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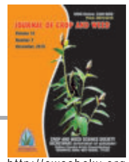

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Combining ability and heterosis for fibre yield, fibre quality and yield attributing traits in tossa jute (*Corchorus olitorius* L.) under normal and drought conditions

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ABSTRACT

Combining ability and heterosis analysis was carried out with 9 parents including 6 lines and 3 testers, in line x tester design in Corchorus olitorius L. under normal and drought condition. The significance of GCA variance was found in days to 50% flowering, stomatal breadth at 45 and 75 days, plant height and fineness under normal and drought, stomatal breadth at 30 days, node number, base and top diameter in normal and green weight, dry stick weight and fibre weight in drought. The significant SCA variance was observed in all the traits in both the conditions except for base diameter in normal and days to 50% flowering in drought.Under drought, OIJ 177 was found good combiner for node number, mid diameter, green and fibre weight, while, JRO 632 was superior for node number and length, mid and top diameter, green weight, dry stick and fibre weight. JRO524 X OIJ177, JRO632 X OEX29, OIN970 X OIJ177, JRO8432 X OIJ177, JRO3690 X OIN791 and JRO8432 X OEX29 were found having significant desirable SCA effect in drought for a number of yield attributing traits may give rise to useful transgressive segregations in advance generations.

Keywords: *Corchorus olitorius*, drought tolerant, GCA, heterosis, line x tester, SCA, tossa jute

Jute, adorably called as "Golden Fibre", is extracted from the bark of plant. *C. olitorius*, one of the cultivated species of jute, belongs to Malvaceae family, contributing 2n=24 number of chromosomes. The *olitorius* species, commonly known as tossa jute is believed to be originated in Africa. Jute is completely biodegradable and recyclable. In India, West Bengal is leading state in raw production of jute and it is followed by Bihar, Assam, Odisha, Uttar Pradesh, Meghalaya and Tripura. Tossa jute covers 90% of the area for the production while white jute covers only 10% area of the total jute in India.The government expert committee has proposed raw jute supply for 2022-23 to be 18 per cent which is higher than in 2021-22 to 95 lakh bales. The jute leaves are very nutritious, to beta carotene, rich in iron, protein, calcium, thiamine, riboflavin, niacin, and dietary fiber besides they provide greens or pot herb after blanching in hot water (Sawarkar *et al*., 2015).

Among abiotic stresses, drought is the most important abiotic factors that affect the growth and development. In jute cultivation, initial establishing of seedling is most important event which rarely happens due to uncertain moisture reserve in the soil profile coupled with high temperature in summer months (March to May), which frequently leads to crop failure or poor fibre yield (Sawarkar *et al*., 2016). In the era of climate change, because of unfavourable climatic conditions, jute fibre yield and quality are gradually decreasing nowadays. The two components i.e. temperature and rainfall are mostly responsible for the drought environment and also dominating components in the jute production. Due to the fluctuating temperature accompanied with erratic rainfall, jute is often subjected to phasic spell of moisture stress during early growth stage which might cause 20 to 30% loss of fibre yield and decrease the fibre quality (Yumnam *et al*., 2017 and Dhar *et al*., 2018). The evergrowing population, global warming, inadequacy and unsuitability water resources are depleting rapidly (Boamah *et al*., 2011). Furthermore, the selection of favourable genotypes with desirable traits needs to detected in developing high yielding varieties. However, limited breeding work has been carried out for improving yield and its components in jute using combining ability. Combining ability studies help in identifying potential lines to get desirable segregates in hybridization (Kumar and Palve, 1995). In order to choose appropriate parents and crosses

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among various mating designs used for assessing the breeding value of parents in early generation, line x tester analysis method has been used widely by plant breeders. The present study evaluated parents and hybrids produced from line x tester mating design. The aim of this study was to determine the general combining ability of the parents and the specific combining ability and the heterosis of the hybrids in the breeding programme to develop high yielding variety under drought condition.

MATERIALS AND METHODS

The experiment was conducted at the Instructional Farm, Bidhan Chandra Krishi Viswavidyalaya, Jaguli, West Bengal under two environments, i) fully irrigated field and ii) drought stress field. In the experiment line x tester design was followed where 9 parents were chosen on the basis of various yield contributing and drought resistance traits. The parents were 3 testers viz., OEX 29, OIJ 177, OIN 791 and 6 lines viz., JRO 524,JRO 632, JRO 3690, JRO 8432 , OIJ 214 and OIN 970.

18 F_1's along with their parents were sown in randomised block design with three replications. The recommended agronomical package of practices were followed. The major recommended nutrients doses of 40 N: 20 P: 20 K kg per hectare was applied, where Phosphrous and Potash were applied as basal dose before sowing, considering physical and chemical properties of soil, presented in Table 1. Intercultural operations like weeding, hoeing and thinning were done after 21 days of germination.

The individual plot size was 2m long and 60 cm wide with a spacing of 30 cm between rows and 7 cm between plants within the rows.Under normal condition irrigation was given in different growth stages– 1st irrigation- presowing, 2nd irrigation- after 15 days of sowing, 3rd irrigation- 21 days after 2nd irrigation and 4th irrigation-30 days after 3rd irrigation.The drought condition was created in the field by watering the field upto 50% field capacity (half of the field capacity of the field) before sowing. When the plants started dying (failed to recover from wilting next morning) the drought field again watered for half of the field capacity except days to 50% flowering, which was studied on plot basis stomatal length(μm) and breadth(μm) at 30, 45 and 75 days were taken under electronic microscope (Nayeem and Dalvi,1989). The plant height (main stem from ground level to the point of forking at pre-bud stage) (cm), node number (nodes on the main stem from soil surface to technical height), node length (length between two nodes), basal, mid and top diameter (using Vernier calliper scale) (cm), bark thickness (using Vernier calliper scale) (mm), green weight (weight of stick/core after retting, fibre extraction and drying) (g), dry stick weight (g), fibre tenacity ((g/tex) and fineness(tex) and fibre weight (g) were recorded from ten plants randomly selected from each parent and cross from each replication of two environments. The fibre tenacity or strength was determined by fibre bundle strength tester and fibre fineness was measured by airflow method using Airflow Fibre Fineness Tester in replicated samples (Singh and Bandyopadhyay,1968), which is widely used for assessing fineness in natural fibres. Heterosis of each was calculated based on parents vs. crosses, sum of squares by partitioning the sum of squares of the genotype to its components. The general combining ability (GCA) variance of parents and the specific combining ability(SCA) variance of hybrids were estimated via line x tester variance analysis according to Singh and Chaudhury (1985).

