PERFORMANCE OF BT AND NON-BT COTTON UNDER RESEARCH FIELD CONDITIONS

Protocol-2 Report

Evaluation of Bt Cotton Hybrids for Control of Bollworm Complex and Yield Performance During On-Farm Trials in India, 1998-1999

Submitted to RCGM
February 8, 1999

mahyco®

MAHARASHTRA HYBRID SEEDS COMPANY LTD
Resham Bhavan, 4th Floor, 78 Veer Nariman Road, Mumbai 400 020, India

PREAMBLE

A technological breakthrough in control of Lepidopteran pests in cotton, such as the Bollworm complex, was achieved in the early 1990's by the Monsanto Company. This technology involved the incorporation of an expressed gene from *Bacillus thuringiensis* (Bt) for the production of Cry1Ac protein in cotton plants. Maharashtra Hybrid Seeds Company, Ltd. (Mahyco) perceived the importance of this technology for control of Lepidopteran (Bollworm) pests and its clear value to the Indian farmer through reduction in use of environmentally damaging pesticides, and associated costs, as well as through increased yield potentials. It was therefore decided to undertake a breeding program to incorporate the Bt gene into elite Indian cotton lines, for development of value-added hybrid cotton seeds. The following is a chronological narrative of research activities related to development of Bt cotton hybrids, and the corresponding regulatory process. At all stages of these activities, the duly constituted Institutional Bio-Safety Committee (IBSC) of Mahyco, which had 25 meetings since its inception, and the Department of Biotechnology (DBT) were kept updated on progress through documentation and discussion.

Import of Bt Cotton Seeds: As per Government of India regulations, an application was made by the Mahyco IBSC to the DBT, for permission to import Bt cotton seeds from Monsanto Co., USA. DBT then granted permission, vide Permit No. BT/BS/01/004/91-Vol II dated March 10, 1995, for the import of 100g of Bt cotton seeds These seeds were received for plant quarantine on January 23, 1996 and were released from quarantine on March 30, 1996.

Green House Operations: Upon receipt of the aforementioned seeds, the Research and Development division of Mahyco took up a fully green-house contained breeding program, as per DBT guidelines. The objective of this program was to incorporate the Bt gene into Mahyco's elite cotton inbred lines. The corresponding breeding work was accelerated by adopting embryo culture from immature bolls, thus it became possible to complete three plus generations per year. The trait has been successfully transferred into 40 plus elite Indian cotton lines. More than 46000 Bioassays and 198,000 ELISA tests were conducted to track the gene. A small quantity of hybrid were made by the Kharif 1997 crop season. At the beginning of the 1998 Kharif season, sufficient amount of experimental hybrid seeds had been generated to take up larger area and multi-location trials. With the intention to ascertain the risk (or the lack of risk) of Bt gene transfer into related Gossypium species, inter-specific crosses were attempted. However these consistently failed to set seed. As per DBT guidelines, the

staff involved in these experiments were regularly medically checked by specialists and their health status was shown to be normal.

Field Studies to Assess Pollen Escape: In July 1996, permission was received from DBT to conduct a limited field trial, on 25 sq.meters., in Jalna (MS) to assess the extent of out-crossing from Bt cotton to a non-transgenic pollen trap at distances starting from 5 meters to 50 meters (Permit No. BT/BS/01/004/91-Vol.III, dated July 16, 1996). The result of this study was submitted to DBT on 18-3-1997 and it was shown that there was no detectable out crossing even as close as 5 meters, i.e., the nearest distance tested. A more detailed and multi-location testing of the probability of out-crossing from Bt cotton was then undertaken. An application was made to RCGM for permission to conduct elaborate pollen trap studies in four additional locations. The permission was received in November 1997 (Permit No. BT/17/02/94-PID/MS6/IBMAHYCO, dated November 10, 1997). In these studies, the first five pollen trap rings were kept between 1 and 5 meters from the Bt pollen source, and another nine rings at 5 meter intervals, up to a distance of 50 meters. The results of these experiments, which involved detailed sampling and Polymerase Chain Reaction (PCR) amplification of DNA related to the Bt gene, were submitted to DBT for the first location on April 27, 1998, for the second and third locations on May 24, 1998, and for the fourth location on August 31. The proposed fifth location experiment was not conducted due to seasonal limitations. The results were as per expectations based on cotton floral part development and pollen characteristics, i.e., the effective distance of out crossing from Bt cotton is only up to 2 meters, at a frequency ranging from only 1% to 6%. As bees are considered to be the predominant agents of cross-pollination in cotton, honey bee hives were provided at all corners of these trials and in three geographical locations (Karnataka, Andhra Pradesh and Tamil Nadu). Normal bee activity, development of the colonies and honey production in the hives were noted at all the locations.

Bt Cotton Aggressiveness and Persistence: Natural shed of Bt cotton seeds were compared with the non-transgenic counterparts for potential weediness properties. A study of the difference of germination rate between these two types was also done. It was shown that there is no difference in these attributes between Bt cotton and conventional, non-transgenic cotton. These experiments clearly indicated that Bt cotton crops do not pose as an aggressor on the natural flora/habitat.

Biochemical and Toxicological Studies: In 1998, comparative chemical analysis, such as protein, oil, ash, carbohydrate and total gossypol content were done. No difference was found between Bt and non-Bt cottonseed, from elite Indian germplasm, which is used for oil extraction and as animal feed. Detailed studies were undertaken

on the toxicity and allergenicity of Bt cottonseed derived from elite Indian germplasm. The toxicological study was conducted by Indian Toxicological Research Center, Lucknow, in the year 1998 and the final report, which indicates that Bt cotton is not toxic to goats (model for ruminant mammals), has been submitted on 29th Jan. 1999. This further supports earlier studies on avian and mammalian models, which have been reported in the literature. Allergenicity studies were also conducted on Brown Norway Rats, exposed to Bt and non Bt Indian cotton germplasm, and shown to pose no threat in this regard. The guinea pig model was not compatible with cottonseed-based feeding and therefore had to be substituted with the above Brown Norway Rat model. These reports were submitted on 18th Dec. 1998.

Multi-Location Field Trials: On the basis of the aforementioned studies, application was made and permission received from RCGM and DBT for conducting extensive multi-location trials in the Kharif season of 1998. Permission was granted vide Permit No. BT/17/02/94-PID/MS6/IBMAHYCO dated 27.07.1998 and 5.8.1998. These experiments consisted of replicated research trials in small plot size at 15 locations and trials of large plot size at 25 locations grown under typical farm conditions. The results of these trials are reviewed in the attached documents. Results from the replicated research trials at 15 locations are referred to as Protocol-1 Report, and results from the large plot trials at 25 locations are referred to as Protocol-2 Report. These reports are now being submitted for consideration by the Review Committee on Genetic Manipulation. (RCGM)

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Bt	*Bacillus thuringiensis*
Bt Cotton	Hybrid cotton with Bt gene insert
DAS	Days After Sowing
ETL	Economic Threshold Level
Non-Bt	Hybrid cotton without Bt gene insert

Protocol -2 Report

EXECUTIVE SUMMARY

Under the guidance of the Department of Biotechnology, Government of India, research trials of Bt cotton hybrids were conducted at 25 farm locations representing nine states of India in Kharif 1998-1999. Objectives of these trials were as follows:

1) To evaluate and monitor Lepidopteran insect load (Bollworm Complex) among Bt and non-Bt hybrids in regional on-farm research trials.

2) To compare Bollworm damage (shedding/retention of squares and bolls), yield and fibre quality in the above hybrids.

At each on-farm trial location, three cotton hybrid entries were planted; one containing the Bt (*Bacillus thuringiensis*) gene, the same cotton hybrid in non-Bt version, and a third cotton hybrid appropriate as a check depending on its regional adaptation. Each of the three hybrid cotton entries was planted in three replications of large plot size (7.5m x 18m = 135 sq. m).

Standard cotton cultivation and management practices were used at each location. However, suitable pesticide applications for Lepidopteran pests (Bollworm Complex: American Bollworm, Spotted Bollworm, Pink Bollworm) were given only in cases where individual plots exceeded economic threshold levels (ETLs), as per advisory guidelines provided by State Agricultural Universities and Research Institutions.

Measurements were made for degree of infestation of major cotton pests and for percentage fruiting body damage at weekly intervals on randomly selected plants in each large plot. Notations were taken of absolute population of Bollworm larvae and resulting percentage damage to fruiting bodies (flowers, squares, green bolls). Sucking pests of cotton (Aphids, Jassids, Whitefly) and their beneficial predators (Lady Bird Beetle, Green Lacewing Bug, Spiders) were also noted. Due to damaging rains resulting in inconsistent collection of data, four trials in three States had to be discontinued. In addition, seven trials in two other States were destroyed by human activity before final boll picking; however, most data at these sites were successfully collected prior to that time.

Results from this study indicate that Bt cotton hybrids provided effective control of Bollworm Complex at each location. Substantial reduction in Bollworm larvae count

and percent fruiting body damage in Bt cotton hybrids as compared to non-Bt hybrids was found at each location. At a few locations, ETLs were surpassed in 7 to 11 monitoring sessions for non-Bt hybrids. However, at these same locations ETLs were surpassed only on one to two occasions for Bt cotton hybrids. Overall, pesticide applications targeted towards Bollworm Complex were reduced by 70% to 100% in Bt cotton hybrids as compared to conventional non-Bt hybrids.

For data averaged over all locations, Bollworm count and fruiting body damage were substantially reduced in Bt hybrids as compared to their non-Bt counterparts. The average Bollworm count (per 10-plant sample) over all Bt hybrids was 1.0, while that of all non-Bt hybrids was 7.9. The average fruiting body damage per plant was 1.7% for Bt hybrids, and 9.0% for non-Bt hybrids (Table 1).

Bt hybrids also provided higher yields than their non-Bt counterparts, as well as compared to other hybrid checks. Averaged over all trial locations, the mean yield advantage of Bt hybrids over non-Bt hybrids ranged from 14% to 59%. The mean yield for all Bt hybrids was 37% higher than the mean yield of all non-Bt versions, and 36% higher that the mean yield of all conventional cotton hybrids taken as a group (non-Bt version & regional checks) Overall pesticide application requirements targeted for Bollworm Complex, based on ETL monitoring, was reduced three-fold for Bt hybrids as compared to non-Bt hybrids (Table 1).

No change in the activity of either cotton sucking pests or beneficial insects was observed as a result of the presence of Bt hybrids. The population of sucking pests was found to be similar among Bt and non-Bt hybrids, thus confirming the high specificity of Bt to target Bollworm Complex. Also, no change was noted in fibre quality measurements between Bt and non-Bt cotton hybrids.

Results from these research trials indicate that utilization of the Bt gene in Indian hybrid cotton germplasm will provide an effective tool for control of Bollworm Complex in cotton production. A powerful use of this technology could be as a major component of an overall integrated pest management (IPM) strategy at the farm level. Large reductions in pesticide spray requirements for control of bollworm, as well as substantial increases in yield, should provide enhanced benefit to farmers. Also, substantial environmental benefits would be obtained through cultivation of Bt cotton hybrids, as a result of large reductions in pesticide requirement.

TABLE 1. Summary of Pooled Data for Yield and Bollworm Complex Reaction from On-Farm Research Trials of Bt and Non-Bt Cotton Hybrids in India, 1998-1999.

HYBRID	Number of Trial Locations [1] *Yield (Bollworm Reaction)*	Yield Measurement: Yield *(Kg/ha)*	Yield Measurement: % Increase in Yield *(Bt versus Non-Bt)*	Bollworm Complex Reaction: Bollworm Larvae Count/ 10 Plants *(Seasonal Average)*	Bollworm Complex Reaction: % Fruiting Body Damage [2] *(Seasonal Average)*	Number of Pesticide Applications for Bollworm Complex: ETL Based [3] *Range (Ave.)*
MECH-1 Bt	1 (1)	1210	58%	0.0	0.4	0 (0)
MECH-1 Non-Bt		765		13.2	8.3	7 (7)
Other Hybrid Checks		840		16.4	7.4	7 (7)
MECH-3 Bt	4 (4)	1569	14%	1.5	2.2	0 (0)
MECH-3 Non-Bt		1377		5.5	9.4	1 – 3 (2.3)
Other Hybrid Checks		1335		6.0	9.9	2 – 3 (2.3)
MECH-12 Bt	3 (4)	1405	17%	1.2	2.5	0 – 2 (0.5)
MECH-12 Non-Bt		1203		8.6	13.5	1 – 7 (3.3)
Other Hybrid Checks		989		9.9	14.3	1 – 7 (3.3)
MECH-160 Bt	3 (3)	2256	51%	0.6	0.3	0 (0)
MECH-160 Non-Bt		1491		3.3	3.3	2 – 4 (3.0)
Other Hybrid Checks		1892		3.4	3.1	2 – 4 (3.0)
MECH-162 Bt	7 (7)	2140	59%	1.2	1.2	1 – 3 (0.6)
MECH-162 Bt		1349		7.6	7.3	1 – 11 (5.1)
Other Hybrid Checks		1534		7.1	7.1	1 – 11 (5.1)
MECH-915 Bt	1 (2)	1583	27%	1.3	3.7	0 (0)
MECH-915 Non-Bt		1242		8.9	12.1	1 – 4 (2.5)
Other Hybrid Checks		1906		8.8	13.2	1 – 4 (2.5)
Mean: Bt Hyb.	19 (21)	1694	37%	1.0	1.7	0.2 §
Mean: Non-Bt Hyb.		1238		7.9	9.0	3.2 §
Mean: Bt Hyb.	19 (21)	1694	36%	1.0	1.7	0.2 §
Mean: Non-Bt & Other Hybrid Checks		1244		8.2	9.1	3.2 §

[1] Data averaged over 19 locations for yield, and averaged over 21 locations for Bollworm reaction.

[2] Damage to fruiting bodies involved either flower parts, squares or bolls.

[3] Pesticide applications for Bollworm Complex based on Economic Threshold Levels (ETL), as per advisory guidelines of State Agricultural Universities and Research Institutions. Values represent range of application number among locations, and average of locations for each hybrid.

§ Average number of Bollworm pesticide applications per hybrid per trial location.

Protocol-2 Report

Evaluation of Bt Cotton Hybrids for Control of Bollworm Complex and Agronomic Performance During On-Farm Trials in Kharif 1998-1999

OBJECTIVES

1. To evaluate and monitor Lepidopteran insect load (Bollworm Complex) among Bt and non-Bt hybrids in regional on-farm research trials.

2. To compare Bollworm damage (shedding/retention of squares and bolls), yield and fibre quality in the above hybrids.

MATERIAL AND METHODS

On-farm research trials were conducted at 25 locations, as approved by the Department of Biotechnology, distributed in nine States of India. Of these trials 7 were in Andhra Pradesh (AP), 6 in Maharashtra (MS), 3 in Karnataka (KTK), 2 each in Gujarat(GJ) , Madhya Pradesh (MP), and Tamilnadu (TN), and one trial each in Haryana (HR), Punjab (PJ) and Rajasthan (RJ). The details of the locations and sowing plans are given in Table 2.

