

Bt COTTON EVALUATION REPORT

CENTRAL & SOUTH ZONE

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EVALUATION OF Bt COTTON HYBRIDS

EXECUTIVE SUMMARY

Three Bt cotton Hybrids were developed by the Maharashtra Hybrid Seeds Company Ltd. (Mahyco). The Department of Biotechnology has required field and laboratory investigations on Bio-safety of the Bt-cotton hybrids. Before releasing for commercial cultivation, the Ministry of Agriculture of the Government of India decided to have detailed field investigations on the agronomic potential, pest management and the economic benefits of the Bt-cotton hybrids through the Indian Council of Agricultural Research (ICAR). Accordingly, the ICAR have agreed for the field evaluation of the MECH Bt cotton hybrids during the year 2001-02 crop season.

As per the directives of the Council vide letter NO. 4-36/98-CC.I Dated 21st June 2001 of the Assistant Director General (CC), the Project Coordinator of AICCIP was directed to take up detailed field investigation on all aspects viz. Plant breeding, Agronomy, Entomology and Plant Pathology in select Central and South Zone AICCIP centres. The test hybrids viz. MECH-184Bt, 162Bt, and 12Bt and their non-Bt counterparts were supplied to the participating AICCIP Centers in the Central and the South Zones by Mahyco. Field experiments were conducted at the following centres:

Central Zone

1. Surat (GAU Gujarat)
2. Junagarh (GAU Gujarat)
3. Khandwa (JNKVV, Madhya Pradesh)
4. Akola (PDKV, Maharashtra)
5. Nanded (MPKV, Maharashtra)
6. Nagpur, CICR Headquarters

South zone

7. Guntur (ANGRAU, Andhra Pradesh)
8. Nandyal (ANGRAU, Andhra Pradesh)
9. Dharwad (UAS, Karnataka)
10. Coimbatore (TNAU, Tamil Nadu) and
11. CICR (RS), Coimbatore (Tamil Nadu)

Three Bt cotton hybrids viz. MECH 184, MECH 162, and MECH 12 and their three non Bt counterparts along with the local and National checks formed a total of eight treatments for testing under different disciplines indicated already. Sowings were completed by 3rd week of July at all locations except in Tamil Nadu where sowings were taken up during August, which is the right sowing time for cotton in the state.

The Bt cotton hybrids showed excellent germination and were found to be true to type with genetic purity above the prescribed standards. Among the three hybrids, MECH 12 was found to be a short compact plant type with semi okra leaf type, while MECH-184 is a semi okra-plant type with medium duration. MECH 162 is a late maturing hybrid with normal leaves.

RESULTS OF INVESTIGATIONS UNDER VARIOUS DISCIPLINES

AGRONOMIC EVALUATION

The agronomic investigations revealed that Bt cotton hybrids were compact with optimum number of functional leaves and were more efficient in converting photosynthate to the economic produce viz., the cotton bolls. The non-Bt hybrids and the check hybrids showed excess vegetation with crowded leaf canopy with higher incidence of shoot borer (*Earias* spp.) damage. At almost all the locations, it was noted that the non-Bt hybrids and the national check NHH 44 put forth excessive vegetative growth and recorded higher incidence of bollworms. At Guntur and Nandyal in Andhra Pradesh and Coimbatore in Tamil Nadu, the non-Bt hybrids and check hybrids were severely affected by bollworms, which resulted in poor boll number per plant. In the current cotton cropping season, which witnessed serious bollworm out break, the Bt cotton hybrids proved efficient in retaining higher number of bolls per plant with less boll and locule damage. The difference in boll number between Bt and non Bt cotton hybrids were very significant. In the Central Zone, the Bt cotton hybrids retained 17 to 20 bolls / plant while non-Bt hybrids retained around 10 to 12 bolls/plant. The National check NHH 44 was on par with the Bt hybrids in the central zone. However, in the south zone Bt cotton hybrids MECH 184 and MECH 162 retained 22 to 25 bolls/plant, while zonal and the national checks retained only 15 and 13 bolls per plant, respectively. In spite of good plant protection measures, the zonal and national checks could retain only 13 to 15 bolls/plant indicating the ineffectiveness of chemical plant protection measures. This may be partly due to the insects developing resistance to the commonly used popular chemical insecticides.

Increased fertilizer levels showed marginal improvement in boll number indicating sufficiency of fertilizer doses at current levels of recommendation .

Both in Central and South zones, MECH-162 Bt registered the highest yield followed by MECH-184 Bt. MECH 12 Bt gave equally higher yield in South zone, while its yield was poor in central zone, indicating the suitability of this hybrid to irrigated conditions only. The non-Bt and the check hybrids yielded just half of the yield of Bt hybrids in spite of adequate chemical plant protection measures. Thus, it is clear that in the seasons of severe bollworm outbreaks, in-built Bt gene in the transgenic Bt cotton hybrids alone could check the bollworm damage effectively and give normal yields. Additionally, it was noted that at all the locations, Bt cotton hybrids matured earlier by 15 to 30 days than their non Bt counterparts and checks, with higher proportion of (90 to 95%) good quality seed cotton, while non-Bt and check hybrids were late in maturing and also had a higher proportion of bad and ill opened seed cotton of poor quality. The percentage of bad *kapas* was noted to be as high as 20 to 40%, depending upon the severity of bollworm damage at different locations. Thus, the Bt cotton hybrids were found high yielding and early maturing with quality *kapas*. The yield advantage from Bt hybrids MECH 162 and MECH 184 was around 5.0 q/ha over non-Bt and the checks. The economic advantage from the above Bt cotton hybrids may be around Rs. 8000 to Rs. 10000 per hectare as compared to the non Bt and check hybrids.

PLANT BREEDING EVALUATION

All Bt-cotton hybrids showed good vigour and growth. The plant height ranged from 90 to 100 cm and was on par with the zonal and national checks. However, Bt cotton hybrid MECH 12 remained stunted in drought prone Central Zone locations. The number of bolls per plant was significantly higher in Bt-cotton hybrids (11.6 to 24.8 boll/plant in Central Zone and 26.6 to 35.0 bolls/plant in South Zone) compared to non Bt (11.9 to 19.9 in Central zone and 18.1 to 26.4 bolls/plant in South Zone) and check hybrids (7.7 to 9.1 bolls/plant). The Bt cotton hybrids registered significantly higher yield compared to non-Bt and check hybrids. The hybrid MECH 162 Bt registered highest yield of 13.3 q/ha in central zone, while the hybrid MECH 184 Bt recorded highest yield (20.0

q/ha) in the south zone. MECH 12Bt has given better yield well above the national and the zonal checks in the South Zone, while its yield was poor in drought prone locations such as Akola and Nanded in Central Zone. The Bt cotton hybrid MECH 12 and MECH 184 are of high quality with extra long staple length, good micronaire and high fibre strength. Both MECH 12 Bt and MECH 184 Bt have big bolls and higher boll weight. Regarding other characters such as ginning out turn, seed index and lint index, Bt cotton hybrids MECH 12 and MECH 184, proved better with higher values compared to the check hybrids. In general, it is clear that Bt cotton hybrid MECH 184 is a good hybrid of high quality suitable for both irrigated and rainfed conditions, while MECH 162 is a medium staple cotton suitable for rainfed condition as well.

C. EVALUATION OF Bt COTTON HYBRIDS AGAINST MAJOR COTTON PESTS

Field experiments were carried out to evaluate the performance of Bt cotton hybrids under ETL based plant protection, unprotected condition and under different IPM modules to work out the plant protection cost benefit of Bt cotton.

1. Evaluation of Bt cotton hybrids under ETL based plant protection

Sucking pests: In Central Zone, the Bt cotton hybrids recorded low thrips population. However, the jassid population was higher in Bt and non-Bt MECH hybrids compared to the check hybrids. MECH 12 was found more susceptible to jassids at all locations. In South zone, there were no significant differences in the incidence of sucking pests in Bt, Non-Bt and Check hybrids.

Besides seed treatment with Imidacloprid, the Bt cotton hybrids required two sprays in the Central zone and three to four sprays in the South zone for the control of sucking pests. Similarly, the non-Bt and check hybrids required 3 to 4 sprays both in the Central and South zones. Among Bt hybrids, only MECH 12 Bt required more number of sprays for sucking pests

Bollworm Complex : The ETL for bollworms was reached 90 DAS on all the Bt hybrids, while in non-Bt and check hybrids, the bollworm population crossed ETL two to three times commencing at 60DAS. In spite of higher number of pesticide sprays given for non-Bt and check hybrids, the bollworm population remained significantly higher in these hybrids at all the locations. All Bt cotton hybrids exhibited resistance to bollworms, particularly to *Helicoverpa* and *Earias*, besides reasonable tolerance to the pink bollworm.

Boll and Locule damage: The results clearly indicated that at all the locations Bt cotton hybrids registered lower damage in bolls and loculi compared to non-Bt and check hybrids. For the control of bollworms, the Bt cotton hybrids required 2 to 3 sprays in Central zone and four sprays in the South zone, while the non-Bt and check hybrids required 4 to 5 sprays in the Central Zone and 5 to 6 sprays in the South Zone.

Seed Cotton Yield: In the Central Zone, MECH-184Bt and MECH 162Bt recorded significantly higher seed cotton yield (15 q/ha) compared to MECH 12 non-Bt and check hybrids, whose yield levels ranged from 7 to 9 q/ha. In the South Zone, all Bt cotton hybrids recorded significantly higher seed cotton yield (15 to 17q/ha) compared to non-Bt and check hybrids (9 to 10 q/ha). It is interesting to note that MECH 12 hybrid, which yielded less in the Central Zone recorded higher yield and were on par with that of other Bt cotton hybrids.

Plant Protection Cost: The average plant protection cost for Bt cotton hybrids was around Rs 5000 per ha for MECH-184Bt in the Central and South zones while the check hybrid NHH-44 required maximum plant protection costing Rs.9000 per ha. The non-Bt hybrids required around Rs. 7000 to 8000 per ha as plant protection cost. In

spite of higher plant protection cost, the pest control especially for bollworm control was not satisfactory in non-Bt and check hybrids.

2. Evaluation of Bt cotton hybrids under unprotected condition:

Insect Reaction: The incidence of sucking pests did not differ significantly among Bt, non-Bt and check hybrids. Regarding bollworm complex, the Bt hybrids proved to be highly resistant. Similarly, Bt cotton hybrids showed minimal boll damage (15 to 25%) and locule damage (11 to 17%) compared to the non-Bt and check hybrids, where the boll and locule damages were significantly higher (25 to 50%).

Seed Cotton Yield: Both in Central and South zones, the MECH-184 and MECH-162 Bt cotton hybrids recorded significantly higher yield under unprotected condition, compared to non-Bt and check hybrids. The yield superiority was around 3 to 5 q/ha of seed cotton.

3. Evaluation of Bt cotton hybrids under IPM:

Under IPM practices, Bt cotton hybrids recorded higher yields (11 to 14 q/ha) compared to the local and national checks (8.37 and 7.31 q./ha). The average plant protection cost for MECH-184 Bt and MECH 162Bt was Rs. 1413 per ha, while MECH 12Bt required Rs. 1727/ha. The local and national check hybrids required Rs. 2845 per ha and Rs. 2001 per ha, respectively. On an average, the Bt cotton hybrids yielded 5 to 6 q/ha more compared to the non-Bt and the check hybrids. Taking into account the additional yield from Bt cotton hybrids, the average additional profit for MECH 184Bt was about Rs. 11000 to 12000 per ha; for MECH-162Bt, it was around Rs 10000 to 12000 per ha compared to local and national checks. Similarly, MECH 12Bt also recorded additional returns of Rs. 7000 to 8000 per ha compared to local and national check hybrids.

4. Evaluation of Bt cotton hybrids for foliar diseases:

The Bt cotton hybrids were screened for their reaction to major diseases viz. bacterial blight, alternaria leaf spot and grey mildew diseases. The Bt Cotton hybrids did not contract any serious disease incidence in limiting the yield compared to non-Bt and check hybrids in almost all the locations. Besides, these diseases are amenable for control. In spite of higher incidence of Grey mildew at Dharwad and alternaria leaf spot at Coimbatore and Guntur centres, the seed cotton yield was not reduced. The analyses of soil samples collected from Bt and non-Bt hybrid plots did not show any significant alteration in microbial population.

EVALUATION OF BT COTTON HYBRIDS

INTRODUCTION

Bt cotton evaluation trials were taken up during the year 2001-02 under All India Coordinated Cotton Improvement Project at the following AICCIP Centers and Central Institute for Cotton Research, Nagpur and Regional Station, Coimbatore.

I. CENTRAL ZONE LOCATIONS

Khandwa, Akola, Surat, Nanded, Junagarh and Nagpur

II. SOUTH ZONE LOCATIONS

Guntur, Dharwad, Nandyal and Coimbatore

On receipt of directives from the Assistant Director General (CC), Indian Council of Agricultural Research, New Delhi vide his letter No. 4-36/98-CCI.CCI dated 21st June, 2001, necessary action was initiated to conduct Bt cotton trials in the Coordinated Program in the Central and South Zones.

Three Bt cotton hybrids supplied by M/s.Maharashtra Hybrid Seeds Company Ltd.,(Mahyco) Mumbai namely MECH-162, MECH-184 and MECH-12 were supplied for evaluation along with the non-Bt versions of the same hybrids by June end 2001. It was decided to evaluate these test entries along with the checks under different disciplines with precise objectives to know the superiority or otherwise of Bt cotton compared to non-Bt, Zonal and National check hybrids. Therefore, five sets of trials were planned at all locations.

The following sets of evaluation trials were carried out:

- i. Agronomy Evaluation of Bt-Cotton Hybrids
- ii. Evaluation of Bt-cotton Hybrid in Breeding Program
- iii. Evaluations of Bt-cotton Hybrid under Plant Protection Program
 - a. Evaluation of Bt-hybrids under pest protected and unprotected conditions.

- b. Evaluation of Bt-hybrids under integrated pest management regimes (IPM).
- c. Evaluation of Bt-hybrids for diseases.

PROTOCOL FOR CONDUCT OF TRIALS:

I. AGRONOMIC EVALUATION

Objectives:

1. To study the responses of Bt-hybrids to graded levels of N: P: K
2. To understand the differential performance if any of Bt and non-Bt hybrids

Treatments:

a. Hybrids = 6 + 1 or 6 + 2, MECH-184 Bt & non-Bt, MECH-162 Bt & Non-Bt; MECH-12 BT & non-Bt, NHH-44 (National check) and Local check.

b. Fertilizers: Three levels, F1 = Normal recommended dose of N:P:K, F2 = 25% above the recommended dose and F3 = 25% below the recommended dose.

c. Design and Replications: Split plot design with hybrids in main plot and fertilizers in sub plot with two or three replications

d. Plot Size: Gross plot = 32.40 sq. m and Net plot = 17.28 sq. m

All other agronomic practices recommended for the respective location are to be followed.

e. Observations to be recorded: Germination, initial and final plant stand, plant height (cm), number of squares, flowers and green bolls per plant, number of monopodia and sympodia per plant, average boll weight (g), total bio-mass, dry matter weight and seed cotton yield of 1st, 2nd and 3rd picking (kg per plot) and total yield (kg per plot). Wherever possible, the Center is advised to carry out cotton quality parameters as per CIRCOT norms.

II. EVALUATION OF Bt-COTTON UNDER BREEDING PROGRAMME

Objectives:

1. To compare the growth and reproduction parameters of Bt-hybrids vis-à-vis their non-Bt counterparts and checks.

2. To evaluate the yield and quality performance of Bt-hybrids under different agro-ecological conditions.

Treatments:

- a. **Hybrids:** 6 + 1 or 6+2, MECH-184 Bt & non-Bt, MECH-162 Bt & Non-Bt; MECH-12 BT & non-Bt, NHH-44 (National check) and Local check (PKV Hy 2, JKHy 1, G Cot Hy 10, Savita)
- b. **Design:** Completely Randomized Design (CRBD) with three replications.
- c. **Plot Size:** Six rows of 6m length, spacing between rows and plants as per local recommendations. All other agronomic practices recommended for the respective location are to be followed including fertilizers and inter culture operations.
- d. **Observations to be recorded:** Germination, initial and final plant stand, plant height (cm), bolls per plant, average boll weight (g), seed cotton yield of 1st, 2nd and 3rd picking kg per plot and total yield kg per plot, GOT (%), lint index, seed index, span length, uniformity ratio, fibre strength, and micronaire

III-A. EVALUATION OF Bt COTTON HYBRID UNDER PROTECTED CONDITIONS ON THE BASIS OF ETL

Objectives:

1. To evaluate Bt-cotton hybrids for sucking pests and bollworm reactions at various stages of crop growth under protected conditions on ETL basis.
2. To examine the population of beneficial insects in various treatments.

a. Treatments: 6 + 1 or 6+2, MECH-184 Bt & non-Bt, MECH-162 Bt & Non-Bt; MECH-12 BT & non-Bt, NHH-44 (National check) and Local check (PKVHy 2, JKHy 1, G Cot Hy 10, Savitha).

b. Design: Randomized block Design (RBD) with three replications.

c. Plot size: 11.4m x 9.6m with plant spacing and other agronomic practices as recommended for the respective location are to be followed including fertilizers and inter culture operations.

d. Observations to be recorded: Germination, sucking pest observations to be recorded on 15 leaves per treatment between 30 DAS and 110DAS at an interval of 15 days for

aphids, jassids, thrips and whitefly as per natural occurrence of the pests. For bollworms, observations are to be recorded on *Earias*, *Helicoverpa* and *Pectinophora* as larval count based on 5 plants data per plot, as well as % square and boll damages commencing from the incidence of the pests. Locule damage are to be recorded at the time of harvest. In case of predators such as *Coccinellids*, *Chrysopa*, spiders and others are to be recorded on the basis of 5 plants per plot at 15 days intervals. Seed cotton yield of 1st, 2nd and 3rd picking kg per plot and total yield kg per plot are recorded,

III-B. EVALUATION OF Bt-COTTON HYBRIDS UNDER UNPROTECTED CONDITION

Objectives:

1. To evaluate the performance of Bt-cotton hybrids for the insect pests and diseases under unprotected conditions.
2. To compare the relative performance of pest and diseases on Bt and non-Bt hybrids.

