Plant Archives Vol. 18 No. 2, 2018 pp. 2042-2046 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

COMBINING ABILITY AND HETEROSIS FOLLOWING LINE X TESTER ANALYSIS FOR FIBER ANATOMICAL CHARACTERS IN CULTIVATED JUTE

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Abstract

The research work was conducted in the year 2011-2012 at the farm of central research institute for jute and allied fibers, Kolkata. The main aim of the research was to estimate fiber yield of different jute varieties with anatomical methods. Fiber anatomical characters such as Total bark diameter, Difference between fiber wedge tip and outer bark layer, Average length of fiber cell wedge, Average width of fiber wedge at base, Average width of fiber wedge at top, Average width of fiber wedge at middle, Number of fibre cell blocks at base, Number of fibre cell blocks at middle and Number of fiber cells in each block were analyzed using a Line × Tester mating design among nine *Corchorus olitorius* jute varieties. The hybrids along with their parents were evaluated at two plant growth stages *viz.*, 30 and 60 days age of the crop. The results showed significant variation at both the dates of observation and it was conspicuous at 60 days age. Considering GCA effects, OMU-42 among the lines and JRO-204 among the testers were superior general combiners. There were 31 combinations exhibiting significant and desirable SCA effects with respect to different characters. Such SCA effects resulted from crosses between parents with high × high, high × medium, medium × low, high × low and low × low and medium × medium general combiners. Further, in the present experiment, only 4 combinations *viz.*, OIM-45 × JRO-204 for total bark diameter, OMU-09 × JRO-524 and OMU-42 × JRO-8432 for average length of fibre cell wedge and OIM-45 × JRO-average width of fibre cell wedge at middle produced significantly desirable SCA effects at both the ages.

Key word: Jute, Combining ability, Heterosis, Line × Tester analysis

Introduction

Jute, one of the most important natural fibers is second only to cotton in amount produced and variety of uses of any vegetable fiber. Jute fibers are composed primarily of cellulose (major component of plant fibre) and lignin (major components of wood fibre). It is thus a ligno-cellulosic fibre that is partially a textile fibre and partially wood. It falls in the bast fibre category. The genus Corchorus contains 40 species, which are fairly wide distributed throughout the tropics and sub-tropical regions of Africa, America, Australia, China, Ceylon, India, Japan and Java (Kundu, 1951). Only two of them *viz.*, *C. olitorius* and *C. capsularis* are of economic importance (Cobley, 1957).

Anatomical studies have been used for the determination of fibre quality in jute (Kundu *et al.*, 1959; Maiti, 1973; Maiti *et al.*, 1977) and only a few attempts have been made to link anatomical characters with fibre yield. However, these results were genotype specific (Maiti and Satya., 2009). Nature of fibre anatomy during early stage might give a telescopic view of the quality and yield of fibre in the mature plants (Satya *et al.*, 2011). Hence genetic analysis of fibre anatomy appeared to be important since such study would provide more information on the nature of gene action for different fibre quality characters and adoption of breeding methods for further improvement.

Materials and methods:

Breeding material and crossing program

The research work was conducted in the year 2011-2012 at the farm of central research institute for jute and allied fibers, Kolkata. The main aim of the research was to estimate fiber yield of different jute varieties with

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anatomical methods. Breeding material (six genotypes including 3 released varieties, 1 mutant and 2 improved line) collected from Central Research Institute of Jute and Allied Fibers, Barrackpore, Kolkata, (West Bengal), India were grown in the Instructional Farm, BCKV Mohanpur, Nadia; (W.B.), India during summer (*Kharif*) season in 2011-12. The six *Corchorus olitorius* genotypes used in the present experiment included OIM-45, OMU-09, OMU-42, JRO-204, JRO-524 and JRO-8432 among which the former three were used as lines and the latter three as the testers.

They were crossed in a Line × Tester mating design. The nine F_1 hybrids and six parental lines were grown following Randomized Block Design (RBD) in three replications in the farm of the Central Research Institute of Jute and Allied Fibers, Barrackpore, Kolkata, (W.B) in 2012. The farm is situated at 22.87^0N latitude and 88.59^0 E longitudes at an elevation of 9.75 m MSL.

