

- A Success Story

BY

A.K. BASU R.S. PARODA

ASIA-PACIFIC ASSOCIATION OF AGRICULTURAL RESEARCH INSTITUTIONS FAO REGIONAL OFFICE FOR ASIA & THE PACIFIC BANGKOK - 1995

FOREWORD

The Asia Pacific Association of Agricultural Research Institutions (APAARI) has decided to bring out a few selected success stories in the Region, which have demonstrated their importance and utility in promoting agricultural growth of the country concerned. Some of the successes are quite impressive. Such successes could be of immense help in the Asia-Pacific region, provided required policy, research and developmental support is extended by other nations.

In the past, three success stories have been published by APAARI, which have reclived wide appreciation. These are:

- 1. Baby corn production in Thailand
- 2. Tilapia farming in the Philippines
- 3. Hybrid Rice in China

In this publication, details concerning development and adoption of Hybrid Cotton Technology in India have been presented. This technology has not only helped India in increasing its cotton production, especially in the rainfed areas, but has also enabled India to increase its export potential for fine quality cottons. The technology has the relevance to similarly placed cotton growing countries in the region, provided policy makers are sensitized to extend the needed support for it in their respective countries. I am sure, the readers would find this publication not only informative but useful for increasing the productivity of cotton in the region.

15 December, 1994

(R.S. Paroda) Executive Secretary APAARI

HYBRID COTTON IN INDIA - A Success Story

I. INTRODUCTION

Cotton is an important industrial crop in India. Cotton and cotton textiles constitute a major share of agricultural export. In sixties, the production of cotton was about 5 million bales, mostly of short and medium staple cotton. With the advent of hybrid cottons in seventies, a sea change was brought in cotton scenario both qualitatively and quantitatively. Today, 13 million bales of cotton consisting of short, medium, long and extra long staple are produced annually. This story tells the success of hybrid cotton research and development and its impact on production and quality of cottons in India.



Hybrid Cotton brought an era of plenty in India

II. HISTORICAL PERSPECTIVE

The phenomenon of heterosis or hybrid vigour is known in cotton since 1894 when Mell first reported an increase in agronomic and fibre properties through cotton hybrids. Thereafter, Balls reported hybrid vigour in the inter-specific crosses between upland and Egyptian cottons. Since then, a number of workers in India, USA and elsewhere recorded the heterosis for various traits both in the intra-hirsutum and inter-specific (Gossypium hirsutum x Gossypium barbadense; Gossypium herbaceum x Gossypium arboreum) crosses. Several workers reported higher heterosis in case of inter-specific (G.hirsutum x G.barbadense) hybrids compared to the intra-specific (G.hirsutum x G.hirsutum) crosses. However this heterosis could not be commercially exploited due to the tedious task of hand emasculation and pollination required for the hybrid seed production, especially in the absence of male sterility systems in cotton during those days.

With an objective to achieve self sufficiency in cotton, especially for the long and extra long staple cottons, serious attempts to develop hybrid cottons combining both the yield and quality attributes began in India in the late thirties mainly at the Cotton Research Station, Surat in Gujarat State of India under the leadership of late Dr. C.T. Patel. To start with, crosses were effected between hirsutum and barbadense species. Some combinations had manifested high heterosis in yield combined with superior fibre quality. Although their commercial exploitation began in late forties with the production of hybrid seeds by hand emasculation and pollination. Several of the promising hybrids were carried to large-scale field trials and mill tests. Simultaneously, the hybrid seed production techniques, economics of seed production and hybrid cultivation were also determined. Issues such as compatibility between



Dr. C.T. Patel

parents, synchronising flowering for crossing, higher number of seeds per boll for increased number of hybrid seeds marker genes for genetic purity test during seed production, etc., were also considered (Patel and Mehta, 1983). Ultimately, efforts of Dr. C.T. Patel, father of hybrid cotton in India. and his team bore fruits. The first promising cotton Hybrid 1 (CO2 x SeaIsland V

135), covered an area of 325 hectares in 1956-57. Somehow, for want of proper organisation to produce pure seeds with reasonable price incentive, this hybrid did not succeed. By 1961-62, Hybrid-2 (BC 68 x SIV 135) covered an area of 519 hectares but due to neppiness of its yarn, it did not find favour with the textile industry. In 1963, Hybrid-3 (G 67 x Moco), an intra-hirsutum hybrid capable of spinning 60s counts without neps, also could not succeed due to the problem of seed production on account of non-synchronous flowering between the parents. Ultimately, their strenuous efforts to commercially exploit heterosis bore fruits during late sixties when Hybrid-4, a cross between G 67, a commercial cultivar of Gujarat and Nectariless an exotic accession from the USA, was developed and released for commercial cultivation.

III. HYBRID COTTONS IN INDIA

Cotton is grown in India in three distinct agroclimatic zones; (i) the northern zone of sandy loam soils where cotton is grown almost entirely under irrigation, (ii) the central zone of predominantly vertisols or deep black cotton soils where cotton is grown mostly as a rainfed crop, and (iii) the southern zone of vertisols and red soils where cotton is predominantly a rainfed crop, whereas the eastern zone also has some cottons (Fig.1).

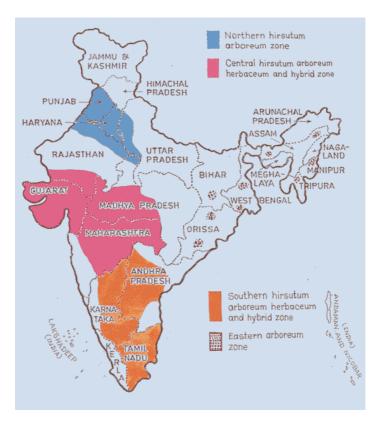


Fig. 1: Cotton Growing Zones in India

A. Species Composition

All the four species of cotton, i.e. Gossypium hirsutum, G. barbadense, G. arboreum and G. herbaceum and tetraploid and diploid hybrids are grown in India. The zone-wise species composition of cotton is given in Table 1.

