

[The evolution of Hybrid-4 cotton has revolutionised the production of good quality cotton in India. Before this success, strenuous research work for nearly twenty years in cotton genetics could enhance the average yield from 213 to 304 kg lint/ha. The yield touched a record value of 6,918 kg seed cotton/ha, i.e., 2,352 kg lint/ha indicating the production potentials when the Hybrid-4 was exploited in the field. By this evolution, India not only reached self-sufficiency but also could export the surplus of the long staple cotton.

In this article the author gives a graphic account of the production of quality cotton by employing Hybrid-4. He also stresses the importance of unskilled manual labour involved in the emasculation and pollination work during the seed production providing gainful employment in rural areas.—Ed.]

EVOLUTION OF HYBRID-4 COTTON

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THE phenomenon of hybrid vigour was known for centuries in many parts of the world, although the exact genetical implications of the phenomenon remained a mystery. It is now accepted that the expression of hybrid vigour is mostly due to the accumulation of a large number of favourable dominant genes in the hybrid generation in comparison with either of the two parents. Hybrid vigour also depends upon the degree of genetic diversity between the parents.

The advantage of heterosis in cereal crops like maize (*Zea mays* L.), sorghum (*Sorghum vulgare* Pers.) and bajra (*Pennisetum typhoides* L.) has been well exploited. A remarkable contribution in increasing the yield per unit area has been achieved by evolving suitable hybrids in these crops. However, cotton crop remained unexplored for hybrid vigour, due to the rather complicated tech-

nique for seed production, involving the use of huge manual labour, as the crossing operation required emasculation and pollination of every individual flower, by human hand, thus making the hybrid seed very expensive. Unlike in cereal crops, evolving suitable cytoplasmic male sterile lines in cotton has not been successful as yet.

Work on the Evolution of Hybrids in Cotton at Surat

Early attempts in this direction resulted in the evolution of three promising hybrids, viz., Hybrid-1, i.e., Co. 2 (*G. hirsutum*) × S.I.V.-135 (*G. barbadense*) in 1950-51, Hybrid-2, i.e., BC. 68 (*G. hirsutum*) an Indo-American strain × S.I.V.-135 (*G. barbadense*) in 1955-56 and Hybrid-3, i.e., G. 67 (*G. hirsutum*) an Indo-American strain × Moco (*G. hirsutum*) in 1962-63. The area covered under Hybrid-2 was about 600 acres. The trade, however, did not appreciate this variety on account of the excessive neppiness of the yarn spun from it. The Hybrid-3 had

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nepfree yarn, but on account of the fact that one of the parents was perennial, seed production created a problem and it was difficult to synchronise the flowering periods of the two parents.

Evolution of Hybrid-4

This hybrid is an inter-hirsutum cross, involving the well-adapted extra long staple Indo-American variety—Gujarat 67 as the female parent, and an exotic hirsutum variety American Nectariless as the male parent. The evolution of Hybrid-4 (Fig. 1) constitutes an important landmark in the cotton improvement work in the world on account of the record increase in the yield. It is capable of spinning good 60s counts with nepfree yarn. It combines a high yield, with good quality and wide adaptability. Some cultivators tried Hybrid-4 cotton under maximisation conditions and broke the world record in cotton yield obtaining as high a yield as 89.5 quintals seed cotton yield per hectare.

The overall economic characters of Hybrid-4 cotton are as follows:

1. Yield of seed cotton (kg/ha)	3000 to 4000
2. Ginning out-turn (percentage)	33 to 34
3. Mean fibre length (mm)	29.0 to 30.0
4. Fibre fineness (MV)	3.8 to 4.4
5. Length uniformity ratio (%)	48 to 51
6. Maturity coefficient	0.70 to 0.80
7. Fibre strength (P.S.I.)	7.5 to 8.5
8. Spinning capacity	60s (combed)
9. Yarn appearance	Nepfree and uniform.

Salient Features of Hybrid-4 Cotton

(1) Heterosis is expressed in terms of very high productivity resulting from an extraordinary bearing capacity, bigger boll size, profuse and continuous flushes overlapping one another, all leading to a bumper yield (216%



FIG. 1. Hybrid-4 cotton—The harbinger of self-sufficiency in long staple cotton in India.

higher over better yielding parent under maximization condition).

(2) Big boll size (wt.: 5 to 6 g), with excellent opening, ensures easy and clean picking, and cuts down harvesting cost.

(3) Due to early maturity, and faster growth and boll development, it escapes frost, and suffers less under deficit moisture conditions created at times, by the failure of late rains.

(4) Comparatively less photo- and thermo-sensitivity which affords scope for taking it as a Pre-monsoon, Kharif or Rabi crop successfully.

(5) Wider adaptability to varied soil and climatic conditions.

(6) Very high response to fertilisers.

(7) High harvest index, i.e., very good plant efficiency.

(8) Tolerance to high rainfall and water-logging conditions to some extent and drought tolerance under rainfed conditions.