All the standard agronomic practices were followed to maintain good health of the crop till harvest. There were three rows at spacing of 30 cm between rows and 10 cm between plants for each of the F_1s and the parents. Data on nine different anatomical characters were collected from five competitive plants selected at random per replication for each of the parents and the hybrids in the following manner: A rapid and non-destructive sampling method for fiber anatomy study was used for the present study. At each harvest age (30 and 60 days), bark of 1 cm 2cm length and 0.5 cm width was carefully removed from the stem at 0.50 m height from the base of the plant with the help of cataract knife. The cut sections were immediately preserved in formalin: acetic acid: alcohol (5:15:80) solution, labeled properly and stored for further anatomical studies. Hand-free cross-sections were prepared using sharp blade and the sections after rinsing with water (5 min) to remove additional mucilage were stained with 1% safranin (aqueous) solution. Stained sections were blotted dry and mounted with a drop of glycerin on a clear glass slide with a cover slip. Observations were recorded on eleven qualitative and quantitative fiber anatomical characters under microscope (Satya *et al.*, 2011) and the data were analyzed (Windowstat, 2012).

Results and Discussion

The data recorded over two plant growth stages (30 and 60 days) were analyzed and results of the ANOVA and Combining Ability (GCA and SCA) are presented in tables 1-3.

Analysis of Variances (ANOVA)

This analysis revealed that among the 54 combinations (6 parameters × 9 characters) there were 41 combinations with significant variation at 30 days age while at 60 days age 26 combinations revealed significant variation (table 1). Therefore, the results indicate that the variation for anatomical characters which might be present at early growth stage in different genotypes may disappear at later stage of growth. However, there were 22 different combinations where significant variation at both the ages could be recorded. Such combinations are from total bark diameter (A) for all the six parameters; for difference between fibre wedge tip and outer bark layer (B) in case of hybrid and parent × hybrid;

Table 1: Analysis of variances of parents and crosses for various anatomical character of F_1 generation at 30 and 60days

Source	Df	A		B		C		D		F		G		H1		H2		I	
of variation		30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days
Replication	2	0.000	0.000	0.000	0.000	C	0.002	0.001**	0.008	0.001**	0.001	0.003**	0.000	0.622	4.422	0.622	0.022	4.866	4.022
Parents (P)	5	0.047**	0.047**	0.001*	0.001	0.002**	0.008**	0.006**	0.006	0.010**	0.010	0.011**	0.011**	2.633**	2.633	1.655	1.655	22.133**	22.133**
Lines (L)	2	0.038**	0.038**	0.000	0.000	0.008**	0.020**	0.014**	0.014	0.017**	0.017	0.018**	0.018**	5.777**	5.777*	1.000	1.000	21.00*	21.000*
Testers (T)	2	0.009**	0.009*	0.001*	0.001	0.020**	0.000	0.000	0.000	0.005**	0.005	0.005**	0.005	0.777**	0.777	3.11*	3.111	30.33**	30.333**
L and T	1	0.140**	0.140**	0.001	0.001	0.000	0.000	0.005**	0.005	0.008**	0.008	0.009**	0.009	0.055	0.055	0.055	0.055	8.000	8.000
Hybrids (H)	8	0.049**	0.170**	0.008**	0.011**	0.000	0.104**	0.007**	0.023	0.017**	0.0160	0.019**	0.058**	2.17**	10.037**	3.037**	5.666	25.416**	40.314**
P×H	1	0.011**	5.555**	0.012**	0.061**	0.007**	4.926**	0.005**	0.373**	0.016**	0.160	0.018**	0.030**	0.003	23.114**	1.070	5.633	8.533	209.79**
Error	28	0.000	0.002	0.000	0.000	0.002**	0.000	0.000	0.004	0.000	0.000	0.000	0.002	0.431	1.725	0.860	1.888	4.104	5.522

Wher Where, * Significant at 5% level of probability, ** Significant at 1% level of probability

Total bark diameter (A), Difference between fiber wedge tip and outer bark layer (B), Average length of fiber cell wedge (C), Average width of fiber wedge at base (D), Average width of fiber wedge at top (F), Average width of fiber wedge at middle (G), Number of fibre cell blocks at base (H1), Number of fibre cell blocks at middle (H2) and Number of fiber cells in each block (I)

