

# HIGHLIGHTS OF ACHIEVEMENTS OF COTTON RESEARCH



Main Cotton Research Station  
Navsari Agricultural University  
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*: Cover Page Photograph:*

G.Cot.Hy-8 (BG-II) Cotton field

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# HIGHLIGHTS OF ACHIEVEMENTS OF COTTON RESEARCH

*Compiled By*

Dr. V. Kumar

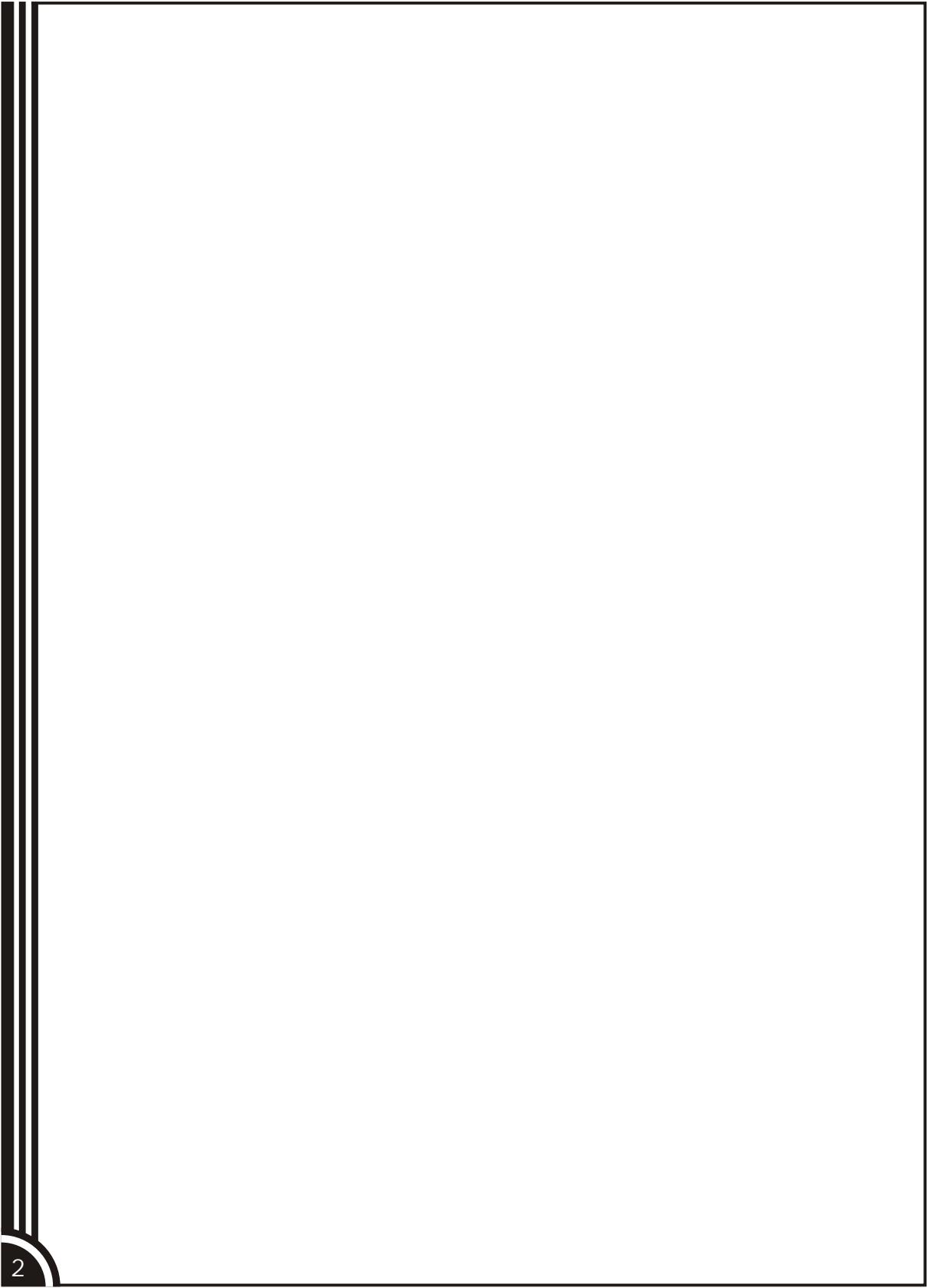
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# COTTON

## *Brief History*

Cotton has been the king of apparel fibre since time immemorial. Archeological excavations of about 300 B.C. in Indus valley and citation in *Reguveda*, written about 15 centuries B.C. reveal the ancient use of cotton fibres. Marco Polo mentioned the cultivation of tree cotton in Gujarat in about 1290 A.D.

The erst-while East India Company attempted to introduce American cotton for cultivation during 18<sup>th</sup> century on experimental basis on cultivator's fields in Gujarat. But since no success was achieved, efforts were made to improve indigenous cottons, particularly after the establishment of a research station at Surat in 1896. However, systematic work on cotton started in 1904 at this station for the first time in the state. Since then the entire research apparatus has been strengthened in terms of manpower, equipments and new stations from time to time. Presently, cotton research in the state is carried out through a well knit network of one main, eight regional and seven sub-stations distributed all over the state and representing all cotton growing agro climatic zones. It is supported by liberal grants from the State Govt., I.C.A.R., Govt. of India and a number of Private Organizations.

## *Agro climatic Zones*

The entire cotton growing area in the state is divided into four zones. These cotton zones are protected by various Cotton Acts. Research stations in each zone, their broad mandate along with the year of establishment are as follows:

(1) South Gujarat Cotton Zone-comprises the entire area south of the river Narmada. The soils are medium to heavy clayey. The annual rainfall ranges from 1000-1500 mm

- |   |   |      |
|---|---|------|
| 1 | Main Cotton Research Station, NAU; Surat- Irrigated (To conduct applied and basic research on crop improvement and production through multidisciplinary approach and provide guidance to regional and sub-stations) | 1896 |
| 2 | Sub-station, NAU; Achhalia Rainfed/Partly Irrigated ( For low rainfall and undulating tract)  | 1963 |
| 3 | Sub-station, NAU; Hansot-Irrigated (Originally started at Shera in 1933 for testing wilt resistance, shifted to Hansot for biocontrol/ IPM research)  | 1964 |

(1) Middle Gujarat Cotton Zone-covers roughly, the area between rivers Sabarmati in the North West and Narmada in the South. The soils vary from clayey to sandy loam and the annual rainfall ranges from 600 to 1000 mm

