

Bt COTTON EVALUATION REPORT

CENTRAL & SOUTH ZONE

Submitted to

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Project Co-ordinator (Cotton Improvement)
All India Coordinated Cotton Improvement Project
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2002-03

Executive Summary

Based on the guidelines received vide letter No. 9(8)/2001-CCI (Vol.1, Part I) dated 7th May, 2002 from Assistant Director General (CC), the Indian Council of Agricultural Research (ICAR), New Delhi, various RCH Bt cotton hybrids of **M/S Rasi Seeds (P) Limited, Athur, Tamil Nadu** were evaluated at their request under the All India Coordinated Cotton Improvement Project in Central and South zones during 2002-03 season. Three RCH Bt cotton hybrids viz., RCH.2 Bt, RCH.20 Bt and RCH.144 Bt in South zone and five RCH Bt cotton hybrids viz., RCH.2 Bt, RCH.20 Bt, RCH.134 Bt, RCH.138 Bt and RCH.144 Bt in Central Zone were evaluated under different disciplines such as Agronomy, Breeding, Entomology and Plant Pathology. Along with the RCH Bt cotton hybrids their respective non-Bt counterparts were also evaluated. MECH.162 Bt was used as the common check in both the Zones. The local checks included were Savitha or DHH.11 in South Zone and NHH.44 and G.Cot.Hy.10/G.Cot.Hy.8 in Central Zone. In spite of drought conditions in most parts of central and southern zones, the results of the evaluations were not affected to a large extent.

Locations:

South Zone

- i) Acharya NG Ranga Agricultural University, Lam Farm, Guntur, Andhra Pradesh
- ii) University of Agricultural Sciences, Dharwad, Karnataka
- iii) Central Institute for Cotton Research, Regional Station, Coimbatore, Tamil Nadu

Central Zone

- i) Gujarat Agricultural University, Athwa Farm, Surat, Gujarat
- ii) Central Institute for Cotton Research, Nagpur, Maharashtra

The following experiments were conducted at all the locations

- i) Agronomic Evaluation
- ii) Evaluation of morphological and economic characteristics of Bt cotton hybrids under Plant Breeding Programme
- iii) Entomological evaluation:
 1. Evaluation under unprotected conditions
 2. Evaluation under protected conditions
 3. Evaluation under Integrated Pest Management (IPM)
- iv) Plant Pathology Evaluation

Agronomy evaluations:

In general, the non-Bt genotypes and local checks were taller in stature with higher LAI and produced more vegetative growth and accumulated higher dry matter/plant. The boll numbers/plant was maximum in RCH.144 Bt in south zone and in RCH.138 Bt in Central Zone. RCH.20 Bt and RCH.20 Non-Bt produced heavier bolls 5.87 g/boll in south Zone and 4.03 g/boll in Central zone. RCH.144 produced smaller bolls with lesser boll weight in both south and central zone. At Surat, RCH.138 Bt gave the highest seed cotton yield. In general, the Bt cotton hybrids recorded less plant height than their non-Bt counterparts.

The boll numbers/plant was maximum in RCH.144 Bt in south zone and in RCH.138 Bt in Central Zone. At south Zone, RCH.20 Bt and Non-Bt recorded heavier bolls of 5.87 and 5.74 g/plant respectively and was closely followed by the RCH.2 Non-Bt, RCH.2 Bt and Savitha. Among the genotypes, RCH.144 Bt and Non-Bt recorded less boll weight of 4.15–4.26 g/boll (Table:A-8). There was no specific response in any centre to three fertiliser levels applied to these hybrids.

At Coimbatore, RCH.20 Bt recorded the highest (3722 kg/ha) seed cotton yield, which was on par with RCH.144 Bt, RCH.144 Non-Bt and

RCH.2 Bt and Non-Bt. The Seed Cotton yield at Dharwad also highest with RCH.2 Bt (2857kg/ha), which was on par with RCH.144 Bt and RCH.20 Bt. The Non-Bt genotypes of RCH.2, RCH.20 and RCH.144 were found significantly inferior to their Bt counterparts. The average seed cotton yield across the three locations ranged from 2294-3373 kg/ha and the highest was being recorded with RCH.2 Bt which was closely followed by RCH.20 Bt, RCH.2 Non-Bt, and RCH.144 Bt and Non-Bt and the lowest seed cotton yield of 2294 kg/ha was recorded in RCH.20 Non-Bt (Table:A-10).

Plant breeding evaluations:

In the Plant Breeding evaluations, it was found that the Bt entries showed similar morphological and yield determining parameters as their non-Bt counterparts. The Bt hybrids had early boll development that culminated in the early maturation of the crop in comparison to non-Bt counterparts. The RCH.2 Bt hybrid matured in 165-175 days,

Guntur center recorded maximum population of Pink bollworm per plant. In RCH Bt hybrids, the range was 0.66-1.30, while it was 4.0 in MECH.162 Bt. In Non-Bt entries including check, the Pink bollworm per plant was recorded between 3.0-6.0.

The crop at Coimbatore and Guntur recorded low to moderate level of fruiting bodies damage while Dharwad had higher level of damage. The mean boll damage for all the centers ranged from 4.6-7.9% in Bt entries and 8.1-13.2 % in Non-Bt entries including check (Table:C-4) under unprotected conditions. The open boll damage as well as locule based damage in RCH Bt hybrids due to bollworms (Table:C-5) was 40-45% less than that in the Non-Bt hybrids as well as in the check hybrids, exhibiting the ability to reduce the bollworm infestation of bolls, even under unprotected conditions.

At Surat, the highest seed cotton yield of 2580 kg/ha was recorded with RCH.138 Bt which was found significantly superior to all other genotypes but was closely followed by RCH.20 Bt, RCH.2 Bt, RCH.134 Bt and RCH.144 Bt. The lowest seed cotton yield of 246 kg/ha was recorded in RCH.20 Non-Bt. However, MECH.162 Bt performed better than local checks like G.cot.Hy.10, G.cot.Hy.S8, RCH.20 Non-Bt and RCH.144 Non-Bt (Table:A-11).

All the five RCH Bt hybrids recorded significantly higher yield over their non-Bt counterparts at Surat. At Nagpur, RCH.20 Bt, RCH.134 Bt and RCH.138 Bt hybrids recorded significantly higher yield over their non-Bt counterparts. All the five RCH Bt hybrids tested recorded higher seed cotton yield over all the three check hybrids.

RCH.20 Bt recorded significantly lower lint index than the non-Bt counterpart. Both RCH.2 Bt and RCH.20 Bt recorded lower seed index than their non-Bt counterparts. Fibre quality wise there was no difference between Bt and non-Bt hybrids.

In central zone, there was no appreciable differences between Bt cotton and its non-Bt counterpart in respect of major fibre quality parameter (Table:B- 13). All the RCH hybrids recorded higher 2.5% span length as compared to the checks. Only RCH.2 Bt (24.1 g/tex) recorded better fibre strength than the G.Cot.Hy.10, the local check. From the overall quality angle, RCH.20 Bt was the best.

In central zone, fruiting bodies damage was recorded to be highest in RCH.2Bt among various RCH Bt hybrids. However, RCH.138Bt and RCH.134 Bt had very low fruiting body damage. The same trends were seen

in the Green boll damage also at Nagpur. However, in Surat, the Bt hybrids had significantly lower damage to fruiting bodies and green bolls (Table:C-9).

RCH.144 and RCH.138 yielded more seed cotton (Table:C-10) than their non-Bt counterparts. The RCH.20 Bt yielded over other Bt hybrids (796 kg/ha), although RCH.20 NBt yielded the highest (881 kg/ha) at this centre. The number of pickings of Bt hybrids did not exceed more than two while the other hybrids needed 4-5 pickings.

In Surat, under irrigated conditions, all the Bt entries yielded better than their non-Bt counterparts as well as the check hybrids. RCH.138 Bt yielded the maximum seed cotton out of all the hybrids (2384 kg/ha) followed by RCH.144 (2214 kg/ha). The Check Bt hybrid, MECH.162 yielded 1649 kg/ha. The non-Bt hybrids of RCH.2 and 20 had drastic reduction in yield under unprotected conditions. The number of pickings in Surat ranged from 2-3 for Bt hybrids, while that for non-Bt hybrids was 5-7.

Entomology evaluations:

Without any protection against pests, the various test hybrids center recorded low to moderate level of boll damage at Coimbatore and Guntur, while Dharwad had higher level of boll damage for all the entries which ranged from 5.2 to 7.9 % in Bt entries and 11.0-16.0 in Non-Bt entries including check. Higher locule damage was recorded at Dharwad, while Guntur and Coimbatore had low to moderate level of locule damage. The open boll damage as well as locule based damage in RCH.Bt hybrids due to bollworms (Table:C-5) was 40-45% less than that in the Non-Bt hybrids as well as in the check hybrids, exhibiting the ability to reduce the bollworm infestation of bolls, even under unprotected conditions.

Without any insect protection, the RCH Bt hybrids yielded more seed cotton (Table:C-6) over the MECH.162 Bt too in all locations in south zone during 2002-03 season. The zonal best was RCH.2 Bt (2173 kg/ha) followed by RCH.144 Bt (1759 kg/ha) and RCH.20 Bt (1612 kg/ha) and then MECH.162 Bt (1525 kg/ha).

The mean seed cotton yield under dryland conditions of Dharwar was significantly and conspicuously higher over that of their non-Bt counterparts. In Lam, Guntur and at Coimbatore the RCH.2Bt yielded the highest among all the test hybrids. The Bt hybrids enabled the harvest of the entire seed cotton in two pickings while the other hybrids could provide the yield in 4-6 pickings.

Fruiting bodies damage was recorded to be highest in RCH.2Bt among various RCH Bt hybrids. However, RCH.138 Bt and RCH.134 Bt had very low fruiting body damage in central zone. The same trends were seen in the Green boll damage also at Nagpur. However, in Surat, the Bt hybrids had significantly lower damage to fruiting bodies and green bolls (Table:C-9).

In Surat, under irrigated conditions, all the Bt entries yielded better than their non-Bt counterparts as well as the check hybrids. RCH.138 Bt yielded the maximum seed cotton out of all the hybrids (2384 kg/ha) followed by RCH.144 (2214 kg/ha). The Check Bt hybrid, MECH.162 yielded 1649 kg/ha. The non-Bt hybrids of RCH.2 and 20 had drastic reduction in yield under unprotected conditions. The number of pickings in Surat ranged from 2-3 for Bt hybrids, while that for non-Bt hybrids was 5-7.

Under protected conditions, none of the hybrids under test crossed the economic threshold for American bollworm in the three centres. However,

the non-Bt and check hybrids were infested with more number of larvae of this species than the Bt hybrids. Clear reduction in the number of American bollworms was seen in RCH Bt hybrids over MECH Bt check hybrid. In the case of Pink bollworm infestation too, the three RCH Bt hybrids showed superiority over all other test hybrids (Table:C-13).

The open boll damage percentage was relatively more in Dharwar out of the three centres of this zone. All the Bt hybrids had lower percent damage over the Non-Bt hybrid as well as the check hybrids (Table:C-15). The percent locule damage also had similar pattern across the three centres. The trend of locule damage (Table:C-15) was also in the expected lines as of Open boll damage in Bt and Non-Bt hybrids.

Under protected conditions, the seed cotton harvest in south zone centres was significantly higher in RCH.2 & 20 Bt hybrids over all the other tested hybrids (Table:C-16). RCH.2 Bt provided over 900 kg over MECH.162 Bt hybrid. Except for RCH.144 Bt hybrid, where there was no significant difference over the yield that of its non-Bt hybrid, the RCH Bt hybrids were superior to their non-Bt counterparts, thus providing the actual support of the bollworm tolerance due to the gene that is placed in the genome with right agronomic background that fits into the zone's growing conditions. Significant also is the fact that Bt hybrids provided more than 78-91% of the seed cotton in the first two pickings within December while the all the rest hybrids needed 4-6 pickings, to end up the crop to the end of February.

There was significant and drastic reduction in fruiting body damage in Bt hybrids at Nagpur as well as in Surat. The green boll damage due to all bollworms followed a similar pattern in both the locations of central zone under protected conditions (Table:C-19). Both open boll damage and locule

damage followed the pattern in which it was noticed that the Bt hybrids had far lower level than their non-Bt hybrids as well as check hybrids at both Nagpur and Surat (Table:C-20).

Under irrigated conditions in Surat center (Table:C-20), seed cotton yield of RCH Bt entries yielded seed cotton between 3508 and 4377 kg/ha; RCH.2 Bt, RCH.134 Bt and RCH.138 Bt recorded significantly higher yield over national check.

Besides seed treatment with imidacloprid, the number of sprays given for Bt entries were four and to that of non-Bt entries including check were eight in Surat under irrigated condition (Table:C-21). Average cost of plant protection was Rs. 4500 and 8500 per hectare to Bt and non-Bt hybrids respectively.

In Nagpur under rainfed condition, RCH.20 Bt, RCH.2, RCH.144, RCH.138 and check entry – G.Cot.Hy.10 required one spray besides seed treatment with imidacloprid and the plant protection cost to each of these entries was Rs. 1500 per hectare. The rest of the entries received only seed treatment and the cost to each of the entry was Rs. 500 per hectare.

Plant Pathology evaluation:

Due to drought conditions, the overall incidences of the three diseases were only low to moderate in southern zone. There was no significant difference among the test hybrids to bacterial blight, grey mildew as well as *Alternaria* leaf spot (Table:D-1 and 2). Bacterial leaf blight was observed only at Dharwad, *Alternaria* leaf spot at all the three places and grey mildew at Dharwad and Coimbatore.

There was moderate incidence of bacterial blight at Surat under unprotected condition (no fungicidal/ bactericidal spray) and no incidence under protected condition. There was no difference between Bt and non-Bt

cotton hybrids with regard to the incidence of the disease. The lowest percent disease incidence was noticed on NHH.44 (common check – 9.67 PDI) and highest on RCH.2 non-Bt (30.03 PDI). At Nagpur, very low incidence of the disease was noticed (Table:D-4). *Alternaria* leaf spot was noticed only at Nagpur. Here also, the disease incidence was low with RCH.20 Bt recording the lowest (1.88 PDI) and G.Cot.hy.10 the highest (6.23 PDI) (Table:D-4).

General conclusions:

It is pertinent to point out that RCH.2 hybrid was released after the AICCIP recommended it for national release in 1999. It is widely adapted to south and central zones and had occupied considerable area in various states of these zones. Although susceptible to sap-sucking pests such as jassids, this hybrid always provided good seed cotton yield. The other RCH hybrids are seen to possess better tolerance to sap-sucking pests with which the early season pesticide application can be avoided and could safeguard the biological activity in cotton fields better. With the test results of all RCH Bt hybrids of both the zones, it can be concluded that the respective location-adapted hybrids could bring about a reduction in bollworm damage to fruiting parts of their plants and offer cotton farmers better seed cotton yield over the various non-Bt and check hybrids that were evaluated in this season. This can ensure a reduction in the cost of pesticides and their application due to inherent tolerance to sap-sucking insects for some of the RCH Bt test hybrids in both the zones. No serious diseases or maladies were noticed in any of the test hybrids in both the zones.

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EVALUATION REPORT OF RCH Bt COTTON HYBRIDS IN CENTRAL & SOUTH ZONES

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INTRODUCTION

Based on the guidelines received vide letter No. 9(8)/2001-CCI (Vol.1, Part I) dated 7th May, 2002 from Assistant Director General (CC), the Indian Council of Agricultural Research (ICAR), New Delhi, various RCH Bt cotton hybrids of **M/S Rasi Seeds (P) Limited, Attur, Tamil Nadu** were evaluated on payment basis and at their request under the All India Coordinated Cotton Improvement Project in Central and South zones during 2002-03 season. Three RCH Bt cotton hybrids viz., RCH.2 Bt, RCH.20 Bt and RCH.144 Bt in South zone and five RCH Bt cotton hybrids viz., RCH.2 Bt, RCH.20 Bt, RCH.134 Bt, RCH.138 Bt and RCH.144 Bt in Central Zone were evaluated. Along with the RCH Bt cotton hybrids their respective non-Bt counterparts were also evaluated. MECH.162 Bt was used as the common check in both the Zones. The local checks included were Savitha or DHH.11 in South Zone and NHH.44 and G.Cot.Hy.10/G.Cot.Hy.8 in Central Zone. In spite of drought conditions in most parts of central and southern zones, the results of the evaluations are not affected to a large extent.

Locations

South Zone

- iv) Acharya NG Ranga Agricultural University, Lam Farm, Guntur, Andhra Pradesh
- v) University of Agricultural Sciences, Dharwad, Karnataka
- vi) Central Institute for Cotton Research, Regional Station, Coimbatore, Tamil Nadu

Central Zone

- iii) Gujarat Agricultural University, Athwa Farm, Surat, Gujarat
- iv) Central Institute for Cotton Research, Nagpur, Maharashtra

The following experiments were conducted at all the locations

- iv) Agronomic Evaluation
- v) Evaluation of morphological and economic characteristics of Bt cotton hybrids under Plant Breeding Programme
- vi) Entomological evaluation:
 - 1. Evaluation under unprotected conditions
 - 2. Evaluation under protected conditions
 - 3. Evaluation under Integrated Pest Management (IPM)
- vii) Plant Pathology Evaluation

Protocol for the conduct of various trials

AGRONOMY EVALUATION

Objectives:

1. To study the response of RCH Bt hybrid to graded levels of fertilizer
2. To study the difference in respect of Bt and Non-Bt hybrids, If any

Main plot treatments:

South Zone

RCH.2 Bt, RCH.2 non-Bt , RCH.144 Bt, RCH.144 non-Bt RCH.20 Bt, RCH.20 non-Bt, MECH.162Bt (common check) and Local check (Savitha at Lam and Coimbatore; DHH.11 at Dharwad).

Central Zone

RCH.2 Bt, RCH.2 non-Bt , RCH.144 Bt, RCH.144 non-Bt, RCH.20 Bt, RCH.20 non-Bt, RCH.134 Bt, RCH.134 non-Bt, RCH.138 Bt, RCH.138 non-Bt , MECH.162Bt (common check), NHH.44 and G.Cot.Hy.10/ G.Cot.Hy.8 (Local checks).

Sub Plots:

F1 – 100% Recommended dose of fertilizer (RDF); F2 – 125% RDF ; F3 – 75% RDF

- Design : Split Plot Design
- Replication : Two
- No. of Rows / Plot : 6
- Spacing : 90 x 60 cm
- Plot Size : 38.4 m²

Observations to be recorded

Leaf area index, Dry matter production, Bolls/Plot, Bolls weight (g), Seed Cotton Yield, Plant height

PLANT BREEDING EVALUATION

Objectives:

- 1.To evaluate the morphological and economic attributes of Bt cotton hybrids *vis a vis* its non-Bt counter parts
- 2.To study the quality parameters of Bt and non-Bt hrbrids

South Zone

Treatments

RCH.2 Bt, RCH.2 non-Bt , RCH.144 Bt, RCH.144 non-Bt RCH.20 Bt, RCH.20 non-Bt, MECH.162Bt (common check) and Local check (Savitha at Lam and Coimbatore; DHH.11 at Dharwad).

Central Zone:

Treatments

RCH.2 Bt, RCH.2 non-Bt , RCH.144 Bt, RCH.144 non-Bt RCH.20 Bt, RCH.20 non-Bt, RCH.134 Bt, RCH.134 non-Bt, RCH.138 Bt , RCH.138 non-Bt , MECH.162 Bt (common check) NHH.44 and G.Cot.Hy.10 (Local checks).

- Spacing : As per local practice
- Design : Randomised Block Design
- Replication : Three
- No. of Rows : Six
- Row length : 6 m

Observations:

Germination, Plant stand, earliness, height, No. of monopodia per plant, No. of Sympodia per Plant, Boll weight (g), Boll number, Yield, Ginning Percentage, lint index, seed index and fibre properties.

