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Field Screening and Evaluation of the Varietal Performance of Jute and Allied Fiber Crops against Viral and Nemic Disease and Their Impact on Yield

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Abstract

Jute is the golden fiber crop of Bangladesh. Viral and Nemic diseases are the major threats to fiber crops, and the fiber yield decreases drastically as the disease infection increases. An experiment was conducted to screen and evaluate ten Jute and allied fiber varieties i.e. BJRI Kenaf-4, BJRI Kenaf-3, HS-95 (Kenaf), HS-24 (Mesta pat), HC-2 (Kenaf), BJRI Deshi pat-8, BJRI Deshi pat-7, BJRI Deshi pat-5, BJRI Deshi pat-6 and CVL-1 against mosaic virus and root-knot nematode disease. It was done in RCBD design with three replications at Sher-e-Bangla Agricultural University (SAU) central farm, Dhaka-1207, from June 2018 to March 2019. In the case of viral infection, variety 4 (HS-24 (Mesta pat)) showed maximum virus incidence (23.11%), whereas variety 2 (BJRI Kenaf-3) had no virus evidence. The most susceptible nematode-infected variety was found in varieties 5 (HC-2 (Kenaf)) and 9 (BJRI Deshi pat-6), which showed 80% incidence, whereas variety 2 (BJRI Kenaf-3) was highly resistance. The growth and yield results showed a significant (0.05%) reduction of plant height (cm) and fiber weight (t/ha) with an increase in the percentage of virus and nematode incidence against all varieties. The highest fiber weight (1.47 t/ha) and the lowest viral (0%) and nemic infection (0%) were found in variety 2 (BJRI Kenaf-3), which showed better performance compared to other varieties. These results revealed that variety 2 (BJRI Kenaf-3) had the best variety in the present study.

Keywords

Mosaic Virus, Nemic Disease, *Meloidogyne javanica*, *Bemisia tabaci*, Jute, Allied Fiber

1. Introduction

Jute (*Corchorus capsularis*, *C. olitorius*), Kenaf (*Hibiscus cannabinus*) and Mesta (*H. sabdariffa*) rank as the second most important natural fibers, after cotton [1] and Jute is often known as the golden fiber of Bangladesh. Jute can endure a wide range of climatic conditions, including tropical and subtropical stress. In Bangladesh, Jute production is roughly 8.4 million bales per hectare [2], Mesta yields 1.9 t/ha [3], and Kenaf ranges from 0.08 to 0.09 million t/ha [4]. Insect pests, nematodes, diseases, and certain abiotic factors throughout different plant growth stages all contribute to these crops' low production. Viruses and parasitic nematodes are two major pathogens that diminish fiber quality and production. Root-knot nematode was initially identified in Holland and England [5]. Only root-knot nematodes are believed to be responsible for a $157 billion yearly loss that is 5% of worldwide production [6] and this number may be much greater in tropical and subtropical regions [7]. These organisms are obligate parasites that specifically target the roots of numerous plant species, with over 3000 species affected as a result of Root-knot nematodes [8]. The J2S penetrate the root walls of these crops and establish a feeding site within the vascular tube that forms larger cells [9]. The foliage of the crops exhibits a transition from yellowish green to yellow; there is a tendency for the leaves to abscise, leading to wilting of the plants. In significant infestations, one may observe inadequate germination and the mortality of seedlings.

The virus may infect Jute and allied fiber plants at any stage of development. The disease rapidly disseminates in the field, negatively impacting growth and yield-related traits due to significant changes in the cellular structures of the affected plants. The Jute leaf mosaic virus is classified within the Geminivirus group, with *Bemisia tabaci* as a consistent vector for its dissemination at the field level. The transmission of the disease via whitefly has also been observed in Kenaf and Mesta mosaic virus as well as via seed or grafting [10] [11]. Recently, the prevalence of the disease has expanded from 20 to 40 percent [12]. The seedling leaves displayed symptoms of leaf mosaic disease, which began as small yellow flecks on the leaf lamina. These flecks eventually expanded and mixed with green patches to form a yellow mosaic. The symptoms appeared crinkled, leathery, and needle-like in Mesta. Under severe circumstances, the diseased plant experiences a great reduction in growth.