RESULTS AND DISCUSSION

Analysis of variance

The analysis of variance for yield and its contributing traits under normal and drought conditions were shown in Table 2. All the traits studied under drought and regular irrigation conditions, the mean squares of the genotypes with respect to parents, crosses, and parents vs. crosses, were significantly different except fibre weight in normal condition, indicating the presence of diverse germplasm resulting into diverged hybrids. Under drought condition parent vs hybrid was significantly differed for all the yield attributing characters except for node number. On the contrary, Ghoshdastidar and Das (1982) found significant variation among parents only for plant height and variation among hybrid and parent vs hybrid was significant for plant height, basal diameter and fibre yield. Kumar *et al.* (2011) reported defficient in significant differences among parents, hybrids and parent vs hybrid. In present investigation under normal condition there were no significant differences among parent vs. hybrid for base diameter, bark thickness, green weight and fibre tenacity. Only lines showed significant variation for few characters viz. days to 50% flowering, stomatal breadth at 45 and 75 days, plant height and node number in normal condition and days to 50% flowering, stomatal breadth at 45 and 75 days and fibre weight in drought conditions indicating the prevalence of additive gene effect on these characters. Significance of parent vs. hybrid for all the characters except base

Table1: Physical and chemical properties of experimental soil before sowing

Soil properties			Values			Method used
Mechanical						
Sand(%)			53.83			International, Pipette method (Piper, 1966)
Silt (%)			26.37			-do-
Clay(%)			19.80			-do-
Texture			Sandy loam			
Chemical						
Soil pH			6.9			Buck mains pH meter method (Jackson, 1973)
Physical	0-15cm	15-30 cm	30-45cm	45-60 cm	60-70 cm	
Bulk density (gcc^{-1})	1.42	1.45	1.50	1.53	1.58	Field method (Bodman,1942)
Field capacity (%)	22.86	21.54	20.10	18.48	18.12	Field method (Coleman,1944)

diameter, bark thickeness, green weight and fibre tenacity under normal condition indicated prevalence of heterosis for all the characters. The significant lines x tester interaction was observed in all the characters except for days to 50% flowering and base diameter under normal and for days to 50% flowering under drought environment which provided the evidences of the importance of interaction effect other than lines or testers on most of the characters under the two distinct environments. Under normal condition stomatal length at 30, 45, 75 days, internode length and green weight were evident to have higher magnitude of interaction component due to line x tester interaction than either due to lines or testers and node number in drought condition and mid diameter, bark thickness and fibre tenacity under both the conditions which indicated the predominance of non additive gene action in the expression of these characters. On the other hand, days to 50% flowering, stomatal breadth at 30, 45 and 75 days, plant height, base and top diameter, dry stick weight, fibre fineness and fibre weight under both the conditions and stomatal length at 30 and 75 days, green weight under drought and node number under normal conditions had lower magnitude of interaction component than either due to lines or testers indicating that these characters were predominantly controlled by additive genes.

Genetic variance

Various genetic variances from line x tester design for yield attributing traits are represented in Table 3.The estimate of predictability ratio revealed the predominance of non additive gene action for all the yield attributing characters studied in both the conditions except for days to 50% flowering. The presence of low estimate of narrow sense heritability in all the characters indicated that these characters were controlled by non additive gene action and hence heterosis breeding may be feasible to make the most use of dominance gene action. The significance of GCA variance was found for days to 50% flowering, stomatal breadth at 45 and 75 days, plant height and fineness under both normal and drought condition, stomatal breadth at 30 days, node number, base and top diameter in normal and green weight, dry stick weight and fibre weight in drought environment. Significant SCA variance was observed in all the characters in both the conditions except for base diameter in normal and days to 50% flowering in drought environment. However, Kumar and Palve (1995) reported GCA and SCA was highly significant for all the characters, except for base diameter for GCA and fibre percentage for SCA. Singh (1973) also showed significant SCA and GCA for all the characters except base diameter for GCA. Higher SCA variance than GCA variance was observed in both the stress and normal condition for all the yield attributing characters except for days to 50% flowering, stomatal breadth at 45 days under both conditions and fibre yield in case of drought situation indicating that the above mentioned characters were predominantly controlled by additive gene action.Ghoshdastidar and Das (1982) also reported higher estimate of SCA variance from GCA for plant height and fibre yield. However, Palve and Kumar (1991) found higher GCA variance than SCA variance for plant height, basal diameter, node number, days to 50% flowering, dry stick weight and fibre yield. Alam and De (1995) found that both GCA and SCA variances were highly significant for base diameter, plant height, green weight and node number while SCA variance only was significant for dry stick weight and fibre weight. Presence of both additive and non additive genetic components in the expression of plant height, node number, days to flowering and fibre yield and additive component for base diameter was reported by Palve and Kumar (1991). Ghoshdastidar and Das (2003) and

Table 2: Analysis of variance of yield attributing characters of F_1 generation along with 9 parents of *C. olitorius* under normal and drought condition in field

Sources of variation	d.f.	Days to 50% flowering		Stomata length 30days (µm)		Stomata length 45days (µm)		Stomata length 75days (µm)		Stomata breadth 30days (µm)		Stomata breadth 45days (µm)		Stomata breadth 75days (µm)		Plant height (cm)		Node number		Inter-node length (cm)	
		N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D
Replication	2	18.630	17.439	0.020	0.001	0.020	0.003	0.021	0.003	0.004	0.0001	0.004	0.0001	0.007	0.001	113.32	98.645	6.168	0.871	0.041	0.031
Genotypes	26	23.308***	42.309***	1.139***	0.417***	1.010***	1.436***	0.610***	1.187***	0.097***	0.239***	0.176***	0.239***	0.103***	0.181***	1526.462***	1336.901***	33.759***	58.066***	0.080***	0.134***
Parents (P)	8	32.584***	104.586***	2.194***	0.465***	2.260***	3.122***	0.461***	2.682***	0.057***	0.375***	0.159***	0.375***	0.066***	0.407***	1684.159***	2048.771***	16.642***	78.052***	0.041**	0.343***
P vs H	1	84.503***	31.997*	8.126***	0.769***	3.879***	5.269***	7.043***	2.507***	0.898***	0.165***	0.406***	0.165***	0.406***	0.055***	4890.572***	6689.350***	105.133***	0.463	0.104**	0.042*
Hybrids(H)	17	15.344*	13.608*	0.231***	0.3744***	0.252***	0.4168***	0.302***	0.4054***	0.068***	0.17986***	0.171***	0.17986***	0.103***	0.08192***	1254.36***	687.053***	37.615***	52.049***	0.096***	0.041***
L effect	5	47.768***	29.869*	0.123	0.4118	0.111	0.4317	0.186	0.4480	0.138	0.51427***	0.487***	0.51427***	0.257**	0.20749**	2752.94*	1321.875	69.983*	23.262	0.093	0.046
T effect	2	0.667	12.668	0.065	0.2442	0.060	0.1667	0.197	0.1674	0.019	0.03312	0.054	0.03312	0.023	0.00860	670.76	490.306	43.632	17.007	0.051	0.029
L X T effect	10	2.067	5.666	0.319***	0.3817***	0.361***	0.4593***	0.381***	0.4317***	0.043***	0.0420***	0.036***	0.0420***	0.042***	0.03380***	621.79***	408.991***	20.228***	73.452***	0.107***	0.040**
Error	34	6.920	6.511	0.0074	0.0069	0.0078	0.0073	0.0081	0.0077	0.0015	0.00121	0.0014	0.00121	0.0025	0.00227	47.028	38.533	2.466	3.490	0.0146	0.011

