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Genetical study on tossa jute (*Corchorus olitorius* L.) for fibre yield and quality parameters

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Abstract

Studies on tossa jute (*Corchorus olitorius* L.) were taken up to ascertain the genetic architecture of fibre yield, its components and quality parameters from 11 × 11 diallel analysis. The combining ability analysis revealed that both additive and non-additive gene action were involved in the inheritance of all the characters. However, preponderance role of additive variances was marked for basal diameter and rest of the characters were governed by mainly non-additive variance excepting fibre percentage where both the variances were effective. Among the parents JRO-524 and KEN/DS/060C exhibited significant *gca* effects for fibre yield, plant height, node number, green weight, stick weight, fibre percentage and fibre fineness. TAN/SM/040C and TAN/NY/013C showed lowest peroxidase activity. Eight hybrid combinations exhibited high mean and significant sea effect for fibre yield and most of the yield component characters and five hybrid combinations showed significant lower peroxidase activity. Most of the *sca* effects involved parents with high × high or high × low *gca* effects. KEN/SM/024C × JRO-3670, JRO-524 × NPL/YPT/026C, KEN/DS/060C × TAN/X/112C crosses are produced better quality fibre for textile purpose.

Key words: Tossa jute, combining ability, yield attributes, peroxidase activity, lignin, fibre quality

Introduction

Though traditional use of jute fibre has been confined within the packaging sector for years, it is now high time to convert towards the tremendous possibilities of its diversified utility. Now there is a pronounced thrust over numerous diversified jute products such as jute household textiles, jute/cotton and jute/other allied fibre blended fine yarn light weight fabric suitable for small scale industries, fancy textile items and also as the raw material for the paper pulp.

The major bottleneck is the highest lignin content (12.5-13.5%) of jute compared to other natural fibres (with a range of 0.5-9.9%) [1]. Thus a breeding work had been undertaken to evaluate some jute (*C. olitorius* L.) germplasms (including IJO accessions) and subsequent hybridization materials with a view to evolve a variety with 8-10% lignin to attain fine quality fibre.

Materials and methods

The experimental material consisted of eleven tossa jute (*C. olitorius* L.) cultivars. These included with three indigenous types (JRO-524, JRO-3670, JRO-3352), three Tanzanian types (TAN/SM/040C, TAN/NY/018C, TAN/X/112C), three Kenyan types (KEN/DS/060C, KEN/SM/024C, KEN/DS/053C) and one each from Thailand (THA/YA/064C) and Nepal (NPL/YPL/026C). They were crossed in all possible combinations without reciprocals at the experimental fields of Central Research Institute of Jute and Allied Fibres, Barrackpore (New Alluvial Zone of W.B.; 88026'E, 22045'N; Alt. 9m.). The resulting 55 F1S were sown with their respective parental lines in a RBD fashion with three replications under rainfed agro-ecosystem during 2003. Each cross was represented by three rows in every replication. Plant spacing between rows and within rows were taken as 30 cm and 6-7 cm respectively. Crosses were grown with usual recommended agronomic practices and harvested at the crop age of 120 days after sowing (DAS). At harvest, five competitive plants were selected at random from all the materials of each replications, for recording observations on fibre yield and nine yield attributes namely plant height (cm), basal diameter (cm), middle diameter (cm), top diameter (cm), green weight (g), stick weight (g), fibre percentage (fibre weight × 100/green weight), internode length (cm), node number and quality parameters viz. fibre fineness (tex), fibre strength (gm/tex), peroxidase activity. Lignin and cellulose were estimated after retting. Non-replicated one set of lignin and cellulose analysis was done for 55 F_1s and parents, thus the data could not incorporate for analysis in diallel design.

Peroxidase activity/g fresh weight [2], lignin (LTGA/100 mg of AIR) [3] and cellulose percentage [3] were estimated through biochemical analysis. Fine fibre improves the yarn properties and enhances the spinability. It can be directly measured by gravitimetric method. Fibre strength or fibre tenacity measured with the help of Fibre Bundle Strength Tester. One-way diallel mating design was employed for combining ability analysis using the fibre yield; nine yield attributes and three quality parameters as per Method-2, Model-1 of Griffing [4].

Results and discussion

The analysis of variance (Table 1) revealed significant differences in all the studied characters among parents (except plant height) and crosses (except basal diameter). This shows that adequate genotypic variability is present in the studied population for fibre yield and other component traits. The estimates of mean square due to general and specific combining ability were highly significant for all the characters indicating the importance of both additive and non-additive gene action in the inheritance of these traits (except basal diameter). However, the estimates of general combining ability (*gca*) and specific combining ability (*sca*) variances and their ratio (Table 2) highlighted the preponderance of dominance variances in the expression of fibre yield, plant height, middle diameter, top diameter, node number, internode length, green weight, stick weight, fibre fineness, fibre strength and peroxidase activity. Similar results were advocated by several workers for plant height, node number and internode length but fibre percentage was controlled by additive type of gene action in both the species of jute [5, 6]. Both additive and dominance variances were important in the expression of fibre percentage but Palve and Kumar; Sinha *et al.*, [7, 8] reported that both the variance were effective for fibre yield in tossa jute. However, only basal diameter was controlled by additive gene action.