The existence of resistant varieties is the most effective way against root-knot and viral disease in Jute and associated fibers. According to [13], Mesta's capacity for resistance made it a useful crop rotation tool for controlling the spread of *M. incognita* and *M. javanica* on Kenaf. Using varieties that are resistant to RKN and viruses decreases the demand for synthetic chemicals. As resistance develops, it gradually reduces the residual harmful effects of pesticides on the environment and non-target microbes. Given the aforementioned facts and findings, we conducted the current study to screen and evaluate Jute and allied fiber crop varieties against viral and nemic diseases in natural field conditions.

2. Methodology

The field experiment was carried out at the Sher-e-Bangla Agricultural University (SAU) central farm, Dhaka-1207, from June 2018 to March 2019. The location of the experimental site was at 23˚46' N latitude and 90˚24' longitude with an elevation of 9 meters above the sea level belonging to the Modhupur tract under the Agro-Ecological Zone (AEZ) 28. The soil texture was silty loam, non-calcareous, dark grey soil of Tejgaon soil series with a pH of 6.7. There was very low or no rainfall during December and January. The average highest temperature during the period of investigation was 29.88˚C and the lowest temperature was 13.64˚C. Altogether 10 seed samples were collected from Bangladesh Jute Research Institute (BJRI), Manik Mia Avenue, Dhaka-1207. Each seed sample was collected in 100 g (Table 1).

Table 1. List and source of varieties used for the present investigation.

Varieties	Name of varieties	Source
1	BJRI Kenaf-4	BJRI
2	BJRI Kenaf-3	BJRI
3	HS-95 (Kenaf)	BJRI
4	HS-24 (Mesta pat)	BJRI
5	HC-2 (Kenaf)	BJRI
6	BJRI Deshi pat-8	BJRI
7	BJRI Deshi pat-7	BJRI
8	BJRI Deshi pat-5	BJRI
9	BJRI Deshi pat-6	BJRI
10	CVL-1	BJRI

2.1. Land Preparation

The Randomized Complete Block Design (RCBD) with three replications ensured that the experiment accounted for any variability in the soil and other environmental factors across different blocks. Dividing the experimental area into three blocks, each with 10 plots helped minimize any potential effects of soil heterogeneity. Each plot, measuring 3 m × 2 m with a spacing 30 cm × 30 cm (each plot contains 60 plants), land was prepared by deep plowing and applying recommended fertilizer doses. 3.5 tons of cow dung fertilizer mixed per hectare 2 - 3 weeks before sowing in well-prepared land. On the day of sowing, 15 kg of urea, 17 kg of TSP and 22 kg of MOP fertilizer were applied to the land. Then, 6 - 7 weeks after sowing, the field was cleared of weeds and seedlings thinned and 100 kg of urea fertilizer per hectare was spread on the land again [14]. Standard cultural practices were followed except for any chemical plant protection techniques (insecticide spray for jute hairy caterpillar and jute semilooper).

2.2. Identification of Viral and Nemic Disease by Visual and Microscopic Observation

Plants grown in the experimental field were checked at 30 days, 50 days and 70 days after seed sowing and gradual symptoms were recorded. For virus disease, the recorded symptoms include mosaic, leaf curling, chlorosis, leaf distortion, and smaller leaflets of plants. Individual plants showing visible symptoms of diseases were recorded.

For nemic disease, the above-ground symptoms were observed. The infected plant root was uprooted safely and a visual count of the number of galls was recorded (Table 2). The nematode root gall was confirmed by microscopic analysis of the nematode and perennial pattern of the nematode by slide preparation. The gall contains roots placed in staining solutions of a beaker and kept for 3 - 4 minutes then washed with water again. After that galled root dried with tissue paper. These dried roots were then kept in distaining solutions for at least 72 hrs and observed under dissecting microscope. The adult female nematodes were then isolated and put on slides and dissected with a sharp blade. After that, the dissected nematodes were cleaned, and a slide was made to observe the perineal pattern of *Meloidogyne* sp. At the time of harvesting, the fiber weight of 10 plants per plot was taken by digital weight.

Table 2. Root-knot index scale [15].

Scale	No. of galls/eggs/egg mass	Reactions
1	0	Highly resistant (HR)
2	1 - 10	Resistant (R)
3	11 - 30	Moderately resistant (MR)
4	31 - 100	Susceptible (S)
5	More than 100	Highly susceptible (HS)

2.3. Parameters Assessed

Data were collected based on growth and yield contributing characters of infected plants or plant parts. They are as follows:

- Number of infected leaves/plants;
- Plant height (cm);
- Root weight (g);
- Number of galls;
- Fiber weight (t/ha).

