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COMBINING ABILITY STUDIES FOR FIBRE YIELD AND ITS ATTRIBUTING TRAITS IN TOSSA JUTE (*Corchorus olitorius* L.)

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ABSTRACT

The combining ability analysis of fifteen diverse genotypes was carried out using Line x Tester mating design. Analysis of variance revealed significant differences($P < 0.01$) among the parents and their hybrids for fibre yield and its attributes traits.Three lines namely OIJ-268 (12.78), OMU-33 (3.22), OIJ-05 (0.28) and tester OIN-255 (4.61)revealed significant GCA effect for fibre yield and were identified as the best general combiners for the improvement of fibre yield and yield attributing traits.The crosses viz. OIJ-268 x S-19 (32.52; 27.1g/plant),OIJ-248 x OMU-19 (19.52; 21.5g/plant),OMU-37 x OMU-27 (19.43; 18.7g/plant), OIJ-05 x JRO-204 (16.61; 20.1g/plant), and OIJ-165xOIN-255 (12.61; 20.9g/plant)were identified as best combinations for fibre yield based on SCA effects and *per se* performance. These crosses also revealed significant amount of heterosis (range; 16.6-68.9%) for fibre yield.The present study was usefull in identifying best general and specific combiners for exploitation of heterosis in jute breeding.

INTRODUCTION

Jute is a long, soft, shiny ligno-cellulosic vegetable fiber extracted through microbial decomposition of whole plants of Corchorus species particularly *Corchorus capsularis* (white jute) and *C. olitorious* (tossa jute). Of the two cultivated species tossa jute is preponderant among the jute growers, because the cultivars were intrinsically high yielders and best fitted in jute based multiple cropping systems in jute growing states (Karmakar *et al.*, 2008). Jute is a major bast fibre crop primarily cultivated in Indian subcontinent, Southeast Asia, and China. Among all natural fibre crops jute stand next to cotton in production (Rowell and Stout, 2007). Jute fibre has diverse uses in manufacturing diversified value-added industrial products and packaging materials like sacks, hessian, burlaps, rope, geotextiles, and fibre composites.

Breeding efforts in jute largely exploited naturally available additive genetic variance, whereas non-additive genetic variance more particularly heterosis has not been exploited. A few studies on jute to understand the nature of gene action revealed the importance of non-additive gene action for majority of yield contributing characters and also observed positive relationship between SCA effects and heterosis estimates (Dastidar and Das 1982; Khatun *et al.*, 2010a, 2010b, 2016; Sengupta *et al.*, 2005).However, there was not much progress made towards hybrid development in jute. Till 2009 a total of 27 improved jute varieties (14 in *C. olitorius* and 13 in *C. capsularis*) have been developed in India and these varieties gives an average productivity of 2.3 tonnes/ha fibre yield (Kar *et al.*, 2009). During 2015-16, India produced raw jute fibre of 8.84 million bales (1 bale = 180 kg) from 0.74 million hectares with reduction of 23% when compared to raw jute production 11.49 million bales in 2014-15 (www.jutecomm.gov.in).With continuous reduction in area and production,there is an urgent need to further enhance the productivity of the crop so that the crop can compete with low cost synthetic fibres.

For designing heterosis breeding programme in jute, the knowledge of general combining ability (GCA) of the genotypes and specific combining ability (SCA) of their crosses are the key for efficient exploitation of heterosis (Kashif and Khaliq, 2003). Combining ability parameters assist breeders to identify the nature of gene action, heritability involved in the expression of quantitative traits, genetic diversity, parental lines selection, heterosis estimation and hybrid development (Palve and Kumar, 1991; Kumar and Palve, 1995; Sengupta *et al.*, 2005; Kumar *et al.*, 2011; Anil Kumar *et al.*, 2016).Taking above facts into consideration, the present study was conducted with an objective to assess the combining ability of fifteen *tossa* jute genotypes and to identify elite parental lines for the improvement of fibre yield.

