Breeding for combining yield and fibre quality in white jute (*Corchorus capsularis* L.) accessions

D. Kumar*, Arpita Das, and Sanjoy Shil

Division of Crop Improvement, Central Research Institute for Jute & Allied Fibres, Barrackpore 700 120, West Bengal, India.

Received 14 February 2011; received in revised form 23 May 2011; accepted 24 May 2011.

Abstract

Diallel crosses were made among eight parents with high yield potential, good fibre quality, and resistance to biotic and abiotic stresses. Twenty crosses showing high F_1 mean, high *gca* and high *gca* effects for one or both parents were identified and carried forward by modified bulk method for selecting transgressive segregates. A micro plot trial was conducted with four best F_7 lines along with two checks. Fibre yield, fibre percentage, and stick weight of all the four lines were higher than that of the checks. Analysis of variance revealed that differences in plant height, fibre yield, stick weight, and fibre percentage were significant. Line 2 derived from the cross combination CIJ 072 × CEX 045 was the best performer with regard to fibre yield, stick weight, and fibre % followed by line 1 derived from JRC 698 × CIJ 121. All four lines had fairly good fibre strength and fineness.

Keywords: Combining ability, High yield, Fibre strength, Fibre fineness.

Introduction

Jute (*Corchorus* spp.), the golden fibre of Bengal and the most important bast fibre of the world, is extracted from *Corchorus olitorius* L. and *C. capsularis* L., grown extensively in India and Bangladesh. Besides, these two countries, it is also grown to some extent in China, Myanmar, and Nepal. Despite the lower yield potential and inferior fibre quality of *C. capsularis* (white jute) compared to *C. olitorius* (tossa jute), the former with fibre having fineness below10 denier has great demand in the diversified and 'value added' jute markets (Ghosh, 1983). Mainly white jute is used for preparing 100% food grade mineral oil-free jute bags, shopping and hand bags, floor coverings, decorative and house hold fabrics, geotextiles, composites, and reinforcements.

In recent years, jute yields have plateaued or even declined, although production technology has advanced (Khatun et al., 2010). Hence, there is need for improving fibre yield and quality of white jute varieties. In addition, the genetic base of jute cultivars is narrow (Mukherjee and Kumar, 2002). Varietal improvement in jute, a predominantly self pollinated crop, has been impaired due to lack of adequate genetic diversity (Joshua and Thakare, 1984). In order to develop an appropriate breeding programme it is essential to assess the nature of inheritance of yield and its component traits and the potential performance of the parents in hybrid combinations. Combining ability studies help in identifying potential lines, which on hybridization would give rise to desirable segregates (Kumar and Palve, 1995). Various mating designs have been used for assessing the breeding value of parents. Estimation of variance and combining ability effects and analysis through diallel and partial diallel cross technique have been suggested by Griffing (1956). Through these techniques good general combining lines and best specific crosses can be estimated. Knowledge of heritable variance due to additive effect gives some insight into the nature of gene action involved. Expected genetic advance is useful measure of the advancement achieved through

*Author for correspondences: Phone (91) 9836949231; Fax (033) 2535 0845; Email <dkumar2k5@yahoo.co.in>.

selection. However, only limited breeding work has been carried out for improving yield and its components in jute using combining ability (Kumar and Palve, 1995, Mitra et al., 2000; Khatun et al., 2010). Keeping this in view the present investigation was undertaken to study the inheritance of yield and quality contributing characters in jute and also to identify suitable parents for developing varieties with higher yield potential and better quality fibres.