2.4. Disease Incidence of Nemic and Viral Disease

Data on disease incidence in the experimental field were recorded through frequent visits after the appearance of symptoms. Disease incidence was calculated by using a standard formula [16] for viral and nemic disease:

$$\text{Disease Incidence}(\%) = \frac{\text{Number of infected plants}(\text{or parts})}{\text{Total number of plants}(\text{or parts})\text{observed}} \times 100$$

2.5. Statistical Analysis

All collected data were subjected to analysis of variance (ANOVA) using the "Statistix 10" software the means among treatments were compared by least significant difference (LSD) tested at the significance level of $\alpha = 0.05$.

3. Results and Discussion

3.1. Identification of Viral Disease of Jute and Allied Fiber Crops by Visual Observation

Jute mosaic disease caused by Jute mosaic virus (JMV) showed the symptoms of light and dark green patches of growing leaves of Jute. A yellow network of veins and chlorosis of leaves were found and the infected plant became stunted in Kenaf vein mosaic disease-infected plants. In the case of Mesta, Mesta yellow vein mosaic disease caused by Mesta yellow vein mosaic virus (MeYVMV) showed complete chlorosis of leaves and yellowing of leaves vein. This symptom of all the infected plants became prominent after the progression of the disease and it first appeared in upper smaller leaves then gradually spread to lower older leaves. Chlorotic intermingled are also observed. The plants became stunted in growth stage (Figure 1).

(a) Jute leaf (b) Kenaf leaf (c) Mesta leaf

Figure 1. Symptoms of virus disease in Jute and allied fiber crops.

3.2. Evaluation of Jute and Allied Fiber Varieties against Viral Disease

The percentage of incidence of viral infection was observed under natural evaluation in different fields with different varieties. The disease incidence varied significantly among varieties as shown in Table 3. At 30, 50 and 70 DAS, the disease incidence (%) ranged from 0 to 8.33, 0 to 21.0 and 0 to 23.33 respectively. At 30 DAS, variety 2 (BJRI Kenaf-3) had no disease incidence whereas variety 4 (HS-24 (Mesta pat)) showed higher virus infection, statistically similar to variety 3 (HS-95 (Kenaf)). On the other hand, variety 2(BJRI Kenaf-3) indicated the lowest virus

infection whereas variety 4 (HS-24 (Mesta pat)) was the highest, statistically identical to varieties 3, 8 and 10 at 50 DAS. At 70 DAS, variety 2(BJRI Kenaf-3) was found to be totally virus free whereas variety 4 (HS-24 (Mesta pat)) was infected mostly which was statistically similar to varieties 1, 3, 5, 6, 8 and 10 respectively. The pooled value indicated that variety 2 (BJRI Kenaf-3) was virus-free and indicated resistance against viral infection up to 70 DAS. The maximum infected variety was variety 4 (HS-24 (Mesta pat)) which was statistically similar to variety 3 (HS-95 (Kenaf)) that and was indicated as the highest susceptible to viral infection.

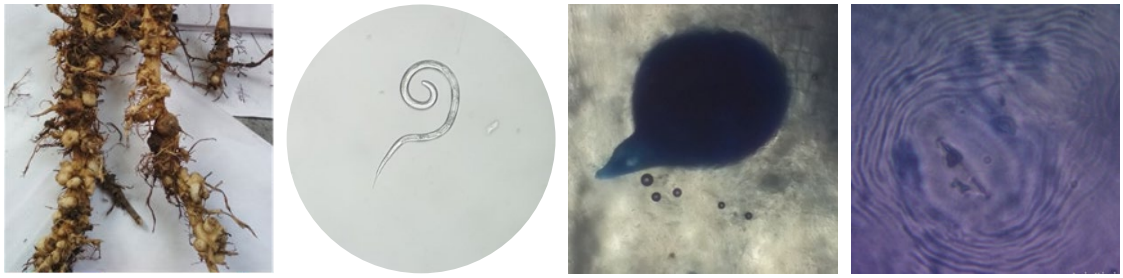
Table 3. Evaluation of Jute and allied fiber varieties against viral disease in natural field conditions.

