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Research Article

Studies on genetic variability and screening for fibre yield components and biotic stress factors in tossa jute (*Corchorus olitorius* L.) germplasm under Terai region of West Bengal

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Abstract

A study was carried out with 75 germplasm accessions along with two checks (JRO-524 and JRO-204) of tossa jute (*Corchorus olitorius* L.), over two years (2013 and 2014) at Instructional Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India, for eight characters, out of which four were fibre yield components (plant height, basal diameter, green weight and fibre yield) and the remaining four were biotic stress components (incidence of yellow mite, semi looper, stem rot and root rot), affecting the fibre yield. The germplasm accessions differed significantly for plant height, fibre yield, the incidence of yellow mite, semi looper and stem rot. The highest fibre yielding accession was OIN-142 (17.15 g/plant) which performed significantly better than the two checks. The mean fibre yield of all the genotypes indicated that the fibre yield loss was more due to the incidence of stem rot and root rot rather than yellow mite and semi looper. The germplasm accession OIN-06, OIN-15, OIN-03, OIN-17, OIN-01, OIN-617, OIN-559 and OEX-09 were found to be tolerant towards stem rot incidence and the root rot incidence was low in OIN-93, OIN-86, OIN-25 and OIN-60. The genotypes were distributed in 12 clusters as per D^2 analysis, out of which cluster-XII had the highest number of genotypes (40) followed by cluster-III (10) and cluster-I (9). The remaining 9 clusters had 2 genotypes each. The highest inter-cluster D^2 value was found between cluster-III and cluster-IV (33.99) and the highest intra-cluster D^2 value was found in cluster-I (35.90). The contribution to total divergence was higher by the four biotic factors namely yellow mite, semi looper, stem rot and root rot as compared to the fibre yield components. The greater difference between the GCV and PCV for the eight characters under study revealed the major role played by the environment in the expression of these characters which were further substantiated by the low heritability and genetic advance of the characters. Among the biotic factors, stem rot and root rot were found to decrease fibre yield significantly with increase in their incidence level. It was the negative association of stem rot and root rot with plant height which was the deciding factor in reducing the fibre yield drastically. On screening of the germplasm accessions by giving proper weightage to tolerance, higher fibre yield and genetic divergence, it was found that the genotypes OIN-03, OIN-06, OIN-15 and OIN-17 in cluster-I and the genotypes OIN-86 and OIN-93 in cluster-XII may be used in a hybridization programme, to enhance fibre yield along with tolerance to the two major biotic stress components, namely stem rot and root rot.

Key words

D^2 statistics, variability, correlation, *Corchorus olitorius,* genotype, biotic factors

Introduction

Jute (*Corchorus sp.*) is grown as fibre crop during pre-kharif season and plays an important role in Indian economy. West Bengal alone contributes to 77 % of the total Indian Jute Sinha *et al*.(2004). Among the two dominant species of *Corchorus* namely *C. capsularis* and *C. olitorius* it is the *C. olitorius* which is cultivated extensively in major jute growing areas of the country due to its higher productivity. Despite tremendous increase in *olitorius* jute productivity, presently it is encountering several problems from climate change issues, nutritional instability due to higher cost of synthetic fertilizers and several other biotic and abiotic stress factors which not only affects the yield but also the quality of the fibre. Among the biotic stress factors it is the stem rot and root rot (*Macrophomina phasiolina tassi Goid*), yellow mite (*Polyphagotersonamous latus banks*) and jute semilooper (*Anomis sabulifera* Guen) which are the major biotic constraints of jute cultivation in Terai Region of West Bengal as reported by Hath and Chakraborty (2004) and Roy *et. al*. (2015a and 2015b).

Studies on genetic divergence in this crop including all the fibre yield components and the biotic stress factors is very much important in formulating a successful breeding program. Multivariate analysis using D^2-statistics Mahalanobis, (1936), is a potential tool for estimating the degree of genetic divergence in any germplasm. Any crop improvement programme is successful only if authentic information on magnitude of genetic variability, genetic advancement, character association and direct and indirect effects of fibre yield attributes and biotic stress factors on fibre yield is available. Genetic diversity for yield components and other factors is important for selection of parents to recover superior transgressive segregates. The presentwork reports on the genetic diversity and variability of tossa jute with respect to fibre yield components and important biotic stress components which drastically reduce fibre yield.

Materials and Methods

The present study was done in two successive seasons of jute growth in 2013 and 2014 under the project "AINP on Jute & Allied Fibres", during the pre-kharif season, at the Instructional Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India. Seventy seven genotypes of tossa jute (*Corchorus olitorius* L.) received from ICAR-CRIJAF, Barrackpore, West Bengal, were sown in Randomized Block Design (RBD) with three replications and each replicate had five lines with an inter and intrarow spacing of 30 cm and 5 to 7 cm, respectively. The recommended agronomic practices were followed to obtain an optimum yield. Observations were recorded from 10 plants which were selected randomly from each replication for the four fibre yield related traits namely, plant height (cm), basal diameter (cm), green weight (g/plant) and fibre yield (g/plant).

The insect pest infestation was recorded at weekly interval since their initiation from ten randomly selected plants from each replication. The semilooper damage was measured as per cent plant infestation based on total number of plants and pest infested plant. The yellow mite population was recorded as number of mite per square centimeter area of underside of the second unfold leaf of the plant. The peak period of pest infestation was considered for comparing the germplasm. The data on semilooper infestation was in percentage and was square root transformed as the entire data was less than 30%.