- |   |   |      |
|---|---|------|
| 1 | Regional station, NAU; Bharuch- Rainfed<br>(For herbaceum cotton including wilt resistance testing) | 1926 |
| 2 | Regional station, SDAU; Talod-Irrigated<br>(For long staple Indo-American cottons)                  | 1957 |
| 3 | Regional station, AAU; Anand-Irrigated<br>(For Egyptian quality cottons)                            | 1977 |

(3) Wagad Cotton Zone-consists of the area lying North East of river Sabarmati, Kutch and Saurashtra excluding Mathio tract. The soils are sandy loam to medium clayey with variable depths. The rainfall is erratic and varies from 300 to 750 mm

- |   |   |      |
|---|---|------|
| 1 | Regional station, AAU; Viramgam- Rainfed<br>(For closed boll/semi open boll herbaceum cotton) | 1922 |
| 2 | Regional station, JAU; Junagadh-Irrigated<br>(For long staple Indo-American cottons)          | 1962 |
| 3 | Sub station, AAU; Dhandhuka- Rainfed<br>(For Bhal area)                                       | 1962 |
| 4 | Sub station, JAU; Ratia & Porbandar-Rainfed<br>(For Ghed area)                                | 1962 |
| 5 | Regional station, SDAU; Bhachau Rainfed<br>(For Kutch area)                                   | 1962 |

(4) Mathio Cotton Zone: comprises of Bhavnagar, Amreli district and some talukas of adjoining districts. The soils are medium black and shallow. The average rainfall is about 500mm

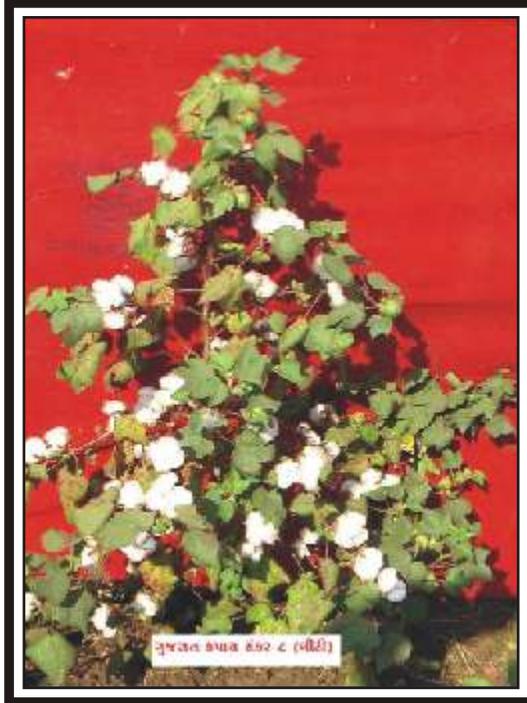
- |   |  |      |
|---|--|------|
| 1 | Regional station, JAU; Amreli-Rainfed (For arboreum cottons) | 1937 |
|---|--|------|

Specific improved varieties of Asiatic cottons (*G. herbaceum* L. and *G. arboreum* L.) are grown in each zone. The American cotton varieties (*G. hirsutum* L.) and hybrids are grown throughout the state wherever the soils and climatic conditions are suitable, though some of them are more localized.

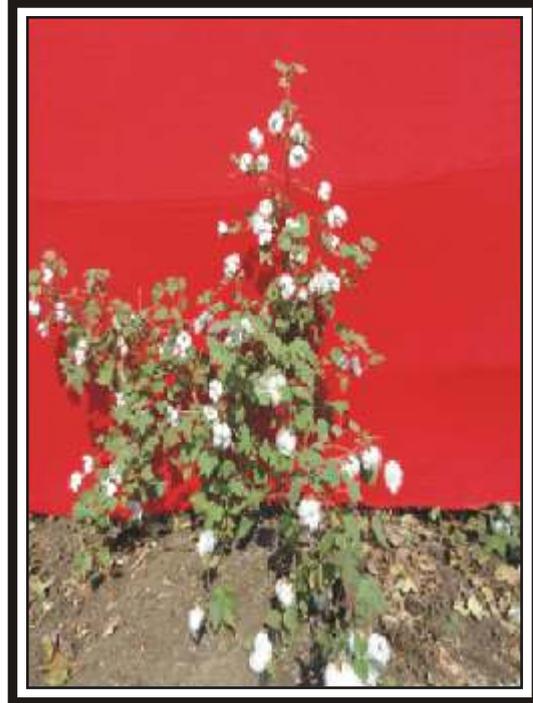
The main research station and its regional/sub-stations are manned by over 44 qualified and competent scientists. The work is carried out under the overall supervision of Director of Research of each of the four Universities and technical guidance and supervision of Research Scientist (Cotton).



Cotton Map of Gujarat



*G. Cot. Hy-8 (BG-II)*



*G. Cot. Hy-6 (BG-II)*



*Recently commissioned Biotech Laboratory Facility*

### *Area, Production and Productivity*

The information on the area, production and productivity of cotton in the state for last 10 years is given in Table I. Area has increased by nearly 50% in the last six years especially after introduction of Bt cotton. The production and productivity are compensate with area.

Table I Area, Production and Productivity of cotton in Gujarat during last ten years.

Year	Area (Million hectares)	Production (Million bales)	Productivity per annum
2002-03	1.498	3.100	351
2003-04	1.647	4.600	475
2004-05	1.995	7.300	657
2005-06	2.080	8.900	728
2006-07	2.390	10.500	746
2007-08	2.520	11.000	743
2008-09	2.470	9.000	633
2009-10	2.625	9.800	635
2010-11	2.620	10.40	675
2011-12	2.800	11.50	698

### *Achievements*

#### The Firstevers

Since its establishment in 1896, the cotton research station, Surat has been a trail-blazer for its research achievements. Though some varieties were evolved earlier, it got first shot in the arm when the first ever Indo-American variety DEVIRAJ (170 Co2), involving American and Asiatic blood was released in 1951 after several years of intensive efforts with inter specific breeding materials. Release of first intra hirsutum hybrid cotton HYBRID-4, from this centre in 1971 was another landmark in the history of cotton. This hybrid proved to be harbinger for researchers elsewhere in the country as well as abroad. Then came the first ever budded cotton G. Cot. 101 which was released in 1977. This cotton combined the properties of perennial as well as annual cotton and is especially suited to the needs of adivasi farmers in the non-conventional cotton areas. Concurrent efforts for development of desi hybrid culminated in the release of hybrid G. Cot.DH-7 in 1984. This was another feather in the cap of this station. In fact, it proved to be a trend setter for development of desi hybrid in other states of the country. In 1989, the first ever long staple desi hybrid G.Cot.DH-9 was released. First GMS

based desi hybrid of Gujarat G.Cot.MDH-11 was released in 2002. Similarly first ELS hybrid G.Cot.Hy-102 (H x B) was released in 2002. The first ever Bt cotton hybrids by Public Sector Institute was released as G.Cot.Hybrid - 6 (BG-II) and G.Cot. Hybrid - 8 (BG-II). Thus the station has the distinction of several firsts to its credit and it is quite heartening to note that many varieties of Gujarat have been widely acclaimed in other states.