A. Description of Field Plots

Treatments	:	Three 1. Bt cotton hybrid 2. Corresponding non-Bt hybrid 3. non-Bt hybrid check
Replications	:	Three
Crop Spacing	:	0.9m x 0.9m (rows x plants)
Plot Size	:	18m x 7.5m = 135 sq.m.
Isolation	:	5m surrounding the plot 2m between replications
Total field Area	:	26.5m x 64 m = 1696 sq.m

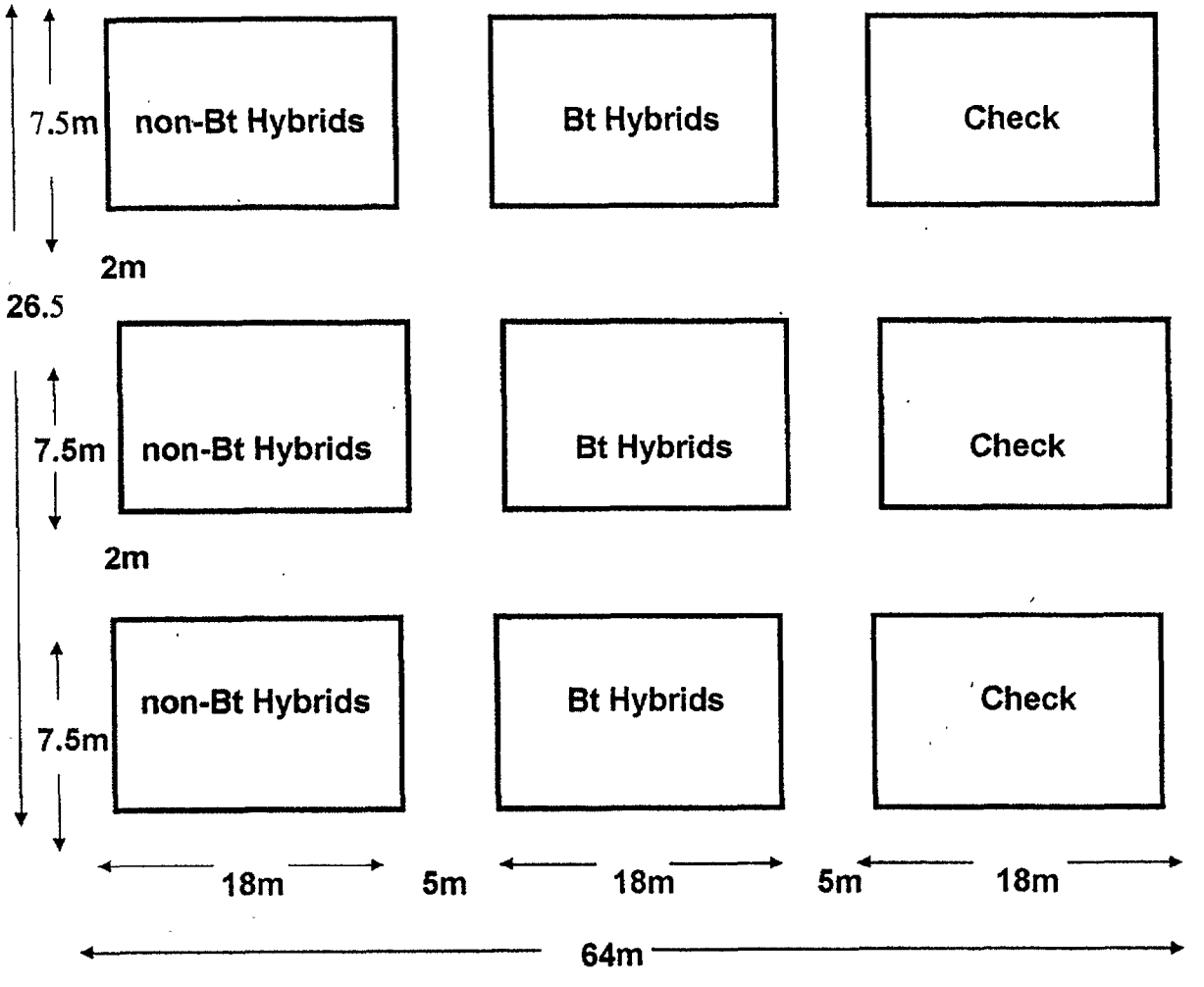
TABLE2: DETAILS OF MULTI LOCATIONAL BT-COTTON TRIALS ORGANISED DURING KHARIF 1998-1999

State	Sr.No.	District	Tehsil/Mandal	Village	Survey No.	Farmer	Name of the Variety	Trial Date
GJ	14	Vadodara	Karjan	Pingarwada	455	Mr. Kishore Bhai T. Shah	MECH-3 NON Bt MECH-3 Bt NHH-44	06.08.98
GJ	15	Rajkot	Gondal	Bhuvna	66	Mr. Naganbhai Tejabhai	MECH-162 NON Bt MECH-162 Bt. NHH-44	04.08.98
KTK	16	Raichur	Sindhanur	Maladagudda	238/A	Mr. Basanna J. Kunsale	MECH-3 NON Bt MECH-3 Bt. NHH-44	05.08.98
KTK	17	Bellary	Hagari Bommanhalli	Ranikkal	291/B	Mr. B.V. Nanjundappa	MECH-12 NON Bt MECH-12 Bt. NHH-44	05.08.98
KTK	18	Haveri	Hangal	Adur	141	Mr. Mahalingappa S. S.	MECH-162 NON Bt MECH-162 Bt. NHH-44	05.08.98
MP	19	Khargone	Barwah	Keeduh	250	Mr. Bansi Lal	MECH-1 NON Bt MECH-1 Bt. NHH-44	30.07.98
MP	20	Khandwa	Burhanpur	Mohammadpura	204	Mr. Chaganlal C. Mahajan	MECH-162 NON Bt MECH-162 Bt. NHH-44	31.07.98
HR	21	Hisar	Hisar	Mayar	82/16	Mr. Lehari Singh	MECH-915 NON Bt MECH-915 Bt.NHH-44	03.08.98
PJ	22	Bhatinda	Talwandi	Maisar Khana	124	Mr. Sher Singh	MECH-915 NON Bt MECH-915 Bt.NHH-44	11.08.98
PJ	23	Sriganganagar	KesriSinghpur	Chak/22F	54	Mr. Ramdas Jain	MECH-915 NON Bt MECH-915 Bt.NHH-44	04.08.98
RJ	24	Theni	Theni	Veerapandi	102/1F	Mr. Narayanswamy	MECH-3 NON Bt MECH-3 Bt. NHH-44	22.08.98
TN	25	Dharmapuri	Uthangaral	Kannanoor	10/1	Mr. A. Jayachandran	MECH-162 NON Bt MECH-162 Bt. NHH-44	14.08.98

TABLE 2: DETAILS OF MULTI LOCATIONAL BT-COTTON TRIALS ORGANISED DURING KHARIF 1998 -1999

State	Sr.No.	District	Tehsil/Mandal	Village	Survey No.	Farmer	Name of the Variety	Trial Date
A P	1	Guntur	Rentachintala	Rentachintala	44	Mr Thumma Fatima Reddy	MECH-162 NON Bt MECH-162 Bt NHH-44	09 08 98
A.P.	2	Mahboobnagar	Bijnepally	Manganur	268	Mr. India Mallikarjun Rao	MECH-12 NON Bt MECH-12 Bt. NHH-44	09.08 98
A.P.	3	Khammam	Madira	Dendukur	581 & 582	Mr. K. Ranga Rao	MECH-3 NON Bt MECH-3 Bt. NHH-44	08.08.98
A.P.	4	Kurnool	Pagadiala	Nagatur	228	Mr. O. Tirupallaiah	MECH-162 NON Bt MECH-162 Bt. NHH-44	07.08.98
A.P.	5	Warangal	Atmakur	Vururgonda	121	Mr. Bollu Sami Reddy	MECH-12 NON Bt MECH-12 Bt. NHH-44	09.08.98
A.P.	6	Ranga Reddy	Vikarabad	Kothagadi	130	Mr. Karella Bakka Reddy	MECH-3 NON Bt MECH-3 Bt. NHH-44	07.08.98
A.P.	7	Adilabad	Adilabad	Ponnari	12/43	Mr. Meghraj Sharma	MECH-1 NON Bt MECH-1 Bt. NHH-44	08.08.98
MS	8	Yavatmal	Kelapur	Both	32	Mr. Arunbhau S. Thakre	MECH-160 NON Bt MECH-160 Bt. NHH-44	05.08.98
MS	9	Jalna	Bhokardan	Viregaon	5	Mr. Baburao T. Pise Patil	MECH-162 NON Bt MECH-162 Bt. NHH-44	04 08.98
MS	10	Parbhani	Sailu	Kolha	45	Mr. Ganpatrao B. Bhise	MECH-12 NON Bt MECH-12 Bt. NHH-44	04.08.98
MS	11	Nanded	Nanded	Barad	338/1	Mr. Kerbaji P. Bhimewar	MECH-162 NON Bt MECH-162 Bt. NHH-44	06.08.98
MS	12	Buldhana	Malkapur	Lonwadi	7	Mr. Narhari G. Patil	MECH-160 NON Bt MECH-160 Bt NHH-44	04.08.98
MS	13	Jalgaon	Chalisgaon	Umberkhed	63-1-A	Mr Dhanraj A. Patil	MECH-3 NON Bt MECH-3 Bt NHH-44	05.08.98

B. **Field Layout of Trials:**



C. **Data Recording:**

To achieve the objectives of these trials, data were collected on the following parameters.

1. Number of Lepidopteran insects larvae.
2. Number and species of sucking insect pests.
3. Percent damaged terminals.
4. Percent damaged intact fruiting bodies.
5. Percent damaged shedding fruiting bodies.
6. Plant stand/plot.
7. Flowering and Maturity (boll bursting) dates.
8. Yield and fibre quality.

D. Experimental Methodology :

The observations were recorded on infestation of major insect pests of cotton and percent fruiting body damage at weekly intervals on ten randomly selected plants in each plot. For recording of non-Lepidopteran (sucking) pests, three leaves were selected on the top, middle and lower canopy of the randomly selected plants. An absolute population of Lepidopteran insects (Bollworm Complex Larvae/10 plants in each plot) and percent fruiting body damage was recorded. Plant stand count, days to picking, and yield were also recorded.

Suitable insecticide applications were made on an as needed basis to control both sucking and Lepidopteran pests for all plots based on Economic Threshold Levels (ETL), as suggested in guidelines given by State Agricultural Universities and Research Institutions.

E. Data Analysis:

The average population of sucking insect pests/30 leaves and Bollworm Complex larval count/10 plants, percent fruiting body damage and percent fruiting bodies shed was compiled. The insect data recorded up to 60 days after sowing (DAS), 61-90 DAS, and 91-120 DAS is reported as an average for the respective period for quick reference.

Tables shown in subsequent pages represent performance of Bt cotton over non-Bt cotton and check hybrids at each location. These tables include average number of Bollworm Complex, aphids, jassids and whitefly, average percent fruiting body damage and plant stand/plot, yield and number of sprays.

Figures shown in subsequent pages represents summation of pooled yield and pesticide spraying data, on a State basis. Other figures also show population dynamics of Bollworm Complex and percent fruiting body damage over the cropping season for each trial location. Annexure-1 presents tables of detailed data for all required parameters, recorded 30 days after sowing at weekly intervals for each trial location.

RESULTS

Data was obtained from 21 of these locations. Trials at four locations, Khargaon (MP), Khandwa (MP), Bhatinda (PJ), and Theni (TN) were damaged due to excessive rains and reliable data could not be collected. In addition, seven trials in two other states (AP, KTK) were destroyed by human activity before final boll picking. However, at most sites, initial yield data and insect reaction data were recorded and are presented in these results.

Observations were recorded on a complex of major Bollworms pests, namely American Bollworm (***Helicoverpa armigera)***, Spotted Bollworm (***Earias vitella and Earias insulana)*** and Pink Bollworm (***Pectinophora gossypiella***). Other Lepidopteran caterpillars also infested the crop at various locations, including Tobacco Caterpillar (***Spodoptera littura***), Cotton Semi-looper (***Tarache notablis***), and Leaf-folder (***Sylepta derogata***). Major sucking insects were Jassids (***Empoasca devastens***), Whitefly (***Bemesia tabaci***) and Aphids (***Aphis gossypi***). At some locations, beneficial insects were also recorded, including Lady Bird Beetle, Green Lacewing Bug, and Spiders.

State-wise summation of results from all 21 trial locations is as follows:

A. Andhra Pradesh (AP)

1. Location- Rentachintala, Guntur: Table AP-1

Plant stand in all the three plots were at par. MECH-162 Bt recorded 21% higher yield over the non-Bt MECH-162 and check NHH-44. High rainfall caused stunted growth of plants in all plots. Average Bollworm Complex count up to 60 DAS, 90 DAS, 120 DAS was lower in Bt hybrid than in the counterpart non-Bt and regional check hybrids. Fruiting body damage (%) was also lower in Bt hybrid than the non-Bt and check. The sucking pest infestation in Bt, non-Bt and NHH-44 hybrids were at par.

2. Location- Manganur, Mehboobnagar: Table AP-2

Yield could not be recorded due to site damage. However, Bollworm Complex counts and other data were recorded. The Bollworm Complex count at 60DAS and 90DAS showed lower Bollworm Complex and low % fruiting body damage at 60DAS, 90DAS and 120DAS on MECH-12 Bt in comparison to non-Bt MECH-12, and NHH-44. Sucking pest infestation was similar for all hybrids.

3. Location- Dendukur, Khammam: Table AP-3

Yield of only two boll picking were obtained due to damage at later stages. Yield of MECH-3 Bt was higher than the non-Bt MECH-3 and NHH-44 by 11% and 25%, respectively. Plant population was highest in NHH-44. Bollworm Complex count and fruiting body damage (%) at all the three stages, 60 DAS, 90 DAS and 120 DAS, were lower in MECH-3 Bt than in the other two hybrids. Sucking pest infestations was similar for all hybrids.

4. **Location- Nagatur, Kurnool: Table AP-4**

Yield of only two boll pickings were obtained due to damage at late stages. Three hybrids, MECH-162, MECH-162 Bt and NHH-44 were tested. MECH-162 Bt was superior in yield than the other two hybrids by 26%. The Bollworm Complex count and % fruiting body damage was less in the Bt hybrid Sucking pest infestation was similar for all hybrids.

5. **Location – Vurugonda, Warangal: Table AP-5**

Yield of MECH-12 Bt (1480 kg/ha) was higher than non-Bt and the check NHH-44 by a margin of 15% and 62% respectively. All hybrids had good plant stand. Bollworm Complex population recorded at 60DAS, 90 DAS, and 120 DAS was least in the Bt hybrid compared to non-Bt and NHH-44. Sucking pest infestation was similar for all hybrids. This field was also destroyed prior to final picking of bolls.

6. **Location- Kothagadi, Ranga Reddy: Table AP-6**

All the three hybrids had uniformly good plant stand. MECH-3 Bt yielded 26% more than the non-Bt version and 42% more than other NHH-44 check. Bollworm Complex population recorded at 60DAS, 90 DAS, and 120 DAS was least in the BT hybrid compared to non-Bt and NHH-44. Sucking pest infestation was similar for all hybrids.

7. **Location- Ponnari, Adilabad: Table AP-7**

MECH-1 Bt recorded 58% higher yield over the non-Bt hybrid and 44% over NHH-44. Bollworm Complex count on the Bt hybrid was almost zero at all the stages compared to non-Bt hybrid which ranged from 9.0 to 18.97 and 13.88 to 24.25 in NHH-44. This plot was destroyed after the third picking. Sucking pest infestation was similar for all hybrids.

B. MAHARASHTRA (MS)

1. **Location-Both, Yeotmal: Table MS-1**

Hybrid MECH-160 Bt, non-Bt and NHH-44 were grown at this location. MECH-160 Bt recorded highest yield (2720kg/ha), 4% more than NHH-44 and 72% more than non-Bt. Bollworm Complex count and % fruiting body damage was low in this trial. The Bt hybrid had very low Bollworm Complex count (0.16 to 0.66) compared to non-Bt and NHH-44 (0.7 to 5.91). Fruiting body damage (%) was also very low in Bt. Sucking pest infestation varied over the duration

of the crop, but overall there was no difference observed between Bt and non-Bt and check hybrids.

2. **Location- Viregoan, Jalna: Table MS-2**

Yield of MECH-162 Bt (2049 kg/ha) was 30% to 77% higher than the non-Bt and NHH-44. The Bt hybrid had very low Bollworm Complex count and fruiting bodies damage (%). Sucking pest reaction was at par in all hybrids at 60 DAS, 90 DAS and 120 DAS. Both non-Bt hybrids exceeded ETL seven times, requiring 7 applications of pesticides for Bollworm Complex. In contrast the Bt plot exceeded ETL only once, requiring 1 application.

3. **Location- Kolha, Parbhani: Table MS-3**

MECH –12 Bt recorded highest yield in this trial. It was 8% higher than the non-Bt counterpart and 18% higher than NHH-44. Bollworm Complex count ranged from 0.31 to 3.57 in Bt as compared to non-Bt (2.5 to 9.47). NHH-44 had Bollworm count higher than other hybrids. Percent fruiting bodies damage was also lower in Bt than in the other hybrids. Both non-Bt hybrids exceeded ETL for Bollworm on seven occasions, requiring 7 applications of pesticides for Bollworm Complex. In contrast the Bt hybrid exceeded ETL only twice, requiring 2 applications. Sucking pest infestation was similar for all hybrids.

4. **Location – Barad, Nanded: Table MS-4**

MECH-162 Bt recorded 18% higher yield over non-Bt counterparts and 23% over NHH-44. Bollworm Complex count on Bt hybrid was below 0.9, while it ranged between 1.55 and 3.75 on the non-Bt counterpart and 1.17 to 3.58 on NHH-44. Average fruiting body damage (%) was also lower in MECH-162 Bt than in the other hybrids. The sucking pests infestation was similar in all hybrids.

5. **Location - Lonwadi, Buldhana: Table MS-5**

MECH-160 Bt yielded 19% higher than the NHH-44, and 71% over MECH-160 non-Bt. The Bollworm Complex count in Bt hybrid was lower than the non-Bt. Fruiting bodies damaged in Bt up to 90 DAS was less than 1%, as against 2% to 5% in the non-Bt version and above 5% in NHH-44. Sucking pests infestation was similar in all hybrids. Beneficial insects at 60 DAS, 90 DAS and 120 DAS were higher in number on Bt than the other hybrids.

6. **Location- Umberkhed, Jalgaon: Table MS-6**

High yield was recorded for all the three hybrids. MECH-3Bt (3012 kg/ha) yield was 3% higher than NHH-44 and 6% more than non-Bt MECH-3. Negligible Bollworm Complex count was recorded on Bt MECH-3 (0.0 to .83) compared

to non-Bt version (1.99 to 4.16). Fruiting body damage was also negligible in Bt hybrid. Sucking pests infestation was similar in all hybrids

C. GUJRAT (GJ)

1. **Location – Pingarwara, Vadodra: Table GJ-1**

The yield increase in the MECH-3 Bt hybrid over the counterpart non-Bt and H-6 was 27% and 22% respectively. Lower Bollworm Complex count and % fruiting body damage was recorded in MECH-3 Bt as compared to the other hybrids. Incidence of sucking pest damage on all hybrids was similar Large numbers of beneficial insects were recorded on all hybrids

2. **Location- Bhunava, Rajkot: Table GJ-2**

MECH-162 Bt recorded higher yield (3975 kg/ha) compared to non-Bt MECH-162 and H-6. Low Bollworm Complex count and % fruiting body damage were recorded in Bt hybrid as compared to the other two hybrids. Both non-Bt hybrids exceeded ETL eleven times, requiring 11 applications of pesticides for Bollworm Complex. In contrast the Bt plot exceeded ETL only once. requiring 3 applications. Sucking pest infestation was similar for all hybrids. Beneficial insects were recorded on all hybrids.