Variety	Percent Disease incidence			Pooled Disease Incidence (%)
	30 DAS	50 DAS	70 DAS	
1	4.33 bc	10.00 c	34.33 ab	16.22 bc
2	0.00 d	0.00 d	0.00 d	0.00 e
3	7.00 ab	19.33 ab	37.67 ab	21.33 ab
4	8.33 a	21.00 a	40.00 a	23.11 a
5	3.67 bc	12.00 c	30.00 ab	15.22 c
6	3.33 cd	12.33 c	31.33 ab	15.67 c
7	2.67 cd	13.00 bc	28.67 b	14.78 c
8	3.00 cd	15.33 abc	32.67 ab	17.00 bc
9	3.00 cd	10.33 c	14.33 c	9.22 d
10	4.33 bc	15.00 abc	30.00 ab	16.44 bc
CV (0.05)	49.26	30.86	22.25	20.97
STD ERROR	1.5955	3.2341	5.0677	2.5514

*Means followed by the same letters do not differ at 5% level of significance, 1 = BJRI Kenaf-4; 2 = BJRI Kenaf-3; 3 = HS-95 (Kenaf); 4 = HS-24 (Mesta pat); 5 = HC-2 (Kenaf); 6 = BJRI Deshi pat-8; 7 = BJRI Deshi pat-7; 8 = BJRI Deshi pat-5; 9 = BJRI Deshi pat-6; and 10 = CVL-1.

3.3. Identification of Nemic Disease of Jute and Allied Fiber Crops by Visual and Microscopic Observation

As with the above-ground symptoms, yellowing of plant leaves and wilting of plants were observed in cases of nematode infection. The plant's xylem system was blocked due to the presence of a nematode, and as a result, the plant became wilted. The infected plant was uprooted with soil and washed, and the gall formation of the root was observed with the naked eye. The perennial pattern was observed under the compound microscope. The area around the vulva and anus of *M. javanica* was observed and the densely annulated object was found under the compound microscope at high magnification (100×). Species identification could be done by this method **(Figure 2)**.



(a) Symptom of Root-knot (b) 2nd stage of juvenile (c) Adult female (d) Perineal pattern of nematode (*M. javanica*)

Figure 2. Symptoms of nemic disease and different growth stage of *M. javanica*.

3.4. Evaluation of Jute and Allied Fiber Varieties against Nemic Disease

According to the index scale, variety 2 (BJRI Kenaf-3) was found to be highly resistant to nemic disease during natural screening where no gall was found in this variety (Table 4). Four varieties i.e. varieties 3, 4, 5 and 9, were found moderately resistant with gall numbers 15 - 29 galls/plant, one variety was found to be resistant with gall number 7.763 galls/plant and four varieties i.e. varieties 1, 7, 9 and 10 were found to be susceptible with gall number 32 - 44 galls/plant. No variety was found to be highly susceptible to root-knot nematodes during natural screening.

Table 4. Evaluation of Jute and Allied fiber varieties against Root-Knot Nematode.

Varieties	% DI of Root Knot	No of galls/plant	Knot Index
1	70.00 b	33.73 ac	4.00 a
2	0.00 f	0.00 f	1.00 d
3	60.00 c	28.23 bc	3.33 b
4	63.33 c	16.53 de	3.00 b
5	80.00 a	37.57 ab	4.00 a
6	33.33 e	7.76 ef	2.00 c
7	53.33 d	24.85 cd	3.33 b
8	53.33 d	15.23 e	3.00 b
9	80.00 a	42.45 a	4.00 a
10	73.33 b	37.24 ab	4.00 a
CV (0.05)	6.73	22.69	7.94
STD ERROR	3.1131	4.5136	0.1988

*Means followed by the same letters do not differ at 5% level of significance, 1 = BJRI Kenaf-4; 2 = BJRI Kenaf-3; 3 = HS-95 (Kenaf); 4 = HS-24 (Mesta pat); 5 = HC-2 (Kenaf); 6 = BJRI Deshi pat-8; 7 = BJRI Deshi pat-7; 8 = BJRI Deshi pat-5; 9 = BJRI Deshi pat-6; and 10 = CVL-1.

