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Research Article

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Estimation and utilization of heterosis and heterobeltosis for yield and yield contributing traits in tossa jute hybrids (F_1) derived from diverse germplasms

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ABSTRACT
Development of high yielding jute variety through the artificial hybridization followed by selection on the basis of heterosis and heterobeltosis are the prerequisites for the breeders. The present study was performed to investigate the heterosis and heterobeltosis effects of 17 hybrids obtained from 15 parents. There are 11 accessions, 2 advanced breeding lines and 2 pre-released varieties of tossa jute having different morpho-phenological characters that were used as breeding parents. The parents were grown under field conditions during September'2020 and hybridization was done during December'2020. The hybrids along with the parents were grown for morphological observation during March-December'2021 in the experimental field at BJRI, Dhaka. Highly significant morpho-genetical variations were observed among the hybrids comparing with their respective parents. Among all the 17 hybrids, the hybrid (F_1) of O-049-1-3 (R) ×Acc.1331 showed positive heterosis over mid parent and better parent for yield contributing characters like fibre (59.57%) and stick weight (76.22%); followed by the hybrids (F_{1s}) of O-049-1-3 (R) × Acc. 3718, O-049-1-3 (R) × O-043-7-9(G), O-043-7-9(G) × O-049-1-3 (R) and Acc. 3424 × Acc. 1334 for the studied characters, respectively. The parents including Acc. 1361, Acc.4311, BJRI Tossa Pat-5 and BJRI Tossa Pat-8 exhibited higher mean performance for the yield contributing traits. Among all the hybrids, five hybrids (29.41%) showed positive result (heterobeltosis) than the respective better parents in respect of fibre yield. These hybrids may be considered for further evaluation in respect of achieving homozygosity followed by developing high yielding tossa jute varieties in Bangladesh.
Keywords: Jute; heterosis; heterobeltosis; fibre yield; jute hybrid.

INTRODUCTION
Crossing between two genetically different plants produces a hybrid. These F_1 hybrids are usually created by means of controlled pollination, sometimes by hand pollination. The F_1 generation refers to the first filial generation. Breeders need to search variability for developing a new variety (Caligari *et al*., 2015). Diverged parental lines promote improved growth and yield characteristics in offspring through the phenomenon of heterosis (hybrid vigour or combining ability). Two populations of breeding stock with desired characteristics are subjected to inbreeding until the homozygosity of the population exceeds a certain level, usually 90% or more. The single cross hybrids (F_1) are grown in one row by standing parents in both sides for evaluating the true hybrid (Sahagún-Castellanos, 2011). The performance means and positive heterosis over mid parent and better parent, heterosis for yield contributing characters for plant height, base diameter, fiber yield and stick yield will be measured so that F_1 hybrids and heterosis can be exploited to create genetic variability followed by the selection of high yielding genotypes to establish superior lines. However, in segregating generations, the degree of heterosis is a key factor for use (M.Y. Muhammad *et al.,* 2014). In China, field experiments on hybrid cotton have brought about 20-30% increase in production (Ansari, 2011). Hybrid cotton seed offer many advantages over the conventional variety seed such as increase in productivity, tolerance to abiotic stresses (drought, heat, cold) and is highly responsive to inputs (Ali, 2011).

MATERIALS AND METHODS
The experiment was conducted at experimental field of BJRI, Dhaka (coordinates: 23° 46' N and 90° 23' E; and with elevation of *sea level*: 23 m), Bangladesh in March to December 2021. The seeds of F_1 hybrid (cross from 2020) along with their parents were sown in row in one meter length followed by the Randomized Complete Block Design. The plants identical to parental plants were discarded, heterozygous plants as like as in mid parents or better performer than parents were the true hybrids. For the estimation of heterosis and heterobeltosis, 98 single crosses were done in

2020 and among them 17 crosses were found successful. Estimate their heterosis and heterobeltosis in terms of plant height, base diameter, fresh weight, fibre yield, stick yield and other characters. The planting density was 20 plant/1m row and space between planting rows was 30 cm. After 120 days of sowing cut the plant at the base. Fresh weight of the plant with leaf and without leaf, base diameter and plant height are taken. Then the plant is emerged under water tank for 20 days for ratting without changing water. After 20 days fiber remove from the stick and wash properly used clean water and take them sun dry. After drying the fiber and stick properly than take weight by electronic balance. The analysis of variance and mean comparisons were performed by using the statistical software's name Sirichai statistics 6.07. The heterosis and heterobeltiosis are calculate by following formula (Falconer, 1989).

$$\text{Heterosis } (\%) = \frac{\text{F1}-\text{MP}}{\text{MP}} \times 100$$

$$\text{Heterobeltosis } (\%) = \frac{\text{F1}-\text{BP}}{\text{BP}} \times 100$$