D. KARNATAKA (KTK)

1. **Location-Maladagudda, Raichur: Table KTK-1**

This trial had a relatively low level of yield as only one boll picking was completed when it was destroyed. MECH-3 Bt had higher yield than the non-Bt and NHH-44. Bollworm Complex count and % fruiting body damage was lower in Bt than the other hybrids. Sucking pest infestation was similar for all hybrids. Beneficial insects were recorded on all hybrids.

2. **Location- Bennikal, Bellary. Table KTK-2**

MECH-12 Bt out yielded non-Bt MECH-12 as well as NHH-44 in the initial boll picking. after which the trial was destroyed. The Bt hybrid had lower Bollworm Complex and % fruiting body damage than the non-Bt counterpart and NHH-44 Sucking pest infestation was similar for all hybrids. Beneficial insects were recorded on all hybrids.

3. Location- Adur, Dharwad: Table KTK-3

MECH-162 Bt out yielded the non-Bt counterpart with a margin of 35% and NHH-44 by a margin of 44%. MECH-162 Bt had much lower Bollworm Complex count and % fruiting body damage as compared to the non-Bt counterpart and NHH-44.

Sucking pest infestation was similar for all hybrids. Beneficial insects were present on all the three hybrids.

E. HARYANA (HR)

1. Location- Mayyer: Table HR-1

MECH-915 Bt out yielded the counterpart non-Bt and NHH-44 by a margin of 27% and 75%, respectively. Bollworm Complex count was lower on the Bt than the non-Bt versions, as well as NHH-44. And the same trend was observed for % fruiting body damage. Sucking pest infestation was similar for all hybrids. Beneficial insects were present on all hybrids.

F. RAJASTHAN (RJ)

1. Location- Sriganganagar: Table RJ-1

This trial was damaged by rain, therefore no valid data could be recorded for yield. However, Bollworm Complex count was lower in Bt than in non-Bt and NHH-44 44. Sucking pest infestation was similar for all hybrids. Beneficial insects were present on all hybrids.

H. TAMILNADU (TN)

1. Location – Dharmapuri: Table TN-1

MECH-162 Bt out yielded non-Bt counterpart as well as NHH-44. Low Bollworm Complex count was recorded on Bt as compared to non-Bt and NHH-44. Sucking pest infestation was similar for all hybrids. Beneficial insects were noted on all hybrids.

OTHER RESULTS AND GENERAL OBSERVATIONS

- Fibre quality data collected at 14 locations indicated similar characteristics among Bt and non-Bt hybrids Annexure-1).

- It was observed that the growth of Bt plants appeared to be shorter in height and more compact than in the non-Bt counterpart. This appears to result from a higher amount of fruiting bodies on Bt hybrids; therefore, greater plant energy partitioning to reproductive rather than vegetative growth.

- It should also be noted that MECH-1, MECH-3 and MECH-12 are early maturing hybrids as compared to the corresponding checks which tend to be longer in long duration hybrids and thus greater yield potential over an extended cropping season baseline. However, when compared for the same period of growth, the Bt cotton hybrids gave higher yield as compared to the checks.

- Relatively little, or no Bollworm pesticide application was required for growth of Bt cotton hybrids in these trials (see State-wise Tables and figures on subsequent pages).

CONCLUSIONS

- Activity of Lepidopteran insects (Bollworm Complex) were found to be substantially lower on Bt cotton hybrids compared to their corresponding non-Bt version and regional check hybrids under normal field cultivation conditions.

- Bt hybrids had substantially lower insect damage in fruiting bodies (shedding and retention) than the non-Bt types. This indicates that more green matured bolls were retained on Bt cotton .

- Bt cotton does not have any impact on sucking insect pests and their natural enemies (beneficial insects). This reconfirms the known mode of action of Bt protein as working specifically against larvae within the Bollworm Complex.

- As reconfirmed in this study substantial Bollworm pesticide spray reductions are possible through cultivation of Bt cotton hybrids; thus providing opportunity for substantial benefit to farmers. However, Bt cotton production should be carefully monitored by growers to ensure effective overall pest control, and could be used as a major component in overall Integrated Pest Management (IPM) strategies..

- . The inherently high yield capacity of Bt cotton hybrid in comparison to traditional hybrids, as shown in these results, has potential to substantially increase cotton production in India, while maintaining fibre quality and providing environmental benefits through large reduction in pesticide applications.

PROTOCOL-2 REPORT

ANDHRA PRADESH

TABLES & FIGURES

TABLE: AP-1 PERFORMANCE OF Bt OVER NON Bt COTTON HYBRIDS AT RENTACHINTALA,GUNTUR

S.No.	PARAMETERS	NON Bt (MECH-162)	Bt (MECH-162)	CHECK (NHH-44)
1	PLANT STAND / PLOT	495.0	495.0	465.0
2	WEIGHT OF FIRST PICKING(Kg)	6.8	8.4	6.8
3	WEIGHT OF SECOND PICKING(Kg)	20.3	24.3	20.0
4	YIELD Kg / PLOT	27.0	32.7	26.8
5	YIELD Kg / Ha	667.0	807.0	670.0
6	% YIELD INCREASE OVER NON Bt AND CHEC	21.0		21.0
7	NO. OF SPRAYS FOR LEPIDOPTERANS	1.0	0.0	1.0
8				
9	AVERAGE NO. OF BOLLWORMS			
	LARVAE/10 PLANTS			
	a) 0 - 60 DAS	0.0	0.0	0.0
	b) 61 - 90 DAS	5.1	1.4	5.3
	c) 91 - 120 DAS	4.7	2.1	6.5
	d) > 120 DAS	5.0	0.7	4.5
10	AVERAGE %FRUITING BODY			
	DAMAGE			
	a) 0 - 60 DAS	0.0	0.0	0.0
	b) 61 - 90 DAS	7.7	2.0	6.5
	c) 91 - 120 DAS	9.5	3.1	9.1
	d) > 120 DAS	5.6	1.8	5.8
11	AVERAGE NO. OF JASSIDS/30 LEAVES			
	a) 0 - 60 DAS	0.0	0.0	0.0
	b) 61 - 90 DAS	4.0	4.8	3.8
	c) 91 - 120 DAS	10.4	8.8	10.0
	d) > 120 DAS	4.8	4.7	5.5
12	AVERAGE NO. OF WHITE FLY/30 LEAVES			
	a) 0 - 60 DAS	1.1	2.3	1.1
	b) 61 - 90 DAS	34.6	37.2	41.2
	c) 91 - 120 DAS	46.3	41.8	45.8
	d) > 120 DAS	47.5	47.8	47.5
13	AVERAGE NO. OF APHIDS/30 LEAVES			
	a) 0 - 60 DAS	80.2	63.4	62.8
	b) 61 - 90 DAS	40.0	52.2	43.0
	c) 91 - 120 DAS	0.0	0.0	0.0
	d) > 120 DAS	0.0	0.0	0.0

REMARKS: Crop was severely affected by rainfall and resulted stunted growth in all plots.

TABLE:AP-2 PERFORMANCE OF Bt OVER NON Bt COTTON HYBRIDS AT MANGANUR,MEHBOOBNAGAR

S.No.	PARAMETERS	NON Bt	Bt	CHECK
		(MECH-12)	(MECH-12)	(NHH-44)
1	PLANT STAND / PLOT	456.0	460.0	472.0
2	WEIGHT OF FIRST PICKING(Kg)			
3	WEIGHT OF SECOND PICKING(Kg)			
4	WEIGHT OF THIRD PICKING(Kg)			
5	WEIGHT OF FOURTH PICKING(Kg)			
6	YIELD Kg / PLOT			
7	YIELD Kg / Ha			
8	% YIELD INCREASE OVER NON Bt AND CHECK			
9	NO. OF SPRAYS FOR LEPIDOPTERANS	3.0	0.0	3.0
10	AVERAGE NO. OF BOLLWORMS			
	LARVAE/10 PLANTS			
	a) 0 - 60 DAS	9.1	1.5	16.1
	b) 61 - 90 DAS	6.3	1.7	6.8
	c) 91 - 120 DAS	1.3	0.0	5.0
	d) > 120 DAS	0.0	0.0	0.0
11	AVERAGE %FRUITING BODY			
	DAMAGE			
	a) 0 - 60 DAS	41.4	6.7	35.9
	b) 61 - 90 DAS	31.7	4.9	27.1
	c) 91 - 120 DAS	12.0	2.5	15.0
	d) > 120 DAS	0.0	0.0	0.0
12	AVERAGE NO. OF JASSIDS/30 LEAVES			
	a) 0 - 60 DAS	30.3	30.4	6.7
	b) 61 - 90 DAS	19.3	19.6	18.6
	c) 91 - 120 DAS	0.0	0.0	0.0
	d) > 120 DAS	0.0	0.0	0.0
13	AVERAGE NO. OF WHITE FLY/30 LEAVES			
	a) 0 - 60 DAS	69.5	101.6	161.7
	b) 61 - 90 DAS	68.8	68.3	59.0
	c) 91 - 120 DAS	0.0	0.0	0.0
	d) > 120 DAS	0.0	0.0	0.0
14	AVERAGE NO. OF APHIDS/30 LEAVES			
	a) 0 - 60 DAS	17.3	25.0	23.4
	b) 61 - 90 DAS	0.0	0.0	0.0
	c) 91 - 120 DAS	0.0	0.0	0.0
	d) > 120 DAS	0.0	0.0	0.0

REMARKS :Crop was severely affected by heavy rainfall and make it difficult to take the larval count. However huge fruiting body damage was recorded on non - Bt and check.This trial was destroyed by activists.

TABLE: AP-3 PERFORMANCE OF Bt OVER NON Bt COTTON HYBRIDS AT DENDUKUR, KHAMMAM

S.No.	PARAMETERS	NON Bt	Bt	CHECK
		(MECH-3)	(MECH-3)	(NHH-4)
1	PLANT STAND / PLOT	469.0	485.0	508.0
2	WEIGHT OF FIRST PICKING(Kg)	30.0	34.0	28.0
3	WEIGHT OF SECOND PICKING(Kg)	15.6	16.6	12.5
6	YIELD Kg / PLOT	45.6	50.6	40.5
7	YIELD Kg / Ha	1125.0	1250.0	1000.0
8	% YIELD INCREASE OVER NON Bt AND CHEC	11.0		25.0
9	NO. OF SPRAYS FOR LEPIDOPTERANS	1.0	0.0	2.0
10	AVERAGE NO. OF BOLLWORMS			
	LARVAE/10 PLANTS			
	a) 0 - 60 DAS	0.0	0.0	0.0
	b) 61 - 90 DAS	8.0	2.0	8.9
	c) 91 - 120 DAS	6.8	2.3	9.3
	d) > 120 DAS	0.0	0.0	0.0
11	AVERAGE %FRUITING BODY			
	DAMAGE			
	a) 0 - 60 DAS	0.0	0.0	0.0
	b) 61 - 90 DAS	14.7	2.0	13.5
	c) 91 - 120 DAS	24.9	7.2	24.9
	d) > 120 DAS	0.0	0.0	0.0
12	AVERAGE NO. OF JASSIDS/30 LEAVES			
	a) 0 - 60 DAS	14.3	8.3	10.5
	b) 61 - 90 DAS	57.0	56.3	34.0
	c) 91 - 120 DAS	15.3	15.0	16.5
	d) > 120 DAS	0.0	0.0	0.0
13	AVERAGE NO. OF WHITE FLY/30 LEAVES			
	a) 0 - 60 DAS	0.0	0.0	0.0
	b) 61 - 90 DAS	43.5	36.0	57.5
	c) 91 - 120 DAS	14.5	12.8	16.0
	d) > 120 DAS	0.0	0.0	0.0
14	AVERAGE NO. OF APHIDS/30 LEAVES			
	a) 0 - 60 DAS	347.3	206.3	344.3
	b) 61 - 90 DAS	0.0	0.0	0.0
	c) 91 - 120 DAS	0.0	0.0	0.0
	d) > 120 DAS	0.0	0.0	0.0

REMARKS Field was destroyed by activists after second picking of the crop.
The damage was more in check plot as compare to other plots.

TABLE: AP-4 PERFORMANCE OF Bt OVER NON Bt COTTON HYBRIDS AT NAGATUR, KURNOOL

S.No.	PARAMETERS	NON Bt (MECH-162)	Bt (MECH-162)	CHECK (NHH-44)
1	PLANT STAND / PLOT	517.0	517.0	522.0
2	WEIGHT OF FIRST PICKING(Kg)	8.2	10.4	8.3
3	WEIGHT OF SECOND PICKING(Kg)	16.4	20.5	16.0
4	YIELD Kg / PLOT	24.6	30.9	24.3
5	YIELD Kg / Ha	607.0	762.9	600.0
6	% YIELD INCREASE OVER NON Bt AND CHEC	26.0		27.0
7	NO. OF SPRAYS FOR LEPIDOPTERANS	7.0	0.0	7.0
8	AVERAGE NO. OF BOLLWORMS			
	LARVAE/10 PLANTS			
	a) 0 - 60 DAS	1.2	0.0	0.4
	b) 61 - 90 DAS	3.0	0.1	1.4
	c) 91 - 120 DAS	8.3	0.9	7.9
	d) > 120 DAS	12.6	0.7	11.2
9	AVERAGE %FRUITING BODY			
	DAMAGE			
	a) 0 - 60 DAS	0.4	0.2	0.0
	b) 61 - 90 DAS	1.7	0.1	3.8
	c) 91 - 120 DAS	4.6	0.1	5.9
	d) > 120 DAS	9.4	0.2	6.3
10	AVERAGE NO. OF JASSIDS/30 LEAVES			
	a) 0 - 60 DAS	15.9	10.6	24.2
	b) 61 - 90 DAS	5.8	14.2	5.3
	c) 91 - 120 DAS	9.8	12.0	6.6
	d) > 120 DAS	9.3	20.3	26.6
11	AVERAGE NO. OF WHITE FLY/30 LEAVES			
	a) 0 - 60 DAS	10.4	30.3	9.1
	b) 61 - 90 DAS	22.7	19.7	26.3
	c) 91 - 120 DAS	45.4	45.6	74.9
	d) > 120 DAS	132.8	70.4	106.7
12	AVERAGE NO. OF APHIDS/30 LEAVES			
	a) 0 - 60 DAS	138.2	203.1	292.5
	b) 61 - 90 DAS	13.3	109.5	53.9
	c) 91 - 120 DAS	3.0	8.9	0.0
	d) > 120 DAS	0.0	28.0	10.8

REMARKS:

:Field was destroyed by AP Department of Agriculture officials after second picking.At that time Bt plot was on full bloom while non - Bt plots were damaged by Bollworms and bearing less number of bolls and flowers. The present yield based on weighted average of two pickings.

TABLE: AP-5 PERFORMANCE OF Bt OVER NON Bt COTTON HYBRIDS AT VURUGONDA,WARANGAL

S.No.	PARAMETERS	NON Bt (MECH-12)	Bt (MECH-12)	CHECK (NHH-44)
1	PLANT STAND / PLOT	484.0	439.0	445.0
2	WEIGHT OF FIRST PICKING(Kg)	15.3	18.2	8.4
3	WEIGHT OF SECOND PICKING(Kg)	24.0	27.7	15.3
4	WEIGHT OF THIRD PICKING(Kg)	12.6	17.1	13.3
5	YIELD Kg / PLOT	52.0	60.0	37.0
6	YIELD Kg / Ha	1283.4	1480.2	912.8
7	% YIELD INCREASE OVER NON Bt AND CHEC	15.0		62.0
8	NO. OF SPRAYS FOR LEPIDOPTERANS	1.0	0.0	1.0
9	AVERAGE NO. OF BOLLWORMS			
	LARVAE/10 PLANTS			
	a) 0 - 60 DAS	1.6	0.0	2.5
	b) 61 - 90 DAS	6.3	0.4	7.5
	c) 91 - 120 DAS	11.1	0.6	14.5
	d) > 120 DAS	11.0	2.7	25.1
10	AVERAGE %FRUITING BODY			
	DAMAGE			
	a) 0 - 60 DAS	4.3	0.9	7.6
	b) 61 - 90 DAS	5.6	0.2	8.5
	c) 91 - 120 DAS	8.8	0.7	15.4
	d) > 120 DAS	3.4	0.2	7.3
11	AVERAGE NO. OF JASSIDS/30 LEAVES			
	a) 0 - 60 DAS	41.1	35.8	25.1
	b) 61 - 90 DAS	23.8	24.1	23.3
	c) 91 - 120 DAS	82.3	94.3	73.9
	d) > 120 DAS	120.7	128.0	99.0
12	AVERAGE NO. OF WHITE FLY/30 LEAVES			
	a) 0 - 60 DAS	4.0	1.5	3.0
	b) 61 - 90 DAS	51.3	52.8	58.0
	c) 91 - 120 DAS	110.9	127.8	153.2
	d) > 120 DAS	70.6	71.0	136.0
13	AVERAGE NO. OF APHIDS/30 LEAVES			
	a) 0 - 60 DAS	101.0	156.3	163.3
	b) 61 - 90 DAS	85.0	61.0	59.5
	c) 91 - 120 DAS	205.0	209.8	53.9
	d) > 120 DAS	0.0	0.0	0.0

REMARKS :Field was destroyed by activists and we could not harvest final picking.Bollworms damage was more in check plot as compare to other non - Bt hybrid.