Table 1: Area (m.ha) under Different Species and Hybrids in India

Total Area	SPECIES					
Notice and the second	G.hirsutum	G.barbadense	G.arboreum	G.herboceum	Hybrid	
Northern cotton zone						
134	134	0	0.20	0	0	
	(85)		(15)			
Central cotton zone						
4.66	1,19	0	1.04	0.68	1.75	
	(26)		(23)	(15)	(36)	
Southern cotton zone						
1.55	0.35	0.01	0.05	0.20	0.95	
	(22)	(1)	(3)	(13)	(61)	
India						
7.55	2.68	0.01	1.29	0.88	2.70	
	(35.5)	(0.01)	(17.0)	(11.5)	(36.0)	

Note: Percentage of total area is shown in parenthesis

B. Advent of Hybrids

First Hybrid-H4

Hybrid 4, an intra-hirsutum hybrid released in 1970, became the first commercial hybrid of India and also in the world. Hybrid 4 showed substantial heterosis over G 67, the better parent (Table 2 and 3).

Table 2: Large Scale Trials of H4 Hybrid Cotton

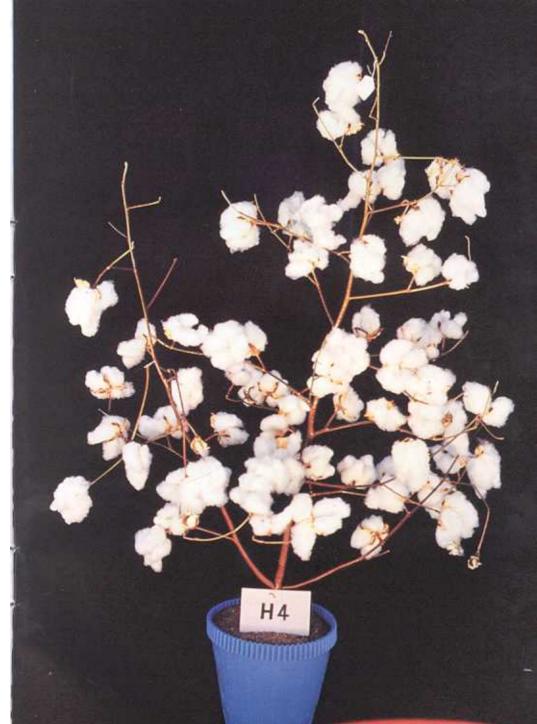
	Yield of seed cotton (kg/ha)				
Year	H 4	G. 67			
1966-67	2236	836			
1967-68	1106	447			
1968-69	2159	747			
Mean	1834	- /p - 677			

Table 3: Yield of H4 Hybrid Cotton in the Maximisation Plots

Year	H4	G. 67
1965-66	3532	2040
1966-67	3927	1716
1967-68	3789	1783
1968-69	5230	2165
1969-70	6918	2181
Mean	4679	1977

High yield potential of H4, superior fibre properties, its wide adaptability backed by a network of seed production and remunerative price of the produce helped in the quick spread of the hybrid.

The release of H 4 for commercial cultivation and its instant popularity gave a fillip to the hybrid cotton research in the country under the aegis of the All India Coordinated Cotton Improvement Project, sponsored by the Indian Council of Agricultural Research. Results were spectacular. A number of hybrids, both intra-specific

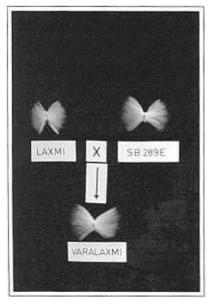


H 4 - The First Cotton Hybrid

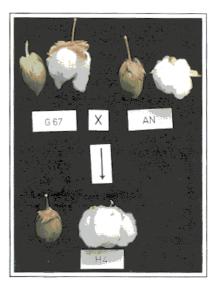
and inter-specific (hirsutum x barbadense), were developed and released for the commercial cultivation in the central and southern regions of India.

Other Hybrids

While H 4 is spinnable to 50s counts Varalaxmi which was released soon after H 4 is spinnable to 80s counts. Varalaxmi was later replaced by DCH 32, which is similar to Varalaxmi in quality but has better yielding ability and is



Fibre Length of Hybrid Varalaxmi



Boll Size of H 4

earlier in maturity. Recently, two inter-specific hybrids namely, TCHB 213 and HB 224, superior to DCH 32, have been released in south India.

H 6, H 8, AHH 468, NHH 44, JKHY 1 are further improvements over H 4 in yield, duration and tolerance to pests and diseases. However, except H 6, all are inferior to H4 in quality.

A few hybrids bred by the private sector have also become popular. Notable among them are MECH 1, MECH 4, Somnath, Jaganath, Ankur, etc. Diploid Interspecific Hybrids

Till 1985, hybrids that developed belonged only to tetraploid, intra- or inter-specific crosses. Hybrid vigour existing in the diploid species was first commercially exploited with the release of G.Cot DH 7, a hybrid between *herbaceum* and *arboreum* species from Surat, from where H 4 was released. This is a significant development in the context of Indian cotton situation where seventy percent cotton is rainfed and the diploid cottons are known to withstand drought. Heterosis exhibited by G.Cot DH 7 over improved varieties was spectacular (Table 4).

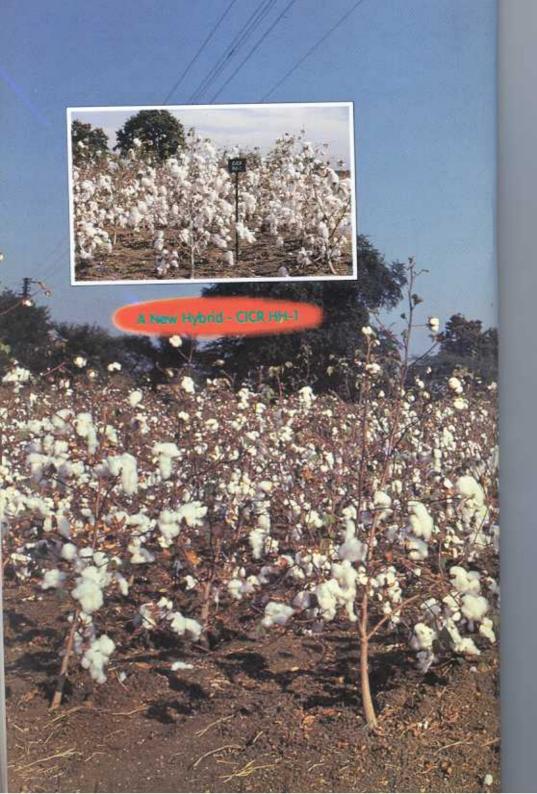
Table 4: Heterosis expressed by Diploid Hybrid under Rainfed Condition (yield of seed cotton in kg/ha)

