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# Combining Ability and Heterosis Study for Fibre Yield and Yield Attributing Characters in Tossa Jute (*Corchorus olitorius* L)

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## Abstract

Present study was carried out to estimate combining ability and heterosis for fibre yield and yield attributing characters among diverse tossa jute germplasm lines and in 21 $F_1$ hybrids derived from 7 x 7 half diallel mating design. Analysis of variance revealed significance of parent's *vs* hybrids for most of the characters indicating presence of heterosis. High *gca* effects for fibre yield, plant height and green weight was recorded by OIN-255. High significant *sca* effects for fibre yield were recorded in OMU-19 x OMU-27 (19.53**) and OIN-255 x OEX-32 (15.50*) crosses. Variances for general combining ability and specific combining ability were significant for few characters indicating additive and non-additive gene actions for those characters. High standard heterosis for fibre yield was recorded by OMU-19 x OMU-27 (41.01**) and OIN-255 x OEX-32 (32.47*) crosses. Genetic parameters indicated that plant height, green weight and stick weight were controlled by additive gene action and basal diameter and fibre yield controlled by non-additive gene action.

**Keywords**

Combining ability; Heterosis; Fibre yield; Genetic parameters

## Introduction

Jute is a major bast fibre crop mainly grown in India and Bangladesh. In India, Jute is mainly grown in West Bengal, parts of Bihar, Assam and Orissa. India produces raw jute fibre of 11.41 million bales from 0.86 million ha of area with an average productivity of 23.72 q/ha in 2013– 14 (www.jutecomm.gov.in). In the year 2013-14 India exported raw jute of 216 M. tonnes worth 1880 crores even though the yields of cultivated varieties have been plateaued, as most of the released varieties were developed from few selected parents [1]. So there is an urgent need to increase the yield levels per unit area as the crop area is decreasing year by year and facing stiff competition from other highly remunerative crops.

Diallel mating designs provide information regarding combining ability, heterosis and genetic parameters useful in planning future breeding programmes. Based on the combining ability analysis, characters with high GCA effect indicate to additive gene effects and high SCA effect indicates dominant gene effects controlling those characters. And non-significance of GCA and SCA effects indicated the presence of non-allelic interactions controlling those characters [2] (Fehr, 1993). But understanding the genetic parameters for fibre yield and yield attributing characters will allow the breeders to precisely execute their breeding and selection programmes. Current study was managed to estimate the genetic parameters and the mode of inheritance for fibre yield and yield attributing traits of *Corchorus olitorius* in a set of half diallel crosses.

## Materials and Methods

Seven germplasm lines were selected based on diversity analysis and used to make 7 X 7 half diallel mating design. Twenty one $F_1$s along with parents and checks were sown in randomized complete block design with three replications. Recommended package of practices were applied to raise a healthy crop. Crop was harvested at 120 days after sowing and data for plant height, basal diameter and green weight were recorded. Data for fibre yield and stick weight was recorded after retting. The data were analyzed using INDOSTAT statistical software, Hyderabad, India, for combining ability, heterosis and genetic parameters based on Griffin's numerical (Table 1) and Haymen's graphical approach (Table 5).

## Results and Discussion

Analysis of variance revealed significant differences among treatments for all characters except for basal diameter. Parent's *vs* hybrids were significant for all the characters except for basal diameter indicating the presence of heterosis for those characters.

Significant GCA effects were observed for each fiber yield and yield attributing characters except basal diameter (Table 2). The estimated GCA effect for the seven parents significantly varied for both fiber yield and yield attributing characters. Among the genotypes, OIN-255 was the best general combiner for fiber yield, plant height and green weight. OMU-27 was also good combiner for plant height and stick weight. OMU-07 recorded negative combining ability effects for plant height, green weight, stick weight and fibre yield. Variance due to GCA were lower than the corresponding SCA variance for all the characters indicating the presence of non-additive gene action controlling the traits. The lower ratio of σ2 GCA/ σ2 SCA indicates a predominance of non-additive gene action (dominant or epistasis) in the inheritance of traits [3] (Sprague and Tatum, 1942). Non-additive gene action for fibre yield and yield attributing characters were earlier reported [4-7].