PLANT PROTECTION EVALUATIONS

Entomological Evaluation

Objectives:

1. To evaluate the Bt cotton hybrids for sucking pests and bollworm reaction at various stages of growth under unprotected, protected and IPM conditions and compares it with their non-Bt counterparts.
2. To study the changes, if any, in the population of beneficial insects in the Bt cotton hybrids

Treatments

Ent. 1: Evaluation under unprotected conditions

Ent 2: Evaluation under ETL based plant protection

South Zone:

RCH.2 Bt, RCH.2 non-Bt, RCH.144 Bt, RCH.144 non-Bt RCH.20 Bt, RCH.20 non-Bt, MECH.162Bt (common check) and Local check (Savitha at Lam and Coimbatore; DHH.11 at Dharwad)

Central Zone:

RCH.2 Bt, RCH.2 non-Bt , RCH.144 Bt, RCH.144 non-Bt RCH.20 Bt, RCH.20 non-Bt, RCH.134 Bt, RCH.134 non-Bt, RCH.138 Bt , RCH.138 non-Bt , MECH.162Bt (common check) NHH.44 and G.Cot.Hy.10 (Local checks)

- Replication : Three
- No. of Rows : Six
- Row length : 6m
- Spacing : Normal spacing

Ent 3: Evaluation of Bt cotton under Integrated Pest Management

Objective: To evaluate the response of Bt cotton hybrids under IPM modules

1. IPM modules developed at the respective centers
2. Bio intensive modules

Treatments: RCH Bt cotton hybrids and Check hybrids

Plot Size: Bulk Plots

Design: Split Plot : Modules in main plots and hybrids in sub plot

Observations to be recorded

1. Sucking pests observation fortnightly intervals from 30 DAS
2. Predators / Parasites observation from 30 DAS

3. Larval count of cotton pests – weekly - from 8th to 20th week
4. Predators / Parasites / Pathogens of cotton pests on *Earias*, *Helicoverpa* and *Pectinophora* – weekly - from 8th to 20th week
5. Percentage fruiting bodies damage / plant from 8th to 20th week
6. Picking wise observation on open boll damage, locule damage, good seed cotton and bad seed cotton

Pathological evaluation

Objectives:

1. To compare the relative incidence of various diseases on Bt cotton hybrids under un-protected (for disease) conditions.
2. To evaluate yield and other parameters

Treatments

South Zone :

RCH.2 Bt, RCH.2 non-Bt , RCH.144 Bt, RCH.144 non-Bt RCH.20 Bt, RCH.20 non-Bt, MECH.162Bt (common check) and Local check (Savitha at Lam and Coimbatore; DHH.11 at Dharwad)

Central Zone :

RCH.2 Bt, RCH.2 non-Bt , RCH.144 Bt, RCH.144 non-Bt RCH.20 Bt, RCH.20 non-Bt, RCH.134 Bt, RCH.134 non-Bt, RCH.138 Bt , RCH.138 non-Bt , MECH.162Bt (common check), NHH.44 and G.Cot.Hy.10 (Local checks)

- Replication : Three
- No. of Rows : Six
- Row length : 6m
- Spacing : Normal spacing

Observations to be recorded

1. Mean disease grade
2. % Disease index for various diseases
3. Seed cotton yield

Agronomy Evaluation

South zone

Germination

The germination was good (Table:A-1) in all centers and the average germination ranged from 90 -99 percent. Gap filling was taken up within 10 days so as to maintain the uniform plant population.

Table:A-1 Germination Percent

Treatments	Coimbatore	Guntur	Dharward	Mean
M ₁ - RCH.2 Bt	100.0	96.7	98.2	98.5
M ₂ - RCH.2 Non-Bt	99.7	97.5	99.6	98.9
M ₃ - RCH.20 Bt	99.7	98.1	99.3	99.0
M ₄ - RCH.20 Non-Bt	93.8	98.6	97.4	96.6
M ₅ - RCH.144 Bt	96.5	97.2	98.2	97.3
M ₆ - RCH.144 Non-Bt	99.	97.8	99.3	98.7
M ₇ - Savitha/ DHH – 11*	76.1	94.7	99.3	90.0
M ₈ - MECH.162/184 Bt**	90.0	97.2	98.5	95.2
SE d	2.67	1.80	0.45	
CD (p= 0.05)	8.67	NS	NS	
CV (%)	6.74	-	-	
F ₁ –100 % RDF	94.41	97.6	98.3	96.8
F ₂ - 125 % RDF	94.01	97.6	99.0	96.9
F ₃ - 75 % RDF	94.54	96.5	98.8	96.6
SE d	2.91	0.60	0.44	
CD (p= 0.05)	NS	NS	NS	
CV (%)	8.73			

* DHH-11 at Dharwad

** MECH.184 Bt at Dharward

Plant Height

The average height of plants ranged from 89.5 – 110.1 cm on 90 DAS and 98 –122.6 cm on 120 DAS at south zone. In general, the non-Bt genotypes and the local checks (Savitha and DHH-11) were taller than their non-Bt counterparts. The entries like RCH.144 Non-Bt, RCH.20 Non-Bt and Savitha were taller as compared to other genotypes (Table:A-2).

The plant height was not influenced due to fertilizer levels.

Table:A-2 Plant Height at 120 DAS – south zone

Treatments	Coimbatore	Guntur	Dharward	Mean
M ₁ - RCH.2 Bt	99.8	86.2	114.7	100.2
M ₂ - RCH.2 Non-Bt	105.6	98.3	107.8	103.9
M ₃ - RCH.20 Bt	110.0	84.5	115.9	103.5
M ₄ - RCH.20 Non-Bt	133.6	104.5	114.9	117.7
M ₅ - RCH.144 Bt	117.3	88.2	121.3	108.9
M ₆ - RCH.144 Non-Bt	141.9	105.8	120.1	122.6
M ₇ - Savitha/ DHH – 11*	126.8	113.2	118.2	119.4
M ₈ - MECH.162/184 Bt**	106.2	92.4	95.3	98.0
SEd	8.62	4.6	8.98	
CD (p= 0.05)	20.38	10.9	NS	
CV (%)	23.47	-	19.38	
F ₁ –100 % RDF	122.5	96.0	111.1	109.9
F ₂ - 125 % RDF	117.8	97.0	114.5	109.8
F ₃ - 75 % RDF	112.6	96.8	114.5	108.1
SEd	2.54	3.8	2.5	
CD (p= 0.05)	5.39	NS	NS	
CV (%)	16.47	-	8.90	

In central zone also (Table:A-3), RCH.144 Non-Bt grew on an average to a height of 132.7 cm, which was closely followed by RCH.144 Bt and local checks like NHH-44 and G.cot.hy-10.

Table:A- 3.Plant height on120 DAS – central Zone

Treatments	Nagpur	Surat	Mean
M ₁ - RCH.2 Bt	84.3	126	105.2
M ₂ - RCH.2 Non-Bt	82.5	127	104.8
M ₃ - RCH.20 Bt	77.5	134	105.8
M ₄ - RCH.20 Non-Bt	89.0	130	109.5
M ₅ - RCH.144 Bt	90.3	167	128.7
M ₆ - RCH.144 Non-Bt	99.3	166	132.7
M ₇ - RCH.134 Bt	69.3	124	96.7
M ₈ - RCH.134 non-Bt	73.5	126	99.8
M ₉ - RCH.138 Bt	78.7	146	112.3
M ₁₀ - RCH.138 Non-Bt	81.2	144	112.6
M ₁₁ - NHH.44	91.3	155	123.2
M ₁₂ - G.Cot.Hy.10	93.8	147	120.4
M ₁₃ - MECH.162 Bt	77.3	124	100.7
M ₁₄ - G.Cot.Hy.8*	-	106	
SEd	-	2.03	
CD (p= 0.05)	0.52	6.28	
CV (%)	-	3.6	
F ₁ –100 % RDF	82.4	136	109.2
F ₂ - 125 % RDF	84.9	137	110.9
F ₃ - 75 % RDF	83.8	138	110.9
SEd	-	1.28	
CD (p= 0.05)	NS	NS	
CV (%)		4.95	

*G.Cot.Hy.8 only at Surat

Leaf Area Index

The average Leaf Area Index (LAI) at 90 DAS ranged from 1.13-2.51 and among the genotypes, RCH.20 Non-Bt, produced higher LAI of 2.51 which was closely followed by MECH.162 Bt and RCH.20 Non-Bt (Table: A-4).

Increasing the fertilizer levels from 75 % RDF to 125 % RDF enhanced the LAI from 1.61 to 1.78. However, the increase was not to the level of significance.

Table:A-4 Leaf Area Index on 90 DAS – South Zone

Treatments	Coimbatore	Guntur	Mean
M ₁ - RCH.2 Bt	1.41	1.55	1.48
M ₂ - RCH.2 Non-Bt	1.46	2.56	2.01
M ₃ - RCH.20 Bt	1.02	1.59	1.31
M ₄ - RCH.20 Non-Bt	1.52	3.49	2.51
M ₅ - RCH.144 Bt	1.00	1.45	1.23
M ₆ - RCH.144 Non-Bt	1.09	1.17	1.13
M ₇ - Savitha/ DHH – 11 *	1.60	1.65	1.63
M ₈ - MECH.162/ 184 Bt **	1.00	3.58	2.29
SEd	0.22	0.18	
CD (p= 0.05)	NS	0.43	
CV (%)	29.61	-	
F ₁ –100 % RDF	1.29	2.13	1.71
F ₂ - 125 % RDF	1.30	2.25	1.78
F ₃ - 75 % RDF	1.19	2.02	1.61
SEd	0.08	0.09	
CD (p= 0.05)	NS	NS	
CV (%)	18.59	-	

Dry matter production

As the case of plant height, the plant Dry matter production (DMP) was in general more in Non-Bt genotypes as compared to their Bt versions and local checks (Table: A-5).

Table:A-5 Plant Dry matter production (g/plant) on 120 DAS - South Zone

Treatments	Coimbatore	Guntur	Dharward	Mean
M ₁ - RCH.2 Bt	265.0	337.0	253.0	285.0
M ₂ - RCH.2 Non-Bt	265.8	342.7	295.2	301.2
M ₃ - RCH.20 Bt	270.2	341.6	266.0	292.6
M ₄ - RCH.20 Non-Bt	329.5	330.3	289.6	316.5
M ₅ - RCH.144 Bt	273.0	269.0	259.9	267.3
M ₆ - RCH.144 Non-Bt	282.5	308.7	238.8	276.7
M ₇ - Savitha/ DHH – 11 [*]	322.2	306.3	227.2	285.2
M ₈ - MECH.162/184 Bt ^{**}	218.3	305.7	231.0	251.7
SEd	12.56	17.5	15.62	
CD (p= 0.05)	29.69	41.4	NS	
CV (%)	7.81	-	-	
F ₁ –100 % RDF	292.4	317.6	269.4	293.2
F ₂ - 125 % RDF	279.4	330.0	263.4	290.9
F ₃ - 75 % RDF	263.1	305.3	239.9	269.4
SEd	16.21	13.0	6.43	
CD (p= 0.05)	NS	NS	19.26	
CV (%)	16.48	-	-	

Number of bolls

The number of bolls/plant was influenced significantly due to genotypes at all the locations. In South Zone, the average boll number/plant across the location ranged from 24.9-43.2 and among the genotypes, RCH, 144 Bt recorded the highest (43.2) bolls/plant which was closely followed by RCH.2 Bt (40.6). At Coimbatore and Lam, MECH.162 Bt produced on an average of 46.7 bolls/plant and the genotype, RCH.20 NonBt and Savitha produced lesser number of bolls/plant (Table: A-6).

Table:A-6 Bolls/plant - South Zone

Treatments	Coimbatore	Guntur	Dharward	Mean
M ₁ - RCH.2 Bt	51.5	45.2	25.2	40.6
M ₂ - RCH.2 Non-Bt	35.0	44.2	21.7	33.6
M ₃ - RCH.20 Bt	46.7	39.2	20.3	35.4
M ₄ - RCH.20 Non-Bt	20.5	40.3	13.8	24.9
M ₅ - RCH.144 Bt	53.0	46.0	20.5	43.2
M ₆ - RCH.144 Non-Bt	43.5	48.2	22.7	38.1
M ₇ - Savitha/ DHH – 11 [*]	23.0	39.9	19.2	27.4
M ₈ - MECH.162/184 Bt ^{**}	46.0	47.3	26.9	40.1
SEd	4.35	2.1	2.52	
CD (p= 0.05)	10.28	5.1	8.44	
CV (%)	18.88	-	22.53	
F ₁ –100 % RDF	40.9	46.1	22.3	36.4

F ₂ - 125 % RDF	39.4	45.1	23.7	36.1
F ₃ - 75 % RDF	39.3	40.2	21.6	33.7
SEd	1.60	2.4	1.02	
CD (p= 0.05)	NS	NS	NS	
CV (%)	11.36		27.43	

In Central Zone also, RCH.20 non-Bt recorded the lowest (19) number of bolls as against the highest (45.5) number of bolls recorded with RCH.138 Bt (Table:A-7).

The boll numbers were not influenced due to fertilizer levels.

Table:A-7 Bolls/plant – Central Zone

Treatments	Nagpur	Surat	Mean
M ₁ - RCH.2 Bt	24.6	39.0	31.8
M ₂ - RCH.2 Non-Bt	26.1	22.0	24.0
M ₃ - RCH.20 Bt	22.1	39.0	30.6
M ₄ - RCH.20 Non-Bt	26.0	12.0	19.0
M ₅ - RCH.144 Bt	28.2	44.0	36.1
M ₆ - RCH.144 Non-Bt	28.2	32.0	30.1
M ₇ - RCH.134 Bt	22.3	42.0	32.2
M ₈ - RCH.134 non-Bt	20.2	48.0	34.1
M ₉ - RCH.138 Bt	31.9	59.0	45.5
M ₁₀ - RCH.138 Non-Bt	25.5	47.0	36.3
M ₁₁ - NHH.44	32.9	31.0	32.0
M ₁₂ - G.Cot.Hy.10	27.8	30.0	28.9
M ₁₃ - MECH.162 Bt	17.2	43.0	30.1
M ₁₄ - G.Cot.Hy.8	-	37.0	
SEd	-	3.37	
CD (p= 0.05)	6.59	10.4	
CV (%)	-	21.9	
F ₁ –100 % RDF		37.0	30.3
F ₂ - 125 % RDF		38.0	32.6
F ₃ - 75 % RDF		38.0	32.1
SEd		0.76	
CD (p= 0.05)	NS	NS	
CV (%)		10.75	

Boll Weight

The boll weight was influenced significantly due to genotypes. At south Zone, RCH.20 Bt and Non-Bt recorded heavier bolls of 5.87 and 5.74 g/plant respectively and was closely followed by the RCH.2 Non-Bt, RCH.2 Bt and Savitha. Among the genotypes, RCH.144 Bt and Non-Bt recorded less boll weight of 4.15–4.26 g/boll (Table: A-8).

Table:A-8 Boll weight (g/boll)- South Zone

Treatments	Coimbatore	Guntur	Dharward	Mean
M ₁ - RCH.2 Bt	5.6	5.08	4.73	5.14
M ₂ - RCH.2 Non-Bt	5.8	4.91	4.80	5.17
M ₃ - RCH.20 Bt	6.0	5.99	5.62	5.87
M ₄ - RCH.20 Non-Bt	6.4	5.26	5.57	5.74
M ₅ - RCH.144 Bt	4.9	3.92	3.95	4.26
M ₆ - RCH.144 Non-Bt	4.8	3.57	4.07	4.15
M ₇ - Savitha/ DHH – 11*	5.6	5.08	4.63	5.10
M ₈ - MECH.162/184 Bt**	5.1	4.14	5.03	4.76
SEd	0.26	0.26	0.19	
CD (p= 0.05)	0.61	0.63	0.62	
CV (%)	8.04	-	9.42	
F ₁ –100 % RDF	5.51	4.82	4.77	5.03
F ₂ - 125 % RDF	5.53	4.65	4.81	5.00
F ₃ - 75 % RDF	5.57	4.78	4.83	5.06
SEd	0.06	0.14	0.08	
CD (p= 0.05)	NS	NS	NS	
CV (%)	3.16	-	6.83	

In Central Zone also, RCH.20 Bt recorded heavier bolls of 4.03 g/boll as compared to only 2.96 g/boll recorded with RCH.144 Non-Bt (Table:A-9).

Table:A-9 Boll weight (g/boll)- Central Zone

Treatments	Nagpur	Surat	Mean
M ₁ - RCH.2 Bt	3.46	3.94	3.70
M ₂ - RCH.2 Non-Bt	3.10	3.87	3.49
M ₃ - RCH.20 Bt	3.90	4.15	4.03
M ₄ - RCH.20 Non-Bt	4.46	2.90	3.68
M ₅ - RCH.144 Bt	3.33	3.60	3.47
M ₆ - RCH.144 Non-Bt	2.83	3.09	2.96
M ₇ - RCH.134 Bt	2.83	3.99	3.41
M ₈ - RCH.134 non-Bt	2.83	4.07	3.45
M ₉ - RCH.138 Bt	2.93	3.51	3.22
M ₁₀ - RCH.138 Non-Bt	2.96	3.57	3.27
M ₁₁ - NHH.44	3.03	3.42	3.23
M ₁₂ - G.Cot.Hy.10	3.20	3.53	3.37
M ₁₃ - MECH.162 Bt	3.03	3.38	3.21
M ₁₄ - G.Cot.Hy.8	-	3.57	
SEd	-	0.16	
CD (p= 0.05)	0.52	0.51	
CV (%)	-	-	
F ₁ –100 % RDF	2.90	3.64	3.27
F ₂ - 125 % RDF	3.00	3.64	3.32
F ₃ - 75 % RDF	3.10	3.56	3.33
SEd	-	0.04	
CD (p= 0.05)	NS	NS	
CV (%)	-	-	

Seed Cotton Yield

The seed cotton Yield was influenced significantly due to genotypes irrespective of the locations. At Coimbatore, RCH.20 Bt recorded the highest

(3722 kg/ha) seed cotton yield which was on par with RCH.144 Bt, RCH.144 Non-Bt and RCH.2 Bt and Non-Bt. The hybrid Savitha recorded the lowest (2616 kg/ha) seed cotton yield, which was on par with MECH.162 Bt and RCH.20 Non-Bt.

At LAM, Guntur, RCH.2 Bt recorded the highest (3634 kg/ha) seed cotton Yield which was on par with RCH.2 Non-Bt (3552 kg/ha) and found significantly superior to other genotypes.

The Seed Cotton yield at Dharwad also was the highest with RCH.2 Bt (2857kg/ha) which was on par with RCH.144 Bt and RCH.20 Bt. The Non-Bt genotypes of RCH.2, RCH.20 and RCH.144 were found significantly inferior to their Bt counterparts. The genotype, MECH.184 performed better than non-Bt genotypes and local check, DHH-11.

The average seed cotton yield across the three locations ranged from 2294-3373 kg/ha and the highest was being recorded with RCH.2 Bt which was closely followed by RCH.20 Bt, RCH.2 Non-Bt, and RCH.144 Bt and Non-Bt and the lowest seed cotton yield of 2294 kg/ha was recorded in RCH.20 Non-Bt (Table: A-10).

Table:A-10 Seed Cotton Yield (kg/ha) - South Zone

Treatments	Coimbatore	Guntur	Dharward	Mean
M ₁ - RCH.2 Bt	3628	3634	2857	3373
M ₂ - RCH.2 Non-Bt	3218	3552	2111	2960
M ₃ - RCH.20 Bt	3722	2888	2585	3065
M ₄ - RCH.20 Non-Bt	2744	2706	1431	2294
M ₅ - RCH.144 Bt	3691	1711	2794	2732
M ₆ - RCH.144 Non-Bt	3708	2845	2100	2884
M ₇ - Savitha/ DHH – 11*	2616	3011	2103	2577
M ₈ - MECH.162/184 Bt**	2875	2491	2575	2647
SEd	220.3	212	82.54	
CD (p= 0.05)	520.9	503	275.9	
CV (%)	11.6	-	-	
F ₁ –100 % RDF	3180	2939	2429	2849
F ₂ - 125 % RDF	3322	2871	2418	2870
F ₃ - 75 % RDF	3324	2754	2112	2730
SEd	165.8	120	42.04	
CD (p= 0.05)	NS	NS	125.9	
CV (%)	14.3	-	-	

At CICR, Nagpur, RCH.20 Non-Bt gave the highest seed Cotton yield of 1439 kg/ha which was on par with RCH.144 Non-Bt, RCH.144 Bt and local checks, NHH.44 and G.cot.Hy.10. The lowest seed cotton yield of 683 kg/ha was recorded with MECH.162 Bt.