3.5. Effect of Growth and Yield Characters of Jute and Allied Fiber Varieties against Virus and Root-Knot Nematode

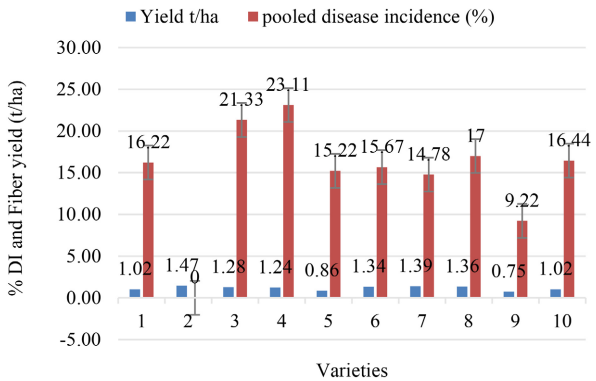
In the case of growth character, the maximum plant height (237.27 cm) was found

in variety 2 (BJRI Kenaf-3) whereas variety 9 (202.2 cm) was the lowest, which was statistically similar to varieties 1 (BJRI Kenaf-4) and 6 (BJRI Deshi pat-8). In the case of root weight, again variety 2 (BJRI Kenaf-3) was found the maximum weight (34.80 g) whereas variety 5 (HC-2 (Kenaf)) was the lowest weight (12.82 g) statistically similar to variety 3 (HS-95 (Kenaf)). Maximum fiber weight (1.47 t/ha) was in variety 2 (BJRI Kenaf-3) which was statistically similar to varieties 6 (BJRI Deshi pat-8), 7 (BJRI Deshi pat-7) and 8 (BJRI Deshi pat-5). Variety 9 (BJRI Deshi pat-6) had the lowest fiber yield (0.75 t/ha) which is statistically similar to variety 5 (HC-2 (Kenaf)) (Table 5).

Table 5. Effect of growth and yield character of Jute and Allied Fiber varieties against viral and nemic disease infection.

Variety	Plant Height (cm)	Root Wt (g)	Green Fiber wt/Variety (g)	Green Fiber Yield (t/ha)
1	212.71 bc	19.37 de	61.33 c	1.02
2	237.27 a	34.80 a	88.00 a	1.47
3	218.17 b	16.30 efg	76.67 b	1.28
4	221.33 b	21.00 cd	74.67 b	1.24
5	214.20 bc	12.82 g	51.67 cd	0.86
6	214.53 bc	25.72 b	80.67 ab	1.34
7	223.97 ab	21.14 cd	83.67 ab	1.39
8	222.17 b	24.82 bc	81.67 ab	1.36
9	202.20 c	18.67 def	45.00 d	0.75
10	219.87 b	14.86 fg	61.33 c	1.02
CV (0.05)	3.94	11.29	8.17	
STD ERROR	7.03	1.93	4.70	

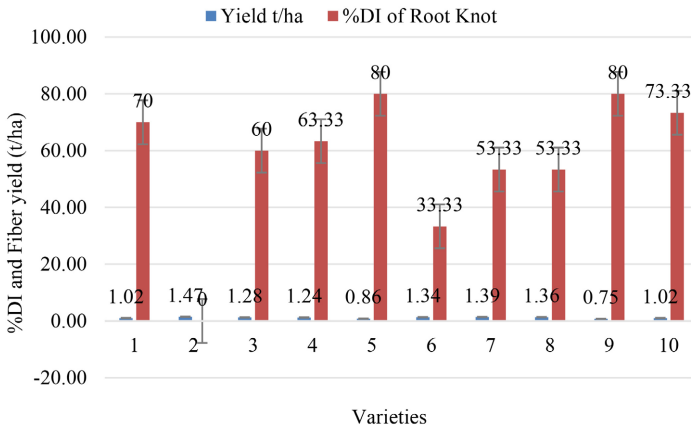
*Means followed by the same letters do not differ at 5% level of significance, 1 = BJRI Kenaf-4; 2 = BJRI Kenaf-3; 3 = HS-95 (Kenaf); 4 = HS-24 (Mesta pat); 5 = HC-2 (Kenaf); 6 = BJRI Deshi pat-8; 7 = BJRI Deshi pat-7; 8 = BJRI Deshi pat-5; 9 = BJRI Deshi pat-6; and 10 = CVL-1.



1 = BJRI Kenaf-4; 2 = BJRI Kenaf-3; 3 = HS-95 (Kenaf); 4 = HS-24 (Mesta pat); 5 = HC-2 (Kenaf); 6 = BJRI Deshi pat-8; 7 = BJRI Deshi pat-7; 8 = BJRI Deshi pat-5; 9 = BJRI Deshi pat-6; and 10 = CVL-1.

