Frontiers in Crop Improvement, Vol. 7 (1) : 9-14 (2019)
Print ISSN : 2393-8234, Online ISSN : 2454-6011

ASTHA FOUNDATION
Meerut (U.P.) INDIA

COMBINING ABILITY STUDIED OF FIBRE YIELD AND IT CONTRIBUTING CHARACTERS IN SOME VARIETIES OF TOSSA JUTE (*Corchorus olitorius* L.)

C.S. Kar, S.K. Pandey and Jiban Mitra
ICAR-Central Research Institute for Jute and Allied Fibres, Barrackpore, Kolkata-700120
Email : cskar@crijaf.org.in

ABSTRACT

Combining ability effects in 7 x 7 full diallel crosses were estimated for fibre yield and its contributing characters in tossa jute (*Corchoru solitorius* L.). Combining ability analysis shown that mean square due to general combining ability (GCA) and specific combining ability (SCA) were significant for all the characters studied suggesting the presence of both additive and non-additive gene action for the inheritance of these characters. The magnitude of GCA variance was considerably higher than that of SCA variance for all characters except plant height indicating the importance of additive gene action for these traits. The character plant height was on the whole controlled by non-additive gene action. Parent JRO_{524} was the best general combiner for fibre yield and yield attributes based on ranking of parents on GCA performance. On the basis of SCA performance, the crosses P3 x P6 (S19 x JRO878), P1 x P4 (JRO524 x KOM62), P6 x P5 (JRO878 x JRO2407), P4 x P5 (KOM62 x JRO2407), P3 x P7 (S19 x JRO8432) were found to be the best for fibre related traits, while based on per se performance were P4 x P1 (KOM62 x JRO524), P1 x P3 (JRO524 x S19), P1 x P2 (JRO524 x JRO204), P4 x P2 (KOM62 x JRO204), P1 x P4 (JRO524 x KOM62). JRO524 x KOM62 can be selectedas best cross for fibre yield based on both per se performance and sca effect whereas cross S19 x JRO8432 appeared to be the acceptable combination for high biomass yield as it recorded significantly high positive sca estimate and per se performance for stick weight as well as also appreciably high sca effects for stem weight, green weight, base diameter and plant height. Non-significant reciprocal effects indicated absence of reciprocal differences of these characters. Most of the crosses displaying good per se performance have also recorded favourably high sca effect and superior performance of most crosses was largely due to epistaticinteraction. For the development of high fibre yielding tossa jute varieties, either pedigree selection method or recurrent breeding is suggested.

Key words : *Combining ability, fibre yield, tossa jute JRO524, JRO204, S19, KOM62, JRO2407, JRO878 and JRO8432.*

Jute popularly known as the golden fibre of India and the most important bast fibre globally is derived from plant *Corchorusolitorius L* (tossa jute or dark jute) and *C. capsularis* L.(white jute). Jute constitutes about 50% of the total global production of bast and hard fibresare primarily used for non-clothing (*technical textile*) applications. It is grown extensively in India and Bangladesh and to some extent in China, Myanmar, and Nepal. *C. olitorius* (tossa jute) possess higher yield potential and better fibre strengthcompared to *C. capsularis* (white jute) yielding finer fibre (1).

In India tossa jute occupies about 90% of total area under jute and varieties like IRO 524, JRO 128 and JR0 8432 occupy maximum acreage. Although newly released varieties like JRO 128, JRO 204, IRAand S 19have very high fibre yield potential of (3-4 tonnes/ha), their area coverage is low because of monopoly of popular old varieties. Thus the presentaverage fibre productivity in India,is much below the potential yield of newly released varieties. There is a need to develop high yielding jute varieties because of the instability in performance of older jute varieties. 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 potentiality of the parents in hybrid combinations. Combining ability studies help in identifying potential lines, which on hybridization would give rise to desirable segregates (2). Combining ability analysis was earlier carried out for chlorophyll content in tossa jute (3), leaf persistency (4), yield and yield components (5, 6) and for seed characters (7). Combining ability analysis were also investigated in white jute for fibre strength (8), yield and its components (2, 9). As jute is generallyharvested before or at the flowering initiation stage, both good quality fibre and seed cannot be obtained from the same selected plant. If a selected plant has to be kept for seed then its fibre content cannot be determined directly and it is essential to select plants on the basis of morphological characters like plant height and base diameter which influence the yield of fibre. Estimation of variance and combining ability effects and analysis through diallel and partial diallel cross technique have been suggested by (10). 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 selection.