For fibre yield SCA effects were significant for only two crosses, those best specific combinations were OMU-19 x OMU-27 (19.53**) and OIN-255 x OEX-32 (15.50*) (Table 3). For plant height OMU-07 x OIN-255 (39.23*) and for green weight OMU-19 x OMU-27 (461.95**) and OIJ-211 x OEX-29 (385.15**). Some of these crosses (OIN-255 x OEX-32 for fibre yield, OMU-07 x OIN-255 for plant height) were related to their parents' GCA effects; at least one of their parents had high or average GCA effects for particular traits. Similar kinds of results were also reported [4,6-9].

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**Table 1:** Analysis of variance for fibre yield and yield attributing traits.

| Source | df | Plant height | Basal diameter | Green weight | Stick weight | Fibre yield |
|---|---|---|---|---|---|---|
| Replications | 2 | 2040.33 | 10.57 | 211318* | 1749.34 | 123.54 |
| Treatments | 27 | 2023.63** | 3.67 | 142478.4** | 4292.66** | 436.14** |
| Parents | 6 | 4601.95** | 1.34 | 135915.6 | 3420.31* | 194.66 |
| Hybrids | 20 | 759.09 | 4.18 | 127467.2* | 3539.21** | 265.34** |
| Parents vs Hybrids | 1 | 11844.62** | 7.3 | 482079.6** | 24595.67** | 5301.08** |
| Error | 54 | 796.21 | 4.14 | 62967.71 | 1406.12 | 114.56 |
| Total | 83 | 1225.47 | 4.14 | 92407.34 | 2353.38 | 219.39 |

**Table 2:** General combining ability for fibre yield and yield attributing traits.

| Parent | Plant height | Basal diameter | Green weight | Stick weight | Fibre yield |
|---|---|---|---|---|---|
| OMU-19 | 0.95 | 0.03 | -4.04 | 4.09 | 2.42 |
| OMU-07 | -23.54** | -0.12 | -102.37* | -25.69** | -5.00* |
| OIN-255 | 10.11* | 0.23 | 134.13** | 12.79 | 4.49* |
| OIJ-211 | 1.49 | 0.27 | -9.98 | -3.79 | -2.07 |
| OMU-27 | 12.87* | 0.2 | 73.73 | 14.59* | 3.28 |
| OEX-29 | 2.4 | -0.27 | -64.52 | -1.07 | -3.29 |
| OEX-32 | -4.29 | -0.33 | -26.93 | -0.93 | 0.16 |
| SE (g) | 18.64 | 1.35 | 165.76 | 24.77 | 7.07 |
| SE (gi-gj) | 28.47 | 2.05 | 253.20 | 37.84 | 10.80 |
| $\sigma^2$ GCA | 112.15 | -0.09 | 4153.37 | 126.26 | 8.611 |
| $\sigma^2$ SCA | 237.63 | 0.03 | 23395.91 | 912.39 | 115.67 |
| $\sigma^2$ GCA/ $\sigma^2$ SCA | 0.47 | -2.89 | 0.17 | 0.13 | 0.07 |
| $\sigma^2$ A | 224.31 | -0.18 | 8306.74 | 252.53 | 17.22 |
| $\sigma^2$ D | 237.63 | 0.03 | 23395.91 | 912.39 | 115.67 |

However, some of the best specific combinations (OMU-19 x OMU-27 for fibre yield, OMU-19 x OMU-27 for green weight) were obtained from parents having poor and negative GCA effects. Similar kinds of results were reported by Kumar and Palve [6] and Sengupta [7].

