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Comparative Evaluation of Genetic Variability and Trait Associations for Fibre Yield and Quality Attributes in Two Cultivated Jute Species (*Corchorus* spp.)

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Abstract

The present investigation was conducted during the summer season of 2017–18 at the Teaching Farm, Bidhan Chandra Krishi Viswavidyalaya, Mondouri, West Bengal, to evaluate thirty jute genotypes (15 white and 15 tossa) for yield and fibre quality traits. Significant genetic variability was observed among the genotypes for all traits studied. Tossa jute generally exhibited higher values for plant height, green biomass, and fibre yield, while white jute showed superior fibre fineness. PCV values were slightly higher than GCV, indicating limited environmental influence. High heritability coupled with moderate to high genetic advance for all traits suggested the predominance of additive gene effects. Positive correlations were observed between fibre yield and traits such as plant height, green weight, fibre percentage, and basal diameter. Path coefficient analysis revealed that green biomass and fibre percentage had the highest direct contribution to fibre yield in both species. Genotypes JRC 517 and BCCO 6 were identified as promising for fibre strength, while CIN 94 and OIN 105 showed superior fibre fineness. These genotypes may serve as potential parents for the simultaneous improvement of yield and fibre quality in jute breeding programs.

Keywords: Yield, variability, gene action, quality, heritability, fibre traits

1. Introduction

Jute (*Corchorus spp*., 2n =14) stands as a major natural fibre crop worldwide, second only to cotton in global production, utilization, and accessibility. In India, the state of West Bengal plays a dominant role, contributing about 74.5% of the total cultivated area and 78.33% of the country's jute output in 2016–17 (IJMA, 2016-17). Jute (*Corchorus* spp.) is an annual fibrous crop of the *Corchorus* genus in the Malvaceae family, earlier classified in the Tiliaceae family or Spermanniaceae family (Heywood et al., 2007). Despite there being 50–60 species under the genus *Corchorus*, only two are cultivated, namely *Corchorus capsularis* L., or white jute, and *Corchorus olitorius* L., or tossa jute. These two species are extensively grown across tropical and subtropical regions worldwide, with major cultivation occurring in Asia, Latin America, and Africa (Hossain et al., 2002; Roy et al., 2018). Among this, only white jute (*C. capsularis*) and dark jute (*C. olitorius*) are commercially cultivated diploid (2n=2x=14) crops traditionally used to make coarse cloth, burlap, rope, and paper. Currently, it is primarily cultivated in Asia, Africa, Eastern Europe, and the Americas. For fibre extraction, the bast or stems need to undergo retting, which affects their quality and is influenced by both genetic and environmental factors. Analyzing the interrelationships among traits and conducting path analysis helps to understand how different traits are associated, breaking down their influence into direct and indirect effects, and revealing the relative contribution of each factor to yield (Pervin and Haque, 2012). Although a good number of research works on yield are available (Islam et al., 2001; Alam et al., 2011), but the quality part remains to be addressed. In comparison to their wild cousins, the two cultivated jute species have about 70% of neutral genetic diversity (Kundu et al., 2012). While Corchorus capsularis self-pollinates, Corchorus olitorius frequently uses cross-pollination. Additionally, their genome sizes are different; C. capsularis has a 336 Mb genome while C. olitorius has a 361 Mb genome (Zhang et al., 2019). Roy et al. (2023) conducted a study to determine the fibre yield and quality of 52 tossa jute genotypes. Variance analysis showed that the 52 genotypes differed in their traits. The diversity analysis further revealed the existence of four distinct clusters, with the genetic distance between clusters being greater than the distance within clusters. The extent of the phenotypic coefficient of variation (PCV) was marginally greater than the genotypic coefficient of variation (GCV) when all characteristics were considered. Notably, high heritability and genetic gain were documented for green weight and fibre yield, suggesting that direct selection of these characters could lead to significant improvement. With these considerations, the current study was conducted to gain a better understanding of the nature and extent of genetic variability, as well as the genotypic and phenotypic correlations between yield and its contributing traits, with a special focus on quality parameters. Ghosh et al. (2013) discovered a notable positive relationship between fibre yield and several variables, including days to 50% flowering, plant height at average flowering, plant base diameter, and fresh weight, in tossa and white jute genotypes. In their study, Guo et al. (1994) made several observations regarding the characteristics of different cultivars of *Corchorus capsularis* and *C. olitorius*, including some of the morphological traits having strong correlation with fibre quality Additionally, they discovered that fiber fineness improved when sowing was delayed to the end of May and also the researchers determined that the amount of fertilizer applied and the age at which the plants were harvested influenced fiber fineness.