Disease incidence data were taken at 15 days interval, 30 DAS up to 90 days of crop age Disease severity and disease incidence was calculated on the basis of this data. In case of stem rot, Precentage Disease Index (PDI) was worked out on the basis of actual damage in the individual plant that might cause loss to the plant and the number of plants observed. For this purpose numerical rating is done on actual damage in the individual plant like other crops, but some specific factors are considered for such rating. By repeated experimentation on actual damage and yield loss thereof, the following ratings have been worked out for practical application. 1. Size of lesion , (a) Minor dots or lesion less than 0.5 cm^2 = ;, (b) Lesion size 0.6 to 1.0 cm^2 = 2;(c) Lesion sixe 1.1 to 2.0 cm^2 = 3; (d) Lesion size more than 2.0 cm^2 = 4, 2. Position of the lesion on the stem, (a) 1st quarter at the top = 1; (b) 2nd quarter from top = 2; (c) 3rd quarter from top = 3; (d) Last quarter at the bottom = 4, 3. Lesion type; (a) Lesion covering less than 10% of stem diameter = 1; (b) Lesion covering 10.1 to 25.0 % of stem diameter = 2; (c) Lesion covering 26.1 to 40.0 %of stem diameter = 4; (d) Lesion covering more than 40% of stem diameter = 8. Maximum score value of an affected plant will be 4+4+8=16 and the minimum value will be 1+1+1 = 3. Unaffected plant will be assigned 0. PDI = [Sum total of numerical ratings / (Number of plants observed × Highest value)] × 100 PDI of 1 or less than 1 = R (Resistant) 1.1 t0 5.0 = MR (Moderately Resistant) 5.1 to 10.0 = MS (Moderately Susceptible)10.1 to 15.0 = S (Susceptible) More than 15 = HS (Highly Susceptible)

Disease incidence: This is done on the basis of percentage of plant infection. This is applicable in case of damping off, wilt and root rot where the whole plant is affected.

Disease incidence (DI)=[(Number of plants infected/Total number of plants observed) ×100]

The disease infection data was expressed in percentage (both PDI and DI) and hence they were subjected to square root transformation. Additionally 0.5 was added to the data for root rot incidence as some of the data were found to be zero. Thereafter they were subjected to square root transformation.

It is also to be mentioned that the data was recorded from the experimental plots which were not subjected to any kind of plant protection measures.

Genetic divergence was studied by multivariate analysis using Mahalanobis D^2 – statistics and the genotypes were grouped into different clusters by Euclidean method (Rao, 1952). The general statistical procedure was followed according to standard method proposed by Steel and Torrie (1980). The analysis of variance (ANOVA) and broad sense heritability (h^2_b) were estimated from the pooled data over two years (2013 and 2014). The phenotypic coefficient of variation (PCV) and the genotypic coefficient of variation (GCV) were

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estimated according to the procedure proposed by Burton (1952). The expected genetic advance and the genotypic correlation was calculated by the method described by Johnson *et al*. (1955). The path analysis was carried out by the method described by Dewey and Lu (1959). The statistical analysis was done using the software 'Windowstat'.

Results and Discussion

The weather parameters showed wide variation during the two years 2013 and 2014 (table 1). The analysis of variance (ANOVA) for fibre yield components and the biotic stress factors in tossa jute germplasm, combined over two years is described in table 2. The ANOVA revealed significant difference in "year", as the source of variation, for the traits plant height (cm), basal diameter (cm), green weight (g/plant), yellow mite incidence (no./sq.cm), semilooper incidence (%) and stem rot incidence (PDI) and no significant difference was found in case of root rot incidence (%) and fibre yield (g/plant). The genotypes constituting of 75 germplasm accessions and two checks (JRO-524 and JRO-204), differed significantly for plant height (cm), yellow mite incidence (no./sq cm), semilooper incidence (%), stem rot incidence (PDI) and fibre yield (g/plant). The genotypes did not differ significantly for basal diameter (cm), green weight (g/plant) and root rot incidence (%). The interaction component 'year × genotypes' differed significantly for all the traits, indicating a significant influence of variation in weather parameters on the different fibre yield components and biotic stress factors in the tossa jute germplasm under study.

The mean performance of the 75 tossa jute germplasm accessions along with two checks, over two years (2013 and 2014) is described in table 3. The highest fibre yielder was the accession OIN-142 (17.153 g/plant) which performed similar to 43 other germplasm accessions, but significantly better than the two checks JRO-524 (12.427 g/plant) and JRO-204 (12.783 g/plant). In most of the high fibre yielding accessions, it was observed that stem rot and root rot incidence was lower than the population mean but in case of yellow mite and semilooper incidence, it varied from accession to accession, although they were superior fibre yielding. In some high fibre yielding accessions, it was found that the yellow mite and semilooper incidence was higher than the population mean which indicated that the fibre yield loss in the germplasm accession was more due to stem rot and root rot incidence, rather than the yellow mite and semilooper incidence.