At Surat, the highest seed cotton yield of 2580 kg/ha was recorded with RCH.138 Bt which was found significantly superior to all other genotypes, but was closely followed by RCH.20 NBt, RCH.2 Bt, RCH.134 Bt and RCH.144 Bt. The lowest seed cotton yield of 1160 kg/ha was recorded in RCH.2 Non-Bt. However, MECH.162 Bt performed better than local checks like Hy-10, Hy-8, RCH.20 Non-Bt and RCH.144 Non-Bt (Table: A-11).

The fertilizer levels did not influence the seed cotton yield significantly.

Table:A-11 Seed Cotton Yield (kg/ha) – Central Zone

Treatments	Nagpur	Surat
M ₁ - RCH.2 Bt	902.0	2121
M ₂ - RCH.2 Non-Bt	850.0	1160
M ₃ - RCH.20 Bt	988.0	2136
M ₄ - RCH.20 Non-Bt	1439	2460
M ₅ - RCH.144 Bt	1033	2043
M ₆ - RCH.144 Non-Bt	1187	1531
M ₇ - RCH.134 Bt	874	2111
M ₈ - RCH.134 non-Bt	743	2001
M ₉ - RCH.138 Bt	931	2580
M ₁₀ - RCH.138 Non-Bt	974	1944
M ₁₁ - NHH.44	1201	1334
M ₁₂ - G.Cot.Hy.10	1099	1572
M ₁₃ - MECH.162 Bt	683	1957
M ₁₄ - G.Cot.Hy.8	-	1692
SEd	-	1264
CD (p= 0.05)	221	390
CV (%)	-	-
F ₁ -100 % RDF	911	1790
F ₂ - 125 % RDF	1052	1766
F ₃ - 75 % RDF	1015	1678
SEd	-	2487
CD (p= 0.05)	NS	718
CV (%)	-	7.5

Plant Breeding Evaluation

South Zone

Three RCH Bt cotton hybrids viz., RCH.2 Bt, RCH.20 Bt and RCH.144 Bt were tested along with their non-Bt counterparts and two check hybrids. MECH.162 Bt was the common hybrid check. **Savitha** was used as the local check at Lam, Guntur in Andhra Pradesh and at CICR, Regional Station, Coimbatore in Tamil Nadu. DHH.11 was used as the local check at UAS, Dharwad in Karnataka. The trial was conducted at three locations in the South Zone.

Sowing conditions and weather

Sowings were undertaken during the first week of August, instead of the normal sowing time of July due to late onset of monsoon at Lam. Due to long dry spells during August and September, crop growth was affected. Even though, there was early occurrence of *Helicoverpa* in September, there after it remained low till October.

At Coimbatore, sowings were done at the appropriate time i.e. 26th August, 2003. Even though, rainfall during the crop growth period was below normal, the crop was maintained in good condition by frequent irrigation. The *Heliothis* damage was very low during the growth period and crop productivity was very good.

Sowings were undertaken with the onset of monsoon in June in Dharwad. Even though, the average rainfall was below normal, the crop was managed well with protective irrigation. Pest incidence also remained low during the crop growth.

Germination and final plant stand

Germination was good in all the entries at all the locations. Due to proper gap filling, field management and negligible seedling mortality, nearly 100 per cent stand was maintained at harvest in most of the hybrids (Table: B-1).

Earliness

In the days for first flowering and 50% flowering there was not much difference between Bt cotton hybrids and their non-Bt counterparts. However, Bartlett's earliness index worked out based on percentage of harvest at each picking showed significant differences between Bt cotton and non-Bt cotton hybrids. RCH.144 Bt cotton was the earliest (0.87) followed by RCH.2 Bt (0.70) and RCH.20 Bt (0.64) (Table: B-1).

Table: B-1 Germination, flowering and Earliness index

Hybrid	Plant Stand			First Flowering (Days)	50 % Flowering (Days)	Bartlett's Earliness Index
	Dharwad	Coimbatore	Mean			
RCH.2 Bt	98	97	97.5	56	60	0.70
RCH2 non-Bt	97	98	97.5	56	62	0.58
RCH20 Bt	96	98	97.5	54	62	0.64
RCH20 non-Bt	96	99	97.5	57	63	0.46
RCH.144 Bt	100	100	100.5	53	57	0.87
RCH144 non-Bt	94	99	96.5	55	57	0.73
MECH162 Bt ©	95	97	96.0	55	60	0.74
Local Check	94	96	95.0	55	62	0.50
CD @ 5%		3.8				0.10
CV %		2.2				8.81

Plant Height

The mean plant height varied from 103.9 cm. to 121.9 cm. at Dharwad and from 97.3 cm. to 123.3 cm. at Coimbatore. In general, the Bt cotton hybrids recorded less plant height than their non-Bt counterparts. However, their differences were not significant. RCH.2 recorded less height than the other two test Bt hybrids (Table: B-2).

Number of monopodia

At Coimbatore, the difference in number of monopodia/plant between Bt and non-Bt hybrids was significant only in RCH.20, where the non-Bt hybrid recorded significantly higher number of monopodia than its Bt

counterpart. In the case of other two hybrids, the differences were not significant both at Dharwad and Coimbatore (Table:B-2).

Number of sympodia

The difference in number of sympodia per plant between Bt hybrids and their respective non-Bt counterparts was not significant. The mean number of sympodia per plant varied from 17.9 to 20.9 (Table:B-2).

Table:B-2 Plant height, no of Monopodia and Sympodia

Hybrids	Plant Height (cm)			No.of Monopodia/ Plant			No.of Sympodia/Plant		
	Dhar Wad	Coimbatore	Mean	Dhar Wad	Coimbatore	Mean	Dhar Wad	Coimbatore	Mean
RCH.2 Bt	106.1	97.9	102.0	3.2	2.3	2.8	15.4	20.3	17.9
RCH2 non-Bt	118.0	105.8	111.9	2.7	2.3	2.5	19.5	22.2	20.9
RCH20 Bt	120.1	103.8	112.0	3.0	2.3	2.7	17.7	22.6	20.2
RCH20 non-Bt	121.9	123.3	122.6	3.3	3.5	3.4	16.8	23.7	20.3
RCH.144 Bt	113.9	108.5	111.2	2.4	1.0	1.7	17.9	22.0	20.0
RCH144 non-Bt	109.9	121.8	115.9	2.1	0.9	1.5	19.1	21.0	20.1
MECH162 Bt ©	103.3	99.3	101.3	2.8	0.4	1.6	16.9	23.7	20.3
Local Check	107.7	108.2	107.9	2.9	2.0	2.5	16.1	21.1	18.6
CD @ 5%	N.S	22.9		N.S	0.5		N.S	3.9	
CV %	9.2	12.1		17.2	16.3		11.9	10.1	

Boll weight

Boll weight did not show significant variation between Bt and non-Bt hybrids (Table:B-3). RCH.20 recorded the highest boll weight (5.6 g.) followed by RCH.2 (5.0-5.1 g.) and RCH.144 (4.1-4.2 g.)

Boll number

Both at Coimbatore and Lam, the mean number of bolls/plant in Bt cotton hybrids was not significantly different from the non-Bt counterpart. However, all the three RCH Bt cotton hybrids at Dharwad recorded significantly higher boll number than its non-Bt counterpart (Table:B-3).

Table:B-3 Boll weight and No of Bolls in Bt cotton Hybrids

Hybrids	Boll Weight (g)				No. of Bolls/Plant			
	Lam	Dhar Wad	Coimbatore	Mean	Lam	Dhar Wad	Coimbatore	Mean
RCH.2 Bt	5.0	4.6	5.3	5.0	45.4	23.1	37.4	35.3
RCH2 non-Bt	5.3	4.7	5.4	5.1	45.1	17.7	36.4	33.1
RCH20 Bt	5.6	5.3	5.8	5.6	39.8	20.3	34.7	31.6
RCH20 non-Bt	5.5	5.1	6.1	5.6	47.4	12.9	35.0	31.8
RCH.144 Bt	4.7	3.8	4.2	4.2	44.5	26.7	36.6	35.9
RCH144 non-Bt	4.5	3.6	4.3	4.1	41.7	19.6	37.1	32.8
MECH162 Bt ©	4.5	4.0	4.2	4.2	41.4	20.1	31.2	30.9
Local Check	5.2	4.5	5.4	5.0	48.7	15.6	25.9	30.2
CD @ 5%	0.6	0.5	0.6		N.S	5.1	7.7	
CV %	6.9	7.0	7.0		11.7	14.8	12.8	

Seed cotton yield

RCH.2 Bt and RCH.20 Bt recorded significantly higher seed cotton yield than its non-Bt counterpart at Dharwad and Coimbatore while the difference in yield between RCH.144 Bt and its non-Bt counterpart was not significant at Coimbatore and Lam. RCH.144 Bt recorded significantly higher yield over its non-Bt counterpart at Dharwad (Table: B- 4).

All the three RCH Bt cotton hybrids recorded higher seed cotton yield over their non-Bt cotton hybrids. While the difference was highest in the case of RCH.2 Bt (29%), it was 17 per cent in RCH.20 Bt and 10 per cent in RCH.144 Bt. Similarly all the three RCH Bt hybrids recorded higher seed cotton yield over the common check MECH.162 Bt (38, 22 and 16 per cent respectively) and the local checks (33, 18 and 12 per cent respectively). Over all, RCH.2 Bt (33.3 q/ha) was the most promising hybrid (Table:B-4).

Table:B-4 Seed Cotton Yield in Bt cotton Hybrids

Hybrids	Seed Cotton yield (q/ha)				% increase over Non-Bt counter part	% increase Over MECH.162 Bt	% increase Over L.C.
	LAM	Dharwad	Coimbatore	Mean			
RCH.2 Bt	32.26	30.97	36.71	33.31	29	38	33
RCH2 non-Bt	33.85	20.94	22.90	25.90		7	4
RCH20 Bt	29.45	29.30	29.54	29.43	17	22	18
RCH20 non-Bt	35.68	18.32	21.34	25.11		4	0
RCH.144 Bt	27.32	26.29	30.22	27.94	10	16	12
RCH144 non-Bt	24.93	22.03	29.48	25.48		6	2
MECH162 Bt ©	25.73	20.26	26.43	24.14			
Local Check	34.75	18.58	21.65	24.99			
CD @ 5%	5.62	3.42	7.87				
CV %	10.5	8.4	16				

Ginning Outturn

RCH.2 Bt and RCH.20 Bt cotton hybrids recorded a marginally higher percentage of ginning outturn than their non-Bt counterparts. However, in the case of RCH.144 Bt, it was marginally lower than that of RCH.144 non-Bt (Table: B-5).

Table:B-5 Percentage Ginning out turn

Hybrids	LAM	Dharwad	Coimbatore	Mean
RCH.2 Bt	34.1	39.4	36.0	36.5
RCH2 non-Bt	33.6	38.4	35.0	35.7
RCH20 Bt	32.7	38.0	35.0	35.2
RCH20 non-Bt	32.4	38.1	32.0	34.2
RCH.144 Bt	34.8	40.7	36.0	37.2
RCH144 non-Bt	35.3	41.3	39.0	38.5
MECH162 Bt ©	35.0	41.2	37.0	37.7
Local Check	33.2	43.3	32.0	36.2
CD @ 5%	0.3	1.6	1.5	-
CV %	2.6	2.2	2.4	

Lint Index

Almost all the Bt cotton hybrids recorded a marginally lower lint index over their non-Bt counterparts. While the differences were significant at Lam, it was non-significant at Dharwad and Coimbatore (Table: B-6).

Seed Index

Both RCH.2 Bt and RCH.20 Bt recorded lower seed index than their non-Bt counterparts. While the differences were significant at Lam and Coimbatore, it was non-significant at Dharwad. In the case of RCH.144, the differences were significant at Lam only (Table: B-6).

Table: B- 6 Lint Index and Seed Index in Bt cotton Hybrids

Hybrids	Lint Index				Seed Index			
	LAM	Dharwad	Coimbatore	Mean	LAM	Dharwad	Coimbatore	Mean
RCH.2 Bt	6.4	6.5	6.5	6.5	11.5	10.0	11.8	11.1
RCH2 N-Bt	6.8	6.5	6.8	6.7	13.3	10.4	12.8	12.2
RCH20 Bt	6.0	6.7	7.1	6.6	13.2	10.9	13.5	12.5
RCH20 N-Bt	6.8	7.1	7.1	7.0	13.8	11.5	14.4	13.2
RCH.144 Bt	4.7	5.4	5.4	5.2	8.6	7.9	9.2	8.6
RCH144 N-Bt	5.9	5.3	5.8	5.7	10.3	7.6	9.2	9.0
MECH162 Bt (c)	5.7	5.5	5.8	5.7	10.2	7.8	9.8	9.3
Local Check	5.8	6.3	5.5	5.9	13.2	8.2	11.9	11.1
CD @ 5%	0.3	0.4	0.5		0.3	1.0	0.7	
CV %	2.6	3.9	4.5			6.7	3.4	

Fibre quality

Quality wise there was no difference between Bt and non-Bt hybrids. In respect of fibre length and strength, the local check Savitha was the best followed by RCH.20 and RCH.2 (Table: B-7).

Table: B-7 Fibre quality of Bt cotton Hybrids at Coimbatore

Hybrids	2.5% Span Length (mm)	Uniformity Ratio %	Micronaire	Bundle Strength (g/tex)	Strength/length ratio
RCH.2 Bt	30.8	49.0	4.6	21.9	0.71
RCH2 non-Bt	32.0	50.5	4.7	22.4	0.70
RCH20 Bt	32.8	47.5	4.2	23.0	0.70
RCH20 non-Bt	33.4	47.5	4.1	21.9	0.66
RCH.144 Bt	28.0	51.0	4.1	20.8	0.74
RCH144 non-Bt	27.5	49.5	4.5	20.4	0.74
MECH162 Bt (c)	26.6	51.5	4.8	20.3	0.76
Savitha (C)	34.9	46.5	4.1	23.9	0.68

Central Zone

Five RCH Bt cotton hybrids viz., RCH.2 Bt, RCH.20 Bt, RCH.134 Bt, RCH.138 Bt and RCH.144 Bt along with their non-Bt counterparts and three checks viz., MECH.162 Bt, NHH.44 and G.Cot.Hy.10 were evaluated at Surat in Gujarat and Nagpur in Maharashtra. The crop was sown on 21st June at Surat and on 27th June at Nagpur. While it was a completely rainfed crop in Nagpur, two irrigation were provided at Surat.

Germination and plant stand

Germination and field plant stand was very good in all the entries at both the locations (Table:B-8).

Flowering

There was not much difference between Bt and non-Bt hybrids for first flowering and 50% flowering. The maximum difference was only 3 days between Bt and non-Bt hybrids for flowering. RCH.134 and RCH.138 were early (61-63 days for 50% flowering) and were on par with the check hybrids. RCH.2 took 66 days for first flowering and 69 – 70 days for 50 % flowering (Table:B-8).

Table:B-8 Germination and flowering at Surat

Hybrids	Germination %	First Flowering (Days)	50 % Flowering (Days)
RCH.2 Bt	99.2	66	69
RCH.2 non-Bt	100.0	66	70
RCH.20 Bt	99.2	63	68
RCH.20 non-Bt	97.5	66	69
RCH.144 Bt	100.0	61	66
RCH.144 non-Bt	99.2	64	67
RCH.134 Bt	99.2	59	62
RCH.134 non-Bt	99.2	58	62
RCH.138 Bt	98.3	59	63
RCH.138 non-Bt	98.3	57	61
MECH.162 Bt (cc)	99.2	59	64
NHH.44(c)	100.0	59	63
G.Cot.Hy.10 (c)	98.3	59	63
CD @ 5%		3.54	2.91
CV %		3.48	2.68

Plant Height

Mean plant height of RCH Bt hybrids was less than their corresponding non-Bt hybrids. However, at Surat, RCH.2 Bt recorded significantly more height than its non-Bt counterpart. In the case of other RCH hybrids, the differences were not significant. At Nagpur, RCH.20 Bt and RCH.144 Bt alone recorded significantly less height than its non-Bt counterparts.

Number of Monopodia

The number of monopodia per plant did not differ significantly between Bt and non-Bt hybrids. The number of monopodia per plant varied from 2 to 4 per plant among the different hybrids tested.

Number of sympodia

The differences in number of sympodia per plant were also not significant and varied from 21 to 27 among the different hybrids tested.

Table:B-9 Plant height, no of Monopodia and Sympodia

Hybrids	Plant Height (cm)			No. of Monopodia per Plant	No. of Sympodia per Plant
	SURAT	NAGPUR	MEAN		
RCH.2 Bt	152.0	95.3	123.6	4.0	24.0
RCH.2 non-Bt	134.0	91.7	112.8	4.0	22.0
RCH.20 Bt	141.0	81.1	111.0	4.0	23.0
RCH.20 non-Bt	145.0	111.9	128.5	5.0	21.0
RCH.144 Bt	168.0	102.7	135.3	2.0	27.0
RCH.144 non-Bt	167.0	122.3	144.6	3.0	24.0
RCH.134 Bt	137.0	87.2	112.1	3.0	23.0
RCH.134 non-Bt	141.0	85.5	113.3	2.0	21.0
RCH.138 Bt	152.0	96.4	124.2	2.0	26.0
RCH.138 non-Bt	156.0	97.5	126.8	2.0	26.0
MECH.162 Bt (cc)	149.0	90.5	119.8	3.0	27.0
NHH.44(c)	150.0	98.1	124.1	2.0	23.0
G.Cot.Hy.10 (c)	161.0	113.5	137.2	2.0	22.0
CD @ 5%	17.2	12.2		1.1	
CV %	6.9	7.4		22.9	

Boll weight

Mean boll weight between Bt and its non-Bt counterparts differ significantly at both the locations (Table:B-10). RCH.2 recorded the highest boll weight (4.5 –4.6 g.) and was significantly superior to all the three checks. RCH.144 recorded the lowest boll weight (3.4 – 3.5 g.) and was on par with the checks.

Boll Number

At Surat, all the RCH Bt cotton hybrids recorded significantly higher boll number than their non-Bt counterparts. RCH.2 Bt (46.0), RCH.144 Bt (56.0) and RCH.135 Bt (42.0) hybrids were also significantly superior to the best checks G.Cot.Hyb.10 (37.0). However, at Nagpur, only RCH.138 Bt (19.6) was significantly superior to its non-Bt counterpart (10.3) and to the best check, MECH.162 Bt (13.5).

Table:B-10 Boll weight and Boll Number

Hybrid	Boll Weight (g)			Bolls/Plant		
	SURAT	NAGPUR	MEAN	SURAT	NAGPUR	MEAN
RCH.2 Bt	4.5	4.1	4.3	46.0	17.4	31.7
RCH.2 non-Bt	4.9	4.0	4.5	17.0	12.6	14.8
RCH.20 Bt	4.8	4.3	4.5	35.0	12.6	23.8
RCH.20 non-Bt	4.8	4.5	4.6	12.0	8.0	10.0
RCH.144 Bt	3.7	3.4	3.5	51.0	15.9	33.4
RCH.144 non-Bt	3.7	3.2	3.4	31.0	16.5	23.7
RCH.134 Bt	4.5	4.1	4.3	39.0	16.3	27.6
RCH.134 non-Bt	4.7	4.0	4.3	28.0	11.5	19.8
RCH.138 Bt	4.2	3.9	4.0	42.0	19.6	30.8
RCH.138 non-Bt	3.8	3.5	3.7	37.0	10.3	23.7
MECH.162 Bt (cc)	3.8	3.5	3.7	33.0	13.5	23.2
NHH.44(c)	3.5	3.6	3.5	30.0	5.1	17.5
G.Cot.Hy.10 (c)	4.0	3.5	3.7	37.0	9.2	23.1
CD @ 5%	0.5	0.5		4.3	5.0	
CV %	6.9	7.8		7.6	22.7	

Seed cotton yield

All the five RCH Bt hybrids recorded significantly higher yield over their non-Bt counterparts at Surat. At Nagpur, RCH.20 Bt, RCH.134 Bt and

RCH.138 Bt hybrids recorded significantly higher yield over their non-Bt counterparts. All the five RCH Bt hybrids tested recorded higher seed cotton yield over all the three check hybrids. RCH.2 Bt recorded the highest mean seed cotton yield of 2734 kg/ha and recorded as much as 60 per cent over the non-Bt counterpart, 62 per cent over MECH.162 Bt, 79 per cent over NHH.44 (common check) and 34 per cent over G.Cot.10 (Local check).