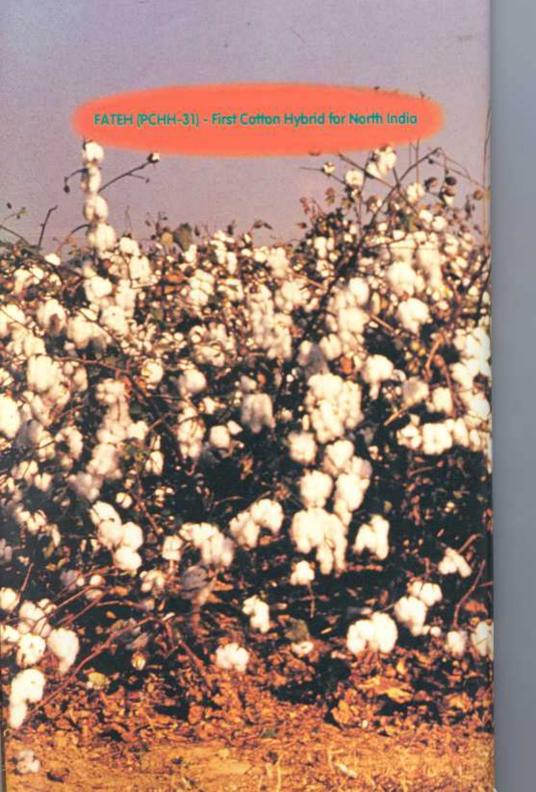
Hybrid	G.arboreum				
G.cot. Hyb.7	Sanjay	Sanjay V 797		Digvijay	
620	400				
1170		480			
1580			1340		
930				630	

Three more diploid inter-species hybrids were released subsequently, two for the central India and one for the south India. G.Cot Hyb 9 deserves special mention in that, it can spin upto 50s counts which is indeed remarkable for a diploid cotton.

C. List of Released Hybrids

A number of hybrids have been released for the commercial







cultivation in India. Some of them are quite popular in different cotton growing regions. Details of their parentage, year of release, spinning potential and the area of adaptation are given in Table 5.

Table 5: List of Hybrids Released for Cultivation alongwith their Characteristics and Area of Adaptation

Hybrid		Year of release	Mean fibre length (mm)	Spinning potential (counts)	Area of adaptation (States of Central and Southern catton zones)
Intra-specific	(Intra-hirsutum)				
Hybrid-4	(G.67 x Am Nectoriless)	1970	28	50s	Gujarat, Maharashtra Andhra Pradesh, South Rajasthan
JKJ-1Y-1	(Khandwa-2 x Reba B.50)	1976	26	44s	Modhya Pradesh and Andhra Pradesh
KNHH-1	(Buri Nectoriless x MCU 5)	1978	28	50s	Maharoshtra
Hybrid-6	(G.Cot 100 x G.Cot 10)	1980	28	60s	Gujaral, Maharashtra and Andhra Pradesh
AF81-468	(AK32 x DHY286-1)	1981	24	40s	Maharashtra
NHH 44	(BN1 x AC 738	1983	24	40s	Maharashtra, Karnataka and Andhra Pradesh
Savita	(T7 x M12)	1987	30	60s	Andhra Pradesh and Tamil Nadu
G.Cot. Hyb.8	(G.Cot 10 x Surat Dwarf)	1988	26	40s	Gujarat
Lam Hybrid -1	(LMSS-2A x LMSS 85)	1989	25	40s	Andhra Pradesh
MECH-4	(C601 x C219)	1990	27	44s	Maharashtra, Gujarat
CICR HH-1	(BN xCP15/2)	1991	25	40s	Maharashtra
NHH 302	(N-515 x NH258)	1993	25	405	Maharashtra
CAHH468	(CAK32A x DHY286 x 1R)	1993	25	40s	Maharashtra

Table Control

Hybrid	Parentoge	Year of release	Mean fibre length (mm)	Spinning potential (counts)	Area of adaptation (States of Central and Southern cotton zones)
Inter-specifi	c (hirsutum x barbadensi	7			
Varalaxmi	(Laxmi SB289E)	1971	31	80s	Karnataka, Maharashtra Andhra Prodesh and Gujarat
*Savitri	(KOP203 x 581085-6)	1979	30	60s	Gujarat and Maharashtra
*KCH-1	(MCU7 x S8289E)	1980	31	60s	Tamil Nadu
*JKHY-11	(Khandwa-2 x ER84492)	1981	30	60s	Madhya Pradesh
*CBS156	(Acala glandless x SB1085-6)		33	100s	Tamil Nadu
DCH-32	(DS28 x S8425YF)	1981	33	80s	Karnataka, Maharashtra Andhra Pradesh and Tamil Nadu
*NHB 12	(NS15 x 58289E)	1989	33	80s	Maharashtra
HB224	(LRA5166 x PI)	1989	33	80s	Tamil Nadu, Andhra Prades and Karnataka
TCHB213	(TCH1218 x TCB209)	1989	33	80s	Tamil Nadu
Inter-specific	: (herbaceum x arbareun	v			
G.Cot. Hyb.7	(Sujay x G27)	1985	22	20s	Gujarat
G.Cot. Hyb.9	(4011 x 824)	1988	28	50s	Gujarat
ODH 2	(SM88 x A-82-1-1)	1991	22	20s	Tamil Nadu, AP and Karnataka
MDCH 201	PHRB 614 x ARB 405)	1993	21.5	20s	Maharashtra, MP and Gujarat

IV. HYBRID SEED PRODUCTION

Hybrid seed production in a self pollinated crop like cotton is indeed a difficult task, especially when large quantity is to be produced for commercial cultivation. It is because of this reason that, heterosis in cotton known since the end of the eighteenth century, remained unexploited till late nineteen-sixties. The vast labour force available in the rural part prompted late Dr. C.T. Patel to take up hybrid seed production on a commercial scale using hand emasculation and pollination technique. Obviously, in order to have standardisation of seed production programme, extensive training of rural men, women and children, training of supervisory staff, fixation of ratio of female and male plants, synchrony of their flowering, timing and method of picking, post harvest handling including ginning, physical and genetic purity tests, etc. had to be taken up.