Where, MP= Mid-parent; BP= Better parent

RESULTS AND DISCUSSION

Heterozygous plants that performed as mid parents or better than the parents (in respect to different characteristics) were considered as the true hybrids. Considering fiber yield, when estimating relative heterosis, seven hybrids out of 17 (O-049-1-3 (R) × Acc. 3718; O-049-1-3 (R) × Acc.5138; O-049-1-3 (R) × O-043-7-9(G); O-049-1-3 (R) × Acc.1331; O-043-7-9(G) × O-049-1-3 (R); Acc. 3424× Acc. 1334 and Acc. 1136 × O-049-1-3 (R)) were found having more yield than the mid parent and the increase in yield ranged from 2.7% (O-043-7-9(G) × O-049-1-3 (R)) to 126.2% (O-049-1-3 (R) × Acc.1331) (Table 1) . But considering heterobeltosis, only five hybrids (O-049-1-3 (R) × Acc. 3718; O-049-1-3 (R) × O-043-7-9(G); O-049-1-3 (R) × Acc.1331; O-043-7-9(G) × O-049-1-3 (R) and Acc. 3424 × Acc. 1334) had positive result regarding fiber yield and increase the yield in this case ranged from 2.09% (O-049-1-3 (R) × Acc. 3718) to 59.57% (O-049-1-3 (R) × Acc.1331) (Table 2, Fig 1). Considering relative heterosis, out of 17 crosses, seven hybrids had positive heterosis for plant weight with leaf, similarly six crosses for plant weight without leaf, four for plant height, seven for base diameter and six crosses had positive heterosis for stick yield (Table 1). The highest plant weight with leaf (66.5%), plant weight without leaf (80.9%), plant height (22.5%), base diameter (50.4 %) and stick yield (149.8 %) were found in the cross-combination O-049-1-3 (R) × Acc.1331 followed by the cross combination Acc. 1136× O-049-1-3 (R) and cross combination O-049-1-3 (R) × Acc. 3718 (Table 1). Again, when calculating heterobeltosis, four hybrids had shown positive result for plant weight with leaf, where four crosses for plant weight without leaf, one for plant height, seven for base diameter and seven crosses had positive heterosis for stick yield (Table 2). In this regard, the highest plant weight without leaf (33.55 %), plant height (3.28 % which is also the only positive heterobeltosis found for plant height), base diameter (33.8 %) and stick yield (76.22 %) were found in the hybrid namely O-049-1-3 (R) × Acc.1331 and the highest plant weight with leaf (28.40 %) was found in the hybrid O-043-7-9(G) × O-049-1-3 (R) (Table 2). Besides these, Table 3 shows the mean performance of different characters of the parents used.

Table 1. Mean performance of F_1 hybrids and percentage increase (+) or decrease (-) over mid parent (relative heterosis).

Sl.	F1 hybrids	Plant weight with leaf (%)	Plant weight without Leaf (%)	PH (%)	BD (%)	FY (%)	St Y (%)
1.	O-049-1-3 (R) × Acc. 3718	24.8	32.6	0.9	19.3	33.4	37.0
2.	O-049-1-3 (R) × Acc.5138	1.3	-6.4	-4.2	5.73	18.1	36.3
3.	O-049-1-3 (R) × O-043-7-9(G)	4.2	5.6	2.6	-6.1	27.8	19.9
4.	O-049-1-3 (R) × Acc.1331	66.5	80.9	22.5	50.4	126.2	149.8
5.	O-043-7-9(G) × O-049-1-3 (R)	17.6	13.3	-9.1	8.9	2.7	15.4
6.	Acc. 3424× Acc. 1334	-13.6	-14.1	-10.5	-5.46	17.1	-6.2
7.	Acc. 3424× O-049-1-3 (R)	-37.7	-36.0	-18.0	7.2	-27.7	-15.9
8.	Acc. 4546× Acc. 4582	-65.1	-69.4	-23.1	-27.5	-53.2	-39.9
9.	Acc. 3718×O-049-1-3 (R)	-38.6	-39.8	-20.3	-13.5	-44.7	-42.7
10.	Acc.3727× BJRI Tossa Pat-5	-6.0	-4.4	-9.6	-4.7	-19.2	-17.4
11.	Acc.3727× O-049-1-3 (R)	-10.1	-15.0	-14.6	1.7	-22.7	-10.0
12.	Acc.4311× O-049-1-3 (R)	-40.3	-41.8	-23.2	-4.2	-34.1	-34.8
13.	Acc.4582× BJRI Tossa Pat-8	-38.4	-41.4	-15.4	-8.3	-25.4	-32.5
14.	Acc. 3424× O-049-1-3 (R)	-26.5	-30.9	-17.2	-1.2	-24.1	-34.8
15.	Acc. 5138× O-049-1-3 (R)	-0.2	-12.9	-5.6	-1.9	-3.7	-3.8
16.	Acc. 1263× O-049-1-3 (R)	3.1	8.0	-3.7	3.8	-23.4	-10.2
17.	Acc. 1136× O-049-1-3 (R)	60.1	63.5	15.6	-17.7	15.6	53.3
	Mean	20.6	23.9	-1.8	6.9	-2.2	83.5
	CV%	186.21	193.18	-541.1	247.98	-1950.43	1387.76
	LSD $_{0.05}$	62.11	74.85	15.79	27.75	69.12	83.53