#### High yielding varieties/hybrids

As a result of intensive efforts, in all 47 high yielding varieties/hybrids have been released since the inception of the research station. The detailed economic characteristics of cultivated varieties are given in Appendix II(A).

#### Agro techniques

Technological innovations have emanated in the form of 70 agro-technique recommendations. The recommendations cover the time of sowing, seed rate, spacing, dose and the time of application of fertilizers irrigation scheduling and weedicides for different varieties and hybrids in different agroclimatic zones of Gujarat. A cotton based intercropping, double cropping system was developed and recommended for rainfed tracts of Bharuch and irrigated areas of Surat (APPENDIX-II (B)).

Thirty one plant protection recommendations on effective doses of different conventional as well as new generation pesticides, threshold based pesticide application, bioagents, viz, parasites, predators, NPV and B.t.k powder, pheromones and mechanical control under the integrated pest management have been developed (APPENDIX II (D)). It could save 3 to 5 insecticidal applications without significant reduction in seed cotton yield and minimize environmental hazards. Recommendations have also been made for different fungicides to control diseases. Sources for different diseases have also been identified.

Use of different growth regulators such as N.A.A., G.A. and C.C.C. has not shown any consistent effect on the productivity of crop. Studies on variability in physiological parameters, their relation with yield and manipulation, drought tolerance and its ameliorations, climate change and its mitigation have generated useful information. Just like several firsts in the area of varietal development programmes, recommendation for economy in fertilizer, particularly phosphorus application to cotton also emerged from this station. Long term experimentation (25 years) at Surat had clearly shown that no or added phosphorus has any significant bearing on yield, quality or soil P status until a few year back. Research carried out on seed technology has generated useful information on development quality, processing and storage aspects of cotton seed and three recommendations have been made. A summarized list is given in Appendix II(B).

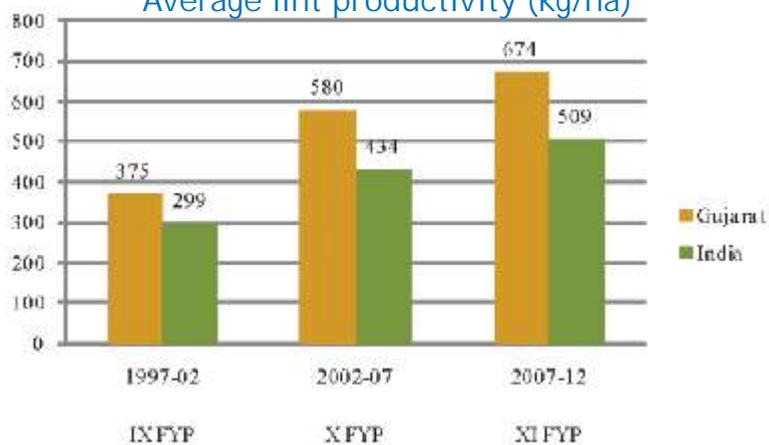
## Impact of Research

As a result of evolution of high yielding varieties and hybrids and the technological innovations, the cotton production has considerably increased and the country which had to import large quantity of cotton in the sixties, has not only become self sufficient, but also emerged as a marginal exporter, despite the fact that consumption has sizably increased over the years. Annual increase in cotton productivity and percent growth rate in Gujarat

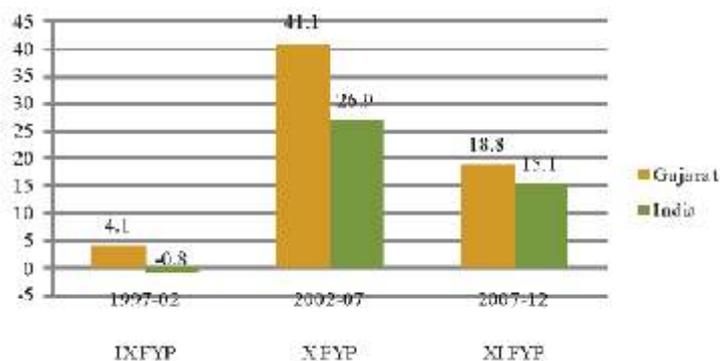
Average lint production (M Bales/year)



Average lint productivity (kg/ha)



Average increase in productivity (kg/ha/year) over previous FYP



The average productivity and growth rate of cotton as well as increase in productivity kg/ha/year for Gujarat is presented in Table-2. Average productivity showed an increasing trend. The annual increase kg/ha/year reflected during X FYP it was 37.04 kg/ha/year against 7.72 kg/ha/year of previous FYP which further rose of 20.4 kg/ha/year in the XI five year plan over the X F.Y.P which is unprecedented ever recorded in any crop, any time in any state? The average annual growth rate (%) was 9.42 % in X five year plan and 3.51 % in XI five year plan against 2.18 % of IX five year plan, over respective previous five year plans.

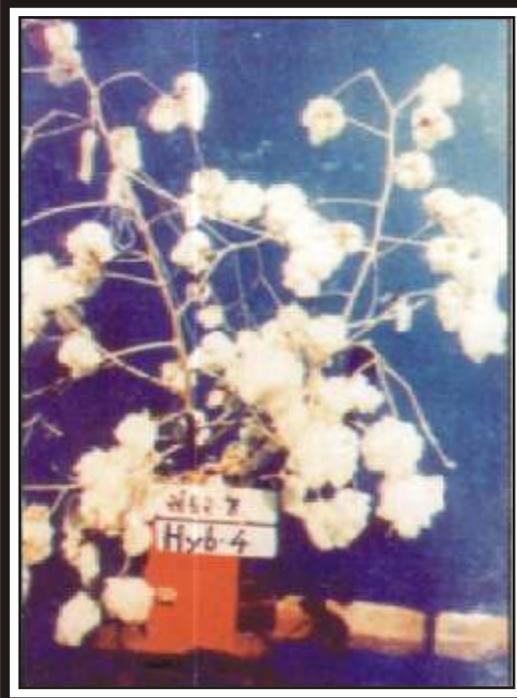
The average production in the state recorded unprecedented 66.9 lakh bales/year in the X FYP against 34.7 lakh bales in previous FYP, adding 6.45 lakh additional bales annually with 18.61% growth over IX FYP (Table-3). The XI five year plan recorded an average production of 103.4 lakh bales per year with 6.94 lakh bales per annum with annual growth rate of over 10.10 % over previous five year plan.