The conduct of the experiment and the observations to be recorded are as per protocol given in C1, except that this trial is to be conducted under unprotected conditions i.e. without giving seed treatment or any other sprays to control pests or diseases. In addition to the observations on pest incidence, periodic evaluation of the plot are to be performed by the Plant Pathologist for the natural occurrences of bacterial blight, Grey mildew, *Alternaria* blight, and boll rots following the procedure of AICCIP.

III-C. EVALUATION OF Bt-COTTON HYBRIDS UNDER DIFFERENT INTEGRATED PEST MANAGEMENT (IPM) MODULES

Objectives:

1. To evaluate the performance of Bt-hybrid under three IPM modules.
2. To examine responses of Bt-hybrids under different IPM strategies and farmers' practices.

a. Hybrids = 3 + 1 or 3 + 2, MECH-184 Bt, MECH-162 Bt, MECH-12 Bt, NHH-44 (National check) or and Local check.

b. IPM Modules: Three, 1. IPM module developed at the Center, 2. Farmers' Practice and 3. Bio-intensive modules.

c. Design and Replications: Split plot design with modules as main plot and hybrids as sub plot with three replications

d. Block Size: Gross plot = 27.6 m by 25.2m with spacing of 60cm x 60cm

All other agronomic practices recommended for the respective location are to be followed.

e. Observations to be recorded: Germination, sucking pest observations to be recorded on 15 leaves per treatment between 30 DAS and 110DAS at an interval of 15 days for aphids, jassids, thrips and whitefly as per natural occurrence of the pests. For bollworms, observations are to be recorded on *Earias*, *Helicoverpa* and *Pectinophora* as larval count based on 5 plants data per plot, as well as % square and boll damages commencing from the incidence of the pests. Locule damage are to be recorded at the time of harvest. In case of predators such as *Coccinellids*, *Chrysopa*, spiders and others are to be recorded on the basis of 5 plants per plot at 15 days intervals. Seed cotton yield of 1st, 2nd and 3rd picking kg per plot and total yield kg per plot are to be recorded.

MONITORING AND EVALUATION OF Bt COTTON HYBRID TRIALS

ICAR appointed Monitoring and Evaluation Teams for Bt-cotton trials carried out by AICCIP comprising of experts from Department of Biotechnology, GOI, Ministry of Agriculture, GOI, Ministry of Forest and Environment GOI, Ministry of Health GOI, and the Scientists comprising of Breeders and Entomologists from ICAR and SAU's. Two teams were formed for evaluation of trials under Central and South Zones under the Chairmanship of Director, CICR, Nagpur for Central Zone and Project Coordinator CICR Coimbatore for the Southern Zone. The teams visited the trials during the grand growth period i.e. in November and December 2001 and submitted their reports to the Council. The summary of the reports is given below:

CENTRAL ZONE:

1. The team observed that the trials have been conducted as per experimental designs and all the centers have followed the protocol.. All the trials were timely planted at all

locations. The season was extremely favourable to bollworm infestation, thus providing clear differences between non-Bt hybrids for bollworm reactions.

2. Boll retention in Bt-hybrids were significantly higher than non-Bt counterparts and the check hybrids. The retention of green bolls were more than 50% higher in Bt hybrids than non-Bt and check hybrids at all locations. Due to early retention of bolls in Bt-plots, the boll burst commenced nearly 15 to 20 days in advance than the other treatments.

3. The bollworm reactions of Bt- hybrids were clearly evident as damage to squares and boll were minimum in Bt hybrids than non-Bt and checks. In-spite of the fact that the higher number of sprays were given in non-Bt and check hybrids.

4. The responses of Bt , non-Bt and check hybrids to pests other than bollworm and pathogens were similar, except that MECH-12 Bt and non-Bt exhibited higher susceptibility to jassid infestation at some locations.

SOUTH ZONE

1. The team observed that the trials have been conducted as per experimental designs and all the centers have followed the protocol.. All the trials were timely planted at all locations. The season was extremely favourable to bollworm infestation. Thus providing clear differences between non-Bt hybrids for bollworm reactions.

2. Bt-cotton hybrids had higher boll retention than the non-Bt counterparts and the checks. Similarly the Bt-cotton showed early opening of bolls.

3. Heavy incidence of bollworm on non-Bt cottons were observed in Guntur, even after 10 rounds of pesticides sprays.. The Bt-cotton entries had 7 to 12 bolls per plant as against 4 to 6 bolls in non-Bt cotton hybrids at Nandyal. Both at Guntur and Nandyal significant damages due to *Spodoptera* and *Earias* were observed. The Bt-entries exhibited significant resistance to *Earias*.

4. Under unprotected conditions MECH-12, showed susceptibility to jassid, while MECH-184 and MECH-162 were tolerant. MECH-162 exhibited relatively higher damage by thrips at Dharwad irrespective of the presence of Bt gene.

Monitoring and Evaluation Team, after visiting the trials of both zones, expressed satisfaction on the way trials have been conducted including the norms of isolation distances followed. Over all performance of conduct of trials indicated that trials were best conducted at Nagpur, Surat and Junagadh in Central Zone; and that in South Zone

were best at Dharwad, Coimbatore and Guntur. Satisfactorily conducted trials are Akola, Nanded and Khandwa in Central Zone and at Nandyal and Siruguppa in South Zone.

RESULTS

The compiled reports on various observations are given in separate subsections discipline-wise.

I. AGRONOMIC EVALUATION

The Agronomy trials have been conducted as per protocol at all locations. The data on plant height, dry matter production, number of bolls per plant, boll weight and seed cotton yield have been recorded and statistically analysed. The results are presented and discussed below.

Plant Height : Data on plant height is given in Table1. Bt-cotton hybrids in Central Zone grew to a height of 75 to 80 cm, while the check hybrid NHH-44 could attain a height of 90cm. In the South Zone, Bt cotton hybrids grew to a height of 90to 100 cm, and were on par with the regional and national checks. The improvement in plant height at South Zone locations was due to assured soil moisture under irrigated conditions. In the Central Zone, MECH-12 Bt showed significant reduction in plant height due to its susceptibility to sucking pests. Higher fertilizer levels led to marginal improvement in plant height.

Table 1. Plant height (cm)

a. Central Zone:

| Treatments | CICR, Nagpur | Akola | Nanded | Surat | Khandwa | Mean |
|-------------------|-----------------|-------|--------|-------|---------|------|
| MECH 184 Bt | 94.1 | 69.1 | 60.9 | 99.5 | 54.9 | 75.7 |
| MECH 184 NBt | 116.2 | 93.9 | 78.9 | 121.3 | 65.3 | 95.1 |
| MECH 162 Bt | 99.1 | 75.3 | 70.2 | 110.4 | 64.1 | 83.8 |
| MECH 162 NBt | 111.6 | 84.4 | 75.0 | 113.2 | 64.0 | 89.6 |
| MECH 12 Bt | 72.3 | 53.4 | 42.2 | 79.5 | 46.1 | 58.7 |
| MECH 12 NBt | 111.7 | 78.1 | 56.8 | 99.7 | 56.3 | 80.5 |
| Regional check | - | 86.6 | 58.9 | 125.1 | 55.7 | 81.6 |
| National check | 117.6 | 75.2 | 59.3 | 125.4 | 68.4 | 89.2 |
| SED | - | 1.85 | - | 5.45 | 1.55 | - |
| CD (P=0.05) | 7.6 | 6.18 | - | 18.23 | 3.20 | - |
| Fertilizer levels | | | | | | |
| 100% RDF | 105.2 | 76.2 | 60.0 | 110.0 | 59.8 | 82.2 |

| | | | | | | |
|-------------|-------|------|------|-------|------|------|
| 125% RDF | 106.7 | 78.1 | 74.4 | 111.4 | 65.7 | 87.3 |
| 75% RDF | 97.7 | 76.7 | 53.9 | 106.4 | 52.5 | 77.4 |
| CD (P=0.05) | 4.77 | NS | - | 3.98 | 1.96 | - |

b. South Zone:

| Treatments | CICR, RS, Coimbatore | TNAU, Coimbatore | Guntur | Dharwad | Nandyal | Mean |
|-------------------|----------------------|------------------|--------|---------|---------|-------|
| MECH 184 Bt | 67.4 | 91.8 | 115.2 | 92 | 88.7 | 91.0 |
| MECH 184 NBt | 85.6 | 114.8 | 117.1 | 98 | 78.0 | 98.7 |
| MECH 162 Bt | 86.2 | 110.1 | 118.7 | 96.1 | 86.1 | 99.4 |
| MECH 162 NBt | 89.2 | 119.6 | 117.5 | 100 | 80.6 | 101.4 |
| MECH 12 Bt | 71.4 | 95.5 | 103.9 | 92.6 | 92.6 | 91.2 |
| MECH 12 NBt | 77.1 | 122.0 | 123.2 | 102.3 | 92.2 | 103.4 |
| Regional check | 96.8 | 97.8 | 116.6 | 108.7 | 83.0 | 100.6 |
| National check | 110.2 | - | 121.9 | 99.8 | 75.0 | 101.7 |
| CD (P=0.05) | 11.44 | 14.40 | NS | NS | - | - |
| Fertilizer levels | | | | | | |
| 100% RDF | 84.5 | 106.2 | 113.9 | 99.9 | 82.8 | 97.5 |
| 125% RDF | 87.6 | 107.7 | 120.4 | 98.1 | 88.1 | 100.4 |
| 75% RDF | 84.3 | 108.0 | 116 | 98 | 82.7 | 97.8 |
| SED | 2.39 | 4.54 | - | 2.2 | - | - |
| CD (P=0.05) | NS | NS | NS | NS | - | - |

Leaf Area Index: The data of two locations compiled in Table 2 revealed that Bt-hybrids had significantly lower leaf area index over the non-Bt counterparts. This parameter indicates excessive vegetation in non-Bt and check hybrids, whereas the Bt cotton hybrids had compact morphoform and limited functional leaves.

Table 2. Leaf Area Index on 90 DAS

| Treatments | Akola | CICR RS, Coimbatore | Mean |
|--------------------------|--------------|---------------------|----------|
| Hybrids | | | |
| MECH 184 BT | 0.436 | 0.940 | 0.688 |
| MECH 184 NBT | 0.752 | 0.680 | 0.716 |
| MECH 162 BT | 0.652 | 0.870 | 0.761 |
| MECH 162 NBT | 0.972 | 0.870 | 0.921 |
| MECH 12 BT | 0.515 | 1.000 | 0.758 |
| MECH 12 NBT | 0.864 | 0.600 | 0.732 |
| Regional check | 0.975 | 1.030 | 1.003 |
| National check | 0.826 | 1.190 | 1.008 |
| CD (P=0.05) | 0.113 | NS | - |
| Fertilizer levels | | | |

| | | | |
|--------------------|-------|-----------|----------|
| 100% RDF | 0.762 | 0.960 | 0.861 |
| 125% RDF | 0.762 | 0.950 | 0.856 |
| 75% RDF | 0.724 | 0.780 | 0.752 |
| CD (P=0.05) | | NS | - |

Dry Matter Production: The dry matter production of Bt, Non Bt and check hybrids ranged from 58 to 133 g/plant in the Central Zone, while it ranged from 201 to 266 g/plant in the South Zone, indicating higher dry matter production in the South Zone (Table 3). The increased dry matter production in the South Zone is mainly due to assured soil moisture. Among the Bt –hybrids, MECH-12Bt remained stunted and produced lesser dry matter in the Central Zone (58g/plant) while the same hybrid produced a dry matter of 201 g/plant in the South Zone. It indicates that MECH-12Bt should be cultivated under assured soil moisture conditions. This hybrid also needs adequate protection against sucking pests. Among the fertility treatments, there was marginal improvement in dry matter production in Central Zone only. The dry matter production of MECH-184Bt and MECH-162Bt were at par with the checks.

Table- 3. Dry Matter Production (g/ plant)

Central Zone

| Treatments | CICR, Nagpur | Akola | Nanded | Surat | Khandwa | Mean |
|--------------------------|-----------------|-------|--------|-------|---------|-------|
| Hybrids | | | | | | |
| MECH 184 Bt | 133.7 | 74.6 | 29.8 | 101.8 | 110.2 | 90.0 |
| MECH 184 NBt | 173.7 | 154.4 | 41.0 | 185.2 | 107.3 | 132.3 |
| MECH 162 Bt | 140.4 | 93.3 | 35.8 | 161.8 | 117.3 | 109.7 |
| MECH 162 N Bt | 192.7 | 102.9 | 42.2 | 191.2 | 129.8 | 131.8 |
| MECH 12 Bt | 73.8 | 45.2 | 17.4 | 58.7 | 98.3 | 58.7 |
| MECH 12 NBt | 131.1 | 136.6 | 28.1 | 121.7 | 109.5 | 105.4 |
| Regional check | - | 139 | 32.5 | 190.7 | 111.0 | 118.3 |
| National check | 162.6 | 138.6 | 37.0 | 210.0 | 117.5 | 133.1 |
| CD (P=0.05) | 33.91 | 41.4 | - | 43.40 | 4.53 | - |
| Fertilizer levels | | | | | | |
| 100% RDF | 141.5 | 111 | 33.0 | 147.9 | 112.6 | 109.2 |
| 125% RDF | 157.3 | 113.3 | 37.5 | 160.3 | 115.1 | 116.7 |
| 75% RDF | 133.2 | 107.4 | 28.4 | 149.7 | 110.1 | 105.8 |
| CD (P=0.05) | NS | NS | - | NS | 2.77 | - |

Table- 3. Dry Matter Production (g/ plant) (contd.)**South Zone:**

| Treatments | CICR RS, Coimbatore | Guntur | Dharwad | Nandyal | Mean |
|--------------------------|------------------------|--------|---------|---------|-------|
| Hybrids | | | | | |
| MECH 184 Bt | 209.2 | 170.6 | 547.0 | 51.6 | 244.6 |
| MECH 184 NBt | 236.7 | 126.6 | 498.0 | 50.3 | 227.9 |
| MECH 162 Bt | 355.0 | 153.8 | 515.0 | 53.3 | 269.3 |
| MECH 162 NBt | 255.8 | 121.3 | 459.0 | 48.0 | 221.0 |
| MECH 12 Bt | 224.2 | 127.4 | 403.0 | 51.0 | 201.4 |
| MECH 12 NBt | 214.2 | 120.3 | 416.0 | 45.0 | 198.9 |
| Regional check | 342.5 | 109.8 | 453.0 | 47.6 | 238.2 |
| National check | 439.2 | 114.1 | 465.0 | 48.6 | 266.7 |
| CD (P=0.05) | 103.3 | 10.2 | NS | - | - |
| Fertilizer levels | | | | | |
| 100% RDF | 275.0 | 135.6 | 463.0 | 48.8 | 230.6 |
| 125% RDF | 287.8 | 132.8 | 453.0 | 51.5 | 231.3 |
| 75% RDF | 290.9 | 123 | 491.0 | 48.0 | 238.2 |
| CD (P=0.05) | NS | 3.5 | NS | - | - |

Number of bolls per plant : Data on boll number per plant is furnished in Table 4. The boll number per plant ranged from 10 to 20 in the Central Zone, while it ranged from 14 to 25 in the South Zone (Fig. 1). Among the Bt-hybrids, MECH-162Bt recorded the highest bolls/plant both in the central and South Zone (21 and 25 bolls/plant). MECH-184 Bt ranked second with 17 and 22 bolls/plant in the central and South Zone, respectively. The regional check recorded lowest bolls/plant (10) in the Central Zone, while NHH-44 recorded lowest bolls/plant (14 bolls/plant) in the South Zone. Among the fertility treatments, there was a marginal improvement in the boll number in both the zones. It indicates that the Bt hybrids and checks respond to higher fertilizer doses.

