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Review Article:

A Review on Cotton Improvement through Interspecific Hybridisation*

by

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Introduction: The genus *Gossypium* to which the cultivated cottons belong comprises of twentytwo different species and offers considerable scope for the synthesis and study of interspecific hybrids for crop improvement as the cultivated species viz., *G. hirsutum* L. and *G. barbadense* L. in the American group and *G. herbaceum* L. and *G. arboreum* L. in the Asiatic group are interfertile within themselves, while the application of polyploidy and backcross techniques has contributed to the exploitation of sterile or partially sterile hybrids also derived from other combinations of interspecific crosses in this genus. There are instances like the development of the American - Egyptian varieties in the U. S. A., and Madras - Cambodia Uganda varieties in Madras resulting from *hirsutum - barbadense* hybridisation and the release of Indo - American crosses in Bombay which are the results of practical significance in cotton improvement through interspecific hybridisation involving cultivated species. Besides, considerable work has also been initiated in the recent past to transfer desirable attributes from the wild species to the cultivated cottons as several of the former have been found to possess useful and rare genes not available within the cultivated biotypes. The useful results achieved so far and the immense potentialities for transferring known and unexpected desirable characters are briefly reviewed and presented below.

Relationship between Species: The interspecific relations among the different species are revealed by the extensive genetical and cytogenetical study notably by Webber, Skovsted, Beasley, Stephens, Iyengar, Patel, Thalkar and Deodikar, Brown and Manzel; and Kalyanaraman and Santhanam, could be summarised as below.

(i) Apart from crosses within the cultivated species which have yielded fertile hybrids, only in crosses involving *anomalum* with the Asiatic cultivated species, *arboreum* and *herbaceum* as also *tomentosum* with the new world cultivated species *hirsutum* and *barbadense*, fertile or partially fertile hybrids have been secured.

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(ii) Four other wild species viz., *thurberi*, *armourianum*, *harknessii* and *aridum* also give fertile or partially fertile hybrids with *barbadense*.

(iii) Within wild species, crosses involving *anomalum* with *triphyllum*, *thurberi* with *raimondii*, *armourianum*, *harknessii* and *aridum*; *raimondii* with *gossyploides* and *armourianum* with *harknessii* and *aridum* give fertile or partially fertile hybrids.

(iv) While many other combination of crosses have yet to be attempted or not yet been reported, on some, produce inviable seeds or sterile hybrids and a few others fail to cross.

Results of Interspecific Hybridisation: In crosses between cultivated species of the American group (2n = 52) John Griffin in 1867 in the United States produced the variety Griffin as a result of hybridisation between *hirsutum* and *barbadense* and backcrossing the hybrid to *hirsutum* parent. Following the recurrent backcross technique as a means of introducing a limited number of genes into a species, as suggested by Harland in 1934, Jenkins and others in the United States, developed the upland long staple variety Sea Island on a series of backcrossings of Upland x Sea Island hybrids to Upland. Similarly, at Shambat in Anglo-Egyptian Sudan, Knight and others transferred resistance to the blackarm from African Upland and some other types to Sakel Egyptian by resorting to a series of backcrossings of African Upland x Sakel Egyptian hybrids to Sakel Egyptian. Apart from these, it is believed that the source of high quality in some of the Upland types like Meade, Tidewater and Wilds in the South Eastern U. S. Cotton and BP - 5^2 in African Uplands (Hutchinson 1955) and MCU. 2, 7727, 7733 and 0744 in Madras - Americans (Santhanam 1957) is *barbadense* involved in their parentage.

In crosses among the species of the cultivated Asiatics (2n = 26) a strain named 15–9–9, known as 'New Cross' was evolved from the cross of Dharwar-1 *(herbaceum)* x 'Rosea' *(arboreum)*, and had gone into general cultivation in some parts of Dharwar District of Bombay State (Pardya and Patel 1959).

The successful production of hybrids between the cultivated species of the Asiatics (2n = 26) and Americans (2n = 52) have been reported by many workers like Zaitzev, Desai, Vysotskii, Nakatomi, Ramanatha Iyer, Kanash, Patel, Harland and Feng. Kinght (1948) transferred a strong partially dominant gene (B_4) governing resistance to blackarm disease from *arboreum* to Domains Sakel *(barbadense)*. Three cytogenetically different techniques like the allotetraploid method, the autotetraploid method and straight transferrence *via* the triploid have been described as the possible

methods of transferring a gene from *arboreum* to *barbadense*. As a result of intensive work carried out at Surat in India, a very valuable gene complex of materials serving as best donor parents were created and two economically useful strains 170–Co–2 (Deviraj) and 134–Co–2–M have been evolved through backcrossing the triploid F_1 of New World x Old World to the New World (Pandya and Patel 1959). The possibility of getting very promising strains by restoring to *inter se* crossing of the Indo - American derivatives has also been indicated by these workers.