(9) High degree of tolerance to blackarm disease (*Xanthomonas malvacearum*).

Breakthrough in Cotton Production by Hybrid-4

Despite the evolution of new varieties and adoption of improved agro-technique, the per hectare yield of lint had gone from 213 kg/ha to 304 kg/ha only, during the previous 20 years; against this, the yield went up to a record value of 6,918 kg/ha seed cotton, *i.e.*, 2,352 kg lint yield per hectare with the introduction of Hybrid-4 under maximization condition showing thereby production potentially under Indian condition. When the Hybrid-4 became available to meet the challenge of cotton inadequacy, India has not only reached self-sufficiency but also has an exportable surplus of long staple cotton. Hybrid-4 has become very popular amongst growers, traders and consumers and it is now being grown in the States of Gujarat, Maharashtra, Madhya Pradesh, Karnataka, Andhra Pradesh and Rajasthan with total coverage of 5.88 lakh hectares.

Seed Production Technique

The seed production technique consists of growing the female and male parents in separate plots in the proportion of 5:1. The sowing periods are so adjusted that there is good synchronisation of the flowering phases in both the parents and an adequate supply of male flowers could be maintained.

Doak's method for the emasculation of the flower-bud is used. This method comprises the removal of the bracts by hand and then the petals along with the entire anthersacs whorl with the thumb nail without damaging the stigma, style, or ovary. Care should also be taken to ensure that the white cover membrane of the ovary is not damaged or removed during this operation as this affects the seed setting. It should also be verified that no anthersac remains at the base of ovary at the time of emasculation. This will cause selfing and the seed of the female parent will be produced. If any such anthersac is left and has already opened and pollens come out of it, then such

flowers should be discarded. After emasculation is over, the flower-bud should be covered with a red tissue paper bag of 9×7 cm size and tied with a thread. The other end of the bag should not touch the stigma of the emasculated bud. The use of red tissue paper bag facilitates the identification of the flower-bud for pollination next day. The emasculation should be done in the morning upto about 8 A.M., *i.e.*, before any anthersac starts bursting and in the afternoon after 3 P.M.

Pollination

The stigma of the female flower is receptive at about 9 A.M. to 10 A.M., depending upon the temperature and moisture and at this time the anthersacs of the male flower burst open. A sticky substance is found on the stigma when it is receptive.

The flower-buds from the male plants should be collected, and the bracts and the petals should be removed from them. They should then be kept in trays or plastic dishes in the sun so that the anthersacs burst open. Those male flower-buds which are already opened should not be chosen. The usual time when anthersacs burst open is about 9 A.M. but it depends again upon the atmospheric conditions. One male flower-bud is sufficient for pollinating about 4-5 female flower-buds. However, if the male flower-bud is not well developed or if the quantity of pollen grains is less, then only 3-4 female flowers should be pollinated with it. Those female flowers which are emasculated should be pollinated on the same day. Only the required number of male flower-buds should be plucked for pollination. If the buds are kept in the sun for a longer period after anthersacs have opened, then the pollen grains become dry and drop down at the time of pollination. Hence such buds should be kept in the shade.

When anthersacs burst open, the colour of the pollen grains becomes yellow. The red tissue paper bag on the emasculated flower.

bud should be removed and the male flower-bud should be rubbed at the tip and also all around on the surface of the stigma of the female flower. This operation can be continued upto 12 noon. In order to prevent contamination from foreign pollens the female flower-bud should now be covered with a white tissue paper bag or straw tube piece and tied with a thread. This completes the crossing operation.

If any open flowers are left after crossing is over, they should be plucked as this will hinder the development of the crossed bolls. If this is not done, there are chances of adulteration in the hybrid seeds at the time of picking, the labourers may pick crossed and uncrossed bolls together. Similarly all the open flowers on the male plants should also be plucked. No boll setting should be allowed on the female plants for 4 to 6 weeks after discontinuing crossing programme.

Success in Crossing

From the past experience, it has been observed that success in crossing is about 40 to 50%. The measure of success depends upon the care taken while crossing, the treatment given to the crop and the atmospheric conditions. For ensuring better results

unskilled but trained and experienced labourers should be engaged. One trained labourer can tackle about 200 to 250 flower-buds in a day when the crop is in full flowering phase.

Seed Certification and Purity Standards

In order to maintain the purity standard of the hybrid seed, produced on a commercial scale, seed certification has been introduced both for germination and genetic purity before the release of the seed. Samples are drawn from each seed lot and tested in a seed testing laboratory for germination, physical purity, etc., and in the field for a grow out test for genetic purity. Advantage is taken, of the distinct time lag in the first initiation of flower-buds between the female parent and the hybrid and the nectariless character as a marker gene in screening the sample population for genetic purity test. The purity standards fixed are (1) Germination minimum: 65%, (2) Physical purity : 97%, (3) Genetic purity: 90%.

Processing and bagging in standard packages are done under strict Departmental or Seed Certification Agency's supervision and each bag is sealed and tagged with a certification label.