Table 4. Number of bolls per plant in Bt cotton hybrids**Central Zone:**

| Treatments | CICR, Nagpur | Akola | Nanded | Surat | Khandwa | Mean |
|-------------------|-----------------|-------|--------|-------|---------|-------|
| Hybrids | | | | | | |
| MECH 184 Bt | 39.0 | 7.53 | 7.01 | 30 | 4.9 | 17.69 |
| MECH 184 NBt | 32.4 | 2.87 | 6.08 | 16 | 5.35 | 12.54 |
| MECH 162 Bt | 37.0 | 13.17 | 7.80 | 38 | 7.67 | 20.73 |
| MECH 162 NBt | 40.0 | 8.17 | 5.23 | 26 | 6.87 | 17.25 |
| MECH 12 Bt | 26.2 | 3.83 | 3.05 | 15 | 3.73 | 10.36 |
| MECH 12 NBt | 32.1 | 4.07 | 2.32 | 13 | 3.63 | 11.02 |
| Regional check | - | 5.73 | 5.49 | 23 | 5.27 | 9.87 |
| National check | 41.2 | 6.83 | 6.11 | 25 | 6 | 17.03 |
| CD (P=0.05) | NS | 4.04 | - | 8.9 | NS | - |
| Fertilizer levels | | | | | | |
| 100% RDF | 36.6 | 6.48 | 5.47 | 21 | 5.27 | 14.96 |
| 125% RDF | 36.5 | 6.76 | 5.77 | 26 | 7.08 | 16.42 |
| 75% RDF | 33.2 | 6.34 | 5.29 | 22 | 3.99 | 14.16 |
| CD (P=0.05) | NS | NS | - | 2.9 | NS | - |

South Zone:

| Treatments | CICR RS, Coimbatore | TNAU, Coimbatore | Guntur | Dharwad | Nandyal | Mean |
|-------------------|------------------------|---------------------|--------|---------|---------|-------|
| Hybrids | | | | | | |
| MECH 184 Bt | 15.6 | 24.0 | 42.9 | 19.9 | 7.8 | 22.04 |
| MECH 184 NBt | 13.4 | 20.3 | 26.6 | 10.1 | 4.5 | 14.98 |
| MECH 162 Bt | 20.2 | 26.1 | 41.8 | 26.3 | 12.2 | 25.32 |
| MECH 162 NBt | 11.0 | 21.6 | 30.9 | 15.5 | 8.7 | 17.54 |
| MECH 12 Bt | 14.4 | 14.6 | 30.1 | 14.4 | 11.2 | 16.94 |
| MECH 12 NBt | 14.2 | 16.0 | 25.4 | 8.4 | 9.1 | 14.62 |
| Regional check | 19.7 | 17.8 | 26.1 | 9.1 | 4.8 | 15.50 |
| National check | 9.7 | - | 24 | 18.1 | 4.1 | 13.98 |
| CD (P=0.05) | 3.81 | 4.51 | NS | NS | 4.00 | - |
| Fertilizer levels | | | | | | |
| 100% RDF | 14.6 | 19.4 | 31.8 | 15.1 | 7.8 | 17.74 |
| 125% RDF | 16.1 | 19.6 | 30.3 | 16.2 | 8.7 | 18.18 |
| 75% RDF | 13.6 | 21.2 | 30.8 | 14.3 | 7.1 | 17.40 |
| CD (P=0.05) | NS | NS | NS | NS | NS | - |

Boll Weight : MECH-12Bt and non-Bt recorded the highest boll weight both in the central and South Zone. There was an improvement in boll weight to an extent of 0.5 to 1.0 g for all the hybrids in the South Zone compared to Central Zone. The data indicated that the boll weight for all the genotypes improved under assured soil moisture conditions. The zonal check and National check recorded lower boll weight (3.0g/boll) in the Central Zone, while NHH-44 recorded lower boll weight (3.6g/boll) in the South Zone (Table 5) . Among the fertility treatments, marginal improvement was recorded in boll weight at higher dose of fertilizer.

Table. 5. Mean Boll Weight (g) of Bt Cotton Hybrids

Central Zone:

| Treatments | CICR, Nagpur | Akola | Nanded | Khandwa | Mean |
|--------------------------|-----------------|-------|--------|---------|------|
| Hybrids | | | | | |
| MECH 184 Bt | 4.1 | 3.61 | 3.6 | 2.57 | 3.47 |
| MECH 184 NBt | 4.2 | 3.32 | 3.3 | 2.97 | 3.45 |
| MECH 162 Bt | 3.5 | 3.17 | 3.1 | 3.74 | 3.38 |
| MECH 162 NBt | 3.4 | 3.05 | 3.0 | 3.27 | 3.18 |
| MECH 12 Bt | 4.3 | 4.46 | 4.4 | 3.35 | 4.13 |
| MECH 12 NBt | 4.8 | 3.94 | 3.9 | 2.73 | 3.84 |
| Regional check | - | 2.94 | 3.0 | 3.04 | 2.99 |
| National check | 3.4 | 3 | 2.9 | 2.75 | 3.01 |
| CD (P=0.05) | 0.5 | 0.37 | - | - | - |
| Fertilizer levels | | | | | |
| 100% RDF | 4.1 | 3.35 | 3.2 | 3.04 | 3.42 |
| 125% RDF | 3.6 | 3.27 | 3.3 | 3.53 | 3.43 |
| 75% RDF | 3.9 | 3.37 | 3.1 | 2.58 | 3.24 |
| CD (P=0.05) | NS | NS | - | - | - |

Table. 5. Mean Boll Weight (g) of Bt Cotton Hybrids (Contd.)**South Zone:**

| Treatments | CICR RS, Coimbatore | TNAU, Coimbatore | Dharwad | Nandyal | Mean |
|--------------------------|------------------------|---------------------|---------|---------|------|
| Hybrids | | | | | |
| MECH 184 Bt | 4.7 | 5.2 | 4.5 | 4.9 | 4.83 |
| MECH 184 NBt | 5.3 | 5.7 | 5.3 | 3.2 | 4.88 |
| MECH 162 Bt | 4.2 | 5.0 | 4.1 | 4.2 | 4.38 |
| MECH 162 NBt | 4.4 | 4.7 | 3.7 | 4.0 | 4.20 |
| MECH 12 Bt | 5.3 | 5.9 | 4.9 | 3.0 | 4.78 |
| MECH 12 NBt | 5.9 | 5.5 | 5.2 | 3.6 | 5.05 |
| Regional check | 4.6 | 4.1 | 4.8 | 3.6 | 4.28 |
| National check | 4.4 | - | 3.8 | 2.6 | 3.60 |
| SED | 0.2 | 0.2 | 0.3 | 0.2 | - |
| CD (P=0.05) | 0.4 | 0.5 | NS | 0.5 | - |
| Fertilizer levels | | | | | |
| 100% RDF | 4.85 | 5.1 | 4.52 | 3.7 | 4.54 |
| 125% RDF | 4.88 | 5.2 | 4.57 | 3.8 | 4.61 |
| 75% RDF | 4.80 | 5.1 | 4.52 | 3.6 | 4.51 |
| CD (P=0.05) | NS | NS | NS | 0.50 | - |

Seed Cotton Yield: The MECH 12Bt was the earliest to mature, followed by MECH 184Bt, MECH 162Bt and the check hybrids. The Bt-hybrids showed early maturity by 15 to 30 days compared to non-Bt hybrids and checks.

The results of seed cotton yield indicated the superiority of Bt hybrids over the non-Bt and check hybrids. MECH-162Bt recorded the highest yield both in Central (11.27 q/ha) and south (12.90 q/ha) zone locations (Table 6). The zonal check at both zones recorded poor yields (5.39q/ha and 5.05 q/ha). Similarly, the NHH-44 also recorded lower yield of 7.07 q/ha in Central Zone and 4.44 q/ha in the South Zone locations. The poor yield of national check in South Zone appears to be due to its extreme susceptibility to bollworm attack. Thus the Bt hybrids MECH-184 and MECH-162 recorded significantly higher yield than the non-Bt and check hybrids. The yield advantage of Bt hybrids was around 5 to 6 q/ha as compared to National and zonal checks

At Surat in the Central Zone and at all locations in South Zone, MECH-12Bt performed better, indicating its suitability to these areas under irrigated/assured soil moisture conditions. In drought prone areas, MECH-162 Bt will be a suitable choice

followed by MECH-184Bt (Fig. 2). All hybrids showed marginal improvement in seed cotton yield at higher fertility levels. Data from all centers indicated that the good kapas (%) is significantly higher in Bt hybrids over the non-Bt counterpart and the check entries.

Table 6 . Seed cotton yield (q/ ha)

Central Zone:

| Treatments | CICR, Nagpur | Akola | Nanded | Surat | Khandwa | Mean |
|--------------------------|--------------|-------|--------|-------|---------|-------|
| Hybrids | | | | | | |
| MECH 184 Bt | 15.97 | 5.16 | 7.01 | 16.52 | 9.50 | 10.83 |
| MECH 184 NBt | 9.67 | 1.01 | 5.58 | 5.51 | 8.92 | 6.14 |
| MECH 162 Bt | 15.32 | 6.10 | 6.72 | 16.94 | 11.25 | 11.27 |
| MECH 162 NBt | 11.73 | 4.06 | 4.36 | 11.32 | 10.64 | 8.42 |
| MECH 12 Bt | 9.79 | 2.81 | 3.73 | 9.28 | 6.71 | 6.46 |
| MECH 12 NBt | 12.05 | 2.56 | 2.52 | 6.27 | 5.94 | 5.87 |
| Regional check | . | 2.75 | 4.58 | 7.47 | 6.76 | 5.39 |
| National check | 11.62 | 2.84 | 4.92 | 8.31 | 7.64 | 7.07 |
| CD (P=0.05) | 2.28 | 0.8 | 0.64 | 5.74 | NS | - |
| Fertilizer levels | | | | | | |
| 100% RDF | 12.98 | 3.49 | 4.86 | 10.38 | 8.09 | 7.96 |
| 125% RDF | 12.76 | 3.50 | 5.34 | 10.89 | 9.63 | 8.42 |
| 75% RDF | 11.18 | 3.24 | 4.59 | 9.33 | 7.54 | 7.18 |
| CD (P=0.05) | 0.92 | NS | 0.36 | 0.96 | NS | - |

South Zone:

| Treatments | CICR RS, Coimbatore | TNAU, Coimbatore | Guntur | Dharwad | Nandyal | Mean |
|--------------------------|---------------------|------------------|--------|---------|---------|-------|
| Hybrids | | | | | | |
| MECH 184 Bt | 7.64 | 11.41 | 18.54 | 21.83 | 1.97 | 12.28 |
| MECH 184 NBt | 4.90 | 1.78 | 1.39 | 7.15 | 1.05 | 3.25 |
| MECH 162 Bt | 8.97 | 12.30 | 14.58 | 19.12 | 9.52 | 12.90 |
| MECH 162 NBt | 4.86 | 1.82 | 1.22 | 10.77 | 2.75 | 4.29 |
| MECH 12 Bt | 9.00 | 10.60 | 15.30 | 19.35 | 8.54 | 12.56 |
| MECH 12 NBt | 7.51 | 6.56 | 1.09 | 6.34 | 3.76 | 5.06 |
| Regional check | 7.76 | 3.41 | 1.08 | 11.30 | 1.70 | 5.05 |
| National check | 4.43 | - | 1.10 | 11.17 | 1.07 | 4.44 |
| CD (P=0.05) | 2.00 | 1.95 | 1.84 | 6.47 | 2.82 | - |
| Fertilizer levels | | | | | | |
| 100% RDF | 6.74 | 7.27 | 6.86 | 13.86 | 3.53 | 7.65 |
| 125% RDF | 7.41 | 6.75 | 7.08 | 13.70 | 3.87 | 7.76 |
| 75% RDF | 6.51 | 6.51 | 6.44 | 12.58 | 3.46 | 7.10 |
| CD (P=0.05) | NS | NS | NS | 0.48 | NS | - |

II. EVALUATION OF BT COTTON HYBRIDS UNDER BREEDING PROGRAMME:

Under the breeding programme, the Bt cotton hybrids viz. MECH 184, MECH 162, MECH 12 and their non-Bt counterparts were tested at 11 locations in central and South Zones along with the respective zonal and national check hybrids. The plant growth and yield attributes were evaluated in detail. The economic yield (seed cotton) was recorded and the fibre quality was assessed. The results on the important growth, yield and quality characters are discussed below:

Germination and plant stand: Germination counts were taken 7 to 15 days after sowing. The germination of all the entries in the trial was above 85 per cent. The Bt cotton entries recorded germination ranging from 94.0 to 95.8 per cent, while their counterparts recorded 93.5 to 95.5 per cent. The germination of NHH 44, the zonal check was on par with the Bt cotton entries.

The final plant stand was recorded at the time of harvest. As a result of good germination, proper crop management and negligible post emergence seedling mortality, the final crop stand was very good with several entries recording 100 per cent stand.

The genetic purity was very high and well above the permissible limits. The genetic purity ranged from 95 to 100 per cent in all the entries. The hybrids were also morphologically uniform and true to type (Table 7).

Table 7. Germination Percentage of Bt cotton Hybrids

Central Zone:

| Hybrid | Khandwa | Surat | Akola | Nanded | Nagpur | Mean |
|-------------|---------|-------|-------|--------|--------|------|
| MECH 184 Bt | 93 | 98 | 100 | 96 | 100 | 97.4 |
| MECH 184 | 78 | 98 | 100 | 100 | 100 | 95.2 |
| MECH 162 Bt | 78 | 98 | 99.2 | 93 | 100 | 93.6 |
| MECH 162 | 83 | 98 | 100 | 90 | 100 | 94.2 |
| MECH 12 Bt | 83 | 98 | 100 | 81 | 100 | 92.4 |
| MECH 12 | 78 | 98 | 100 | 90 | 100 | 93.2 |
| Local Check | 62 | 98 | 95 | 93 | — | 87.0 |
| NHH 44 (ZC) | — | 98 | 99.2 | 90 | 100 | 96.8 |

South Zone:

| Hybrid | Guntur | Nandyal | Dharwad | Coimbatore | Mean |
|-------------|--------|---------|---------|------------|------|
| MECH 184 Bt | 95 | 98 | 100 | 83 | 94.0 |
| MECH 184 | 95 | 99 | 99 | 89 | 95.5 |
| MECH 162 Bt | 94 | 97 | 99 | 92 | 95.5 |
| MECH 162 | 95 | 97 | 100 | 88 | 95.0 |
| MECH 12 Bt | 92 | 96 | 100 | 95 | 95.8 |
| MECH 12 | 92 | 97 | 99 | 86 | 93.5 |
| Local Check | 83 | 99 | 99 | 87 | 92.0 |
| NHH 44 (ZC) | 95 | 99 | 99 | 89 | 95.5 |

Plant height: Plant height of all the hybrids ranged around 80 to 100cm in Central Zone and 100 to 118cm in South Zone locations. The Bt cotton hybrids, in general, were marginally shorter than their non-Bt counterparts. Among the locations, it was observed that the plant growth of all the hybrids, including the check was stunted at Khandwa and Akola due to prolonged dry spell. MECH-12 Bt and non-Bt hybrids recorded lower plant height in the Central Zone locations due to their susceptibility to jassids and the consequent poor vigour and growth, especially at typical drought prone locations like Akola, Nanded and Khandwa (Table 8; Fig 3).

Table 8. Plant Height (cm) of Bt cotton Hybrids**Central Zone:**

| Hybrid | Khandwa | Surat | Junagarh | Akola | Nanded | Nagpur | Mean |
|-------------|---------|-------|----------|-------|--------|--------|-------|
| MECH 184 Bt | 56.2 | 114.0 | 106.0 | 77.3 | 82.3 | 111.9 | 91.3 |
| MECH 184 | 69.7 | 134.0 | 104.0 | 95.0 | 94.3 | 126.1 | 103.8 |
| MECH 162 Bt | 59.9 | 104.0 | 98.0 | 83.0 | 93.8 | 112.6 | 91.9 |
| MECH 162 | 60.0 | 131.0 | 104.0 | 96.0 | 84.3 | 121.3 | 99.4 |
| MECH 12 Bt | 38.7 | 75.0 | 73.0 | 66.7 | 63.4 | 87.2 | 67.3 |
| MECH 12 | 50.1 | 82.0 | 72.0 | 84.3 | 76.8 | 127.1 | 82.0 |
| Local Check | 48.9 | 153.0 | 100.0 | 98.3 | 97.1 | - | 99.5 |
| NHH 44 (ZC) | - | 134.0 | 100.0 | 100.3 | 88.0 | 132.1 | 110.9 |

South Zone:

| Hybrid | Guntur | Nandyal | Coimbatore | Mean |
|-------------|--------|---------|------------|-------|
| MECH 184 Bt | 124.0 | 115.0 | 106.2 | 115.1 |
| MECH 184 | 118.0 | 109.0 | 121.2 | 116.1 |
| MECH 162 Bt | 126.0 | 100.0 | 124.1 | 116.7 |
| MECH 162 | 121.0 | 98.0 | 127.2 | 115.4 |
| MECH 12 Bt | 112.0 | 110.0 | 94.8 | 105.6 |
| MECH 12 | 125.0 | 107.0 | 106.5 | 112.8 |
| Local Check | 114.0 | 101.0 | 115.5 | 110.2 |
| NHH 44 (ZC) | 128.0 | 106.1 | 120.5 | 118.2 |

Number of bolls per plant: MECH-162 Bt hybrid recorded the highest boll number both in central (25 bolls/plant) and South Zone (36 bolls/plant) followed by MECH-184, while MECH-12 Bt and non-Bt hybrids recorded lower boll number in the Central Zone. MECH-12 Bt and MECH-184 Bt were on par with the check hybrids in the South Zone. All the hybrids showed higher boll number in the South Zone compared to the Central Zone locations. The non-Bt counterparts recorded significantly lesser boll number at all the locations (Table 9; Fig. 4).

