.	BJRI Deshi Pat 10	674
12.	O-9897	741
13.	BJRI Tossa Pat 4 (O-72)	716
14.	BJRI Tossa Pat 5	692
15.	BJRI Tossa Pat 6 (O-3820)	699
16.	BJRI Tossa Pat 8 (Robi-1)	684
17.	BJRI Tossa pat-9	753
18.	BJRI Kenaf −2 (HC-95)	1186
19.	BJRI Kenaf −3 (HC-3)	1208
20.	BJRI Kenaf −4	1161

Conclusions

Through comprehensive morphological analyses, we have identified significant variability in seed traits among different jute and kenaf varieties. Morphologically, jute seeds are typically small, round to oval, with a smooth, shiny coat and brownish or grey coloration, whereas kenaf seeds are larger, more elongated, with a rougher, duller surface and dark brown to black coloration. Observing germination and growth patterns, including germination rates and early seedling morphology, further helps differentiate varieties. Lower WTS and higher germinating capability seed requires lower amount for showing in the field and also such types of variety seleted as superior variety if seed and fibre yield also higher. It may be helpful for breeding purposes to develop such kind of high fibre yielding varieties. These findings guide for varietal differentiation of seed, seed rate determination, determination of seed purity, potential seed yielder variety, breeding programs, and conservation activities for jute and kenaf genetic resources. Further studies should be conducted for determination of different showing time, biochemical composition and storage capacity of jute and kenaf seed and effects on germination, seedling growth, plant performance and yield.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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