A. Crossing Technique

Equipment and materials necessary for crossing 0.4 ha seed production plot have been worked out by Mehta and Patel (1983). They are:

- 1. 0.25 to 0.3 million white tissue paper bags of 9 x 7 cm size, free from acid, are used to cover the flower buds after pollination.
- 2. Red tissue paper bags (about 20,000) are used to cover the flower buds after emasculation, so as to prevent them from being pollinated by foreign pollens. Sometimes, in place of red bags the white bags with their half portion made red are also to be used. The use of these bags facilitates identification of the flower buds to be pollinated from the buds which have already been pollinated previously.
- 3. About 10-12 kg of cotton thread of 4 to 6 size may be cut into about 22 cm pieces and used for tieing the bags.
- 4. One big size tray to keep the male flower buds before crossing

- A magnifying glass to seed the pollen grains.
- 6. About 25 to 30 labourers are necessary for emasculation and crossing work during the peak flowering period. The number of labourers will be less initially as the number of flowers are less but it is increased according to



Covering of Emasculated Flower Bud

the availability of flowers.

Doak method of emasculation is used. Pollination is done between 9 AM to 12 noon when the stigma remains receptive. Care needs to be taken during the crossing work such as: selection of flower buds of appropriate size, no anther is left inadvertently after emasculation, open flowers and bolls are plucked before emasculation and male plants are uprooted after crossing work is over.

B. Success of Crossing

Success of crossing in tetraploid intra-hirsutum, and interspecific crosses is upto 50 per cent. In diploid inter-specific crosses, the success is, however, not more than 20 to 25 per cent.

C. Purity of Parental Lines

Parental lines used in the crossing programme must meet certain standards of purity. In this context, seed producer should clearly know the morphological characters of male and female parents. Certification is done by the Inspectors of the State Seed Certification Agencies.

D. Seed Processing

Ginning of hybrid cotton seed material is done only at the notified ginning centres, directly supervised by the District Seed Certification Officer or his representative at the prescribed time and date. Gins are cleaned well before and after for maintaining genetic purity.

The seeds are then delinted by the specialised mechanical delinters or by the wet acid delinting or dry acid delinting, followed by removal of all traces of acid, drying in shade and treatment with pesticide/fungicide before packing in cloth bags with certification seal and label for marketing. The packing is preceded by seed testing lab/field test for germination, purity and inert matter. Seed testing includes purity analysis, germination percentage determination, field tests for genetic purity (grow out test) etc. The minimum seed certification standard for germination of cotton prescribed by ISTA is 60 per cent and hence, only those lots with 60% and above are certified. (Anonymous, 1990).

Genetic purity standards of hybrids are as follows:

Standards	Conventional hybrids (%)	CMS hybrids (%)
Genetic purity	90.0	95
Self plant	8.5	4
Off types	1.5	1

E. Cost of Hybrid Seed Production

In India, hybrid cotton seed production is done mainly through manual labour, except for a few newly released hybrids based on male sterility. The cost of hybrid seed production includes the cost of field operations, cost of fertilisers, pesticides and other materials, irrigation charges, labour cost for emasculation and pollination and other field operations including the cost of land leased. Table 6 gives the cost in Rupees/US dollar per hectare of seed production. Net income per hectare works out to 24,500 Indian rupees or 819 US dollars.

Table 6: Cost of Hybrid Cotton Seed Production/Hectare

Particulars of operation	C	ost
	Rs/hectore	US\$/hectare
Preparatory cultivation	950	30
Cost of seed, registration & inspection charges	1,750	58
Fertilizers	5,000	167
Sowing	250	8
Inter-cultivation	900	30
Plant protection	6,250	208
Emasculation and pollination	24,000	800
Irrigation	1,500	50
Seed cotton picking	600	20
Transport to gin and ginning	400	13
Land lease	5,000	167
Total	46,600	1,551
Economics Income		
Seed yields (7.5 qtis/ha x Rs. 9,000/qtl)	67,500	2,250
Lint (3 qtls/ha x Rs. 1200/qtl)	3,600	120
Total Income	71,100	2,370
Expenditure	46,600	1,551
Net Income	24,500	819

^{*} Quintal = 0.1 ton or 100 kg. (Source: Yogeswar Rao, 1990)

F. Role of Private and Public Sector Agencies

About 36 per cent area under cotton in India is covered under hybrids. This works out to be around 2.7 million hectares. Considering the seed rate of 2.5 kg seeds per hectare, the total requirement of hybrid seeds annually is 67,500 quintals (6,750 tonnes). Various public and private seed agencies are involved in the production of hybrid seeds. The public sector includes the State Seed Corporations of the cotton growing states and the State Farms Corporation of India (SFCI). They produce seeds of hybrids developed by Federal Institutes and State Agricultural University. The cotton hybrids developed in the public sector are registered and notified to enable certification of the seeds by the State certification agencies. Private seed companies, which are mainly concentrated in Gujarat and Maharashtra in Central India and Andhra Pradesh, Karnataka and Tamil Nadu in South India, produce hybrid seeds of both the public bred hybrid as well as hybrids developed by them. As a policy, the Indian Council of Agricultural Research (ICAR) provides the seeds free of cost, of public bred hybrids to the Private Seed Organizations for commercialisation in order to ensure quick availability of seeds to the farmers.

It is estimated that about 55% of the hybrid seed requirement is met by the private sector. Private sector seed companies, both Indian and Multinationals, play an important role towards hybrid cotton seed production. The main State Seed Corporations producing the hybrid seeds are: Maharashtra State Seed Corporation, Gujarat State Seed Corporation, Madhya Pradesh State Seed Corporation, Karnataka State Seed Corporation, and Andhra Pradesh State Seed Corporation. Central State Farms under SFCI also produce seeds of hybrid cotton.

The main areas of seed production are Maharashtra, Gujarat, Madhya Pradesh, Tamil Nadu, Andhra Pradesh and Karnataka in Central and South India.

G. Seed Certification

Responsibility for the production of breeder seed of parental lines lies with the breeder concerned. Breeder seeds are monitored by a team consisting of the breeder, representatives of the State Seed Corporation and the National Seed Corporation and a representative of the State Seed Certification Agency to ensure purity and quality. Foundation seeds and certified seeds of parental lines are produced by the seed corporations/private seed producers for certified hybrid seed production. This they do with the help of trained farmers and labourers.