## Heterosis

Mean performance, specific combining ability and standard heterosis (Over JRO 2014) values were presented in Table 4. High mean fibre yield was recorded by OMU-19 x OMU-27 (16.73g) and OIN-255 x OEX-32 (15.72g) and best check JRO 204 fibre yield was 11.86 g. High significant and positive standard heterosis for fibre yield was recorded by OMU-19 x OMU-27 (41.01**) and OIN-255 x OEX-32 (32.47*) and these crosses were recorded high mean values and high SCA effects. Yield is cumulative effect of other yield attributing characters and this phenomenon can be observed in high yielding $F_1$s OMU-19 x OMU-27 and OIN-255 x OEX-32 which recorded high mean values for yield attributing characters like plant height, basal diameter, green weight and stick weight.

No hybrid was recorded significant positive standard heterosis for plant height, Basal diameter, similar reports of non-significant heterosis was by Basak and Dana [10] and green weight indicating that all hybrids were on per with the best check for these characters.

Estimates of genetic parameters D (Additive effects) and H1 (Dominance effects) were significant for plant height (1253.77* and 1201.24*) (Table 5), this indicates the presence of both additive and non-additive gene interactions governing the character. For the characters green weight (111143.00*), stick weight (4028.60*) and fibre yield (398.66*) H1 was only significant indicating the presence of non-additive gene interactions. Average degree of dominance for basal diameter (1.39), green weight (2.22), stick weight (2.46) and fibre yield (3.87) recorded more than unit value, so these characters may be governed by over dominance, whereas plant height recorded 0.98 which is equal to one indicating presence of complete dominance. Plant height (2.99) and stick weight (1.37) recorded more than unit value for the ratio of dominance/ recessive genes indicating these characters having excess of dominant genes in the parents whereas, green weight (1.09) and fibre yield (1.07) were recorded near to the value of one indicating equal proportion of dominance and recessive genes in the parents, whereas the character basal diameter recorded value less than one (0.40) indicating presence of excess of recessive genes in the parents. For the characters plant height (0.19), basal diameter (0.28), stick weight (0.22), and fibre yield (0.23) positive and negative alleles were unequally distributed (H1/H2 values) and for green weight (0.25) positive and negative alleles were equally distributed in the parents.

Environment component was significant for all the characters under study, indicating influence of environment on character expression. And these results were supported by low heritability for all the characters. Number of dominant gene groups (h2/H2) for plant height (2.27), basal diameter (0.30), green weight (0.70), stick weight (1.23) and fibre yield (2.63) were recorded.

## Conclusion

For productivity enhancement in jute, exploitation of non-additive (dominance and epistatic interaction) variance is very much needed which directly depends on estimation of combining ability and identification of superior crosses. Therefore the information generated under present work Vis a Vis identified superior crosses (OMU-19 x OMU-27 (16.73g) and OIN-255 x OEX-32 (15.72g) can