Table 9. Number of Bolls Per Plant of Bt cotton Hybrids**Central Zone:**

| Hybrid | Khandwa | Surat | Junagarh | Akola | Nanded | Nagpur | Mean |
|-------------|---------|-------|----------|-------|--------|--------|------|
| MECH184 Bt | 8.4 | 39.0 | 28.9 | 11.1 | 15.1 | 20.3 | 20.5 |
| MECH 184 | 7.9 | 32.0 | 20.7 | 8.4 | 8.8 | 9.6 | 14.6 |
| MECH 162 Bt | 10.2 | 48.0 | 34.7 | 16.5 | 14.5 | 25.1 | 24.8 |
| MECH 162 | 11.4 | 47.0 | 26.3 | 6.9 | 11.6 | 16.1 | 19.9 |
| MECH 12 Bt | 5.8 | 17.0 | 11.7 | 11.0 | 5.3 | 18.9 | 11.6 |
| MECH 12 | 6.7 | 17.0 | 14.3 | 9.0 | 8.1 | 16.1 | 11.9 |
| Local Check | 12.2 | 51.0 | 33.3 | 10.3 | 11.4 | - | 23.6 |
| NHH 44 (ZC) | - | 41.0 | 21.3 | 13.3 | 7.3 | 14.4 | 19.5 |

South Zone:

| Hybrid | Guntur | Nandyal | Dharwad | Coimbatore | Mean |
|-------------|--------|---------|---------|------------|------|
| MECH 184 Bt | 42.2 | 39 | 20.9 | 38.0 | 35.0 |
| MECH 184 | 14.0 | 34 | 17.7 | 25.0 | 22.7 |
| MECH 162 Bt | 37.2 | 49 | 21.2 | 37.0 | 36.1 |
| MECH 162 | 14.8 | 40 | 27.1 | 24.0 | 26.5 |
| MECH 12 Bt | 34.6 | 32 | 18.7 | 21.0 | 26.6 |
| MECH 12 | 12.3 | 18 | 19.9 | 22.0 | 18.1 |
| Local Check | 12.0 | 39 | 27.6 | 24.0 | 25.7 |
| NHH 44 (ZC) | 16.5 | 38 | 27.1 | 21.0 | 25.7 |

Boll Weight: Both in the central and South Zone locations there were no significant differences in boll weight between the MECH-Bt and non-Bt hybrids. MECH-12 hybrid recorded the highest mean boll weight of 4.3 g. MECH-162 non-Bt and Bt recorded lowest boll weight of 3.5 and 3.7g, respectively. The check hybrids recorded lower boll weight as compared to the MECH hybrids. Both MECH-184 and MECH-12 hybrids are of bigger boll types and recorded a mean boll weight of over 5 g and were superior to national and zonal checks (Table 10, Fig.5).

Table 10. Boll Weight (g) of Bt cotton Hybrids**Central Zone:**

| Hybrid | Khandwa | Surat | Junagarh | Akola | Nanded | Nagpur | Mean |
|-------------|---------|-------|----------|-------|--------|--------|------|
| MECH 184 Bt | 3.4 | 4.7 | 4.1 | 3.6 | 4.0 | 4.7 | 4.1 |
| MECH 184 | 3.5 | 4.8 | 4.7 | 3.3 | 4.0 | 4.4 | 4.1 |
| MECH 162 Bt | 3.5 | 3.7 | 3.3 | 3.1 | 3.7 | 4.7 | 3.7 |
| MECH 162 | 2.8 | 3.6 | 3.8 | 3.0 | 3.6 | 4.3 | 3.5 |
| MECH 12 Bt | 3.5 | 4.9 | 3.9 | 4.3 | 3.5 | 5.6 | 4.3 |
| MECH 12 | 3.9 | 5.3 | 4.4 | 3.8 | 3.3 | 5.2 | 4.3 |
| Local Check | 4.0 | 4.0 | 3.7 | 3.0 | 3.6 | – | 3.7 |
| NHH 44 (ZC) | – | 4.0 | 3.8 | 2.9 | 3.4 | 3.9 | 3.6 |
| CD @ 5% | – | 0.8 | 0.3 | – | – | 0.5 | |

South Zone:

| Hybrid | Guntur | Nandyal | Dharwad | Coimbatore | Mean |
|-------------|--------|---------|---------|------------|------|
| MECH 184 Bt | 5.0 | 4.0 | 5.4 | 6.1 | 5.1 |
| MECH 184 | 4.5 | 4.0 | 6.3 | 7.3 | 5.5 |
| MECH 162 Bt | 4.5 | 3.4 | 4.6 | 5.4 | 4.5 |
| MECH 162 | 4.0 | 4.0 | 4.3 | 5.7 | 4.5 |
| MECH 12 Bt | 5.6 | 2.4 | 6.9 | 6.8 | 5.4 |
| MECH 12 | 5.1 | 3.4 | 6.1 | 7.3 | 5.5 |
| Local Check | 4.4 | 3.6 | 4.8 | 5.6 | 4.6 |
| NHH 44 (ZC) | 4.1 | 3.6 | 4.3 | 4.9 | 4.2 |
| CD @ 5% | | | 1.1 | 0.6 | |

Ginning per cent: The Bt cotton hybrids showed a marginal improvement in ginning out turn over their respective non-Bt counterparts, both in central and South Zone locations. The zonal check NHH-44 recorded the lowest ginning out turn both in central and South Zone locations. MECH-12 Bt recorded the highest ginning out turn of 38.2 per cent, followed by MECH-162 Bt with 37.1 per cent in South Zone (Table 11, Fig. 6).

Table 11. Ginning Per cent of Bt cotton Hybrids**Central Zone:**

| Hybrid | Khandwa | Surat | Junagarh | Akola | Nanded | Nagpur | Mean |
|-------------|---------|-------|----------|-------|--------|--------|------|
| MECH 184 Bt | 35.0 | 32.8 | 33.3 | 35.8 | 35.6 | 41.0 | 35.6 |
| MECH 184 | 40.0 | 32.3 | 33.2 | 34.0 | 35.0 | 32.3 | 34.5 |
| MECH 162 Bt | 37.0 | 35.3 | 35.5 | 36.6 | 35.8 | 37.3 | 36.3 |
| MECH 162 | 35.0 | 33.4 | 35.2 | 34.4 | 36.3 | 30.0 | 34.0 |
| MECH 12 Bt | 37.0 | 34.3 | 35.4 | 36.8 | 34.9 | 41.7 | 36.7 |
| MECH 12 | 37.0 | 31.4 | 34.3 | 35.5 | 34.3 | 41.2 | 35.6 |
| Local Check | 35.0 | 32.5 | 34.4 | 35.6 | 37.8 | – | 35.1 |
| NHH 44 (ZC) | – | 32.1 | 34.5 | 33.3 | 36.1 | 32.1 | 33.6 |
| CD @ 5% | | 1.9 | 1.5 | – | – | 9.6 | |

South Zone:

| Hybrid | Guntur | Nandyal | Dharwad | Coimbatore | Mean |
|-------------|--------|---------|---------|------------|------|
| MECH 184 Bt | 33.1 | 36.3 | 37.8 | 38.2 | 36.4 |
| MECH 184 | 33.1 | 36.8 | 38.3 | 36.6 | 36.2 |
| MECH 162 Bt | 35.2 | 36.1 | 38.1 | 38.9 | 37.1 |
| MECH 162 | 33.7 | 36.5 | 35.8 | 35.6 | 35.4 |
| MECH 12 Bt | 35.5 | 36.6 | 40.1 | 40.4 | 38.2 |
| MECH 12 | 33.7 | 36.0 | 39.5 | 38.7 | 37.0 |
| Local Check | 32.8 | 34.0 | 40.5 | 33.7 | 35.3 |
| NHH 44 (ZC) | 33.0 | 34.0 | 35.5 | 34.8 | 34.3 |
| CD@5% | | | | 2.2 | |

Lint index: The lint index represents the weight of lint obtained from 100 seeds. There was no difference in lint index between the MECH BT and their respective non-Bt counter parts. All the MECH hybrids were superior to the check hybrids. The highest lint index was recorded in MECH-12 Bt (5.8 g) and non-Bt (5.9g) in the Central Zone and 6.9 g and 6.6 g, respectively in the South Zone (Table 12, Fig. 7).

Table 12. Lint Index (g) of Bt cotton Hybrids**Central Zone:**

| Hybrid | Surat | Junagarh | Akola | Nanded | Nagpur | Mean |
|-------------|-------|----------|-------|--------|--------|------|
| MECH 184 Bt | 5.1 | 5.1 | 4.9 | 5.1 | 7.8 | 5.6 |
| MECH 184 | 4.9 | 5.9 | 4.3 | 5.6 | 6.2 | 5.4 |
| MECH 162 Bt | 4.6 | 5.1 | 4.8 | 4.6 | 5.1 | 4.8 |
| MECH 162 | 4.7 | 4.8 | 5.1 | 4.5 | 5.6 | 4.9 |
| MECH 12 Bt | 5.1 | 5.8 | 5.5 | 4.6 | 8.1 | 5.8 |
| MECH 12 | 5.1 | 5.6 | 5.9 | 4.6 | 8.4 | 5.9 |
| Local Check | 4.3 | 4.6 | 4.9 | 4.3 | — | 4.5 |
| NHH 44 (ZC) | 3.9 | 4.4 | 4.0 | 4.4 | 3.7 | 4.1 |
| CD@5% | | | | | 0.5 | |

South Zone:

| Hybrid | Guntur | Nandyal | Dharwad | Coimbatore | Mean |
|-------------|--------|---------|---------|------------|------|
| MECH 184 Bt | 5.3 | 4.3 | 7.0 | 8.2 | 6.2 |
| MECH 184 | 5.0 | 4.4 | 6.7 | 7.4 | 5.9 |
| MECH 162 Bt | 5.7 | 3.9 | 6.1 | 6.6 | 5.6 |
| MECH 162 | 4.8 | 3.8 | 5.3 | 6.1 | 5.0 |
| MECH 12 Bt | 6.4 | 5.0 | 8.1 | 8.1 | 6.9 |
| MECH 12 | 5.8 | 5.0 | 7.7 | 7.9 | 6.6 |
| Local Check | 4.8 | 3.8 | 6.4 | 6.3 | 5.3 |
| NHH 44 (ZC) | 4.9 | 3.4 | 5.1 | 5.5 | 4.7 |
| CD@5% | | | 0.6 | 1.0 | |

Seed index: There was not much difference between the Bt cotton hybrids and their non-Bt counterparts for seed index. MECH-184 Bt and MECH-12 Bt cotton hybrids recorded higher seed weight compared to MECH-162 Bt and check hybrids (Table 13 Fig. 8).

Table 13. Seed Index (g) of Bt cotton Hybrids**Central Zone:**

| Hybrid | Surat | Junagarh | Akola | Nanded | Nagpur | Mean |
|-------------|-------|----------|-------|--------|--------|------|
| MECH 184 Bt | 10.5 | 10.3 | 8.9 | 9.2 | 11.2 | 10.0 |
| MECH 184 | 10.2 | 11.9 | 8.3 | 10.4 | 12.1 | 10.6 |
| MECH 162 Bt | 8.5 | 9.3 | 8.4 | 8.3 | 8.2 | 10.2 |
| MECH 162 | 9.3 | 8.8 | 9.8 | 7.9 | 9.5 | 9.1 |
| MECH 12 Bt | 9.8 | 10.0 | 9.4 | 8.5 | 10.6 | 9.7 |
| MECH 12 | 11.2 | 10.7 | 10.2 | 8.8 | 11.5 | 10.5 |
| Local Check | 9.0 | 8.8 | 7.9 | 7.0 | — | 8.2 |
| NHH 44 (ZC) | 8.3 | 8.4 | 7.8 | 7.0 | 8.2 | 7.9 |

South Zone:

| Hybrid | Guntur | Nandyal | Dharwad | Coimbatore | Mean |
|-------------|--------|---------|---------|------------|------|
| MECH 184 Bt | 11.5 | 8.2 | 11.4 | 13.2 | 11.1 |
| MECH 184 | 11.6 | 8.2 | 10.7 | 12.9 | 10.9 |
| MECH 162 Bt | 11.2 | 6.5 | 10.0 | 10.3 | 9.5 |
| MECH 162 | 10.2 | 7.1 | 9.6 | 11.1 | 9.5 |
| MECH 12 Bt | 11.4 | 9.0 | 12.1 | 11.9 | 11.1 |
| MECH 12 | 11.8 | 9.0 | 11.8 | 12.5 | 11.3 |
| Local Check | 11.2 | 7.4 | 9.4 | 12.4 | 10.1 |
| NHH 44 (ZC) | 10.4 | 7.6 | 9.2 | 10.3 | 9.4 |
| CD@5% | | | 1.6 | 1.2 | |

Seed Cotton Yield: In the Central Zone, MECH-162 Bt has recorded highest seed cotton yield of 13.3 q/ha, followed by MECH-184 Bt with 11.8q/ha. The local and national check hybrids recorded low yields (9.1 and 7.7q/ha).

In the South Zone, MECH-184 Bt recorded the highest yield (20q/ha) followed by MECH-12 Bt (18.7q/ha). The non-Bt counterparts yielded only 7 to 9 q/ha. The local and national checks also yielded 7 to 9 q/ha only. It is interesting to note that the hybrid MECH-12 Bt which recorded poor yield in the Central Zone locations (6.5 q/ha) has done well in the South Zone with a mean yield of 18.7 q/ha. It indicates that this hybrid MECH-12 Bt is suitable for irrigated/assured soil moisture conditions. (Table 14, Fig. 9).

**Table 14. Seed Cotton Yield (q/ha) of Bt cotton Hybrids
Central Zone:**

| Hybrid | Khandwa | Surat | Junagarh | Akola | Nanded | Nagpur | Mean |
|-------------|---------|-------|----------|----------|--------|--------|------|
| MECH 184 Bt | 5.8 | 22.0 | 11.2 | 5.0 | 6.4 | 20.1 | 11.8 |
| MECH 184 | 4.1 | 13.1 | 9.8 | 1.6 | 4.2 | 4.0 | 6.1 |
| MECH 162 Bt | 4.9 | 25.5 | 16.5 | 5.9 | 5.7 | 21.3 | 13.3 |
| MECH 162 | 5.1 | 16.6 | 13.1 | 3.8 | 2.9 | 8.8 | 8.4 |
| MECH 12 Bt | 2.5 | 9.4 | 5.0 | 2.8 | 1.7 | 17.7 | 6.5 |
| MECH 12 | 3.6 | 6.9 | 6.4 | 3.0 | 1.6 | 9.0 | 5.1 |
| Local Check | 4.6 | 24.5 | 11.4 | 1.9 | 2.9 | – | 9.1 |
| NHH 44 (ZC) | – | 14.9 | 12.0 | 1.3 | 1.5 | 8.6 | 7.7 |
| Local Check | JkHy1 | H.10 | H.10 | PKV Hy 2 | PHH316 | – | |
| CD5% | – | 5.4 | 3.5 | – | 1.1 | 4.2 | |

South Zone:

| Hybrid | Guntur | Nandyal | Dharwad | Coimbatore | Mean |
|-------------|--------|---------|---------|------------|------|
| MECH 184 Bt | 23.7 | 14.9 | 28.5 | 13.0 | 20.0 |
| MECH 184 | 5.1 | 7.2 | 13.0 | 2.8 | 7.0 |
| MECH 162 Bt | 18.4 | 10.9 | 21.5 | 10.4 | 15.3 |
| MECH 162 | 4.8 | 8.2 | 16.1 | 3.0 | 8.0 |
| MECH 12 Bt | 22.3 | 12.8 | 25.3 | 14.2 | 18.7 |
| MECH 12 | 5.1 | 7.9 | 14.1 | 10.0 | 9.3 |
| Local Check | 4.4 | 6.6 | 22.3 | 2.3 | 8.9 |
| NHH 44 (ZC) | 5.8 | 7.2 | 14.1 | 4.3 | 7.9 |
| Local Check | Savita | Savita | DHH 11 | Savita | |
| CD@5% | | | 4.4 | 2.1 | |

Fibre Quality: Important fibre quality parameters like 2.5% span length, fibre uniformity, fineness (micronaire) and strength (Bundle Strength) were tested at three locations viz., Nagpur, Junagarh and Surat. The results are furnished in Table 15 and Fig. 10 to Fig. 13. **Cotton hybrids MECH-184 Bt and MECH-12 BT were significantly superior to the national check hybrid NHH 44 and were on par with G Cot Hy 10.** As regards uniformity and fineness, there was not much variation among the hybrids tested. MECH-184 Bt recorded higher fibre strength (24.1 g/tex), as against NHH-44 (21.1 g/tex).