Perusal of table 3 reveals that, significantly lower yellow mite incidence (no./sq. cm) was recorded in OIN-133, OIN-30, OIN- 138, OIN-77, OIN-104, OIN-15, OIN-06 and OIN-108. Significantly higher yellow mite incidence (no./sq. cm) was noticed in OIN-49, OIN-22, OIN-60, OIN-74, OIN-03, OIN-01 and OIN-156. Comparatively lower percentage of semilooper damage was recorded in OIN-25, OIN-38, OIN-09, OIN-116 OIN-03 and OIN-49. Comparatively higher percentage of semilooper damage was found in OIN-1123, OIN-138, OIN-145, OIN-647, OIN-128, OIN-130, OIN-63, OIN-112 and OIN-133. Gotyal *et al*. (2014) also reported that the jute germplasms CIN-153, CIJ-42, CIJ-12, CIN-163, CIN-01 and CEX-17 were relatively less susceptible against semilooper infestation which varied from 1.3 % to 13.6 %. Likewise, relatively less susceptible jute germplasms against yellow mite were Padma, NDC-2005-2, CIN-22, CIN-211 and NDC-2005-5. Among the 75 germplasm accessions along with the 2 checks (JRO-524 and JRO-204), the most susceptible germplasm against stem rot was found to be OIN-108 (3.56), which was followed by JRO-524 (3.55), OIN-48 (3.49), OIN-1041 (3.46), OIN-65 (3.45) and OIN-84 (3.38). The lesser suseptible accessions were OIN-06 (2.32) which was followed by OIN-15 (2.37), OIN-03 (2.44), OIN-17 (2.46), OIN-01 (2.47), OIN-617 (2.54), OIN-559 (2.55) and OEX-09 (2.56). Meena *et al*. (2015), reported that four germplasms namely OIN-853, OIN-125, OIN-154 and OIN-651 were found moderately resistant against the stem rot disease whereas, OIN-270 and OIN-932 were found to be moderately susceptible and OEX-27, OIN-467, OEX-15, OIJ-150, OIJ-52, JR0-524 and OIN-110 were found to be susceptible to stem rot. Root rot incidence was more in OIN-1123 (3.59), OIN-06 (3.18) and OIN-49 (2.70) and the less susceptible germplasm accessions against root rot of jute were OIN-93 (1.57), OIN-86 (1.71), OIN-25 (1.89) and OIN-60 (1.98).

The D^2-analysis revealed that the 75 tossa jute germplasm accessions along with two checks (JRO-524 and JRO-204) were distributed in 12 clusters (table 4). A similar of clustering of tossa jute germplasm was observed by Roy *et. al.* (2011) and Roy *et. al.* (2015), in tossa jute genotypes. Cluster-XII had the highest number of genotypes (40) followed by cluster-III (10) and cluster-I (9). The remaining nine clusters had two genotypes each. The average intra and inter cluster D^2 values are presented in table 5. The highest inter-cluster D^2 value was found between cluster-III and IV (33.993) followed by cluster-III and cluster-XI (33.898) and cluster-I and cluster-XII (33.417), which revealed that the genotypes in these clusters were divergent and could be used in a hybridization programme. The highest intra-cluster distance was found in cluster-I (35.903) followed by cluster-III (28.944) and cluster-XII (27.450), which indicated that the genotypes in these clusters were divergent and could be used for hybridization. The maximum contribution to divergence was exhibited by the character fibre yield (45.762%), followed by semilooper incidence (23.548%), root rot incidence (10.663%) and stem rot incidence (9.296%). Cluster-XI exhibited the highest mean fibre yield (16.350 g/plant), followed by cluster-X (15.557 g/plant) and cluster VI (15.202 g/plant). Cluster-XI which was the highest fibre yielding cluster was less affected by yellow mite, stem rot and root rot as evidenced by its low mean value for these factors in comparison to the population mean. However, cluster-XI was more affected by semilooper due to its higher incidence as compared to the population mean but it did not affect its fibre yield considerably, since it was still the highest fibre yielder. For selection of divergent clusters, preference would have to be given to fibre yield as it is the highest contributor (45.762%) towards divergence followed by semilooper incidence (23.548%) and root rot incidence (10.663%). Except fibre yield (g/plant), the contribution to divergence of the four biotic factors namely incidence of yellow mite, semilooper, stem rot and root rot, was higher than that of the fibre yield components namely plant height, basal diameter and green weight.

The phenotypic coefficient of variation (PCV) was found to be greater than the genotypic coefficient of variation (GCV) in case of all the characters (table 7). The GCV and PCV were found to differ significantly for all the fibre yield components and biotic stress factors, which indicated a major role played by the environment in the expression of these characters. This is in agreement with the findings of Sawarkar *et. al.* (2014). The heritability and genetic advance (% of mean) were also found to be very low for all the traits except incidence of yellow mite and semilooper. This is contradictory to the findings of Roy *et al.* (2015) who reported that higher heritability and genetic advance for fibre yield components. This was perhaps due to the greater interaction of the environment with the genotypes under present study. The effect of the environment on the different traits has already been illustrated earlier in table 2, where the years (environments) were found to differ significantly for all the traits except root rot and fibre yield. The interaction of the year (environment) with the genotypes i.e., year × genotypes component of the sources of variation was found to differ significantly for all the traits. This significant interaction of the year (environment) with the genotypes has been truly reflected by greater difference between GCV and PCV and lower value of heritability and GA (% of mean).