Sources of variation	d.f.	Base diameter (cm)		Mid diameter (cm)		Top diameter (cm)		Bark thickness (mm)		Green weight (g)		Dry stick weight (g)		Fibre tenacity (g/tex)		Fibre fineness (tex)		Fibre weight (g)	
		N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D
Replication	2	0.0033	0.003	0.0013	0.001	0.0011	0.001	0.003	0.001	79.94	2.946	0.454	0.790	0.761	0.166	0.009	0.007	0.181	0.102
Genotypes	26	0.003**	0.010***	0.007***	0.017***	0.003***	0.014***	0.024***	0.004***	192.213***	686.981***	8.223***	38.461***	0.990***	5.677***	0.061***	0.410***	0.255***	4.634***
Parents (P)	8	0.003*	0.019***	0.004***	0.032***	0.003***	0.028***	0.044***	0.004***	142.085***	1241.580***	3.375***	67.377***	1.291***	12.708***	0.042***	0.457***	0.102	4.234***
P vs H	1	0.001	0.045***	0.005**	0.022***	0.012***	0.004***	0.0002	0.046***	37.559	1027.555***	6.341***	30.371***	0.966	0.015***	0.357***	0.013*	0.548**	1.538***
Hybrids(H)	17	0.0032**	0.0043***	0.0089***	0.0100***	0.0027***	0.0079***	0.016***	0.0012*	224.90***	405.959***	10.616***	25.329***	0.850**	2.702***	0.053***	0.412***	0.309***	5.004***
L effect	5	0.0056	0.0052	0.0043	0.0084	0.0034	0.0147	0.006	0.0013	220.26	359.864	13.754	45.945	0.824	2.368	0.074	0.613	0.349	12.813**
T effect	2	0.0029	0.0030	0.0043	0.0103	0.0054	0.0003	0.009	0.0000	68.67	917.147	0.860	13.342	0.389	0.745	0.079	0.410	0.254	2.614
L X T effect	10	0.0020	0.0040***	0.0121***	0.0107***	0.0017***	0.0060***	0.022***	0.0013*	258.47***	326.768***	10.998***	17.418***	0.955**	3.260***	0.037***	0.311***	0.300***	1.578***
Error	34	0.0012	0.0010	0.0005	0.0004	0.00040	0.0003	0.0010	0.0005	29.176	19.411	0.186	0.356	0.281	0.064	0.0030	0.003	0.065	0.040

*Significant at 5% level ** Significant at 1% level *** Significant at 0.1% level

Table 3: Genetic variance from Line X Tester analysis for yield attributing traits of *C. olitorius* under normal and drought condition in field

Sources of variation	Days to 50% flowering		Stomata length 30days (µm)		Stomata length 45days (µm)		Stomata length 75days (µm)		Stomata breadth 30days (µm)		Stomata breadth 45days (µm)		Stomata breadth 75days (µm)		Plant height (cm)		Node number		Inter-node length (cm)	
	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D
σ^2gca	1.320 ***	1.134**	0.006	0.024	0.006	0.022	0.014	0.022	0.006*	0.007	0.020 ***	0.020 ***	0.010**	0.008**	123.519 **	64.585*	4.037**	1.253	0.004	0.002
σ^2sca	-1.445	-0.097	0.104 ***	0.125 ***	0.118 ***	0.151 ***	0.124 ***	0.141 ***	0.014 ***	0.021 ***	0.012 ***	0.014 ***	0.013 ***	0.011 ***	192.484 ***	124.933 ***	5.972***	23.412 ***	0.031 ***	0.010 **
σ^2A	2.640	2.268	0.013	0.048	0.012	0.043	0.027	0.044	0.011	0.013	0.040	0.040	0.020	0.016	247.039	129.170	8.073	2.506	0.009	0.004
σ^2D	-1.445	-0.097	0.104	0.125	0.118	0.151	0.124	0.141	0.014	0.021	0.012	0.014	0.013	0.011	192.484	124.933	5.972	23.412	0.031	0.010
h^2 % (N.S.)	79.302	54.564	10.799	27.229	8.779	22.010	17.660	23.602	44.321	38.306	76.607	74.251	59.505	58.227	54.378	48.652	54.491	9.286	19.607	22.858
σ^2A/ σ^2D	-1.827	-23.361	0.124	0.381	0.098	0.287	0.219	0.314	0.824	0.634	3.397	2.964	1.556	1.483	1.283	1.034	1.352	0.107	0.279	0.399
$\frac{\sigma_A^2}{\sigma_A^2+\sigma_D^2}$	2.209	1.045	0.110	0.276	0.089	0.223	0.180	0.239	0.452	0.388	0.773	0.748	0.609	0.597	0.562	0.508	0.575	0.097	0.218	0.285

Sources of variation	Base diameter (cm)		Mid diameter (cm)		Top diameter (cm)		Bark thickness (mm)		Green weight (g)		Dry stick weight (g)		Fibre tenacity (g/tex)		Fibre fineness (tex)		Fibre weight (g)	
	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D
σ^2gca	0.0002*	0.0002	0.0003	0.001	0.0003*	0.001	0.0005	0.00002	8.727	46.056*	0.529	2.172*	0.026	0.111	0.005*	0.038*	0.018	0.569 ***
σ^2sca	0.0003	0.001 ***	0.0039 ***	0.003 ***	0.0005***	0.002 ***	0.0070***	0.00030**	77.270 ***	103.339 ***	3.610 ***	5.697 ***	0.231 **	1.067 ***	0.011 ***	0.103 ***	0.080 ***	0.514 ***
σ^2A	0.0005	0.0005	0.0006	0.001	0.0006	0.001	0.0010	0.00004	17.453	92.112	1.057	4.343	0.051	0.222	0.011	0.075	0.036	1.138
σ^2D	0.0003	0.001	0.0039	0.003	0.0005	0.002	0.0070	0.00030	77.270	103.339	3.610	5.697	0.231	1.067	0.011	0.103	0.080	0.514
h^2 % (N.S.)	40.613	26.161	12.294	27.186	50.842	35.088	12.109	7.966	16.845	45.819	22.388	42.793	13.830	16.951	47.106	42.047	26.371	68.389
σ^2A/ σ^2D	1.528	0.455	0.146	0.387	1.310	0.561	0.144	0.127	0.226	0.891	0.293	0.762	0.221	0.208	0.967	0.732	0.448	2.212
$\frac{\sigma_A^2}{\sigma_A^2+\sigma_D^2}$	0.604	0.312	0.128	0.279	0.567	0.359	0.126	0.112	0.184	0.471	0.227	0.433	0.181	0.172	0.491	0.423	0.309	0.689