Note: PH = Plant height; BD = Base diameter; FY= Fiber yield; St Y= Stick yield

Table 2. Mean performance of F_1hybrids and percentage increase (+) or decrease (-) over better parent (heterobeltiosis).

Sl.	F_1 hybrids	Plant weight with leaf (%)	Plant weight without Leaf (%)	PH (%)	BD (%)	FY (%)	St Y (%)
1.	O-049-1-3 (R) × Acc. 3718	16.36	14.86	-7.68	9.92	2.09	38.05
2.	O-049-1-3 (R) × Acc.5138	-12.06	-18.53	-12.35	0.3968	-7.16	48.67
3.	O-049-1-3 (R) ×O-043-7-9(G)	-2.10	-1.11	-2.76	-6.19	15.82	17.36
4.	O-049-1-3 (R) × Acc.1331	27.06	33.55	3.28	33.8	59.57	76.22
5.	O-043-7-9(G) × O-049-1-3 (R)	28.40	24.07	-3.94	9.67	2.72	51.00
6.	Acc. 3424× Acc. 1334	-32.2	-33.61	-16.45	-14.28	6.34	-26.02
7.	Acc. 3424× O-049-1-3 (R)	-28.13	-29.52	-21.81	10.0	-36.25	2.13
8.	Acc. 4546× Acc. 4582	-67.8	-71.86	-21.85	-28.7	-61.53	-26.31
9.	Acc. 3718×O-049-1-3 (R)	-44.1	-48.98	-27.25	-20.63	-58.14	-45.02
10.	Acc.3727× BJRI Tossa Pat-5	-32.63	-31.32	-21.53	-13.09	-36.61	-40.34
11.	Acc.3727× O-049-1-3 (R)	-20.73	-26.12	-23.42	-0.31	-32.81	-22.3
12.	Acc.4311× O-049-1-3 (R)	-45.40	-46.50	-21.98	-11.01	-37.48	-45.08
13.	Acc.4582× BJRI Tossa Pat-8	-50.53	-53.48	-26.23	-15.31	-40.01	-50.96
14.	Acc. 3424×	-17.76	-26.17	-16.45	0.95	-33.93	-20.91
15.	Acc. 5138× O-049-1-3 (R)	-10.96	-23.91	-13.65	-7.14	-21.01	-1.13
16.	Acc. 1263×O-049-1-3 (R)	-29.36	-29.78	-24.24	-13.96	-52.93	-40.72
17.	Acc. 1136× O-049-1-3 (R)	21.83	22.51	-2.84	0.79	-9.11	25.72
	Mean	2.71	2.051	-10.60	1.59	-20.02	-3.51
	CV%	1339.62	1956.63	-86.85	913.06	-185.00	-1850.24
	LSD $_{0.05}$	58.74	64.90	14.88	23.53	59.90	104.99

Note: PH = Plant height; BD = Base diameter; FY= Fiber yield; St Y= Stick yield

Table 3. Mean Performance of 15 parents

Sl.	Mother plant	Plant weight with leaf (gm)	Plant weight without leaf (gm)	PH (m)	BD (mm)	FY (gm)	St Y (gm)
1.	Acc. 1136	58.66	50.83	2.08	22.16	5.90	9.00
2.	Acc. 1263	39.16	31.33	1.75	9.33	2.33	5.16
3.	Acc.1331	64.83	55.33	2.10	10.00	4.50	6.83
4.	Acc. 1334	89.83	75.66	2.37	10.66	6.50	12.83
5.	Acc. 3424	161.1	137.83	2.79	13.33	9.16	26.0
6.	Acc. 3718	96.33	79.46	2.51	10.66	5.50	13.83
7.	Acc.3727	86.33	80.16	2.42	12.0	7.83	14.50
8.	Acc.4311	173.33	157.16	2.96	15.0	13.3	31.16
9.	Acc. 4546	145.33	128.0	2.40	13.0	13.0	9.50
10.	Acc. 4582	128.33	111.50	2.50	12.66	9.50	14.5
11.	Acc.5138	91.66	86.50	2.53	11.33	6.66	17.5
12.	BJRI Tossa Pat-5	195.33	178.33	3.28	14.66	14.50	38.50
13.	BJRI Tossa Pat-8	200.50	182.96	3.31	15.00	14.83	33.83
14.	O-049-1-3 (R)	148.83	132.16	3.06	13.0	11.67	24.5
15.	O-043-7-9(G)	119.0	108.66	2.75	12.66	11.67	24.5
	Mean	114.58	101.38	2.53	12.63	9.43	16.89
	CV%	22.62	21.64	6.28	41.14	29.81	35.69
	LSD $_{0.05}$	41.90	35.48	.2581	8.40	4.68	9.74