Financial assistance is provided to the State Seed Corporations by the State Governments/Commercial Banks for the procurement and the operational expenditure on seed so produced and stored. The responsibility of seed distribution rests with these Corporations in order to ensure price stability both at the production and distribution stages. Where a hybrid is grown in more than one state, the original



Hand Emasculation in Cotton

breeder supplies the basic seed (nucleus seed) to the breeders of other states designated as sponsored breeders for the production of breeder seeds to ensure availability of adequate quantity in different states. While most of the states used foundation seeds for production of hybrids, the Gujarat state uses the breeder seed directly for certified hybrid seed production.

Allotment of the breeder seed of parental lines is done by the Ministry of Agriculture, Government of India on the basis of advance indents received from hybrid seed producing agencies and so produced by the breeders concerned. Breeder seed production is monitored by the Project Coordinator, All-India Coordinated Cotton Improvement Project under ICAR.

H. Measures for Reduction of Cost

High cost of hybrid seed is deterrent for proper spread of this technology particularly in rainfed areas. Alternate methods of hybrid seed production have, therefore, received attention. Male sterility is one such method extensively used in other crops. In cotton also attempts have been made to use different systems for hybrid seed production. There are different sources of male sterility now being used for the development of hybrid cottons. They are:

1. Genetic male sterility (GMS): Gregg male sterile line of Weever conditioned by ms 5ms6 double recessive genes is the most promising. Varieties of G.hirsutum with MS5MS5 MS6MS6 genes when crossed to Gregg ms5ms5 ms6ms6 line segregate in F2 into a ratio of 15:1 for male fertile: male sterile lines. The backcross population segregates into 1:1 fertile: sterile plants. The male fertile plants are rouged at the flowering stage before hybrid seed production. In India, several hybrids have been developed using this system. CPH 2 (Suguna) proved very promising in the multilocation trials under the All-India Coordinated Cotton Improvement Project. It has recorded 28 q/ha mean seed cotton yield,

35 per cent ginning out turn and 24 mm mean fibre length. Several other hybrids were subsequently developed. GMS based MECH 1, Ankur 15 and a few other hybrids developed by the private seed companies are popular amongst cotton farmers. The popular conventional hybrids such as H 4 and Varalaxmi have also been reconstituted in the Gregg genetic background.

2. Cytoplasmic genetic male sterility (CMS) was developed by Meyer (1975) by transferring G. hirsutum genome to the cytoplasm of diploid wild American species G. harknessii. Restorer lines were also developed in hirsutum and barbadense background. Restoration is controlled by a single gene expressing incomplete dominance. Cytoplasmic genic male sterility of harknessii has been transferred to many Indian hirsutum cottons. Indian restorer lines have also been developed lately. Five exotic cotton genotypes namely MEX 685-3, Dixie King ne restorer, Demeter III(1), Demeter III(2) and DES 146c are stable restorers. The restorer factor has now been transferred to indigenous lines. Several hundred hybrids have been developed with CMS background utilising the CMS lines and restorers.

The following plan is used for hybrid seed production:

1. Maintenance of CMS 'A' line : 'A' CMS line (pollen sterile)

X

'B' line (Isogenic pollen

fertile line)

2. Maintenance of 'B' line : 'B' line a sterility maintainer

by selfing (pollen fertile)

3. Maintenance of 'R' line : 'R' line a fertility restorer

line by selfing (pollen fertile)

4. Plan for hybrid seed production : A X R CMF hybrid

(Fertile commercial hybrid)

One such hybrid, MECH 4, has been released for cultivation in the central cotton zone. CAHH 468, CMS version of AHH 468, a popular conventional hybrid of rainfed tract of Vidarbha in Maharashtra, has also been recommended for release for commercial cultivation. AK 32 and DHY 286-1 has been converted into CMS and restorer lines, respectively. CAHH 468 is on par with AHH 468 in all characteristics except in maturity where CAHH 468 is about 15 days earlier than AHH 468.

A few more hybrids bred by the private sector are under cultivation in the central and southern regions of India. Merits of CMS based hybrids are shown in Table 7. The cost of seed production using this system is reduced to almost half.

Table 7: Advantages of CMS Based Hybrids over Traditional Hybrids

Hybrids	Traditional hybrid	CMS based hybrid
Mandays for production of 1 kg hybrid seed	3.7	0.33
Cost of production of 1 kg hybrid seed	US\$ 3	US\$ 1.5
Retail selling price to the farmers	US\$ 6	US\$ 4
Shedding % of crossed bolls	More due to mechanical injury	Negligible
Immature seeds (%)	High	Low
Self pollinated bolls	Some	Negligible
Spread of hybrids	. Slow	Rapid
Disadvantages		
Rural employment generation	More	Less
Unit of seed production	Small being labour intensive	Large due to minimal labour requirement
Genetic purity standard (%)	90	× 95
Use of F2 seed as planting material	Possible	Not possible

Hybrids have wide adaptability as evident from the cultivation of intra-hirsutum hybrids H-4, H-6, JKHY-1, NHH 44 and interspecific hybrid DCH 32 in considerably large rainfed areas in the

States of Central and Southern India (9 degree to 21 degree N latitudes). The hybrids now occupy more than one million hectares. The deeper root system, large canopy and larger number of flushes overlapping one another give the hybrids an edge over varieties in the rainfed areas.

Since the release of H 4 in 1970, hybrids have spread over the years and they presently occupy 2.7 million hectares out of 7.5 million hectares under cotton, which constitute about 36 per cent of the total area in the Central and Southern India (Fig. 2).