The observations from the genotypic association between the different traits showed that the fibre yield was positively associated with plant height, green weight and incidence of yellow mite and semilooper (table 8), which is in accordance with the findings of Islam *et al.* (2001) and Satyanarayana *et al*. (2015) for fibre yield components in white jute (*Corchorus capsularis* L.) and roselle (*Hibiscus sabdariffa* L.). Negative association of fibre yield was found to be with that of basal diameter and incidence of stem rot and root rot. Among the biotic factors, incidence of stem rot and root rot were found to decrease fibre yield significantly, with increase in their incidence level, as depicted by their significant negative association with fibre yield.

The maximum direct effect on fibre yield was exhibited by plant height and closely followed by green weight. Islam *et. al.* (2004) and Pervin and Haque (2012) also reported similar findings in white jute (*Corchorus capsularis* L.) and tossa jute (*Corchorus olitorius* L.), respectively. Hence direct selection for these two traits would significantly increase the fibre yield in the present tossa jute germplasm (table 9). The direct effect of three biotic stress factors namely incidence of yellow mite, semilooper and root rot were found to be negative, which further indicated that any increase in their incidence level would decrease the yield. Inspite of positive association with fibre yield, the incidence of yellow mite and semilooper had negative direct effects which were compensated by their indirect effect on fibre yield via plant height. This is to say that the plant height had nullified the negative effects of the incidence of yellow mite and semilooper. On the other hand the incidence of stem rot and root rot had negative association with fibre yield and low direct effects on fibre yield with the stem rot incidence having a negligible positive direct effect (0.116) and the root rot incidence having a negative direct effect on fibre yield (-0.095). It was the negative association of the stem rot and root rot incidence with plant height which was the deciding factor in reducing the fibre yield drastically. It is evident from the present study that any of the biotic factors attacking the main stem in tossa jute causes the maximum loss in fibre yield as the main stem is the deciding factor for plant height.

The tossa jute genotypes were ranked among themselves within their group formed as per tolerance to the four different biotic stress factors (table 10). In ranking within the group, the genotypes whose fibre yield did not differ significantly from the highest fibre yielding genotype OIN-142 (17.15g/plant) and their higher tolerance to the respective biotic stress factor, were selected and ranked from one onwards. The highest average rank was exhibited by the genotype OIN-133 (1.0) on the basis of tolerance to yellow mite incidence and fibre yield, which was followed equally by two other genotypes OIN-30 (2.5) and OIN-06 (2.5). In case of tolerance to stem rot incidence and fibre yield, OIN-06 (2.5) ranked the first followed by six other genotypes OIN-17 (3.0), OIN-01 (3.0), OIN-03 (4.0), OIN-15 (4.5), OEX-09 (5.0) and OIN-559 (6.0). However, among these seven genotypes showing tolerance towards stem rot incidence, only four genotypes namely OIN-06, OIN-17, OIN-03 and OIN-15 belonged to the divergent cluster-I and the remaining three genotypes OIN-01, OEX-09 and OIN-559 did not belong to any of the divergent clusters and hence their inclusion in the list of parents for hybridization is not recommended as it won't be fruitful because promising segregates for higher fibre yield and tolerance to stem rot incidence cannot be obtained by using them. With respect to root rot incidence and fibre yield three genotypes namely OIN-93 (2.0), OIN-86 (2.0) and OIN-25 (2.0) had the same average rank. All these genoytpes were distributed in distinct divergent clusters.

The distribution of the tossa jute germplasm accessions exhibiting higher fibre yield along with tolerance to the different biotic stress factors in the three goups of divergent clusters are presented in table 11. In the first group of divergent clusters consisting of cluster-I and XII, five genotypes having higher average rank namely OIN-03, OIN-06, OIN-09, OIN-15 and OIN-17 belonged to cluster-I and three genotypes namely OIN-86, OIN-93 and OIN-133 belonged to cluster-XII. Among these eight genotypes distributed in cluster-I and XII, only three genotypes had higher tolerance to stem rot namely OIN-06, OIN-15 and OIN-17 and two genotypes namely OIN-86 and OIN-93 had higher tolerance to root rot. In the second group of divergent clusters consisting of cluster-III and IV, only two biotic stress factor tolerant genotypes namely OIN-25 and OIN-30 belonged to cluster-III whereas, cluster-IV had no such high ranking genotype. In the third group of divergent clusters consisting of cluster-III and XI, only two genotypes namely OIN-25 and OIN-30 belonged to cluster-III and cluster-XI had no high ranking genotypes. As evident from the character association analysis (table 8) and the direct and indirect effects (table 9), among the four biotic stress factors, only two i.e. stem rot and root rot had negative association with fibre yield due to which the fibre yield of the susceptible genotypes were drastically reduced and hence in the present study of the tossa jute germplasm, emphasis is to be laid on tolerance to stem rot and root rot incidence in combination with higher fibre yield. In this regard, although the divergence of cluster-III and IV is the highest but cluster-IV has no promising genotype, so this group of divergent clusters are not taken into consideration and not recommended for selection of genotypes for a hybridization programme. At the same time the other highly divergent cluster-III and XI also cannot be considered as cluster-XI has no promising genotype (table 11). So the only option for source of suitable genetically divergent parents for hybridization in the tossa jute germplasm under study, is cluster-I and XII. From cluster-I three genotypes, namely OIN-06, OIN-15 and OIN-17 and cluster-XII two genotypes, namely OIN-86 and OIN-93 can be selected as parents for successful hybridization programme to realize high fibre yielding genotypes along with higher tolerance to the biotic stress factors,.