Apart from the utilisation of species hybrids among the cultivated species, the roll of allied wild species of *Gossypium* in the improvement of cultivated cottons is also equally important as some of the wild cottons are known to possess very useful characters like resistance to drought, pests and diseases, and low fibre weight and strength in a degree not available in any of the cultivated species. The role of wild species of *Gossypium* as sources of new and rare genes for useful characters has been recently surveyed by Kalyanaraman and Santhanam (1954), Kesava Iyengar (1957), Pandya and Patel (1957), Ganesan (1957) and Santhanam (1957). The need for intensified work for the elucidation of certain fundamental aspects of cotton improvement through interspecific hybridisation on a long range basis has also been emphasised by these workers.

Beasley (1942) showed by doubling the species hybrid of *G. arboreum* x *G. thurberi* and crossing the same to *G. hirsutum*, that not only the fertility was restored but also enormous variability with no apparent relation to the characteristics of the two parents could be obtained.

In Anglo-Egyptian Sudan at Shambat, work on the transference of high lint strength from *G. thurberi* to Domains Sakel (Egyptian *barbadense*) had resulted in $B.C_3.F_3$ generation, plants with Pressley strength indices upto 10·2 as compared to 7·7 for Sakel lines (Knight *et al.* 1952). However, a true breeding homozygous Sakel line for higher lint strength is yet to be isolated. Attempts are also being made at this station to transfer lint quality and major hairiness genes from *G. anomalum* to Sakel cotton (Knight *et al.* 1953). Further, the transference of narrow bract from *G. anomalum* to Sakel, to reduce trash in picking is also attempted. The increased number of ovules per locule obtained in *G. armourianum* is also intended to be transferred to Sakel.

The work of transferring bollworm resistance from *G. thurberi* and *G. armourianum* is also in progress and a number of plants having good bollworm resistance as also jassid and white-fly resistance have been isolated by Knight *et al.* (1953).

In Trinidad (West Indies) Hutchinson *et al.* (1943) obtained in the second backcross of *barbadense* x *raimondii* hexaploid with Sea Island cotton, vigorous types with larger bolls than Sea Island and also types whose seeds showed an exceptionally good cover of lint, unlike the Sea Island parent

In Texas (United States), Beasleys's complex polyploid *(arboreum* x *thurberi)* x *hirsutum* has been backcrossed to Upland cottons and a good number of high lint strength segregates have been obtained (Cuany 1952).

In North Carolina also, the same tri-species hybrid had yielded in the fourth backcross generation, 26 plants out of 1,200 segregates with high lint strength of Pressley index of 11·0 and over. The yield of the high strength segregates was, however, found to be poor.

At Stoneville in Mississipi, transference by Dr. J. R. Meyer of the caducous bract of *G. armourianum* to Upland cotton is reported (Guany 1952). This is expected to reduce trash in mechanically harvested cotton.

J. H. Harrison in California is reported to have transferred the strength factors of Hopi cotton to Acala and successfully evolved the strain Hopi-Acala 50 (Cuany 1952).

Bollworm immunity from *G. thurberi* has been attempted to be transferred to Upland cottons at Indore (Ganesan 1947). A synthetic tetraploid *thurboreum* i. e. *(thurberi* x *arboreum)* F_1 doubled had been obtained and this was crossed to cultivated *hirsutum*. An enormous amount of variability in morphological, physiological and economical characters was noticed in the material carried forward upto F_3 stage (Ganesan 1952). Further selection work is reported to be in progress and no suitable lines would appear to have been isolated (Annual Report of the Institute of Plant Industry, Indore for 1952—'53). The hybrid of *hirsutum* x *raimondii* had also been produced at this station and the hexaploid obtained by doubling this F_1 was successfully crossed to *hirsutum*. The hybrid progenies have been observed to possess fine and strong lint, jassid tolerance and high vegetative vigour (Ganesan 1947). The transfer of lint fineness from *anomalum* to the cultivated Americans was attempted through hybridisation of the synthetic tetraploid *arboreum* x *anomalum* F_1 doubled with *hirsutum*. *G. anomalum* was found to be highly susceptible to wilt under Indore conditions and this proved to be a major problem in tackling this work at this station. The co-tom types which are hybrid derivatives of Co. 2 *(hirsutum)* x *tomentosum* originally produced at Surat, when crossed with local type Indore - 2 at Indore, gave out some superior types with good adaptation and yield possessing disease and pest resistance besides combining desirable fibre characters (Ganesan 1957).