Materials and Methods

The Central Research Institute for Jute & Allied Fibres (CRIJAF), Barrackpore, India (22°45'N and 88°26'E) has a collection of about 894 white jute germplasm but the breeding values have not been worked out yet. Hence, an attempt was made to analyze the combining ability of selected parents and the performance of segregating progenies for nine years. During 2001–02, partial diallel (diallel without reciprocals) crosses were made among eight parents [P_1–JRC 212, P_2–JRC 321, P_3–JRC 698, P_4–NPL/KUC/029C (Acc. No. CIJ 064), P_5–NPL/KUC/123C (Acc. No. CIJ 072), P_6–CHN/FJ/037C (Acc. No. CIJ 121), P_7–Cap NM Burma (Acc. No. CEX 045) and P_8–Cap Big Rough Pod (Acc. No. CEX 050)] of known yield potential, fibre quality as well as biotic and abiotic stress tolerance. Twenty eight F_1s along with their parents were sown in a randomized block experiment with three replications (2002–03). The plot size was 2 m long and 60 cm wide with a spacing of 30 cm between rows and 7 cm between plants within the rows. Observations on fibre yield (weight of fibres after retting, extraction, and drying), plant height (main stem from ground level to the point of forking at pre-bud stage), basal diameter (stem diameter close to soil surface at harvesting), node number (nodes on the main stem from soil surface to technical height), and green weight (weight of stick/core after retting, fibre extraction, and drying) were recorded on 10 randomly selected plants of each parent and cross in all replications. The experimental data were analyzed following Model 1 and Method 2 of Griffing (1956). On the basis of *gca* and *sca* effects, 20 crosses were made for selection of transgressive segregates in the advance generation by modified bulk method of selection. During 2005–06, parents F_1, F_2, F_3 and F_4 of these cross combinations were grown to study the variability within and between generations. Fifty single plants from F_4 generation having better growth performance compared to the check varieties from each of the 20 crosses were selected for seed multiplication. Five promising lines having better growth performance were selected from each of the 20 crosses for seed multiplication and a micro plot trial laid out in the subsequent year. A trial with 100 lines (five each from 20 crosses) with two checks namely JRC 698 and JRC 212 was also conducted in that year. Finally during 2008–09, a micro plot trial was conducted with four best F_7 lines along with two checks. Observations on plant height, fibre yield, stick weight, fibre percentage (dry fibre weight to dry fibre plus dry stick weight), fibre strength, and fibre fineness were recorded. Fibre fineness was measured by Airflow Fibre Fineness Tester (NIRJAFT, Kolkata) from three replicate samples by airflow method (Singh and Bandyopadhyay, 1968), which is widely used for assessing fineness in natural fibres. Average fibre strength was determined by fibre bundle strength tester (NIRJAFT, Kolkata). Fibre percentage was transformed to angular values for final analysis. Analysis of variance was worked out with means of the selected plants from each cross combinations (Indostat Statistical Software Package; Indostat Pvt. Ltd., Hyderabad, India).

Results and Discussion

As can be seen from Table 1, fibre yield among the parents was highest in CIJ 121(9.60 g) followed by JRC 212 (9.33 g) and plant height was maximum in CEX 050 (320 cm). Fibre yield among the hybrids was maximum for JRC 212 x JRC 698 (10.53 g), followed by JRC 212 x JRC 321 (10.17 g). This entry also exhibited maximum height (333 cm) and was followed by CEX 045 x CEX 050. Analysis of variance for combining ability revealed no statistically significant differences for the characters studied. This lack of significant differences among the parents, hybrids, and parents vs. hybrids indicates the absence of any profound genetic variability among the selected parents as they are either ‘ruling varieties’ or advanced lines.

Table 1. Mean performance of parents and hybrids for yield and its contributing characters in an 8x8 diallel cross of jute (*Corchorus capsularis*) at Barrackpore, India.