Table:B-11 Seed Cotton yield (kg/ha)

Hybrid	SURAT	NAGPUR	MEAN	% increase over Non-Bt counterpart	% increase over MECH.162(Bt)	% increase over NHH.44	% increase over G. G.COT.H Y.10
RCH.2 Bt	3453	2015	2734	70	62	79	34
RCH.2 non-Bt	1431	1792	1612		-5	5	-21
RCH.20 Bt	2901	1794	2348	103	39	54	15
RCH.20 non-Bt	955	1353	1154		-32	-24	-44
RCH.144 Bt	3198	1751	2475	34	46	62	21
RCH.144 non-Bt	1938	1751	1845		9	21	-10
RCH.134 Bt	3035	1773	2404	34	42	57	18
RCH.134 non-Bt	2253	1327	1790		6	17	-12
RCH.138 Bt	3017	1953	2485	24	47	63	21
RCH.138 non-Bt	2421	1572	1997		18	31	-2
MECH.162 Bt (c)	2103	1280	1692		0	11	-17
NHH.44(c)	1805	1251	1528		-10	0	-25
G.Cot.Hy.10 (c)	2552	1539	2046		21	34	0
CD @ 5%	289	382					
CV %	7.13	13.82					

Ginning per cent

Ginning percentage showed some variation between hybrids and locations. However, most of the differences were non-significant. RCH.134 and RCH.144 recorded the highest ginning outturn of 37 per cent and were on par with MECH.162 Bt (C).

Table:B-12 Ginning Percentage

Hybrid	SURAT	NAGPUR	MEAN
RCH.2 Bt	34.1	39.1	36.6
RCH.2 non-Bt	32.0	35.5	33.8
RCH.20 Bt	31.2	34.4	32.8
RCH.20 non-Bt	30.5	39.3	34.9
RCH.144 Bt	35.3	39.3	37.3
RCH.144 non-Bt	36.1	38.1	37.1
RCH.134 Bt	34.8	38.9	36.9
RCH.134 non-Bt	36.8	37.4	37.1
RCH.138 Bt	34.0	35.3	34.7
RCH.138 non-Bt	33.8	33.6	33.7
MECH.162 Bt (c)	34.5	38.1	36.3
NHH.44(c)	33.2	36.5	34.9
G.Cot.Hy.10 (c)	31.8	34.5	
CD @ 5%	1.8	5.3	
CV %	3.2	8.6	

Lint Index

RCH.20 Bt recorded significantly lower lint index than the non-Bt counterpart. In the case of other RCH hybrids, the differences were not significant.

Seed Index

As in the case of lint index, RCH.20 Bt recorded significantly lower seed index than its non-Bt counterpart. In the case of other RCH hybrids, the difference was not significant.

Table:B-13 Lint Index and Seed Index

Hybrid	Lint index			Seed index		
	SURAT	NAGPUR	MEAN	SURAT	NAGPUR	MEAN
RCH.2 Bt	5.3	4.0	4.6	10.2	8.8	9.5
RCH.2 non-Bt	5.1	3.2	4.2	10.8	8.4	9.6
RCH.20 Bt	5.2	3.5	4.3	11.3	9.7	10.5
RCH.20 non-Bt	6.0	6.1	6.0	13.7	12.6	13.1
RCH.144 Bt	4.3	3.5	3.9	7.8	7.2	7.5
RCH.144 non-Bt	4.5	3.2	3.9	8.0	8.2	8.1
RCH.134 Bt	4.7	3.5	4.1	8.8	7.2	8.0
RCH.134 non-Bt	5.0	3.3	4.2	8.5	7.8	8.1

RCH.138 Bt	4.2	2.8	3.5	8.2	7.2	7.7
RCH.138 non-Bt	4.3	2.7	3.5	8.5	7.7	8.1
MECH.162 Bt (c)	4.2	3.4	3.8	8.0	7.5	7.7
NHH.44(c)	4.3	2.6	3.5	8.7	6.4	7.6
G.Cot.Hy.10 (c)	4.2	3.1	3.6	9.0	7.9	8.5
CD @ 5%	0.7	1.4		1.2	1.5	
CV %	8.2	24.4		7.7	10.7	

Fibre quality

There was no appreciable differences between Bt cotton and its non-Bt counterpart in respect of major fibre quality parameters (Table:B-14). All the RCH hybrid recorded higher 2.5% span length as compared to the checks. Only RCH.2 Bt (24.1 g/tex) recorded better fibre strength than the G.Cot.Hy.10, the local check. From the overall quality angle, RCH.20 Bt was the best.

Table:B-14 Fibre quality of Bt cotton Hybrids (Nagpur)

Hybrid	2.5% Span Length (mm)	U.R %	Micronaire	Bundle Strength (g/tex)	Strength/ length ratio
RCH.2 Bt	27.6	49.3	3.8	21.7	0.79
RCH.2 non-Bt	27.7	48.3	3.7	22.0	0.79
RCH.20 Bt	29.8	48.0	3.7	24.1	0.81
RCH.20 non-Bt	21.3	49.0	4.0	23.4	0.75
RCH.144 Bt	25.5	49.7	3.6	20.6	0.81
RCH.144 non-Bt	25.5	50.0	3.8	20.6	0.81
RCH.134 Bt	24.6	50.0	3.8	21.8	0.89
RCH.134 non-Bt	24.4	48.3	3.6	22.2	0.91
RCH.138 Bt	26.2	48.3	3.5	20.7	0.79
RCH.138 non-Bt	25.2	48.3	3.0	23.0	0.91
MECH.162 Bt (c)	23.9	51.3	4.0	20.3	0.85
NHH.44(c)	23.0	48.3	3.1	20.7	0.90
G.Cot.Hy.10 (c)	25.4	48.0	3.2	23.3	0.92
CD @ 5%	1.5	2.2	0.6	1.5	-
CV %	3.3	2.6	9.3	4.1	-

PLANT PROTECTION EVALUATION

Entomological experiments

The Entomological experiments, as given elsewhere, were conducted under unprotected, protected at economic thresholds of various pest species as well as under IPM modules of each location.

The three RCH Bt hybrids, viz., 2, 20 and 144 and their non-Bt hybrids were tested against Savita and MECH.162 Bt hybrids in South zone. Five RCH hybrids, viz., 2, 20, 134, 138 and 144 were tried with their non-Bt hybrids and check hybrids such as NHH.44, G.cot.hy.8 or 10 were tried in central zone.

Evaluation under unprotected conditions

The RCH Bt and non-Bt hybrids were tested along with respective check hybrids of each zone under no plant protection against any pests.

In accordance with the protocol given elsewhere, the observations of incidence of sap sucking pests such as aphids, jassids, thrips and whitefly were recorded at weekly intervals. Similar observations were recorded species-wise of weekly incidence bollworms such as AMERICAN BOLLWORM (ABW), SPOTTED BOLLWORM (SBW) and PINK BOLLWORM (PBW). In addition to this, their percentage damage to fruiting bodies, green and open bolls as well as on locules were calculated from the respective observations at appropriate time of crop growth stage.

SOUTH ZONE

The data on number of jassids, aphids, thrips and whiteflies on 3 leaves are presented in Table:C-1. Among the centers, Guntur followed by Dharwad recorded higher population of jassids, mainly due to dry weather conditions while Coimbatore had low population. The mean population of all the centers for Bt entries and Non-Bt entries showed marginal differences between them. However RCH.2 and RCH.20 entries of Bt and Non-Bt recorded higher population than ETL.

Population of aphid was low in Coimbatore and Guntur centers and moderately higher in Dharwad center. However all the entries except RCH.20 recorded population below ETL level in all the centers. In Coimbatore, RCH.20 Non-Bt recorded higher population (45.5) than ETL level (30).

Thrips population crossed the ETL level in Dharwad center and all the entries recorded higher population, 50 to 70 but the differences were only marginal. In contrast to this in Coimbatore center it was very low in all the entries, 2.0 to 4.0. In Guntur moderate level of thrips population was observed in all the entries except RCH.144 Bt and Non-Bt, which recorded moderately higher population (11.0-42.0). MECH.162 Bt and Savita recorded higher population, 30-42. The whitefly population was very low in all the centers and there were marginal differences among the entries.

Table:C-1 Population of sucking pests in Bt cotton hybrids

Entries	No. of Jassids/3 leaves				No. of Aphids/3 leaves			
	Dharwad	Guntur	Coimbatore	Mean	Dharwad	Guntur	Coimbatore	Mean
RCH.2 Bt	4.5	9.7	2.8	5.7	21.9	1.3	2.0	8.4
RCH.2 NBt	5.4	15.5	3.5	8.1	18.6	0.0	0.9	6.5
RCH.20 Bt	4.8	11.3	2.9	6.3	29.4	0.2	4.7	11.4
RCH.20 NBt	4.8	10.3	4.1	6.4	21.9	2.6	45.5	23.3
RCH.144 Bt	5.1	3.5	2.9	3.8	27.9	22.3	0.8	17.0
RCH.144 NBt	4.5	4.4	3.5	4.1	27.6	29.7	0.9	19.4
MECH.162 Bt	3.3	2.5	2.9	2.9	14.7	8.3	7.7	10.2
Savita	4.8	4.1	2.5	3.8	28.2	6.0	1.8	12.0
C.D. at 5 %	2.2	0.40	NS		9.5	1.06	2.2	
Entries	No. of Thrips/3 leaves				No. of Whiteflies/3 leaves			
	Dharwad	Guntur	Coimbatore	Mean	Dharwad	Guntur	Coimbatore	Mean
RCH.2 Bt	62.1	18.3	3.3	27.90	5.4	0.5	1.3	2.4
RCH.2	49.5	11.0	3.6	21.37	4.8	0.5	1.1	2.1
RCH.20 Bt	62.4	18.7	2.4	27.83	5.7	0.7	0.7	2.4
RCH.20	64.2	15.3	2.8	27.43	10.8	0.3	0.8	4.0
RCH.144 Bt	69.9	34.3	3.5	35.90	6.6	0.7	1.3	2.9
RCH.144	63.0	29.5	3.1	31.90	6.0	0.8	1.0	2.6
MECH.162 Bt	69.0	41.7	4.1	38.27	6.0	0.8	1.0	2.6
Savita	63.5	32.9	2.7	33.03	7.5	1.1	0.9	3.0
C.D. at 5 %	11.2	0.51	NS		1.92	0.12	NS	

Predators population

Predators population was very low in all the centers and there were marginal differences among the entries in all the centers (Table: C-2).

Table: C-2 Population of predators in Bt cotton hybrids

Entries	Predators *(LBB+GLW +MB+ Spiders) / plant			
	Dharwad	Guntur	Coimbatore	Mean
RCH.2 Bt	1.50	0.72	0.0	0.74
RCH.2	1.10	0.92	0.14	0.72
RCH.20 Bt	1.60	0.46	0.0	0.69
RCH.20	1.10	0.86	0.20	0.72
RCH.144 Bt	1.50	0.86	0.0	0.79
RCH.144	0.90	1.42	0.06	0.79
MECH.162 Bt	1.30	0.74	0.0	0.68
Savita	2.20	0.94	0.06	1.07
C.D. at 5 %	-	-	NS	

*LBB = Ladybird beetle, GLW = Green lacewing , MB= Mirid bug

Incidence and damage of bollworms

The data on larval population per plant of *Helicoverpa* and Pink bollworm are presented in Table:C-3. Higher population was recorded at Dharwad among the three centers. The Bt entries had 1.0-1.1, while the Non-Bt entries had 2.1-2.2. Guntur and Coimbatore recorded comparatively low population. The over all mean population of *Helicoverpa* bollworm ranged between 0.4 and 0.5 in Bt entries and 0.9 to 1.3 in Non-Bt entries and check hybrids.

Guntur center recorded maximum population of Pink bollworm per plant. In RCH Bt hybrids, the range was 0.66-1.30, while it was 4.0 in MECH.162 Bt. In Non-Bt entries including check, the Pink bollworm per plant was recorded between 3.0-6.0. However, low population was observed in Dharwad and still, the Bt hybrids had less number of Pink bollworm than the non-Bt and check hybrids.

Table:C-3 Bollworm population under unprotected conditions

Entries	<i>H. armigera</i> larvae/plant				<i>P. gossypiella</i> larvae/plant			
	Dharwad	Guntur	Coimbatore	Mean	Dharwad	Guntur	Coimbatore	Mean
RCH.2 Bt	1.03	0.14	0.0	0.39	0.21	0.66	0.70	0.52
RCH.2 NBt	2.11	0.14	0.50	0.92	0.53	3.00	1.30	1.61
RCH.20 Bt	1.08	0.00	0.00	0.36	0.19	0.70	1.30	0.73
RCH.20 NBt	2.14	0.72	0.20	1.02	0.92	5.30	2.30	2.84
RCH.144 Bt	1.12	0.0	0.0	0.37	0.15	1.30	0.30	0.58
RCH.144 NBt	2.18	0.26	1.30	1.25	0.86	6.00	1.30	2.72
MECH.162 Bt	1.10	0.40	0.10	0.53	0.60	4.00	0.30	1.63
Savita	2.07	0.66	0.90	1.21	0.92	3.33	1.30	1.85
C.D. at 5 %	0.24	0.13	0.30		0.18	1.91	NS	

Fruiting bodies damage

The crop at Coimbatore and Guntur recorded low to moderate level of fruiting bodies damage while Dharwad had higher level of damage. The mean boll damage for all the centers ranged from 4.6-7.9 % in Bt entries and 8.1-13.2 % in Non-Bt entries including check (Table: C-4).

Table: C-4 Fruiting bodies damage in Bt cotton hybrids

Entries	Fruiting bodies damage (%)			
	Dharwad	Guntur	Coimbatore	Mean
RCH.2 Bt	10.3	5.4	0.1	5.3
RCH.2	13.5	6.0	4.9	8.1
RCH.20 Bt	12.4	2.6	1.9	5.6
RCH.20	14.9	6.8	2.9	8.2
RCH.144 Bt	13.7	0.0	0.1	4.6
RCH.144	16.9	11.6	10.5	13.0
MECH.162 Bt	11.3	9.2	3.3	7.9
Savita	16.3	16.3	6.9	13.2
C.D. at 5 %	2.4	15.8	5.9	

Open boll and locule damage

The various hybrids at Coimbatore and Guntur center recorded low to moderate level of boll damage while Dharwad had higher level of boll damage for all the entries which ranged from 5.2 to 7.9 % in Bt entries and 11.0-16.0 in Non-Bt entries including check. Higher locule damage was recorded at Dharwad while Guntur and Coimbatore had low to moderate level of locule damage. The mean locule damage for all the centers ranged from 5.7 to 11.0 % in Bt entries and 12.2-14.2 % in Non-Bt entries including check (Table:C-5).

The open boll damage as well as locule based damage in RCH Bt hybrids due to bollworms (Table:C-5) was 40-45% less than that in the Non-Bt hybrids as well as in the check hybrids, exhibiting the ability to reduce the bollworm infestation of bolls, even under unprotected conditions.

Table:C-5 Bollworms damage and seed cotton yield

Entries	Open boll damage (%)				Locule damage (%)			
	Dharwad	Guntur	Coimbatore	Mean	Dharwad	Guntur	Coimbatore	Mean
RCH.2 Bt	9.9	3.5	2.8	5.4	25.9	2.5	1.4	9.9
RCH.2 NBt	19.4	7.0	9.7	12.0	25.0	6.7	5.0	12.2
RCH.20 Bt	8.3	3.6	3.7	5.2	24.1	2.1	1.1	9.1
RCH.20 NBt	23.6	10.5	13.9	16.0	28.1	8.0	6.4	14.2
RCH.144 Bt	8.5	5.4	4.2	6.0	12.3	3.4	1.5	5.7
RCH.144 NBt	16.8	7.3	9.0	11.0	26.4	8.0	3.1	12.5
MECH.162 Bt	13.7	5.0	5.1	7.9	24.1	6.3	2.5	11.0
Savita	17.8	9.4	12.6	13.3	29.5	6.3	5.7	13.8
C.D. at 5 %	-	5.18	5.63		11.29	8.02	4.4	

Seed cotton yield

Without any insect protection, the RCH Bt hybrids yielded more seed cotton (Table:C-6) over the MECH.162 Bt too in all locations in south zone during 2002-03 season. The zonal best was RCH.2 Bt (2173 kg/ha) followed by 144 Bt (1759 kg/ha) and 20 Bt (1612 kg/ha) and then MECH.162 Bt (1525 kg/ha).

The mean seed cotton yield under dryland conditions of Dharwar was significantly and conspicuously higher over that of their non-Bt counterparts. In Lam, Guntur the RCH.2Bt yielded 1550 kg/ha, the highest among all the test hybrids. There was no significant difference between other test hybrids in this location. However, in Coimbatore, RCH.2 Bt and its non-Bt counterpart yielded the highest amongst all hybrids. The Bt hybrids enabled the harvest of the entire seed cotton in two pickings while the other hybrids could provide the yield in 4-6 pickings.

Table:C-6 Seed cotton yield in various test hybrids

Entries	Seed cotton yield (kg/ha)			
	Dharwad	Guntur	Coimbatore	Mean
RCH.2 Bt	2098	1538	2883	2173
RCH.2 NBt	1049	1091	2407	1516
RCH.20 Bt	1691	1191	1953	1612
RCH.20 NBt	904	1335	1739	1293
RCH.144 Bt	2313	1256	1709	1759
RCH.144 NBt	998	1354	1736	1363
MECH.162 Bt	1693	1199	1684	1525
Savita	1054	1161	1923	1379
C.D. at 5 %	482	324	NS	

Central Zone

Sap-sucking pests

In Nagpur, all the entries except check entries NHH.44 and G.Cot.hy.10 recorded medium to high population of jassids and there were marginal differences among the Bt and their non-Bt counterparts. In Surat, all the hybrids recorded moderate level of jassid population and the difference between hybrids was marginal.

The aphid population was very low at Surat, while it was at moderate level in Nagpur. However, there were no differences among the entries. The thrips population at Nagpur and Surat was moderate in all hybrids. The whitefly population was quite low in both the centres in all the test hybrids (Table:C-7).

Table:C-7 Incidence of various sap sucking pests

Entries	No. of Jassids/3 leaves		No. of Aphids/3 leaves	
	Nagpur	Surat	Nagpur	Surat
RCH.2 Bt	5.27	4.50	16.73	6.66
RCH.2 NBt	6.40	6.00	12.33	4.80
RCH.20 Bt	6.70	6.66	16.27	5.40
RCH.20 NBt	4.97	4.50	13.30	6.30
RCH.144 Bt	5.20	4.80	18.27	6.00
RCH.144 NBt	5.40	3.90	15.57	7.50
RCH.134 Bt	5.67	4.20	26.93	6.00
RCH.134 NBt	6.77	4.80	18.70	6.33
RCH.138 Bt	6.07	4.50	27.10	6.30
RCH.138 NBt	7.40	4.80	31.97	7.20
MECH.162 Bt	-	4.80	-	6.20
NHH.44	3.93	4.60	18.53	5.10

G.Cot.hy.-10	4.00	4.50	14.87	6.00
G.Cot.hy.-8	-	4.20	-	6.66
CD (P=0.05)	NS	1.32	NS	NS
Entries	No. of Thrips/3 leaves		No. of Whitefly/3 leaves	
	Nagpur	Surat	Nagpur	Surat
RCH.2 Bt	18.03	11.10	1.10	2.40
RCH.2 NBt	17.73	13.80	0.47	2.10
RCH.20 Bt	17.97	15.00	0.73	2.10
RCH.20 NBt	17.83	13.80	1.13	2.40
RCH.144 Bt	21.77	15.00	0.27	2.10
RCH.144 NBt	22.30	16.50	0.60	2.10
RCH.134 Bt	27.67	16.50	0.90	2.10
RCH.134 NBt	26.07	17.70	0.90	2.40
RCH.138 Bt	25.17	16.20	1.03	2.40
RCH.138 NBt	21.53	17.70	3.07	2.10
MECH.162 Bt	-	17.70	-	2.10
NHH.44	22.87	17.10	1.53	2.40
G.Cot.hy.-10	30.00	19.20	1.47	2.40
G.Cot.hy.-8	-	15.60	-	2.40
CD (P=0.05)	NS	NS	NS	NS

Incidence and damage due to bollworm

The American bollworm population did not cross ETL (1 larva/plant) in the test hybrids in both Nagpur and Surat. Bt hybrids showed 0.0-0.35 larva per 5 plants at Nagpur while, in Surat it was 0.71-0.75 (Table:C-8). In the case of Spotted bollworm (*Earias*), there was a reduced incidence in Bt hybrids in comparison to Non-Bt hybrids and check hybrids.