Table 15. Fibre Quality of Bt cotton hybrids

Central Zone

| Hybrid | 2.5%Span Length(mm) | | | | U.R(%) | | | |
|-------------|---------------------|-------|----------|-------------|--------|-------|----------|------|
| | Nagpur | Surat | Junagarh | Mean | Nagpur | Surat | Junagarh | Mean |
| MECH 184 Bt | 28.2 | 29.9 | 30.0 | 29.4 | 52 | 53 | 48 | 51.0 |
| MECH 184 | 30.7 | 30.9 | 30.5 | 30.7 | 53 | 48 | 49 | 50.0 |
| MECH 162 Bt | 26.1 | 26.9 | 27.7 | 26.9 | 52 | 50 | 48 | 50.0 |
| MECH 162 | 27.1 | 27.9 | 26.1 | 27.0 | 52 | 49 | 48 | 49.7 |
| MECH 12 Bt | 29.8 | 29.8 | 28.4 | 29.3 | 52 | 48 | 44 | 48.0 |
| MECH 12 | 31.2 | 31.6 | 30.2 | 31.0 | 51 | 47 | 45 | 47.7 |
| Local Check | — | 29.2 | 29.1 | 29.2 | 52 | — | 49 | 50.5 |
| NHH 44 (ZC) | 26.1 | 27.2 | 26.7 | 26.7 | 51 | 50 | 49 | 50.5 |

| Hybrid | Micronaire | | | | Bundle Strength (g/tex) | | | |
|-------------|------------|-------|----------|------------|-------------------------|-------|----------|------|
| | Nagpur | Surat | Junagarh | Mean | Nagpur | Surat | Junagarh | Mean |
| MECH 184 Bt | 4.0 | 4.8 | 3.6 | 4.1 | 24.8 | 23.5 | 20.3 | 22.9 |
| MECH 184 | 4.4 | 3.7 | 4.4 | 4.2 | 25.0 | 22.7 | 22.0 | 23.2 |
| MECH 162 Bt | 4.2 | 4.9 | 4.4 | 4.5 | 21.0 | 22.2 | 20.3 | 21.2 |
| MECH 162 | 4.4 | 4.6 | 4.4 | 4.5 | 22.3 | 19.3 | 22.1 | 21.2 |
| MECH 12 Bt | 4.3 | 4.2 | 3.8 | 4.1 | 23.0 | 21.8 | 21.8 | 22.2 |
| MECH 12 | 4.4 | 4.4 | 4.2 | 4.3 | 25.1 | 19.8 | 17.6 | 20.8 |
| Local Check | — | 4.6 | 4.4 | 4.5 | — | 26.1 | 22.7 | 24.4 |
| NHH 44 (ZC) | 4.3 | 4.4 | 4.2 | 4.3 | 21.8 | 20.4 | 18.0 | 20.1 |

South Zone (Coimbatore Centre)

| Hybrid | 2.5% Span Length (mm) | U.R.% | Micronaire | Bundle Strength (g/tex) |
|-------------|-----------------------|-------|------------|-------------------------|
| MECH 184 Bt | 28.8 | 51.0 | 3.7 | 23.5 |
| MECH 184 | 30.6 | 50.2 | 4.0 | 21.9 |
| MECH 162 Bt | 26.9 | 49.1 | 4.5 | 21.3 |
| MECH 162 | 28.5 | 49.5 | 4.4 | 21.3 |
| MECH 12 Bt | 30.9 | 46.3 | 4.3 | 22.0 |
| MECH 12 | 31.9 | 46.5 | 4.3 | 22.6 |
| Local Check | 34.5 | 47.3 | 4.0 | 25.0 |
| NHH 44(ZC) | 27.9 | 50.0 | 4.4 | 21.4 |

III. PLANT PROTECTION TRIALS:

Three sets of trials were carried out to evaluate the performance of Bt cotton hybrids against pest and diseases. In the first two trials, the population of sucking pests and bollworm and damages due to bollworms were evaluated under the normal pest protection (ETL) regimes. The second trial was designed to screen the Bt cotton hybrids along with their non-Bt counterparts and check hybrids for their reaction to pest and diseases under natural conditions by avoiding any intervention through pesticides or other management practices (totally unprotected conditions). The third set of trials was designed to evaluate the Bt cotton hybrids under various IPM modules to find out suitability of Bt cotton hybrids in the IPM package.

All the trials were timely planted which resulted in optimum germination and plant stand in all the three sets of trials at all the locations. Due to favourable climatic conditions, the bollworm infestation was of higher order at all locations and hence differences among the treatments were extremely clear. Evaluation of the Bt-hybrids under different agro-climatic conditions has also brought out the differences in the occurrences of other pests and diseases. Thus, this season was favourable for evaluation of Bt cotton hybrids for their performance.

III A: EVALUATION OF Bt-COTTON HYBRIDS UNDER ETL BASED PROTECTED CONDITIONS

CENTRAL ZONE: It was seen that the number of sprays given for sucking pests varied from two to four, while for bollworm control ETL based sprays were given (3 in case of Bt and 5 to 6 sprays in case of non-Bt hybrids and checks) . The pooled data over the locations are given in Table 16:

Table 16. Average number of sprays undertaken based on ETL

| Sprays for | MECH-184 | | MECH-162 | | MECH-12 | | Checks | |
|---------------|----------|-----|----------|------|---------|-----|--------|-----|
| | Bt | NBt | Bt | NBt | Bt | NBt | Ck1 | CK2 |
| Sucking pests | 2.0 | 2.0 | 2.0 | 2.0 | 4.0 | 4.0 | 3.0 | 2.0 |
| Bollworms | 2.7 | 5.0 | 3.0 | 4.75 | 3.5 | 4.5 | 6.3 | 6.3 |
| Total | 4.7 | 7.0 | 5.0 | 6.75 | 7.5 | 8.5 | 9.3 | 8.3 |

Sucking pests:

The data on number of aphids, jassids and thrips on 15 leaves basis are given in Table 17 and Fig. 14. It was observed that there was no major variation in aphids population among the treatments. The highest aphid population was recorded at Khandwa on all entries, while it was lowest at Akola and Nagpur. The aphid population at Khandwa indicated that except for MECH-184, the differences between Bt, non-Bt and checks were marginal. The jassid population was also higher at Khandwa. The data clearly indicated that all MECH- hybrids had higher population of jassids than local check. Amongst MECH hybrids, MECH-12 was more susceptible to jassids at all the locations. However, there was no differential susceptibility between Bt and non-Bt counterparts. Thrips infestations were higher at Akola and Surat. However, all the MECH hybrids were less susceptible than the local checks. In case of Bt-hybrids, lower thrips population was noticed in MECH-184Bt and MECH-162Bt over their non-Bt counterparts.

Table 17: Population of Sucking Pests in Bt cotton Hybrids in Central Zone

| No. of Aphids /15 leaves (60DAS) under protected condition | | | | | | | |
|---|--------|---------|---------|--------------|--------|--------------|------|
| Entries | Akola | Khandwa | Nanded | Surat | Nagpur | Junagadh | Mean |
| MECH 184 Bt | 0.9 | 177.1 | 5.0 | 24.3 | 0.0 | 22.3 | 38.3 |
| MECH 184 NBt | 1.2 | 108.3 | 26.6 | 14.0 | 0.8 | 21.3 | 28.7 |
| MECH 162 Bt | 1.6 | 122.3 | 14.6 | 18.0 | 1.8 | 27.3 | 30.9 |
| MECH 162 NBt | 1.1 | 120.9 | 58.3 | 12.3 | 0.0 | 31.7 | 37.4 |
| MECH 12 Bt | 1.1 | 180.2 | 9.0 | 11.7 | 0.1 | 39.7 | 40.3 |
| MECH 12 NBt | 0.9 | 175.8 | 5.0 | 3.3 | 0.0 | 43.7 | 38.1 |
| Local check | 2.7 | 109.5 | 0.0 | 10.3 | | 32.3 | 25.8 |
| NHH 44 | 1.5 | 113.6 | 1.3 | 3.7 | 0.3 | 28.0 | 24.7 |
| No. of Jassids/ 15 leaves (60DAS) under protected condition | | | | | | | |
| Entries | Akola | Khandwa | Nanded | Surat | Nagpur | Junagadh | Mean |
| MECH 184 Bt | 17.4 | 103.4 | 9.0 | 11.7 | 2.7 | 20.3 | 27.4 |
| MECH 184 NBt | 13.1 | 130.5 | 12.3 | 5.1 | 3.5 | 17.3 | 30.3 |
| MECH 162 Bt | 18.9 | 63.2 | 11.0 | 8.2 | 5.4 | 31.0 | 23.0 |
| MECH 162 NBt | 13.8 | 68.4 | 9.7 | 7.2 | 2.9 | 29.0 | 21.8 |
| MECH 12 Bt | 56.1 | 119.5 | 52.3 | 12.0 | 14.9 | 31.7 | 47.8 |
| MECH 12 NBt | 33.5 | 114.9 | 53.7 | 8.0 | 6.0 | 40.7 | 42.8 |
| Local check | 8.7 | 51.5 | 13.3 | 8.2 | | 30.7 | 18.7 |
| NHH 44 | 15.9 | 58.3 | 9.0 | 5.9 | 3.5 | 29.3 | 20.3 |
| Name of Local Check Hybrid | PKV H2 | JKHY1 | PHH 316 | G. COT HY-10 | ----- | G. COT HY-10 | |
| No. of Thrips/ 15 leaves (60DAS) under protected condition | | | | | | | |
| Entries | AKOLA | Khandwa | Nanded | Surat | Nagpur | Junagadh | Mean |
| MECH 184 Bt | 107.1 | 33.8 | 1.8 | 85.7 | 1.1 | 11.3 | 40.1 |
| MECH 184 NBt | 108.6 | 32.1 | 8.8 | 120.0 | 0.5 | 10.7 | 46.8 |
| MECH 162 Bt | 116.5 | 32.5 | 19.3 | 159.3 | 2.7 | 10.7 | 56.8 |
| MECH 162 NBt | 142.3 | 33.2 | 19.5 | 173.7 | 1.7 | 10.7 | 63.5 |
| MECH 12 Bt | 53.9 | 31.2 | 78.3 | 132.3 | 0.0 | 14.3 | 51.7 |
| MECH 12 NBt | 71.4 | 22.8 | 60.5 | 126.7 | 1.4 | 16.7 | 49.9 |
| Local check | 150.3 | 30.5 | 9.0 | 180.7 | | 15.0 | 64.3 |
| NHH 44 | 138.7 | 30.1 | 10.7 | 145.0 | 1.2 | 12.7 | 56.4 |
| Name of Local Check Hybrid | PKV H2 | JKHY1 | PHH 316 | G. COT HY-10 | ----- | G. COT HY-10 | |

Bollworm Complex: The data on *Helicoverpa*, *Pectinophora* and *Earias* larval populations are presented in Table 18 and Fig. 15. The *Helicoverpa* larval population was generally of higher order at Akola and Khandwa. There was significantly higher population of bollworms particularly *Helicoverpa* and *Earias* on non-Bt and check plots

as compared to Bt cotton hybrid plots. Under the protected conditions, the ETL was reached in the Bt hybrids at 90 DAS only, while in non-Bt hybrids and checks the ETL crossed three times commencing from 60 DAS at all the locations. Therefore, in spite of higher number of sprays given on the non-Bt and check hybrids, the over all population of bollworms remained high in these entries. Bt hybrids exhibited excellent tolerance to bollworm populations, particularly *Helicoverpa* and *Earias*.

Table 18: Larval population of bollworms

| Helicoverpa Larval Population / 5 plants under protected condition | | | | | | |
|---|--------|---------|---------|--------------|--------|------|
| Entries | Akola | Khandwa | Nanded | Surat | Nagpur | Mean |
| MECH 184 Bt | 1.3 | 0.0 | 2.7 | 1.4 | 0.2 | 1.1 |
| MECH 184 NBt | 5.5 | 14.2 | 2.0 | 2.1 | 0.2 | 4.8 |
| MECH 162 Bt | 0.6 | 0.8 | 2.3 | 0.9 | 0.1 | 1.0 |
| MECH 162 NBt | 2.3 | 3.9 | 2.0 | 1.6 | 0.2 | 2.0 |
| MECH 12 Bt | 0.3 | 0.6 | 2.3 | 1.2 | 0.1 | 0.9 |
| MECH 12 NBt | 2.0 | 15.8 | 1.7 | 1.6 | 0.2 | 4.2 |
| Local check | 2.7 | 18.2 | 1.7 | 1.2 | | 4.7 |
| NHH 44 | 2.3 | 20.5 | 1.3 | 1.3 | 0.2 | 5.1 |
| Pectinophora Larval Population / 5 plants under protected condition | | | | | | |
| Entries | AKOLA | Khandwa | Nanded | Surat | Mean | |
| MECH 184 Bt | 0.0 | 0.0 | 4.3 | 0.0 | 1.1 | |
| MECH 184 NBt | 0.0 | 0.0 | 3.3 | 0.0 | 0.8 | |
| MECH 162 Bt | 0.0 | 0.0 | 4.3 | 0.0 | 1.1 | |
| MECH 162 NBt | 0.0 | 0.0 | 4.3 | 0.0 | 1.1 | |
| MECH 12 Bt | 0.0 | 0.0 | 3.3 | 0.0 | 0.8 | |
| MECH 12 NBt | 0.0 | 0.0 | 4.0 | 0.0 | 1.0 | |
| Local check | 0.0 | 0.0 | 6.0 | 0.0 | 1.5 | |
| NHH 44 | 0.0 | 0.0 | 5.3 | 0.0 | 1.3 | |
| Name of Local Check Hybrid | PKV H2 | JKHY1 | PHH 316 | G. COT HY-10 | | |
| Earias Larval Population / 5 plants under protected condition | | | | | | |
| Entries | Akola | Khandwa | Nanded | Surat | Nagpur | Mean |
| MECH 184 Bt | 0.1 | 0.1 | 0.7 | 1.5 | 0.1 | 0.5 |
| MECH 184 NBt | 0.7 | 2.9 | 0.3 | 2.6 | 0.1 | 1.3 |
| MECH 162 Bt | 0.2 | 0.0 | 0.3 | 2.1 | 0.0 | 0.5 |
| MECH 162 NBt | 0.7 | 3.1 | 1.0 | 2.3 | 0.1 | 1.4 |
| MECH 12 Bt | 0.2 | 0.1 | 0.3 | 1.9 | 0.0 | 0.5 |
| MECH 12 NBt | 0.7 | 5.2 | 1.0 | 2.3 | 0.1 | 1.8 |
| Local check | 0.8 | 5.0 | 0.7 | 2.1 | | 1.7 |
| NHH 44 | 0.6 | 3.6 | 1.7 | 2.4 | 0.2 | 1.7 |

Open boll and Locule damage: The data on bollworm population were also supported by the data on open boll damage and the locule damage at harvest. This was also reflected in the seed cotton yield. (Table 19). The data clearly indicated that at all locations, Bt cotton hybrids registered least open boll damage and locule damage compared to non-Bt counterpart and the check hybrids. The mean boll damage in Bt cotton hybrids ranged from 15 to 16% as against 38 to 41% in non-Bt counterparts and 38% in checks. This indicated an in-built superiority of Bt cotton hybrids over non-Bt hybrids and checks. The locule damage ranged from 10 to 12% among the Bt hybrids as compared to 24 to 30% in non-Bt counterparts and 24 to 25% in check hybrids, thus indicating lower locule damage in Bt cotton hybrids (Fig. 16).

Table 19: Open boll, locule damage and seed cotton yield of Bt cotton hybrids in Central zone

| Open Boll Damage(%) under Protected Condition | | | | | | | |
|---|-------|---------|--------|-------|----------|----------|-------|
| Hybrids | Akola | Khandwa | Nanded | Surat | Junagadh | Mean | |
| MECH 184 Bt | 22.57 | 5.72 | 14.65 | 25.90 | 6.58 | 15.07 | |
| MECH 184 NBt | 71.96 | 24.55 | 35.54 | 46.21 | 29.14 | 41.48 | |
| MECH 162 Bt | 20.65 | 7.90 | 15.23 | 28.85 | 7.00 | 15.93 | |
| MECH 162 NBt | 67.77 | 16.9 | 33.15 | 48.07 | 27.01 | 38.58 | |
| MECH 12 Bt | 15.55 | 5.66 | 17.26 | 31.77 | 5.78 | 15.19 | |
| MECH 12 NBt | 79.72 | 19.24 | 24.42 | 53.23 | 21.98 | 39.72 | |
| Local Check | 60.00 | 30.61 | 28.51 | 35.82 | 33.06 | 37.60 | |
| NHH 44 | 67.12 | 26.3 | 28.26 | 37.06 | 29.73 | 37.69 | |
| Locule Damage (%) under Protected Condition | | | | | | | |
| Hybrids | Akola | Khandwa | Nanded | Surat | Junagadh | Mean | |
| MECH 184 Bt | 5.88 | 5.17 | 10.89 | 22.25 | 3.86 | 9.61 | |
| MECH 184 NBt | 35.40 | 23.85 | 21.10 | 42.72 | 17.16 | 28.05 | |
| MECH 162 Bt | 7.40 | 6.47 | 9.50 | 23.44 | 3.40 | 10.04 | |
| MECH 162 NBt | 30.64 | 18.38 | 18.09 | 41.79 | 13.0 | 24.38 | |
| MECH 12 Bt | 4.34 | 6.22 | 12.37 | 32.79 | 2.63 | 11.67 | |
| MECH 12 NBt | 48.35 | 18.16 | 25.42 | 43.78 | 13.70 | 29.88 | |
| Local Check | 27.93 | 28.73 | 17.83 | 28.49 | 16.49 | 23.89 | |
| NHH 44 | 25.36 | 32.5 | 18.19 | 31.12 | 16.38 | 24.71 | |
| Seed Cotton Yield (q /ha) under Protected Condition | | | | | | | |
| Hybrids | Akola | Khandwa | Nanded | Surat | Nagpur | Junagadh | Mean |
| MECH 184 Bt | 11.48 | 8.50 | 16.51 | 19.35 | 18.35 | 16.31 | 15.08 |
| MECH 184 NBt | 2.64 | 3.30 | 7.61 | 9.32 | 7.07 | 12.43 | 7.06 |
| MECH 162 Bt | 9.12 | 7.92 | 14.09 | 19.16 | 17.50 | 21.98 | 14.96 |
| MECH 162 NBt | 4.90 | 3.52 | 8.62 | 15.95 | 10.08 | 14.35 | 9.57 |
| MECH 12 Bt | 8.62 | 4.26 | 10.98 | 15.85 | 4.72 | 13.73 | 9.69 |
| MECH 12 NBt | 4.77 | 4.77 | 12.15 | 9.65 | 9.02 | 14.83 | 9.20 |
| Local Check | 4.58 | 4.18 | 9.55 | 14.72 | - | 14.17 | 9.44 |
| NHH 44 | 4.28 | 4.08 | 7.87 | 17.71 | 9.02 | 15.55 | 9.75 |

Seed Cotton Yield: The data on seed cotton yield from five locations of Central Zone depicted a very clear picture of difference in yield between Bt and non-Bt counterparts and check hybrids. Higher yield in the range of 10 to 15 q/ha was observed in Bt hybrids as against 7 to 10 q/ha in non-Bt counterparts and 9 to 10 q/ha in checks (Table 19 and Fig. 17).