Hence it can be concluded that in the tossa jute germplasm under study, emphasis may be laid on the characters plant height and green weight for direct increase in fibre yield. On screening of the germplasm accessions by giving proper weightage to tolerance to biotic stress factors, higher fibre yield and genetic divergence, the genotypes OIN-06, OIN-15 and OIN-17 in cluster-I and the genotypes OIN-86 and OIN-93 in cluster-XII, may be used in a hybridization programme, to enhance fibre yield along with tolerance to the two major biotic stress factors of tossa jute namely stem rot and root rot.

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Table 1. Details of weather parameters during tossa jute (*C. olitorius* L.) germplasm growth period in 2013 and 2014

Months	Temperature (°C)				Relative Humidity (%)				Total Rainfall (mm)	
	2013		2014		2013		2014		2013	2014
	Max	Min	Max	Min	Max	Min	Max	Min		
March	30.27	16.72	30.70	15.50	98.87	41.87	66.00	53.00	0.00	19.20
April	30.33	20.15	34.80	18.80	96.03	53.57	53.00	46.00	122.50	9.80
May	30.44	23.08	32.10	22.60	98.84	70.81	78.00	72.00	251.00	312.00
June	32.30	25.38	32.50	24.90	99.00	74.33	89.00	82.00	404.00	604.30
July	31.74	25.86	33.40	26.00	99.00	77.16	84.00	79.00	757.50	297.30
August	32.02	25.32	31.60	25.40	99.00	75.74	89.00	86.00	343.05	451.30
September	31.81	24.61	31.60	24.30	99.00	75.00	90.00	86.00	404.00	380.40

Table 2. ANOVA for fibre yield components, insect pest and disease incidence in tossa jute (*C. olitorius*) germplasm combined over two years (2013 and 2014)

Sources of variation	df	Mean Sum of Squares							
		Plant height (cm)	Basal diameter (cm)	Green weight (g/plant)	Yellow Mite incidence (no./sq.cm area)	Semilooper incidence (%)	Stem rot (PDI)	Root Rot incidence (%)	Fibre yield (g/plant)
Year	1	5153.15*	1.78*	212099.57*	3564.46**	252.96**	138.79**	0.07	9.41
Error	4	660.51	0.18	13748.81	8.36	0.25	2.89	3.69	22.75
Genotypes	76	967.12*	0.04	4223.75	75.57**	0.60**	0.55**	0.90	16.02*
Year × Genotypes	76	1138.44**	0.06*	5151.86*	86.45**	0.61**	0.60**	1.58**	19.50**
Error	304	714.01	0.04	3719.46	7.17	0.15	0.28	0.80	11.86

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

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Table 3. Mean performance of the 75 tossa jute germplasm accessions along with two checks, over two years 2013-14

S. No.	Germplasm Accession	Plant height (cm)	Basal diameter (cm)	Green weight (g/plant)	Yellow Mite incidence (no./sq.cm area)	Semi looper incidence (%)	Stem rot (PDI)	Root Rot incidence (%)	Fibre yield (g/plant)
1	OIN-01	311.50	1.65	240.41	16.35	3.41	2.48	2.28	15.86
2	OIN-03	303.23	1.48	221.48	16.63	2.81	2.44	2.26	14.80
3	OIN-06	291.00	1.49	235.23	5.29	3.23	2.32	3.18	15.02
4	OIN-09	317.23	1.50	267.98	6.56	2.73	2.75	2.92	15.27
5	OIN-15	301.70	1.39	200.11	5.27	3.01	2.38	2.17	12.43
6	OIN-17	316.60	1.49	249.71	5.95	3.30	2.46	2.53	15.69
7	OIN-18	318.88	1.68	245.44	8.00	3.31	2.84	2.55	14.60
8	OIN-22	303.20	1.53	246.78	19.37	3.11	2.99	2.23	13.42
9	OIN-25	281.03	1.45	226.81	8.93	2.59	2.57	1.89	15.22
10	OIN-30	304.78	1.48	235.03	4.65	3.36	3.09	2.41	14.24
11	OIN-32	304.82	1.55	223.85	5.56	3.34	3.30	2.90	13.77
12	OIN-38	284.88	1.33	169.23	6.03	2.68	3.19	3.14	10.63
13	OIN-40	296.48	1.46	168.46	6.75	2.99	2.78	2.84	11.72
14	OIN-41	312.00	1.44	228.48	8.63	2.91	3.06	2.62	14.17
15	OIN-48	285.68	1.41	207.89	5.67	2.96	3.49	2.84	10.64
16	OIN-49	294.47	1.50	190.38	19.61	2.87	3.05	2.71	12.14
17	OIN-52	295.15	1.45	214.91	9.73	3.01	3.24	2.17	14.02
18	OIN-59	294.50	1.48	217.62	6.55	3.13	2.59	2.10	13.73
19	OIN-60	293.67	1.38	170.74	17.86	3.28	2.81	1.99	10.18
20	OIN-62	271.96	1.36	153.21	7.52	3.01	3.00	2.09	9.79
21	OIN-63	288.89	1.38	201.66	6.29	3.72	3.22	2.58	12.61
22	OIN-65	300.07	1.41	178.46	7.21	3.37	3.45	2.65	12.19
23	OIN-68	303.73	1.45	228.74	8.07	3.45	2.66	2.45	14.86
24	OIN-69	300.03	1.45	199.99	9.23	3.24	2.69	2.11	13.10
25	OIN-71	317.38	1.64	211.87	5.87	3.46	2.72	2.39	11.19
26	OIN-72	310.83	1.50	222.06	5.97	3.46	2.56	2.50	13.59
27	OIN-73	311.30	1.40	220.98	6.57	3.19	2.97	1.84	13.07
28	OIN-74	322.33	1.48	221.88	16.78	3.45	3.05	1.87	14.84
29	OIN-76	300.53	1.58	254.28	6.77	3.54	3.11	2.42	12.67
30	OIN-77	290.65	1.59	236.60	5.01	2.94	2.77	2.55	17.98
31	OIN-83	304.22	1.32	204.44	7.73	3.17	3.26	2.47	14.05
32	OIN-84	306.63	1.55	221.45	8.48	3.43	3.38	2.03	14.98
33	OIN-86	292.77	1.43	212.47	6.72	3.41	2.92	1.71	14.05
34	OIN-93	290.03	1.45	206.20	9.19	2.74	3.13	1.57	13.61
35	OIN-94	289.13	1.65	207.16	8.55	3.23	2.60	2.87	12.02
36	OIN-104	290.42	1.59	201.73	5.21	3.44	2.71	2.11	12.49
37	OIN-108	284.23	1.48	201.61	5.31	3.13	3.56	2.60	13.10
38	OIN-111	288.27	1.62	220.26	6.38	2.83	2.49	2.76	12.38
39	OIN-112	301.38	1.68	193.71	9.53	3.73	2.78	2.80	12.26