2. Materials and Methods

A field experiment was carried out in the summer season, March- September of 2017–18 at the Teaching Farm of Bidhan Chandra Krishi Viswavidyalaya, located in Mondouri, Nadia, West Bengal, India (22.87° N latitude, 88.59° E longitude; elevation 9.75 meters above sea level). The experimental site had well-drained sandy loam soil with a neutral pH of 6.9. A Randomised Complete Block Design (RCBD) with three replications was used to grow a total of 30 jute genotypes, 15 of which were white and 15 of which were tossa kinds, acquired from the All India Network Project on Jute & Allied Fibres (AINPJAF). Row spacing was set at 30 cm, and plant spacing was set at 6–7 cm.

Data were collected from five randomly chosen plants from the central rows of each plot, with emphasis on five major yield-contributing traits: plant height (cm), green biomass plant^{-1} (g), basal diameter (cm), dry fibre yield plant^{-1} (g), and fibre content percentage at harvest (120 days post-sowing). During the period of cultivation, limited genetic improvement work pertaining on combining the best traits of both species *viz.,* tossa jute and white jute has been done owing majorly to their sexual incompatibility and this leads to a restricted genetic pool which necessitates a robust breeding strategy for improvement of jute yield and fibre quality.

Fibre quality was assessed based on fineness and tensile strength, following standardized protocols outlined by Kumar et al. (2011). Before statistical analysis, fibre% data were transformed into angular (arcsine) values. Variability among the 30 jute genotypes for each trait was analyzed using MS Excel and OPSTAT online software. Heritability and estimates of the genotypic and phenotypic coefficients of variation (PCV and GCV) were calculated using Singh and Chaudhary's (1979) methodology. Genetic advance was calculated using the formula given by Allard (1960). Correlation coefficients were derived according to the procedures described by Johnson et al. (1955) and Al-Jibouri et al. (1958), while path analysis was performed as per the method proposed by Dewey and Lu (1959).

3. Results and Discussion

Although a slight difference in the sowing time exists but in this case, sowing of the two cultivated species was done simultaneously to avoid any environmental effects.

3.1. Morphological studies of yield-attributing traits

The ANOVA (Table 1) revealed highly significant differences among genotypes for all evaluated traits, indicating strong potential for genetic improvement through selection. The mean performance data (Tables 2 and 3) for various white and tossa jute genotypes likewise reflected considerable genetic variability among the entries.

Higher values for all the traits were observed in *C. olitorius* as expected. For plant height, the range observed in white jute was 176.23 cm (CIN 87) to 309.17 cm (JRC-698), whereas in tossa jute, it ranged from 237.65 cm (OIN 105) to 335.67 cm

Table 1: ANOVA of seven yield attributing and quality traits characters in white and tossa jute

Source of variation	df	Plant height (cm)	Basal diameter	Green weight	Fibre percent	Fibre fineness	Fibre strength	Dry fibre weight
White jute								
Replication	2	1928.37	0.730	1796.00	10.77	0.0009	0.0227	12.33
Genotype	14	3651.80**	0.892**	2556.36**	2.72**	0.043	31.35**	20.91**
Error	28	5.20	0.095	13.58	0.25	0.0011	0.45	0.29
Tossa jute								
Replication	2	3728.25	0.33	3551.50	3.88	0.053	5.03	58.63
Genotype	14	1990.80	0.027	3128.75	3.84	0.788	81.96	23.48
Error	28	8.73	0.0015	6.83	0.025	0.0062	1.15	0.173

Table 2: Mean performance of seven yield attributing and quality traits in 15 genotypes of White jute