Plant Protection Cost: The average cost of plant protection in Bt cotton hybrids ranged from Rs. 4700 per ha for MECH-184 Bt to Rs. 7500 per ha in case of MECH-12 Bt . In case of non-Bt, this was in the range of Rs.7000 to 8500 per ha. The check hybrid NHH-44 required maximum plant protection cost to the tune of Rs. 9300 per ha.

SOUTH ZONE:

In this zone, three to four sprays were given for the control of sucking pests. For bollworm control, four sprays were given in the case of Bt cotton hybrids and nearly seven sprays on non-Bt hybrids and check hybrids (Table 20)

Table 20. Average number of sprays undertaken based on ETL

| Sprays for | MECH-184 | | MECH-162 | | MECH-12 | | Checks | |
|---------------|----------|------|----------|------|---------|------|--------|------|
| | Bt | NBt | Bt | NBt | Bt | NBt | Ck1 | CK2 |
| Sucking pests | 3.5 | 3.5 | 3.5 | 3.5 | 4.0 | 4.0 | 3.5 | 3.5 |
| Bollworms | 4.0 | 6.5 | 4.0 | 6.5 | 4.0 | 6.5 | 6.0 | 6.5 |
| Total | 7.5 | 10.0 | 7.5 | 10.0 | 8.0 | 10.5 | 9.5 | 10.0 |

Sucking Pests: The data on sucking pests under both protected and unprotected conditions are presented in Table 21 and depicted in Fig. 18 and Fig. 19. The jassids, aphids and thrips populations were generally high at Dharwad. Under protected conditions, the infestation of sucking pest was low. However, the differences in the populations on different hybrids were only marginal.

Table 21: Incidence of sucking pests under protected and unprotected conditions in Bt and non- Bt cotton hybrids in South zone

| Treatments | Guntur | | Nandyal | | Dharwad | | Coimbatore | |
|-------------------|--------|------|---------|-----|---------|-------|------------|------|
| | P | UP | P | UP | P | UP | P | UP |
| Jassids/15 leaves | | | | | | | | |
| 1. MECH 184 Bt | 38.0 | 52.0 | 52.0 | 162 | 8.62 | 19.60 | 16.3 | 15.7 |
| 2. MECH 184 NBt | 27.0 | 7.3 | 54.0 | 162 | 9.48 | 19.43 | 12.5 | 9.3 |
| 3. MECH 162 Bt | 28.0 | 23.3 | 52.0 | 115 | 7.62 | 22 | 10.3 | 8.3 |
| 4. MECH 162 NBt | 6.33 | 17.5 | 54.0 | 124 | 7.14 | 23.42 | 13.3 | 8.3 |
| 5. MECH 12 Bt | 50.0 | 51.3 | 62.0 | 182 | 10.33 | 30.35 | 23.8 | 13 |
| 6. MECH 12 NBt | 11.0 | 32.0 | 68.0 | 189 | 10.90 | 28.35 | 18.0 | 10.3 |
| 7. Local Check | 29.0 | 23.3 | 52.0 | 102 | 11.33 | 24.33 | 19.8 | 8.3 |
| 8. NHH 44 | 5.0 | 9.3 | 48.0 | 98 | 52.19 | 24.75 | 13.5 | 8.7 |
| Aphids/15 leaves | | | | | | | | |
| 1. MECH 184 Bt | 20.0 | 23.3 | 21.0 | 98 | 11.53 | 121.5 | 9.5 | 12.0 |
| 2. MECH 184 NBt | 28.0 | 25.0 | 56.0 | 96 | 16.43 | 95.25 | 12.0 | 7.7 |
| 3. MECH 162 Bt | 311 | 83.0 | 286 | 88 | 13.44 | 112.9 | 18.5 | 10.7 |
| 4. MECH 162 NBt | 215 | 10.3 | 302 | 86 | 14.01 | 128.2 | 29.7 | 4.3 |
| 5. MECH 12 Bt | 86.6 | 2 | 308 | 0 | 9.54 | 105.7 | 19.2 | 6.3 |
| 6. MECH 12 NBt | 40.0 | 20.3 | 382 | 0 | 13.91 | 117.5 | 22.7 | 8.7 |
| 7. Local Check | 116 | 39.3 | 352 | 92 | 12.10 | 93 | 25.2 | 19.3 |
| 8. NHH 44 | 112 | 28.3 | 348 | 90 | 14.14 | 105.6 | 22.2 | 11.7 |
| Thrips/15 leaves | | | | | | | | |
| 1. MECH 184 Bt | 0 | 0 | 58.0 | 82 | 59.67 | 157 | | |
| 2. MECH 184 NBt | 4.33 | 0 | 59.0 | 86 | 58.03 | 153.6 | | |
| 3. MECH 162 Bt | 1.0 | 0 | 46.0 | 98 | 61.61 | 162.0 | | |
| 4. MECH 162 NBt | 0 | 1 | 48.0 | 96 | 55.74 | 145.1 | | |
| 5. MECH 12 Bt | 0 | 0 | 68.0 | 104 | 53.44 | 127.9 | | |
| 6. MECH 12 NBt | 0 | 0 | 69.0 | 102 | 45.47 | 121.4 | | |
| 7. Local Check | 4.66 | 2 | 52.0 | 82 | 52.19 | 139 | | |
| 8. NHH 44 | 0 | 0 | 54.0 | 92 | 56.67 | 150.5 | | |

P = Protected, UP = Unprotected

Bollworm Complex: The data on bollworm complex incidence under protected and unprotected conditions are given in Table 22 and presented in Fig. 20 and Fig. 21.. The data clearly revealed that larval population of *Helicoverpa*, *Earias* and *Pectinophora* were higher in unprotected conditions. At Dharwad, Bt cotton hybrids exhibited higher level of bollworm resistance under unprotected conditions. Interestingly, at Dharwad, all Bt-hybrids also exhibited lower population of pink bollworm than the non-Bt and check hybrids. The data on fruiting bodies damage due to bollworm complex are furnished in Table 22. The differences between Bt and non-Bt are extremely clear. All Bt hybrids exhibited tolerance to bollworm complex damage.

Table 22: Bollworm complex data under Protected and unprotected conditions in Bt & non-Bt cotton hybrids at 90/120 DAS in Southern zone

| Hybrids | Guntur | | Nandyal | | Dharwad | | Coimbatore | | |
|---|--------|------|---------|----|---------|------|------------|-----|--|
| | P | UP | P | UP | P | UP | P | UP | |
| <i>Helicoverpa armigera</i> / 5 plants | | | | | | | | | |
| 1. MECH 184 Bt | 0 | 0 | 1 | 2 | 2.25 | 4.55 | 0 | 0.3 | |
| 2. MECH 184 NBt | 0 | 1.66 | 6 | 7 | 6.9 | 7.25 | 3.8 | 2.0 | |
| 3. MECh 162 Bt | 0 | 0 | 3 | 3 | 3.15 | 5.25 | 0.3 | 0 | |
| 4. MECH 162 NBt | 1.33 | 1.66 | 8 | 5 | 9.0 | 9.85 | 6.3 | 1.7 | |
| 5. MECH 12 Bt | 0 | 0 | 2 | 4 | 4.5 | 5.90 | 0.3 | 0 | |
| 6. MECH 12 NBt | 0 | 0 | 6 | 6 | 7.4 | 8.1 | 2 | 0.3 | |
| 7. Local Check | 0.33 | 1.66 | 6 | 17 | 8.65 | 5.95 | 3.3 | 2.7 | |
| 8. NHH 44 | 0.66 | 3.33 | 7 | 18 | 5.25 | 6.85 | 5.0 | 3.3 | |
| <i>Earias</i> spp./ 5 plants | | | | | | | | | |
| 1. MECH 184 Bt | | | 1 | 1 | 0.11 | 0.41 | 0.8 | 0 | |
| 2. MECH 184 NBt | | | 2 | 2 | 0.22 | 0.59 | 2.3 | 1.7 | |
| 3. MECH 162 Bt | | | 1 | 2 | 0.11 | 0.31 | 1.3 | 0 | |
| 4. MECH 162 NBt | | | 1 | 3 | 0.22 | 0.56 | 3.5 | 3.7 | |
| 5. MECH 12 Bt | | | 1 | 2 | 0.11 | 0.49 | 0 | 0 | |
| 6. MECH 12 NBt | | | 2 | 4 | 0.11 | 0.82 | 1.8 | 1.3 | |
| 7. Local Check | | | 3 | 4 | 1.89 | 0.47 | 2 | 3.3 | |
| 8. NHH 44 | | | 4 | 4 | 1.55 | 0.62 | 2.3 | 3.0 | |

Table 22 (Contd.)

| Hybrids | Guntur | | Nandyal | | Dharwad | | Coimbatore | |
|---------------------------------|--------|----|---------|-----|---------|-------|------------|----|
| | P | UP | P | UP | P | UP | P | UP |
| Pink Boll Worm/ 10 bolls | | | | | | | | |
| 1. MECH 184 Bt | | | | 82 | 2.00 | 2 | | |
| 2. MECH 184 NBt | | | | 86 | 4.67 | 7.34 | | |
| 3. MECH 162 Bt | | | | 98 | 1.33 | 2.67 | | |
| 4. MECH 162 NBt | | | | 96 | 6.67 | 10.67 | | |
| 5. MECH 12 Bt | | | | 104 | 1.33 | 4 | | |
| 6. MECH 12 NBt | | | | 102 | 4.33 | 10.67 | | |
| 7. Local Check | | | | 82 | 5.30 | 6.10 | | |
| 8. NHH 44 | | | | 92 | 6.33 | 10.67 | | |

P = Protected, UP = Unprotected

Open boll and locule damage: The mean boll damage in Bt cotton hybrids ranged from 16 to 20% as against 30 to 44% in non-Bt counterparts and 31 to 36% in checks (Table 23). This indicated an in-built superiority of Bt cotton hybrids over non-Bt and checks. The locule damage in Bt hybrids ranged from 12 to 14% as compared to 23 to 33% in non-Bt counterparts and 22 to 28 in check hybrids, thereby indicating lower damage in Bt-hybrids (Table 23 and Fig. 22).

Seed Cotton Yield: The data on seed cotton yield from different locations of South Zone depicted a very clear picture of differences in yield between Bt cotton hybrids and non-Bt counterparts and check hybrids. The seed cotton yield ranged from 15 to 17 q/ha in Bt hybrids as compared to 8 to 9 q/ha in non-Bt counterpart and 10 to 11 q/ha in check hybrids (Table 23 and Fig. 23).

Plant Protection Cost: The average cost of plant protection for Bt cotton ranged from Rs. 4891 per ha in MECH-162 Bt to Rs.5109 per ha in case of MECH-12 Bt. In case of non-Bt, this ranged between Rs. 7425 and 7643 per ha. The check hybrid NHH-44 required maximum cost of plant protection at Rs. 9381 per ha (Table 23 and Fig. 23).

Table 23: Open boll damage, locule damage and seed cotton yield and cost of plant protection in Bt cotton hybrids in South zone

| Open Boll Damage under Protected conditions | | | | | |
|--|--------|---------|------------|------------|-------|
| Hybrids | Guntur | Dharwad | Coimbatore | Mean | |
| MECH 184 Bt | 15.23 | 10.06 | 23.90 | 16.40 | |
| MECH 184 NBt | 39.56 | 18.95 | 56.60 | 38.37 | |
| MECH 162 Bt | 19.41 | 7.68 | 28.70 | 18.60 | |
| MECH 162 NBt | 24.92 | 23.84 | 40.70 | 29.82 | |
| MECH 12 Bt | 28.56 | 8.28 | 22.70 | 19.85 | |
| MECH 12 NBt | 53.26 | 24.8 | 54.20 | 44.09 | |
| Local Check | 41.31 | 17.56 | 48.60 | 35.82 | |
| NHH 44 | 40.51 | 14.74 | 38.50 | 31.25 | |
| Locule Damage under Protected conditions | | | | | |
| Hybrids | Guntur | Nandyal | Dharwad | Coimbatore | Mean |
| MECH 184 Bt | 12.81 | 20.97 | 21.64 | 13.60 | 13.21 |
| MECH 184 NBt | 29.00 | 32.58 | 36.15 | 34.80 | 31.90 |
| MECH 162 Bt | 11.65 | 19.96 | 23.42 | 15.80 | 13.73 |
| MECH 162 NBt | 23.85 | 29.23 | 28.25 | 22.40 | 23.13 |
| MECH 12 Bt | 12.55 | 20.75 | 20.18 | 11.90 | 12.23 |
| MECH 12 NBt | 36.55 | 37.20 | 33.37 | 30.20 | 33.38 |
| Local Check | 22.12 | 28.06 | 35.00 | 32.90 | 27.51 |
| NHH 44 | 23.96 | 29.31 | 26.99 | 20.60 | 22.28 |
| Seed Cotton Yield (Q/ha) under Protected conditions | | | | | |
| Hybrids | Guntur | Nandyal | Dharwad | Coimbatore | Mean |
| MECH 184 Bt | 16.36 | 13.62 | 21.75 | 8.77 | 15.13 |
| MECH 184 NBt | 7.21 | 7.63 | 12.46 | 8.49 | 8.95 |
| MECH 162 Bt | 18.92 | 13.68 | 18.58 | 8.44 | 14.91 |
| MECH 162 NBt | 4.51 | 7.80 | 13.56 | 10.57 | 9.31 |
| MECH 12 Bt | 22.99 | 12.61 | 21.53 | 11.77 | 17.23 |
| MECH 12 NBt | 5.09 | 7.55 | 12.52 | 8.68 | 8.46 |
| Local Check | 11.84 | 7.96 | 15.31 | 8.72 | 10.96 |
| NHH 44 | 7.60 | 7.86 | 13.31 | 12.77 | 10.39 |
| Plant Protection cost (Rs./ha) (Protected conditions) | | | | | |
| | Guntur | Dharwad | Coimbatore | Mean | |
| MECH 184 Bt | 9298 | 2413 | 2962 | 4891 | |
| MECH 184 NBt | 11277 | 3513 | 7485 | 7425 | |
| MECH 162 Bt | 9298 | 2413 | 2962 | 4891 | |
| MECH 162 NBt | 11277 | 3513 | 7485 | 7425 | |
| MECH 12 Bt | 9298 | 2413 | 3615 | 5109 | |
| MECH 12 NBt | 11277 | 3513 | 8138 | 7643 | |
| Local Check | 11277 | 3513 | 6369 | 7053 | |
| NHH 44 | 11277 | 3513 | 7485 | 9381 | |

III-B: EVALUATION OF Bt COTTON HYBRIDS UNDER UNPROTECTED CONDITIONS

CENTRAL ZONE

Sucking Pest: The screening of hybrids under natural conditions for sucking pests indicated no wide differences between the entries at 60 DAS (Table 24; Fig. 24).