Table4: Proportional contribution of lines, testers and their interactions to the total variance for different yield attributing characters of *C. olitorius* under normal and drought condition in field

Sources of variation	Days to 50% Flowering		Stomata length 30days (µm)		Stomata length 45days (µm)		Stomata length 75days (µm)		Stomata breadth 30days (µm)		Stomata breadth 45days (µm)		Stomata breadth 75days (µm)		Plant height (cm)		Node number		Inter-node length (cm)	
	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D
Lines	91.565	64.555	15.668	32.351	12.971	30.464	18.133	32.502	59.688	43.386	83.762	84.095	73.502	74.494	64.550	56.588	54.720	13.145	28.376	33.249
Testers	0.511	10.951	3.319	7.674	2.812	4.704	7.697	4.857	3.213	9.410	3.683	2.166	2.658	1.235	6.291	8.396	13.646	3.844	6.253	8.317
LineXTester	7.924	24.493	81.013	59.975	84.217	64.832	74.171	62.641	37.099	47.203	12.556	13.739	23.840	24.271	29.159	35.017	31.633	83.011	65.371	58.434

Contd...

Sources of variation	Base diameter (cm)		Mid diameter (cm)		Top diameter (cm)		Bark thickness (mm)		Green weight (g)		Dry stick weight (g)		Fibre tenacity (g/tex)		Fibre fineness (tex)		Fibre weight (g)	
	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D
Lines	51.657	36.009	14.346	24.846	37.817	54.755	11.195	33.005	28.805	26.072	38.107	53.351	28.518	25.780	41.271	43.790	33.246	75.310
Testers	10.767	8.277	5.670	12.139	23.816	0.517	6.984	0.409	3.592	26.579	0.953	6.197	5.379	3.244	17.682	11.707	9.682	6.146
LineXTester	37.577	55.715	79.984	63.015	38.366	44.728	81.821	66.586	67.603	47.349	60.940	40.452	66.103	70.976	41.047	44.503	57.072	18.544

Table5: General combining ability (gca) effects of 9 parents for yield attributing traits of *C. olitorius* under normal and dought condition in field

Parents	Days to 50% Flowering		Stomata length 30days (µm)		Stomata length 45days (µm)		Stomata length 75days (µm)		Stomata breadth 30days (µm)		Stomata breadth 45days (µm)		Stomata breadth 75days (µm)		Plant height (cm)		Node number	
Lines (gi)	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D
JRO3690	0.722	1.111	-0.011	0.025	0.040	0.017	0.047	0.092**	0.097***	0.191***	0.278***	0.164***	-0.011	0.058***	25.806***	15.778***	2.546***	-1.370*
OIJ214	2.389**	2.444**	0.043	0.041	0.027	0.052	0.071**	0.052	0.191***	0.005	0.417***	0.423***	0.118***	0.089***	-10.794***	0.556	-2.009***	0.963
JRO524	1.722*	0.444	-0.162***	-0.391***	-0.177***	-0.349***	-0.229***	-0.385***	-0.053***	-0.037**	-0.003	-0.073***	0.158***	0.034*	12.206***	8.111***	3.435***	1.963**
JRO8432	-1.944*	-0.889	-0.057	0.127***	0.088**	0.011	0.027	0.046	0.136***	0.035**	-0.021	0.231***	0.320***	-0.279***	6.206**	-3.222	0.880	0.463
OIN970	-3.611***	-2.889**	0.193***	0.236***	0.111***	0.333***	0.180***	0.296***	0.001	-0.150***	0.038**	0.124***	0.056**	0.053***	6.628**	0.111	1.009	0.407
JRO632	0.722	-0.222	-0.006	-0.037	-0.089**	-0.064*	-0.100**	0.003	0.100***	0.047***	0.149***	0.078***	0.019	0.150***	24.795***	20.222***	3.813***	2.426***
SE (gi)	**0.843**	**0.814**	**0.029**	**0.027**	**0.029**	**0.029**	**0.030**	**0.029**	**0.013**	**0.012**	**0.012**	**0.011**	**0.016**	**0.015**	**2.220**	**1.949**	**0.507**	**0.598**
Tester (gj)																		
OIJ177	-0.111	0.111	0.056**	-0.085***	0.022	-0.092***	0.041	-0.110***	0.016	-0.044***	0.044***	0.023**	0.020	0.006	2.078	-4.556**	1.259**	1.093*
OIN791	0.222	0.778	0.064**	0.133***	0.066**	0.100***	0.073***	0.072**	-0.037***	-0.023*	-0.061***	-0.049***	0.022	0.018	6.872***	-1.139	1.741***	0.324
OEX29	-0.111	-0.889	-0.008	-0.047*	-0.044*	-0.008	-0.119***	0.038	0.021*	0.068***	0.017	0.036**	-0.042***	-0.024*	-4.794**	5.695***	-0.482	0.769
SE (gj)	**0.596**	**0.575**	**0.020**	**0.019**	**0.021**	**0.020**	**0.021**	**0.021**	**0.009**	**0.009**	**0.009**	**0.008**	**0.011**	**0.011**	**1.570**	**1.378**	**0.358**	**0.423**

*Significant at 5% level ** Significant at 1% level *** Significant at 0.1% level

Contd...