40	OIN-113	297.88	1.54	231.40	6.49	3.29	2.85	2.38	12.29
41	OIN-116	261.88	1.45	224.06	6.30	2.78	3.36	2.91	11.93
42	OIN-128	301.93	1.41	200.41	6.38	3.76	2.62	1.80	12.57
43	OIN-130	311.60	1.46	234.73	7.04	3.75	2.67	1.86	14.17
44	OIN-133	312.93	1.50	224.04	4.41	3.78	2.67	1.83	15.79
45	OIN-134	288.23	1.40	210.16	8.02	2.97	3.32	2.83	12.50
46	OIN-136	287.95	1.44	221.74	8.12	3.10	2.95	2.23	13.69
47	OIN-138	277.73	1.41	189.32	4.92	3.88	2.68	2.46	10.51
48	OIN-141	288.73	1.48	253.02	6.12	3.51	2.84	2.32	15.55
49	OIN-142	304.25	1.61	256.50	6.94	3.62	2.71	2.30	17.15
50	OIN-145	303.73	1.51	241.00	5.95	3.87	2.87	2.29	14.02
51	OIN-147	302.43	1.42	235.42	8.84	3.56	3.03	2.43	13.75
52	OIN-148	312.63	1.46	229.50	7.22	3.66	2.80	2.55	13.21
53	OIN-156	305.13	1.47	232.34	16.33	3.54	3.11	2.37	15.01
54	OIN-421	325.47	1.50	243.56	6.81	3.62	2.62	2.38	14.63
55	OIN-471	313.90	1.54	222.71	8.34	3.48	3.01	2.88	12.33
56	OIN-490	309.42	1.48	248.56	5.93	3.05	3.22	3.15	13.54
57	OIN-508	284.53	1.46	182.83	6.32	3.06	3.35	2.68	12.37
58	OIN-559	313.03	1.49	241.62	5.51	3.46	2.56	2.00	13.63
59	OIN-617	310.40	1.38	195.55	14.75	3.49	2.55	2.47	13.19
60	OIN-647	310.13	1.58	260.87	8.61	3.76	3.19	2.36	16.94
61	OIN-656	305.80	1.49	296.25	14.77	3.44	3.11	2.21	14.38
62	OIN-1041	304.87	1.47	243.39	7.08	3.54	3.46	2.66	12.79
63	OIN-1123	291.57	1.44	206.83	8.30	4.20	2.89	3.59	10.70
64	OIJ-63	326.70	1.50	226.37	7.61	3.56	3.19	2.31	14.03
65	OIJ-88	316.27	1.46	243.11	14.70	3.46	2.82	2.19	15.35
66	OIJ-211	322.60	1.47	258.80	6.93	3.32	2.58	1.87	15.99
67	OIJ-226	309.53	1.50	262.53	6.40	3.43	3.15	2.53	15.36
68	OIJ-241	311.07	1.58	276.43	6.67	3.43	3.15	2.99	15.04
69	OIJ-276	312.20	1.47	208.99	8.70	3.12	3.07	2.57	13.99
70	OIJ-278	296.43	1.43	197.68	8.80	3.24	3.03	1.91	14.13
71	OIJ-296	317.10	1.55	214.74	8.84	3.02	2.94	2.41	14.27
72	OEX-05	309.33	1.45	206.13	7.00	3.64	2.81	2.15	13.61
73	OEX-09	317.13	1.56	252.01	6.45	3.16	2.57	1.81	15.12
74	OEX-13	302.77	1.43	201.64	7.95	3.14	3.10	2.42	12.95
75	OEX-29	295.50	1.48	186.77	8.65	3.19	3.00	2.67	11.52
76	JRO-524 +	302.67	1.44	198.15	6.94	3.41	3.55	2.78	12.43
77	JRO-204 +	316.57	1.49	190.85	8.92	3.23	2.87	2.38	12.78
	Mean	302.05	1.49	221.14	8.31	3.31	2.92	2.42	13.58
	CV (%)	8.85	13.64	27.58	32.23	11.73	17.93	36.93	25.36
	Sem (±)	10.91	0.08	24.90	1.09	0.16	0.21	0.36	1.41
	CD (P=0.05)	30.36	-	-	3.04	0.44	0.60	-	3.91