Table 1. ANOVA for parents, crosses and combining ability for 13 characters in tossa jute

Characters	Treat-ments	Parents	Crosses	Parents vs. Crosses	*gca*	*sca*
Fibre yield	13.85**	14.13**	13.93**	6.81	11.72**	3.33**
Plant height	706.24**	109.40	805.59**	1309.33**	418.57**	202.11**
Basal diameter	0.51	2.83**	0.03	3.09*	0.26	0.15
Middle diameter	0.015**	0.016*	0.015**	0.0006	0.0103**	0.004**
Top diameter	0.0048**	0.0045*	0.0049**	0.00029	0.00204**	0.00154**
Node number	70.68**	46.48**	76.24**	12.51	46.51**	19.39**
Internode length	0.15**	0.19**	0.14**	0.14*	0.04**	0.05**
Green weight	1909.96**	2169.23**	1893.90**	184.57	1367.21**	503.83**
Stick weight	72.20**	50.48*	76.23**	71.47	48.42**	19.63**
Fibre %	7.98**	6.29**	8.42**	1.03	10.18**	1.29**
Fibre fineness	0.13*	0.108*	0.13**	0.17*	0.06**	0.04**
Fibre strength	10.69**	9.395*	11.10**	1.59	3.20*	3.63**
Peroxidase activity	10.86**	5.006**	11.17**	52.49**	3.72*	5.74*

*,** significant at 1%, 5% level respectively

JRO-524 and KEN/DS/060C exhibited significant *gca* effects for fibre yield (Table 3). These two strains also performed better in respect of significant *gca* effects for plant height, node number, green weight, stick weight, fibre percentage and fibre fineness. THAYA'A/064C and JRO-3352 recorded, as finer quality fibre but TAN/SM/040C and NPL/YPY/026C were exhibited high *gca* effect for fibre strength. TAN/SM/C40C and TAN/NY/018C showed lowest peroxidase activity and significant *gca* effects in the desirable direction. Exploitation of these parents in the hybridization programme would be effective to utilize fixable components (additive) of genetic variation for the improvement of yield and yield attributing characters in jute.

Significant *sca* effects of best five crosses along with high mean values are presented in Table 4. KEN/DS/060C × TAN/SM/040C, KEN/DS/060C × TAN/X/112C, TAN/SM/040C × KEN/DS/053C, TAN/NY/018C × TAN/X/112C, TAN/NY/018C × KEN/SM/024C, TAN/X/U2C × THA/YA/064C, THA/YA/064C × JRO-3670 and KEN/SM/024C × KEN/DS/053C were found to possess highest *sca* effects coupled with high mean for fibre yield and yield attributing characters such as plant height, middle diameter and top diameter, green weight, stick weight and fibre percentage. KEN/SM/024C × JRO-3670 (L × H) was found as fineness quality fibre where as JRO-524 × TAN/NY/018C (H × L) and KEN/SM/024C × JRO-3670 (L × L) were found to posses' high *sca* effects for fibre strength.

Plant peroxidases (Class III; EC 1.11.1.7; donor, hydrogen peroxide oxidoreductase) are heme-containing enzymes of approximately 300 amino acids. The majorities are N-glycosylated and are believed to be localized in the cell wall or the vacuole [9]. Crosses KEN/DS/060C × THA/VA/064C (H × L), KEN/DS/053C

Table 2. GCA and SCA ratio for 13 characters of 11 × 11 diallel crosses in tossa jute

Characters	Fibre yield	Plant height	Basal diameter	Middle diameter	Top diameter	Node number	Inter-node length	Green weight	Stick weight	Fibre %	Fibre fineness	Fibre strength	Peroxi-dase activity
τ^2 g	0.81	2.14	27.570	0.0040	0.0006	0.0001	3.160	0.002	88.03	3.11	0.74	0.003	0.022
σ^2s	2.14	142.02	−0.047	0.0015	0.0008	14.0300	0.039	281.040	11.70	0.77	0.130	2.119	5.688
σ^2g/σ^2s	0.37	0.19	−0.085	0.4000	0.1250	0.2250	0.051	0.313	0.260	0.97	0.023	0.010	0.049

