Interspecific Hybrids of Jute between *Corchorus olitorius* L. and Semi-wild *C. capsularis* L.

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Hybridization between *Corchorus olitorius* L. and *C. capsularis* L. was repeated by changing the variety of one of the parents. Using a semi-wild species of *C. capsularis*, namely, Lalnaris as male parent instead of the cultivar D154, much F_1 hybrids were obtained whereas in the earlier cross application of hormone as well as embryo culture were necessary to obtain F_1 hybrids. When Lalnaris was used there was no necessity to use either hormone or embryo culture to obtain fruit set. The F_1 s obtained in the present investigation showed heterosis in respect of height and there was less variability in the F_2 . They also showed more pollen and seed fertility than the F_2 s reported earlier.

Introduction

By means of various techniques, such as by suppressing the formation of abscission layer at the pedicel of the pollinated flower with the help of IAA, culturing the hybrid embryos in artificial medium, using pollen of the male species grafted on to the female species, it has been possible in the past to obtain reasonably fertile F_1 hybrids between *C. olitorius* and *C. capsularis* (ISLAM and RASHID 1960. SWAMINATHAN *et al.* 1961, HAQUE and ISLAM 1969).

In spite of the initial success no improved strain could be isolated from the above hybrid derivatives. The lack of success was due to the reversion of the progeny to only parental type in F_4 and subsequent generations. Since there is a great need to evolve varieties from the cross of the above two cultivar species, attempts were made to circumvent the barrier of crossability by hybridizing the *olitorius* cultivar with (a) a semi-wild race of *capsularis* as well as with (b) F_1 s of the cross, cultivar *capsularis* x semi-wild *capsularis*. In the following account, the result of the above attempt is reported.

Materials and Methods

The following *Corchorus* species and the hybrid progenies were used in the present work:

- (1) *Corchorus olitorius* L., cv. 04, $2n=14$
- (2) *C. capsularis* L., race Lalnaris, semi-wild, $2n=14$
- (3) *C. capsularis* L., CV. D154, $2n=14$
- (4) (04 x Lalnaris) F_1
- (5) (04 x Lalnaris) F_2
- (6) (04 x (D154 x Lalnaris)) F_1

To avoid the chance of self-pollination emasculation was done on the previous evening and the flowers emasculated were covered with the paper bags/gelatine capsules. Pollination was made in the following morning between 7.30 and 8.30 A.M.

Morphology of the parental plants: For morphological description of the two cultivars of *C. olitorius* and *C. capsularis*, namely 04 and C.G. respectively Hooker's Flora of British India Vol.1 may be referred to (MASTERS 1874). Since no description of Lalnaris is available, in the following account Lalnaris has been compared with D 154.

C. capsularis L. Lalnaris: Annual, profusely branched herb, usually attaining a height of 78.2 ± 10.5 cm. Stem: bushy, red, cylindrical with a base diameter of 0.84 ± 0.01 cm, angle of branching $41.6 \pm 4.1^\circ$. Leaves: similar to cultivar but much smaller in size with smaller B/L ratio, colour green with reddish tinge, venation not pronounced like cultivar, pale red, petiole and stipule dull red like the stem color. Flower: like those of cultivar except that there are slightly smaller in size with a smaller number of stamens (17.2 ± 3.4 as against 20.0 ± 4.3 in cultivar), flower buds characterised by a red tip. Characteristics of fruit and seed are like the cultivars.

Results

(a) 04×Lalnaris and its F_1 hybrids

One hundred and thirty three crosses were made using 04 of *C. olitorius* as female and Lalnaris as male. Although the number of fruit set was 93, finally 87 fruits were harvested, of these only 34 contained viable seeds. The percentage of viable hybrid seeds was 21. Hybrid seeds along with the control parents were timely sown in rows in the experimental plot. The percentage of germination of hybrid seeds was 83 as against 97 in 04 and 98 in Lalnaris control (Table 1). A total of 163 F_1 s were obtained. Both F_1 s and their parents flowered simultaneously. Out of the 163 F_1 s 76 were branched and 87 unbranched (branches were recorded after they had been in flower). The absence of branch may be due to the imperfect penetrance of the gene responsible for branching. The F_1 s attained a greater height (275.8 ± 80.6 cm) compared to 04 control (224.0 ± 43.3 cm). The greater height attained by the F_1 s indicated that in spite of their being interspecific hybrid they showed heterosis in respect of height. The F_1 s were also dominant in respect of the base diameter.

The angle of branching was $40.6 \pm 6.7^\circ$ in the F_1 s as against 43.9° in profusely branched Lalnaris and no branching in 04. The internodal distance in the F_1 s was 5.5 ± 0.0 cm compared to 6.3 ± 1.1 cm in 04 and 2.2 ± 0.5 cm in Lalnaris indicating that the F_1 s were intermediate in respect of internodal distance. The F_1 s were also intermediate in respect of petiole length and number of seeds per fruit. B/L ratio of the leaves in the F_1 s was 0.47 ± 0.53 ; in 04 and Lalnaris these figures were 0.48 ± 0.07 and 0.09 ± 0.07 respectively.