TABLE: AP-6. PERFORMANCE OF Bt OVER NON Bt COTTON HYBRIDS AT KOTHAGADI,RANGA REDDY

S.No.	PARAMETERS	NON Bt (MECH-3)	Bt (MECH-3)	CHECK (NHH-44)
1	PLANT STAND / PLOT	487.0	479.0	481.0
2	WEIGHT OF FIRST PICKING(Kg)	21.0	27.0	18.0
3	WEIGHT OF SECOND PICKING(Kg)	33.0	41.0	30.0
4	WEIGHT OF THIRD PICKING(Kg)			
5	YIELD Kg / PLOT	54.0	68.0	48.0
6	YIELD Kg / Ha	1333.0	1679.0	1185.0
7	% YIELD INCREASE OVER NON Bt AND CHE	26.0		42.0
8	NO OF SPRAYS FOR LEPIDOPTERANS	3.0	0.0	3.0
9	AVERAGE NO. OF BOLLWORMS			
	LARVAE/10 PLANTS			
	a) 0 - 60 DAS	0.6	0.0	1.9
	b) 61 - 90 DAS	3.0	0.3	5.2
	c) 91 - 120 DAS	3.4	0.3	8.0
	d) > 120 DAS	0.0	0.0	0.0
10	AVERAGE %FRUITING BODY			
	DAMAGE			
	a) 0 - 60 DAS	1.6	0.6	8.7
	b) 61 - 90 DAS	5.2	1.4	4.3
	c) 91 - 120 DAS	7.0	1.1	7.1
	d) > 120 DAS	0.0	0.0	0.0
11	AVERAGE NO. OF JASSIDS/30 LEAVES			
	a) 0 - 60 DAS	19.6	27.5	18.9
	b) 61 - 90 DAS	22.5	23.7	49.2
	c) 91 - 120 DAS	24.1	20.7	10.7
	d) > 120 DAS	0.0	0.0	0.0
12	AVERAGE NO. OF WHITE FLY/30 LEAVES			
	a) 0 - 60 DAS	8.3	6.4	7.1
	b) 61 - 90 DAS	23.5	22.0	32.5
	c) 91 - 120 DAS	33.6	29.1	22.7
	d) > 120 DAS	0.0	0.0	0.0
13	AVERAGE NO. OF APHIDS/30 LEAVES			
	a) 0 - 60 DAS	1.5	0.0	1.3
	b) 61 - 90 DAS	21.0	22.2	20.0
	c) 91 - 120 DAS	0.0	0.0	0.0
	d) > 120 DAS	0.0	0.0	0.0

REMARKS : In Bt plot yield increase over check was more as compared to corresponding ing non-Bt hybri

TABLE: AP-7 PERFORMANCE OF Bt OVER NON Bt COTTON HYBRIDS AT PONNARI,ADILABAD

S.No.	PARAMETERS	NON Bt	Bt	CHECK
		(MECH-1)	(MECH-1)	(NHH-44)
1	PLANT STAND / PLOT	492.0	486.0	488.0
2	WEIGHT OF FIRST PICKING(Kg)	12.0	21.0	14.0
3	WEIGHT OF SECOND PICKING(Kg)	11.0	15.0	11.0
4	WEIGHT OF THIRD PICKING(Kg)	8.0	13.0	10.0
5	YIELD Kg / PLOT	31.0	44.0	34.0
6	YIELD Kg / Ha	765.4	1209.8	839.5
7	% YIELD INCREASE OVER NON Bt AND CHEC	58.0		44.0
8	NO. OF SPRAYS FOR LEPIDOPTERANS	7.0	0.0	7.0
9	AVERAGE NO. OF BOLLWORMS			
	LARVAE/10 PLANTS			
	a) 0 - 60 DAS	0.0	0.0	0.0
	b) 61 - 90 DAS	9.0	0.0	13.9
	c) 91 - 120 DAS	12.3	0.0	15.9
	d) > 120 DAS	19.0	0.0	24.3
10	AVERAGE %FRUITING BODY			
	DAMAGE			
	a) 0 - 60 DAS	0.0	0.0	0.0
	b) 61 - 90 DAS	10.6	2.1	7.5
	c) 91 - 120 DAS	9.3	0.5	7.5
	d) > 120 DAS	9.2	0.3	10.1
11	AVERAGE NO. OF JASSIDS/30 LEAVES			
	a) 0 - 60 DAS	24.4	23.6	10.4
	b) 61 - 90 DAS	46.9	43.5	16.4
	c) 91 - 120 DAS	55.5	51.8	18.5
	d) > 120 DAS	76.0	72.6	52.1
12	AVERAGE NO. OF WHITE FLY/30 LEAVES			
	a) 0 - 60 DAS	0.0	0.0	0.0
	b) 61 - 90 DAS	0.0	0.0	0.0
	c) 91 - 120 DAS	4.4	3.3	6.0
	d) > 120 DAS	32.8	35.0	37.0
13	AVERAGE NO. OF BENEFICIALS/10 PLANTS	5.1	5.6	6.7
	a) 0 - 60 DAS	16.1	15.9	10.6
	b) 61 - 90 DAS	9.0	10.9	8.5
	c) 91 - 120 DAS	0.0	0.0	0.0
	d) > 120 DAS			

REMARKS :Field was destroyed after 3rd picking by AP Department of Agriculture officials.