However, only limited breeding work has been carried out for improving yield and its components in tossa

Table-1 : Details of the parents included in the study.

Sl. No	Genotypes	Origin	Distinguishing characteristics
1.	JRO-524 (Navin)	Sudan green x JRO-632	Full green stem, non-dehiscent pod on maturity, blackish grey seed,
2.	JRO-204 (Suren)	IDN/SU/053 x KEN/DS/060	Stem green, non-shattering pod, resistant to premature flowering, non-lodging tall cylindrical stem,
3.	S-19 (Subala)	(JRO-620 x Sudan Green) x Tanganyika-I	Stem, leaf vein, leaf petiole, stipule and pod red, leaf lamina green,
4.	KOM-62 (Rebati)	Gamma-ray derivative of JRO-878	Full green stem, blackish grey seed, non-dehiscent pod,
5.	JRO 2407 (Samapti)	KEN/SM/024 × JRO 524	Stem completely red, non-branching, leaf green, ovate lanceolate, stipule red, pod non dehiscent, seed coat green,
6.	JRO-8432 (Shakti)	IC 15901 x Tanganyika-I	Full green stem, steel grey seed, non-dehiscent on maturity,
7.	JRO-878 (ChaitaliTossa)	JRO-620 x Sudan green	Red stem, pods non shattering, blackish grey seed,

jute using combining ability analysis (3, 11). The present investigation was undertaken to study the inheritance of yield and its contributing characters intossa jute and also to identify suitable parents for developing varieties with higher fibre yield potential along with high biomass.

MATERIALS AND METHODS

Seven genetically diverse varieties of tossa jute were selected and crossed according to diallel mating design, including reciprocals during 2013. The genotypes included were JRO 524, JRO 204, S19, KOM 62, JRO 2407, JRO 878 and JRO 8432.

Seven parentsand 42 F_1s were grown in randomized block design with three replications at the CRIJAF, Barrackpore during rainy season in 2014. Each genotype grown in a 2m long and 60 cm wide plot, with the spacing of 30 cm between rows and 7 cm between plants within the row. Recommended agronomic practices followed in order to achieve good crop growth. Observations were recorded on ten randomly selected plants for seven quantitative traits. Data were recorded for height from base to tip of top leaf, base diameter, green weight, stem weight and leaf weight after harvesting at 120 days duration before flowering. Fibre weight and stick weight were recorded after retting in water under uniform condition and sundrying until constant weight achieved.

The experimental data were analysed following Model 1, Method 1 of (10). Analysis of variance was carried out taking means of the selected plants from each cross combinations (Windostat Statistical Software Package; Indostat Pvt. Ltd., Hyderabad, India).

RESULTS AND DISCUSSION

Analysis of variance (Table-2) revealed that mean square due to general (gca) and specific combining ability (sca) effects were significant for all the characters studied indicating the importance of both additive and non-additive genetic variance in their inheritance. Reciprocal effects were non-significant for all characters suggesting absence of maternal inheritance of these characters.

The estimates of gca effects (table 3) showed that both the parents JRO 524 and JRO 204 were good combiner for all the characters except for plant height. S19 although displayed more potentiality as a good general combiner for plant height but did not contributed as good combiner for fibre yield or other component characters. JRO 2407 and JRO 878 showed poor combiner for fibre yield and other component characters. Highest estimated gca effects for base diameter, fibre weight and stick weight were observed in parent JRO 524 whereas for green weight, stem weight and leaf weight were observed in parent JRO 204

The per se performance of the parents given in parentheses indicated that the parents which were high performing were also good general combiners for the respective characters (Table 3). Therefore it can be inferred that the potential parents for breeding tossa jute for fibre yield and its contributing characters should be selected on the basis of their per se performance. The results are in corroborate with (11, 12). Generally plant height and base diameter are considered to be the primary parameters for predicting fibre yield in case of bast fibre crops like jute. But from this study it was observed that although S19 having significant and positive gca effect for plant height along with non-significant gca effects for base diameter did not contributed significantly for fibre yield. Whereas, JRO 524 and JRO 204 having non-significant gca effects for plant height along with significant positive gca for base diameter were good general combiner for fibre yield. Hence considering plant height and base diameter solely for prediction of fibre yield in jute may be misleading. This was also questioned earlier as evident from the research findings of (13). However, use of plant height and base diameter for selection was

Table-2 : Analysis of variance for combining ability analysis in tossa jute (*Corchorus olitorius* L.)