+ Check Variety

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Table 4. Distribution of 77 tossa jute germplasm accessions in different clusters (pooled over 2 years)

Cluster No.	Total no. of germplasm accessions	Source	Name of germplasm accessions
I	9	ICAR-CRIJAF, Barrackpore, Kolkata, West Bengal	OIN-01, OIN-03, OIN-06, OIN-09, OIN-15, OIN-17, OIN-18, OIN-65 and JRO-524
II	2	-do-	OIN-148 and OIN-421
III	10	-do-	OIN-22, OIN-25, OIN-30, OIN-32, OIN-38, OIN-40, OIN-41, OIN-48, OIJ-276 and OIJ-296
IV	2	-do-	OIN-130 and OEX-05
V	2	-do-	OIN-136 and OEX-13
VI	2	-do-	OIJ-226 and OIJ-241
VII	2	-do-	OIN-69 and JRO-204
VIII	2	-do-	OIN-72 and OIN-559
IX	2	-do-	OIN-68 and OIN-147
X	2	-do-	OIJ-211 and OEX-09
XI	2	-do-	OIN-141 and OIN-142
XII	40	-do-	OIN-49, OIN-52, OIN-59, OIN-60, OIN-62, OIN-63, OIN-71, OIN-73, OIN-74, OIN-76, OIN-77, OIN-83, OIN-84, OIN-86, OIN-93, OIN-94, OIN-104, OIN-108, OIN-111, OIN-112, OIN-113, OIN-116, OIN-128, OIN-133, OIN-134, OIN-138, OIN-145, OIN-156, OIN-471, OIN-490, OIN-508, OIN-617, OIN-647, OIN-656, OIN-1041, OIN-1123, OIJ-63, OIJ-88, OIJ-278 and OEX-29

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Table 5. Average intra (diagonal) and inter-cluster (off-diagonal) D^2 values of 77 tossa jute germplasm accessions

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
I	**35.90**	28.76	30.87	31.06	18.26	27.66	17.59	28.91	20.88	21.69	30.43	33.42
II		**0.75**	32.35	1.66	14.65	4.33	14.16	2.26	4.74	5.53	4.48	24.42
III			**28.94**	33.99	14.19	28.39	15.44	31.15	22.13	22.30	33.90	31.57
IV				**1.12**	15.05	6.06	14.86	3.09	5.44	6.20	4.02	24.77
V					**1.19**	11.35	2.55	13.68	6.01	6.48	15.18	17.02
VI						**1.22**	15.15	7.12	4.51	7.36	4.21	22.57
VII							**1.31**	13.43	6.78	6.32	17.41	17.91
VIII								**1.33**	7.32	4.85	6.68	24.97
IX									**1.98**	4.45	5.03	18.10
X										**2.02**	8.50	20.15
XI											**2.29**	24.88
XII												**27.450**

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Table 6. Cluster means for eight characters of tossa jute germplasm accessions

Cluster	Plant height (cm)	Basal diameter (cm)	Green weight (g/plant)	Yellow Mite incidence (no./sq.cm area)	Semilooper incidence (%)	Stem rot (PDI)	Root Rot incidence (%)	Fibre yield (g/plant)
I	306.99	1.50	226.33	8.69	3.18	2.74	2.59	14.26
II	319.05	1.48	236.53	7.01	3.64	2.71	2.47	13.92
III	300.22	1.47	213.03	8.31	3.01	3.05	2.59	13.21
IV	310.47	1.46	220.43	7.02	3.69	2.74	2.01	13.89
V	295.36	1.44	216.19	8.04	3.12	3.03	2.33	13.32
VI	310.30	1.54	269.48	6.54	3.43	3.15	2.76	15.20
VII	308.30	1.47	195.42	9.07	3.24	2.78	2.24	12.94
VIII	311.93	1.50	231.84	5.74	3.46	2.56	2.25	13.61
IX	303.08	1.44	232.08	8.46	3.51	2.85	2.44	14.31
X	319.87	1.52	255.41	6.69	3.24	2.57	1.84	15.56
XI	296.49	1.55	254.76	6.53	3.57	2.77	2.31	16.35
XII	298.57	1.49	215.90	8.71	3.35	2.99	2.39	13.18
Population Mean	302.05	1.49	221.14	8.31	3.31	2.92	2.42	13.58
Percent Contribution	0.85	1.23	1.40	7.25	23.55	9.30	10.66	45.76

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Table 7. Genetic parameters for the different characters of 77 genotypes of tossa jute