Parents	Inter-node length (cm)		Base diameter (cm)		Mid diameter (cm)		Top diameter (cm)		Bark thickness (mm)		Green weight (g)		Dry stick weight (g)		Fibre tenacity (g/tex)		Fibre fineness (tex)		Fibre weight (g)	
Lines	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D
JRO3690	0.164***	0.044	0.010	0.015	0.022**	-0.003	-0.006	0.00001	0.007	0.003	5.111**	-4.111**	-0.327*	3.458***	-0.414*	0.196*	-0.066***	0.088***	-0.113	-0.048
OIJ214	-0.136**	-0.063	-0.021	-0.006	-0.006	-0.022**	0.023**	-0.062***	0.040***	0.016*	4.444*	4.556**	0.573***	1.512***	0.088	-0.286**	0.058**	-0.420***	-0.009	2.216***
JRO524	0.022	0.096**	0.010	0.029**	0.004	0.036***	0.018**	0.003	0.031**	0.008	1.222	9.778***	1.184***	2.042***	0.263	-0.865***	0.135***	-0.117***	0.092	-0.247***
JRO8432	-0.008	0.051	0.016	0.008	-0.006	0.047***	-0.029***	-0.015**	-0.011	0.003	-3.889*	-1.111	1.340***	-2.375***	0.306	0.022	-0.012	0.096***	0.338***	0.798***
OIN970	0.027	-0.020	0.025*	-0.005	-0.033**	-0.009	-0.012	0.010*	-0.019	-0.019**	2.778	2.880*	1.094***	-0.542**	0.086	0.542***	0.122***	-0.011	0.229**	0.716***
JRO632	-0.071	0.085*	-0.040**	-0.041***	0.027**	0.023**	0.006	0.063***	0.014	0.004	-7.222***	7.556***	-1.677***	-1.042***	-0.329	0.391***	0.007	0.364***	-0.079	0.998***
SE (gi)	**0.038**	**0.034**	**0.011**	**0.010**	**0.007**	**0.007**	**0.006**	**0.005**	**0.010**	**0.007**	**1.721**	**1.364**	**0.137**	**0.191**	**0.170**	**0.081**	**0.018**	**0.018**	**0.082**	**0.062**
Tester (gj)																				
OIJ177	0.055	0.046	-0.014	0.003	0.016**	0.023***	-0.003	0.005	0.016*	0.001	1.444	8.222***	-0.188	-0.250	-0.165	-0.160**	0.061***	0.125***	0.136*	0.342***
OIN791	0.052	0.021	0.003	0.011	0.002	0.001	0.015**	0.001	0.026***	0.002	2.222	4.611***	0.052	-0.708***	0.117	0.229***	0.009	0.013**	0.054	0.069
OEX29	-0.003	-0.025	0.011	-0.014	-0.014**	-0.025***	0.019***	-0.003	0.009	0.001	0.778	-3.611***	0.240*	0.958***	0.048	-0.069	0.070***	-0.168***	-0.082	-0.411***
SE (gj)	**0.027**	**0.024**	**0.008**	**0.007**	**0.005**	**0.005**	**0.005**	**0.004**	**0.007**	**0.005**	**1.217**	**0.965**	**0.097**	**0.135**	**0.121**	**0.057**	**0.013**	**0.013**	**0.058**	**0.044**

*Significant at 5% level ** Significant at 1% level *** Significant at 0.1% level

Table 6: Specific combining ability (SCA) effects of F_1 hybrids for yield attributing traits of *C. olitorius* under normal and drought condition in field

Hybrids	Days to 50% Flowering		Stomata length 30days (µm)		Stomata length 45days (µm)		Stomata length 75days (µm)		Stomata breadth 30days (µm)		Stomata breadth 45days (µm)		Stomata breadth 75days (µm)		Plant height (cm)		Node number		Inter-node length (cm)	
	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D
JRO3690 X OIJ177	0.555	1.445	0.396***	0.340***	0.454***	0.398***	0.365***	0.403***	0.010	-0.133***	-0.098***	-0.149***	0.129***	-0.131***	0.778	4.889	1.426	0.648	0.120	0.024
JRO3690 X OIN791	1.111	0.889	0.305***	-0.398***	0.387***	-0.521***	0.383***	-0.475***	0.103***	0.243***	-0.010	0.041*	-0.023	0.128***	-0.472	3.972	2.408***	0.565	-0.147*	-0.007
JRO3690 X OEX29	0.556	0.556	0.091	0.059	-0.067	0.123*	0.018	0.022	-0.064**	-0.109***	0.106***	0.107***	-0.101***	0.003	0.306	8.861*	0.982	1.213	0.267***	0.031
OIJ214 X OIJ177	-0.222	0.222	0.265***	-0.093	0.279***	-0.107*	0.230***	-0.097	0.054*	0.030	0.015	0.135***	0.012	-0.058*	3.078	13.222***	2.648**	2.648*	0.075	0.028
OIJ214 X OIN791	0.444	1.556	0.019	0.093	0.050	0.084	0.034	0.032	-0.214***	-0.091***	0.068***	0.061**	0.001	0.061*	8.872*	-10.194**	2.185*	-3.102**	0.042	0.012
OIJ214 X OEX29	-0.222	-1.778	0.216***	-0.0001	0.228***	0.072	0.196***	0.065	0.160***	0.067**	0.083***	0.199***	-0.013	-0.003	5.795	-3.078	-0.463	0.454	-0.117	-0.040
JRO521 X OIJ177	0.444	1.222	0.473***	0.560***	0.462***	0.578***	0.450***	0.544***	0.025	0.071**	-0.092***	0.014	0.056	0.081**	2.422	-17.444***	-2.963**	0.852	0.012	0.027
JRO524 X OIN791	-0.889	-0.444	0.201***	-0.148**	0.018	-0.158**	0.012	-0.135*	0.126***	0.073**	0.037	0.075	-0.029	-0.014	9.128*	7.639*	3.703***	-0.935	-0.037	-0.066
JRO524 X OEX29	0.444	0.778	-0.272***	-0.412***	-0.444***	-0.420***	-0.493***	-0.410***	-0.100***	-0.144***	0.056*	0.011	0.027	0.067*	6.705	9.805**	0.741	1.787	0.025	0.093
JRO8432 X OIJ177	-0.889	-1.444	-0.001	-0.150**	0.159**	-0.283***	-0.025	-0.187***	-0.013	0.023	0.058**	-0.084***	0.176***	0.115***	14.578***	12.389***	2.907**	-8.685***	0.139*	0.163**
JRO8432 X OIN791	0.778	0.111	0.079	0.032	0.024	0.151**	-0.223***	0.012	0.038	-0.121***	-0.110***	0.010	0.193***	-0.127***	-23.872***	4.028	1.093	5.065***	0.163*	0.003
JRO8432 X OEX29	0.111	1.555	0.080	0.117*	0.183***	0.131*	0.218***	0.229***	0.051*	0.098***	0.052*	0.094***	-0.017	0.012	9.294*	-8.361*	1.815*	3.620**	0.302***	-0.166**
OIN970 X OIJ177	0.778	0.556	-0.254***	0.148**	-0.196***	0.086	-0.308***	0.129*	0.090***	0.124***	0.024	0.0002	0.080**	0.021	3.411	1.944	1.118	0.630	0.078	0.035
OIN970 X OIN791	-0.556	-1.111	0.213***	0.156**	0.060	0.147**	0.185**	0.184***	-0.051*	-0.137***	0.074**	-0.060**	-0.048	-0.098***	11.461**	2.639	1.148	3.954***	0.002	-0.085
OIN970 X OEX29	-0.222	0.555	0.011	0.008	0.136*	0.061	0.123*	0.055	-0.039	0.013	0.051*	0.060**	0.128***	0.119***	-14.872***	0.694	-2.296*	3.324**	-0.080	0.018
JRO632 X OIJ177	0.444	0.889	0.349***	-0.509***	0.282***	-0.500***	0.253***	-0.535***	0.066**	-0.114***	0.093***	0.111***	0.060*	0.014	19.422***	-11.111**	0.648	6.870***	0.185**	-0.175**
JRO632 X OIN791	-0.889	-0.778	0.293***	0.265***	0.319***	0.296***	0.345***	0.386***	0.074**	0.034	0.089***	0.060**	-0.090**	0.051	12.628**	-0.078	-1.352	5.546***	-0.022	0.141*
JRO632 X OEX29	0.444	-0.111	0.056	0.244***	-0.037	0.205***	-0.092	0.148**	-0.008	0.081***	-0.182***	-0.051*	0.031	-0.065*	6.795	11.139**	0.703	-1.324	0.207**	0.034
SE(ij)	**1.461**	**1.409**	**0.050**	**0.047**	**0.050**	**0.050**	**0.052**	**0.050**	**0.022**	**0.021**	**0.021**	**0.019**	**0.028**	**0.026**	**3.845**	**3.376**	**0.878**	**1.036**	**0.067**	**0.059**