Parents/ hybrids	Fibre yield (g per plant)	Plant height (cm)	Base diameter (cm)	Number of nodes	Green weight (kg)
P_1 JRC 212	9.33	306	1.40	67	13.8
P_2 JRC 321	7.23	303	1.37	67	12.30
P_3 JRC 698	8.13	308	1.50	68	13.4
P_4 CIJ 064	7.07	283	1.43	65	12.0
P_5 CIJ 072	9.30	313	1.54	71	15.4
P_6 CIJ 121	9.60	305	1.52	67	15.2
P_7 CEX 045	8.93	311	1.46	68	14.5
P_8 CEX 050	7.13	320	1.35	69	15.0
P_1x2	10.17	333	1.53	70	16.1
P_1x3	10.53	303	1.60	68	16.4
P_1x4	8.67	311	1.46	66	14.3
P_1x5	7.20	296	1.30	67	11.9
P_1x6	9.10	308	1.38	68	12.9
P_1x7	9.73	307	1.50	68	13.9
P_1x8	9.70	329	1.48	71	15.3
P_2x3	8.47	321	1.49	71	14.8
P_2x4	7.30	311	1.41	69	12.9
P_2x5	8.60	310	1.48	71	13.9
P_2x6	7.77	299	1.43	66	12.6
P_2x7	7.46	321	1.39	71	13.2
P_2x8	7.53	325	1.42	70	13.2
P_3x4	9.70	301	1.50	68	14.8
P_3x5	9.43	317	1.51	71	14.5
P_3x6	8.73	295	1.44	68	14.4
P_3x7	8.00	310	1.41	66	13.2
P_3x8	8.03	285	1.47	67	12.4
P_4x5	8.07	310	1.44	68	12.9
P_4x6	9.23	298	1.58	64	13.9
P_4x7	8.00	316	1.44	70	13.7
P_4x8	8.37	320	1.48	71	14.9
P_5x6	9.88	318	1.52	70	15.3
P_5x7	8.87	317	1.46	69	14.4
P_5x8	10.17	329	1.56	70	17.5
P_6x7	9.47	299	1.45	66	14.1
P_6x8	9.63	317	1.48	69	14.9
P_7x8	9.40	330	1.48	70	15.4
P Mean	8.34	306	1.45	68	13.9
F_1 Mean	8.83	313	1.47	71	14.2
F_1–P	0.49	6.6	0.02	3.5	0.28

Similar observations were reported earlier too (Joshua and Thakare, 1984).

Combining ability analysis (Table 2) revealed that seven parents viz., P_1, P_6, P_5, P_8, P_3, P_2 and P_7 were desirable combiners with high *gca* values for either yield or yield attributing characters. Since *C. capsularis* is predominantly a self-pollinated crop, utilization of dominance

Table 2. General combining ability (gca) effects of the parents for various characters in 8 × 8 diallel cross of jute (*C. capsularis*) at Barrackpore, India.

Parents	Fibre yield (g)	Plant height (cm)	Base diameter (cm)	Node number	Green weight (kg)
JRC 212 (P_1)	0.53	0.75	(–) 0.01	(–) 0.44	1.08
JRC 321 (P_2)	(–) 0.67	2.64	(–) 0.03	0.46	(–) 6.01
JRC 698 (P_3)	0.07	(–) 3.21	0.03	(–) 0.07	(–) 0.04
CIJ 064 (P_4)	(–) 0.50	(–) 5.83	(–) 0.00	(–) 1.07	(–)6.08
CIJ 072 (P_5)	0.23	2.13	0.02	1.12	3.94
CIJ 121 (P_6)	0.45	(–) 5.67	0.01	0.05	(–) 0.30
CEX 045 (P_7)	0.03	1.89	(–) 0.01	0.05	(–) 0.30
CEX 050 (P_8)	(–) 0.14	7.29	(–) 0.01	1.09	6.33
SE (gi)	0.3235	3.5500	0.0193	0.5873	3.8309
SE (gi-gi)	0.4891	5.3671	0.0292	0.8879	5.7918
CD $_{5\%}$	0.93	10.29	0.05	1.70	11.11

T $_{5\%}$ at 70 df = 2.899, 1% at 70 df = 3.435

component in the absence of male sterile lines is not possible. Non-additive gene action for fibre yield and yield contributing characters in *C. capsularis* has been widely reported (Kumar et al., 1988; Kumar and Palve, 1995; Khatun et al., 2010). However, in another cultivated species of jute (*C. olitorius*), the preponderance of additive type of gene action in the inheritance of all these characters was reported by Saha et al. (1996). Such a difference in expression of gene action controlling yield is possible when different sets of parents with different genetic background are used. Of the 28 crosses, 20 crosses ($P_1 \times P_2$, $P_1 \times P_{3,}$ $P_1 \times P_{5,}$ $P_1 \times P_{6,}$ $P_1 \times P_{7,}$ $P_2 \times P_{3,}$ $P_2 \times P_{5,}$ $P_2 \times P_{6,}$ $P_2 \times P_{7,}$ $P_2 \times P_{8,}$ $P_3 \times P_{5,}$ $P_3 \times P_{6,}$ $P_3 \times P_{7,}$ $P_3 \times P_{8,}$ $P_5 \times P_{6,}$ $P_5 \times P_{7,}$ $P_5 \times P_{8,}$ $P_6 \times P_{7,}$ $P_6 \times P_8$ and $P_7 \times P_8$) showing high *gca* effects at least in one of the parents and high *sca* effects for their hybrids were carried forward for selection of transgressive segregates from advance generation.