Table:C-8 *Helicoverpa* and *Earias* larval incidence

Entries	<i>H.armigera</i> larvae/5 plants		<i>Earias</i> larvae/5 plants
	Nagpur	Surat	surat
RCH.2 Bt	0.0	0.73	0.78
RCH.2	0.0	1.11	0.97
RCH.20 Bt	0.35	0.75	0.80
RCH.20	1.0	1.22	0.92
RCH.144 Bt	0.0	0.71	0.74
RCH.144	0.65	1.30	0.94
RCH.134 Bt	0.35	0.73	0.71
RCH.134	0.35	1.16	0.97
RCH.138 Bt	0.0	0.73	0.72
RCH.138	1.35	1.26	0.97
MECH.162 Bt	NT	0.84	0.84
NHH.44	2.15	1.44	1.07
G.Cot.hy.-10	2.35	1.32	1.09
G.Cot.hy.-8	NT	1.33	1.01
CD (P=0.05)	1.60	0.14	0.12

NT- not tried

Fruiting bodies damage was recorded to be highest in RCH.2Bt among various RCH Bt hybrids. However, RCH.138 Bt and RCH.134 Bt had very low fruiting body damage. The same trends were seen in the Green boll damage also at Nagpur. However, in Surat, the Bt hybrids had significantly lower damage to fruiting bodies and green bolls (Table:C-9).

Table:C-9 Fruiting bodies damage and Green boll damage

Entries	Fruiting bodies damage (%)		Green boll damage (%)	
	Nagpur	Surat	Nagpur	Surat
RCH.2Bt	8.62	4.42	6.67	4.87
RCH.2 NBt	6.05	11.51	0.35	14.78
RCH.20 Bt	0.68	5.13	0.53	5.53
RCH.20 NBt	1.07	12.48	0.00	12.63
RCH.144 Bt	4.78	4.48	2.34	4.86
RCH.144 NBt	3.06	11.94	0.00	13.10
RCH.134 Bt	0.38	4.27	0.00	6.74
RCH.134 NBt	4.96	10.92	4.01	13.24
RCH.138 Bt	0.00	5.10	0.27	6.11
RCH.138 NBt	0.32	11.78	1.12	13.09
MECH.162 Bt	NT	6.86	NT	5.92
NHH.44	4.51	12.50	2.25	13.69
G.Cot.hy.-10	5.86	12.04	3.67	14.28
G.Cot.hy.-8	NT	13.43	NT	12.25
C. D at 5 %	NS	2.70	NS	2.03

NT- not tried

The per cent open boll damage was found to be more in RCH.2 Bt at Nagpur in comparison to other Bt test hybrids. Similar trend was found in the case of per cent locule damage (Table:C-10). However, in Surat, there was marked difference between Bt and non-Bt hybrids as regards the percent open boll damage and locule damage with Bt hybrids recording very low damage in either case. In some Non-Bt RCH hybrids, the percent damage was seen to be more than the check hybrids.

Seed cotton yield

RCH.144 and RCH.138 yielded more seed cotton (Table:C-10) than their non-Bt counterparts. The RCH.20 Bt yielded over other Bt hybrids (796 kg/ha), although RCH.20 NBt yielded the highest (881 kg/ha) at this centre.

The number of pickings of Bt hybrids did not exceed more than two while the other hybrids needed 4-5 pickings.

In Surat, under irrigated conditions, all the Bt entries yielded better than their non-Bt counterparts as well as the check hybrids. RCH.138 Bt yielded the maximum seed cotton out of all the hybrids (2384 kg/ha) followed by RCH.144 (2214 kg/ha). The Check Bt hybrid, MECH.162 yielded 1649 kg/ha. The non-Bt hybrids of RCH.2 and 20 had drastic reduction in yield under unprotected conditions. The number of pickings in Surat ranged from 2-3 for Bt hybrids, while that for non-Bt hybrids was 5-7.

Table:C-10 Open boll damage, Locule damage and Seed cotton yield

Entries	Open boll damage (%)		Locule damage (%)		Seed cotton yield (kg/ha)	
	Nagpur	Surat	Nagpur	Surat	*Nagpur	**Surat
RCH2 Bt	10.7	4.5	5.8	3.4	601	2204
RCH.2 NBt	12.0	27.6	3.8	22.1	653	666
RCH.20 Bt	8.0	8.5	2.8	5.6	796	1654
RCH.20 NBt	17.3	22.7	8.5	18.6	881	568
RCH.144 Bt	4.0	3.1	2.0	2.0	501	2214
RCH.144 NBt	20.0	16.1	7.8	11.5	351	1381
RCH.134 Bt	8.0	5.4	2.4	3.5	461	2073
RCH.134 NBt	8.0	7.5	3.7	9.0	335	1510
RCH.138 Bt	8.0	6.3	3.7	3.8	503	2384
RCH.138 NBt	8.0	4.8	3.6	3.1	271	1389
MECH.162 Bt	NT	9.2	NT	6.1	NT	1649
NHH.44	21.3	15.9	7.2	12.3	680	1461
G.Cot.hy.-10	12.0	13.5	5.1	9.0	539	1111
G.Cot.hy.-8	NT	23.3	NT	15.6	NT	1417
C.D. at 5 %	0.95	2.6	0.80	3.60	82	467
C.V. (%)	12.74	-	14.19	-	8.91	-

NT- Not tried. * Yield under Rainfed condition, ** Yield under irrigated condition

Evaluation under protected conditions at economic threshold level of bollworms

Imidachloprid @ 7 g/kg seed was uniformly treated on the seeds of all test hybrids to ward off sap sucking pests in addition to systemic insecticides as and when these pests crossed economic threshold levels (ETL) at different stages of crop growth in this experiment. The non-Bt hybrids were protected

with suitable insecticides from bollworm damage as and when these pests crossed the ETL.

SOUTH ZONE

Sap-sucking pests

It was observed that there were no major differences in jassid population on the various test hybrids at Dharwad and Coimbatore centers (Table:C-11). However in Guntur, RCH.2 Bt, Non-Bt and RCH.20 Bt and Non-Bt recorded higher population (6.5 to 14.0). In Guntur, the aphid population was also high in RCH.144 Bt and Non-Bt, while all other entries recorded low population and there were marginal difference in aphid population. Thrips and whiteflies population were below ETL level in all entries. There was marginal differences in all the centers except Dharwad which recorded higher population of thrips (24.0-36.0).

Table:C-11 Population of sap-sucking pests

Entries	No. of Jassids/3 leaves				No. of Aphids/3 leaves			
	Dharwad	Guntur	Coimbatore	Mean	Dharwad	Guntur	Coimbatore	Mean
RCH.2 Bt	2.1	6.5	1.0	3.2	6.0	4.0	11.2	7.1
RCH.2 NBt	2.4	14.0	1.3	5.9	4.5	0.3	4.3	3.0
RCH.20 Bt	2.1	6.5	1.2	3.3	7.2	0.0	16.4	7.9
RCH.20 NBt	1.5	7.5	1.0	3.3	3.5	9.5	6.1	6.4
RCH.144 Bt	2.4	3.3	0.9	2.2	4.8	18.5	4.7	9.3
RCH.144 NBt	2.4	3.5	1.1	2.3	3.2	42.1	8.4	17.9
MECH.162 Bt	1.5	1.9	0.7	1.4	5.4	0.0	7.6	4.3
Savita	3.0	4.2	0.6	2.6	4.5	9.3	2.9	5.6
C.D. at 5 %	0.72	0.17	NS		2.0	1.2	NS	

Entries	No. of Thrips/3 leaves				No. of Whiteflies/3 leaves			
	Dharwad	Guntur	Coimbatore	Mean	Dharwad	Guntur	Coimbatore	Mean
RCH.2 Bt	27.0	15.9	2.8	15.2	6.0	1.5	0.3	2.6
RCH.2 NBt	24.0	15.8	2.4	14.1	4.8	0.7	0.4	2.0
RCH.20 Bt	30.0	12.5	3.0	15.2	4.8	1.1	0.2	2.0
RCH.20 NBt	36.0	18.3	2.4	18.9	5.1	1.9	0.4	2.5
RCH.144 Bt	30.0	34.4	2.7	22.4	6.2	1.0	0.1	2.5
RCH.144 NBt	30.0	37.6	2.8	23.5	5.7	1.9	0.3	2.6
MECH.162 Bt	27.0	24.3	2.7	18.0	3.9	1.5	0.2	1.9
Savita	27.0	27.8	2.5	19.1	3.9	1.1	0.3	1.8
C.D. at 5 %	5.7	0.76	NS		1.8	0.12	NS	

Population of predators

There were marginal differences among the entries and also among the centers in recording the predators population viz., lady bird beetle (LBB), Green lace wing (GLW), mirid bug (MB) and spiders observed showed that their population ranged from 0.6-1.0 per plant (Table:C-12).

Table:C-12 Population of Predators

Entries	Predators (LBB+GLW +MB+ Spiders)/plant			
	Dharwad	Guntur	Coimbatore	Mean
RCH.2 Bt	1.46	0.52	0.20	0.73
RCH.2 NBt	1.06	0.46	0.80	0.77
RCH.20 Bt	1.64	0.54	0.90	1.03
RCH.20 NBt	1.09	0.52	0.06	0.56
RCH.144 Bt	1.49	0.12	0.06	0.56
RCH.144 NBt	0.93	0.46	0.30	0.56
MECH.162 Bt	1.28	0.54	0.20	0.67
Savita	2.16	0.46	0.14	0.92
C.D. at 5 %	-	-	NS	

Incidence and damage of bollworm complex

None of the hybrids under test crossed the economic threshold for American bollworm (*H.armigera*) in the three centres. However, the non-Bt and check hybrids were infested with more number of larvae of this species than the Bt hybrids. Clear reduction in the number of American bollworms was seen in RCH Bt hybrids over MECH Bt check hybrid. In the case of Pink bollworm (*P. gossypiella*) infestation too, the three RCH Bt hybrids showed superiority over all other test hybrids (Table:C-13). The incidence of PBW in Guntur was high in spite of insecticide application and it is seen that all the non-Bt and check hybrids showed more incidence of PBW.

Table:C-13 Larval population of bollworms

Entries	<i>H. armigera</i> larva/plant				<i>P. gossypiella</i> larva/plant			
	Dharwad	Guntur	Coimbatore	Mean	Dharwad	Guntur	Coimbatore	Mean
RCH.2 Bt	0.18	0.00	0.00	0.06	0.19	0.70	0.00	0.30
RCH.2 NBt	0.38	0.94	1.10	0.81	0.52	5.00	1.70	2.41
RCH.20 Bt	0.14	0.00	0.00	0.05	0.15	0.30	0.00	0.15
RCH.20 NBt	0.24	0.94	1.50	0.89	0.80	5.70	1.70	2.73
RCH.144 Bt	0.21	0.00	0.00	0.07	0.17	1.70	0.00	0.62
RCH.144 NBt	0.33	0.66	0.60	0.53	0.45	5.30	2.00	2.58
MECH.162 Bt	0.28	0.66	0.00	0.31	0.10	1.30	0.00	0.47
Savita	0.41	1.34	0.90	0.88	1.73	5.70	2.00	3.14
C.D. at 5 %	0.12	0.11	0.30		0.21	2.08	0.46	

Fruiting bodies damage

The three RCH Bt hybrids were uniformly less damaged of their fruiting bodies by bollworms in the three locations. The check hybrids recorded damage range of 5.6 to 9.8 including that in the MECH.162 Bt (Table:C-14).

Table: C-14 Fruiting bodies damage

Entries	Percent Fruiting bodies damage			
	Dharwad	Guntur	Coimbatore	Mean
RCH.2 Bt	2.9	0.0	0.3	1.1
RCH.2 NBt	5.0	9.8	4.9	6.6
RCH.20 Bt	3.4	0.0	0.6	1.3
RCH.20 NBt	4.5	12.1	8.8	8.5
RCH.144 Bt	6.0	3.5	0.6	3.4
RCH.144 NBt	5.6	10.0	8.9	8.2
MECH.162 Bt	4.2	11.6	1.0	5.6
Savita	5.1	15.2	9.0	9.8
C.D. at 5 %	1.8	9.1	3.0	

Open boll and locule damage

The open boll damage percentage was relatively more in Dharwar out of the three centres of this zone. All the Bt hybrids had lower percent damage over the Non-Bt hybrid as well as the check hybrids (Table:C-15).

The percent locule damage also had similar pattern across the three centres. The trend of locule damage (Table:C-15) was also in the expected lines as of Open boll damage in Bt and Non-Bt hybrids.

Table:C-15 Bollworms damage and seed cotton yield

Entries	Open boll damage (%)				Locule damage (%)			
	Dharwad	Guntur	Coimbatore	Mean	Dharwad	Guntur	Coimbatore	Mean
RCH.2 Bt	12.89	3.86	2.49	6.41	18.92	1.26	1.23	7.14
RCH.2 NBt	12.82	6.73	14.14	11.23	25.43	9.35	6.53	13.77
RCH.20 Bt	16.23	4.12	3.74	8.03	16.87	0.84	1.52	6.41
RCH.20 NBt	18.77	9.70	21.89	16.79	35.07	7.93	11.23	18.08
RCH.144 Bt	14.57	2.92	1.93	6.47	20.49	4.20	0.59	8.43
RCH.144 NBt	15.81	4.96	11.04	10.60	26.41	8.10	4.85	13.12
MECH.162 Bt	14.77	4.47	4.36	7.87	19.26	3.70	2.00	8.32
Savita	18.15	12.43	18.14	16.24	26.77	11.50	10.14	16.14
C.D. at 5 %	-	2.37	6.97		8.81	8.97	4.95	

Seed cotton yield

Under protected conditions, the seed cotton harvest in south zone centres was significantly higher in RCH.2 & 20 Bt hybrids over all the other tested hybrids (Table:C-16). RCH.2 Bt provided over 900 kg over MECH.162 Bt hybrid. Except for RCH.144 Bt hybrid, where there was no significant difference over the yield that of its non-Bt hybrid, the RCH Bt hybrids were superior to their non-Bt counterparts, thus providing the actual support of the bollworm tolerance due to the gene that is placed in the genome with right agronomic background that fits into the zone's growing conditions. Significant also is the fact that Bt hybrids provided more than 78-91% of the seed cotton in the first two pickings within December while the all the rest hybrids needed 4-6 pickings, to end up the crop to the end of February.

Table:C-16 Seed cotton yield of various test hybrids

Entires	Seed cotton yield (kg/ha)			
	Dharwad	Guntur	Coimbatore	Mean
RCH.2 Bt	3224	3813	4179	3739
RCH.2 NBt	2401	3678	3621	3233
RCH.20 Bt	3217	3364	3443	3341
RCH.20 NBt	2320	2924	2923	2722
RCH.144 Bt	3062	2058	3149	2756
RCH.144 NBt	2725	3627	3387	3246
MECH.162 Bt	2584	3364	2468	2805
Savita	2317	3513	2806	2879
C.D. at 5 %	631	862	NS	

CENTRAL ZONE

Sap-sucking pests

In Nagpur, the RCH Bt hybrids were seen to have more jassid infestation over their non-Bt counterparts as well as NHH.44 or G.cot.hy.10. The aphid population and incidence of thrips were more or less similar in all

the hybrids. The incidence of whitefly was quite low although there was no difference between any hybrid (Table: C-17).

At Surat, the RCH.2 non-Bt hybrid had maximum jassid incidence, while all others had similar population. Aphid incidence was very low. Thrips population also was more in Bt hybrids.

Table:C-17 Population of sap-sucking pests

Entries	No. of Jassids/3 Leaves		No. of Aphids/3 leaves	
	Nagpur	Surat	Nagpur	Surat
RCH.2 Bt	4.23	5.70	19.10	5.10
RCH.2 NBt	3.27	8.10	29.80	4.50
RCH.20 Bt	6.67	6.60	25.10	4.20
RCH.20 NBt	2.50	3.90	24.20	4.50
RCH.144 Bt	3.37	3.90	24.90	7.20
RCH.144 NBt	2.53	3.90	35.20	6.00
RCH.134 Bt	3.00	3.60	31.90	7.50
RCH.134 NBt	3.07	4.50	30.10	8.10
RCH.138 Bt	3.40	3.60	30.60	7.50
RCH.138 NBt	4.30	3.90	36.40	7.80
MECH.162 Bt	-	3.90	-	7.20
NHH.44	2.27	4.20	24.60	9.30
G.Cot.hy.-10	2.27	3.00	27.30	8.40
G.Cot.hy.-8	-	3.00	-	7.80
CD (P= 0.05)	1.91	1.50	NS	2.40
Entries	No. of Thrips/3 leaves		No. of Whitefly/3 leaves	
	Nagpur	Surat	Nagpur	Surat
RCH.2 Bt	14.80	18.00	1.60	
RCH.2	13.80	15.90	1.10	
RCH.20 Bt	13.10	14.10	0.90	
RCH.20	21.30	16.20	2.20	
RCH.144 Bt	23.90	21.00	1.70	
RCH.144	24.90	19.20	1.90	
RCH.134 Bt	20.90	19.20	2.30	
RCH.134	18.60	18.00	1.80	
RCH.138 Bt	24.80	19.80	3.40	
RCH.138	20.70	18.00	1.90	
MECH.162 Bt	-	20.40	-	
NHH.44	18.50	17.40	1.60	
G.Cot.hy.-10	19.30	21.60	2.10	
G.Cot.hy.-8	-	18.90	-	
CD (P= 0.05)	NS	3.45	NS	

Bollworm incidence

Although none of the bollworms crossed the ETL in this zone under protected conditions in any hybrid under evaluation, the data in Table:C-18 shows that Bt hybrids had lower ABW population in comparison to their non-Bt hybrids as well to that of check hybrids at Surat.

The ABW incidence on Bt hybrids was very low in comparison their non-Bt and check hybrids at Nagpur. However, the Spotted bollworm incidence did not show any such differential response between any hybrid.

Table:C-18 *Helicoverpa* and *Earias* larval incidence

Entries	<i>H.armigera</i> /5 plants		<i>Earias</i> larvae/5 plants
	Surat	Nagpur	Nagpur
RCH.2 Bt	0.73	0.0	0.74
RCH.2 NBt	1.13	1.15	0.79
RCH.20 Bt	0.74	0.0	0.73
RCH.20 NBt	1.05	0.65	0.83
RCH.144 Bt	0.78	0.0	0.71
RCH.144 NBt	0.99	2.50	0.83
RCH.134 Bt	0.73	0.0	0.73
RCH.134 NBt	0.88	0.15	0.84
RCH.138 Bt	0.76	0.35	0.71
RCH.138 NBt	1.01	2.50	0.78
MECH.162 Bt	0.87	NT	0.80
NHH.44	1.23	3.00	0.84
G.Cot.hy.-10	1.19	3.15	0.84
G.Cot.hy.-8	1.12	NT	0.89
C.D.(P=0.05)	0.15	NS	NS

NT - Not tried

Fruiting body damage

There was significant and drastic reduction in fruiting body damage in Bt hybrids at Nagpur as well as in Surat. The green boll damage due to all bollworms followed a similar pattern in both the locations of central zone under protected conditions (Table:C-19).

Table:C-19 Percent fruiting bodies damage and Green boll damage

Entries	Fruiting body damage		Green boll damage	
	Nagpur	Surat	Nagpur	Surat
RCH.2 Bt	0.47	5.45	0.29	6.13
RCH.2 NBt	2.78	12.50	4.47	10.02
RCH.20 Bt	0.39	4.88	0.00	5.52
RCH.20 NBt	13.10	11.70	7.47	8.33
RCH.144 Bt	0.35	4.61	0.44	5.67
RCH.144 NBt	9.94	8.95	11.00	9.85
RCH.134 Bt	1.43	5.10	0.00	5.46
RCH.134 NBt	11.30	7.93	9.61	8.50
RCH.138 Bt	0.37	5.11	0.00	5.72
RCH.138 NBt	13.30	9.85	8.73	9.21
MECH.162 Bt	NT	6.71	NT	6.10
NHH.44	13.80	10.64	10.40	9.23
G.Cot.hy.-10	15.40	10.21	9.48	11.27
G.Cot.hy.-8	NT	11.46	NT	8.98
C.D. (P=0.05)		2.14		1.83

NT- Not tried.