**Table 3:** Specific combining ability for fibre yield and yield attributing traits.

| Cross | Plant height | Basal diameter | Green weight | Stick weight | Fibre yield |
|---|---|---|---|---|---|
| OMU-19 x OMU-07 | 4.33 | -0.08 | -15.90 | 13.48 | 1.82 |
| OMU-19 x OIN-255 | 2.20 | -0.50 | -208.41 | -25.67 | -3.00 |
| OMU-19 x OIJ-211 | -11.34 | 0.68 | -71.59 | -24.62 | -8.90 |
| OMU-19 x OMU-27 | 9.44 | 1.66 | 461.95** | 65.19** | 19.53** |
| OMU-19 x OEX-29 | -17.82 | -1.51 | -152.98 | 56.19** | 11.44 |
| OMU-19 x OEX-32 | 19.80 | 0.67 | 98.82 | 10.05 | 5.65 |
| OMU-07 x OIN-255 | 39.23* | 0.99 | 156.71 | 27.11 | 10.08 |
| OMU-07 x OIJ-211 | 23.99 | -0.03 | 120.50 | 29.03 | 9.65 |
| OMU-07 x OMU-27 | 18.34 | 0.17 | 69.04 | 18.31 | 6.29 |
| OMU-07 x OEX-29 | 19.00 | 0.04 | 215.84 | 28.65 | 8.20 |
| OMU-07 x OEX-32 | 10.10 | -1.36 | -24.11 | -35.15 | -7.25 |
| OIN-255 x OIJ-211 | 3.59 | -2.15 | -273.10* | -27.11 | -4.18 |
| OIN-255 x OMU-27 | 8.48 | 1.10 | 49.89 | 40.09 | 5.45 |
| OIN-255 x OEX-29 | -5.03 | 2.19 | 87.63 | -3.57 | 6.30 |
| OIN-255 x OEX-32 | -23.09 | 0.27 | 317.64 | 51.22* | 15.50* |
| OIJ-211 x OMU-27 | -16.43 | -0.36 | 11.96 | -22.58 | -3.63 |
| OIJ-211 x OEX-29 | 25.29 | 2.13 | 385.15** | 22.41 | 10.13 |
| OIJ-211 x OEX-32 | 17.39 | 0.24 | -52.96 | 12.60 | 6.14 |
| OMU-27 x OEX-29 | 7.91 | 0.21 | -2.53 | 6.69 | 10.24 |
| OMU-27 x OEX-32 | 5.74 | -0.03 | -116.29 | -25.77 | 6.11 |
| OEX-29 x OEX-32 | 2.81 | -0.66 | -138.76 | 9.11 | -9.30 |
| Sij | 41.60 | 3.00 | 369.98 | 55.29 | 15.78 |
| Sij--Sik | 61.81 | 4.46 | 549.64 | 82.14 | 23.44 |
| Sij--Skl | 57.81 | 4.17 | 514.14 | 76.83 | 21.93 |