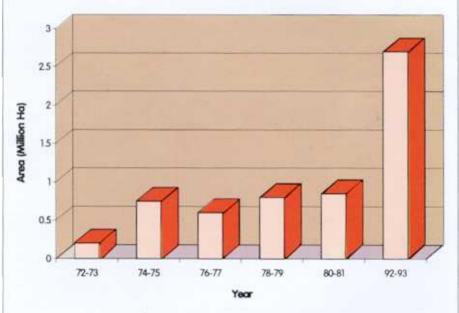
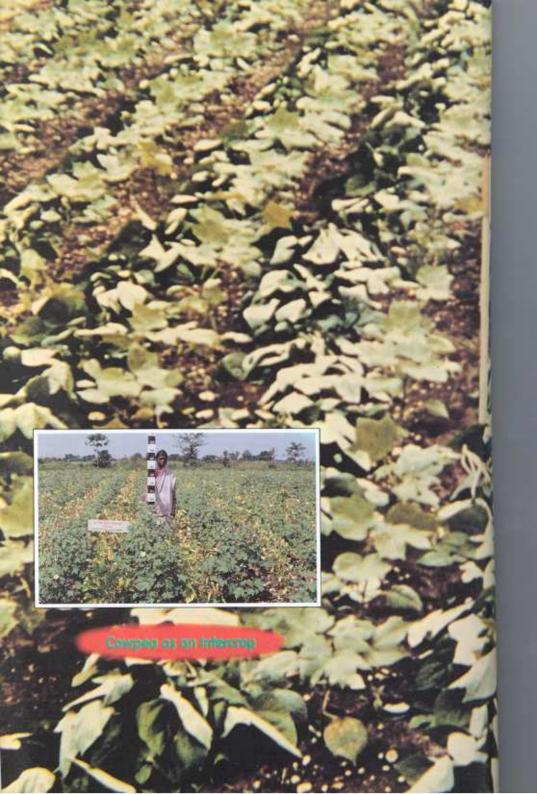
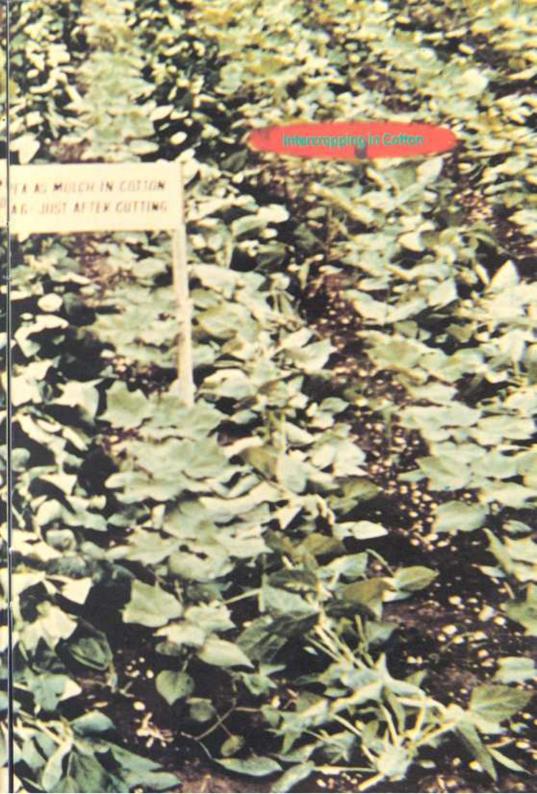


Fig. 2: Spread of Hybrid Cotton

Apart from higher productivity, hybrids are endowed with better fibre quality fetching them higher price and thus profitable to farmers. In the beginning, more emphasis was given on cottons with long and extra long staples in view of the shortages in the country.





Subsequently medium and superior medium stapled hybrids were also bred and released in order to correct the imbalance in the production of various categories of cotton. Now the country has all categories of hybrids capable of spinning from 20s counts to 80s counts. To illustrate this point, the fibre properties of H 4, Varalaxmi and DCH 32 are given in Tables 8 and 9. It is significant to note that hybrids do not suffer in their quality in the rainfed areas having well distributed rainfall. It is, however, advisable not to grow extralong staple hybrids in the rainfed situation where moisture stress during the critical boll development stage may occur since it would affect the maturity of the fibres.

Table 8: Fibre Properties of Hybrid-4 *vis-a-vis* Varieties Grown in Maharashtra

Hybrid	Mean fibre length (mm)	Range Micronaire Value (mg/in)	Bundle strength (g/t)	Spinning potential
Hybrid-4 (I)	23.9 to 29.0 (26.8)	2.9 to 4.4 (3.6)	33.2 to 42.9 (36.9)	40s-50s
Hybrid 4 (R)	22.9 to 27.9 (26.7)	2.9 to 4.0 (3.6)	37.0 to 43.4 (40.6)	40s
Laxmi (I)	23.4 to 28.2 (25.1)	3.0 to 4.1 (3.6)	35.4 to 45.0 (40.4)	40s
Laxmi (R)	20.1 to 26.4 (23.6)	2.8 to 4.2 (3.5)	38.6 to 47.2 (43.5)	30s-40s
Buri 1007	24.6 to 28.5 (26.6)	2.4 to 4.6 (3.6)	40.7 to 50.4 (45.4)	30s-40s

Figures in bracket indicate average values

I = Irrigated

R = Rainfed

Hybrids presently produce about 3.8 million bales out of the total production of 6.8 million bales. This constitutes about 56.5 per cent in the Central and South zones (Table 10).

Table 9: Fibre Properties of Varalaxmi and DCH-32

Hybrid	Mean fibre length (mm)	Range Micronaire Value (mg/in)	Bundle strength (g/t)	Spinning potential
Varalaxmi (I)	27.2 to 33.8 (31.0)	2.4 to 3.6 (3.1)	35.4 to 49.8 (44.5)	60s-80s
Varalaxmi (R)	26.9 to 33.3 (29.8)	2.7 to 3.4 (3.0)	42.9 to 47.2 (45.1)	60s-80s
DCH-32 or Jayalaxmi (I)	30.7 to 34.8 (33.4)	3.0 to 3.4 (3.2)	42.9 to 47.4 (45.7)	60s-80s

Figures in bracket indicate average values

I = Irrigated

R = Rainfed

Table 10: Area and Production of Hybrids

State	Total Area (m ha)	Area under hybrids (m ha)	Percent area under hybrids (m ha)	Total production (m bales)	Production of hybrids (m bales)	Percent of total production
Central zone						
Maharashtra	2.48	0.10	40.3	1.80	0.90	50.0
Gujarat	1.15	0.55	47.8	2.00	1.19	59.5
Madhya Pradesh	0.48	0.20	41.7	0.36	0.14	39.0
Southern zone						
Andhra Pradesh	0.80	0.50	62.5	1.20	0.72	60.0
Karnataka	0.61	0.42	68.8	0.98	0.78	79.6
Tamil Nadu	0.27	0.03	11.0	0.47	0.12	25.5
Total (Central & South zone)	5.79	1.80	272.1	6.81	3.85	313.6

(Adopted from Rakesh et al., 1994)

Presently the most popular hybrids are: H 4, H 6, H 8, AHH 468, NHH 44, JKHY 1, MECH 1, Ankur 15, Somnath (intra-hirsutum) and DCH 32 (inter-specific). Among the newer hybrids, Savita (intra-hirsutum) and TCHB 213 (inter-specific) and some private

sector bred hybrids are becoming popular. Inter-specific (herbaceum x arboreum) hybrids, of which four have been released so far, have not spread due to the constraints in seed production.