Table 2: Estimation of Combining Ability (GCA) For Anatomical Character of F_1 at 30 and 60 Days

LINES	A		B		C		D		F		G		H1		H2		I	
	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days
OIM-45	0.077**	-0.120**	-0.008	0.005	-0.020**	-0.098**	-0.031**	-0.041	-0.001	-0.034**	0.002	-0.056*	0.185	-1.074*	-0.074	-0.889	-1.333	-2.074*
OMU-09	-0.041**	-0.009	0.016	0.023*	0.040**	-0.037**	0.007	-0.024	0.011**	-0.017*	0.016**	-0.054*	-0.593*	-0.963	0.037	-0.778	-0.556	2.593**
OMU-42	-0.036**	0.129**	-0.008	-0.027*	-0.020**	0.135**	0.024**	0.065*	-0.009*	0.051**	-0.018**	0.110**	0.407	2.037**	0.037	1.667*	1.889*	-0.519
TESTER																		
JRO-204	0.056**	0.061*	-0.043**	-0.050**	0.013*	0.047**	0.039**	-0.033	0.061**	0.017*	0.064**	0.026	0.074	0.370	0.259	-0.111	-0.222	0.549
JRO-524	-0.121**	-0.122**	-0.024*	-0.026*	0.017**	-0.099**	0.005	0.046	0.016**	0.027**	0.019**	0.015	-0.037	0.704	0.370	0.111	-1.556	-1.074
JRO-8432	0.066**	0.061*	0.068**	0.076**	-0.030**	0.052**	-0.044**	-0.014	-0.077**	-0.045**	-0.083**	-0.041	-0.037	-1.074*	-0.630	0.012	1.778*	1.815

Where, * Significant at 5% level of probability, ** Significant at 1% level of probability

A=Total bark diameter (A), Difference between fiber wedge tip and outer bark layer (B), Average length of fiber cell wedge (C), Average width of fiber wedge at base (D), Average width of fiber wedge at top (F), Average width of fiber wedge at middle (G), Number of fibre cell blocks at base (H1), Number of fibre cell blocks at middle (H2) and Number of fiber cells in each block (I)

for average length of fibre cell wedge (C) in case of parents, lines and parent × hybrid; in case of average width of fibre wedge at base (D) for parent × hybrid; in case of average width of fibre wedge at middle (G) for parents, lines, hybrids and parent × hybrid; in case of number of fibre cell blocks at base (H1) for lines and hybrids and for number of fibre cells in each block (I) for parent, lines, testers and hybrids.

Estimation of General Combining Ability (GCA)

Sprague and Tatum (1942) proposed the concept of combining ability as measure of gene action. The Combining Ability refers to the capacity of genotype to transmit superior performances of its crosses.

General Combining Ability (GCA) for Anatomical Character at 30 and 60 days

Among the lines, OM-45 revealed significantly positive GCA effect for total bark diameter (A) at 30 days only (table 2). OMU-09 exhibited significantly positive GCA effect for average length of fiber cell wedge (C), average width of fiber wedge at top (F) and average width of fiber wedge at middle (G) at 30 days age while it could do so for number of fibre cells in each block (I) at 60 days. Noticeably, OMU-42 revealed significantly desirable GCA effect for A, difference between fibre wedge tip and outer bark layer (B), C, F, G, number of fibre cell blocks at base (H1) and number of fiber cells blocks at middle (H2) at 60 days age and for average width of fibre wedge at base (D) at both the ages and for number of fibre cells in each block (I) at 30 days. Therefore, it may be stated that OMU-42 is the best general combiner considering the number of characters for which a parent exhibits significantly desirable GCA effect and also considering that unlike other parents it had significantly desirable GCA effects at 60 days age.