MATERIALS AND METHODS

Fifteen tossa jute genotypes including already developed varieties (S-19 and JRO-204) were selected based on diversity analysis. Among them nine genotypes were used as female parents (OEX-02, OIJ-05, OIJ-165, OIJ-211, OIJ-248, OIJ-268, OIN-211, OMU-33 and OMU-37) and six as male parents (OIN-255, OMU-07, OMU-19, OMU-27, S-19 and JRO-204)in a line x tester mating design that resulted in 54 F_1hybrids. The 54 F_1 crosses along with their parents and checks were evaluated in randomized complete blocks design with three replication sat experimental field of ICAR-CRIJAF, Barrackpore, Kolkata.The crosses and the parents were randomised separately among themselves in consecutive blocks as advocated by Arunachalam (1974).Each genotype was grown in a row of 4 m length at 30 cm row spacing and plant to plant spacing of 5-7 cm was maintained by thinning.Standard package of practices was followed to raise good crop. At 120 days after sowing, according to Sen *et al.*, 1977,five random plants were selected and observations were recorded on plant height (PHT; cm), basal stem diameter (BD; mm), green biomass yield (GBY; g/plant),wood yield (WY; g/plant), fibre yield (FY; g/plant).Mean data of five plants were used for further data analysis. All data were analyzed using Windostat statistical package (WINDOSTAT ver. 9.1). The general combining ability(GCA) effects for lines and testers as well as specific combining ability (SCA) effects for hybrids were estimated according to the Line x Tester analysis developed by Kempthorne (1957) and emphasized by Arunachalam (1974).The estimates of heterosis was derived following Hallauer and Miranda (1981).

RESULTS AND DISCUSSION

Analysis of variance detected significant differences (P<0.01) among genotypes (parents and crosses)for majority of characters (Table 1) indicating the existence of considerable variation among these sets of genotypes, which allow selection of preferred parent and hybrids for future breeding programme.Like wise significant differences(P<0.01) between parents vs hybrids was observed for fibre yield and its attributing traits indicates presence of heterosis in hybrids (Sharma, 2006).The genetic variability among the crosses was partitioned into the components attributable to the lines, tester and interaction among lines x tester.Line effect showed significant differences (P<0.05) for plant height and basal stem diameter; tester effect for plant height. Line x tester effect showed highly significant (P<0.01) differences for majority of yield attributing traits, which is a prerequisite for any linex tester mating design.

In *tossa* jute, tall plant type with high basal stem diameter is an ideal plant type for getting higher fibre yield as they were reported to be highly correlated (Sawarkar *et al.*, 2014). Genotypes having high green biomass yield and average wood yield are also desirable since this trait combination ensures high fibre recovery percentage which ultimately leads to higher fibre yield. Therefore, all the parents with significant positive GCA effects for plant height, basal stem diameter, green biomass yield and fibre yieldare considered desirable for generating superior hybrids. General combining ability estimates for fibre yield and its attributing traits (Table 2)of fifteen parental lines showed that parents with high GCA effects differed for various traits.The critical analysis of lines indicated that among female parents,OIJ-268(12.78) had significant positive GCA effect for fibre yield followed by OMU-33 (3.22) and OIJ-05 (0.28).These genotypes had positive GCA effect for all the traits studied and it's already established that GCA effect is controlled by stable additive gene effects, parents with significant GCA effects are considered to be good combiners and inclusion of such genotypes in breeding program can accelerate yield improvement process (Sengupta *et al.*, 2005; Dar *et al.*, 2016).

Among testers, OIN-255 recorded significant positive GCA effect for plant height (14.72), green biomass yield (133.14), wood yield (24.77),fibre yield (4.61) and high GCA effect for basal stem diameter (0.59).The combining ability analysis established that good general combiners for fibre yield also had good or average combining ability for one or more of the yield components.Further, it may be suggested that lines namely OIJ-268, OMU-33, OIJ-05 may be expected to produce superior hybrids when crossed with tester *viz.*OIN-255 for all important characters including fibre yield. The above conclusion is drawn based on the findings of Chavan and Nerkar (1994), suggested that at least one good general combiner is essential for getting a good hybrid combination.