*Significant at 5% level ** Significant at 1% level *** Significant at 0.1% level

Contd...

Hybrids	Base diameter (cm)		Mid diameter (cm)		Top diameter (cm)		Bark thickness (mm)		Green weight (g)		Dry stick weight (g)		Fibre tenacity (g/tex)		Fibre fineness (tex)		Fibre weight (g)	
	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D
JRO3690 X OIJ177	-0.010	-0.018	-0.008	0.057***	-0.004	-0.013	-0.076***	0.006	4.889	3.445	1.555***	0.750*	-0.287	-0.385**	-0.117***	0.406***	-0.283	-0.501***
JRO3690 X OIN791	0.010	-0.017	0.024	-0.005	0.024*	0.027**	0.032	-0.018	-8.444**	5.278*	-0.882***	2.208***	0.644*	0.028	0.139***	-0.409***	0.354*	0.832***
JRO3690 X OEX29	0.000	0.056*	0.016	-0.051***	0.021	-0.014	0.011**	0.012	3.333	-8.722***	-0.673**	-2.958***	0.357	0.358*	0.022	0.002	0.071	-0.330**
OIJ214 X OIJ177	-0.015	0.011	0.064***	0.060***	-0.030*	-0.012	0.140***	0.010	0.556	-5.222*	0.355	0.750*	-0.353	0.019	-0.133***	-0.132***	0.150	-0.203
OIJ214 X OIN791	0.009	0.033	-0.052***	-0.055***	0.008	0.018**	-0.088***	0.002	3.222	2.389	0.282	0.791**	0.259	-1.059***	0.048	0.039	-0.448**	0.297**
OIJ214 X OEX29	0.074	0.023	-0.012	-0.005	0.037**	-0.006	0.053**	-0.008	-3.778	7.611**	-0.073	0.042	0.094	1.040***	0.085*	0.093**	0.298*	0.500***
JRO524 X OIJ177	0.013	0.032	-0.083***	0.027**	0.026	0.038***	-0.096***	0.007	5.222	6.111**	-1.423***	-3.083***	0.136	0.213	0.105**	0.036	0.139	1.348***
JRO524 X OIN791	0.071	0.025	0.014	-0.019	-0.006	0.010	0.038*	-0.010	0.889	-3.056	0.107	0.625	-0.086	0.485**	-0.055	-0.265***	0.32*	-0.342**
JRO524 X OEX29	0.034	-0.057**	0.070***	0.046***	0.020	-0.048***	0.059**	0.017	6.111*	-3.056	1.316***	2.458***	0.051	-0.272	0.049	0.229***	0.182	-1.006***
JRO8432 X OIJ177	-0.006	0.021	0.078***	0.041***	0.018	0.057***	0.088***	0.018	-6.111*	8.444**	-1.112***	0.917**	0.209	1.648***	0.143***	-0.439***	0.081	-0.127
JRO8432 X OIN791	0.002	0.026	-0.052***	0.022	0.026*	-0.055***	0.039*	0.008	3.333	5.722*	-1.048***	0.542	0.759*	-1.456***	-0.087**	0.477***	0.284	0.183
JRO8432 X OEX29	0.004	0.005	-0.076	-0.019	0.008	-0.002	0.018**	0.027*	2.556	-2.722	2.160***	0.375	0.549	-0.192	-0.056	-0.037	0.365*	0.310**
OIN970 X OIJ177	0.012	0.002	0.035**	-0.044***	0.001	-0.058***	-0.061**	-0.026*	5.222	4.445	2.521***	-1.250***	0.449	-0.388**	0.055	0.013	0.112	0.052
OIN970 X OIN791	0.016	0.015	-0.004	0.018	0.006	0.032***	0.027	0.001	6.889*	5.278*	-0.615*	0.209	0.334	1.069***	0.035	0.003	0.234	0.051
OIN970 X OEX29	0.028	0.013	0.040**	0.026*	0.005	0.026**	0.035**	0.025*	-12.111***	-9.722***	-1.906***	1.042**	0.784*	-0.682***	0.020	0.010	0.123	0.103
JRO632 X OIJ177	0.006	-0.044*	-0.015	-0.087***	-0.009	-0.013	0.006	-0.001	9.778**	-17.222***	1.896***	3.750***	-0.155	-0.881***	0.057	0.142***	0.025	-0.567***
JRO632 X OIN791	-0.039	0.037*	0.070***	0.083***	0.010	0.032***	0.030	0.021	-6.111*	0.611	2.719***	2.792***	-0.393	0.934***	-0.080*	0.135***	-0.103	-0.081
JRO632 X OEX29	0.033	0.007	-0.056***	0.003	0.000	0.044***	-0.036*	-0.020	15.889***	16.611***	-0.823**	-0.958**	0.548	-0.253	0.023	-0.297***	0.079	0.629***
SE(ij)	**0.019**	**0.017**	**0.013**	**0.011**	**0.011**	**0.009**	**0.017**	**0.012**	**2.981**	**2.363**	**0.097**	**0.330**	**0.295**	**0.141**	**0.031**	**0.031**	**0.142**	**0.107**

*Significant at 5% level ** Significant at 1% level *** Significant at 0.1% level

Table 7: Six important crosses with their status in respect to general combining abilities of involving parents, specific combining abilities, average heterosis and heterobeltiosis for fibre yield under normal condition in field