### *Ongoing programmes*

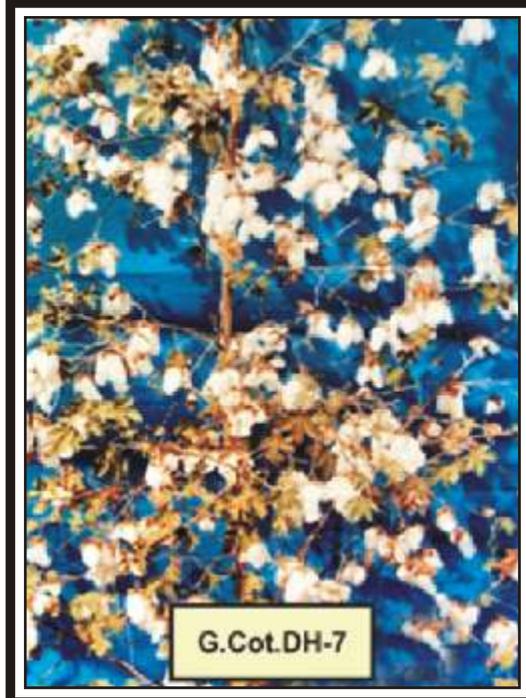
#### Varietal improvement

The station has one of the richest collections of interspecific cotton hybrids prepared in nineteen twenties to forties. Some of them have generated good varieties and basic breeding materials having higher boll weight, short duration, tolerance/resistance to sucking pests, high yield potential and desired fibre characters and used practically all over the country. During last decade, new such varieties/hybrids were added and their characterization and large scale exploration is being done. Several entries/hybrids are contributed to AICCIP/TMC trials by NAU, amongst them some appeared very promising and stood amongst top five entries in overall performance for respective zone.

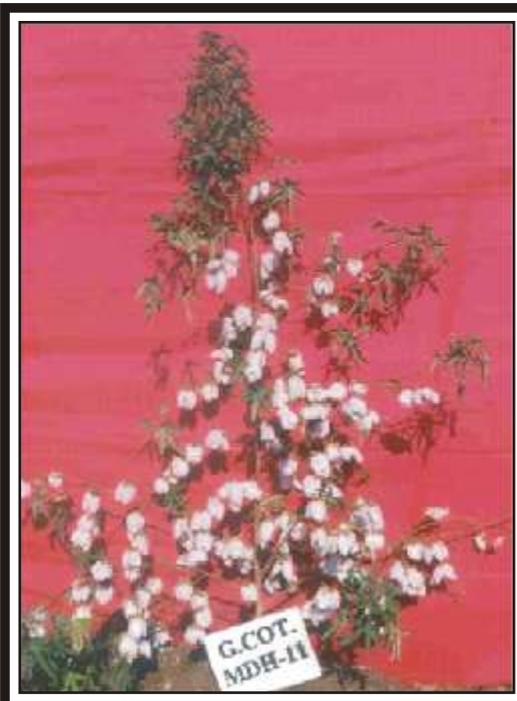
The research work on naturally coloured cotton is also in progress although at slow pace. Development of new Bt cotton hybrids, marker assisted selection for jassid resistance and water stress tolerance, use of mutations for herbicide tolerant cotton, improvement in boll opening in barbadense and some specific program currently underway



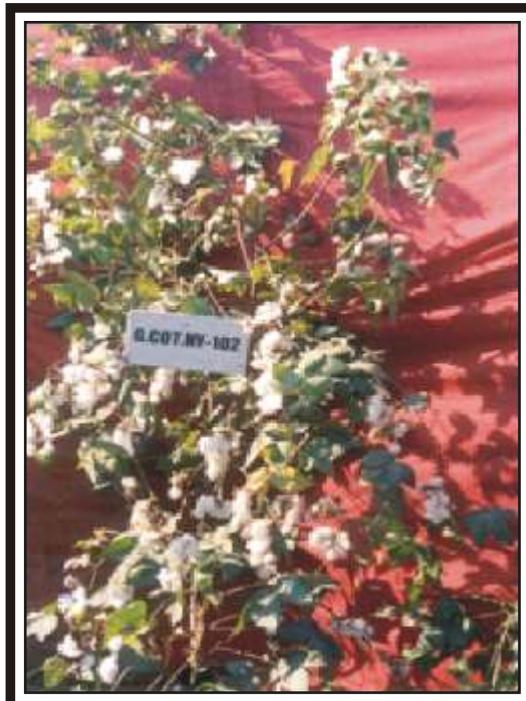
*Hybrid-4: The first successful commercial cotton hybrid in the world*



*The First desi cotton hybrid of the world*



*G.Cot.MDH-11: Male sterility based first desi cotton hybrid of the state*



*G.Cot.Hy-102: The first Hirsutum x Barbardense ELS hybrid of the state*



*Dr. K.C. Jain, ADG (Commercial Crops), ICAR, New Delhi in discussion with Research Scientist Dr. V. Kumar during his visit to the research station.*



*Glimpses of Inauguration of National Conference on Cotton held at Main Cotton Research Station, Surat October 19-21, 2010.*

## Agro techniques

In agronomy, apart from working out the input requirements of the varieties in breeders' pipeline which is a continuous process, efforts are made to workout agro-techniques for increased productivity at lower cost. Studies are also underway for increasing the efficiency of added fertilizers, through bio-fertilizers, organic amendments etc. To minimize/conserves water use, experiments on conventional irrigation methods, mulches and drip systems are going on. Studies on organic farming, use of micronutrient, water management exploring potential of Bt cotton are currently under way.



*Irrigating cotton in alternate furrows saves considerable water*



*Pigeon Pea as a barrier crop around cotton field*

The physiological research in cotton includes studies on usefulness of defoliants, antitranspirants and growth regulators for increasing yield of cotton. Studies on variability in physiological parameters and their relation with growth and yield also undertaken. Research on drought tolerance and amelioration of drought, modification of morpho-frame in Bt cotton etc are going on.

### Physiological Manipulation of Bt Cotton Plant Morphoframe



*Square removal through Ethylene application*



*Compact morphoframe*



*Application of Maleic Hydrazide (500mg/l) at 85 days after sowing enhances seed cotton yield.*

In Biochemistry, studies on oil content, its quality and nutritional aspects of cotton seed protein are undertaken. Biochemical basis of drought tolerance is also under study. In addition to this, plant and soil samples from different trials and station are analyzed. Causes of no response to added phosphorus and methods for getting the same are being investigated.