The percentage of fertile pollen grains in F_1 s was 94.4 as against 96.1 in 04 and 98.6

Table 1. Details of crossing results

Parents	No. of crosses	No. of fruit set	% of fruit set	No. of fruits with mature seeds	Total no. of mature seeds	% of germination	
						Seeds sown	No. of seeds germinated
<i>C. olitorius</i> var 04× <i>C. capsularis</i> var Lalnaris	133	93	69	34	714	253	209 (83%)
(04×Lalnaris) F_1	38	28	73	Not observed	3429	3429	2572 (75%)
04×(D154× Lalnaris) F_1	137	90	66	27	816	356	316 (89%)

in Lalnaris. This was an interesting observation because the interspecific hybrids are usually characterised by a considerable percentage of sterile pollen. However, it was not ascertained whether all the stained PGs of the hybrid were viable. The number of seeds per fruit in F_1 s was 121.5 ± 27.1 compared to 155.2 ± 93.1 in 04 and 37.1 ± 6.4 in Lalnaris.

(b) (04×Lalnaris) F_1

Among the F_1 plants only those which showed heterosis in respect of plant height combined with smaller number of branches at the base were selected for selfing. Out of 38 F_1 selfed flowers 23 fruits were obtained and these yielded 3429 viable seeds (80%). All F_2 seeds were initially sown in seed bed. The percentage of germination was 75 (Table 1). When the F_2 s were one month old, segregation was studied in respect of stem, stipule, petiole color. It was observed that out of 2572 F_2 s, 1941 were red and 631 were green. This segregation showed a 3 : 1 ratio (P 69%).

After the above segregation study was over, nearly 450 healthy F_2 seedlings were removed at random and transplanted in plot. There were 388 mature plants for detailed study.

The F_2 s obtained a height of 175.9 ± 38.1 cm as against 275.8 ± 80.6 cm in F_1 s, 240.3 ± 52.4 cm in 04 and 78.2 ± 10.5 cm in Lalnaris. This showed that the height of F_2 s decreased compared to F_1 s and this was probably due to the fact that the F_2 s were grown at a later date than the normal time. No clear cut ratio was obtained in the segregation of branching vs non-branching character (233 unbranched and 155 branched). None of the F_2 s were found to be as tall as the control 04, a fact which suggests that the inheritance of branching character is neither monogenic nor digenic.

Out of 388 F_2 s, 283 were red and 105 were green both in their stem and stipule. The chi-square test showed a 3 : 1 ratio (p 60%).

The base diameter in F_2 s was found to decrease compared to both F_1 s and the control 04. The petiole length in F_2 s showed heterosis over F_1 s and control 04. The B/L ratio of leaves in F_2 s was 0.46 ± 0.06 as against 0.47 ± 0.00 in F_1 s and 0.39 ± 0.04 in 04.

04 was backcrossed to about 35 green and red stemmed F_2 s. Since it was observed that fruit set was not normal, 300 ppm indole acetic acid in lanolin paste was smeared around the pedicel of the pollinated flowers. The use of hormone improved the average fruit set from 58 to 78% as shown in Table 2. The fruit size was larger in hormone treated crosses.

(c) 04×(D154×Lalnaris) F_1 and its F_1 hybrids

One hundred thirty seven crosses were made using 04 as female and the apparently healthy looking selected F_1 s of the cross, D 154×Lalnaris. Although the fruit set was

Table 2. Percentage of fruit set in the backcross of (04×Lalnaris) F_2 to 04

Parents		No. of fruit treated		No. of fruit (percent of fruit set)	
Female	Male	With hormone	Without hormone	With (H)	Without (H)
04	F_2 (Green)	30	35	26 (86%)	24 (68%)
04	F_2 (Red)	30	33	21 (70)	16 (48)
Mean		—	—	— (78)	— (58)

higher (66%) comparatively a small number (27) of fruits contained viable seeds and the remaining fruits were found to contain only inviable seeds. Viable seeds were sown timely direct in the field. The percentage of germination was 89. A total of 231 mature F_1 s was obtained, of these 53 were branched and 178 were unbranched.

The F_1 s attained a height of 251.1 ± 73.9 cm compared to 224.0 ± 43.1 cm in 04 and 180.0 ± 46.6 cm in the F_1 s, D 154 and Lalnaris. The F_1 s were more vigorous and were better than 04, displaying better performance (heterosis in respect of height) of the interspecific over intraspecific hybrids.

The base diameter of F_1 s was found to be intermediate between the two parents (1.26 ± 0.35 cm in the interspecific F_1 s, 1.04 ± 0.28 cm in 04 and 1.47 ± 0.51 cm in (D 154 $\times$ Lalnaris) F_1).