Sl.No.	High *per se* performance crosses	General Combining Ability (GCA)	Specific Combining Ability(SCA)	Relative heterosis (MP)	Heterobeltiosis (BP)
1.	JRO8432 X OIN791	HXP	-	5.27**	-
2.	JRO8432 X OIJ177	HXH	-	3.56*	-
3.	JRO524 X OIJ177	PXH	-	-	-
4.	OIJ214 X OIJ177	PXH	-	-	-
5.	OIJ214 X OEX29	PXP	0.30*	-	-
6	JRO3690 X OIN791	PXP	0.35*	-	-

Table 8: Six important crosses with their status in respect to general combining abilities of involving parents, specific combining abilities, average heterosis and heterobeltiosis with respect for fibre yield under drought condition in field

Sl.No.	High *per se* performance crosses	General Combining Ability (GCA)	Specific Combining Ability (SCA)	Relative heterosis (MP)	Heterobeltiosis (BP)
1.	JRO524 X OIJ177	PXH	1.35***	17.58**	-
2.	JRO632 X OEX29	HXP	0.63***	27.08**	26.96**
3.	OIN970 X OIJ177	HXH	Non significant	31..35**	30.96**
4.	JRO8432 X OIJ177	HXH	-	30.38**	30.37**
5.	JRO3690 X OIN791	PXP	0.83***	10.81**	-6.26**
6	JRO8432 X OEX29	HXP	0.31**	22.97**	20.14**

Table 9: Four important crosses with their status in respect to general combining abilities of involving parents, specific combining abilities with high *per se* performance of fibre quality characters and high fibre yield under normal condition in field

Sl.No.	High *per se* performance	Fibre tenacity	Fibre tenacity GCA	Fibre tenacity SCA	Fibre fineness GCA	Fibre fineness SCA	Fibre fineness
1.	JRO8432 X OIJ177	Present	AXP	-	Present	PXP	0.14***
2.	JRO3690 X OIN791	Present	PXA	0.64*	Present	PXP	0.14***
3.	JRO524 X OIJ177	-	-	-	Present	HXP	0.10**
4.	OIJ214 X OEX29	-	-	-	Present	HXH	0.08*

Table 10: Four important crosses with their status in respect to general combining abilities of involving parents, specific combining abilities with high *per se* performance of fibre quality characters and high fibre yield under drought condition in field

Sl.No.	High *per se* performance	Fibre tenacity	Fibre tenacity GCA	Fibre tenacity SCA	Fibre fineness GCA	Fibre fineness SCA	Fibre fineness
1.	JRO8432 X OIJ177	Present	AXP	1.65***	-	-	-
2.	OIN970 X OIJ177	-	-	-	Present	PXH	-
3.	JRO524 X OIJ177	-	-	-	Present	PXH	-
4.	JRO3690 X OIN791	Present	HXH	-	-	-	-

Khatun *et al*. (2010) also observed importance of both the additive and non additive gene action for yield and its attributing traits and Palve and Kumar (1994) reported the same for fibre strength. Sengupta *et al*. (2005) observed that most yield and its attributing traits including fibre tenacity, fibre fineness were controlled by non-additive gene action except basal diameter while Kumar *et al*. (2002) and Khatun *et al*. (2010) supported the predominant role of additive genetic variations for yield and its attributing traits.

Contribution of lines, testers and their interaction

The contribution of lines, testers and their interaction are represented in Table 4. The expressions of each trait were shown in the form of contribution of line, tester and interaction between them. The contributions were much affected by their growing condition. Contributions of line x tester were high for all the characters except for days to 50% flowering, stomatal breadth at 45 and 75 days, plant height under both conditions and stomatal breadth at 30 days, node number, base diameter under normal and top diameter, dry stick weight and fibre weight under drought condition.

General combining ability

Jute being a self pollinated crop, GCA effects of the parent would be more important than SCA effects since the ultimate unit of selections is a true breeding type.The general combining ability of parents of yield related characters under normal and drought condition in field are represented in Table 5. Parents with high GCA effects for different traits indicate preponderance of additive gene action with large adaptability and could be extensively used in hybridization program as donor parents for their improvement (Khatun *et al*., 2010). Under normal environment, JRO 3690 was found best general combiner for five characters like plant height, internode length, mid diameter, green weight and dry stick weight and it was followed by OIJ 214 for node number, top diameter, bark thickness, green weight. Among testers, OIJ 177 was found as good general combiner for four important characters like node number, mid diameter, bark thickness and fibre weight. While under drought condition, JRO 632 was found superior for a number of characters like node number, internode length, mid and top diameter, green weight, dry stick weight and fibre weight and among testers OIJ 177 could be considered as good which showed good general combining abilities for node number, mid diameter, green weight and fibre weight. Similar results of high estimate of GCA for yield and its attributing traits were earlier reported Palve and Kumar (1991) and Kumar and Palve (1995) for earliness to flowering and. Palve and Kumar (1994) recorded high GCA for fibre strength and fibre fineness by Sengupta *et al.* (2005).

Specific combining ability

The desirable specific parental combinations for yield and its components are presented in Table 6. SCA effects for the crosses can estimate non additive impact. All the crosses in both normal and drought environments failed to show significant negative SCA estimates for days to 50% flowering. Highest significant positive SCA estimates for stomatal length at 30 and 45 days was found in JRO524 × OIJ177 and cross JRO3690 x OIJ177 at 75 days involving parents with poor x poor general combining abilities under both conditions. In case of stomatal breadth, highest significant positive SCA were found at 30 days, OIJ214 x OEX29 involving high x high general combining abilities under normal, JRO3690 x OIN791 having high x poor parental combinations under drought, at 45 days, hybrid JRO3690 x OEX29 involving high x high under both conditions and at 75 days, JRO3690 x OIJ177 under normal and JRO3690 x OIN791 under drought involving high x poor combinations. Under normal condition, highest negative SCA effect was found in JRO524 × OIJ177 for number of nodes involving high x poor combination of parents. Highest SCA effect was found in JRO3690 × OEX29 with highest *per se* performance involving high x poor general combining abilities for internode length, JRO8432 × OIJ177 (poor x high) with highest *per se* performance for mid diameter, OIJ214 × OEX29 (high x high) with highest *per se* performance for top diameter, OIJ214 × OIJ177 (high x high) for bark thickness, JRO632 × OEX29 (poor x average) for green weight, OIN970 × OEX29 (poor x high) for dry stick weight, JRO3690 × OIN791(high x high) for fibre tenacity, JRO8432 × OIJ177 (poor x poor) for fibre fineness and JRO3690 × OIN791(poor x poor) for fibre weight. Under drought condition, significant positive SCA effect for plant height was found in OIJ214 × OIJ177 (poor x poor) with high *per se* performance,for node number revealed in JRO8432 × OIJ177 (average x poor), for internode length, only two crosses were found i.e. JRO8432 × OIJ177 and JRO632 × OIN791 involving average x average and high x poor general combining parents respectively. In case of base diameter, JRO632 × OIN791 and JRO3690 × OEX29 had highest positive significant SCA effect involving poor x average and average x poor general combiners respectively, while for mid diameter, JRO632 × OIN791 (high x average) with highest *per se* performance and for top diameter, JRO8432 × OIJ177 cross showed highest SCA effect along with highest *per se* performance in drought condition. Palve and Kumar (1991) reported high SCA estimate for plant height, number of node, basal diameter and dry stick weight. Further in drought condition, only cross OIN970 × OEX29 was found to have highest and significantly positive SCA estimate with high *per se* performance involving poor and average general combining parents for bark thickness, JRO632 × OEX29 (high x poor) for green weight, JRO524 × OIJ177 (high x high) for dry stick weight, JRO8432 × OIJ177 (average x poor) for fibre tenacity, JRO8432 × OIN791 (high x high) for fibre fineness and JRO524 × OIJ177 (poor x high) for fibre weight.