#### Pest and Diseases control

In entomology, work on integrated pest management and insecticide resistance management (IRM) is undertaken. This involved combination of different pest management methods viz., cultural, mechanical, biological, physical etc. coupled with judicious application of appropriate pesticides. The screening of varieties/cultures for resistance to different pests is in progress. The study on weather parameters responsible for fluctuations in pest intensities is undertaken so that likely pest incidence could be predicted. New molecules for control of pest are tested every year. Pink bollworm which is attaining a greater proportion in this area is also under intensive monitoring and control measures studies.

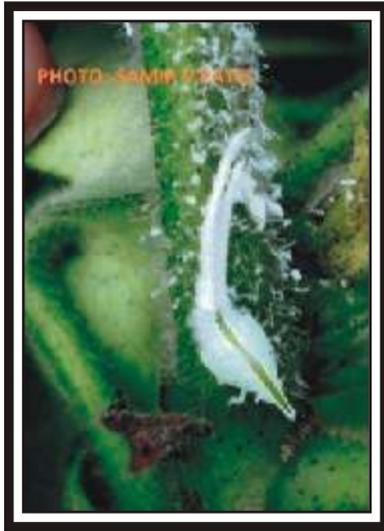


*Interspersing maize to conserve predators*



*Mealy Bug infested Cotton Ball*

In plant pathology, large scale screening of seedling and adult plants is being done for identification of genes for resistance or tolerance to various diseases so that they may be utilized in breeding. Surveys for determining incidence and losses due to diseases are undertaken. Chemical and biological control measures for important diseases are investigated.



*Unidentified insect  
Family: Flatidae*



*A cotton twig infested by Mealy Bug  
parasitized by Aenasius bambawalei Hayat*

### *Breeder seed production*

Breeder seed production is under taken to meet the entire demand of breeder seed from public sector, private sector, cooperatives and farmers. Statement showing the information on breeder seed production of parents of hybrids and stable varieties of cotton during last five years is given here under.

Sr. No.	Year	Production of seed (kg)
1.	2007-08	3643
2.	2008-09	11421
3.	2009-10	9566
4.	2010-11	5307
5.	2011-12	3872

### *Front Line Demonstrations*

Front line demonstrations are core issue for dissemination of technology at farmers field. The details of last five years are given under

Years	No of FLDs allotted	No. of successful FLDs	Success %	Seed cotton yield (kg/ha)		% increase over check
				FLD	Control	
2007-08	75	71	71	1959	1732	13.10
2008-09	100	90	90	1745	1535	13.68
2009-10	100	100	100	2126	1786	19.00
2010-11	100	100	100	1763	1433	23.0
2011-12	50	50	100	1623	1421	14.2

### *Extension Programmes organized*

Final outcome of the research as recommendation has to reach to the ultimate stake holders i.e., to farmers for which training/orientation program are organized for extension functionaries, farmers, NGO's and other user agencies. Details of such programmes in last few years is as follow:

Sr. No	Date	Place	Particular	No of participants
1	13-14/12/07	MCRS, Surat	Extension workers and dealers training shibir organized under TMC MM-II programme	45
2	29-30/08/08	MCRS, Surat	Extension workers and dealers training shibir organized under TMC MM-II programme	50
3	24-31/10/07	MCRS, NAU, Surat	Eight days National training programme of Integrated Pest Management in association with NCIPM, New Delhi	30
4	16/09/08	MCRS, NAU, Surat	Training programme for Agricultural Officers of Shri Ganesh Khand Udyog Sahakari Mandali Ltd., Vataria, Dist:- Bharuch on Production Technology in Cotton	12
5	23/09/08	MCRS, Surat	Training Programme for Staff of Gujarat State Seed Certification Agency, Ahmedabad	30
6	29-30/08/08	MCRS, NAU, Surat	Training Programme for Dealers and Extension Workers of State Dept. of Agriculture	48
7	29-31/07/10	MCRS, NAU, Surat	Three days Training Programme on Production and Protection Technology in Cotton for Progressive Farmers of Kutch District under ATMA Project	45

### *Awards and Honors*

Scientists of the station have been recognized/ awarded/ honored for their contribution and achievements by various agencies/ organization. Some of the recent gains are given here under:

No.	Awards and Honors	Year
1	Dr. V. Kumar received A Sanman Patra from Agrawal Samaj Trust, Surat for meritorious services to agriculture	2006
2	Main Cotton Research Station Surat jointly received AICCIP Award 2007-08 for cotton research	2007
3	Dr. V. Kumar awarded for his outstanding contributions and achievements in cotton research by NAU, Navsari and ISCI, Mumbai during National Conference.	2010
4	Dr. V. Kumar conferred with Dr. R. H. Dastur Memorial Award for outstanding contribution in Plant Physiology by the Indian Society for Cotton Improvement, CIRCOT, Mumbai.	2011
5	Confederation of Indian Industry (CII) Western Zone, Ahmedabad felicitated Dr. V. Kumar for partnering in Indian Agriculture and India's Cotton Revolution.	2012
6	Punjab Agriculture University Vice Chancellor Dr. B.S.Dhillon honored Dr. V. Kumar at Regional Station Faridkot (7-9-2012) for his services to cotton development.	2012

### *Publications*

Research, findings and achievements are not only transformed into farmers recommendations but are published as research publications, popular articles, book/ bulletin, presented in conferences/ seminars and extension programmes:

Year	Paper published	Paper presented	Popular articles	Book/ booklets
2007-08	4	13	2	1
2008-09	4	11	5	--
2009-10	2	10	4	2
2010-11	2	26	5	3
2011-12	1	17	1	-

### *Future Perspectives*

The varietal improvement and consequent incidental agronomic and plant protection investigations are continuous unending process. In agriculture, which is an applied biological science, an innovation solves some problem leading to certain progress but the same is soon followed by new problems. Any slackening of efforts in agricultural research is beyond comprehension. Keeping resource availability, priorities have been considered and following areas of research identified.