Open boll damage and Locule damage

Both open boll damage and locule damage followed the pattern in which it was noticed that the Bt hybrids had far lower level than their non-Bt hybrids as well as check hybrids at both Nagpur and Surat (Table:C-20).

Table:C-20 Open boll damage , Locule damage and Seed cotton yield

Entries	Open boll damage (%)		Locule damage (%)		Seed cotton Yield kg/ha	
	Nagpur	Surat	Nagpur	Surat	*Nagpur	**Surat
RCH.2 Bt	4.0	8.3	1.7	6.2	1328	3963
RCH.2 NBt	8.0	12.8	3.7	10.1	1354	2479
RCH.20 Bt	8.0	2.9	3.8	2.3	1293	3634
RCH.20 NBt	21.3	13.8	8.3	10.5	1328	2027
RCH.144 Bt	0.0	4.3	0.0	3.3	913	3508
RCH.144 NBt	14.7	9.6	7.5	6.8	1089	3238
RCH.134 Bt	0.0	8.3	0.0	6.0	818	4377
RCH.134 NBt	17.3	15.2	7.3	11.8	1020	2914
RCH.138 Bt	1.3	7.2	0.7	5.3	1285	4164
RCH.138 NBt	13.3	7.2	6.7	5.8	775	3380
MECH.162 Bt	NT	13.4	NT	7.6	NT	3187
NHH.44	4.0	8.9	1.4	6.2	1099	3271
G.Cot.hy.10	13.3	11.7	4.8	8.3	1168	2881
G.Cot.hy.8	NT	6.5	NT	4.5	NT	2837
C.D. at 5 %	1.10	1.8	0.70	1.6	176	537

NT- Not tried * Yield under Rainfed condition. **Yield under irrigated condition

Seed cotton yield

Under irrigated conditions in Surat center (Table:C-20), seed cotton yield of RCH Bt entries yielded seed cotton between 3508 and 4377 kg/ha while the non-Bt entries recorded 2027 to 3380 kg/ha. MECH.162 Bt and check entries (NHH.44, G.cot.hy.10 and G.cot.hy.8) recorded 3187 and 2837 to 3271 kg/ha respectively. RCH.2 Bt, RCH.134 Bt and RCH.138 Bt recorded significantly higher yield over national check.

In contrast to this, under rainfed conditions of Nagpur, the seed cotton yield of all test hybrids did not show significant variation.

Number of sprayings and plant protection cost

Besides seed treatment with imidacloprid, the number of sprays given for Bt entries were four and to that of non-Bt entries including check were

eight in Surat under irrigated condition (Table:C-21). Average cost of plant protection was Rs. 4500 and 8500 per hectare to Bt and non-Bt hybrids respectively.

In Nagpur under rainfed condition, RCH.20 Bt, RCH.2, RCH.144, RCH.138 and check entry – G.Cot.hy.10 required one spray besides seed treatment with imidacloprid and the plant protection cost to each of these entries was Rs. 1500 per hectare. The rest of the entries received only seed treatment and the cost to each of the entry was Rs. 500 per hectare.

Table:C-21 Number of sprays in ETL based protection

Entries	Nagpur			Surat		
	Sucking pests	Bollworms	Total	Sucking pests	Bollworms	Total
RCH.2 Bt	0	0	0	4	0	4
RCH.2 NBt	0	1	1	4	4	8
RCH.20 Bt	1	0	1	4	0	4
RCH.20 NBt	0	0	0	4	4	8
RCH.144 Bt	0	0	0	4	0	4
RCH.144 NBt	0	1	1	4	4	8
RCH.134 Bt	0	0	0	4	0	4
RCH.134 NBt	0	0	0	4	4	8
RCH.138 Bt	0	0	0	4	0	4
RCH.138 NBt	0	1	1	4	4	8
MECH.162 Bt	NT	NT		4	0	4
NHH.44	0	0	0	4	4	
G.Cot.hy.-10	0	1	1	4	4	8
G.Cot.hy.-8	NT	NT		4	4	8

NT – Not tried. 1) Nagpur – Rainfed crop 2) Surat – Irrigated crop

Evaluation under Integrated Pest Management modules

South zone

The potential of Integrated Pest Management was evaluated for RCH hybrids. Different centres from the two zones undertook location-specific IPM modules.

ANGRAU, Lam (Guntur) followed the under-mentioned IPM measures for bollworm suppression in the RCH Bt hybrid evaluation trials.

Date	IPM Measure	Dose	Target Pest
25-09-02	NSKE + H.NPV	25 Kg/ha + 500 LE/ha	Thrips and Helicoverpa initial brood
15-10-02	NSKE + Chlorpyrifos	25 Kg/ha + 1l/ha	Thrips
24-10-02	NSKE	25 Kg/ha	Jassid & Aphid
12-11-02	NSKE + H.NPV	25 Kg/ha + 500 LE/ha	Helicoverpa
19-11-02	Stem application with imidacloprid	25 ml/ha	Aphid, Jassid and Mealy bug
20-12-02	Stem application with monocrotophos	250 ml/ha	Aphid and Mealy bug

In Dharwar, the IPM modules given below were taken up for testing the RCH hybrids.

1) Adoptable IPM module

Target	Bt Genotypes	Check and non-Bt hybrids
Sucking pest	Seed treatment with Imidachloprid 70 WS @ 10g/kg	seed treatment with Imidachloprid 70 WS @ 10 g/kg
	Acetamiprid 20 SP @ 0.1 g/L.	Acetamiprid 20 SP @ 0.1 g/L.
	NSKE 5%	Acetamiprid 20 SP @ 0.1 g/L.
Bollworms	Trichogramma release	Trichogramma release
	NSKE 5%	NSKE 5%
	HaNPV	HaNPV
		Thiodicarb 75 WP @ 1.0 g/L.
		Spinosad 48 SC @ 0.1 ml/L.
Other treatments	Bhendi as trap crop, Pheromone traps, Copper-oxychloride + Streptomycin, NAA	Bhendi as trap crop, Pheromone traps, Copper-oxychloride + Streptomycin, NAA

2) RPP – insecticide schedule

Target	Bt Genotypes	Check and non-Bt hybrids
Sucking pest	Seed treatment with Imidachloprid 70 WS @ 10g/kg	seed treatment with Imidachloprid 70 WS @ 10 g/kg
	Acetamiprid 20 SP @ 0.1 g/L.	Acetamiprid 20 SP @ 0.1 g/L.
	Acetamiprid 20 SP @ 0.1 g/L.	Acetamiprid 20 SP @ 0.1 g/L.
Bollworms	Profenphos 50 EC @ 2.5 ml/L.	Thiodicarb 75 WP @ 1.0 g/L.
		Endosulfan 35 EC @ 2.8 ml/L.
		Spinosad 48 SC @ 0.1 ml/L.
		Profenphos 50 EC @ 2.5 ml/L.
		Spinosad 48 SC @ 0.1 ml/L.
Other treatments	Copper-oxychloride + Streptomycin, NAA	Copper-oxychloride + Streptomycin, NAA

3) Bio intensive module

Target	Bt Genotypes	Check and non-Bt hybrids
Sucking pest	NSKE 5%	NSKE 5%
	<i>Verticillium laccani</i>	<i>Verticillium laccani</i>
	NSKE 5%	NSKE 5%
	<i>Meterhium anisoplea</i>	<i>Meterhium anisoplea</i>
Bollworms	Trichogramma release	Trichogramma release
	NSKE 5%	Btk spray
	HaNPV	NSKE 5%
	<i>Nomureae rileyi</i>	HaNPV
		<i>Nomureae rileyi</i>
		<i>Meterhium anisoplea</i>
Other treatments	Bhendi as trap crop, Pheromone traps, Copper-oxychloride + Streptomycin, NAA	Bhendi as trap crop, Pheromone traps, Copper-oxychloride + Streptomycin, NAA

At Coimbatore, the following three modules were tried.

Crop stage DAS	Module I Location specific IPM		Module II Bio-intensive IPM		Module III Need based Chemical control	
	Non-Bt and Check entry	Non-Bt and Check entry	Non-Bt and Check entries	Bt. entries	Bt. entries	Bt. entries
85	Metasystox + Nimbecidine	Metasystox + Nimbecidine	Metasystox + Nimbecidine	Metasystox	Metasystox	Metasystox
92	Indoxacarb	Indoxacarb	Indoxacarb	--	--	--
106	Chlorpyrifos	Egg parasite <i>T. chilonis</i> release	Chlorpyrifos	Chlorpyrifos	--	Chlorpyrifos
121	Thiodicarb	Nimbecidine	Thiodicarb	Thiodicarb	Nimbecidine	Thiodicarb
170	Endosulfan	Nimbecidine	Endosulfan	--	Nimbecidine	--
		Endosulfan			--	

Boll damage

At all the centres, the respective modules did not have any implication to reduce bollworm damage to bolls, based on percent open boll damage in any test hybrid (Table:C-22).

Table:C-22 Percent open boll damage

Entries	Module I				Module II				Module III			
	Dharwad	Gun tur	Coim bator e	Mean	Dharwad	Gun tur	Coimba tore	Mean	Dharwad	Gun tur	Coimba tore	Mean
RCH.2 Bt	10.63	10.0	4.83	8.49	10.14	-	0.65	5.40	11.40	5.0	1.02	5.81
RCH.2 NBt	12.33	0.0	4.67	8.50	9.21	-	5.58	7.40	9.91	0.0	4.64	7.28
RCH.20 Bt	29.17	-	12.06	20.62	16.76	-	7.38	12.07	10.92	-	16.61	13.77
RCH.20 NBt	11.45	-	14.62	13.04	13.84	-	17.13	15.49	14.68	-	32.37	23.53
RCH.144 Bt	11.86	0.0	4.25	8.06	13.87	-	1.99	7.93	12.55	0.0	1.70	7.13
RCH.144 NBt	14.35	-	17.89	16.12	17.92	-	8.08	13.00	12.93	-	7.92	10.43
MECH.162 Bt	10.84	15.0	6.29	10.71	14.01	-	2.59	8.30	11.45	10.0	4.19	8.55
Savita	14.78	30.0	13.49	19.42	21.27	-	18.80	20.04	15.10	30.0	18.40	21.17

Seed cotton yield

The seed cotton yield (Table:C-23) that was harvested from this evaluation of RCH hybrids as well as other test hybrids did not show any significant influence of IPM treatments across various hybrids.

Table:C-23 Seed cotton yield (kg/ha) under IPM

Entries	Module I				Module II				Module III			
	Dharwad	Guntur	Coimbatore	Mean	Dharwad	Guntur	Coimbatore	Mean	Dharwad	Guntur	Coimbatore	Mean
RCH.2 Bt	3342	1673	3789	2935	2316	-	4261	3289	3285	2844	3752	3294
RCH.20 Bt	3205	1624	3656	2828	2260	-	3908	3084	3326	2451	3263	3013
RCH.144 Bt	3035	1138	3127	2433	1781	-	3163	2472	3115	1678	3294	2696
RCH.2	2940	-	3009	2974	1462	-	3396	2429	2451	-	3231	2841
RCH.20	2294	-	3062	2678	1259	-	2821	2040	2381	-	2252	2317
RCH.144	2585	-	2846	2715	1127	-	2644	1886	2788	-	2813	2801
MECH.162 Bt	2720	1533	2708	2320	2097	-	3698	2898	2639	2196	3209	2681
Savita	2284	1240	2362	1962	1387	-	3144	2266	2376	2190	2037	2201

Central zone

At Nagpur, because of low pest pressure, no additional pest management interventions were made except as per the undermentioned treatment schedule.

Treatment	Date of release	Plant protection agents	Dose/ha
All treatment	27/08/02	<i>Trichogramma chilonis</i>	1 lakh
All treatment	19/09/02	<i>Trichogramma chilonis</i>	1 lakh

At Surat, the following three modules, viz., M-I, M-II and M-III were undertaken in all the five Bt and their non-Bt hybrids as well as the check hybrids, as given below.

Date	Insecticide	Bt hybrids			Non Bt + check hybrids		
		M-I	M-II	M-III	M-I	M-II	M-III
19/8	Acetamiprid	Sprayed	Sprayed	Sprayed	Sprayed	Sprayed	Sprayed
5/9	Endosulphan	--	--	--	Sprayed	Sprayed	Sprayed
16/9	Indoxacarb + Imidacloprid	--	--	--	Sprayed	Sprayed	Sprayed
20/9	Trichogramma Chrysopa	--	--	--	Released	Released	--
1/10	Spinosad	--	--	--	Sprayed	Sprayed	Sprayed
3/10	Trichogramma Chrysopa	--	--	--	Released	Released	--
20/10	Acetamiprid	Sprayed	Sprayed	Sprayed	Sprayed	Sprayed	Sprayed
29/10	Chlorpyrifos +	--	--	--	Sprayed	Sprayed	Sprayed

	Trizophos						
13/11	Ethion + Imidacloprid	Sprayed	Sprayed	Sprayed	Sprayed	Sprayed	Sprayed
20/11	Ethion	Sprayed	Sprayed	Sprayed	--	--	--
	Total sprayings	4	4	4	7	7	7

- All Bt and Non Bt were treated in all the trials.
- In unprotected trials (Ento) none was treated with Imidacloprid.

IPM Module-1 (M-I)

1. seed treatment with Imidachloprid @ 10 g/kg seed
2. mechanical control of early shoot borer as and when required
3. installation of pheromone trap @ 5 per ha one week after germination to monitor bollworm moths
4. early release of *Chrysoperla* @ 10,000 eggs per hectare – 3 releases
5. spray neem formulations @ 2.5 l/ha
6. release *Trichogramma* @ 1.5 lakh/ha (6 releases)
7. spraying Bt formulation @ 1.0 kg/ha
8. spraying of H NPV @ 250 LE/ha for American bollworm
9. spraying of S NPV @ 250 LE/ha for Spodoptera, if required
10. hand collection of eggs and full grown bollworms
11. sowing of maize as intercrop (10: 1) and marigold and castor as a trap crop
12. spraying systemic insecticides for sucking pests as and when required
13. spraying of conventional insecticides at ETL

IPM Module II (M-II)

1. application of phorate 10G @ 1 kg ai/ha 7 days after germination
2. need-based application of Triazophos 0.05% for whitefly control
3. random planting of maize @ 10% of plants and sowing of marigold around cotton as trap crop
4. collection and destruction of damaged fruiting parts, eggs and bollworms
5. installation of pheromone trap @ 10/ha synchronizing with appearance of bollworms
6. need based application of NSKE 5% or any neem based formulation at recommended doses at the appearance of egg or initiation of bollworm damage
7. need-based application of H NPV 450 LE/ha for *Helicoverpa* and S NPV @ 250 LE for *Spodoptera*
8. need-based application of any insecticides alternatively, viz., endosulfan (0.07%), quinalphos (0.05%), profenophos (0.05%) or any other synthetic pyrethroids at recommended dose. Spraying of synthetic pyrethroid group insecticide should be done only at 1st and 2nd flush. In any case, the spray of synthetic pyrethroids should not exceed two.

IPM Module III (M-III)

Recommended pest control practices

Boll damage

The trials of various IPM modules on Bt hybrids versus the check hybrids did not indicate any special effect on the reduction of percent boll damage in both Surat. The results in Table:C-24 are not indicative of any

impact of the treatments. The pest load was not sufficient to indicate any special effects of treatment at Nagpur.

Table:C-24 Percent Boll damage

Entries	Bio – IPM Module		IPM Module	RPP*
	Nagpur	Surat	Surat	Surat
RCH.2 Bt	21.33	0.62	-	1.54
RCH.20 Bt	8.00	1.01	0.22	1.16
RCH.144 Bt	-	-	-	0.15
RCH.134 Bt	5.33	0.00	0.19	0.24
RCH.138 Bt	6.67	0.21	0.64	0.78
NHH.44	6.67	9.98	9.30	12.65
MECH.162 Bt	13.33	9.15	8.79	10.29
G.Cot.hy.-10	NT**	3.47	3.25	2.75
G.Cot.hy.-8	NT	7.19	5.46	9.24

*RPP- Recommended Package of Practice **NT- Not tried

Seed cotton yield

The data in Table:C-25 is not indicative of any special influence of treatments of pest management on the seed cotton yield of the test hybrids.

Table:C-25 Seed cotton yield (kg/ha)

Entries	IPM Module			RPP*
	Nagpur	Surat	Surat	Surat
RCH.2 Bt	811	3541	3592	3109
RCH.20 Bt	946	3458	3196	2729
RCH.144 Bt	681	3192	3571	3185
RCH.134 Bt	750	3084	3284	2720
RCH.138 Bt	625	3346	4249	3456
NHH.44	712	2042	2360	2694
MECH.162 Bt	657	1991	2812	2125
G.Cot.hy.-10	NT**	2207	2812	1242
G.Cot.hy.-8	NT	1673	2648	1406

*RPP- Recommended Package of Practice **NT – Not tried

Plant Pathology Evaluations

South zone

Three Bt cotton hybrids (*viz.*, RCH.2 Bt, 20 Bt and 144 Bt) were screened along with their non-Bt counterparts and check hybrids against bacterial leaf blight disease, *Alternaria* leaf spot disease and Grey mildew disease. Bacterial leaf blight was observed only at Dharwad, *Alternaria* leaf spot at all the three places and grey mildew at Dharwad and Coimbatore.

Due to drought conditions, the overall incidences of the three diseases were only low to moderate in this zone. There was no significant difference among the hybrids to bacterial blight, grey mildew as well as *Alternaria* leaf spot (Table:D-1 and 2).

Table:D-1 Reaction against Bacterial blight and Grey mildew

Hybrid	Bacterial blight		Grey mildew		
	Dharwad		Dharwad		Coimbatore – Unprotected (Disease Grade)
	Protected (PDI)	Unprotected (PDI)	Protected (PDI)	Unprotected (PDI)	
RCH.2 Bt	9.33	14.00	15.17	30.23	0.00
RCH.2 Non Bt	8.23	16.60	16.67	28.13	0.00
RCH.20 Bt	8.57	18.27	16.07	29.27	0.00
RCH.20 Non Bt	9.30	17.17	16.17	25.37	0.00
RCH.144 Bt	8.80	18.47	16.00	25.10	1.67
RCH.144 Non Bt	8.87	18.60	17.10	29.30	2.67
MECH.162 Bt (C)	9.93	17.87	15.90	26.83	0.00
DHH.11/Savita (LC)	9.53	19.03	15.03	28.90	0.00
C.D. @ 5%	N.S.	N.S.	N.S.	N.S.	--
CV %	5.18	14.71	6.62	6.31	--

Table:D-2 Reaction against *Alternaria* leaf spot

Hybrid	Dharwad (PDI)		Lam (PDI)		Coimbatore- Unprotected (grade)
	Protected	Unprotected	Protected	Unprotected	
RCH.2 Bt	15.73	28.67	32.50	17.28	0.67
RCH.2 Non Bt	16.47	29.37	24.90	16.33	0.67
RCH.20 Bt	17.67	31.17	26.45	15.00	0.33
RCH.20 Non Bt	17.33	29.37	27.40	18.85	0.67
RCH.144 Bt	16.13	27.63	27.91	11.25	2.67
RCH.144 Non Bt	17.07	28.43	27.92	11.60	3.33
MECH.162 Bt (C)	17.93	28.00	26.15	16.46	1.00
Savita/DHH.11 (LC)	16.27	29.03	28.33	16.77	1.33
C.D. @ 5%	N.S.	N.S.	N.S.	N.S.	--
CV %	3.49	3.93	10.50	11.00	--

Grade: 0-4 Scale Table

Seed Cotton Yield

At Dharwad, RCH.2 Bt and RCH.144 Bt gave significantly higher seed cotton yield than their non-Bt hybrids under unprotected condition, but under protected condition, where the hybrids were sprayed one round each of copperoxychloride and mancozeb, there was no significant difference among the hybrids. At Lam, Guntur, there was significant difference between RCH.2 and RCH.20 Bt and their non-Bt counterparts in seed cotton yield both under protected (three sprays of mancozeb) and unprotected condition. However, RCH.144 Bt gave lower seed cotton yield than RCH.144 non-Bt both in protected and unprotected conditions.