The yield range (potential) of important hybrids is shown in Table 11. Most of the hybrids are capable of producing about 3,000-4,000 kg/ha of cotton seed.

Table 11: Yield Range (Potential) of some Commercial Hybrids

Hybrid	Yield Range (kg/ha)	
(Intra-hirsutum)		
Hybrid-4	3000-4000	
JKHY-1	3000-3500	
Godavari (NHH-1)	1000-1200 (R)	
G.Cot. Hybrid 6	3000-4000	
PKV. Hybrid 2 (AHH 468)	1000-1200 (R)	
(hirsutum x barbadense)		
Varalaxmi	3000-4000	
CBS. 156	3000-3500	
Savitri (RHR 253)	2500-3000	
KCH-1	1500-2500	
JKHY-11	2000-3000	
DCH-32 (Jayalaxmi)	3000-4000	

(Source: Basu, 1983)

VI. THE IMPACT OF HYBRID COTTONS ON PRODUCTION, PRODUCTIVITY, QUALITY AND EXPORT

The advent of hybrids in seventies brought a sea change in the quantity and quality of cotton in India. Production, which was about 5 million bales before the advent of hybrids, rose to 13 million bales in 1992-93. Productivity rose from 122 kg lint per hectare to 290 kg lint per hectare during the same period. Hybrids also contributed to

the improvement of quality of cottons. Long and extra-long staple cottons, which constituted only 24 per cent of the production when hybrids appeared on the scene, now constitute about 54 per cent of the production (Fig. 3). While the growth rate of production of cotton in India was 2.6 per cent from 1947-48 to 1992-93, the growth rate of long and extra-long staple cotton for the same period was 6 to 7 per cent mainly due to the predominant role played by the hybrids.

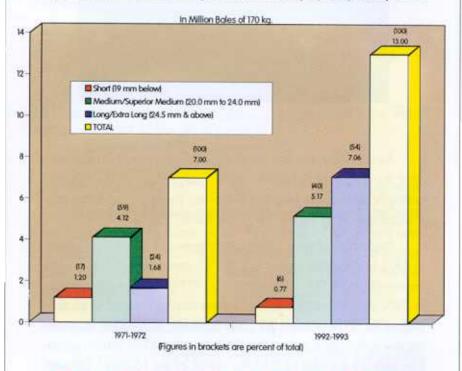


Fig. 3: Quality Improvement - Staple Groupwise Production

Higher production also enabled the country to export cotton, yarn and textiles in large quantities. Table 12 shows the import and export figures of cotton since the advent of hybrids in India.

Table 12: Imports and Exports of Indian Cotton

Period	Million bales	
	Imports	Exports
1970-71	0.88	0.17
1971-72 to 1975-76	1.77	1.36
1976-77 to 1980-81	1.19	1.45
1976-77 to 1980-81	1.19	1.45
1981-82 to 1985-86	0.12	2.02
1986-87 to 1990-91	0.38	4.08
1992-93	0.07	1.38

(Adopted from Rakesh et al., 1994)

As is evident, the exports of raw cotton increased substantially after the advent of hybrids in India. Large share of the exported cotton belongs to the long and extra-long staple cotton, being contributed mainly by the hybrids H 4, H 6 and DCH 32.

Production of spun cotton yarn improved from 881,000 tonnes in 1971 to 1523,000 tonnes in 1992-93, production of cotton cloth improved from 8,588 million meters in 1973 to 21,291 million metres in 1992-93. Value of export of cotton textiles touched to all time high of Rs. 4856 crores (US\$ 1,500 million). Incidentally export of the raw cotton, yarn and textiles (both cotton and non cotton) constitute only 33 per cent of the total export of the country. Garment industry is showing tremendous growth over the last one decade.

VII. GENERATION OF EMPLOYMENT

Hybrid seed being produced manually, using hand emasculation and pollination technique, has good employment potential in

the rural India. Estimation of labour requirement for hybrid seed production (excluding CMS/GMS based hybrids) is as under:

A. For Crossed Seed Production

- Estimated crossed seed production of 2 million kg
 million ha at the rate of 2.5 kg/ha
- Estimated labour unit generated at the rate of 5 labour unit/kg of crossed seed

B. Due to Additional Production, Harvesting etc.

- Additional production in 2 million hectares = 2.8 million quintals at the rate of 20 per cent over a variety (7 q/ha for variety)
- Additional labour units required for harvesting 2.8 million Qtls at the rate of one labour unit for 20 kg seed cotton

 Total requirement of labour units

 (A + B = 25 + 14) = 39 million labour units

60 per cent of the labour force employed for cotton hybrid seed production is *women* labour (about 23 million). Thus, hybrid seed production programme alone generated employment for 25 million additional rural labour (mainly women) units. This estimate was made a few years ago. Area under hybrids has since increased.

VIII. THE SEED INDUSTRY

The success of the Indian seed industry (public and private) owes a great deal to the hybrid cotton along with hybrid sorghum, hybrid maize and hybrid pearlmillet. It is estimated that more than hundred seed organisations, big and small, are presently engaged in hybrid cotton seed production. The seed industry in India is quite capable of even meeting the regional/international hybrid seed demand quite successfully.

IX. PROSPECTS OF HYBRIDS IN THE NORTH

The requirement of cotton in India is estimated to be around 19 million bales by 2000 AD in view of the increase in population (960 million), increase in per caput consumption of cloth (21.5 metres) and anticipated increase in export (5000 million metres). Area under cotton in India has stabilised around 7.5 million hectares. Area under irrigation is also not likely to increase substantially. Increase in productivity of the existing rainfed and irrigated areas is the only way to achieve the target of the year 2000 AD.