Table 24. Population of Sucking pests in Bt cotton hybrids under unprotected conditions

| No. of Aphids /15 leaves (60DAS) under unprotected condition | | | | | | | |
|--|--------|---------|---------|--------------|--------|--------------|-------|
| Entries | Akola | Khandwa | Nanded | Surat | Nagpur | Junagadh | Mean |
| MECH 184 Bt | 471.9 | 131.4 | 8.3 | 36.6 | 0.0 | 33.3 | 113.6 |
| MECH 184 NBt | 478.2 | 141.5 | 20.0 | 43.9 | 0.0 | 30.0 | 118.9 |
| MECH 162 Bt | 480.0 | 139.0 | 3.0 | 13.9 | 0.0 | 41.7 | 112.9 |
| MECH 162 NBt | 472.6 | 133.2 | 13.0 | 41.9 | 0.0 | 45.3 | 117.7 |
| MECH 12 Bt | 567.3 | 259.1 | 18.3 | 22.1 | 0.0 | 56.0 | 153.8 |
| MECH 12 NBt | 533.8 | 270.4 | 13.0 | 0.9 | 0.0 | 60.7 | 146.5 |
| Local Check | 346.9 | 109.5 | 3.3 | 16.3 | | 47.7 | 104.7 |
| NHH 44 | 252.4 | 103.0 | 22.6 | 13.3 | 0.0 | 40.7 | 72.0 |
| No. of Jassids/ 15 leaves (60DAS) under unprotected condition | | | | | | | |
| Entries | Akola | Khandwa | Nanded | Surat | Nagpur | Junagadh | Mean |
| MECH 184 Bt | 16.9 | 89.4 | 15.3 | 36.5 | 15.3 | 20.3 | 32.3 |
| MECH 184 NBt | 12.9 | 81.2 | 5.0 | 15.4 | 9.4 | 28.3 | 25.4 |
| MECH 162 Bt | 23.5 | 80.1 | 22.6 | 18.4 | 14.2 | 51.0 | 35.0 |
| MECH 162 NBt | 16.3 | 83.0 | 40.6 | 15.0 | 10.8 | 47.0 | 35.5 |
| MECH 12 Bt | 28.2 | 123.8 | 93.3 | 53.6 | 22.9 | 68.3 | 65.0 |
| MECH 12 NBt | 25.9 | 126.0 | 86.6 | 46.5 | 22.8 | 63.3 | 61.9 |
| Local Check | 5.1 | 51.5 | 10.0 | 14.7 | | 51.0 | 26.5 |
| NHH 44 | 13.1 | 58.3 | 14.0 | 11.3 | 11.2 | 49.0 | 26.1 |
| No. of Thrips/ 15 leaves (60DAS) under unprotected condition | | | | | | | |
| Entries | Akola | Khandwa | Nanded | Surat | Nagpur | Junagadh | Mean |
| MECH 184 Bt | 16.3 | 33.8 | 56.3 | 209.0 | 0.0 | 22.3 | 56.3 |
| MECH 184 NBt | 24.9 | 28.5 | 2.6 | 227.0 | 0.0 | 15.0 | 49.7 |
| MECH 162 Bt | 22.2 | 35.8 | 24.0 | 336.0 | 0.8 | 17.3 | 72.7 |
| MECH 162 NBt | 28.9 | 35.1 | 26.6 | 391.0 | 1.0 | 21.0 | 83.9 |
| MECH 12 Bt | 7.8 | 30.1 | 29.0 | 170.0 | 0.0 | 27.3 | 44.0 |
| MECH 12 NBt | 6.9 | 24.1 | 31.0 | 222.0 | 0.0 | 31.7 | 52.6 |
| Local Check | 33.1 | 33.2 | 18.0 | 404.0 | | 32.7 | 104.2 |
| NHH 44 | 42.6 | 30.1 | 14.0 | 370.0 | 1.7 | 30.7 | 81.5 |
| Name of Local Check Hybrid | PKV H2 | JKHY1 | PHH 316 | G. COT HY-10 | ----- | G. COT HY-10 | |

Bollworm Complex: The data on bollworm population, boll and locule damage have given a very clear picture in respect of differences between Bt cotton hybrids and non-Bt cotton hybrids (Table 25 and Table 26; Fig. 25). These observations were similar to the data recorded under protected conditions. The Bt hybrids proved to be highly tolerant to multiplication of bollworm larvae.

Table 25. Larval Population of *Helicoverpa* and *Earias* bollworms in Bt cotton hybrids under unprotected condition

| <i>Helicoverpa</i> Larval Population / 5 plants under unprotected condition | | | | | | |
|--|-------|---------|--------|-------|--------|------|
| Entries | Akola | Khandwa | Nanded | Surat | Nagpur | Mean |
| MECH 184 Bt | 0.2 | 0.1 | 1.3 | 1.2 | 0.1 | 0.6 |
| MECH 184 NBt | 0.5 | 15.0 | 2.3 | 1.3 | 0.3 | 3.9 |
| MECH 162 Bt | 0.3 | 0.2 | 0.7 | 0.8 | 0.1 | 0.4 |
| MECH 162 NBt | 0.3 | 16.3 | 1.0 | 1.5 | 0.2 | 3.9 |
| MECH 12 Bt | 0.0 | 2.0 | 1.0 | 0.8 | 0.1 | 0.8 |
| MECH 12 NBt | 0.0 | 13.5 | 2.7 | 0.8 | 0.2 | 3.4 |
| Local Check | 0.3 | 18.2 | 1.3 | 1.2 | --- | 5.3 |
| NHH 44 | 0.8 | 20.5 | 1.3 | 1.3 | 0.4 | 4.8 |
| <i>Earias</i> Larval Population / 5 plants under unprotected condition | | | | | | |
| Entries | Akola | Khandwa | Nanded | Surat | | Mean |
| MECH 184 Bt | 0.0 | 0.0 | 5.3 | 0.0 | | 1.3 |
| MECH 184 NBt | 0.0 | 0.0 | 6.7 | 0.0 | | 1.7 |
| MECH 162 Bt | 0.0 | 0.0 | 3.7 | 0.0 | | 0.9 |
| MECH 162 NBt | 0.0 | 0.0 | 4.7 | 0.0 | | 1.2 |
| MECH 12 Bt | 0.0 | 0.0 | 3.7 | 0.0 | | 0.9 |
| MECH 12 NBt | 0.0 | 0.0 | 3.7 | 0.0 | | 0.9 |
| Local Check | 0.0 | 0.0 | 6.7 | 0.0 | | 1.7 |
| NHH 44 | 0.0 | 0.0 | 5.7 | 0.0 | | 1.4 |

Open boll and locule damage : The bollworm population data were also supported by the data on boll damage at 120 DAS and open boll damage (Table 26). The data clearly indicate that at all locations Bt cotton hybrids registered least open boll damage and locule damage compared to non-Bt counterparts and the check hybrids. The mean boll damage in Bt cotton hybrids ranged from 15.32 to 25.58% as against 31.6 to 47.1% in non-Bt counterparts and it ranged from 51.3% to 52.5% in check hybrids (Table 26). This indicated again an in-built superiority of Bt cotton hybrids over non-Bt and check

hybrids. The locule damage in Bt hybrids ranged from 11.74% in MECH-12 Bt to 17.91% in MECH-184 as compared to 22.62% to 28.88% in non-Bt hybrids and 29.86 to 30.11% in check hybrids, thus indicating lower locule damages in Bt-hybrids (Table 26; Fig. 26).

Seed Cotton Yield: The data on seed cotton yield from six locations of Central Zone depicted a very clear picture of differences in yield between Bt and non-Bt counterparts and check hybrids. Highest yield was observed in MECH-162Bt (10.22q/ha), which was 3.98 q/ha higher than non-Bt counterparts and 4.06 q/ha higher than the checks. Similarly, MECH-184 Bt yielded 9.41 q/ha. The yield superiority was 4.51 q/ha more than the non-Bt counterpart and 3.25 q/ha more than the best check (Table 26; Fig. 27).

Table 26 : Open boll, locule damages and seed cotton yield of Bt Cotton hybrids in Central Zone

| Open Boll Damage under Unprotected Condition | | | | | | |
|---|---------|---------|--------|--------|----------|-------|
| Hybrids | Akola | Khandwa | Nanded | Surat | Junagadh | Mean |
| MECH 184 Bt | 44.44 | 1.80 | 14.20 | 38.83 | 10.44 | 21.94 |
| MECH 184 NBt | 79.16 | 22.30 | 35.69 | 58.61 | 39.71 | 47.09 |
| MECH 162 Bt | 54.43 | 2.10 | 14.65 | 45.47 | 11.24 | 25.58 |
| MECH 162 NBt | 79.62 | 22.10 | 30.19 | 56.81 | 40.84 | 45.91 |
| MECH 12 Bt | 0.00 | 1.90 | 17.07 | 48.92 | 8.70 | 15.32 |
| MECH 12 NBt | 0.00 | 22.50 | 27.11 | 71.98 | 36.25 | 31.56 |
| Local Check | 81.98 | 20.90 | 26.63 | 45.39 | 49.99 | 51.29 |
| NHH 44 | 68.96 | 20.60 | 25.37 | 47.30 | 48.98 | 52.49 |
| Locule Damage under Unprotected Condition | | | | | | |
| Hybrids | Akola | Khandwa | Nanded | Surat | Junagadh | Mean |
| MECH 184 Bt | 38.70 | 1.20 | 9.60 | 34.73 | 5.34 | 17.91 |
| MECH 184 NBt | 28.01 | 17.30 | 19.66 | 46.08 | 23.66 | 26.94 |
| MECH 162 Bt | 18.33 | 1.80 | 9.14 | 36.18 | 5.45 | 14.18 |
| MECH 162 NBt | 40.04 | 15.20 | 18.99 | 47.42 | 22.41 | 28.88 |
| MECH 12 Bt | 0.00 | 1.00 | 10.54 | 42.58 | 4.60 | 11.74 |
| MECH 12 NBt | 0.00 | 14.90 | 17.61 | 56.76 | 23.82 | 22.62 |
| Local Check | 47.95 | 20.80 | 14.27 | 38.97 | 28.54 | 30.11 |
| NHH 44 | 42.27 | 21.20 | 14.48 | 40.32 | 31.05 | 29.86 |
| Seed Cotton Yield (q/ha) under Unprotected Condition | | | | | | |
| Hybrids | Khandwa | Nanded | Surat | Nagpur | Junagadh | Mean |
| MECH 184 Bt | 5.54 | 8.21 | 12.06 | 10.42 | 10.84 | 9.41 |
| MECH 184 NBt | 2.30 | 3.31 | 4.76 | 5.99 | 8.13 | 4.90 |
| MECH 162 Bt | 4.28 | 6.31 | 14.70 | 12.86 | 12.97 | 10.22 |
| MECH 162 NBt | 1.99 | 3.08 | 8.44 | 9.85 | 7.86 | 6.24 |
| MECH 12 Bt | 2.94 | 4.22 | 3.56 | 0.85 | 9.23 | 4.16 |
| MECH 12 NBt | 1.39 | 3.43 | 4.23 | 2.23 | 7.03 | 3.66 |
| Local Check | 3.18 | 4.03 | 8.90 | | 6.51 | 5.66 |
| NHH 44 | 3.08 | 3.19 | 8.76 | 8.56 | 7.23 | 6.16 |

SOUTH ZONE:**Sucking Pests:**

The data on sucking pests under both protected and unprotected conditions are presented in Table 21. The population of jassids, aphids and thrips were generally high at Dharwad. Under protected condition, the infestation of sucking pests were low. However, the differences among the different entries were only marginal.

Bollworm Complex : The data presented in Table 22 on bollworm population and on boll and locule damage have indicated clearly the differences in bollworm population and damage on Bt cotton hybrids and non-Bt hybrids. The observations noted earlier for Central Zone have been validated by the data obtained under unprotected conditions. The Bt cotton hybrids proved to be highly tolerant to multiplication of bollworm larvae.

Open boll and locule damage: The bollworm population data were also supported by the data on open boll damage at harvest (Table 27; Fig. 28). The data clearly indicated that the Bt cotton hybrids registered least open boll damage and locule damage at all locations, compared to non-Bt counterparts and the check hybrids. The mean boll damage in Bt cotton hybrids ranged from 22.56 to 29.54% as against 39.47 to 56.19% in non-Bt counter parts. In checks, it ranged from 31.78% to 50.20%. This indicated the in-built superiority of Bt cotton hybrids over non-Bt and checks. The locule damage in Bt hybrids ranged from 16.54% in MECH-184 Bt to 23.21% in MECH-162 as compared to 31.01% to 47.47% in non-Bt hybrids and 18.41 to 32.36% in check hybrids, indicating lower locule damages in Bt cotton hybrids .

Seed Cotton Yield: The data on seed cotton yield from four locations of South zone depicted a very clear picture as regards differences in yield between Bt and non-Bt counterparts and check hybrids. Bt cotton hybrids recorded higher yield in the range of 7.56 to 10.17 q/ha as against 4.27 to 5.61 q/ha in non-Bt counterpart and in check it ranged from 3.85 to 4.4 q/ha (Table 27; Fig. 29).

Table 27: Open boll, locule damage and seed cotton yield in South Zone

| Open Boll Damage (Unprotected condition) | | | | | |
|---|--------|------------|------------|------------|-------|
| Hybrids | Guntur | Dharwad | Coimbatore | Mean | |
| MECH 184 Bt | 29.70 | 12.28 | 25.70 | 22.56 | |
| MECH 184 NBt | 77.08 | 42.07 | 47.70 | 55.62 | |
| MECH 162 Bt | 39.20 | 15.21 | 30.70 | 28.37 | |
| MECH 162 NBt | 45.68 | 26.13 | 46.60 | 39.47 | |
| MECH 12 Bt | 35.20 | 20.92 | 32.50 | 29.54 | |
| MECH 12 NBt | 72.33 | 40.85 | 55.40 | 56.19 | |
| Local Check | 52.50 | 34.40 | 63.70 | 50.20 | |
| NHH 44 | 28.75 | 22.29 | 44.30 | 31.78 | |
| Locule Damage (Unprotected condition) | | | | | |
| | Guntur | Coimbatore | Mean | | |
| MECH 184 Bt | 18.97 | 14.10 | 16.54 | | |
| MECH 184 NBt | 46.07 | 30.50 | 38.29 | | |
| MECH 162 Bt | 26.11 | 20.30 | 23.21 | | |
| MECH 162 NBt | 32.71 | 29.30 | 31.01 | | |
| MECH 12 Bt | 18.40 | 16.30 | 17.35 | | |
| MECH 12 NBt | 64.74 | 30.20 | 47.47 | | |
| Local Check | 29.92 | 34.80 | 32.36 | | |
| NHH 44 | 11.72 | 25.10 | 18.41 | | |
| Seed cotton Yield (Q/ha) Under Unprotected Condition | | | | | |
| | Guntur | Nandyal | Dharwad | Coimbatore | Mean |
| MECH 184 Bt | 10.94 | 11.93 | 12.53 | 5.28 | 10.17 |
| MECH 184 NBt | 1.86 | 7.60 | 8.12 | 4.87 | 5.61 |
| MECH 162 Bt | 6.63 | 13.37 | 8.44 | 6.92 | 8.84 |
| MECH 162 NBt | 1.20 | 7.31 | 4.15 | 4.40 | 4.27 |
| MECH 12 Bt | 6.02 | 12.38 | 6.77 | 5.08 | 7.56 |
| MECH 12 NBt | 1.82 | 7.50 | 5.34 | 3.50 | 4.54 |
| Local Check | 1.56 | 5.30 | 6.30 | 4.42 | 4.40 |
| NHH 44 | 1.57 | 5.36 | 5.16 | 3.32 | 3.85 |

III.C: EVALUATION OF Bt COTTON HYBRIDS UNDER IPM

The Bt cotton hybrids were evaluated under IPM module, Bio-intensive module and Farmers' Practice for assessing the bio-efficacy and compatibility of Bt-hybrids. The details of plant protection are listed below in Table 28.

Table 28. Number of sprays under different IPM modules

| Location | MECH-184Bt | | | MECH-162Bt | | | MECH-12Bt | | | Local Check | | | National Check | | |
|------------|------------|-----|-----|------------|-----|-----|-----------|-----|-----|-------------|-----|-----|----------------|-----|-----|
| | IPM | BI | FP | IPM | BI | FP | IPM | BI | FP | IPM | BI | FP | IPM | BI | FP |
| Akola | 1+2 | 1+2 | 1+6 | 1+2 | 1+2 | 1+6 | 1+3 | 1+2 | 1+6 | 1+5 | 1+5 | 1+6 | 1+6 | 1+6 | 1+6 |
| Khandwa | 1+2 | 1+2 | 3+2 | 1+2 | 1+2 | 3+2 | 1+2 | 1+2 | 3+2 | 1+3 | 1+2 | 3+3 | 1+3 | 1+2 | 3+3 |
| Nanded | 1+3 | 0+4 | 1+3 | 1+3 | 1+3 | 1+3 | 2+3 | 2+3 | 2+3 | NI | NI | NI | 0+4 | 0+4 | 1+3 |
| Coimbatore | 0+1 | 0+1 | 0+1 | 0+1 | 0+1 | 0+1 | 1+1 | 1+1 | 1+1 | 1+2 | 1+2 | 1+2 | NI | NI | NI |
| Average | 1+2 | 1+2 | 1+3 | 1+2 | 1+2 | 1+3 | 1+2 | 1+2 | 2+3 | 1+3 | 1+3 | 2+3 | 1+4 | 1+4 | 2+4 |

Note: Numbers that figure first indicate number of sprays for sucking pest and the number that figure second indicate number of sprays for bollworms; NI= not included; IPM= Integrated pest management; BI = Bio-intensive IPM module; FP= Farmers' practice

All Bt cotton hybrids on an average required one additional spray beside seed treatment for the sucking pest and two sprays for the control of bollworms. The local check and national check hybrids required one spray for sucking pests and 3 to 4 sprays for bollworm control. Bio-intensive module was at par with the IPM module in respect of sprays for the sucking pests and control of bollworms. The results of the IPM practices with Bt cotton hybrids are given in Table 29.

Open boll damage: The open boll damage in Bt cotton hybrids ranged from 13.56 to 15.79% as compared to 28.32 and 24.8% boll damage in local and national check respectively (Table 29).

Locule damage: It ranged from 8.55 to 9.38% in Bt cotton hybrids as against 15.15% and 23.47% in local and national check, respectively (Table 29).

Seed Cotton yield: Under IPM practices, Bt cotton hybrids recorded seed cotton yield in the range of 11.66 to 14.00 q/ha as compared to 8.37 and 7.31 q/ha by local check and national check, respectively (Table 30; Fig. 30). The plant protection cost was in the range of Rs. 1413 to Rs.1727 per ha when IPM followed in Bt cotton hybrids, as against Rs. 2645 in case of local check and Rs. 2000 per ha in national check. This indicated a yield advantage of 4 q/ha in Bt cotton over checks and reduction in cost of plant protection on an average of Rs.1000 per ha. Thus, a total benefit of around Rs. 8000 per ha was seen in case of Bt (Table 31; Fig 31).