Fig : AP-1 YIELD OF Bt AND NON Bt COTTON HYBRIDS IN ANDHRA PRADESH

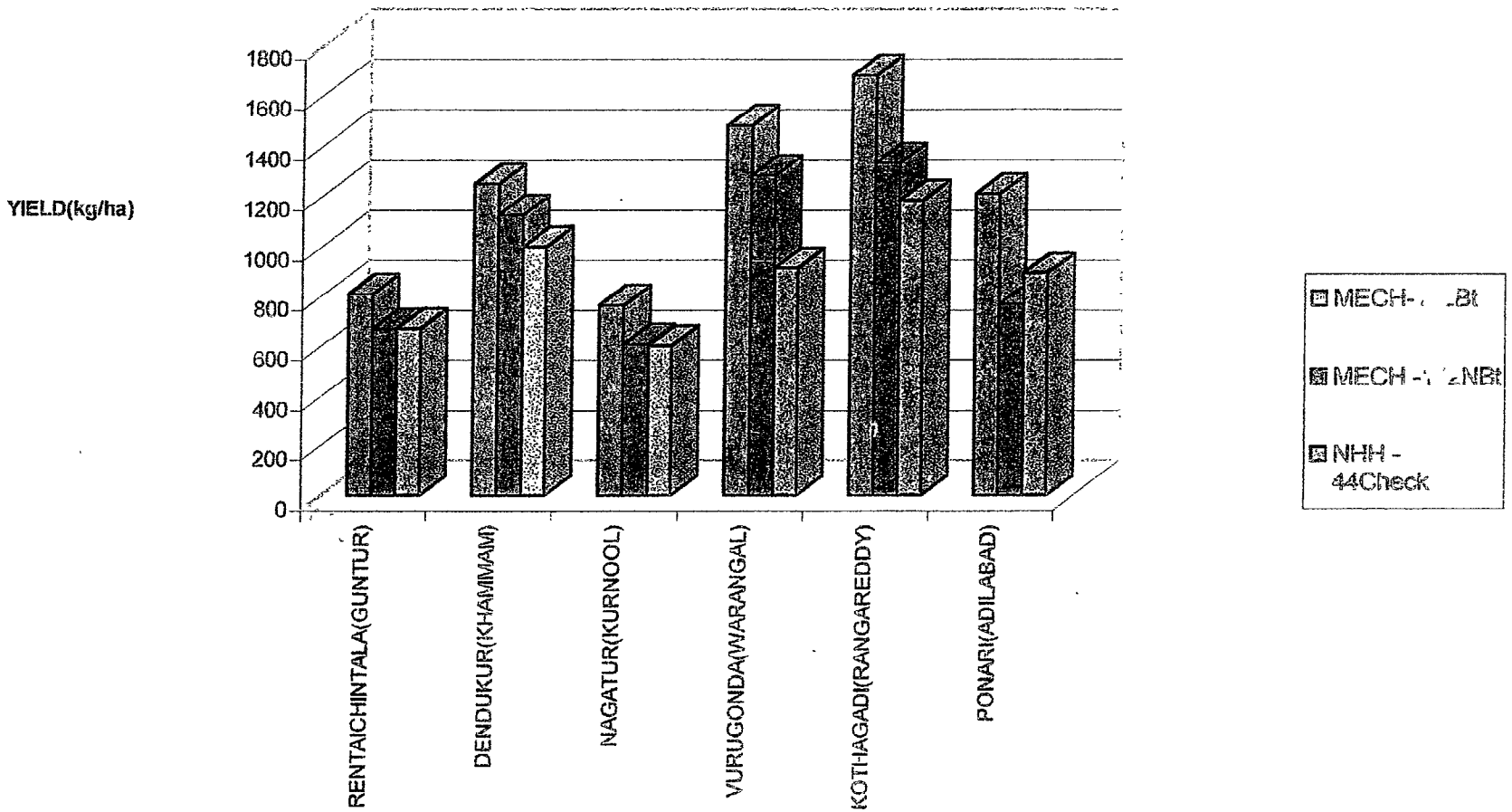


Fig : AP-2 COMPARATIVE SPRAYING FOR BOLLWORM COMPLEX ON Bt AND NON Bt COTTON HYBRIDS IN ANDHRA PRADESH

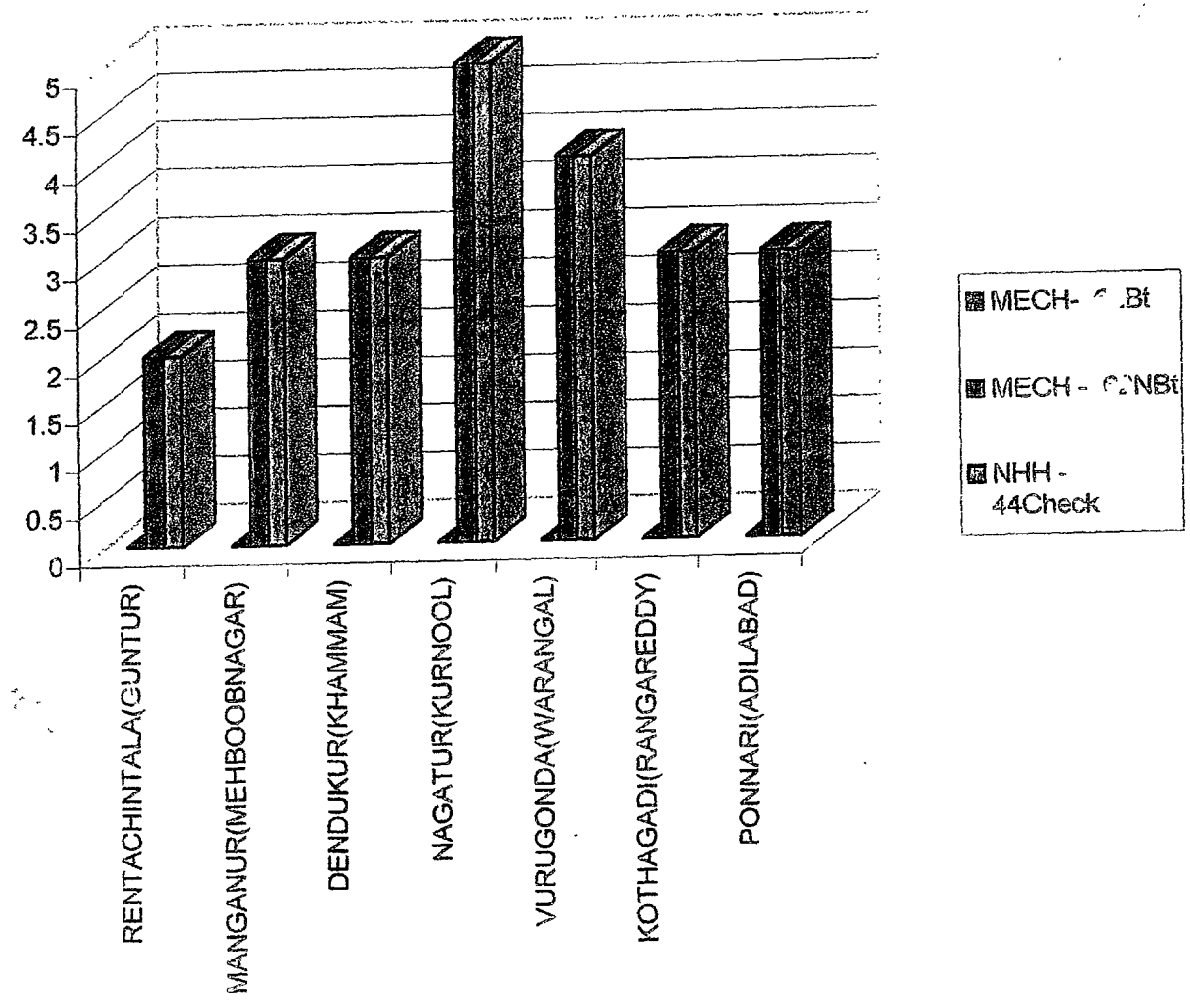


FIG: AP-3 POPULATION OF BOLLWORMS AND % FRUITING BODY DAMAGE ON COTTON AT RENTACHINTALA

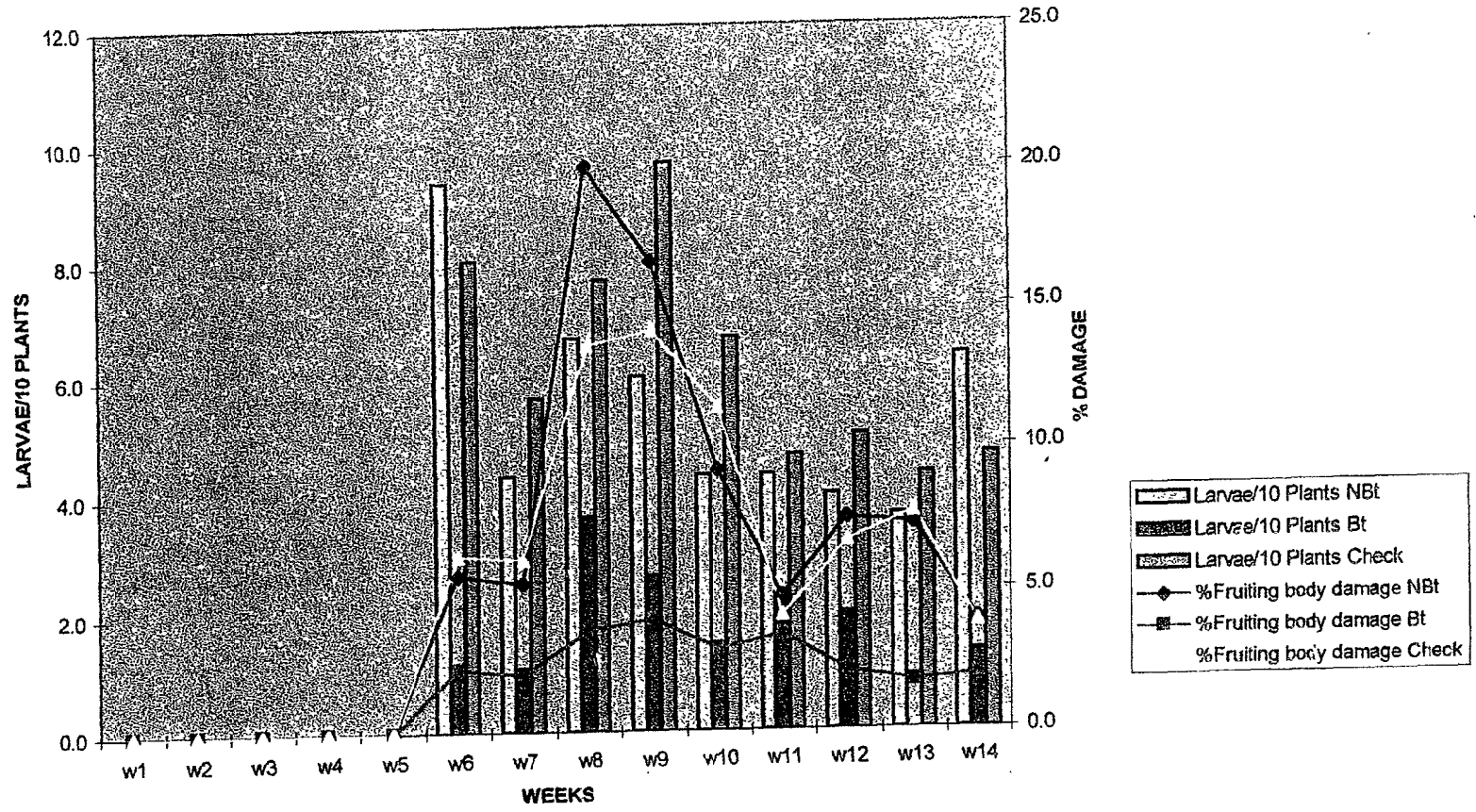


FIG: AP-4 POPULATION OF BOLLWORMS AND % FRUITING BODY DAMAGE AT MANGANUR,MEHBOOBNAGAR

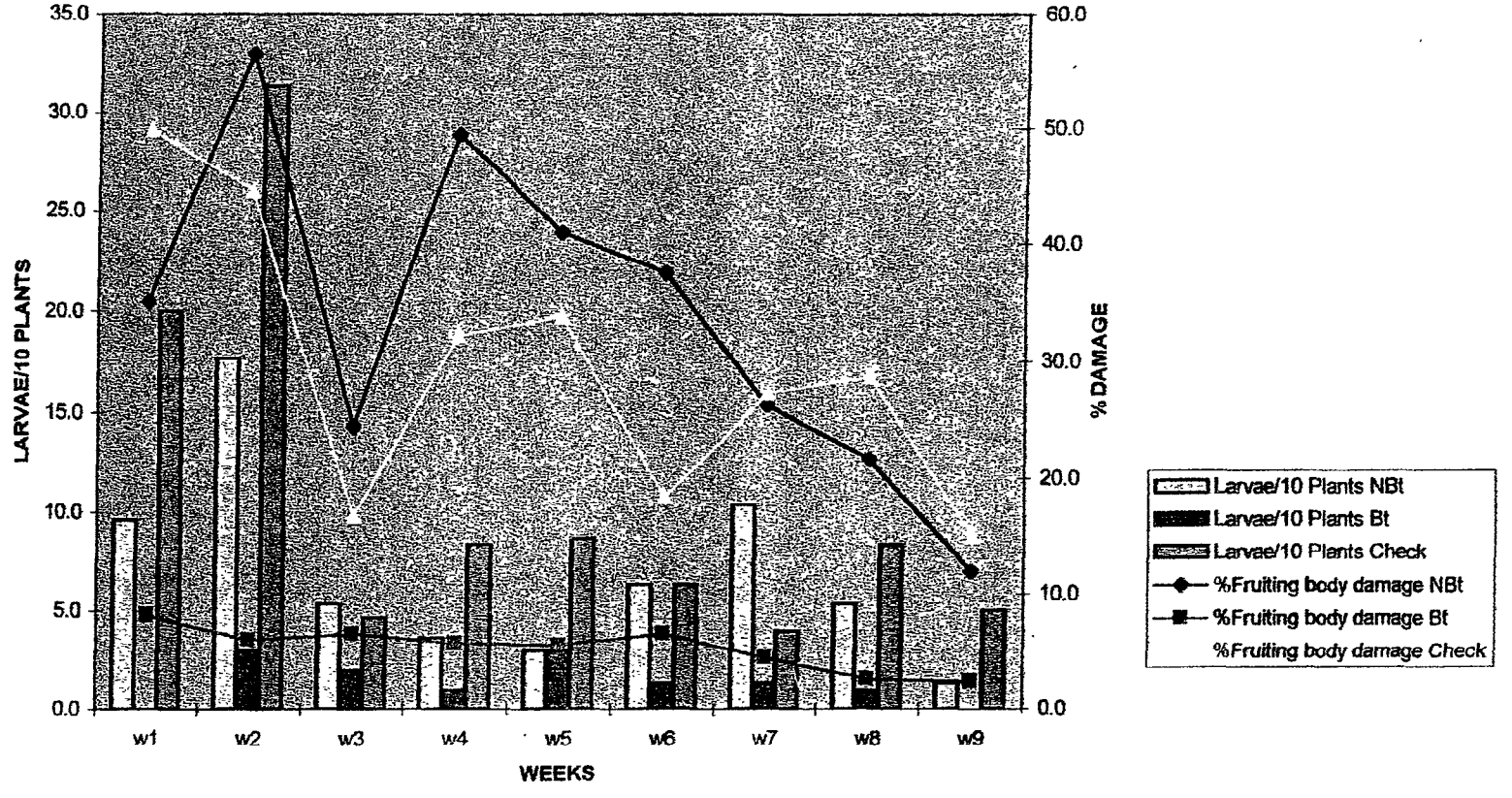


FIG: AP-5 POPULATION OF BOLLWORMS AND % FRUITING BODY DAMAGE AT DENDUKUR,KHAMMAM

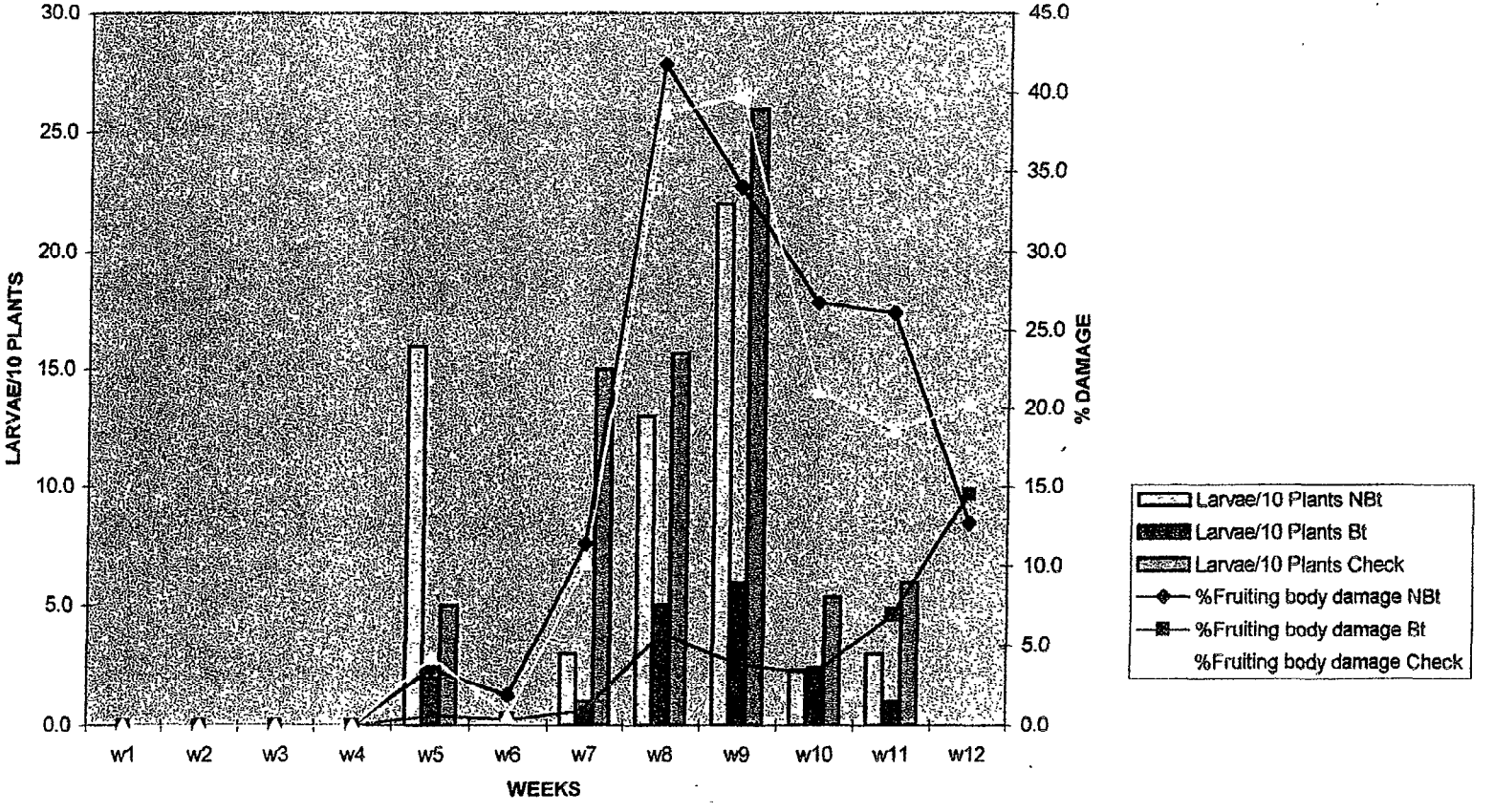


FIG: AP-6 POPULATION OF BOLLWORMS AND %FRUITING BODY DAMAGE AT NAGATUR KURNOOL

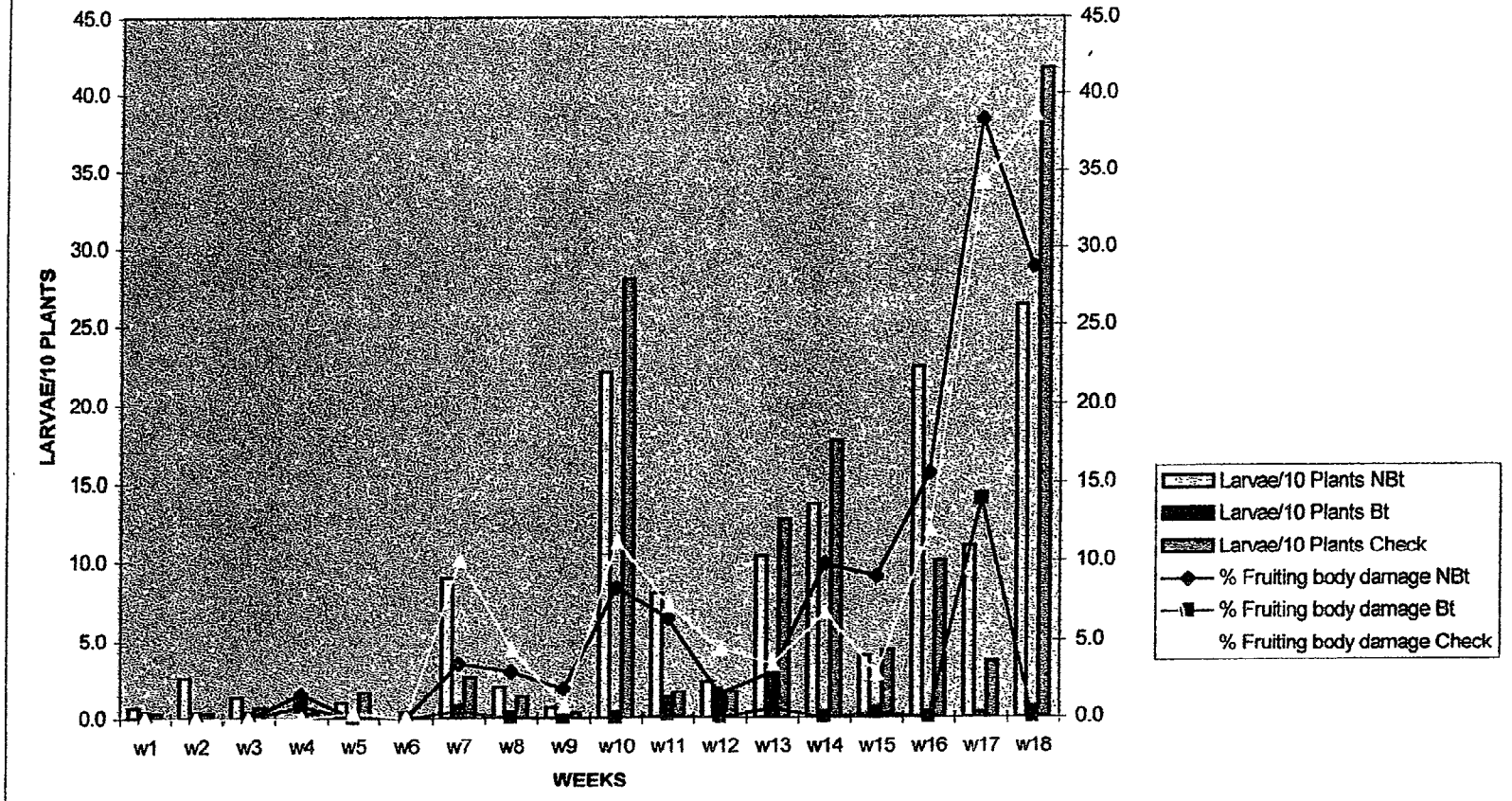


FIG: AP-7 POPULATION OF BOLLWORMS AND % FRUITING BODY DAMAGE ON COTTON AT VURUGONDA,WARANGAL

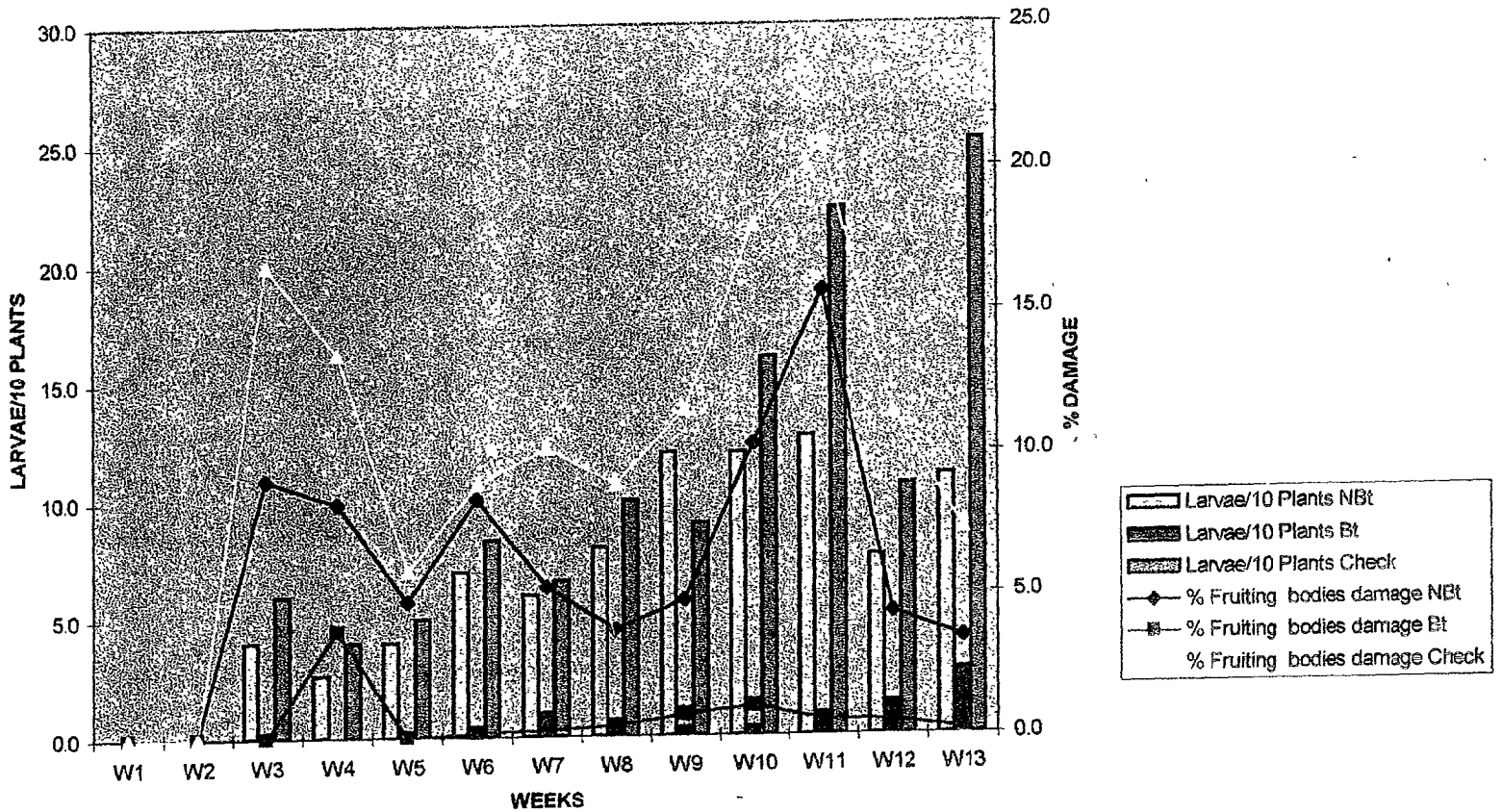
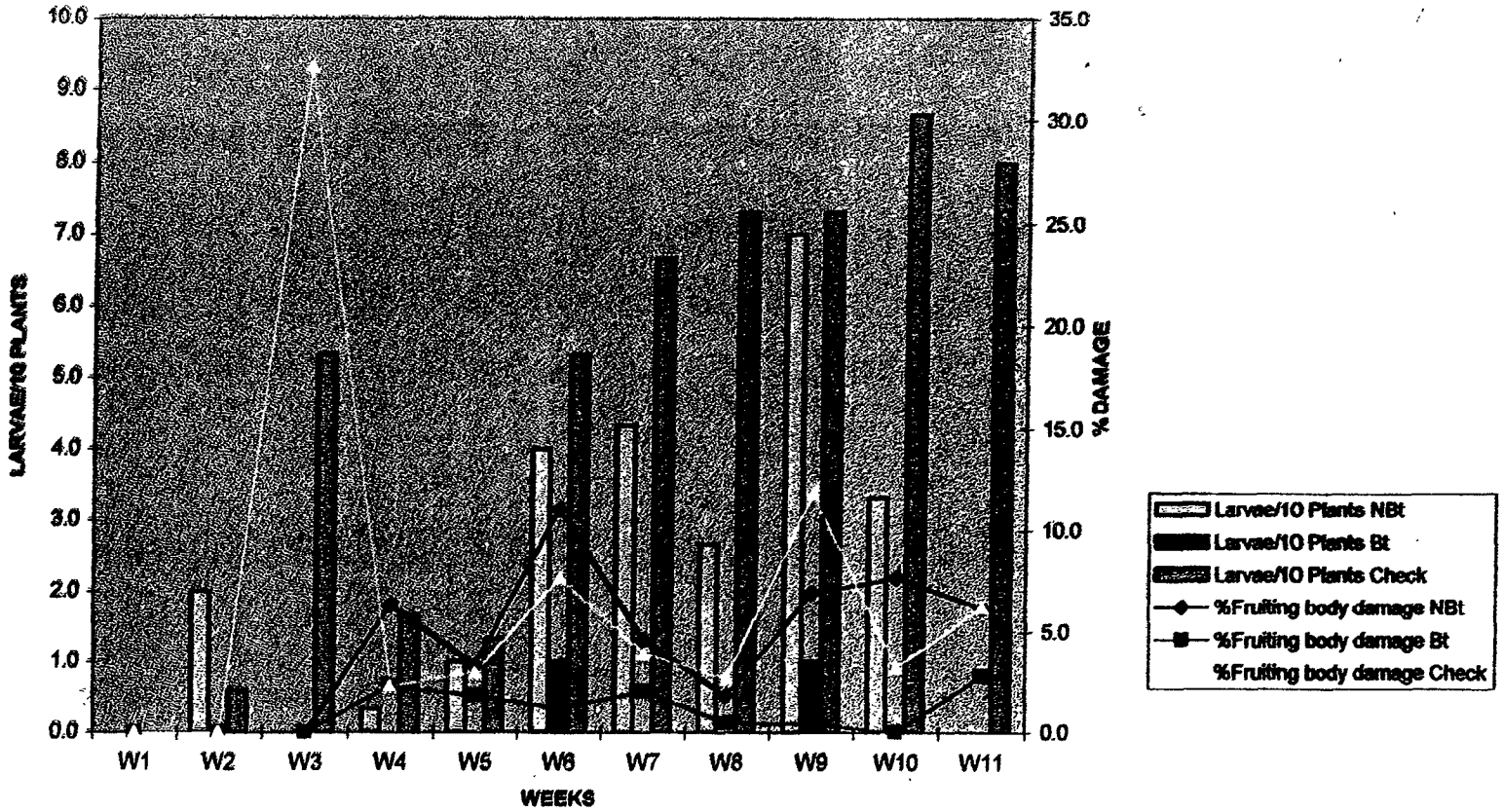