At Coimbatore, the yield differences between Bt and their non-Bt counterparts were non-significant. However, RCH.2 Bt recorded the highest seed cotton yield of 3785 kg/ha and was significantly superior to both the check hybrids (Table: D-3).

Table:D-3 Seed Cotton Yield of Bt cotton hybrids (kg/ha)

Hybrid	Dharwad		Lam		Coimbatore	Zonal Mean Seed Cotton Yield
	Protected	Unprotected	Protected	Unprotected	Unprotected	
RCH.2 Bt	2193	2104	1722	1273	3785	2215
RCH.2 Non Bt	3053	1421	2026	1592	3395	2297
RCH.20 Bt	1277	1572	1678	1230	3296	1811
RCH.20 Non Bt	1097	1553	1613	1303	3149	1743
RCH.144 Bt	1282	1836	947	738	3074	1575
RCH.144 Non Bt	1109	1161	1577	1085	3192	1625
MECH.162 Bt (C)	1663	1476	1374	767	2828	1621
DHH.11/ Savita (LC)	1466	1238	1635	1273	2501	1623
C.D. @ 5%	N.S.	550	395	502	594	
CV %	54.60	20.62	14.40	24.70	10.70	

Central zone

Reaction of Bt cotton hybrids against foliar diseases

Five Bt cotton hybrids *viz.*, RCH.2 Bt, RCH.20 Bt, RCH.144 Bt, RCH.134 Bt and RCH.138 Bt, along with their non-Bt counterparts and check

hybrids were tested at two centers *viz.*, Nagpur and Surat against bacterial leaf blight and *Alternaria* leaf spot.

There was moderate incidence of bacterial blight at Surat under unprotected condition (no fungicidal/ bactericidal spray) and no incidence under protected condition. There was no difference between Bt and non-Bt cotton hybrids with regard to the incidence of the disease. The lowest percent disease incidence was noticed on NHH.44 (common check – 9.67 PDI) and highest on RCH.2 non-Bt (30.03 PDI). At Nagpur, very low incidence of the disease was noticed (Table:D-4).

Alternaria leaf spot was noticed only at Nagpur. Here also, the disease incidence was low with RCH.20 Bt recording the lowest (1.88 PDI) and G.Cot.hy. 10 the highest (6.23 PDI) (Table:D-4).

Table:D-4 Reaction against Bacterial blight and *Alternaria* leaf spot (Percent Disease Incidence)

Hybrid	Bacterial blight		<i>Alternaria</i> leaf spot
	Surat	Nagpur	Nagpur
RCH.2 Bt	29.55	1.32	3.52
RCH.2 Non Bt	30.03	2.94	2.40
RCH.20 Bt	28.52	2.01	1.87
RCH.20 Non Bt	27.52	6.41	5.20
RCH.144 Bt	19.47	4.93	2.66
RCH.144 Non Bt	19.48	2.12	4.14
RCH.134 Bt	25.09	1.44	3.99
RCH.134 Non Bt	23.16	0.89	4.95
RCH.138 Bt	18.42	2.20	3.02
RCH.138 Non Bt	18.39	0.20	3.82
MECH.162 Bt (C)	28.25	0.43	5.03
NHH.44 (CC)	9.67	0.74	5.73
G.Cot.hy. 10 (LC)	28.38	2.22	6.23
G.Cot.hy. 8 (LC)	13.98	--	--
C.D. @ 5%	2.10	--	--
CV %	13.33	--	--

Seed Cotton Yield

At Surat, all the five RCH Bt cotton hybrids gave significantly higher yield than their respective non-Bt counterparts. RCH.138 Bt yielded the

highest seed cotton (4387 kg/ha) followed by RCH.144 Bt (4070 kg/ha) and RCH.2 Bt (3924 kg/ha) (Table:D-5).

Table:D-5 Seed Cotton Yield of Bt cotton hybrids at Surat

Hybrid	Seed Cotton Yield (kg/ha)	Hybrid	Seed Cotton Yield (kg/ha)
RCH.2 Bt	3924	RCH.138 Bt	4387
RCH.2 Non Bt	1539	RCH.138 Non Bt	2828
RCH.20 Bt	3492	MECH.162 Bt (C)	2928
RCH.20 Non Bt	737	NHH.44 (C)	2037
RCH.144 Bt	4070	G.cot.Hy.10 (LC)	2793
RCH.144 Non Bt	2427	G.cot.Hy.8 (LC)	2940
RCH.134 Bt	3430	C.D. @ 5%	578
RCH.134 Non Bt	2597	CV %	12.02

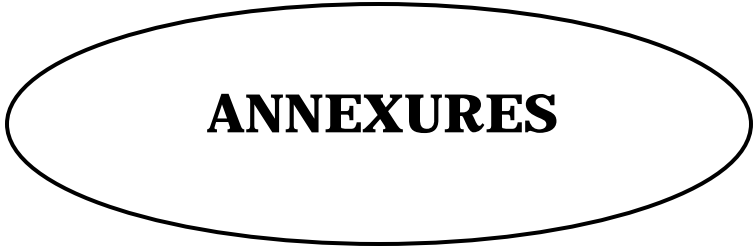
Inferences

1. It is concluded from the ICAR-RCH Bt hybrids evaluation experiments, conducted during *Kharif* 2002-03 that the RCH Bt hybrids are agronomically adapted to both southern and central zones. RCH.2 and 20 Bt seem to be adapted to southern states. RCH.144 was found to be an early hybrid with determinate bearing under south zone conditions and may be useful for being fitted in rice-fallow cultivation. RCH.134 Bt and 138 Bt hybrids are better adapted to central zone.
2. Under unprotected conditions, the bollworms were significantly less on Bt hybrids over their non-Bt counterparts and check hybrids. Due to this, the plant protection cost shall be reduced to a great extent over the non-Bt hybrids. It was also significantly noted that some of the hybrids such as RCH.134 Bt and 138 Bt had low population of sap-sucking insects such as jassids. This shall pave the way for avoidance of insecticide application against early season pests in central zone under monsoon conditions, resulting in a better opportunity for the build up natural enemies in the initial crop stage.
3. There was a tremendous reduction in the number of sprays from 8 to 4 in Surat (irrigated cotton) while at Nagpur, these could be cultivated with one spray against sap-sucking pests during this season. In the south zone centers also, similar reduction in number of sprays was possible with 2 or 3 sprays for sucking pest susceptible hybrids such as RCH.2 Bt hybrid.
4. Although there was no difference in response of the test hybrids to various fertilizer levels in any centre, the earliness of fruit set and maturation of early formed bolls to yield seed cotton that could be collected in two pickings seems to be advantageous to RCH Bt

hybrids in comparison to 4-6 pickings needed in the non-Bt and check hybrid.

5. The fibre properties of these hybrids are similar to the check hybrids and are suitable to meet the present market demand.
6. Under the severe to moderate drought conditions, when this evaluation has been undertaken, there was no serious reduction in seed cotton yield under rainfed cropping conditions of either Dharwad or Nagpur.
7. The RCH Bt hybrids did not show any serious diseases and maladies in various locations where the evaluations were undertaken.

* * * * *



ANNEXURES

ICAR TRIAL FOR TESTING RASI Bt COTTON HYBRIDS

MONITORING REPORTS FOR CENTRAL & SOUTH ZONE

2002 KHARIF SEASON

Central Zone

The Central Zone monitoring team for RCH Bt hybrid trials at Surat and CICR, Nagpur was formulated by ICAR vide F.No. 9(8)/2001/-CC I (R) dated 27.8.02.

1. Dr A.S.Ansingkar, Senior Cotton Breeder & Head of Cotton Research Station, Marathwada Agricultural University, Nanded

2. Dr.T.P.Rajendran, the then Principal Scientist (Ent.), CICR

Itinerary of the Monitoring team:

9th December - arrival of Dr TP Rajendran and Dr AS Ansingkar at Surat and visit to the GAU RCH trial plots and proceed to CICR, Nagpur

10th December – Arrival of Dr TP Rajendran at Nagpur and visit to the RCH trial fields

11th December – return to Coimbatore

Monitoring Report:

The team visited Cotton research Station, Athwa Farm of GAU at Surat on 9th December and saw the Agronomy, Breeding, Entomology and Plant Pathology experiments using five RCH Bt and their non-Bt hybrids along with zonal check, NHH.44 and local check, G.Cot.hybrids 8 & 10 in all these evaluation.

The experiments were conducted with three irrigations at the time of monitoring. The crop growth in all these evaluation experiments was very good. The details of the different experiments are given below:

Date of Sowing	: 21.06.2002
Soil Type	: Deep Black
Soil depth	: Deep
Soil Texture	: Heavy/Light/Medium
Soil P ^H	: 7 to 8.50
Soil Fertility	: N-150-250, P-10-20, K-500-700 Kg/ha.
Previous Crop	: Cotton
Whether Irrigated/Rainfed	: Irrigated

Agronomic requirements of bt cotton hybrids in relation to graded levels of under irrigated condition

Treatments.

(A) Varieties: 14

Nitrogen levels: 3

1.RCH-2 Bt 5.RCH-144Bt 9.RCH1138Bt 13. MECH-162 Bt(C) 1. N1- 240 kg N/ha(100%)

2.RCH-2	6.RCH-144	10.RCH-138	14. G.Cot.Hy-8 (C)	2. N2- 300 kg N/ha(125%)
3.RCH-22Bt	7.RCH-134Bt	11. NHH-44 (C)		3. N3- 180 kg N/ha(75%)
4.RCH-22	8.RCH-134	12. G.Cot.Hy-10(C)		

Design : Split plot

No. of Replication : 2

Number of plant/hill : 1

Rows/plot : 6

Row length : 6.0m

Number of plants/row : 10

Spacing : 90 x 60 cm

Plot size : Gross: 5.4 x 6.0 m Net : 3.6 x 6.0m

Plant Breeding

1. Design of the experiment : R.B.D.
2. No.of varieties/treatment : 10+4 = 14
3. Name of checks used (L.C.) : G.Cot.Hy.10&G.Cot.Hy.8
C.C. : NHH-44 and MECH-162 Bt
4. No.of replication : 3
5. Plot size :
 - a) Distance of rows in gross plot(m) : 1.20
 - b) Length of rows in gross plot(m) : 0.45
 - c) No.of rows in gross plot : 4
 - d) Gross plot size (m) : 4.50 x 4.80
 - e) Length of rows in net plot(m) : 4.50
 - f) No.of rows in plot (Net) : 2
 - g) Net plot size (m) : 3.60 x 2.40
6. Date of sowing : 21.06.2002
7. Date of gapfilling (If applicable): 01.07.2002 and 18.07.2002
8. Date of harvest : 02.12.02 and 22.01.03
9. Crop grown in previous season: Cotton
10. Soil type : Heavy black
11. pH value : 7.52
12. Soil fertility status at the time of planting (soil test)

- | | |
|----------|--------------------------------|
| Nutrient | Status value (available Kg/ha) |
| N | 228.0 |
| P | 18.34 |
| K | 390 |
12. Fertilizer applied
- | | | | |
|----------|----------|-------|--------------|
| Nitrogen | Date | Basal | Top dressing |
| | 17.07.02 | -- | 80- Kg N/ha |
| | 06.08.02 | -- | 80 Kg N/ha |
| | 02.09.02 | -- | 80 Kg N/ha |
14. No.of irrigation applied : Two
15. Dates of irrigation : 13.10 & 26/11/2002
16. No.of weeding done : Five
17. Date of weeding :15/7,3/8,20/8,11/9&5/10/02
18. Other cultural operations with:3/7 and 20/7/02
 dates of Interculturing :Two : 30/7 and 20/7/02
19. Plant protection measures adopted :

Date	Insecticide	Bt cotton	Non Bt cotton + checks
19.08.02	Acetamiprid	Sprayed	Sprayed
07.09.02	Acetamiprid + Chlorpyrifos	Sprayed	Sprayed Sprayed
16.09.02	Imidacloprid Profenphos + Cypermethrin	Sprayed --	Sprayed Sprayed
26.09.02	Indoxacarb	MECH-162 Bt only	Sprayed
04.10.02	Quinalphos	MECH-162 Bt only	Sprayed
14.10.02	Acetamiprid	Sprayed	Sprayed
21.10.02	Methyl-O-demeton + Quinalphos	Sprayed --	Sprayed Sprayed
13.11.02	Ethion 50% EC + Imidacloprid	Sprayed	Sprayed
Total sprays		6, MECH-162 (8)	8

20. Damage due to Nature of damage
- | | |
|-----------------------|----------|
| Aphids/jassids/thrips | Moderate |
| Heliothis | Heavy |
| Spotted bollworm | Slight |
21. Is the experiment reliable : Yes

PLANT PATHOLOGY

Evaluation of Bt cotton hybrids for plant diseases under unprotected condition

Design : R.B.D.
 Replication : 3
 Treatments : 1. RCH-2 Bt 2. RCH-2 Non Bt
 3. RCH-20 Bt 4. RCH-20 Non Bt
 5. RCH-144 Bt 6. RCH-144 Non Bt
 7. RCH-134 Bt 8. RCH-134 Non Bt
 9. RCH-138 Bt 10. RCH-138 Non Bt
 11. NHH-44(C) 12. G.Cot.Hy-10(C)
 13. MECH-162 Bt(C) 14. G.Cot.Hy-8(C)
 No. of rows : 4
 No. of dibbles : 10
 Plot size(m) : Gross : 4.8 x 4.5 Net : 2.4 x 3.6
 Spacing (m) : 1.20x0.45
 Block size(Sq.mt.) : 332.64.
 Experimental area : 0.12 ha
 Date of sowing : 21.06.2002
 Date of weeding : Six : 4/7, 16/7, 2/8, 29/8, 15/9, 19/10
 Date of interculturing Two : 3/7, 20/7

Fertilizer application : Date Basal Top dressing
 17/7 -- 80 Kg N/ha
 6/8 -- 80 Kg N/ha
 2/9 -- 80 Kg N/ha
 Date of irrigation : Two : 7 & 8/10, 25 & 26/11

Plant protection measures :

Date	Insecticide	Bt cotton	Non Bt cotton + check
19/8	Acetamiprid	Sprayed	Sprayed
7/9	Acetamiprid Chlorpyrifos	Sprayed --	Sprayed Sprayed
16/9	Imidacloprid Profenophos + Cypermethrin	Sprayed --	Sprayed Sprayed
26/9	Indoxacarb	MECH-162 Bt only	Sprayed
4/10	Quinalphos	MECH-162 Bt only	Sprayed
14/10	Acetamiprid	Sprayed	Sprayed
21/10	Methyl-o- demeton + Quinalphos	Sprayed --	Sprayed Sprayed
13/11	Ethion 50 EC + Imidacloprid	Sprayed	Sprayed
	6 SPRAYS	8 SPRAYS	

Germination %(overall) : 94.34
 Replicationwise germination%: R-I R-II R-III
 94.5 94.3 94.3
 Crop condition : Very good

Entomology:

Trial. No - 1

Entomology

Trial : No.2

Name of experiment	:	Evaluation of Bt cotton hybrids	under unprotected conditions
Design	:	R.B.D.	
Replication	:	Three	
Treatments	:	10+4	
		1. RCH-2-BT	2. RCH-2 Non-Bt
		3. RCH-20 Bt	4. RCH-20 Non-Bt
		5. RCH-144 Bt	6. RCH-144 Non-Bt
		7. RCH-134 Bt	8. RCH-134 Non-Bt
		9. RCH-138 Bt	10. RCH-138 Non-Bt
		11. NHH-44(NC)	12. G.Cot.Hy-10(LC)
		13. MECH-162 Bt(NC)	14. G.Cot.Hy-8(LC)
No. of rows/plot	:	Five	
No. of dibbles/row	:	10	
Plot size	:	Gross : 6.0 x 4.5 Net : 3.6 x 3.6	
Spacing (mt)	:	1.20 x 0.454	
Block size(m)	:	454 mt.sq.	
Experimental area	:	0.15 ha	
Date of sowing	:	21.06.2002.	
Date of weeding	:	Three : 20/7, 12/7, 25/11	
Date of interculturing	:	Five : 3/7, 5/7, 22/7, 11/8, 29/8	
Fertilizer application	:	Date Basal Top dressing	
		17.7.02 -- 80 Kg N/ha	
		06.8.02 -- 80 Kg N/ha	
		02.9.02 -- 80 Kg N/ha	
Date of irrigation	:	Two : 11/10, 27/11	

Plant protection measure:

Date	Insecticides	Bt	Non Bt+ check
19/8	Acetamiprid		Sprayed
5/9	Endosulphan		Sprayed
17/9	Indoxacarb + Acetamiprid	-- sprayed	Sprayed Sprayed
1/10	Spinosad	--	Sprayed
19/10	Acetamiprid	Sprayed	Sprayed
29/10	Chlorpyrifos	--	Sprayed
13/11	Ethion + Acetamiprid	Sprayed	Sprayed
	Total spray	4	7

Trial : No.3

Name of experiment : Evaluation of Bt cotton hybrids under unprotected conditions

Design : --

Replication : --

Treatments/variety : Varieties :

V1: RCH-2-BT	V2: RCH-2 Non-Bt
V3: RCH-144 Bt	V4: RCH-20 Non-Bt
V5: RCH-138 Bt	V6: NHH-44
V7: G.Cot.Hy-10	V8: MECH-162 Bt

No. of rows/plot :

No. of dibbles/row : 50

Plot size : Gross : 4.8 x 22.5 Net : 2.4 x 20.3

Spacing (mt) : 1.20 x 0.45

Block size(m) : M-I : 1067.04, M-II, 972, M-III: 1067.04

Experimental area : 0.5 ha

Date of sowing : 21.06.2002.

Date of Germination : 25.06.2002.

Date of weeding : Three : 20/7, 12/9, 25/11

Date of interculturing : Five : 3/7, 5/7 ,22/7, 11/8, 29/8

Fertilizer application : Date Ba Top dressing sal

17.7.02	--	80 Kg N/ha
06.8.02	--	80 Kg N/ha
02.9.02	--	80 Kg N/ha

Date of irrigation : Two : 11/10, 27/11

CENTRAL INSTITUTE FOR COTTON RESEARCH, NAGPUR

Title	: Agronomical evaluation of Bt Rasi hybrid cotton in vertisol
Project Investigator	: Dr. M.R.K.Rao, Head, Crop Production Division & Dr. Jagvir Singh, Senior Scientist
Division	: Crop Production
Soil type	: Shallow to medium deep
Date of Sowing	: 1 st July, 2002
Date of Germination	: 15 th July, 2002
Irrigation	: First at germination time and second at boll development stage (at severe moisture stress stage of crop)
Treatments	: Main plot : As per protocol Sub plot : F1 - 75 % RDF, F2 : 100 % RDF And F3 – 125 % RDF (RDF- Recommended Dose of Fertiliser 90 : 45 : 45)
Plot size	: Gross: 5.4 m x 6.0 m = 32.4 sq. m. Net : 3.6 m x 4.8 m = 17.28 sq. m.
Design	: Split plot with two replications
Insecticide sprays	: <ul style="list-style-type: none">• Metasystox for all hybrids (Bt & Non Bt) - 14/8/02• Actra for all hybrids (Bt & Non Bt) - 23/8/02• Metasystox + Streptocycline + Carbaryl - 12/9/02 (Bt & Non Bt)• Endosulfan for non Bt hybrids - 27/9/02
Rainfall	: 952 mm (upto Dec., 2002)

Data on morpho-characters (viz. plant height, number of sympodia, monopodia, squares and flowers) was tabulated at 120 DAS. Significant difference were evident in hybrids while fertility levels failed to have a significant impact. In general, plant height was significantly more in non - Bt counterpart of all the five Rasi hybrids as compared to the Bt. Counterparts in hybrid 2. The values of local and regional check was also significantly higher than the Rasi hybrids. RCH.20 Bt had significantly higher number of monopodia as compared to RCH.20 Non Bt and other hybrids, while the rest differed little. Sympodial number in RCH.20 Non Bt was significantly higher than RCH.20 Bt, while 2 Bt, 144 Non Bt and 162 Bt recorded the minimum number of sympodia. Significant difference was not observed for number of squares and flowers either in the hybrids or for the Fertilizer levels tried. Boll number was significantly higher in 125% RDF (F3) as compared to 100 % RDF (F2). Difference in the boll number were not significant amongst Bt and non Bt counterparts, even though amongst the 20 Non Bt and 144 Bt records relatively higher boll numbers and the lowest number was even in 162 Bt. Amongst the five Bt and non Bt counterparts, the dry matter yield (q/ha) was the highest in 20 Non Bt and which was significantly higher than 20 Bt and other hybrids. Amongst the others four hybrids the difference between Bt and non Bt were not

significant with respect to dry matter accumulation. The regional as well as local check recorded much higher values than mostly of the hybrids. 162 Bt recorded the lowest dry matter yield due to severe incidence of sucking pests.