Parents, F_1, F_2, $F_{3,}$ and F_4 of the selected 20 cross combinations were grown to study the variability within and between generations. Higher variability within and between generations for plant height among $F_{2,}$ $F_{3,}$ and F_4 generations of the selected 20 desirable cross combinations were noted (Table 3). But a comparison of parents vs. hybrids revealed lack of reasonable genetic variability. Fifty single plants having better growth performance than the check variety from each of the 20 crosses were selected from the F_4 generation. Again on the basis of growth performance, five best promising lines were selected from each of the 20 crosses from F_5 generation.

Analysis of variance for fibre yield of 100 lines with two checks in F_6 generation is presented in Table 4. Fibre yield of the selected four lines were significantly higher than both check varieties (JRC 698 and JRC 212). Among the four selected F_6 lines, line 1 (fibre yield: 10.33 g) derived from the cross combination JRC 698 × CIJ 121 was the best performer followed by line 2 (10.17 g) derived from the cross combination CIJ 072 x CEX 045. Likewise, mean fibre yield, fibre percentage, plant height and stick weight of the four best F_7 lines were numerically higher than the checks (Table 4). Line 2 was the best performer with regard to fibre yield, stick weight, and fibre %, followed by line 1 and both lines were significantly superior to the best check variety in terms of fibre yield and had better quality and strength.

Despite the absence of reasonable genetic variability among the parents, hybrids, and parent vs. hybrids, there was predominant non-additive gene action for fibre yield and yield contributing characters in *C. capsularis*. The four lines selected can be used either for heterosis breeding or for hybridization programme oriented towards evolving transgressive segregants for fibre yield and other yield components.

Table 3. Mean, range, standard deviation, and coefficient of variations (%) for plant height of 20 desirable crosses at F_2, F_3, and F_4 generations at Barrackpore, India.

Sl. No.	Generation	Mean (cm)	Range (cm)	S. D.	C.V. (%)
1	Parents	–	167.3–201.6	–	–
2	F_1	–	160.2–221.4	–	–
F_2 Generation					
1	JRC-212 × JRC-321	207.8	170–240	14.78	7.11
2	JRC-212 × JRC- 698	209.8	180–235	14.94	7.12
3	JRC-212 × CIJ-072	202.6	170–250	25.89	12.77
4	JRC-212 × CIJ-121	221.6	185–240	13.28	5.99
5	JRC-212 × CEX-045	193.3	120–220	19.31	9.99
6	JRC-321 × JRC- 698	201.5	175–230	12.40	6.15
7	JRC-321 × CIJ-072	186.0	170–205	25.74	13.84
8	JRC-321 × CIJ-121	176.5	130–220	17.72	10.04
9	JRC-321 × CEX-045	190.0	160–230	15.76	8.29
10	JRC-321 × CEX-050	182.3	160–210	32.70	18.48
11	JRC- 698 × CIJ-072	178.0	150–205	15.46	8.68
12	JRC- 698 × CIJ-121	184.3	165–210	12.09	6.56
13	JRC- 698 × CEX-045	177.5	165–210	14.78	8.33
14	JRC- 698 × CEX-050	173.5	135–210	20.05	11.56
15	CIJ-072 × CIJ-121	176.5	150–205	15.46	8.76
16	CIJ-072 × CEX-045	184.6	160–210	13.26	7.18
17	CIJ-072 × CEX-050	176.3	155–205	16.15	9.16
18	CIJ-121 × CEX-045	201.5	190–235	11.61	5.56
19	CIJ-121 × CEX-050	204.8	170–240	16.53	8.07
20	CEX-045 × CEX-050	191.3	160–215	16.71	8.73
F_3 Generation					
1	JRC-212 × JRC-321	223.1	185–255	23.72	10.63
2	JRC-212 × JRC- 698	200.3	150–240	21.21	10.59
3	JRC-212 × CIJ-072	193.1	150–240	22.87	11.84
4	JRC-212 × CIJ-121	208.6	160–240	18.38	8.81
5	JRC-212 × CEX-045	200.0	175–260	19.60	9.80
6	JRC-321 × JRC- 698	210.8	170–240	18.72	8.88
7	JRC-321 × CIJ-072	189.6	180–250	23.94	12.62
8	JRC-321 × CIJ-121	170.6	150–210	19.99	11.71
9	JRC-321 × CEX-045	176.5	150–205	15.87	8.99
10	JRC-321 × CEX-050	192.6	130–240	21.56	11.19
11	JRC- 698 × CIJ-072	178.3	150–220	18.53	10.39
12	JRC- 698 × CIJ-121	207.8	175–230	16.22	7.81
13	JRC- 698 × CEX-045	176.7	158–200	12.91	7.31
14	JRC- 698 × CEX-050	188.5	160–225	15.43	8.18
15	CIJ-072 × CIJ-121	169.9	135–185	11.97	7.04
16	CIJ-072 × CEX-045	161.3	140–185	12.95	8.03
17	CIJ-072 × CEX-050	158.5	145–190	10.04	6.33
18	CIJ-121 × CEX-045	162.8	140–180	11.76	7.22
19	CIJ-121 × CEX-050	182.0	148–210	16.63	9.14
20	CEX-045 × CEX-050	181.2	142–205	14.29	7.89
	F_4 Generation	-	210–395	-	-