Figure 3. Different levels of fiber yield (Kg/ha) among different varieties in case of virus infection (%).

A comparison of different levels of fiber yield among different varieties due to the percentage of viral and nemic infection was shown in Figure 3 and Figure 4, where the variety showed the highest fiber production compared to other varieties. Due to no infection in the viral and nemic areas, it was found in the field evaluation.



1 = BJRI Kenaf-4; 2 = BJRI Kenaf-3; 3 = HS-95 (Kenaf); 4 = HS-24 (Mesta pat); 5 = HC-2 (Kenaf); 6 = BJRI Deshi pat-8; 7 = BJRI Deshi pat-7; 8 = BJRI Deshi pat-5; 9 = BJRI Deshi pat-6; and 10 = CVL-1.

Figure 4. Different levels of fiber yield (Kg/ha) among different varieties in case of nematode infection (%).

4. Discussion

The viral disease, which showed up as light and dark green spots on developing leaves, was found to be present in jute during the field examination. The mesta plant had total chlorosis, but the kenaf plant had a network of yellow veins. Young leaves of infected plants are more likely to display the leaf mosaic disease symptom than older leaves, which is in agreement with the findings of Haque *et al.* [17]. Early signs of jute yellow mosaic disease were little yellow flakes on the lamina, according to Ghosh *et al.* [18]. The fabric's yellow mosaic pattern originated from these flakes becoming bigger and blending green and chlorotic patches.

Field evaluation calculated the viral disease incidence. The disease incidence varied significantly among the ten varieties, with the pooled value of disease incidence indicating that variety 2 (BJRI Kenaf-3) demonstrated resistance against viral infection, while variety 4 (HS-24 (Mesta pat)) displayed a higher level of virus infection. Benchasri *et al.* [19] performed similar research to assess resistance to Yellow Vein Mosaic Virus and yield reduction of okra in field settings in Southern Thailand. The okra variety KN-OYV-03 exhibited moderate resistance, but the okra variety OP showed considerable susceptibility to the Yellow Vein Mosaic Virus (OYVMV). Solangi *et al.* [20] performed the same study on tomato cultivars about tomato leaf curl disease. Researchers indicate that the varieties Advanta-1211, Lima, and T-1359 exhibited the lowest incidence and severity of this virus.

Nematode infection symptoms included yellowing of the leaves and stunted

growth above ground, as well as a visible gall on the infected root shown below ground. We observed the perennial pattern under the compound microscope, focusing on the area around the vulva and anus. Siddique *et al.* [21] used a similar method to identify the nematode from infected plants.

The current investigation revealed that variety 1 and variety 5 were vulnerable to *M. javanica*, but variety 2 exhibited significant resistance. Patra and Nayak (2021) performed research and discovered that among 25 screened tomato varieties, only two exhibited resistances with the lowest gall count (4 - 6 galls/plant); one variety was moderately resistant (25 galls/plant), nine varieties were susceptible (32 - 66 galls/plant), and eleven were highly susceptible (105 - 132 galls/plant).

Variety 2 (BJRI Kenaf-3) produced the highest amount of raw fiber (1.47 t/ha) and variety 9 (BJRI Deshi pat-6) produced the least amount (0.75 t/ha) when tested against other varieties in terms of plant height, root weight, and raw fiber production. In another investigation by Hassan *et al.* [22], they found that the jute type BJC-7370 did better than others in terms of green plant weight (232.4 g plant–1), stick weight (58.97 g plant-1), and fiber yield (58.97 g plant-1). The Kenaf type HC-3 also produced fiber (19.91 g plant-1). So, the kenaf variety HC-3 and the jute variety BJC-7370 performed better in terms of growth, yield, and traits related to yield. Under the AEZ-13, they also made more fiber and seeds.

5. Conclusion

During field evaluation, variety 2 (BJRI Kenaf-3) showed the best performance against viral and nematode infections compared with other varieties as well as fiber yield. So, based on disease reaction and fiber production, variety 2 (BJRI Kenaf-3) showed the best position, and variety 7 (BJRI Deshi pat-7) was in the second-highest position. On the other hand, variety 9 (BJRI Deshi pat-6) was the lowest fiber-yielding variety that was susceptible to virus and nematode disease. This study was done in only one AEZ, so further studies on other AEZs with more varieties of jute and allied fiber crops should be considered. By selecting resistant variety against virus and root knot nematode disease may be managed which are eco-friendly to environment.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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