The cross with superior SCA effect may be result of the combination of parents with difference in general combining abilities, for example, high x high, high x poor and poor x poor. There is no strong relation in high x high combination of parents resulting in to high SCA effect always. This might be due to the internal cancellation of gene effect in parents or the lack of genetic diversity in the involving parents of the specific crosses (Jones, 1958, Singh and Gupta, 1969). On the contrary, the interaction of dominant genes contributed by both the parents having high GCA may generate superior hybrid and such crosses may be exploitable following simple breeding methods like pedigree selection to get desirable segregants. The good and poor general combiners from superior hybrids could be due to dominant and recessive type interaction with non additive and non fixable genetic component. In such situation, random mating and selection among segregants could help to isolate transgressive segregants at later part of selection cycle. The parentage of the hybrid belonging to poor combining abilities may be due to interaction at higher order and found to be highly non fixable , but it could provide desirable segregants by adapting cyclic selection or biparental breeding strategies.

From the present investigation, under normal irrigated condition, 61 crosses and under drought 73 crosses showed significant desirable SCA effect of which under normal conditions these were grouped into 7 (high x high), 30 (high x poor) and 24 (poor x poor) and that under drought as 15(high x high), 37 (high x poor) and 21(poor x poor), respectively.The most important yield attributing characters indicating five important crosses and were highlighted under normal field condition viz., JRO8432 × OIJ177, JRO3690 × OIN791, JRO524 × OIJ177, OIN970 × OEX29 and OIJ214 × OEX29 and in droughtc ondition the crosses were JRO8432 × OIJ177, JRO632 × OIN791, JRO632 × OEX29, JRO524 × OIJ177 and OIJ214 × OEX29. Among crosses, JRO8432 × OIJ177, JRO524 × OIJ177 and OIJ214 × OEX29 were common in both conditions. Of all the crosses, OIJ214 × OEX29 was found as superior hybrid showing significant desirable SCA effect for a number of yield attributing characters in drought environment of field. Another important cross, JRO8432 × OIJ177 also showed significant SCA effect in the normal environment. Similar results were obtained by Kumar and Palve (1995), Alam and De (1995), Sengupta *et al.* (2005) and Khatun *et al.* (2010) who reported high SCA for fibre yield and its attributing traits.

Important crosses with their status in respect to general combining abilities of involving parents, specific combining abilities, average heterosis and heterobeltiosis for fibre yield and fibre quality under normal and drought condition

Six important crosses with respect to their general combining abilities of involving parents, specific combining abilities, average heterosis and heterobeltiosis for fibre yield in normal and drought condition are presented in Table 7 and 8. Under normal condition JRO8432 × OIN791, JRO8432 × OIJ177, JRO524 × OIJ177, OIJ214 × OIJ177, OIJ214 × OEX29 and JRO3690 × OIN791 and under drought condition such important crosses were JRO524 × OIJ177, JRO632 × OEX29, OIN970 × OIJ177, JRO8432 × OIJ177, JRO3690 × OIN791 and JRO8432 × OEX29. Of these six crosses, the *per se* performance of JRO8432 × OIJ177, JRO524 × OIJ177 and JRO3690 × OIN791 was found superior in both drought and normal irrigated environments. Under normal situation, only one cross JRO8432 × OIJ177 had parents with high general combining abilities whereas in drought environment the above mentioned cross along with OIN970 × OIJ177 involved parents with high general combining abilities and these crosses will help to isolate desirable segregants following simple breeding method. Under normal situation, remaining three crosses involved parents where one of them possessed high general combining abilities and other two crosses the parents have poor general combining abilities. In contrast, under drought condition significant desirable SCA effect was noticed in OIJ214 × OEX29 and JRO3690 × OIN791 which suggested that interaction of dominance and epistatic gene action was involved in expression of yield characters and complex breeding method like cyclic selection could be advocated for identification of desirable lines. The crosses JRO524 × OIJ177, JRO632 × OEX29, JRO8432 × OEX29 had significant SCA effect involving one of the parents with high general combining abilities and for which the dominant and additive gene action was found to be equally responsible in expression for this character. But, JRO3690 × OIN791 with high yield positive significant SCA effect involved poor x poor general combining parents and for which complex breeding method should be followed to obtain desirable line. All these crosses under normal environment failed to show heterobeltiosis but average heterosis was exhibited in two crosses JRO8432 × OIN791 and JRO8432 × OIJ177. But in drought environments, all the crosses showed significant average heterosis and significant heterobeltiosis in JRO632 × OEX29, OIN970 × OIJ177, JRO8432 × OIJ177, JRO8432 × OEX29 and from these crosses high yielding stable segregants may be obtained from advance generation of selection. However, under drought environment, JRO3690 × OIN791 had shown negative heterobeltiosis, so this cross might not show equally potentiality to obtain high yielding segregants surpassing the *per se* performance of the hybrids.

Four important crosses with respect to their general combining abilities of involving parents, specific combining abilities, average heterosis and heterobeltiosis for fibre yield are presented in Table 9 and 10. JRO8432 × OIJ177, high yielding hybrid showed superior performance for fibre tenacity as well as fibre fineness under normal condition and this cross also showed superior performance for yield and fibre tenacity in drought environment. JRO3690 × OIN791 showed superior fibre tenacity in both the environment. High yielding hybrids OIJ214 × OEX29 under normal environment was found superior for fibre fineness while OIN970 × OIJ177 was superior for both yield and fibre fineness in drought environment. Under normal environment, JRO3690 × OIN791, JRO524 × OIJ177 and OIJ214 × OEX29 could be considered in combination breeding from their stable segregants to complement deficiency either for fibre tenacity or fibre fineness with an aim to develop high yielding jute with superior fibre quality. Similarly, all the four crosses as outlined in drought environments may be combined with their stable segregants to fulfil the same target.

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