**Table 4:** Mean performance, SCA and standard heterosis of fibre yield and yield attributing traits.

| Cross | Plant height (cm) | | | Basal diameter (mm) | | | Green weight (g) | | | Stick weight (g) | | | Fibre yield (g) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | SCA | Std. heterosis | Mean | SCA | Std. heterosis | Mean | SCA | Std. heterosis | Mean | SCA | Std. heterosis | Mean | SCA | Std. heterosis |
| OMU-19 x OMU-07 | 326.6 | 4.33 | -1.74 | 14.9 | -0.08 | -6.62 | 230.51 | -15.90 | -19.97 | 36.07 | 13.48 | 25.87 | 11.53 | 1.82 | -2.81 |
| OMU-19 x OIN-255 | 358.13 | 2.20 | 7.74 | 14.84 | -0.50 | -7.04 | 239.31 | -208.41 | -16.91 | 35.93 | -25.67 | 25.41 | 12.47 | -3.00 | 5.06 |
| OMU-19 x OIJ-211 | 335.97 | -11.34 | 1.07 | 16.06 | 0.68 | 0.65 | 237.85 | -71.59 | -17.42 | 32.83 | -24.62 | 14.56 | 9.97 | -8.90 | -15.96 |
| OMU-19 x OMU-27 | 368.13 | 9.44 | 10.75 | 16.98 | 1.66 | 6.39 | 361.30 | 461.95** | 25.44 | 54.47 | 65.19** | 90.09** | 16.73 | 19.53** | 41.01** |
| OMU-19 x OEX-29 | 330.4 | -17.82 | -0.6 | 13.32 | -1.51 | -16.52 | 210.66 | -152.98 | -26.86 | 49.53 | 56.19** | 72.87** | 13.80 | 11.44 | 16.29 |
| OMU-19 x OEX-32 | 361.33 | 19.80 | 8.7 | 15.35 | 0.67 | -3.82 | 268.54 | 98.82 | -6.76 | 40.33 | 10.05 | 40.76 | 13.33 | 5.65 | 12.36 |
| OMU-07 x OIN-255 | 370.67 | 39.23* | 11.51 | 16.18 | 0.99 | 1.36 | 292.67 | 156.71 | 1.61 | 40.53 | 27.11 | 41.46 | 13.60 | 10.08 | 14.61 |
| OMU-07 x OIJ-211 | 346.8 | 23.99 | 4.33 | 15.19 | -0.03 | -4.80 | 256.60 | 120.50 | -10.91 | 37.60 | 29.03 | 31.22 | 12.20 | 9.65 | 2.81 |
| OMU-07 x OMU-27 | 352.53 | 18.34 | 6.06 | 15.33 | 0.17 | -3.95 | 263.05 | 69.04 | -8.67 | 39.13 | 18.31 | 36.58 | 12.60 | 6.29 | 6.18 |
| OMU-07 x OEX-29 | 342.73 | 19.00 | 3.11 | 14.72 | 0.04 | -7.75 | 264.76 | 215.84 | -8.08 | 38.07 | 28.65 | 32.85 | 11.67 | 8.20 | -1.69 |
| OMU-07 x OEX-32 | 327.13 | 10.10 | -1.58 | 13.26 | -1.36 | -16.94 | 224.29 | -24.11 | -22.13 | 25.33 | -35.15 | -11.59 | 9.27 | -7.25 | -21.91 |
| OIN-255 x OIJ-211 | 360.07 | 3.59 | 8.32 | 13.43 | -2.15 | -15.85 | 225.18 | -273.10* | -21.82 | 34.07 | -27.11 | 18.89 | 11.33 | -4.18 | -4.49 |
| OIN-255 x OMU-27 | 376.33 | 8.48 | 13.22 | 16.61 | 1.10 | 4.09 | 306.52 | 49.89 | 6.42 | 51.19 | 40.09 | 78.64** | 14.33 | 5.45 | 20.79 |
| OIN-255 x OEX-29 | 352.36 | -5.03 | 6.00 | 17.22 | 2.19 | 7.92 | 286.42 | 87.63 | -0.56 | 39.32 | -3.57 | 37.23 | 13.19 | 6.30 | 11.12 |
| OIN-255 x OEX-32 | 327.6 | -23.09 | -1.44 | 15.24 | 0.27 | -4.49 | 339.94 | 317.64 | 18.03 | 50.31 | 51.22* | 75.57** | 15.72 | 15.50* | 32.47* |
| OIJ-211 x OMU-27 | 342.8 | -16.43 | 3.13 | 15.19 | -0.36 | -4.85 | 270.11 | 11.96 | -6.22 | 35.33 | -22.58 | 23.31 | 11.20 | -3.63 | -5.62 |
| OIJ-211 x OEX-29 | 374.07 | 25.29 | 12.54 | 17.21 | 2.13 | 7.83 | 317.10 | 385.15** | 10.10 | 41.20 | 22.41 | 43.79 | 12.64 | 10.13 | 6.52 |
| OIJ-211 x OEX-32 | 359.47 | 17.39 | 8.14 | 15.26 | 0.24 | -4.39 | 236.99 | -52.96 | -17.72 | 39.27 | 12.60 | 37.04 | 12.53 | 6.14 | 5.62 |
| OMU-27 x OEX-29 | 368.07 | 7.91 | 10.73 | 15.22 | 0.21 | -4.64 | 256.31 | -2.53 | -11.01 | 41.73 | 6.69 | 45.65* | 13.73 | 10.24 | 15.73 |
| OMU-27 x OEX-32 | 359.2 | 5.74 | 8.06 | 14.91 | -0.03 | -6.6 | 241.07 | -116.29 | -16.30 | 35.27 | -25.77 | 23.08 | 13.60 | 6.11 | 14.61 |
| OEX-29 x OEX-32 | 345.8 | 2.81 | 4.03 | 13.8 | -0.66 | -13.53 | 208.93 | -138.76 | -27.46 | 35.47 | 9.11 | 23.78 | 9.20 | -9.30 | -22.47 |
| Check JRO 204 | 332.4 | | | 15.96 | | | 288.02 | | | 37.2 | | | 11.86 | | |
| CD value | 46.31 | | | 3.00 | | | 82.31 | | | 12.31 | | | 3.51 | | |