Note: PH = Plant height; BD = Base diameter; FY= Fiber yield; St Y= Stick yield

Heterosis is a commonly found biological phenomenon in nature. Heterosis refers to the heterozygote that is produced by the hybridization of two or more genetically dissimilar parents. Hybrids are superior to parents in terms of yield, growth rate, viability, and disease resistance (Hochholdinger and Hoecker, 2007). Heterosis occurs when there is net directional dominance (Jinks, 1981). The present study identified numerous useful crosses for detailed analyses of heterosis. This study was performed to find out the degree of heterosis of different agronomic characters in some hybrids of jute. It was observed that the degree and direction of heterosis varied indifferent crosses. Among the 17 crosses, few exhibited positive heterosis over mid-parent and better parent for the traits studied e.g., plant weight with leaf, plant weight without leaf, plant height, base diameter, fiber yield and stick yield. Similar result of positive heterosis over mid and better parent for plant height, basal diameter, stick weight and fiber yield were reported earlier (Roy *et al*., 2020; Palve *et al*., 1991; Kumar *et al*., 2018). Among the 17 crosses, five crosses (O-049-1-3 (R) × Acc. 3718; O-049-1-3 (R) × O-043-7-9(G); O-049-1-3 (R) × Acc.1331; O-043-7-9(G) × O-049-1-3 (R) and Acc. 3424 × Acc. 1334) showed positive heterosis over both the mid and better parents for fiber yield. Similar findings of positive heterosis in fiber yield of tossa jute was also reported by Palve 2003. One of these five crosses (O-049-1-3 (R) × Acc.1331) had 126.2% more fiber yield than the mid parent.

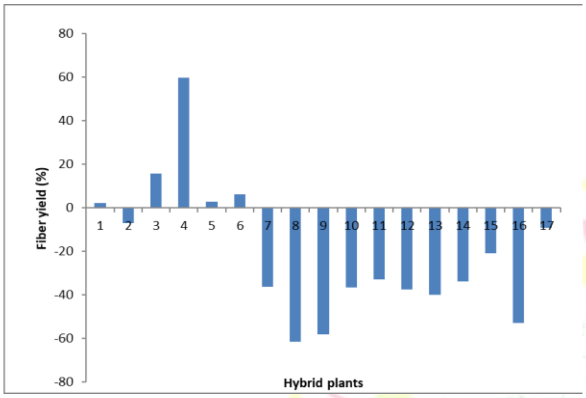

Fig1. Heterobeltosis in 17 crosses for fiber yield

Heterosis is a complex biomass phenomenon. According to different studies, the strength and formation mechanism of heterosis may be different in different biological species, different varieties of the same crop and different traits. The key to heterosis formation lies in the genetic differences between parents and the genetic basis of phenotypic differences between hybrids and their parents originates from differences in genomic composition (Wu *et al*., 2021). The degree of heterosis increases with the increase of genetic difference (Usatov *et al*., 2014; Boeven *et al*., 2020). From a study on cotton hybrids, Shahzad *et al.* (2020) found that the over dominance of gene expression levels plays a key role in the early biomass vigor. Liu *et al*., (2021) determined that the growth heterosis of hybrids is determined by the combined ability of cell division and photosynthesis and the early development of hybrid leaves might enhance the growth heterosis of hybrids. Liu *et al*., (2021) also reported that cell division and photosynthesis of hybrid plants are important components of growth vigor. These could be the reasons behind the surprising vigor of some of the hybrids studied in this experiment. So, the presence of high magnitude of heterosis for fibre yield other yield contributing characters found in different hybrids in this experiment are worth for studying further.

CONCLUSION

It is noticed that the crosses involving genotypes O-049-1-3 (Red) and Acc.1331 exhibited higher performance mean and their crosses shows positive heterosis over mid parent and better parent heterosis for yield contributing characters like fibre yield and stick weight.

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