Table 3. GCA effects of parents for 13 characters in tossa jute

Sl. No.	Parents	Fibre yield	Plant height	Basal diameter	Middle dia-meter	Top dia-meter	Node number	Inter-node length	Green weight	Stick weight	Fibre %	Fibre fine-ness	Fibre stren-gth	Peroxi-dase activity
1.	JRO-524	1.807**	9.344**	–0.405**	0.020	0.005	1.77**	–0.026	17.89**	–0.22**	3.14**	0.08*	0.50	0.79**
2.	KEN/DS/060C	1.384**	5.845**	0.112	0.055**	0.000	2.56**	–0.059*	12.41**	0.62**	2.43**	–0.08*	–0.11	0.88*
3.	TAN/SM/040C	–0.424	0.529	0.063	0.024	–0.001	1.21*	0.081**	–0.03	0.42**	1.58*	0.05	0.57	–2.14*
4.	TAN/NY/018C	–0.778**	–5.002*	0.013	–0.016	–0.003	–1.95**	0.039	–5.74	0.56**	–1.03	–0.05	–0.13	–0.67*
5.	TAN/X/112C	–0.262*	–0.741	0.055	0.006	0.010	–0.69	0.020	3.32	0.27**	–0.23	0.04	0.35	–0.34
6.	THA/YA/064C	0.158	4.380*	0.090	0.016	0.023**	1.48*	–0.025	5.39	–0.67**	0.79	–0.10*	–0.94**	–0.34
7.	KEN/SM/024C	0.684*	4.052*	0.068	0.008	0.010	2.03**	–0.077**	5.48	–0.33**	0.58	–0.06	–0.50	0.92**
8.	KEN/DS/053C	–0.439	–2.702	0.010	–0.022	–0.015*	–0.25	–0.018	–8.55*	0.33**	–1.39	–0.04	–0.32	0.23
9.	NPL/YPY/026C	–0.703*	–4.656*	0.010	–0.033*	–0.016*	–2.24**	0.078**	–11.44**	–0.57**	–2.001**	0.12*	0.52	0.19
10.	JRO-3670	–0.086	–0.571	0.013	–0.023	0.004	–1.52	0.058*	–2.49	0.41**	–0.62	0.23**	–0.31	0.49*
11.	JRO-3352	–1.339**	–10.477	–0.029	–0.034**	–0.017**	–2.77**	0.038	–16.25**	–0.84**	–3.26**	–0.10*	0.38	–0.009
	SE(gi)	±0.288	±2.049	±0.118	±0.013	±0.007	±0.612	±0.029	±3.950	±0.061	±0.744	±0.04	±0.33	±0.191

*,**significant at 1%, 5% level respectively

Table 4. Best three crosses and their mean, *sca* and *gca* status of 11 × 11 diallel in tossa jute

Characters	Crosses	Mean	*sca*	*gca* status
Fibre	KEN/DS/060C × TAN/X/112C	15.9	4.628**	H × L
yield	TAN/NY/018C × TAN/X/112C	12.2	3.089**	L × L
	TAN/NY/018C × KEN/SM/024	13.1	3.043**	L × H
Green	TAN/NY/018C × TAN/X/112C	190.7	51.753**	L × M
weight	THA/YA/064C × JRO-3670	185.1	40.821**	M × L
	KEN/DS/060C × TAN/X/112C	196.7	39.607**	H × M
Stick	KEN/DS/060C × TAN7X/112C	37.5	101.68**	H × L
weight	TAN/NY/018C × TAN/X/112C	33.8	99.29**	L × L
	THA/YA/064C × JRO-3670	34.1	87.85**	M × L
Plant	KEN/DS/060C × TAN/X/112C	308.0	21.119**	H × L
height	THA/YA/064C × JRO 3670	301.5	25.914**	H × L
	TAN/SM/040C × KEN/DS/053C	292.0	23.396**	M × L
Basal	JRO-524 × NPL/YPY/026C	1.5	0.555**	L × M
dia-	JRO 524 × JRO 3670	1.5	0.531**	L × M
meter	JRO 524 × KEN/SM/024	1.5	0.507**	L × M
Mid.	TAN/NY/018C × TAN/X/112C	1.1	0.134**	L × L
dia-	KEN/DS/060C ×TAN/SM/040C	1.1	0.102*	H × M
meter	KEN/SM/024 × KEN/DS/053C	1.0	0.095*	L × L
Top	TAN/X/112C × THA/YA/064C	0.5	0.076**	H × H
dia-	TAN/NY/018C × TAN/X/112C	0.5	0.072**	L × H
meter	KEN/DS/060C × JRO 3670	0.5	0.066**	M × M
Node	TAN/NY/018C × TAN/X/112C	73.2	10.637**	L × L
no.	TAN/X/112C × THA/YA/064C	76.1	10.114**	L × H
	TAN/SM/040C × KEN/DS/053C	73.0	6.853**	H × L
Inter-	THA/YA/064C × KEN/DS/053C	4.9	0.723**	L × L
node	KEN/DS/060C × TAN/D/112C	4.6	0.420**	L × M
length	JRO 524 × JRO 3670	4.7	0.408**	L × H
Fibre	JRO 524 × KEN/DS/053C	32.4	2.577**	H × M
%age	TAN/NY/018 C × KEN/SM/024	31.6	2.542**	L × H
	KEN/SM/024 × JRO 3670	32.6	2.412**	H × H
Fibre	KEN/SM/024C × JRO 3670	1.9	–0.443**	L × H
fine-	KEN/DS/060C × THA/YA/064C	2.0	–0.379**	L × L
ness	KEN/DS/060C × KEN/SM/024C	2.0	–0.366**	L × L
Fibre	JRO 524 × TAN/NY/018C	27.4	3.847**	H × L
stren-	KEN/SM/024C × JRO 3670	26.7	3.420**	L × L
gth	JRO 524 × NP/YPY/026C	25.6	3.170**	H × H
Peroxi-	KEN/DS/060C × THA/YA/064C	2.5	–3.943**	H × L
dase	KEN/DS/053C× NPL/YPY/026C	2.6	–3.735**	L × H
activity	TAN/X/112C × JRO 3352	2.4	–3.537**	L × H