At Surat (Bombay) attempts were made to transfer the leaf hairiness of *tomentosum* to *hirsutum* with a view to induce jassid resistance. *G. tomentosum* was crossed with Co. 2 *(G. hirsutum)* and the F_1 was back-crossed to Co. 2 and also outcrossed to Sea Island and long staple Indo-American strains till most of the wild characters of *tomentosum* excepting hairiness were eliminated. After the fourth backcross, selections for desired agronomic characters were made and as a result some promising cultures named "Co-tom" were isolated. They not only proved to be highly resistant to jassids besides to drought, but possessed as well good combination of ginning outturn and staple length. However, they are required to be improved for yield (Pandya and Patel 1959).

The transference of *anomalum* characters to Cambodia-2 was also attempted through the synthesis of a hexaploid (Co-2 x *anomalum)* F_1 doubled. In the second backcross to Co. 2, a few plants with 28·5 mm. *halo-length* and others with 46·8 per cent ginning were obtained as compared to 23·7 mm. and 37·5 per cent respectively, for Co. 2 (Deodikar 1950). Subsequent work of backcrossing the pentaploid of (Co. 2 x *anomalum)* F_1 doubled = (hexaploid x Co. 2) with the long stapled Indo-American strains resulted in the isolation of some promising types called 'Co-ano'. One of these, when tested for spinning, gave 2,169 lb. lea-strength on 40's and had a fibre weight of $0{\cdot}102 \times 10^6$ oz. per inch indicating thereby the contribution of quality genes by the wild parent *anomalum* (Pandya and Patel 1959). The crosses involving *armourianum* were also studied but have not yielded anything noteworthy than a few odd types noted for healthy leaf growth, round boll and long peduncle.

In Madras also, hybridisation work involving wild species of *Gossypium* was taken up as early as 1937–'38, at the Cotton Breeding Station, Coimbatore, and has been in progress on a limited scale. As a result, fairly a good number of crosses were effected involving notably *anomalum, raimondii, stocksii, armourianum, harknessii, tomentosum, davidsonii* and *darwinii* with all the four cultivated species and the materials utilised for selection work. The hexaploid synthesised by colchicine treatment of the sterile triploid hybrid of 4463 *(hirsutum)* x *raimondii*, was observed to possess 30 mm. lint length, 30 per cent ginning and 93 per cent fibre maturity as compared to 25 mm., 33 per cent and 56 per cent respectively for the cultivated parent 4463 (Kalyanaraman and Santhanam 1954). By backcrossing this fertile hexaploid to the cultivated tetraploids, a large volume of variable materials was built up which yielded blackarm resistant types combining good yield and ginning per cent as well. Besides, further studies indicated that *raimondii* with a short coat of seed hairs and low

ginning per cent had contributed to a high range of variability for *halo-length* and ginning per cent even in F_8 stage (Kesava Iyengar *et al.* 1955). The hybrid of *darwinii* x *taitense* when backcrossed to *hirsutum* and selection effected after the second backcross stage, yielded transgressive variability for lint length upto 34 mm. and normal fertility was restored in the fourth generation. An outstanding culture viz., No. 9–8 isolated as above was found to be consistently jassid tolerant (Kalvanaraman and Santhanam 1954).

Attempts have been made to utilise *G. anomalum* in the hybridisation programme for transference of lint fineness to the cultivated *arboreums*, notably in the Punjab by Afzal *et al.* (1945), and in Madras by Kalyanaraman and Santhanam (1954, 1955) and Kesava Iyengar *et al.* (1958). While these workers succeeded in isolating some useful types, it was also recognised that the expected improvement in lint fineness was not fully realised due to the restricted selections made in a limited number of plants in the early generations. These workers suggested the technique of backcrossing as offering the most satisfactory solution to the problem of low fertility in the F_1 of *arboreum - anomalum*.

As part of the programme for the transference of lint fineness from *G. anomalum* to the background of G. *arboreum*, backcrosses of the first generation hybrids to cultivated *arboreum* strains were effected and the behaviour of a fairly larger population of BC_1 F_1 plants has been reported by Marappan (1960). The results obtained by this worker from the fairly large number of BC_1 F_1 plants indicated the wider scope for recombination and selection of fine linted plants in this generation. He has suggested for further work of *inter se* crossing among selected BC_1 F_1 plants and a second backcross to the *arboreum* parent utilising some of the extremely fine linted plants.

From the foregoing, it would be seen that the role of wild germ plasm for cotton improvement through interspecific hybridisation has been well realised by cotton workers, although an improved strain of cotton with new characters transferred from wild parents is yet to be grown on any commercial scale. Among the several wild species that have attracted the attention of cotton breeders in different parts of the world for gene transfer, *G. anomalum*, *G. thurberi*, *G. raimondii* and (Hopi) *G. hirsutum* race *punctatum* would appear to have yielded some promising results. Of these again, *G. anomalum*, the South African wild species noted for its extreme fineness and strength of fibres besides resistance to jassids and blackarm has been extensively used for character transfer to the cultivated New World and to the cultivated Old World cottons by many workers.

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