FIG: AP-8 POPULATION OF BOLLWORMS AND % FRUITING BODY DAMAGE AT KOTHAGADI,RANGAREDDY



PROTOCOL-2 REPORT

MAHARASHTRA

TABLES & FIGURES

FIG: AP-9 POPULATION OF BOLLWORMS AND % FRUITING BODY DAMAGE ON COTTON AT PONNARI,ADILABAD

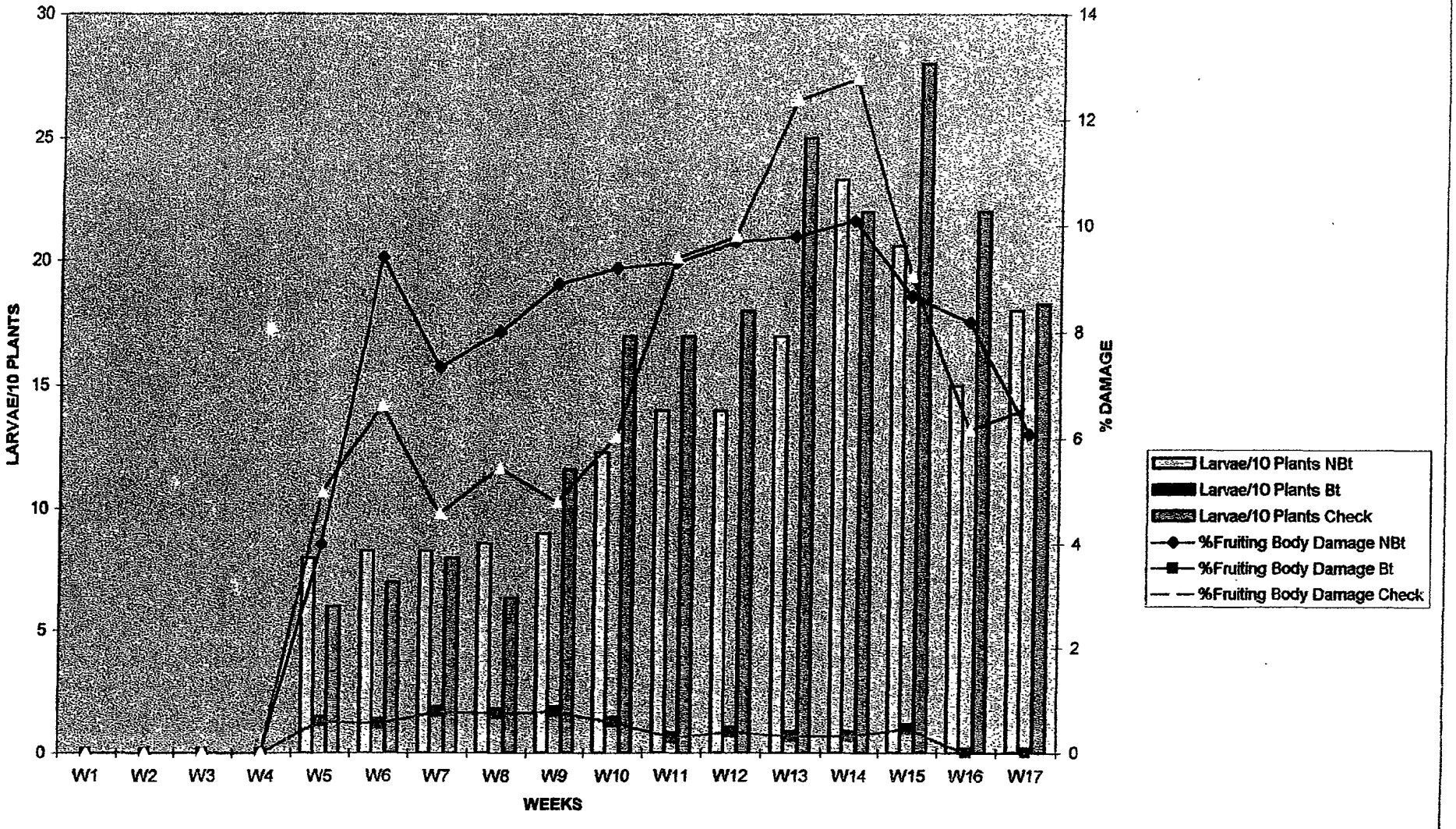


TABLE: MS-1 PERFORMANCE OF Bt OVER NON Bt COTTON HYBRIDS AT BOTH,YEOTMAL

S.No.	PARAMETERS	NON Bt (MECH-160)	Bt (MECH-160)	CHECK (NHH-44)
1	PLANT STAND / PLOT	480.0	478.0	475.0
2	WEIGHT OF FIRST PICKING(Kg)	19.8	35.2	31.0
3	WEIGHT OF SECOND PICKING(Kg)	9.5	18.5	20.3
4	WEIGHT OF THIRD PICKING(Kg)	10.1	25.7	22.8
5	WEIGHT OF FOURTH PICKING(Kg)	24.8	30.8	20.2
6	YIELD Kg / PLOT	64.2	110.2	94.3
7	YIELD Kg / Ha	1585.1	2720.0	2328.3
8	% YIELD INCREASE OVER NON Bt AND CHEC	72.0		17.0
9	NO. OF SPRAYS FOR LEPIDOPTERANS	4.0	0.0	4.0
10	PERCENT BAD COTTON	10.2	1.6	12.6
11	PERCENT LOCULE DAMAGE	8.4	0.4	5.5
12	AVERAGE NO OF BOLLWORMS			
	LARVAE/10 PLANTS			
	a) 0 - 60 DAS	0.7	0.3	0.8
	b) 61 - 90 DAS	2.4	0.2	1.7
	c) 91 - 120 DAS	2.9	0.2	3.0
	d) > 120 DAS	5.9	0.7	4.5
13	AVERAGE %FRUITING BODY			
	DAMAGE			
	a) 0 - 60 DAS	0.0	0.0	0.0
	b) 61 - 90 DAS	3.3	0.1	3.9
	c) 91 - 120 DAS	3.3	0.1	2.1
	d) > 120 DAS	5.9	0.7	5.2
14	AVERAGE NO. OF JASSIDS/30 LEAVES			
	a) 0 - 60 DAS	9.0	6.5	14.4
	b) 61 - 90 DAS	46.8	44.1	41.8
	c) 91 - 120 DAS	27.1	36.6	35.0
	d) > 120 DAS	71.5	61.5	65.3
15	AVERAGE NO. OF WHITE FLY/30 LEAVES			
	a) 0 - 60 DAS	38.4	37.2	48.5
	b) 61 - 90 DAS	270.0	234.5	235.1
	c) 91 - 120 DAS	114.7	81.5	84.6
	d) > 120 DAS	224.7	157.9	173.0
16	AVERAGE NO. OF APHIDS/30 LEAVES			
	a) 0 - 60 DAS	130.9	209.1	150.2
	b) 61 - 90 DAS	55.6	48.7	46.3
	c) 91 - 120 DAS	17.2	12.2	12.0
	d) > 120 DAS	3.5	5.2	2.0

REMARKS :In Bt cotton plot per cent yield increase was more over non - Bt as compare to check Overall field condition was excellent

TABLE: MS-2 PERFORMANCE OF Bt OVER NON Bt COTTON HYBRIDS AT JALNA,VIREGAON

S.No.	PARAMETERS	NON Bt (MECH-162)	Bt (MECH-162)	CHECK (NHH-44)
1	PLANT STAND / PLOT	498.0	496.0	499.0
2	WEIGHT OF FIRST PICKING(Kg)	25.0	28.0	12.0
3	WEIGHT OF SECOND PICKING(Kg)	17.0	20.0	13.0
4	WEIGHT OF THIRD PICKING(Kg)	11.0	16.0	10.0
5	WEIGHT OF FOURTH PICKING(Kg)	11.0	19.0	12.0
6	YIELD Kg / PLOT	64.0	83.0	47.0
7	YIELD Kg / Ha	1580.2	2049.5	1160.0
8	% YIELD INCREASE OVER NON Bt AND CHEC	30.0		77.0
9	NO. OF SPRAYS FOR LEPIDOPTERANS	7.0	1.0	7.0
10	PERCENT LOCULE DAMAGE	12.0	2.0	9.0
11	AVERAGE NO. OF BOLLWORMS LARVAE			
	PER 10 PLANTS			
	a) 0 - 60 DAS	0.0	0.0	0.0
	b) 61 - 90 DAS	10.3	0.0	8.3
	c) 91 - 120 DAS	12.5	2.9	13.8
	d) > 120 DAS	1.7	0.6	2.7
12	AVERAGE %FRUITING BODY			
	DAMAGE			
	a) 0 - 60 DAS	0.0	0.0	0.0
	b) 61 - 90 DAS	9.0	0.3	12.0
	c) 91 - 120 DAS	6.5	0.9	4.9
	d) > 120 DAS	2.0	0.2	1.2
13	AVERAGE NO. OF JASSIDS/30 LEAVES			
	a) 0 - 60 DAS	13.6	15.1	19.3
	b) 61 - 90 DAS	15.5	24.6	7.6
	c) 91 - 120 DAS	3.2	3.1	3.5
	d) > 120 DAS	0.0	0.0	0.0
14	AVERAGE NO. OF WHITE FLY/30 LEAVES			
	a) 0 - 60 DAS	38.8	35.5	37.5
	b) 61 - 90 DAS	65.5	65.6	68.2
	c) 91 - 120 DAS	93.0	95.0	100.2
	d) > 120 DAS	39.3	26.6	25.8
15	AVERAGE NO. OF APHIDS/30 LEAVES			
	a) 0 - 60 DAS	60.0	59.2	42.5
	b) 61 - 90 DAS	36.7	68.3	30.8
	c) 91 - 120 DAS	22.5	69.1	34.2
	d) > 120 DAS	9.9	16.7	9.9

REMARKS :In Bt plot bollworm larvae crossed the threshold once and thus treated by recommended insecticides.The yield increase in Bt plot over check was more as compare to non - Bt.

TABLE: MS-3 PERFORMANCE OF Bt OVER NON Bt COTTON HYBRIDS AT KOLHA,PARBHANI

S.No.	PARAMETERS	NON Bt (MECH-12)	Bt (MECH-12)	CHECK (NHH-44)
1	PLANT STAND / PLOT	482.0	480.0	480.0
2	WEIGHT OF FIRST PICKING(Kg)	6.3	22.0	3.3
3	WEIGHT OF SECOND PICKING(Kg)	5.5	11.3	4.0
4	WEIGHT OF THIRD PICKING(Kg)	13.5	4.5	14.0
5	WEIGHT OF FOURTH PICKING(Kg)	33.0	25.0	32 0
6	YIELD Kg / PLOT	58.3	62.8	53.3
7	YIELD Kg / Ha	1438.3	1549.4	1314.8
8	% YIELD INCREASE OVER NON Bt AND CHEC	8.0		18.0
9	NO. OF SPRAYS FOR LEPIDOPTERANS	7 0	2.0	7.0
10	PERCENT BAD COTTON	4.0	1.5	2.5
11	PERCENT LOCULE DAMAGE	3.0	1.4	3.1
12	AVERAGE NO. OF BOLLWORMS			
	LARVAE/10 PLANTS			
	a) 0 - 60 DAS	7.1	0.0	7.2
	b) 61 - 90 DAS	9.5	3.6	12.7
	c) 91 - 120 DAS	7.7	3.2	7.5
	d) > 120 DAS	2.5	0.3	3.8
13	AVERAGE %FRUITING BODY			
	DAMAGE			
	a) 0 - 60 DAS	6.9	0.0	10.2
	b) 61 - 90 DAS	10.6	2.5	15.3
	c) 91 - 120 DAS	6.1	2.9	5.5
	d) > 120 DAS	2.2	1.4	2.7
14	AVERAGE NO. OF JASSIDS/30 LEAVES			
	a) 0 - 60 DAS	46.2	48.6	29.8
	b) 61 - 90 DAS	55.5	57.6	51.6
	c) 91 - 120 DAS	44.2	46.7	35.4
	d) > 120 DAS	19.1	18.6	12.4
15	AVERAGE NO. OF WHITE FLY/30 LEAVES			
	a) 0 - 60 DAS	22.7	27.5	17.0
	b) 61 - 90 DAS	23.4	18.4	20.2
	c) 91 - 120 DAS	42.0	36.6	51.2
	d) > 120 DAS	23.0	20.9	16.7
16	AVERAGE NO. OF APHIDS/30 LEAVES			
	a) 0 - 60 DAS	7.3	8.2	3.2
	b) 61 - 90 DAS	5.0	6.4	5.5
	c) 91 - 120 DAS	1.7	0.7	1.7
	d) > 120 DAS	6.5	10.0	9.1

REMARKS :In Bt plot bollworm larvae crossed the threshold twice and treated by recommended insecticides.The yield increase in Bt was more over check as compare to corresponding non - Bt plot

TABLE: MS-4 PERFORMANCE OF Bt OVER NON Bt COTTON HYBRIDS AT BARAD,NANDED

S.No.	PARAMETERS	NON Bt (MECH-160)	Bt (MECH-160)	CHECK (NHH-44)
1	PLANT STAND / PLOT	482.0	476.0	480.0
2	WEIGHT OF FIRST PICKING(Kg)	34.0	45.0	37.0
3	WEIGHT OF SECOND PICKING(Kg)	19.0	21.0	17.0
4	WEIGHT OF THIRD PICKING(Kg)	15.0	14.0	11.0
6	YIELD Kg / PLOT	68.0	80.0	65.0
7	YIELD Kg / Ha	1679.0	1975.0	1604.0
8	% YIELD INCREASE OVER NON Bt AND CHEC	18.0		23.0
9	NO. OF SPRAYS FOR LEPIDOPTERANS	2.0	0.0	2.0
10	PERCENT BAD COTTON	1.7	0.1	2.9
11	PERCENT LOCULE DAMAGE	0.9	0.4	1.5
12	AVERAGE NO. OF BOLLWORMS			
	LARVAE/10 PLANTS			
	a) 0 - 60 DAS	1.7	0.3	1.2
	b) 61 - 90 DAS	3.8	0.2	3.6
	c) 91 - 120 DAS	3.7	0.9	3.4
	d) > 120 DAS	1.6	0.3	2.3
13	AVERAGE %FRUITING BODY			
	DAMAGE			
	a) 0 - 60 DAS	0.0	0.0	0.0
	b) 61 - 90 DAS	3.6	0.1	2.9
	c) 91 - 120 DAS	4.3	0.5	3.8
	d) > 120 DAS	1.2	0.2	1.9
14	AVERAGE NO. OF JASSIDS/30 LEAVES			
	a) 0 - 60 DAS	30.3	31.4	35.0
	b) 61 - 90 DAS	29.2	35.5	34.7
	c) 91 - 120 DAS	39.1	41.6	49.3
	d) > 120 DAS	15.9	15.8	18.0
15	AVERAGE NO. OF WHITE FLY/30 LEAVES			
	a) 0 - 60 DAS	10.8	6.1	6.0
	b) 61 - 90 DAS	26.8	28.8	24.9
	c) 91 - 120 DAS	35.5	36.0	40.4
	d) > 120 DAS	28.3	29.3	34.3
16	AVERAGE NO. OF APHIDS/30 LEAVES			
	a) 0 - 60 DAS	77.7	59.3	66.1
	b) 61 - 90 DAS	20.7	18.9	16.0
	c) 91 - 120 DAS	0.0	0.0	0.0
	d) > 120 DAS	0.0	0.0	0.0

REMARKS :Per cent yield increase in Bt over check was more as compare to corresponding non - Bt. Coparatively low infestation was observed in this region.