- Breed varieties and hybrids using hybridization, biotechnology, selection and use of wild species tolerant / resistant to biotic and abiotic stresses factors.
- Enhance productivity and quality and reduce duration of desi cotton for organic cotton and technical textile.
- Evolve high yielding physiologically efficient and low input responsive cotton varieties suitable for cultivation under scanty rainfall conditions.
- Workout suitable agro-techniques for each of the traditional as well as newly coming up varieties/hybrids to obtain maximum produce per unit of land, inputs and time in the changing environment scenari.
- Keep a constant watch on changing pest and disease pressure and to evolve suitable bio-chemo, agro-techniques to keep them under control so that production hazards are minimized.
- Produce high quality seeds of parents of hybrids and stable varieties.
- Demonstrate the technology at farmers field through various extension modes.
- Develop new transgenic hybrid with higher yield and stability
- Intensify research on jassid resistance and stress tolerance using marker assisted selection.
- Initiate research on climate change its effect on physiology & devise strategies to mitigate the same.
- Trait based improvement programme for boll weight, strength and fineness in hirsutum, boll opening & jassid tolerance in barbadense.

## APPENDIX-I

Major Cotton Research Schemes at M.C.R.S., Surat during last five years.

Sr. No.	Name of the scheme
	<i>I.C.A.R.</i>
1	All India Co-ordinated Cotton Improvement Project
2	Front Line Demonstration
	<i>PLAN SCHEMES</i>
1	To establish of excellence for cotton research
2	Improving research facilities for cotton
	<i>NON PLAN SCHEMES</i>
1	Scheme for research in budded cotton
2	Project for research in cotton
	<i>Technology Mission on Cotton Mini Mission-I (TMC-MM-I)</i>
1	Development of diploid (desi) cotton cultivars with high fibre quality: MM 1.1 (Bharuch)
2	Development of tetraploid cotton cultivars with high fibre quality and resistance to drought and biotic stresses : MM 1.2
3	Genetic diversity through introgression of useful genes: MM 1.3
4	Development of extra long staple <i>G. barbadense</i> with improved fibre qualities to meet the requirement of textile industries: MM 1.4
5	Maintenance breeding, seed production, enhancement of seed viability and studies on marker based purity evaluations : MM 1.5
6	Integrated nutrient management for high quality fibre and yield : MM 2.1
7	Integrated water management system for better fibre quality and high production : MM 2.2
8	Refining regional-level prediction of yield : MM 2.4
9	Integrated pest management (IPM) at village level to produce cost effective, quality fibre : MM 3.1
10	Development and validation of IPM/IRM strategies for Bt and conventional cotton under different ecosystems: MM 3.2
11	Evaluation of cotton production technologies for fibre quality, yield and cost benefit ratio : MM 5.1
	<i>Technology Mission on Cotton Mini Mission-II (TMC-MM-II)</i>
1	Insect Resistance Management (IRM)
	<i>Rashtriya Krishi Vikas Yojana under National Agriculture Development Programme of Government of India</i>
1	Community approach for implementation of Eco-friendly IPM of mealy bug in cotton (From 2008-09)
2	Development of cotton ( <i>Gossypium</i> spp.) for salt affected soils of Gujarat and their management for higher yield
3	Strengthening of facilities for developing transgenic cotton and their production technology for enhancing yield in Gujarat

## APPENDIX-II (A) : Economic characters of varieties/hybrids released from Gujarat

Sr. No.	Varieties	Type	Year of release	Maturity days	Seed cotton yield kg/h.	2.5 % span length (mm)	G.P. (%)	Fibre fineness (mv)	LUR	Fibre strength (g/tex)	Maturity Coefficient	Spinning count	Oil Content (%)
1	Digvijay	Herbaceum	1956	260	663	23.1	39.0	4.4	50	9.5(PSI)	0.75	40	17.20
2	G.Cot. 17	Herbaceum	1995	200-230	1375	22.5	40.5	4.1	51	47.1(0mm)	0.79	--	17.58
3	G.Cot. 23	Herbaceum	2000	190-210	1300	22.4	39.1	4.2	52	22.9(3.2mm)	0.81	16-20	18.52
4	G.Cot. 16	Hirsutum	1995	135-140	1606	26.8	36.7	4.2	49	47.9(0mm)	0.83	40	21.78
5	V-797	Herbaceum	1966	260-300	787	22.6	39.9	3.9	47	7.7(PSI)	0.82	31	18.17
6	G.Cot. 13	Herbaceum	1981	245-280	887	23.2	39.4	4.3	48	45.1(0mm)	0.74	30	19.13
7	G.Cot. 12	Hirsutum	1981	210-220	600	24.3	36.0	4.3	46	8.4(PSI)	0.80	23	16.57
8	G.Cot. 21	Herbaceum	1998	215-225	1129	23.6	42.1	5.3	48	52.8(0mm)	--	20	18.98
9	G.Cot. 18	Hirsutum	1999	175-180	1535	27.4	34.0	3.6	48	17.6(0 mm)	0.85	--	21.20
10	G.Cot. 15	Arboreum	1989	120-150	1108	21.1(MFL)	32.8	5.7	50	47.2(0mm)	0.78	--	18.30
11	G.Cot. 19	Arboreum	1997	110-120	1101	25.4	34.5	4.4	50	50.8(0mm)	0.76	--	18.31
12	Deviraj	Hirsutum	1951	290	1250	27.4	36.3	3.7	45	7.2(PSI)	0.77	43	--
13	G.Cot. 10	Hirsutum	1974	180	1350	24.3	35.7	4.2	48	8.9(PSI)	0.72	40	19.40
14	G.Cot. 20	Hirsutum	2007	170-190	1760	25.5	34.9	4.7	51	21.7 (3.2 mm)	0.82	30-40	--
15	Hybrid-4	Hirsutum	1971	210-230	2103	26.7	33.4	3.5	40-51	7.5-8.5(PSI)	0.70-0.80	40-60	21.82
16	G.Cot. Hy-6	hybrid Hirsutum	1980	190-210	(3400*) 1305	27.5(MFL)	33.6	4.2	48	8.7(PSI)	0.77	60-70	21.70
17	G.Cot. DH-7	hybrid Desi	1984	180-200	(3800*) 1808	21.8(MFL)	37.5	5.6	49	9.4(PSI)	0.76	28-30	19.01
18	G.Cot. Hy-8	hybrid Hirsutum	1988	170-190	(2600*) 1824	25.8	36.5	4.5	50	47.8(0mm)	0.83	40-50	20.00
19	G.Cot. DH-9	hybrid Desi	1989	180-200	(3775*) 2108	28.4	34.1	4.7	47	49.2(0mm)	0.80	40-50	18.92
20	G.Cot. Hy-10	hybrid Hirsutum	1995	190-210	1837 (3805*)	28.9	34.6	4.3	48	43.7(0mm)	0.83	40-50	17.61
21	G.Cot. MDH-11	Male sterility	2002	120-140	1307 (2727*)	23.8	36.5	5.7	51	19.0(0mm)	0.83	20-30	20.49
22	G.Cot. Hy-102	Hir x Barb. Intra	2002	220-230	1967	34.0	33.4	3.6	48	25.3(3.2mm)	0.76	60-80	17.06
23	G.Cot. Hy-12	hirsutum	2005	175-190	1829	26.6	34.2	4.2	51	22.9(3.2mm)	0.80	40-50	23.39

APPENDIX II (B) : Recommendations for cotton cultivation

A : Agronomic Practices on cotton.