**Table 5:** Haymens Genetic parameters for fibre yield and yield attributing traits.

| Genetic parameters | Plant height | Basal diameter | Green weight | Stick weight | Fibre yield |
|---|---|---|---|---|---|
| D (Additive effects) | 1253.77* | -1.01 | 22549.88 | 667.31 | 26.59 |
| F (mean Fr over array) | 1224.26* | -1.21 | 4266.37 | 512.66 | 6.56 |
| H1(Dominance effect) | 1201.24* | 1.94 | 111143.00* | 4028.60* | 398.66* |
| H2 | 911.83* | 2.18 | 112124.50* | 3544.17* | 369.52* |
| E ( environment component) | 280.22* | 1.46* | 22755.31* | 472.79* | 38.30* |
| Mean degree of Dominance | 0.98 | 1.39 | 2.22 | 2.46 | 3.87 |
| Ration of genes with +/- effects | 0.19 | 0.28 | 0.25 | 0.22 | 0.23 |
| H2/H1 | 0.78 | 1.12 | 1.01 | 0.88 | 0.93 |
| Ration of dominance & recessive effects | 2.99 | 0.40 | 1.09 | 1.37 | 1.07 |
| Va (Additive gene effects) | 159.46 | -0.02 | 8651.00 | 319.54 | 24.59 |
| Vd (Dominance gene effects) | 227.96 | 0.55 | 28031.13 | 886.04 | 92.38 |
| h2/H2 (no. of gene groups) | 2.27 | 0.30 | 0.70 | 1.23 | 2.63 |
| $h^2$ (Heritability narrow sense) | 0.24 | -0.01 | 0.15 | 0.19 | 0.16 |

be of commercial importance after multi-location trials that will significantly contribute to the jute improvement programme.

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## References

1. Kar CS, Kundu A, Sarkar D, Sinha MK, Mahapatra BS (2009) Genetic diversity in jute (Corchorus spp) and its utilization: A Review. Indian J Agric Sci. 79 (8): 575-586.
2. Fehr W R (1993) Principles of Cultivar Development (Vol 1). MacMillan Publ Co, New York, USA.
3. Sprague GF, Tatum LA (1942) General and specific combining ability in single crosses of corn. J Am Soe Agron. 34: 923 -932.
4. Dastidar KG, Das PK (1982) Combining Ability and Heterosis in white Jute. Indian J Genet 42: 28-31.
5. Kumar D, Arpita D, Sanjoy S (2011) Breeding for combining yield and fibre quality in white jute (Corchorus capsularis L.) accessions. J Trop Agric 49: 72-77.
6. Kumar D, Palve SM (1995) Combining Ability studies for yield and some of its attributes in white Jute (Corchorus Capsularis L.). Indian J Gene 55: 260-263.
7. Sengupta D, Nandy S, Mitra S, Dutta P, Sinha M K, et al. (2005) Genetical study on tossa jute (Corchorus olitorius L.) for yield and quality parameters. Indian J Genet Plant Breed 65: 29-32.
8. Rahima K, Sarker R H, Sobhan MA (2010) Combining Ability for Yield and Yield Contributing Characters of White Jute (Corchorus capsularis L.). Bangla J Bot 39: 79-85.
9. Singh D P (1972) Combining Ability in Jute. Indian J Genet Plant Breed 33: 77-81.
10. Basak S K, Dana S (1971) Gene Effects and Heterosis in Jute. Indian J Genet Plant Breed 31: 480-485.

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