TABLE: MS-5 PERFORMANCE OF Bt OVER NON Bt COTTON HYBRIDS AT LONWADI,BULDHANA

S.No.	PARAMETERS	NON Bt	Bt	CHECK
		(MECH-160)	(MECH-160)	(NHH-44)
1	PLANT STAND / PLOT	414.0	453.0	473.0
2	WEIGHT OF FIRST PICKING(Kg)	21.1	31.2	27.0
3	WEIGHT OF SECOND PICKING(Kg)	12.0	17.1	13.9
4	WEIGHT OF THIRD PICKING(Kg)	10.3	24.1	18.2
5	WEIGHT OF FOURTH PICKING(Kg)	5.7	11.5	11.5
6	YIELD Kg / PLOT	49.0	83.9	70.6
7	YIELD Kg / Ha	1209.8	2071.6	1743.2
8	% YIELD INCREASE OVER NON Bt AND CHEC	71.0		19.0
9	NO. OF SPRAYS FOR LEPIDOPTERANS	3.0	0.0	3.0
10	PERCENT BAD COTTON	17.0	0.5	13.5
11	PERCENT LOCULE DAMAGE	5.3	0.5	6.0
12	AVERAGE NO. OF BOLLWORMS			
	LARVAE/10 PLANTS			
	a) 0 - 60 DAS	4.6	0.5	4.9
	b) 61 - 90 DAS	4.4	0.8	4.3
	c) 91 - 120 DAS	2.5	0.7	4.7
	d) > 120 DAS	4.3	1.3	4.6
13	AVERAGE %FRUITING BODY			
	DAMAGE			
	a) 0 - 60 DAS	3.4	0.1	4.4
	b) 61 - 90 DAS	5.7	0.3	5.3
	c) 91 - 120 DAS	2.3	0.3	2.5
	d) > 120 DAS	4.1	1.2	4.8
14	AVERAGE NO. OF JASSIDS/30 LEAVES			
	a) 0 - 60 DAS	20.9	24.3	19.4
	b) 61 - 90 DAS	9.2	13.3	23.2
	c) 91 - 120 DAS	20.7	21.0	23.7
	d) > 120 DAS	28.4	25.6	25.8
15	AVERAGE NO. OF WHITE FLY/30 LEAVES			
	a) 0 - 60 DAS	168.3	181.6	168.5
	b) 61 - 90 DAS	66.4	52.1	51.6
	c) 91 - 120 DAS	26.9	21.2	21.8
	d) > 120 DAS	36.8	34.7	43.8
16	AVERAGE NO. OF BENEFICIALS/10 PLANTS			
	a) 0 - 60 DAS	5.1	7.4	3.1
	b) 61 - 90 DAS	11.5	13.1	3.6
	c) 91 - 120 DAS	2.0	3.2	2.2
	d) > 120 DAS	2.4	2.0	1.6

REMARKS :Per cent yield increase in Bt plots was more over corresponding non - Bt as compare to check.

TABLE:MS-6 PERFORMANCE OF Bt OVER NON Bt COTTON HYBRIDS AT UMBERKHED,JALGAON

S.No.	PARAMETERS	NON Bt (MECH-3)	Bt (MECH-3)	CHECK (NHH-44)
1	PLANT STAND / PLOT	470.0	444.0	435.0
2	WEIGHT OF FIRST PICKING(Kg)	26.0	32.0	33.0
3	WEIGHT OF SECOND PICKING(Kg)	40.0	36.0	35.0
4	WEIGHT OF THIRD PICKING(Kg)	32.0	35.0	38.0
5	WEIGHT OF FOURTH PICKING(Kg)	17.0	19.0	12.0
6	YIELD Kg / PLOT	115.0	122.0	118.0
7	YIELD Kg / Ha	2839.0	3012.0	2914.0
8	% YIELD INCREASE OVER NON Bt AND CHEC	6.0		3.0
9	NO. OF SPRAYS FOR LEPIDOPTERANS	2.0	0.0	2.0
10	AVERAGE NO. OF BOLLWORMS			
	LARVAE/10 PLANTS			
	a) 0 - 60 DAS	0.0	0.0	0.0
	b) 61 - 90 DAS	4.2	0.0	1.8
	c) 91 - 120 DAS	4.4	0.8	2.3
	d) > 120 DAS	2.0	0.0	1.3
11	AVERAGE %FRUITING BODY			
	DAMAGE			
	a) 0 - 60 DAS	0.0	0.0	0.0
	b) 61 - 90 DAS	5.1	0.0	5.2
	c) 91 - 120 DAS	6.2	0.6	12.2
	d) > 120 DAS	5.6	0.0	3.5
14	AVERAGE NO. OF JASSIDS/30 LEAVES			
	a) 0 - 60 DAS	70.5	62.3	62.1
	b) 61 - 90 DAS	46.2	56.3	49.4
	c) 91 - 120 DAS	35.9	37.9	26.1
	d) > 120 DAS	17.3	17.8	18.7
15	AVERAGE NO. OF WHITE FLY/30 LEAVES			
	a) 0 - 60 DAS	8.7	7.9	80.8
	b) 61 - 90 DAS	142.0	144.0	150.5
	c) 91 - 120 DAS	132.9	93.1	121.0
	d) > 120 DAS	24.6	26.5	27.8
16	AVERAGE NO. OF BENEFICIALS/10 PLANTS			
	a) 0 - 60 DAS	15.8	15.0	6.6
	b) 61 - 90 DAS	20.0	15.0	3.3
	c) 91 - 120 DAS	2.5	10.0	4.2
	d) > 120 DAS	0.8	1.7	0.0

REMARKS :Average infestation of bollworms was low in the region.The yield increase over non - Bt was high as compare to check.