Sr.	Variety/hybrid	Seed rate (kg/ha)	Spacing in cm		Fertilizer (kg/ha)		
			Irrigated	Rainfed	Irrigated	Rainfed	
G. herbaceum (Open boll type)							
		Dibbling	Drilling				
1.	Digvijay	4-5	8-10	150x30	90x30	50 50 in 2 splits	20 20
2.	G. Cot. 16	3-4	8-10	--	90x30	--	40 40
3.	G. Cot. 17, G. Cot. 23	4-5	8-10	-	120x30 or 150x45	--	40 40
G. herbaceum (closed and semi open boll types)							
4.	V-797	10-12	15-20	--	45x22.5	--	20 20
5.	G. Cot. 13, G. Cot. 21	10-12	15-20	--	120x30	--	20 20
G. arboreum							
6.	G. Cot. 15	3-4	15-20	--	60x150-20	--	12.5 12.5
7.	G. Cot. 19	3-4	15-20	--	60x150-20	--	12.5 12.5
G. hirsutum							
8.	Deviraj	8-10	12-15	120-150x60	--	25	50* -
9.	G. Cot. 10	2.5-3.0	8-10	90x30(NG)90x60(SG)	90x30	50(NG)75	100*(NG)150* -
10.	G. Cot. 12	8-10	12-15	90-120x60-75	--	25	25 -
11.	G. Cot. 16	3-4	8-10	---	90x30	--	40 (BCH) 40

Sr.	Variety/hybrid	Seed rate (kg/ha)		Spacing in cm		Fertilizer (kg/ha)			
		Dibbling	Drilling	Irrigated	Rainfed	Irrigated	Rainfed		
Intra-hirsutum hybrids									
12.	Hybrid-4	2.5-3.0	--	120x60(SRT)	--	80	240**	--	--
				90x60(TLD)	--	45-60-60	135**	--	--
13.	G. Cot. Hy.6	2.5-3.0	--	120x45(SRT)	90x30(BCH)	80	240**	60	60
				90x45(JND)	--	40	120**	--	--
				90x60(TLD)	--	40	120**	--	--
				90x30(ACH)	--	40	120**	--	--
14.	G. Cot. Hy.8	4.0	--	120x60 (2 p/h) 120x45(1)	--	80(SRT)	240**	40	40
				90x30(JND)	--	40	40	--	--
				90x30(TLD)	--	40	120**	--	--
15.	G. cot. Hy.10	2.5-3.0	--	120x45	120x30	60(SRT)	180**	40(BHR)	40
Desi hybrids									
16.	G. Cot. DH.7	3.0	--	9. x60or120x60(SRT)	90x60(BCH)	40	120**	60	60
17.	G. Cot. DH.9	3.0	--	90x60	--	40(SRT)	120**	40	40
				--	120x30		--	40-40(KHBD)	40
Bt cotton									
18.	RCH 2	-	--	120 x 45	-	60:40:00	180**	-	-

19	Intercropping of soybean with G. Cot. 11 cotton	For securing higher profit, farmers of South Gujarat Zone-II are advised to adopt intercropping of Soybean in cotton with 100% of recommended dose of nitrogen to cotton (80 Kg N/ha) and 50% recommended dose of N and P to soybean (10 Kg N and 20 Kg P2O5/ha) or 50% recommended dose of nitrogen to cotton and 100% recommended dose of N and P to soybean (Bharuch)
20	Intercropping of Urid with G. Cot. 11 or Tur BDN-2	For securing higher profit, farmers of south Gujarat Zone-II growing rainfed cotton G. Cot. 11 or Tur BDN-2 at distance of 120cm between rows are advised to intercrop two rows of Urid (30 cm apart) between the rows (Bharuch)
21	Intercropping of Urid and Mung with G. Cot. Hy.6	For securing higher net profit, farmers of South Gujarat Zone-II growing irrigated cotton G. Cot. Hy.6 at a distance of 120 cm between rows are advised to intercrop one row of soybean (Gujarat-1) or Urid (Zandewal) or Mung (Gujarat-2) between the rows (Surat).
22	Double cropping with G. Cot. Hy-6 and G. Cot. Hy-8 and Wheat and Groundnut	For securing higher net monetary returns, farmers of South Gujarat Zone II growing irrigated cotton G. Cot. Hy.6 and G. Cot. Hy-8 are advised to grow wheat (Lok-1) or Groundnut (Gujarat-2) as second crops.
23	Use of drip in cotton	The hybrid cotton growing farmers of North Gujarat in rainfed situation are advised to irrigate the crop through drip with paired row planting method (0.45 x 0.60 x 1.80 m) to save 40% of irrigation water and get about 23% increase in yield over surface method of irrigation. The system should be laid out with 2.4 m and 0.45 m lateral and dripper spacing, respectively. For saving system cost, lateral should be placed in the paired row of cotton and operated at 1.2 kg/cm <sup>2</sup> with 4 lph dripper discharge. The system should be operated for 40 minutes during September and October, 35 minutes during November and December while 45 minutes in January on alternate days.

24	Ploughing depth and ridges and furrow method of sowing	Farmer of South Gujarat zone-II growing rainfed cotton (G.Cot.Hy-12) are advised to plough their field 20 cm deep before monsoon and to adopt ridge and furrow method of sowing for getting higher profitable seed cotton yield.
25	Foliar sprays of KNO <sub>3</sub> in cotton	Farmer of South Gujarat zone-II growing cotton G. Cot.Hy-10 under irrigated condition are advised to apply three foliar sprays of 3% KNO <sub>3</sub> at squaring, flowering and boll development stages for getting higher profitable seed cotton yield.
<b>B: Physiology and Biochemistry</b>		
1	Ethylene spray in cotton	The farmers of south Gujarat growing Bt cotton are advised to spray 45 ppm Ethylene (1.25 ml/10 lit of 39% commercial product) at square initiation stage (35-40 DAS) to obtain high yield and net return of cotton.
2	Detopping and spray of Maleic Hydrazide	Farmers of South Gujarat growing Bt or conventional cotton hybrids under irrigated conditions are advised to go for detopping at 95 days after sowing followed by nipping of sympodial meristem at 105 DAS to obtain high yield and net return.