Table 29. Percent Open Boll Damage

Note: NI = Not Included

| | MECH 184 BT | | | MECH 162 BT | | | MECH 12 BT | | | Local Check | | | National Check | | |
|------------|-------------|-------|-------|-------------|-------|-------|------------|-------|-------|-------------|-------|-------|----------------|-------|-------|
| | IPM | BI | FP | IPM | BI | FP | IPM | BI | FP | IPM | BI | FP | IPM | BI | FP |
| Nagpur | 3.68 | 4.52 | 5.27 | 1.45 | 2.88 | 2.12 | 0.46 | 6.61 | 1.90 | NI | NI | NI | 5.24 | 3.78 | 4.98 |
| Akola | 20.00 | 20.00 | 10.00 | 20.00 | 16.66 | 16.66 | 13.33 | 16.66 | 26.60 | 43.33 | 70.00 | 70.00 | 66.66 | 66.86 | 63.33 |
| Khandwa | 1.90 | 2.90 | 2.10 | 1.90 | 3.10 | 2.30 | 2.30 | 3.00 | 2.00 | 19.80 | 27.20 | 22.80 | 20.90 | 27.80 | 23.10 |
| Nanded | 24.18 | 19.95 | 25.76 | 25.74 | 23.65 | 28.40 | 23.58 | 23.21 | 29.50 | NI | NI | NI | 33.19 | 29.55 | 33.47 |
| Surat | 41.96 | 42.76 | 40.41 | 36.92 | 37.57 | 37.50 | 32.11 | 32.80 | 34.09 | 45.83 | NI | NI | NI | NI | NI |
| Nandyal | 5.00 | NI | 8.00 | 4.40 | NI | 5.38 | 4.44 | NI | 4.52 | 13.63 | NI | 15.97 | 7.10 | NI | 22.60 |
| Dharwad | 11.35 | 1.39 | 14.62 | 12.94 | 8.70 | 12.03 | 13.39 | 6.61 | 14.39 | 20.42 | 20.87 | 15.67 | 15.72 | 15.86 | 16.79 |
| Coimbatore | 18.21 | 16.30 | 16.42 | 18.80 | 15.72 | 16.96 | 18.85 | 20.18 | 20.87 | 26.89 | 29.67 | 25.27 | NI | NI | NI |
| Mean | 15.79 | 15.40 | 15.32 | 15.27 | 15.47 | 15.17 | 13.56 | 15.58 | 16.73 | 28.32 | 36.97 | 29.94 | 24.80 | 28.77 | 26.55 |

Locule Damage

Note: NI = Not Included

| | MECH 184 BT | | | MECH 162 BT | | | MECH 12 BT | | | Local Check | | | National Check | | |
|------------|-------------|-------|-------|-------------|-------|-------|------------|-------|-------|-------------|-------|-------|----------------|-------|-------|
| | IPM | BI | FP | IPM | BI | FP | IPM | BI | FP | IPM | BI | FP | IPM | BI | FP |
| Akola | 6.61 | 4.92 | 2.50 | 5.83 | 4.96 | 4.92 | 3.28 | 4.13 | 6.50 | 16.66 | 46.66 | 29.16 | 28.69 | 29.75 | 29.16 |
| Khandwa | 0.20 | 1.00 | 0.80 | 0.30 | 1.00 | 0.90 | 0.90 | 1.10 | 1.20 | 14.80 | 17.50 | 17.00 | 16.6 | 18.3 | 18.2 |
| Nanded | 19.71 | 17.74 | 21.82 | 19.06 | 21.40 | 41.87 | 19.71 | 22.31 | 25.24 | NI | NI | NI | 25.12 | 24.81 | 26.33 |
| Coimbatore | 11.00 | 11.00 | 12.00 | 9.00 | 8.00 | 9.00 | 11.00 | 10.00 | 12.00 | 14.00 | 16.00 | 18.00 | NI | NI | NI |
| Mean | 9.38 | 8.67 | 9.28 | 8.55 | 8.84 | 14.17 | 8.72 | 9.39 | 11.24 | 15.15 | 26.72 | 21.39 | 23.47 | 24.29 | 24.56 |

Table 30: Seed Cotton Yield (Kg/ha)

| | MECH 184 BT | | | MECH 162 BT | | | MECH 12 BT | | | Local Check | | | National Check | | |
|------------|-------------|------|------|-------------|------|------|------------|------|------|-------------|------|------|----------------|------|------|
| | IPM | BI | FP | IPM | BI | FP | IPM | BI | FP | IPM | BI | FP | IPM | BI | FP |
| Nagpur | 1779 | 1654 | 1600 | 1711 | 1649 | 1822 | 611 | 562 | 575 | NI | NI | NI | 990 | 1026 | 1221 |
| Akola | 560 | 601 | 710 | 404 | 555 | 601 | 412 | 241 | 521 | 169 | 120 | 258 | 186 | 160 | 363 |
| Khandwa | 1064 | 794 | 970 | 1000 | 727 | 934 | 687 | 401 | 594 | 591 | 411 | 505 | 550 | 382 | 482 |
| Nanded | 1089 | 1090 | 1266 | 1004 | 1022 | 939 | 575 | 427 | 708 | NI | NI | NI | 494 | 604 | 526 |
| Surat | 1703 | 1532 | 1646 | 1812 | 1566 | 1620 | 1915 | 1758 | 1954 | 1682 | NI | NI | NI | NI | NI |
| Guntur | 1458 | NI | 980 | 1554 | NI | 786 | 2591 | NI | 645 | 286 | NI | 199 | 373 | NI | 179 |
| Nandyal | 1542 | NI | 1410 | 1631 | NI | 1479 | 1306 | NI | 1215 | 1050 | NI | 870 | 1004 | NI | 861 |
| Dharwad | 2465 | 1801 | 2238 | 1985 | 1519 | 1641 | 1508 | 949 | 1402 | 1550 | 1226 | 1347 | 1522 | 1098 | 1390 |
| Coimbatore | 936 | 956 | 935 | 1199 | 1222 | 1289 | 895 | 844 | 892 | 533 | 688 | 622 | NI | NI | NI |
| Mean | 1400 | 1204 | 1306 | 1367 | 1180 | 1235 | 1167 | 740 | 945 | 837 | 611 | 634 | 731 | 654 | 717 |

Cost of Plant Protection (Rs/ha)

Note: NI = Not Included

| | MECH 184 BT | | | MECH 162 BT | | | MECH 12 BT | | | Local Check | | | National Check | | |
|------------|-------------|------|------|-------------|------|------|------------|------|------|-------------|-------|------|----------------|-------|------|
| | IPM | BI | FP | IPM | BI | FP | IPM | BI | FP | IPM | BI | FP | IPM | BI | FP |
| Akola | 826 | 880 | 4060 | 826 | 880 | 4062 | 1347 | 880 | 4060 | 2483 | 3688 | 4060 | 2953 | 4158 | 4060 |
| Khandwa | 450 | 300 | 900 | 450 | 300 | 900 | 450 | 300 | 900 | 750 | 300 | 1050 | 750 | 300 | 1050 |
| Nanded | 1390 | 1140 | 1510 | 1390 | 1140 | 1510 | 1840 | 1550 | 1960 | NI | NI | NI | 1140 | 1140 | 1510 |
| Surat | 2400 | 1665 | 4175 | 2400 | 1665 | 4175 | 2400 | 1665 | 4175 | 4095 | NI | NI | NI | NI | NI |
| Junagath | NI | NI | NI | NI | NI | NI | 1824 | 1400 | 1825 | 2736 | 2100 | 2736 | NI | NI | NI |
| Dharwad | 2501 | 9527 | 2712 | 2501 | 9527 | 2712 | 2501 | 9527 | 2712 | 3161 | 10527 | 3392 | 3161 | 10527 | 3392 |
| Coimbatore | 912 | 700 | 912 | 912 | 700 | 912 | NI | NI | NI | NI | NI | NI | NI | NI | NI |
| Mean | 1413 | 2369 | 2378 | 1413 | 2369 | 2379 | 1727 | 2554 | 2605 | 2645 | 4154 | 2810 | 2001 | 4031 | 2503 |

Table 31: IPM Trial – Cost Benefit Analysis

| Entries | Yield (q/ha) | Gross Income (Rs./ha) | Plant Protection Cost (Rs./ha) | Per cent amount spent on Plant protection | Net Income (Rs./ha) | Net Profit Over (Rs./ha) |
|--------------------|--------------|-----------------------|--------------------------------|---|---------------------|--------------------------|
| | (1) | (2) | (3) | (4) | (5)=(2)-(3) | (6) |
| MECH 184 Bt | 14.00 | 25200 | 1413 | 5.61 | 23787 | |
| Local Check | 8.37 | 15066 | 2845 | 18.88 | 12221 | 11566 |
| National Check | 7.31 | 13158 | 2001 | 15.21 | 11157 | 12630 |
| | | | | | | |
| MECH 162 Bt | 13.67 | 24606 | 1413 | 5.74 | 23193 | |
| Local Check | 8.37 | 15066 | 2845 | 18.88 | 12221 | 10972 |
| National Check | 7.31 | 13158 | 2001 | 15.21 | 11157 | 12036 |
| | | | | | | |
| MECH 12 Bt | 11.67 | 21006 | 1727 | 8.22 | 19279 | |
| Local Check | 8.37 | 15066 | 2845 | 18.88 | 12221 | 7058 |
| National Check | 7.31 | 13158 | 2001 | 15.21 | 11157 | 8122 |

IV. Pathological Evaluation of Bt cotton hybrids

CENTRAL ZONE

Reaction of Bt Cotton Hybrids against foliar diseases

The Bt Cotton hybrids were screened for their reaction mainly to Bacterial blight and Alternaria leaf spot diseases. Bacterial blight incidence was noticed at Khandwa, Surat, Nanded and Akola (Table 32). Even though the disease incidence was noticed at varying intensities at different centres, there was no distinct difference in the susceptibility to diseases between Bt and non-Bt hybrids. All were susceptible at varying degrees (Fig. 32).

Alternaria leaf spot incidence was low at Junagarh and Akola and moderate at Nanded, where the disease incidence was noticed. However, there was no difference between Bt and non-Bt hybrids and also the checks in their reaction to Alternaria leaf spot (Table 33; Fig. 33).

Grey mildew incidence was not noticed in the trial plots in this zone. At Khandwa centre, the hybrids were also tested against *Myrothecium* leaf spot. Eventhough all hybrids including the checks exhibited higher susceptibility, there was no difference in the reaction between Bt and non-Bt cotton hybrids to *Myrothecium* leaf spot.

SOUTH ZONE

Reaction of Bt Cotton hybrids to foliar diseases

In the South Zone, the hybrids were tested against the foliar diseases viz., Bacterial blight, alternaria leaf spot and grey mildew at Lam (Guntur), Coimbatore and Dharwad centres.

Bacterial blight incidence was noticed only at Lam (Guntur) and Dharwad. The incidence was low at Dharwad. However, at the Lam center, both MECH 184 Bt and MECH 12 Bt showed higher susceptibility to this disease compared to non-Bt hybrids and checks. (Table 32; Fig. 32)

Higher incidence of *Alternaria* leaf spot was noticed both at Lam (Guntur) and Coimbatore centres. At both the centres, the two Bt cotton hybrids viz., MECH 184 Bt and MECH 12 Bt showed higher susceptibility to this disease compared to non-Bt hybrids and checks. At Dharwad, there was no difference among the hybrids as regards their reaction to this disease due to low incidence. (Table 33; Fig.33).

Against Grey mildew, MECH 184 Bt and MECH 12 Bt were again found to be more susceptible than their non-Bt counterpart hybrids at Lam (Guntur) centre. However, there was not much difference in the reaction of the hybrids at Dharwad and Coimbatore centres. (Table 34; Fig. 34).

Overall, in both the zones, in spite of higher incidence of diseases, the seed cotton yield was not significantly affected at all places.

Effect of Bt cotton hybrids on Soil microflora

At the CICR, Regional Station, Coimbatore, soil samples were collected from the plots wherein the Bt and non-Bt cotton hybrids were grown and analysed for bacteria, fungi and actinomycetes. The results indicated that the Bt Cotton hybrids have not distinctly altered the microbial population and there was no difference among the hybrids in this regard (Fig. 35)

Table 32: Reaction of Bt cotton Hybrids against Bacterial Blight (Percent Disease Incidence)

| Hybrids | CENTRAL ZONE | | | | | | SOUTH ZONE | | | |
|-------------|--------------|------------|--------|--------|-------|--------------|------------|------------|------------|--------------|
| | Khandwa-I* | Khandwa-II | Surat* | Nanded | Akola | Mean | Lam* | Dharwad-I* | Dharwad-II | Mean |
| MECH 184 Bt | 36.35 | 46.20 | 40.07 | 16.57 | 3.98 | 28.63 | 52.33 | 3.85 | 2.75 | 19.64 |
| MECH 184 | 37.66 | 48.70 | 44.15 | 16.19 | 3.78 | 30.10 | 2.33 | 4.41 | 2.91 | 3.22 |
| MECH 162 Bt | 37.70 | 44.16 | 30.81 | 14.84 | 3.93 | 26.29 | 0.67 | 2.34 | 2.13 | 1.71 |
| MECH 162 | 34.82 | 45.83 | 32.16 | 15.31 | 3.78 | 26.38 | 0.00 | 2.66 | 1.93 | 1.53 |
| MECH 12 Bt | 32.34 | 41.66 | 28.87 | 15.20 | 3.52 | 24.32 | 43.33 | 2.86 | 2.20 | 16.13 |
| MECH 12 | 32.52 | 40.85 | 8.66 | 14.90 | 3.29 | 20.04 | 3.33 | 2.72 | 2.03 | 2.69 |
| Local Check | 36.13 | 46.66 | 33.99 | 15.24 | 3.88 | 27.18 | 2.67 | 3.64 | 2.10 | 2.80 |
| NHH 44 | -- | -- | 17.19 | 16.22 | 4.24 | 12.55 | 3.00 | 3.37 | 2.20 | 2.86 |

*Protected against insect pests

Table 33: Reaction of Bt cotton Hybrids against Alternaria Leaf spot (Percent Disease Incidence)

| Hybrids | Central Zone | | | | | South Zone | | | | | |
|-------------|--------------|-------------|--------|-------|------------|------------|------------|------------|---------------|---------------|-------------|
| | Junagarh-I* | Junagarh-II | Nanded | Akola | Mean | Lam* | Dharwad-I* | Dharwad-II | Coimbatore-I* | Coimbatore-II | Mean |
| MECH 184 Bt | 4.13 | 6.27 | 13.78 | 0.89 | 6.3 | 64.67 | 7.08 | 6.51 | 46.2 | 41.0 | 33.1 |
| MECH 184 | 4.33 | 4.73 | 13.96 | 0.72 | 5.9 | 24.67 | 7.27 | 6.34 | 42.0 | 30.3 | 22.1 |
| MECH 162 Bt | 4.07 | 3.60 | 14.60 | 0.48 | 5.7 | 27.00 | 4.91 | 5.42 | 15.0 | 19.7 | 14.4 |
| MECH 162 | 4.73 | 4.93 | 14.72 | 0.75 | 6.3 | 26.33 | 5.78 | 5.77 | 20.5 | 23.3 | 16.3 |
| MECH 12 Bt | 4.60 | 5.53 | 14.86 | 0.59 | 6.4 | 38.33 | 4.81 | 5.86 | 26.7 | 30.0 | 21.1 |
| MECH 12 | 4.37 | 3.53 | 14.76 | 0.72 | 5.9 | 24.33 | 5.22 | 5.84 | 20.5 | 19.3 | 15.0 |
| Local Check | 5.00 | 4.55 | 15.24 | 0.46 | 6.3 | 28.00 | 4.16 | 6.23 | 19.0 | 20.0 | 15.5 |
| NHH 44 | 4.53 | 5.13 | 16.22 | 0.35 | 6.6 | 26.33 | 5.11 | 6.47 | 17.5 | 21.3 | 15.3 |

*Protected against insect pests

Table 34: Reaction of Bt cotton Hybrids against Grey mildew (Percent Disease Incidence)

| Hybrids | South Zone | | | | | |
|-------------|------------|------------|------------|---------------|-----------------|--------------|
| | Lam* | Dharwad-I* | Dharwad-II | Coimbatore-I* | Coimbatore - II | Mean |
| MECH 184 Bt | 51.33 | 44.01 | 17.13 | 17.20 | 13.00 | 28.53 |
| MECH 184 | 9.33 | 42.80 | 18.43 | 8.70 | 11.30 | 18.11 |
| MECH 162 Bt | 8.67 | 40.48 | 15.38 | 25.00 | 16.30 | 21.17 |
| MECH 162 | 5.67 | 40.08 | 15.73 | 37.50 | 18.30 | 23.46 |
| MECH 12 Bt | 22.33 | 40.14 | 14.51 | 10.20 | 9.30 | 19.30 |
| MECH 12 | 5.00 | 40.16 | 15.30 | 29.50 | 8.70 | 19.73 |
| Local Check | 6.00 | 29.21 | 15.61 | 26.70 | 10.30 | 17.56 |
| NHH 44 | 3.30 | 40.12 | 15.14 | 28.50 | 12.70 | 19.95 |

*Protected against insect pests