Source of variation	Degree of freedom	Plant height (cm)	Base diameter (mm)	Green weight (g)	Stem weight (g)	Leaf weight (g)	Fibre weight (g)	Stick weight (g)
Replicates	2	4292**	22.4**	25649**	19439**	209.7**	66.9**	271**
Treatments	48	1191**	4.8**	3864**	3041**	63.04**	16.01**	106**
Parents	6	585*	4.5**	2146	1443	60.1	6.63	52.9
Crosses	41	215	1.87*	1809*	1220*	55.6**	7.16	45.2*
Parent vs.crosses	1	44871**	126.8**	98420**	87302**	386.7**	435.55**	2907**
F_1's	20	230	2.21*	2096*	1528*	62.4**	6.86	51.9*
Reciprocals	20	207	1.57	1610	944	51.3*	7.80	39.9
F_1 vs. reciprocals	1	81	1.07	40	583	4.57	0.22	13.7
Error A	96	209	1.21	1109	763	27.6	5.14	26.6
Total	146	588	2.68	2351	1768	41.7	9.56	55.9
GCA	6	316**	3.99**	2747**	1657**	73.6**	10.7**	68.9**
SCA	21	787**	2.24**	1884**	1629**	18.8 *	7.99**	53.3**
Reciprocal	21	31	0.27	274	215	8.2	1.15	7.6
Error B	96	70	0.40	369	254	9.2	1.71	8.9

Table-3 : General combining ability effects of parents for fibre yield and its component characters in tossa jute.

Parents	Plant height (cm)	Base diameter (mm)	Green weight/plant (g)	Stem weight/plant (g)	Leaf weight/plant (g)	Fibre weight/plant (g)	Stick weight/plant (g)
1 JRO524	1.28 (290)	0.64 ** (12.8)	18.31** (165)	13.90 ** (135)	2.62 ** (22.3)	1.60 ** (10.97)	2.87 ** (23.57)
2 JRO204	2.49 (287)	0.63 ** (12.6)	19.88** (167)	14.64 ** (134)	3.53 ** (22.7)	0.72 * (10.33)	2.54 ** (21.9)
3 S19	7.85 ** (298)	0.31 (12.4)	2.98 (154)	3.50 (129)	0.17 (17.7)	-0.02 (9.53)	1.33 (21.3)
4 KOM62	-1.11 (274)	-0.11 (11.4)	-7.31 (133)	-3.24 (116)	-2.59 ** (13.7)	-0.22 (7.87)	-0.86 (16.1)
5 JRO 2407	-1.23 (272)	-0.65** (10.1)	-12.48 * (112)	-11.10 ** (93)	-1.85 * (14.0)	-0.70 * (8.37)	-2.70** (14.2)
6 JRO 8432	-7.82** (259)	-0.24 (11.1)	-11.10 * (122)	-8.60 * (97)	-1.31 (13.0)	-0.57 (8.10)	-1.56 * (14.83)
7 JRO 878	-1.46 (267)	-0.57**	-10.29 * (99)	-9.10 * (81)	-0.57 (12.0)	-0.80 * (6.77)	-1.62 * (13.43)
SE(gi)±	2.06	0.16	4.76	3.94	0.75	0.32	0.73
h^2 Broad Sense	0.94	0.88	0.85	0.87	0.68	0.84	0.87
GCA/SCA Ratio	0.025	0.139	0.112	0.073	0.479	0.102	0.097

Significant at *P = 0.05, The figures in bold indicate the top gca effects for different characters.

advocated when plants are allowed for seed maturity and the estimate of fibre yield is not available.In that case the technique used is to keep seed from selected sister lines of the same height category in the same plot and harvest the rest for estimating the yield (13).