Genotype	Plant height (cm)	Basal diameter (cm)	Green weight (g)	Fibre percent	Fibre Fineness (tex)	Fibre strength (tex g^{-1})	Dry fibre weight (g)
CIN-86	274.37	1.17	146.00	5.20	1.61	4.33	7.93
CIN-87	176.23	1.40	112.17	4.08	1.42	6.73	4.84
CIN-93	245.83	1.43	113.99	4.82	1.40	8.43	6.19
CIN-94	297.57	1.30	154.17	5.72	1.33	7.93	10.21
CIN-95	248.50	1.54	167.72	6.74	1.34	12.53	11.69
CIN-102	270.68	1.78	216.47	5.65	1.43	16.20	13.36
CIN-115	232.07	1.56	178.89	6.40	1.41	10.03	11.88
CIN-120	230.50	1.61	149.06	5.96	1.44	10.90	9.59
CIN-132	232.08	1.32	104.25	6.93	1.61	9.30	8.62
CIN-134	246.42	1.59	179.14	6.24	1.53	10.53	12.92
CIN-135	279.33	1.47	145.50	7.29	1.71	11.97	12.37
BCCC-1	254.42	1.55	136.39	6.36	1.51	8.97	9.38
BCCC-2	279.50	1.50	169.17	5.98	1.57	11.52	11.49
JRC-517	306.50	1.49	162.67	6.53	1.65	14.95	12.35
JRC-698 (Check)	309.17	1.53	156.50	7.81	1.64	14.93	13.58
Grand mean	258.87	1.48	152.80	6.11	1.50	10.61	10.42
SE	1.86	0.04	3.00	0.40	0.0272	0.55	0.44
CV	0.88	3.93	2.41	8.20	2.21	6.35	5.20

Table 3: Mean performance of seven yield attributing and quality traits in 15 genotypes of tossa jute

Genotype	Plant height (cm)	Basal diameter (cm)	Green weight (g)	Fibre percent	Fibre fineness (tex)	Fibre strength (tex g^{-1})	Dry fibre weight (g)
OIN-90	281.23	1.16	120.33	5.65	1.99	12.07	6.85
OIN-96	283.90	1.28	121.33	5.31	1.34	7.10	6.47
OIN-105	237.65	1.52	191.61	4.05	1.28	7.17	7.82
OIN-107	317.33	1.41	219.08	6.68	2.67	12.80	14.68
OIN-122	324.77	1.35	204.67	6.33	2.46	5.70	13.00
OIN-129	322.90	1.46	216.28	6.61	2.85	18.90	14.34
OIN-702×JRO-204	335.67	1.43	215.75	6.27	2.32	19.07	13.56
OIN-914×JRO-524	315.83	1.29	225.67	6.33	2.18	14.63	14.35
OIN-914×JRO-8432	326.67	1.23	182.33	7.26	2.92	17.77	13.30
OIN-217×OIN-580	330.17	1.31	156.33	8.77	2.64	17.20	13.78
JRO-128×JRO-878	317.33	1.34	176.00	7.91	2.74	17.93	13.95
JRO-524	324.00	1.34	181.17	6.87	2.59	20.77	12.52
JRO-204	332.33	1.42	194.00	7.02	2.61	19.86	13.67
JRO-8432	310.33	1.25	170.67	7.63	2.80	18.95	13.06
BCCO-6 (Check)	315.00	1.35	183.17	7.31	2.77	20.97	13.45
Grand mean	311.67	1.34	183.89	6.66	2.41	15.39	12.31
SE	2.41	0.032	2.13	0.131	0.064	0.875	0.340
CV	0.94	2.97	1.42	2.41	3.27	6.96	3.38

(BCCO 101). For basal diameter, the range observed in white jute was 1.17 cm (CIN 86) to 1.78 cm (CIN-102), whereas in tossa jute, it ranged from 1.16 cm (OIN 90) to 1.52 cm (OIN 105). Green weight plant^{-1} was more in the tossa jute genotype BCCO 102 (225.67 g) than in the white jute (216.47 g). Fibre yield is always higher in tossa jute an average mean is 12.31 g against 10.42 g in white jute. Similar was observed for fibre percentage, thus indicating better fibre recovery in tossa jute. However, fibre fineness is more than 1.50 tex observed in tossa jute against 2.41 tex observed in tossa jute. Higher values indicate greater coarseness of the fibre. Consistent with this, the present study identified the finest fibres in genotypes CIN-94 and CIN-95 (with tex values of 1.33 and 1.34, respectively). For tossa jute, the finest fibre was found in the genotype OIN-105 (1.28 tex). Regarding fibre strength, the highest value for white jute was recorded in genotype JRC-517 (14.95), while the strongest fibre in tossa jute was found in genotype BCCO-6 (20.97).