In case of the three testers, significantly desirable GCA effect for as many as six characters *viz.*, A, B, C and F at both the ages and for the characters D and G, at 30 days age could be recorded from JRO-204. In case of JRO-524 however, significantly desirable GCA effect could be recorded for B and F at both the ages and for C and G at 30 days age, JRO-8432 registered significantly positive GCA effect for A at both the ages and for average length of fiber cell wedge C and I at 60 and 30 days respectively. Thus the results indicate that in case of some of the parents the GCA effect for a character was significant at 30 days age but it did not persist till 60 days or the *vice versa.* Therefore, considering the GCA effect at both the ages OMU-42 among the lines and JRO-204 among the testers were the best general combiners.

Specific Combining Ability (SCA) for Anatomical Character at 30 and 60 days

In the present experiment data on nine anatomical characters of bast fibre were collected at two different ages of the F_1s generated from crossing between three lines and three testers. Thus there were 162 (9 × 2 × 9 =162) character combinations for which the SCA effects obtained (Table 3). However, there were 31 combinations exhibiting significant and desirable SCA effects with respect to different characters where eight combinations had both the parents with significantly desirable GCA effects, five combinations had high × medium combinations, four had medium × low, seven combinations had high × low and four combinations had low× low combiners and three crosses had medium × medium combiners.

Further, in the present experiment, there were 20 cross combinations where the SCA effects were significantly desirable at 30 days; 11 combinations revealed to produce significantly desirable SCA effects at 60 days and only 4 combinations *viz.*, OIM-45 × JRO-204 for total bark diameter, OMU-09 × JRO-524 and OMU-42 × JRO-8432 for average length of fibre cell wedge and OIM-45 × JRO-8432 for average width of fibre cell wedge at middle produced significantly desirable SCA effects at both the ages.

It may, therefore, be stated that desirable SCA effect of any cross combination need not necessarily depend on the level of GCA effects of the parents involved. The SCA effect is an important index to determine the usefulness of a particular cross combination for exploitation of heterosis (Peng and Virmani, 1990). Desirable SCA effect involving both the parents with desirable GCA effects indicate additive × additive effect and simple selection may be practiced for improvement. According to Dubey, (1975), the desirable performance of combination with parents having high ´ low GCA effects may be ascribed to the interaction between dominant allele from good combiner and recessive alleles from poor combiners.

Moreover, a high ´ low cross can result in strong transgressive segregants for the desired characters due to segregation of genes with strong potentials and their specific buffers. According to Singh *et al.* (1983) crosses involving one parent with significantly desirable GCA effect and the other with poor GCA effect would throw up transgressive segregates giving rise to new population, if the additive genetic system present in the good combiner and the epistatic effect present in the crosses act in a complementary fashion to maximize desirable plant attributes which could be exploited for further breeding purposes. When the crosses exhibiting positive significant SCA effects, involving one good and one poor or both poor combiners as parent that would indicate the importance of genetic divergence of parents involved in the crosses and balanced gene complexes associated with low degree of inbreeding depression. Further, high SCA effect involving medium × medium, medium × high or high × high general combiners may be exploited further using pedigree method of breeding for the development of pure lines. Similar opinion has been made by Kumar *et al.* (2006) and Shukla and Gautam (1990).

In case of total bark diameter, five cross combinations *viz.*, OIM-45 × JRO-204, OIM-45 × JRO-524, OMU-42 × JRO-204, OMU-42 × JRO-524 and MU-09 × JRO-8432 at 30 days and three *viz.*, OIM-45 × JRO-204, OMU-09 × JRO-524 and OMU-42 × JRO-8432 at 60 days recorded significantly positive SCA effect. Conspicuously, none of the crosses produced significantly positive estimates of SCA either at 30 or at 60 days age of the crop for difference between fiber wedge tip and outer bark layer. Considering Average length of fiber cell wedge, three combinations *viz.*, OIM-45 × JRO-204, OMU-09 × JRO-524 and OMU-42 × JRO-8432 at 30 days and another three *viz.*, OMU-09 × JRO-524, OMU-42 ×

Table 3: Estimation of Combining Ability (SCA) For Anatomical Character of F_1 at 30 and 60 days