Note :

SRT = Surat, BCH= Bharuch, ACH=Achhalia, VIR= Viramgam, TLD= Talod, KHB= Khedbraham JND= Janagadh

\* Through two equal splits \*\*Through three equal splits

## APPENDIX II (C) Seed Technology

1	Seed germination and other seed parameters are not affected by picking or position of boll. Therefore, it is recommended to the seed producers of American cotton (e.g. G.Cot.10) that all pickings are alike with respect to fulfilling seed certification standards of germination (65 %) and can be used for seed purpose.
2	It is recommended to the cotton growing farmers especially seed producers of desi cotton (e.g. G.Cot.11) that seed germination is not affected by either picking or position of boll. Therefore, all pickings are alike and can be used for seed purpose.
3	Acid delinting of cotton seed does not improve or advance the germination, hence it is advised that the practice of acid delinting of parent/breeder seed may be discontinued.

## APPENDIX II (D) Plant Protection Entomology

No	Pest/disease	Measures to be taken
1.	Bollworm complex*	<ul style="list-style-type: none"> <li>· Cypermethrin 10EC @ 50g ai/ha</li> <li>· Decamethrin 2.8 EC @ 15g ai/ha</li> <li>· Fenvalerate 20 EC @ 100 g ai/ha</li> <li>· Alphamethrin 10 EC @ 25 g ai/ha</li> <li>· Profenphos 50 EC @ 1.0 kg ai/ha</li> <li>· Quinalphos 20 AF @ 2.5 l/ha</li> <li>· Polytrin C 44 EC @ 1.0 l/ha</li> <li>· Spinosad 48 SC @ 75g ai/ha</li> <li>· Bulldock 2.5 SC@ 18g ai/ha</li> </ul>
	*Synthetic pyrethroids should be sprayed twice @ 15-20 days interval at the peak flowering stage alternated with conventional pesticides.	
2.	<i>Helicoverpa armigera</i> **	Novaluron 10 EC @ 100g ai/h
	** The IGR is sprayed when pest crosses the ETL	
3.	Pink bollworm	<ul style="list-style-type: none"> <li>· Decis tablet 25% @ 10 g ai/ha (20 tab/ha)</li> <li>· Betacyfluthrin 2.5 SC@ 18g ai/ha</li> <li>· Spinosad 48 SC@ 50 g ai/ha</li> <li>· Methyl-o-demeton @ 1.0 l/ha</li> </ul>

4.	Aphids, Jassids, Thrips and White flies ***	<ul style="list-style-type: none"> <li>· Imidacloprid 200 SL@ 20g ai/ha</li> <li>· Acetamiprid 20 SP @ 10g ai/ha</li> <li>· Thiamethoxam 25 WG @ 25g ai/ha</li> </ul> Seed treatment : <ul style="list-style-type: none"> <li>· Imidacloprid 70 WS @ 7.5 g/kg seed or</li> <li>· Thiamethoxam 70 WS @ 2.8g ai/kg seed or</li> <li>· Imidacloprid 600 FS @ 9ml/kg seed.</li> </ul>
***Need based application of any of the insecticides is recommended.		
5.	White flies	Triazophos 40 EC @ 0.75 Kg ai/ha
6.	Cotton pest complex	IPM strategy : <ul style="list-style-type: none"> <li>· Seed treatment with Imidacloprid @ 7.5 g/kg seeds.</li> <li>· Hand collection of infected shoots with spotted bollworms in the early stage.</li> <li>· Planting of Maize as a inter crop (10:1), Marigold and Castor as trap crops in and around the cotton.</li> <li>· Installation of pheromone trap @ 5/ha. One week after germination</li> <li>· Early release of Chrysoperla @ 10000 eggs or larva /ha (2 release)</li> <li>· Spraying of Neem form. or Neem seed kernel suspension @ 5%</li> <li>· Release of Trichogramma @ 1.5 lakh/ha (3 releases)</li> <li>· Spraying of HNPV @ 450 LE/ha for Helicoverpa and SNPV @ 250 LE/ha for Spodoptera.</li> <li>· Hand collection of eggs and larva of Helicoverpa and eggs and larval masses of spodoptera from main and trap crops.</li> <li>· Need based application of insecticides for pests based on ETL.</li> </ul>
7.	Pink bollworm	For the control of effective and economical control of cotton pink bollworm in Hybrid Cotton G.Cot.Hy.10, application of Spinosad 45 SC @ 580 g a.i. / ha (100 ml/ha), CBR 1:3.58 (Additional benefit of safer insecticide) or Deltamethrin tablet 25% @ 10 g a.i./ha (20 tablets / ha each of 2.0 g weight), CBR 1:10.38 or betacyfluthrin 2.5 SC @ 18 g a.i. / ha (720 ml / ha), CBR 1: 6.10 at 10 days interval starting from incidence of pink bollworm are recommended under South Gujarat Agro climatic condition.

Plant Pathology		
1	Seed borne diseases #	Delinting with sulphuric acid @100 ml/kg seed and seed dressing with mercuric fungicide @2-3 g/kg of seed
<i>#Wash the seeds thoroughly after acid delinting dry it in shade before seed dressing</i>		
2	Bacterial blight \$	Streptomycin sulphate @ 0.005% + copper oxychloride 0.2% spray Bacterial blight ( <i>Xanthomonas axonopodis</i> Pv. malvacearum) disease of cotton causes 11.95, 11.14 and 9.26% avoidable loss in seed cotton yield of cultivars LRA-5166, G.Cot.Hy-10 and BC-68-2, respectively.
<i>\$ Two to three sprays at 15 days interval after disease initiation</i>		
3	Wilt and Root rot	Follow cultural practices like long term crop rotation, balanced application of NPK, organic manure, mixed cropping of Moth or Urid, irrigation at short intervals, green manuring and destruction of infected debris. Farmers of Gujarat growing cotton are advised to follow soil amendment with farm yard manure @ 20 tons/ha or pressmud or poultry manure @ 2 tons/ha for effective and economical management of root rot disease. Farmers of Gujarat growing cotton recommended to following seed treatment with commercially available biocontrol agent <i>Trichoderma viride</i> @ 5g/kg seed for safer, effective and economical management of root rot disease.
4	Alternaria leaf spot ®	Captafol or Mancozeb @ 0.2% spray
<i>® Four sprays at 20 days interval after disease initiation</i>		



Extension literature for farmers



Where the seeds of cotton research were first nurtured



Present Main Cotton Research Station, Surat