Table-4 show the performance of some selected crossed based on their per se performance for primarily fibre yield along with other characters and corresponding sca effects. Out of 14 top performing crosses, JRO 524 the high GCA parent for fibre yield is one of the parents in 10 crosses and JRO 204 another parent having high gca also exhibited high fibre yield but with negative sca effect in three cross combinations 3 x 2, 4 x 2 and 7 x 2 . Higher sca effect of the high x lowgcacross combinations may be due ca parent manifesting complementary interaction effect. However, a major part of heterosisdisplayed by such crosses may be due to additive x dominance and dominance x dominance type of gene action and was non-fixable. Six cross combinations, 1 x 2, 1 x 3, 1 x 4, 1 x 5, 1 x 7, 2 x 1, 3 x 1, 7 x 1 showed high and positive sca estimates for fibre yield per plant (Table-4). Of them 1 x 2 and 2 x 1 recorded highsca estimate involving parents with high x high gca effects, indicating additive x

Table-4 : Some of crosses exhibiting high per se performance for fibre yield.

Crosses	Plant height (cm)		Base diameter (mm)		Green weight/plant (g)		Stem weight/plant (g)		Leaf weight /plant (g)		Fibre weight/plant (g)		Stick weight/plant (g)	
	Mean	SCA	Mean	SCA	Mean	SCA	Mean	SCA	Mean	SCA	Mean	SCA	Mean	SCA
1 x 2	327	1.22	15.4	0.17	250	2.5	217	5.38	29	-3.93	16	0.30	37	0.22
2 x 1	324	1.17	14.9	0.20	230	9.8	194	11.00	16	6.33	15	0.35	32	2.13
1 x 3	342	9.20	15.0	0.44	247	19.1	204	5.86	26	1.59	16	0.94	36	2.19
3 x 1	336	3.17	15.1	-0.02	233	7.2	186	9.00	24	0.83	15	0.68	34	0.78
1 x 4	326	6.15	14.8	0.19	234	8.2	205	8.43	21	-0.65	16	1.84	34	1.99
4 x 1	329	-1.50	14.0	0.38	203	15.7	176	14.83	19	1.17	17	-0.75	32	1.30
1 x 5	328	9.61	14.3	0.51	228	20.9	193	19.12	18	-0.55	15	1.19	32	3.52
5 x 1	333	-2.50	14.1	0.07	224	1.8	194	-0.33	23	-3.00	15	0.02	33	-0.42
1 x 7	331	4.34	14.9	0.55	216	10.3	207	18.79	28	3.16	15	1.28	36	3.15
7 x 1	319	5.67	13.7	0.58	220	-1.8	183	12.00	23	2.33	15	0.03	31	2.53
3 x 2	347	-4.50	15.0	-0.25	255	-18.3	216	-13.83	31	-2.17	15	-0.57	36	-2.08
4 x 2	336	-1.00	15.3	-0.35	240	-16.7	209	-12.67	22	-1.67	16	-1.42	35	-1.82
6 x 3	327	1.00	14.2	0.33	205	-0.8	180	13.83	19	1.00	15	-0.38	32	1.28
7 x 2	328	1.33	14.9	-0.20	245	-4.0	206	-3.00	26	0.17	15	-0.45	32	0.40

additive gene interactions for this character. Where both the parents were good general combiners, high sca effects manifested by crosses might be assigned to major additive x additive gene interaction.

Base Diameter (Mm)

It was evident that majority of the hybrids showing higher estimates of scaeffect in desirable direction involve high x low gca parents and a few high x highand low x low combinations (Table 4) for fibre yield and its contributing characters.