The number of stamens in F_1 s was intermediate between the parents. The percentage of pollen stainability was 95.8 in F_1 s compared to 96.1 in 04 and 98.1 in (D 154 $\times$ Lalnaris) F_1 s. F_1 s showed dominance of elongated pod size of the female parent (04) over the globular pod of the male. Only the fruits of red stemmed F_1 individuals showed red streaks along the furrows. 04 had no such red streaks while Lalnaris had red streaks with greenish tinge. The number of seeds per fruit was 123.9 ± 28.9 in F_1 s as against 155.2 ± 33.1 in 04 and 31 ± 11.7 in (D 154 $\times$ Lalnaris) F_1 s.

Discussion

The present attempt was made to hybridize the two cultivar jute species via a semi-wild race of *C. capsularis*, namely Lalnaris as male parent. Although the earlier workers (ISLAM and RASHID 1960, SWAMINATHAN *et al.* 1961, CHAUDHURY and MIA 1961, MIA and SHAIKH 1967, HAQUE and ISLAM 1967) succeeded on producing partially fertile hybrid between the two cultivars, they reported high interspecific incompatibility. In the present crosses such as 04 $\times$ Lalnaris and 04 $\times$ (D 154 $\times$ Lalnaris) F_1 no such incompatibility was experienced; instead high percentage of fruit set as well as a good number of highly fertile F_1 s were obtained. ISLAM and RASHID (1960) used hormone (IAA) around the pedicel of the pollinated flowers to enhance the pollen tube growth and arrest earlier formation of abscission layer in the pedicel of the pollinated flower. Both SWAMINATHAN *et al.* (1961) and MIA and SHAIKH (1967) used irradiated pollen of the male parent to obtain F_1 hybrids. HAQUE and ISLAM (1967) used hormone and embryo culture technique for the same purpose. In the present case simply crosses were made replacing cultivar D 154 of *capsularis* with Lalnaris. Almost all the earlier workers including HAQUE and ISLAM (1967) reported a low percentage of fruit set and the F_1 hybrids they obtained were few in each case. Here the fruit set was high and a good number of F_1 plants were obtained. The F_1 s reported by earlier workers showed a low percentage of both pollen and seed fertility both of which improved in subsequent generations. Unlike the earlier F_1 s the present F_1 populations showed a high pollen and seed fertility.

In the past there were doubts about the hybrid nature of the two cultivar jute species but in the present case the hybrid nature of the F_1 plants could be proved because of the dominance of the male parent in respect of red pigment of (a) stem and (b) flower but tip. The high pollen fertility of the present F_1 s, unlike those of the F_1 s obtained

by ISLAM and RASHID (1960), HAQUE and ISLAM (1967) indicated that Lalnaris, a semi-wild race of *capsularis* was more closely related to the cultivar *olitorius* than the cultivar of *capsularis*, namely D 154.

It may be mentioned here that in interspecific crosses such as *Nicotiana* has often been achieved when the variety of a species has been changed in the cross.

ISLAM and RASHID (1960) and HAQUE and ISLAM (1967) reported that the hybrid between *C. olitorius* cv. C.G. and *C. capsularis*, cv. D 154 showed dominance of the male parent in respect of (a) B/L ratio of leaf, (b) notch in the upper margin of the petal and (c) pollen grain diameter. On the other hand in the character of (1) serration of leaf, (2) shape of the flower bud, (3) shape of the fruit and (4) presence of ribs on the fruit wall, their F_1 s showed the dominance of female character. Their hybrids were intermediate in characters of (a) stipule, (d) size of flower bud (c) color of petals and (d) size of petals.

The present F_1 hybrid population showed heterosis in height and base diameter over 04, the female parent; on the other hand they displayed the red pigmentation in all the plant parts i.e. in stem, flower tip, etc. like their male parent.

It may be mentioned here that the F_1 hybrids of *C. olitorius* × *C. capsularis* reported earlier by the present authors and SWAMINATHAN *et al.* (1961) were far from being transgressive in height and base diameter, and they were weak and dwarf with considerable sterility. The heterosis observed in the present population must therefore be ascribed to the fact that Lalnaris and D 154 differ a great deal in respect of their genotype.

The F_2 s showed segregation in respect of green vs red pigmented individuals. Similar ratio was obtained (HAQUE 1970) in respect of color in stem and other plant parts in the hybrid derivatives of the advanced generation of a natural interspecific cross, *C. olitorius* × *C. aestuans*.

The F_1 individuals showed further improvement in pollen fertility and the percentage was found to be almost equal to that of the parents. HAQUE and ISLAM (1967) pointed out that once a hybrid is obtained in any interspecific cross of the genus *Corchorus*, the extent of fertility improves in subsequent generations.

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ジュートにおける *Corchorus olitorius* L. と半野生 *C. capsularis* L.
との種間雑種

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これまでジュートでは *C. olitorius* L. と *C. capsularis* L. との種間雑種は通常の交雑では困難であった。しかしながら, *C. capsularis* L. の半野生種を母体に用いることによって, かなり容易に雑種を得ることができた。えられた個体は, 雑種強勢を示し高い種子稔性を示した。