CROSSES	A		B		C		D		F		G		H1		H2		I	
	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days
OIM-45 X JRO-204	.052**	0.098*	-0.008	-0.006	0.028**	0.028	0.033**	0.013	0.050**	0.003	0.048**	-0.094*	-0.074	0.407	-0.815	0.778	-2.000	2.741
OIM-45 X JRO-524	0.038*	-0.096*	0.013	0.021	-0.002	-0.032	-0.044**	-0.106*	-0.075**	-0.027*	-0.083**	-0.063	-0.630	-0.926	-0.593	-0.778	2.333	1.741
OIM-45 X JRO-8432	0.014	-0.002	-0.006	-0.015	-0.026*	0.004	0.011	0.096	0.025**	0.025	0.036**	0.156**	0.704	0.519	1.407*	0.000	-0.333	-4.481**
OMU-09 X JRO-204	-0.024	-0.160**	0.012	0.010	-0.042**	-0.170**	-0.016	-0.032	-0.035**	0.019	-0.042**	-0.063	0.037	-0.704	-0.259	-0.333	3.556*	-0.259
OMU-09 X JRO-524	-0.071**	0.343**	-0.003	-0.007	0.051**	0.227**	0.007	0.046	0.066**	-0.064**	0.060**	0.072	-0.519	0.630	0.296	0.778	-2.444	-2.926
OMU-09 X JRO-8432	0.096**	-0.183**	-0.009	-0.003	-0.009	-0.057*	0.009	-0.014	-0.031**	0.045**	-0.018*	-0.009	0.481	0.074	-0.037	-0.444	-1.111	3.185*
OMU-42 X JRO-204	0.077**	0.062	-0.004	-0.004	0.014	0.141**	-0.016	0.019	-0.015*	-0.022	-0.006	0.156**	0.037	0.296	1.074	-0.444	-1.556	-2.481
OMU-42 X JRO-524	0.033*	-0.248**	-0.010	-0.014	-0.049**	-0.195**	0.037**	0.060	0.009	0.091**	0.023**	-0.009	1.148*	0.296	0.296	0.000	0.111	1.185
OMU-42 X JRO-8432	-0.110*	0.186**	0.014	0.017	0.034*	0.054*	-0.021	-0.080	0.006	-0.070**	-0.018*	-0.147**	-1.185**	-0.593	-1.370*	0.444	1.444	1.296

Where, * Significant at 5% level of probability, ** Significant at 1% level of probability A=Total bark diameter (A), Difference between fiber wedge tip and outer bark layer (B), Average length of fiber cell wedge (C), Average width of fiber wedge at base (D), Average width of fiber wedge at top (F), Average width of fiber wedge at middle (G), Number of fibre cell blocks at base (H1), Number of fibre cell blocks at middle (H2) and Number of fiber cells in each block (I)

JRO-204, OMU-42 × JRO-8432 exhibited the significantly positive (desirable) estimates of SCA. Only two cross combinations *viz.*, OIM-45 × JRO-204 and OMU-42 × JRO-524 at 30 days age revealed significantly desirable SCA effects for average width of fiber wedge at base but none at 60 days could do so. In case of average width of fiber wedge at top, three combinations, OIM-45 × JRO-204, OIM-45 × JRO-8432 and OMU-09 × JRO-524 at 30 days and two, OMU-42 × JRO-524 and OMU-09 × JRO-8432 at 60 days produced significantly desirable SCA effects.

Considering average width of fiber wedge at middle OIM-45 × JRO-204, , OMU-09 × JRO-524 and OMU-42 × JRO-524 at 30 days and two combinations OIM-45 × JRO-8432 and OIM-42 × JRO- 204 at 60 days yielded significantly desirable SCA effects. Interestingly, for number of fibre cell blocks at base and number of fibre cell blocks at middle only one combination each at 30 days *viz.*, OMU-42 × JRO-524 and OIM-45 × JRO-8432 respectively recorded significantly positive SCA effects. In case of number of fiber cells in each block, OIM-45 × JRO-8432 and OMU-09 × JRO-8432 had significantly desirable CSA effect at 30 and 60 days respectively.

Conclusion

It may be concluded that besides the crosses which produced desirable SCA effects where both the parents had significantly desirable GCA effects the other crosses *viz.*, OIM-45 × JRO-204, OMU-09 × JRO-524, OMU-42 × JRO-8432 and OIM-45 × JRO-8432 might be prospective in future breeding programme.

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