According to Sprague and Tatum (1942) the SCA is controlled by non-additive gene action and is an important criterion for the evaluation of hybrids. The SCA analysis revealed some useful cross combinations with significant positive SCA effects for fibre yield and its attributing traits.A total of seven crosses showed significant positive SCA effects for fibre yield and it was ranged from 32.52 to -22.16. Crosses with significant SCA effects for fibre yield along with *per se* performance and GCA effects of parents involved in the crosses are listed in the Table 3.The crosses OIJ-268 x S-19 (32.52) followed by OIJ-248 x OMU-19 (19.52),OMU-37 x OMU-27 (19.43), OIJ-05 x

Table 1 : Analysis of variance for combining ability effects of fibre yield and yield components in jute

Source of Variation	df	PHT	BD	GBY	WY	FY
Genotypes	68	1305	3.6	135083.8**	5319.8**	929.7**
Parents	14	554.3	6.8**	62655	4092.0**	824.4**
Parent vs Crosses	1	8492.0**	26.1**	2099955**	112934.3**	25064.4**
Crosses	53	1367.7	2.4	117143**	3613.6**	502.1**
Line effect	8	2286.1*	4.8*	116287.3	5511.9	555.3
Tester effect	5	3059.0*	3.4	152182.4	6224.2	628.5
Line * Tester effect	40	972.7	1.8	112934.2**	2907.6**	475.7**
Error	136	1077.6	2.8	54420.1	1600.9	80
Total	206	1326.3	3.5	86658.2	2984.8	364.3

PHT: plant height (cm); BD: basal stem diameter (mm); GBY: green biomass yield (g/plant); WY: wood yield (g/plant); FY: fibre yield (g/plant). *, ** Significant at *P=0.05* and *P=0.01*, respectively

Table 2: Performance *per se* of parental lines and their general combining ability (GCA) effects

Parent	Performance *per se*					GCA effects				
	PHT	BD	GBY	WY	FY	PHT	BD	GBY	WY	FY
Female Parents										
OEX-02	361.1	15.5	261.4	38.5	16.1	-3.68	0.33	65.61	-1.67	-0.11
OIJ-05	323.3	13.6	252.9	24	7.5	4.39	0.7	37.7	24.66*	0.28
OIJ-165	331	14.4	217	28.7	8.2	-17.86 *	0.11	-54.17	-8.06	-0.06
OIJ-211	337.6	14.1	202	29.2	7.9	-17.65 *	-0.83 *	-64.9	-10.84	-5.56*
OIJ-248	360.1	15.5	262.9	39.7	14.5	3.99	-0.82 *	-130.77	-16.78	-1.89
OIJ-268	342.4	14.2	210.7	25.6	10.4	15.94	0.41	63.25	22.44*	12.78**
OIN-211	366.7	15.4	304.6	44.7	15.5	5.25	0.04	31.39	-14.06	-3.61
OMU-33	340.9	13.4	256.1	38.9	9.1	6.91	0.04	113.63	20.38*	3.22
OMU-37	354.1	13.5	219.8	31.1	10.5	2.72	0.02	-61.75	-16.06	-5.06*
Male Parents										
OIN-255	367.9	15.4	288.8	43.4	14.5	14.72*	0.59	133.14**	24.77**	4.61*
OMU-07	352.3	14.8	243.5	42.3	10.2	-1.08	-0.41	-7.44	-0.23	0.91
OMU-19	358.2	18.3	257.1	47.5	13	-3.11	-0.17	20.11	-9.56	2.87
OMU-27	365.3	18.2	244.4	35.3	11.2	-17.48*	-0.1	-70.35	-20.54 *	-7.87**
S-19	354.5	14.3	220.5	38	15.5	5.6	0.23	-70.91	5.11	3.2
JRO-204	359.7	14.3	262.9	43.7	17.6	1.35	-0.15	-4.54	0.44	-3.72*

PHT: plant height (cm); BD: basal stem diameter (mm); GBY: green biomass yield (g/plant); WY: wood yield (g/plant); FY: fibre yield (g/plant). *, ** Significant at $P=0.05$ and $P=0.01$, respectively

Table 3 : Summary of cross combinations with significant SCA effects for mean fibre yield, performance *per se*, GCA effects of parents for fibre yield and heterosis