The present investigation showed that threecrosses namely 1 x 4 (JRO 524 x KOM 62), 3 x 6 (S19 x JRO 878) and 6 x 5 (JRO 878 x JRO 2407), showed high scaperformance for fibre yield and whereas 3 x 6 (S19 x JRO 878), 3 x 7 (S19 x JRO 8432) and 4 x 5 (KOM 62 x JRO 2407) exhibited significant sca effects for stick weight. Among them 3 x 7 (S19 x JRO 8432) and 4 x 5 (KOM 62 x JRO 2407) were also recorded high per se performance and sca effect for plant height and base diameter whereas cross 3 x 6 (S19 x JRO 878) recorded significant sca for base diameter only.In general, parents with high per-se performance exhibited very high general combining ability effects. In majority of the highest specific combinations at least one of the parents was found to be the best general combiner (14). This indicates that there is a strongtendency of transmission of specific genetic architecture for higher genetic gain from theparents to the offspring. Such crosses are likely to throw up desirable transgressive segregates in subsequent generations if the additive genetic system present in thegood general combiner and complementary epistasis if present in the cross acts inthe same direction for maximum expression of the character under consideration.The best cross 1 x 4 (JRO 524 x KOM 62) for fibre yield can be selected based on per se performance and sca effect when fibre yield alone is selection criterion for generation advancement. The cross 3 x 7 (S19 x JRO 8432) appeared to be the acceptable combination for high biomass as it recorded significantly high positive sca estimate and per se performance for stick weight as well as also appreciably high sca effects for stem weight, green weight, base diameter and plant height in the present set of experiment.

A conspicuous feature was the record of negative sca effect of the hybrid 3 x 2 (S19 x JRO 204), 4x1 (KOM 62 x JRO524), 4 x 2 (KOM 62 x JRO 204), for plant height and fibre yield/plant though the parents 1(JRO524) and 2(JRO 204) were good general combiners for these traits. This unusual phenomenon might be attributed to the lack of genetic diversity of alleles among the parents and accrual of similar analogous alleles in the cross for the relevant characters (15). Most of the crosses which showed good per se performance also possessed favourably high sca effect (Table-4). This indicated that per se performance of hybrids were reflected in their respective sca effect. In case of jute selection of crosses based on higher per se performance for plant height or total biomass alone for can be misleading. Jute plants generally require a fairly long vegetative period in order to attain good height and stem thickness. Although the greater the height and the greater the thickness of the stem, the larger is the yield of fibre (1), but higher biomass may contribute more towards stick weight compared to fibre weight. Late maturing types or keeping jute crop in field in longer duration generally yield more, however fibre

Table 5 : Five best crosses based on *per se* performance and sca performance for fibre yield and it contributing characters.

Sl. No.	Characters	Per se performance			Based on sca effects		
		Crosses	Mean	SCA	Crosses	SCA effects	
1	Plant height (cm)	3x7	349	17.11*	3x7	17.11*	HxL
		3x2	347	-4.50	5x6	16.70*	LxL
		1x3	342	9.20	4x5	16.32*	LxL
		4x5	341	16.32*	2x4	12.44*	LxL
		7x3	339	5.33	2x3	11.65*	LxH
2	Base diameter (mm)	1x2	15.4	0.17	2x7	0.94*	HxL
		4x2	15.3	-0.35	4x5	0.92*	LxL
		3x1	15.1	-0.02	3x7	0.88*	LxL
		1x3	15.0	0.44	3x6	0.77*	LxL
		3x2	15.0	-0.25	2x4	0.69	HxL
3	Green weight/plant (g)	3x2	255	-18.3	2x7	31.9*	HXL
		1x2	250	2.5	4x5	30.3*	LXL
		1x3	247	19.1	3x7	30.2*	LXL
		7x2	245	-4.0	5x6	21.4	LXL
		4x2	240	-16.7	1x5	20.9	HXL
4	Stem weight/plant (g)	1x2	217	5.38	3x6	27.53*	LXL
		3x2	216	-13.83	4x5	26.60*	LXL
		4x2	209	-12.67	2x7	25.38*	HXL
		3x6	208	27.53*	3x7	22.36*	LXL
		1x7	207	18.79	1x5	19.12	HXL
5	Leaf weight /plant (g)	3x2	31	-2.17	2x1	6.33*	HXH
		1x2	29	-3.93	2x3	4.35*	HXL
		1x7	28	3.16*	1x6	3.74*	HXL
		2x3	26	4.35*	2x5	3.54	HXL
		7x2	26	0.17	1x7	3.16	HXL
6	Fibre weight/plant (g)	4x1	17	-0.75	3x6	1.88*	LXL
		1x3	16	0.94	1x4	1.84*	HXL
		1x2	16	0.30	6x5	1.83*	LXL
		4x2	16	-1.42	4x5	1.49	LXL
		1x4	16	1.84*	3x7	1.43	LXL
7	Stick weight/plant (g)	3x7	37	5.02*	4x5	5.05*	LXL
		1x2	37	0.22	3x7	5.02*	LXL
		1x3	36	2.19	6x5	4.48	LXL
		3x2	36	-2.08	3x6	4.42*	LXL
		1x7	36	3.15	1x5	3.52	HXL