Hybrids have, therefore, to play an important role towards increased productivity. Considering the importance of hybrids, a special project on cotton hybrid research was launched by the Indian Council of Agricultural Research (ICAR) in 1989. This project is operating at 13 centres in all the three cotton growing zones of the country with scientific manpower of 22 scientists and equal number of technicians. This is in addition to the All-India Coordinated Cotton Improvement Project with 31 centres with 115 scientific and 140 technical manpower. The Central Institute for Cotton Research at Nagpur, with its two Regional Stations, having a scientific staff strength of 90, is also involved in hybrid research. A large number of organisations in the private sector have also intensified their efforts on hybrid cotton. Besides, the Federal and State development agencies including Cotton Corporations of India, State Seed Corporations, Maharashtra Cotton Growers Cooperative Marketing Federation and several non-Government organisations such as Indian Cotton Mills Federation, South India Mills Association, East India Cotton Association, All-India Cooperative Cotton Growers Federation are actively involved in the extension activities aiming at the promotion of hybrid cotton among farmers.

The new hybrid cotton project has already shown promising

results in the North India, where three hybrids namely, PCHH 31(Fateh), HHH81 and Raj 16 have been released for the first time. These hybrids are further expected to improve the productivity of cotton in the largely irrigated area under cotton in the northern region.

X. SECRETS OF SUCCESS

The successes of hybrid cotton in India are largely based on the following secrets:

- 1. Excellent support extended by the Government for the research and development of hybrid cotton, including required infrastructure and human resource.
- 2. Well-organized hybrid cotton seed industry, both Public and Private in different cotton growing States.
- 3. Extensive transfer of technology and field extension programmes, supported well by required input outlets in the rural areas
- 4. Minimum support price and required incentives for production of hybrid cotton, including subsidy on fertilizers and pesticides.
- Organized infrastructure for cotton marketing and rural credit system.
- Extensive extension and publicity programmes undertaken by the different State Seed Corporations and the Private Seed Organizations.
- 7. Relatively cheap labour, well-trained for hybrid cotton seed production, thus enabling seed cost to be quite reasonable and within purchasing power of the farmers.
- 8. Long duration of crop growth in the central and southern India with black cotton soils suiting well for the cotton hybrids of both medium to long duration.
- In-built tolerance of hybrids to moisture stress conditions and their
 wide adaptability and stability to perform well under rainfed conditions throughout the cotton growing regions of India, except irrigat-

- ed north region suited to short-duration cottons. Hybrids for this region have also been released recently.
- 10. Appropriate market intervention, procurement and timely policy decisions of the Government relating to supply of cotton for internal use by extensive textile industry as well as export of cotton, yarn and garments.

XI. EPILOGUE

Successful cultivation of hybrid cotton in India has brought a new hope for hybrid cotton research and development in other countries as well. Spread of hybrid cotton would help increase global cotton production. China has already taken initiative and brought some sizeable area under hybrid cotton. Many other cotton growing countries of the Asia-Pacific region have similar prospects for hybrid cotton cultivation. A collaborative programme among interested countries in the region could help in accelerating required growth in this direction. Much could be learnt in this regard from the experiences and achievements attained by the cotton researchers and farmers in India.

SELECTED REFERENCES

- Anonymous 1990. Hybrid Cotton in India. Bulletin, Central Institute for Cotton Research, Nagpur.
- Basu, A.K. 1983. Spectrum of hybrid cotton in India. *Indian. Fmg.* 33(9): 16-22
- Basu, A.K. 1989. Technology for increasing cotton production in India. All Ind. Coord. Cott. Imp. Proj. CICR RS Coimbatore. pp 63
- Davis, D.D. 1978. Hybrid cotton: Specific problems and potentials. Adv. in Agron. 30: 129-157.
- Jayswal, A.P. and Sundaramurthy, V.T. 1990. Pest problems in hybrid cotton in India and their management. Paper presented at FAO-ICAR Expert Consult. on Hybrid Cotton Cent. Instt. for Cott. Res. Nagpur, India Oct. 22-25.
- Katarki, B.H. 1971. A high-yielding hybrid cotton of quality. *Indian Fmg.* 21(8): 35-36.
- Meyer, V.G. 1975. Male Sterility from Gossypium harkenssii. J. Hered. 66: 23-27.
- Oka, P.G. and Sundaram, V. 1983. Technological performance of various hybrid cottons. *Indian Fmg* 33(9): 32-36
- Paroda, R.S. and Basu, A.K. 1990. Cotton scenario with particular reference to hybrid cotton in India. Proc. FAO-ICAR Regional Expert Consult. on Hybrid Cotton. Oct. 22-25, 1990. CICR Nagpur. pp 38-67.
- Patel, C.T. 1971. Hybrid 4, a new hope towards self sufficiency in cotton in India. Cott. Dev. 1: 1-6.
- Patel, C.T. and Mehta, N.P. 1983. Hybrid cotton: A landmark in cotton improvement. *Indian Fmg.* 33(9): 7-14.
- Patel, C.T. and Mehta, N.P. 1983. Hybrid seed production technique for exploitation of heterosis in cotton. *Indian Fmg.* 33(9): 23-31.

development of hybrid cotton. *J. Indian Soc. Cott. Imp.* 3: 79-85.

Sundaramurthy, V.T., Jayaswal, A.P., Bhamburkar, M.W. and Banerjee, S.K. 1990. Insect-pests and their management in cotton. *In*: Cotton

Scenario in India - A Souvenir. ICAR, New Delhi.

cotton, Cott. Dev. 8: 21-26.

cottons in India. Cott. Dev.12: 35-45.

Cott. Dev. Bombay. April, 1994.

46-56.

Patil, T.T. 1990. Experience in hybrid seed production. FAO-ICAR Reg. Expert Consult. on hybrid cotton. CICR Nagpur, Oct. 22-25.
 Ramchandran, K., Joshi, L.S. and Menon, C.B. 1978. Cost of pest control in

Ramchandran, K., Roybhowmik, A.B. and Venkatraman, M. 1982. Hybrid

Rakesh, R.C., Thilakan, E.I.S and Joshi, S.S. 1994. Cotton in India. Dte. of

Singh, T.H., Chahal, G.S., Bhardwaj, H.L. and Tikku, P.L. 1980. Exploitation of heterosis in cotton - A review. J. Indian Soc. Cott. Imp. 5(2):

Srinivasan, K. and Gururajan, K.N. 1978a. Transference of male sterility to some improved cotton varieties. J. Indian. Soc. Cott. Imp. 3: 17-20.
Srinivasan, K. and Gururajan, K.N. 1978b. Role of male sterile line in the

Orawan Lieng:

DESIGNED BY

J