Hybrid	SCA effect	Performance per se			GCA effect		GCA	Heterosis
		F1	P1	P2	P1	P2	status	
OIJ-268 x S-19	32.52**	27.1	10.4	15.5	12.78**	3.2	HxH	68.88**
OIJ-248 x OMU-19	19.52**	21.5	14.5	13	-1.89	2.87	LxH	34.02**
OMU-37 x OMU-27	19.43**	18.7	10.5	11.2	-5.06*	-7.87**	LxL	16.6
OIJ-05 x JRO-204	16.61**	20.1	7.5	17.6	0.28	-3.72*	HxL	24.9**
OIJ-165 x OIN-255	12.61*	20.9	8.2	14.5	-0.06	4.61*	LxH	29.88**
OIJ-248 x JRO-204	10.78*	18.5	14.5	17.6	-1.89	-3.72*	LxL	14.94
OIN-211 x OMU-07	10.54*	19	15.5	10.2	-3.61	0.91	LxH	18.26
OIJ-248 x S-19	-11.48*	15.4	14.5	15.5	-1.89	3.2	LxH	-4.15
OIJ-211 x OIN-255	-11.56 *	14.9	7.9	14.5	-5.56*	4.61*	LxH	-7.05
OMU-37 x JRO-204	-11.72*	13.3	10.5	17.6	-5.06*	-3.72*	LxL	-17.01
OIN-211 x JRO-204	-12.17*	13.5	15.5	17.6	-3.61	-3.72*	LxL	-15.77
OIJ-248 x OMU-07	-12.52*	14.7	14.5	10.2	-1.89	0.91	LxH	-8.3
OIJ-165 x OMU-27	-15.57**	12.7	8.2	11.2	-0.06	-7.87**	LxL	-20.75*
OIJ-05 x OMU-19	-15.65**	14.9	7.5	13	0.28	2.87	HxH	-7.05
OIJ-165 x JRO-204	-17.72**	13.1	8.2	17.6	-0.06	-3.72*	LxL	-18.26
OIJ-268 x OMU-19	-21.15**	16.3	10.4	13	12.78**	2.87	HxH	1.66
OIJ-268 x OMU-07	-22.16**	15.7	10.4	10.2	12.78**	0.91	HxH	-2.07

PHT: plant height (cm); BD: basal stem diameter (mm); GBY: green biomass yield (g/plant); WY: wood yield (g/plant); FY: fibre yield (g/plant). *, ** Significant at $P=0.05$ and $P=0.01$, respectively.

JRO-204 (16.61), and OIJ-165xOIN-255 (12.61) expressed significant SCA effects as well as high *per se* performance for fibre yield similar results were reported by Anil Kumar *et al.*, 2016. Interestingly, crosses (OIJ-248 x OMU-19 and OMU-37 x OMU-27) involving mutant lines recorded high *per se* performance and SCA effects which suggests presence of desirable gene combinations for fibre yield attributes in mutant genotypes. Importance of mutant genotypes in enhancing fibre yield of tossa jute was emphasised by Satya *et al*., 2014 by evaluating mutant genotypes for morpho-anatomical traits.

Among 54 hybrids, cross OIJ-268 x S-19 recorded highest SCA effect for fibre yield, *per se* performance (27.1g/plant) and involved high x high general combiners as parents. It was assumed that favourable interaction between positive alleles in the cross is responsible for superior hybrid performance (Balakrishnan and Das, 1996; Kandaswami and Ramalingam, 1995; Dar *et al*., 2015).The favorable combination of positive alleles can be fixed in subsequent generation if no repulsion phase linkages are involved,hence this hybrid is recommended for recombination breeding.However, there were crosses with high x low and low x low general combiner exhibiting high SCA effects and *per se* performance for fibre yield, such results were explained by Jinks (1956) as due to over-dominance and epistasis. Similar kinds of results were also reported by Kumar and Palve (1995) in white jute and Sengupta *et al.*, (2005) in *tossa* jute.

The cross OIJ-268 x S-19 recorded higher fibre yield (27.1 g/plant) with significant positive heterosis (68.88%) followed by

OIJ-248 x OMU-19 (21.5 g/plant, 34.02%),OIJ-165 X OIN-255 (20.9g/plant, 29.88%)and OIJ-05 x JRO-204 (20.1g/plant, 24.9%). These hybrids are of considerable practical importance and can be directly used to exploit heterosis for higher fibre yield.

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