3.2. Genetic analysis of yield attributing traits

For white jute, the PCV varied from 8.22% for fibre fineness to 30.88% for fibre strength. In contrast, for tossa jute, the lowest PCV was recorded for plant height (8.30%), while the highest was observed for fibre strength (34.43%). Similarly, in white jute, GCV ranged from 7.92% for fibre fineness to 30.22% for fibre strength, while in tossa jute, it ranged from 6.93% for basal diameter to 33.72% for fibre strength (Table 4). For all traits studied, PCV exceeded GCV by a small margin, suggesting a modest impact of environmental factors on trait expression. These results align with earlier research on jute (Tejbir et al., 2009; Das et al., 2012). Additionally, the combination of high heritability and moderate to high genetic advance across all traits indicates that additive genetic effects predominantly govern their inheritance. These results align with earlier research on jute (Kumar et. al., 2005). Additionally, the combination of high heritability and moderate to high genetic advance across all traits indicates that additive genetic effects predominantly govern their inheritance. Therefore, selecting these traits would be effective in this population. Comparable findings were observed by Nayak and Baisakh (2007) and Senapati et al. (2006). Additionally, studies on fibre fineness have also been conducted in cotton by Meena et al. (2023) and Chowdhury et al. (2023).

Table 4: Genotypic variability parameters considering seven yield attributing and quality traits in white and tossa jute

Traits	Range		GCV %	PCV %	H^2 (BS)	GA	GA % of mean
	Max	Min					
White jute							
Plant height	309.17	176.23	13.47	13.50	99.60	71.67	27.68
Basal diameter	1.78	1.17	9.56	10.34	85.50	0.27	18.24
Green weight	216.47	104.25	19.05	19.20	98.40	59.50	38.93
Fibre percent	7.29	4.08	14.86	16.97	76.60	1.64	26.84
Fibre fineness	1.33	1.71	7.92	8.22	92.70	0.24	16.01
Fibre strength	14.95	4.33	30.22	30.88	95.80	6.47	60.98
Dry fibre weight	13.58	4.84	25.15	25.68	95.90	5.29	50.76
Tossa jute							
Plant Height	335.67	237.65	8.25	8.30	98.70	52.60	16.87
Basal diameter	1.52	1.16	6.93	7.55	84.40	0.18	13.43
Green weight	225.65	120.33	17.54	17.60	99.30	66.24	36.02
Fibre percent	8.77	4.05	16.93	17.10	98.00	2.30	34.53
Fibre fineness	2.92	1.28	21.19	21.44	97.70	1.04	43.1
Fibre strength	20.97	5.70	33.72	34.43	95.90	10.47	68.03
Dry fibre weight	14.68	6.47	22.63	22.88	97.80	5.68	46.14

Correlation studies (Table 5) represent a strong correlation of plant height, green weight, fibre % with fibre yield in both the sp. Fibre strength, which is a very important quality parameter, was positively correlated with basal diameter in white jute genotypes; however, for tossa jute, it was positively associated with fibre percent and higher values of fibre fineness (coarseness). The genotypic correlation coefficients were typically greater than the phenotypic ones, indicating a stronger underlying genetic association between the traits.

These observations align with earlier reports by Prakash et al. (2004), Senapati et al. (2006), Nayak and Baisakh (2008), and Kumar et al. (2011). Path coefficient analysis is

Table 5: Phenotypic (P) and genotypic (G) correlation among seven yield attributing and quality traits of white and jute

Characters		Basal diameter	Green weight	Fibre percent	Fibre fineness	Fibre strength	Dry fibre weight
White jute							
Plant height	G	-0.026	0.400	0.551*	0.432	0.57*	0.633*
	P	-0.027	0.400	0.468	0.412	0.445	0.618*
Basal diameter	G	1	0.673**	0.237	-0.168	0.767**	0.593*
	P	1	0.600*	0.232	-0.172	0.708**	0.535*
Green weight	G		1	0.240	-0.123	0.611*	0.806**
	P		1	0.184	-0.107	0.599*	0.777**
Fibre percent	G			1	0.550*	0.615*	0.772**
	P			1	0.427	0.521*	0.686**
Fibre fineness	G				1	0.204	0.291
	P				1	0.202	0.256
Fibre strength	G					1	0.805**
	P					1	0.760**
Tossa jute							
Plant height	G	-0.083	0.387	0.768**	0.820**	0.632*	0.826**
	P	-0.069	0.383	0.756**	0.798**	0.613*	0.813**
Basal diameter	G	1	0.649**	-0.277	-0.102	-0.019	0.245
	P	1	0.600*	-0.279	-0.098	0.001	0.206
Green weight	G		1	0.030	0.358	0.204	0.724**
	P		1	0.028	0.353	0.199	0.718**
Fibre percent	G			1	0.844**	0.684**	0.708**
	P			1	0.824**	0.664**	0.708**
Fibre fineness	G				1	0.741**	0.848**
	P				1	0.714**	0.828**
Fibre strength	G					1	0.623*
	P					1	0.605*