Characters	Mean	Range	GCV	PCV	Heritability (Broad Sense)	GA as percentage of Mean
Plant height (cm)	302.05	212.50 - 379.00	1.86	6.79	0.08	1.05
Basal diameter (cm)	1.49	0.90 - 2.52	2.37	9.58	0.06	1.21
Green weight (g/plant)	221.14	58.40 - 444.96	5.09	19.49	0.07	2.74
Yellow Mite incidence (no./sq.cm area)	8.31	1.85 - 50.94	40.54	46.74	0.75	72.45
Semilooper incidence (%)	3.31	1.37 - 6.00	8.37	11.61	0.52	12.44
Stem rot (PDI)	2.92	0.71 - 4.65	7.67	14.19	0.29	8.54
Root Rot incidence (%)	2.42	0.71 - 4.88	6.72	26.13	0.07	3.56
Fibre yield (g/plant)	13.58	4.00 - 24.90	4.65	19.77	0.06	2.25

Table 8. Genotypic correlation between fibre yield components, insect pest and disease incidence in tossa jute

Characters	Basal diameter (cm)	Green weight (g/plant)	Yellow Mite incidence (no./sq.cm area)	Semilooper incidence (%)	Stem rot (PDI)	Root Rot incidence (%)	Fibre yield (g/plant)
Plant height (cm)	-0.29*	0.93*	0.36*	0.99*	-0.51*	-0.86*	0.93*
Basal diameter (cm)		-0.08	0.09	0.66*	-0.54*	0.88*	-0.74*
Green weight (g/plant)			0.12	0.84*	0.10*	0.60*	1.00*
Yellow Mite incidence (no./sq.cm area)				-0.24*	-0.05	-0.40*	0.51*
Semilooper incidence (%)					-0.13	-0.15	0.93*
Stem rot (PDI)						0.08	-0.26*
Root Rot incidence (%)							-0.67*

* Significant at 5% probability level

Table 9. Direct (diagonal) and indirect (off-diagonal) effects of different yield components and biotic factors on fibre yield in tossa jute

Characters	Plant height (cm)	Basal diameter (cm)	Green weight (g/plant)	Yellow Mite incidence (no./sq.cm area)	Semilooper incidence (%)	Stem rot (PDI)	Root Rot incidence (%)	Correlation with Fibre yield (g/plant)
Plant height (cm)	**0.77**	0.03	0.65	-0.03	-0.50	-0.06	0.08	0.93*
Basal diameter (cm)	-0.31	**0.10**	-0.04	-0.01	-0.34	-0.06	-0.08	-0.74*
Green weight (g/plant)	0.97	0.01	**0.51**	-0.01	-0.43	0.01	-0.06	1.00*
Yellow Mite incidence (no./sq.cm area)	0.39	-0.01	0.06	**-0.08**	0.12	-0.01	0.04	0.51*
Semilooper incidence (%)	1.06	-0.07	0.43	0.02	**-0.51**	-0.02	0.01	0.93*
Stem rot (PDI)	-0.54	0.05	0.05	0.00	0.07	**0.12**	-0.01	-0.30*
Root Rot incidence (%)	-0.91	-0.09	0.31	0.03	0.08	0.01	**-0.10**	-0.67*

* Significant at 5% probability level, Residual Effect = 0.78

Table 10. Ranking of tossa jute germplasm accessions on the basis of their tolerance to biotic stress components and fibre yield and their distribution in different clusters

Germplasm Accession	Fibre yield (g/plant)	Ranking according to tolerance to the biotic stress component	Ranking according to fibre yield (g/plant)	Average Rank on the basis of tolerance to biotic stress factors and fibre yield	Distribution in different divergent clusters
Yellow Mite incidence (no./sq.cm area)					
OIN-133	15.79	1	1	1.0	Cluster-XII
OIN-30	14.24	2	3	2.5	Cluster-III
OIN-06	15.02	3	2	2.5	Cluster-I
Semi looper incidence (%)					
OIN-25	15.22	1	2	1.5	Cluster-III
OIN-09	15.27	2	1	1.5	Cluster-I
OIN-03	14.80	3	3	3.0	Cluster-I
Stem rot (PDI)					
OIN-06	15.02	1	4	2.5	Cluster-I
OIN-15	12.43	2	7	4.5	Cluster-I
OIN-03	14.80	3	5	4.0	Cluster-I
OIN-17	15.69	4	2	3.0	Cluster-I
OIN-01	15.86	5	1	3.0	-
OIN-559	13.63	6	6	6.0	-
OEX-09	15.12	7	3	5.0	-
Root Rot incidence (%)					
OIN-93	13.61	1	3	2.0	Cluster-XII
OIN-86	14.05	2	2	2.0	Cluster-XII
OIN-25	15.22	3	1	2.0	-

Table 11. Distribution of tossa jute germplasm accessions exhibiting higher fibre yield along with tolerance to biotic stress components, in three different groups of divergent clusters

Group	Clusters	Genotypes present in the cluster
1	I	OIN-03, OIN-06, OIN-09, OIN-15 and OIN-17
	XII	OIN-86, OIN-93 and OIN-133
2	III	OIN-25 and OIN-30
	IV	Nil
3	III	OIN-25 and OIN-30
	XI	Nil

The groups 1, 2 and 3 have been formed according to the genetic divergence of the clusters