Table 4. Average fibre yield of best *capsularis* lines in F6 and F7 generations at Barrackpore, India.

Line No.	Pedigree	Generation F_6 Fibre yield/plant (g)	F_7 Plant ht (cm)	Fibre wt/ plant (g)	Stick weight/ plant (g)	Fibre %	Fibre strength (g/tex)	Fibre fineness (tex)
1 (P_3xP_6)	(JRC 698 x CIJ 121)	10.33	255.75	10.07	8.49	30.78	22.05	1.3
2 (P_5xP_7)	(CIJ 072 x CEX 045)	10.17	249.90	9.96	11.06	36.34	19.96	1.5
3 (P_2xP_5)	(JRC 321 x CIJ 072)	9.63	265.00	9.34	9.31	29.60	21.94	1.72
4 (P_1xP_2)	(JRC 212 x JRC 321)	9.73	252.00	9.17	7.91	30.54	16.32	1.36
JRC 698	Check	6.63	249.25	6.22	7.83	26.11	25.71	1.80
JRC 212	Check	6.13	233.00	6.03	7.54	23.96	23.97	1.61
C.D. 5%		2.99	12.47	0.36	0.64	3.18	–	–

References

Ghosh, T. 1983. *Handbook on Jute*, FAO, Rome, pp. 29–31.

Griffing, B. 1956. The concept of general and specific combining ability in relation to diallel crossing system. Aust. J. Biol. Sci., 9: 463–493.

Joshua, D.C. and Thakare, R.G. 1984. Inheritance of induced mutant characters in jute (*Corchorus capsularis* L.). Curr. Sci., 53: 697–700.

Khatun, R., Sarkar, R.H., and Sobhan, M.A. 2010. Diallel analysis in seven quantitative traits in deshi jute (*Corchorus capsularis* L.). Bangladesh J. Bot., 39 (2): 137–141.

Kumar, D. and Palve, S.M. 1995. Combining ability studies for yield and some of its attributes in white jute (*Corchorus capsularis* L.). Indian J. Genet., 55: 260–263.

Kumar, D., Saha, A., and Basak, S.L. 1988. Diallel cross analysis over years for yield and its components in jute (*Corchorus capsularis* L.). SABRAO J., 22: 37–44.

Mitra, S. Manna, M., Sasmal, B.G., and Bera, A.K. 2000. Combining ability for chlorophyll content in tossa jute. J. Interacademicia, 4(3): 360–365.

Mukherjee, S. and Kumar, D. 2002. Screening of tossa jute (*Corchorus olitorius* L.) germplasm for male sterility. Indian J. Genet., 62: 361–362.

Saha, A., Kumar, D., and Basak, S.L.1996. Diallel cross analysis over years for yield and its components in jute (*Corchorus olitorius* L.). Bangladesh J. Bot., 25: 59–63.

Singh, N.G. and Bandyopadhyay, S.B. 1968. An airflow method for the determination of the fibre fineness of jute and mesta. J. Textile Instt., 59 (3): 148–156.