key to unraveling the associations among different traits. In white jute, green biomass plant^{-1} made the highest direct contribution to fibre yield (0.621), closely followed by fibre percentage (0.537); a similar pattern was observed in tossa jute as well. This indicates that selecting for these traits could be a reliable strategy for enhancing yield. The low residual effects in both species further confirm their major role in yield determination. These findings are consistent with those reported by Senapati et al. (2006) and Pervin and Haque (2012). On the other hand, traits like plant height, fibre fineness, basal diameter, and fibre strength showed minimal to insignificant direct influence on yield (Table 6).

3.3. Comparative genetic analysis of yield attributing traits

The mean values of plant height, green weight, and fibre weight were higher in *C. olitorius* (311 cm, 183 g, and 12.31 g) compared to *C. capsularis* (258 cm, 152.8 g, and 10.42 g). However, it was found that the basal diameter was slightly larger in *C. capsularis*. *C. capsularis* also had finer fibres (1.5 tex) compared to *C. olitorius* (2.41 tex). In contrast, fibre strength was higher in *C. olitorius* (15.39 g tex^{-1}) than in *C. capsularis* (10.61 g tex^{-1}). A similar case was reported by Guo et al. (1994). They found that the cultivars of *C. capsularis* generally had finer fibers compared to those of *C. olitorius*. Additionally, they identified certain associations between fiber fineness and other plant attributes. The researchers noted a negative correlation between fiber fineness and bark dried weight. Conversely, a positive correlation was found between fiber fineness and both bark percentage and branching height. They also observed that fiber fineness varied along the plant's height. The middle portion of the plant exhibited finer fibers than top or base portions.

Table 6: Path coefficient at phenotypic level of 15 genotypes in white jute and 15 genotypes in tossa jute (Showing direct and indirect effect of different characters)

Characters	Plant height	Basal diameter	Green weight	Fibre percent	Fibre fineness	Fibre strength	Dry fibre weight
White jute							
Plant height	0.047	0.000	0.248	0.296	0.019	0.024	0.633*
Basal diameter	-0.001	0.016	0.418	0.127	-0.007	0.041	0.593*
Green weight	0.019	0.011	0.621	0.129	-0.005	0.033	0.806**
Fibre percent	0.026	0.004	0.149	0.537	0.024	0.033	0.772**
Fibre fineness	0.020	-0.003	-0.076	0.295	0.044	0.011	0.291
Fibre strength	0.021	0.012	0.379	0.330	0.009	0.054	0.805**
Residual effect=0.0093							
Tossa jute							
Plant height	0.076	0.001	0.257	0.438	0.054	0.000	0.826**
Basal diameter	-0.006	-0.014	0.431	-0.158	-0.007	0.000	0.245
Green weight	0.029	-0.009	0.664	0.017	0.023	0.000	0.724**
Fibre percent	0.058	0.004	0.020	0.571	0.055	0.000	0.708**
Fibre fineness	0.062	0.001	0.238	0.482	0.065	0.000	0.848**
Fibre strength	0.048	0.000	0.136	0.390	0.048	0.000	0.623*
Residual=0.0001							

4. Conclusion

The majority of traits were governed primarily by additive gene effects, suggesting that selection would be an effective strategy for enhancing these traits. Characters like green weight and fibre percentage should be given more importance during selection for fibre yield improvement. Simultaneous improvement for quality parameters, i.e., fibre strength (JRC 517, and BCCO 6) and fibre fineness (CIN 94 and OIN 105), can be taken with yield since these two characteristics have a negligible direct effect on yield.

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