quality is compromised in such case. The ratio of fibre to stick weight varies with duration from the vegetative to the flowering and pod stages. More fibre is produced in early in the growth stage compared to later stages when proportion of stick increased (16). Fibre yield and quality, the two key considerations in the improvement of jute, should be taken care of simultaneously (17). It is remarkable that the crosses demonstrating greater sca effects in desirable direction also showed favourably high heterosis over better parent. Hence the mean performance of crosses could be considered as a criterion of sca effect and selection of promising crosses based on per seperformance would be realistic.

REFERENCES

1. Ghosh, R.L.M. (1983). Jute breeding experimental technique. Selection and handling of breeding material. *Indian Cent. Jute Comm., Agr. Res. Bull. 2.* 1945
2. Kumar, D. and Palve, S.M. (1995). Combining ability studies for yield and some of its attributes in white jute. *Indian J. Genet. Pl. Breed. 55 (3):* 260-263.
3. Mitra, Shauli; Manna, M.; Sasmal, B. G.; Bera, A. K. (2000). Combining ability for chlorophyll content in tossa jute. *Journal of Inter-academicia 4:* 3 pp. 360-365

4. Ghoshdostidar, K.K. (1966). Combining ability for leaf persistancy and some yield contributing characters in olitorius jute. *Exptl. Genet.* 2, 66-71.

5. Chaudhury, S.K. and Sasmal, B.C. (1992). Heterosis and combining ability for fibre strength in tossa jute (*Corchorus olitorius* L.). *Bangladesh J. Bot. 21(2) :* 213-218.

6. Saha, A.; Kumar, D. and Basak, S.L. (1996). Diallel crossanalysis over years for yield and its components in jute (*Corchorusolitorius* L.). *Bangladesh J. Bot., 25 :* 59–63.

7. De, D.K. and Ghoshdostidar, K.K. (1991). Combining ability analysis for seed characters in jute (*Corchorus olitorius* L.). Bangladesh *J. Bot. 20 (1):* 17-20.

8. Palve, S.M. and D. Kumar (1991). Combining ability for fibre strength in white jute (*Corchorus capsularis* L.). *Phytobreedon 7(1&2) :* 4-8.

9. Ghoshdastider, K.K. and Das, P.K. (1982). Combining ability and heterosis in white jute. *Indian J. Genet. 42 :* 28-31.

10. Griffing, B. (1956). Concept of general and specific combining ability in relation to diallel crossing systems. *Aust. J. Biol. Sci. 9:* 463-493.

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

12. Kumar, D.; Das, Arpita; Shil, Sanjoy. (2011). Breeding for combining yield and fibre quality in white jute (*Corchorus capsularis* L.) accessions. *Journal of Tropical Agriculture,* 49 (1/2), p72.

13. Ray. Basudev (1968). Breeding procedure for jute. *Indian Council Agricultural Research. Tech. Bull., No. 17.* New Delhi.

14. Shah M.K.N.; Yusuf, M.J. and Bukhtiar, B.A. (1994). Combining ability studies in jute. *J. Agril. Res. 32(3) :* 239-242.

15. Alam, M.S. and Husain, M. (1985). Combining ability in jute. Bangladesh *J. Jute Fib. Res. 10(1&2):* 55-58.

16. Kar, B.K. and De Sarkar, B.K. (1952). Physiology of fibre growth in jute. Proc. Indian Sci. Congr.

17. Kundu, B.C. (1956). Jute-world's foremost bast fibre, I. Botany Agronomy, Diseases and Pest. *Economic Botany, 10(3) :* 203-240

Received : October-2018; Revised : November-2018; Accepted : December-2018