*,**significant at 1%, 5% level respectively

× NPL/YPY/026C (L × H), TAN/X/112C × JRO-3352 (L × H), TAN/SM/040C × THA/YA/064C (L × H) and JRO-524 × JRO-3670 (H × H) revealed low peroxidase activity (2.43-3.31 activity/g fresh wt.) with negative significant *sca* effects. Classical peroxidases have been implicated in several primary and secondary metabolites, particularly in lignin polymerization [10, 11, 12]. Normally, *sca* effects do not contribute much to the improvement of self-pollinated crop. However, when *sca* effects were observed in the crosses having at least one good genera' combiner, the possibility of their exploitation in breeding increases. In the present study most of the best crosses, which were also good specific combiners, involved at least one high general combiner as well as the best performing parents.

Thus considering the *gca* and *sca* effects, the crosses KEN/DS/060C × TAN/X/112C, TAN/NY/018C × TAN/X/112C, TAN/NY/018C × KEN/SM/024, KEN/DS/060C × TAN/SM/040C, TAN/SM/040C × KEN/DS/053C, KEN/DS/060C × THA/YA/064C, KEN/SM/024 × JRO-3670 and JRO-524 × NPL/YPY/026C may be used in the breeding programme aiming at evolving of high yield and better quality fibre. Among these superior crosses, KEN/DS/060C × TAN/X/112C recorded highest fibre yield/plant (15.9g), along with higher plant height (308 cm), high green weight (196.70 g), high stick weight (37.50g), high fibre percentage (30.71%), high cellulose content (59%) and moderately low lignin content (1377.9 LTGA unit). The quality of jute fibre is usually judged by its suitability for production of various types of yarns and its behavior in the manufacturing process of end products. The fibre which spines into the finest yarn is considered to be of very good quality. The major constituents of retted jute fibre are cellulose and lignin along with hemicellulose, fat and wax. The rigidness of jute fibre is imparted by the presence of high lignin, which renders the fibre coarse.

Reduction of lignin content of jute fibre will elevate the quality of fibre to a great extent. The textile industry prefers low lignin content of jute fibre for easy blending with cotton. Hence, three crosses KEN/SM/024C × JRO-3670, JRO-524 × NPL/YPT/026C, KEN/DS/060C × TAN/X/112C were chosen to select transgressive segregates for low lignin content, better fibre quality coupled with high fibre yield than the ruling check variety JRO-524 (Table 5) and may be used for textile purpose. For effective utilization of these cross combinations, it is suggested to make *inter se* crosses among those combinations so as to have a multiple parent input in a central gene pool which will supplement genetic recombination and will break undesirable linkages high fibre yield and quality parameters. Further exploitation of such populations will lead to the development of desirable transgressive segregants for high yield coupled with better quality fibre.

Table 5. Best three crosses for textile quality fibre and mean values of their quality parameters

Name	Lignin	Cellulose (%)	Fibre fineness	Fibre strength	Fibre (%)
KEN/SM/024C × JRO-3670	1171.8	51.5	1.9	25.58	32.6
JRO-524 × NPL/YPY/026C	1311.3	51.4	2.1	26.63	31.0
KEN/DS/060C × TAN/X/112C	1377.9	59.0	2.2	26.69	30.7
JRO-524 (Check)	1521.1	40.3	2.8	23.44	28.9

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