Significant differences were not evident in Bt and non Bt counterparts Rasi hybrids for number of burst bolls, while numerically higher number of bolls was evident in NHH-44, followed by 138 Bt and the lowest in 162 Bt. Amongst the fertility levels F3 – 125 % RDF had significantly higher number as compared to F2 – 100 % RDF but little difference as compared to F1 – 75 % RDF. The boll weight value was the highest in 20 Non Bt which was significantly superior over all the other hybrids including its non Bt counterparts. Fertility levels did not had a significant impact on boll weight.

Breeding Evaluation

1.	Name of Partieipating Centre	Central Institute for cotton Research, Nagpur
2.	Address	Post Bag No. 2, Shankar Nagar, P.O. Nagpur -440010 (M. S.)
3.	Name of Investigators	Dr. Phundan Singh Dr. Punit Mohan
4.	Details of Bt Cotton Trails	Breeding Trial on Bt Cotton
5.	Date of Sowing	27-06-2002
6.	Soil type	Black
7.	Soil depth	Medium deep to shallow
8.	Soil texture	Medium
9.	Soil Ph	8.0 – 8.3 mean 8.15
10.	Soil fertility (based on available N, P, K, status and organic matter)	Low in organic carbon, N and P, medium in K
11.	Previous crop	Desi cotton
12.	Whether irrigated / rainfed	Rainfed
13.	Agro climate a. Rainfall b. No. of rainy days	952 mm. (May, 2002 to Dec. 2002) 50 No.
14.	Experimental details	Design : RBD Replications : 3 Entries : 13 Non -Bt. : RCH-2, RCH-20, RCH-134, RCH-138, RCH-144, NHH-44 (Check), G.Cot.hy.. 10 (Check). Bt : RCH-2, RCH-20, RCH-134, RCH- 138, RCH-144, MECH-162. Rows / entry : 6 Spacing : 60 x 60 cm. Dibbles / row : 10 Plot size : 6 m x 3.6 m = 21.6 sq.m.
15.	Germination	100%
16.	No. of Sprays given	Nil

Name of Genotype	Final Plant Stand (No.)	Plant Height (cm)	Boll Number/ Plant	Boll Weight (g)
RCH.2 Bt	59.33	95.27	17.40	4.06
RCH.2 Non Bt	59.00	91.67	12.57	4.01
RCH.20 Bt	59.66	81.07	12.63	4.26
RCH.20 Non Bt	59.00	111.93	8.03	4.45
RCH.144 Bt	59.00	102.67	15.87	3.35
RCH.144 Non Bt	58.66	122.27	16.47	3.18
RCH.134 Bt	59.66	87.20	16.27	4.06
RCH.134 Non Bt	57.00	85.53	11.53	3.95
RCH.138 Bt	59.66	96.40	19.60	3.85
RCH.138 Non Bt	60.00	97.53	11.33	3.51
NHH.44 (Check)	59.00	98.13	5.07	3.56
G Cot. Hy. 10 (Check)	59.33	113.47	9.20	3.50
MECH.162 Bt	56.00	90.53	13.47	3.50
CD 0.05%	1.61	12.18	4.95	0.50
CV %	1.62	7.38	22.67	7.78

Entomology Experiment

The Bt-cotton pest management trial at CICR, Nagpur was conducted under rainfed conditions at the CICR, farm. The crop was sown on 20th June 2002. There were four main experiments.

1. Evaluation under completely unprotected conditions
2. Evaluation under ETL based protection against all pests (sucking pests & bollworms).
3. Evaluation of IPM package for Bt-cotton.

There were a total of 108 plots of 32.4 sq M each under the last three experiments and 21 plots of 84.24 sq M each under IPM package evaluation. The crop was in good condition and first picking was carried out in the second week of November.

1. Sucking pest damage (especially jassids) was significantly high in RCH-20 as compared to its non-BT counterpart. Jassid infestation was also higher in RCH-2, RCH-138 and RCH-144 compared to their respective non-Bt hybrids. Seed treatment with 'Gaucho' conferred protection against sucking pests for upto 35-40 days after sowing. Metasystox was sprayed on RCH-20 at 65 days after sowing.
2. There was only one peak occurrence of *Helicoverpa armigera* in the 3-4th week of September. Because of the low infestation levels of all three bollworms, differences in damage to fruiting parts and overall yield were not very apparent between non-BT and BT of some of the hybrids. The difference was not significant especially in case of some of the hybrids which were innately partly tolerant to bollworms. Based on

economic threshold levels of *H. armigera* populations (in some replicate plots), endosulfan was sprayed at 95 days after sowing in all non-Bt hybrids (except RCH-20 & RCH-134-NBT).

1. Evaluation under completely unprotected conditions

There were no significant differences in sucking pest infestation, predator/parasite populations and damage to squares and green bolls. However, some of the Bt hybrids exhibited a slightly higher population (statistically non-significant) of aphids and jassids in the Bt-hybrids compared their counterpart non-Bt. Similarly damage to squares was higher in non-Bt hybrids, compared to the Bt counterparts. Damage caused by pink bollworm was highest in the check hybrids (NHH-44 & H-10) and non-Bt hybrids of RCH-134 and RCH-20. The damage was significantly higher as compared to their corresponding Bt-hybrids. The yields of RCH-Bt-134, RCH-Bt-138 and RCH-Bt-144 were significantly higher than or equivalent to their non-Bt counterparts.

2. Evaluation under ETL based protection against all pests (sucking pests & bollworms)

There was minimum difference in sucking pest infestation between all treatments except for Jassids at 60 DAS and aphids at 90 DAS. Of all the treatments, RCH-Bt-20 had the highest Jassid population. There were no differences in predator populations in any of the treatments. However, the parasitoid *Apanteles* spp. populations were found to be highest on RCH-NBt-20. The differences in larval infestation and square damage were non-significant between all treatments. However, larval populations were high (reaching ETL) in some replicate plots of non-Bt hybrids which had to be sprayed. Damage to green and open bolls was significantly high in the non-Bt counterparts of RCH-134, 138 and 144 compared to all the Bt-hybrids. Highest yields of 12.9-13.54Q/ha were recorded in RCH-2 and 20 Bt- and non-Bt hybrids.

3. Evaluation under protection for sucking pests only

The difference in sucking pest and predator incidence between Bt and non-Bt hybrids was non-significant in all treatments. In general (except in the case of RCH-Bt-2 at 90 DAS) all non-Bt and check hybrids had higher *H. armigera* larval infestation compared to the Bt-hybrids. No larvae were recorded on RCH-Bt-20 and RCH-Bt-138. Damage to squares and bolls, was significantly high in all the non-Bt hybrids as compared to their Bt counterpart hybrids. The yields were high in the Bt-hybrids of RCH-Bt-20 and RCH-Bt-134 compared to the corresponding non-Bt hybrids.

4. Evaluation of IPM package for Bt-cotton

The differences in sucking pest infestation between the treatments was minimum. The infestation was statistically significant only in Jassids (45 & 60 DAS), and whitefly (60 DAS).

There was no statistical difference in predator populations between the treatments. *Helicoverpa* attack was very less and did not exceed a level of more than one larva per 30 plants samples in any of the RCH-Bt hybrids, whereas MECH-162 had 2-3 larvae and the check variety up to 7-12 larvae per 30 plants between 90-105 DAS.

Damage to squares was highest in NHH-44 followed by MECH-162. A Damage of 2-4-2.7% was recorded in RCH-Bt-20 and RCH-Bt-134 compared to 16.57% in NHH-44 at 105 DAS. Damage to green bolls was minimum in all the Bt-hybrids, whereas bolls of NHH-44 were damaged up to 20 per cent. Pink bollworm damage (damage in open bolls and loculi) was highest in RCH-Bt-2 followed by MECH-162, RCH-Bt-20, NHH-44, RCH-Bt-138 and RCH-Bt-134. No damage to open boll and loculi was observed in RCH-Bt-144.

Trichogramma chilonis were released twice in all treatments as per the IPM time-table schedule recommendations.

Report of Monitoring Team for South Zone on evaluation of RCH Bt Cotton Hybrids

A three member team under the leadership of **Sh. A. Kannan**, i/c. Project Coordinator, **Dr. T. Surulivelu** and **Dr. B.M. Khadi** constituted by the council to monitor the trials of Bt cotton hybrids developed by M/S Rasi Seeds Ltd., Attur. As Dr. Khadi was away on official visit to Uzbekistan, **Dr. Kategere** was coopted.

The team visited the trial plots at Agricultural Research Stations at Dharwad and , LAM-Guntur on 13th and 15th of November 2002 respectively. The trial at Central Institute for Cotton Research , Regional Station , Coimbatore is yet to be monitored.

General Observations

The crop was in peak boll stage with good crop stand at both places. The population of insect pests especially *H. armigera* as well as the foliar diseases were very low. The plant height in all Bt entries was shorter by 3-4 cm compared to non-Bt entries and check. Two deviations were observed in the protocol issued.

1. In Agronomy trial the check hybrid has been changed to MECH.184 instead of MECH.162
2. Due to paucity of area in accommodating all experiments in one block, only four rows per entry have been taken up instead of six under pathology trial at Dharwad.

At LAM – Guntur, the isolation required could not be given due to paucity of lands. Otherwise the trials were carried out as per the protocol suggested.

The Sowing details of different trials at two locations are furnished below

Trial	Date of sowing	
	Dharwad	Guntur
Breeding	1-6-2002	5-8-2002
Agronomy	19-6-2002	,,
Entomology		
i. Screening under unprotected conditions	19-6-2002	,,
ii. ETL based plant protection	5-6-2002	,,
iii. IPM Module	5-6-2002	,,
Pathology	20-6-2002	,,

**Dharwad
Agronomy**

The growth of the plant or the number of bolls per plant has not been influenced by different levels of fertilizer.

Entomology

a. Unprotected condition

Higher jassid population was observed on Bt and non-Bt version of RCH.20 and RCH.144 and recorded 16-23 per 5 plants as compared to six in the check. Aphids and thrips were observed above ETL in almost all entries and recorded 169-212 / 5 plants and 46-137 / 5 plants respectively. The population of whitefly remained low in all the entries.

The population of *H.armigera* was low and was found to be 1-2 per 5 plants in Bt entries as against 5-6 in per 5 plants non-Bt and check entries. Similarly pink bollworm population was around four in Bt versions as against 8-11 in non-Bt versions out of 5 plants.

b. ETL based plant protection

Populations of all the sucking pests were very low and thrips were at moderate level, but well below economic threshold level. The boll numbers of Bt versions and non-Bt versions of various RCH genotypes in different trials are furnished below

Trial	Boll numbers / average of 5 plants							
	RCH.2 Bt	RCH.2 NBt	RCH.20 Bt	RCH.20 NBt	RCH.14 4 Bt	RCH.144 NBt	DHH. 11	MECH.162 Bt
a. Breeding	23.6	17.7	20.3	12.9	26.7	19.6	15.6	20.1
b. Agronomy	16.2	17.2	16.5	14.8	21.2	16.3	14.8	17.2 (MECH.184)
c. Entomology								
i. Unprotected	20.5	20.9	18.5	16.2	17.5	18.3	21.8	21.0
	31.2	23.2	26.5	25.0	28.6	22.6	30.1	24.7
ii. Protected	26.3	14.1	27.1	21.4	26.0	19.3	21.3	18.3
iii. IPM	24.0	20.2	28.6	18.9	35.9	24.9	22.3	24.7
a. IPM on RPP*	26.3	14.7	27.9	20.2	27.9	24.0	21.5	21.8
b. Biointensive								
c. Pathology	21.7	14.5	20.4	15.1	24.5	17.5	16.4	21.3
Mean	23.7	17.8	23.2	18.0	23.7	20.3	20.5	21.1

- RPP- Regular Plant Protection

Target	Bt genotypes	Checks
Sucking pests	i. Seed treatment with Imidacloprid 70 WS @ 10 g/ kg ii. Acetamiprid 20 SP @ 0.1 g /litre iii. Acetamiprid 20 SP @ 0.1 g/ litre	i. Seed treatment with Imidacloprid 70 WS @ 10 g/ kg ii. Acetamiprid 20 SP @ 0.1 g /litre iii. Acetamiprid 20 SP @ 0.1 g/ litre
Bollworms	i. Profenophos 50 EC @ 2.5 ml/litre	i. Thiodicarb 75 WP @ 1.0 g/litre ii. Endosulfan 35 EC @ 2.8 ml/litre iii. Spinosad 48 SC @ 0.1 ml/litre iv. Profenophos 50 EC @ 2.5 ml/litre
Other treatments	Copper – oxychloride + Streptomycin , NAA	Copper – oxychloride + Streptomycin, NAA

Bio- intensive

Target	Bt genotypes	Checks
Sucking pests	i. NSKE 5% ii. <i>Verticillium lecani</i> iii. NSKE 5 % iv. <i>Metarhizium anisopleae</i>	i. NSKE 5% ii. <i>Verticillium lecani</i> iii. NSKE 5 % iv. <i>Metarhizium anisopleae</i>
Bollworms	i. <i>Trichogramma</i> release ii. NSKE 5 % iii. HaNPV iv. <i>Nomureae rileyi</i>	i. <i>Trichogramma</i> release ii. Btk spray iii. NSKE 5 % iv. HaNPV v. <i>Nomureae rileyi</i> vi. <i>Metarhizium anisopleae</i>
Other treatments	<i>Bhendi</i> as trap crop, pheromone traps, copper –oxychloride + <i>Streptomycin</i> , NAA	<i>Bhendi</i> as trap crop, pheromone traps, copper –oxychloride + <i>Streptomycin</i> , NAA

On an average test entries of Bt versions recorded high boll numbers.

Pathology

Both Bt and non-Bt versions of RCH.144 was found to be susceptible to *Alternaria* leaf spot. Other entries remained free from foliar diseases.

Agricultural Research Station, LAM-Guntur

The crop in general was good and was subjected to prolonged dry spell in August and early September. The rain fall was meagre in the month of September and registered 26.1mm as against the decennial average of 191.50mm. But subsequent rains in the month of October, the crop recovered. As a result of prolonged dry weather during August- September months the *Helicoverpa* population from the badly affected stunted crop of green gram and black gram migrated to existing fairly a good crop of cotton. This period recorded fairly a higher population of *Helicoverpa*. The dry weather has also favored an unusual build-up of population of thrips which resulted in drying of foliage.

Breeding

All the entries exhibited good number of boll retention and was almost on par among Bt and non-Bt versions and registered around 42 bolls / plant.

Agronomy

Higher number of bolls was observed (28-29) in all Bt versions as compared to 12-24 in non-Bt versions and checks. Higher dose of fertilizer application appears to have induced rank growth and square dropping. Bt and non-Bt versions of RCH.144 have been found lodging in all the trials.

Entomology

a. Unprotected trial

The jassid populations were higher in Bt and non-Bt versions of RCH.2 and RCH.20 (10-16 / 3 leaves) while the thrips populations were higher in Bt and non-Bt versions of RCH.144, MECH.162 Bt and Savita. Incidence of pink bollworm or spotted bollworm was not observed. The economic threshold level of *H. armigera* crossed twice in all non-Bt entries on 93 and 99 DAS.

b. ETL based protection

The Bt entries have not received any spray of insecticides whereas non-Bt versions and the check received six sprays and the Economic threshold level of square damage by bollworms crossed on 74, 93 and 99 DAS.

The mean boll number of Bt and non-Bt versions in different entomology trials are furnished below

Trial	Mean Boll number / plant							
	RCH.2 Bt	RCH.2 NBt	RCH.2 0 Bt	RCH.2 0 NBt	RCH.1 44 Bt	RCH.144 NBt	Savita	MECH.162 Bt
i. Unprotected	33	21.0	26	25.2	24.8	34.5	26.2	27.1
ii. Protected	43	22.2	36	20.0	30.2	36.4	23.1	27.0
iii. IPM	27.2	-	27	-	22.3	-	13.8	19.0
iv. Farmers' practice	47.1	-	35.8	-	39.4	-	23.3	41.6
Mean	37.5	21.6	31.2	22.6	29.3	35.4	21.6	28.7

IPM

1. NSKE + NPV
2. NSKE + Chlorpyrifos
3. NSKE + Chlorpyrifos

Farmers Practice

1. Acephate
2. Acephate (washed due to rain)
3. NSKE + Chlorpyrifos (washed due to rain)
4. NSKE + Chlorpyrifos
5. Chlorpyrifos
6. Monocrotophos
7. Spinosad

It has been observed that the mean number of bolls retained has always been found more in Bt versions than in non-Bt versions except RCH.144.

Pathology

As the disease pressure was low, no incidence of diseases have been reported.

CICR, Regional Station, Coimbatore-3

A three member team, Dr T.P. Rajendran, Project Coordinator and Head, CICR, Regional Station, Coimbatore-641 003, Dr B.M. Khadi, Senior Scientist (Cotton), Agricultural Research Station, Dharwad Farm, Dharwad – 580 007 and Dr T. Surulivelu, Principal Scientist (Entomology), CICR, Regional Station, Coimbatore – 641 003 visited the ICAR-GM-Bt-RCH Hybrid trial plots at CICR, Regional Station, Coimbatore on 10th January, 2003.

General Observations : Three Bt hybrids namely RCH-2, RCH-20 and RCH-144 were included in the trials along with their Non-Bt counter parts and two check hybrids (MECH.162 Bt and Savitha). The trials were laid out as per the Protocol and the stand of the crop was very good. The Crop was in a boll opening stage (136 DAS). The expression of Bt gene in reducing the boll damage was satisfactory in all the trials namely Plant Breeding, Entomology, Agronomy and Plant Pathology.

Plant Breeding : RCH-2 Bt and 144 Bt hybrids were shorter by 6-7 cm, while RCH.20 Bt was significantly shorter by more than 20 cm as compared to their Non-Bt counter parts. There were not much differences in *Monopodia* and *Sympodia*. However, the Bt hybrids had 9-15 bolls higher as compared to their Non-Bt counter parts.

Agronomy : All the hybrids had a very good germination , 93-100% except Savitha which had only 76%. The root length development was greater in Savitha (35 cm) as compared to all other entries which had 29 to 33 cm. The leaf area index was less, 1.00-1.09 in RCH-144 as compared to other RCH entries which had upto 1.52 and 1.60 in Savitha hybrid. Among the entries, there were not much differences in dry matter production. All the Non-Bt entries were taller by 6-24 cm as compared to Bt counter parts.

Entomology :

- ETL Based Protection : All the entries required one spray for sucking pests control during the mid-growth period (85 DAS) in addition to seed treatment. In respect of bollworms incidence and damage, the non-Bt entries reached ETL thrice on 85, 106 and 121 DAS, while the Bt entries reached ETL only once on 121 DAS. Boll damage in Bt entries were less than 2%, whereas, it was 4 to 6% in Non-Bt entries. The boll numbers ranged from 40 to 56 per plant and were more or less equal in both Bt and Non-Bt entries. Three sprays one each with Endosulfan, Indoxacarb and Chlorpyrifos at recommended concentration were given to Non-Bt entries on 85, 106 and 121 DAS while only one spray with Chlorpyrifos was given to Bt entries on 121 DAS.
- Screening trial (Unprotected) : As the plant growth was restricted due to unprotected condition, the sucking pest population was at moderate level. The boll damage ranged from 2.4 to 3.5% in Bt entries and 4.3 to 9% in Non-Bt entries while the Savitha had 7.4%.
- IPM trial : All the Non-Bt entries received mechanical control and one spray with Nimbecidine 0.5%. (Neem compound). In addition to this, two and four sprays were given to Bt and Non-Bt entries respectively. The boll number ranged from 46 to 69 and 41 to 61 in Bt and Non-Bt entries respectively.
- Plant Pathology trial : *Alternaria leaf spot* and *grey mildew* diseases were observed at low levels in all the entries. The boll number ranged from 42 to 54 and 46 to 52 in Bt and non-Bt entries respectively