Fig : MS-1 YIELD OF Bt AND NON Bt COTTON HYBRIDS IN MAHARASHTRA

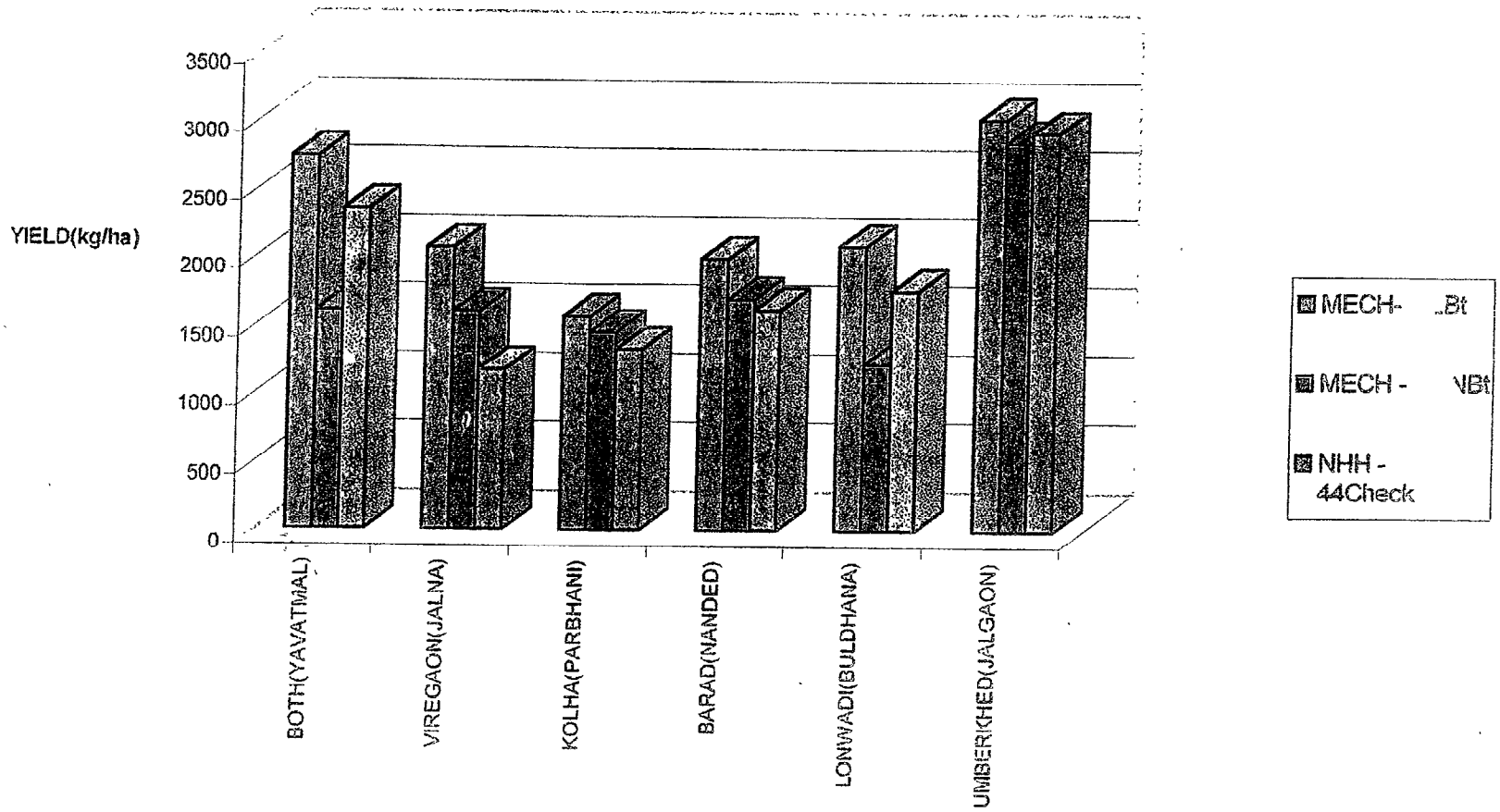


Fig : MS-2 COMPARATIVE SPRAYING FOR BOLLWORM COMPLEX ON Bt AND NON Bt COTTON HYBRIDS IN MAHARASHTRA

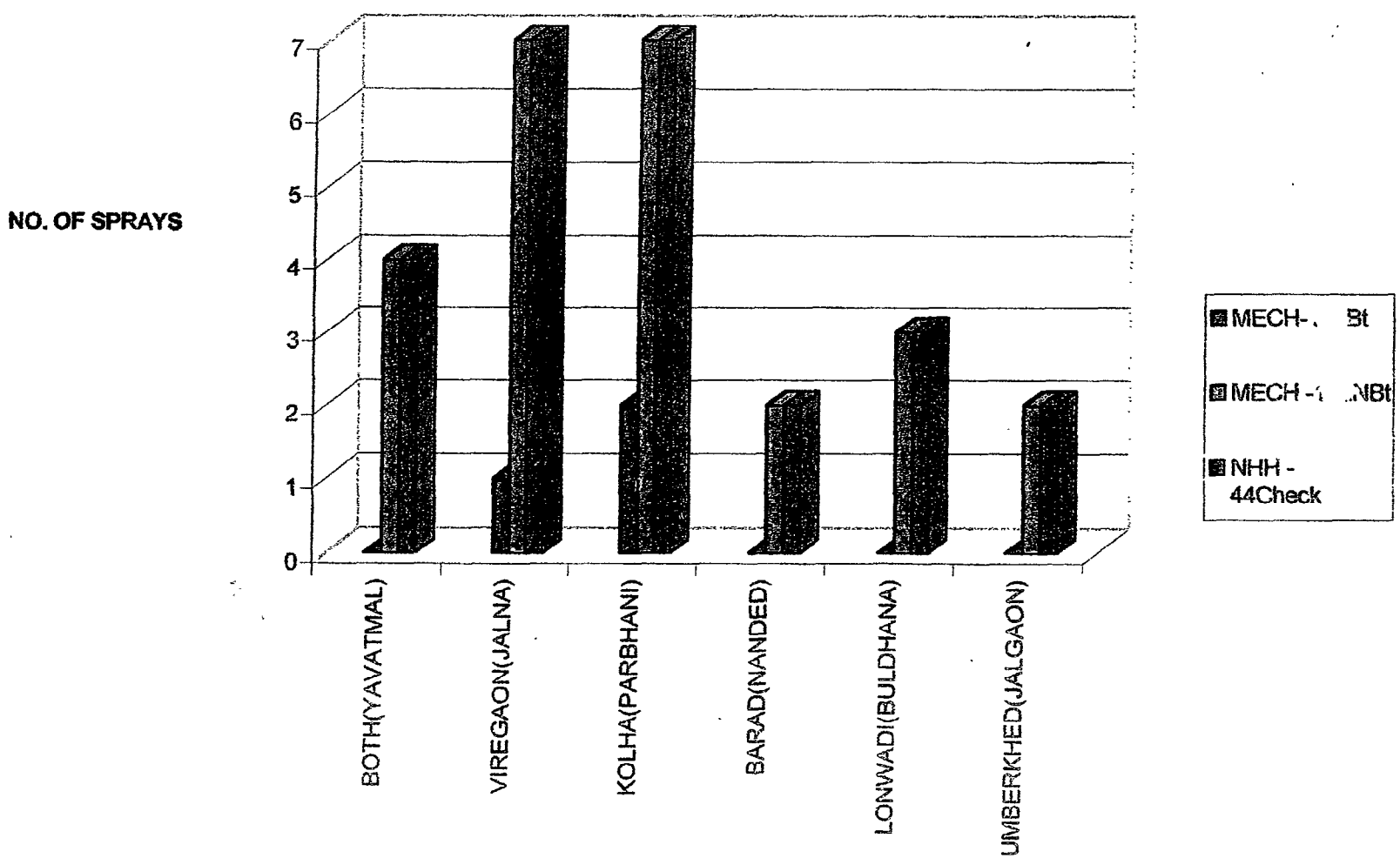


FIG: MS-3 POPULATION OF BOLLWORMS AND % FRUITING BODY DAMAGE ON COTTON AT BOTH,YEOTMAL

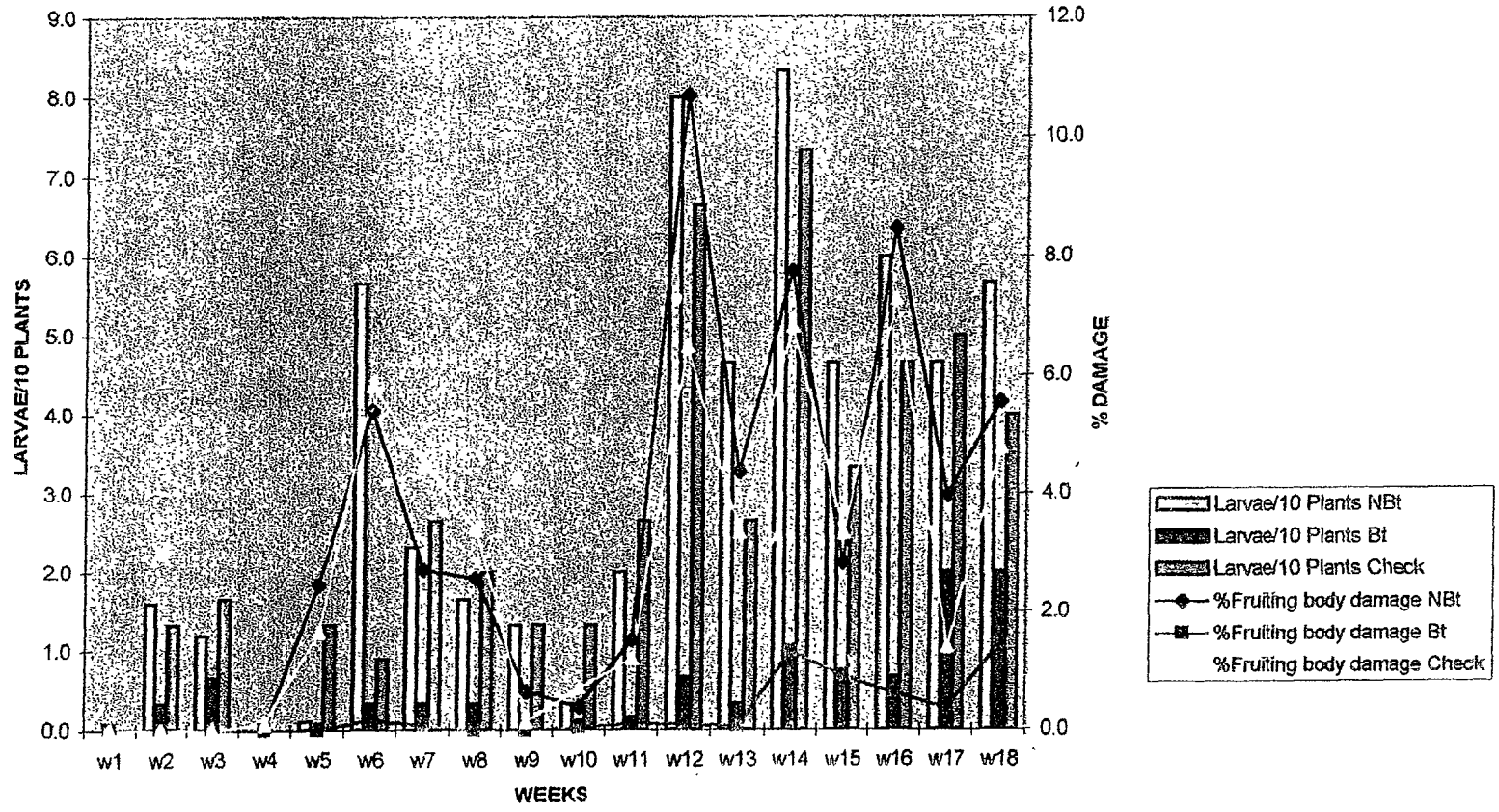


FIG: MS-4 POPULATION OF BOLLWORMS AND % FRUITING BODY DAMAGE ON COTTON AT VIREGAON,JALNA

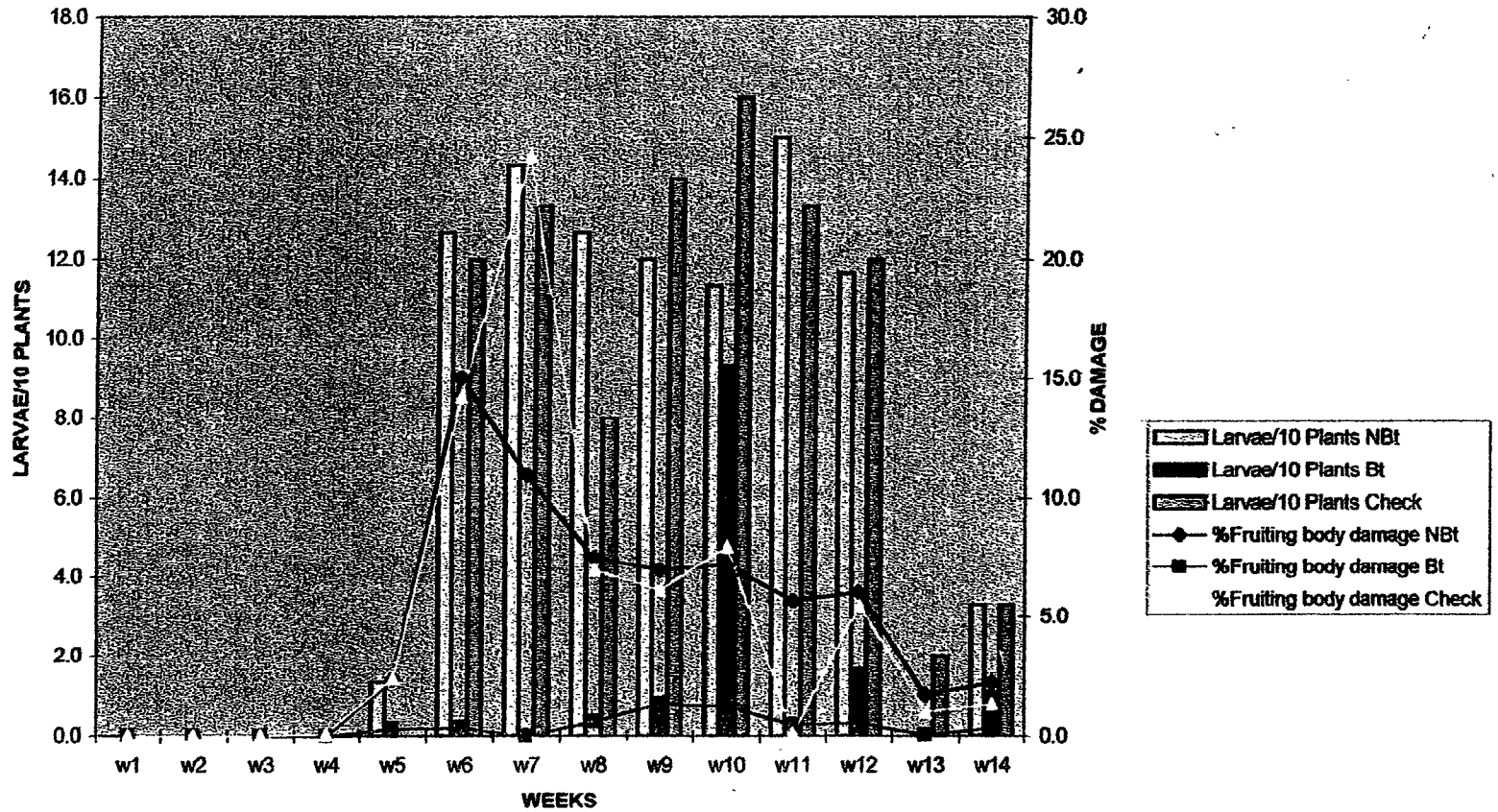


FIG: MS-5 POPULATION OF BOLLWORMS AND % FRUITING BODY DAMAGE ON COTTON AT KOLHA, PARBHANI

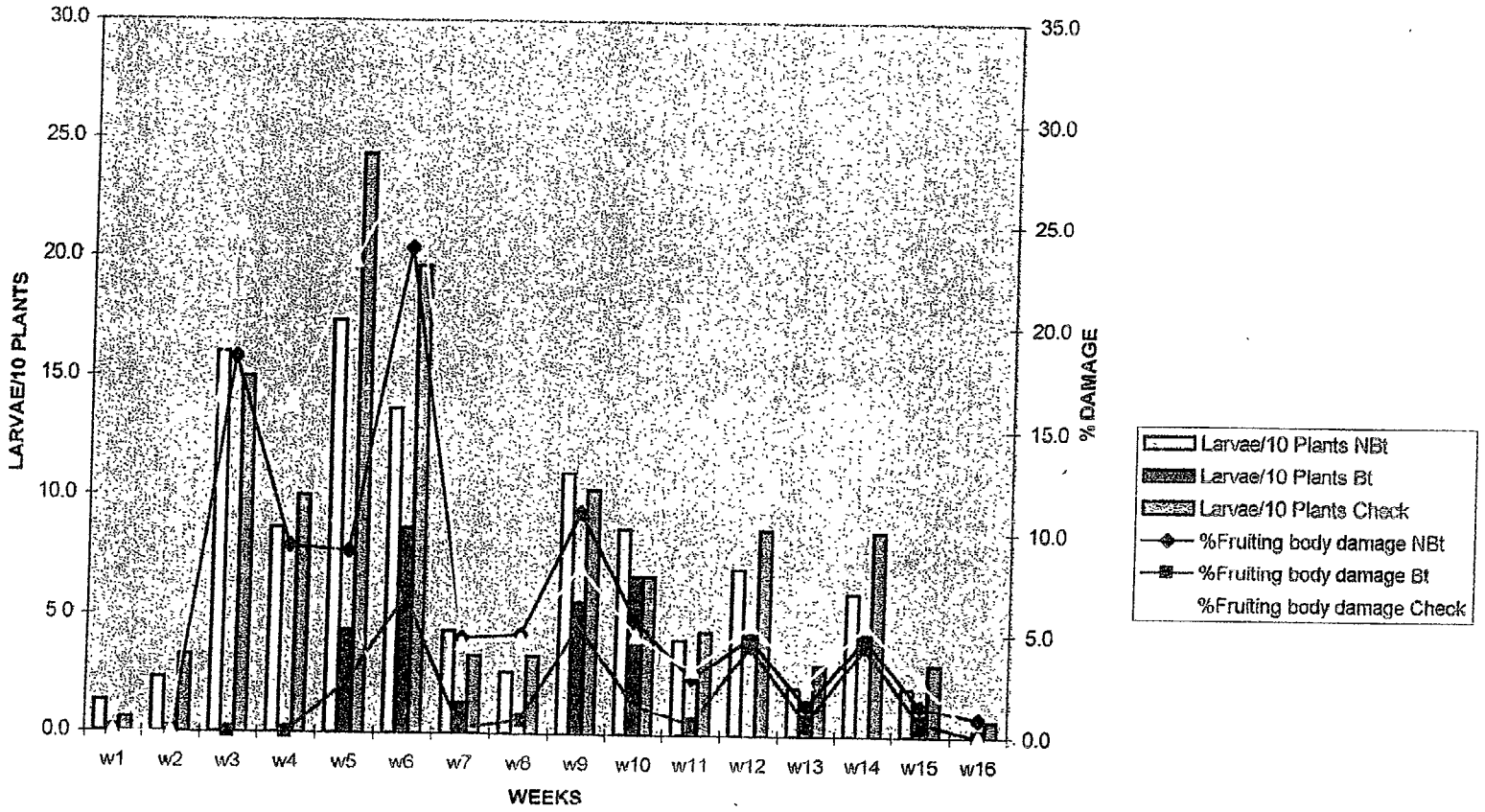


FIG: MS-6 POPULATION OF BOLLWORMS AND % FRUITING BODY DAMAGE ON COTTON AT BARAD,NANDED

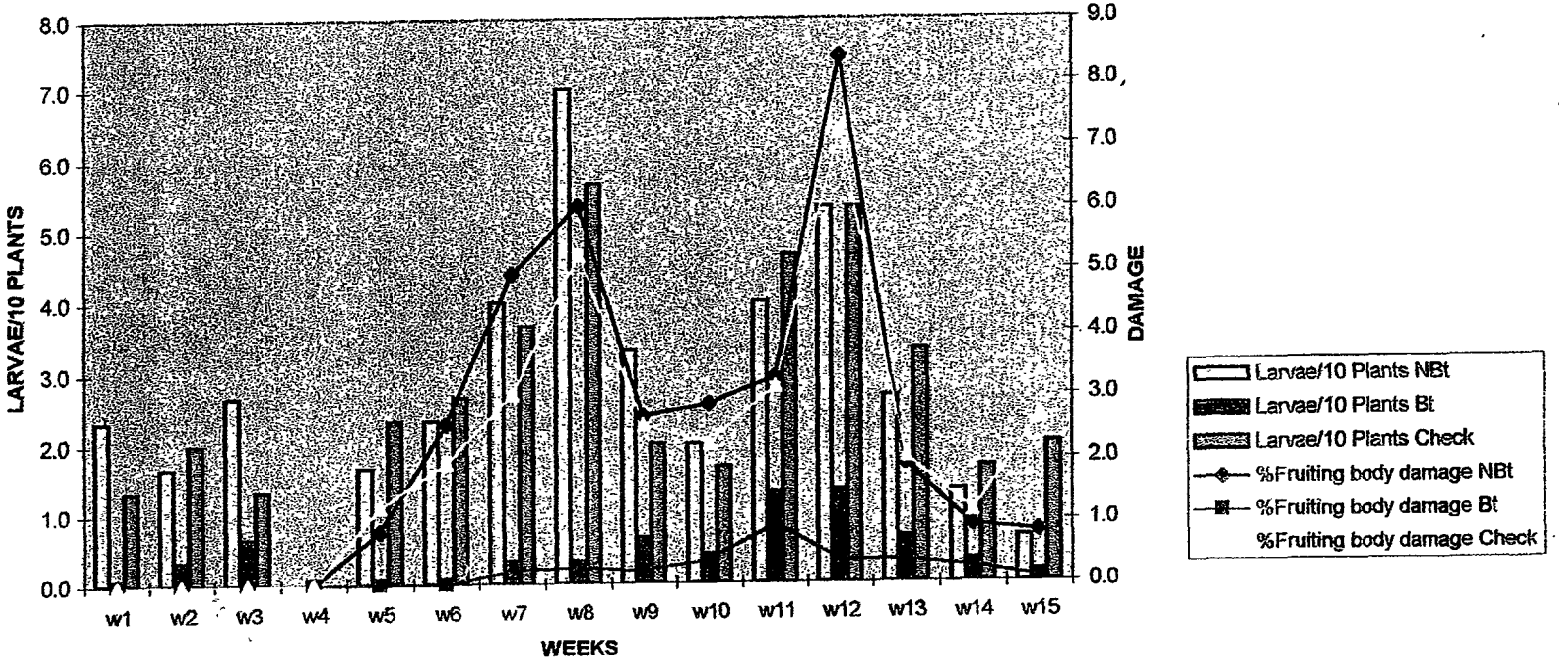


FIG: MS-7 POPULATION OF BOLLWORMS AND % FRUITING BODY DAMAGE ON COTTON AT LONWADI,BULDHANA

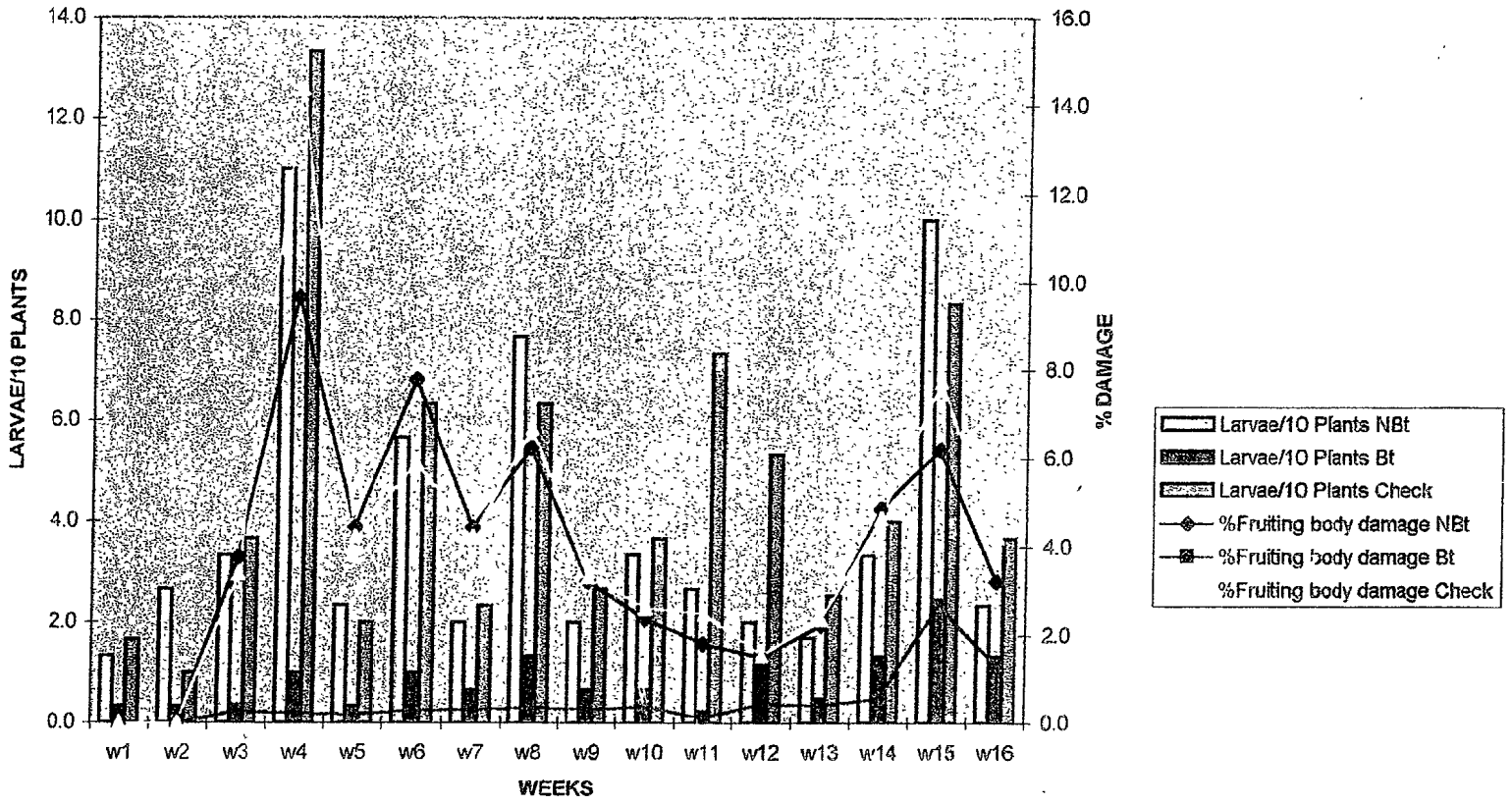
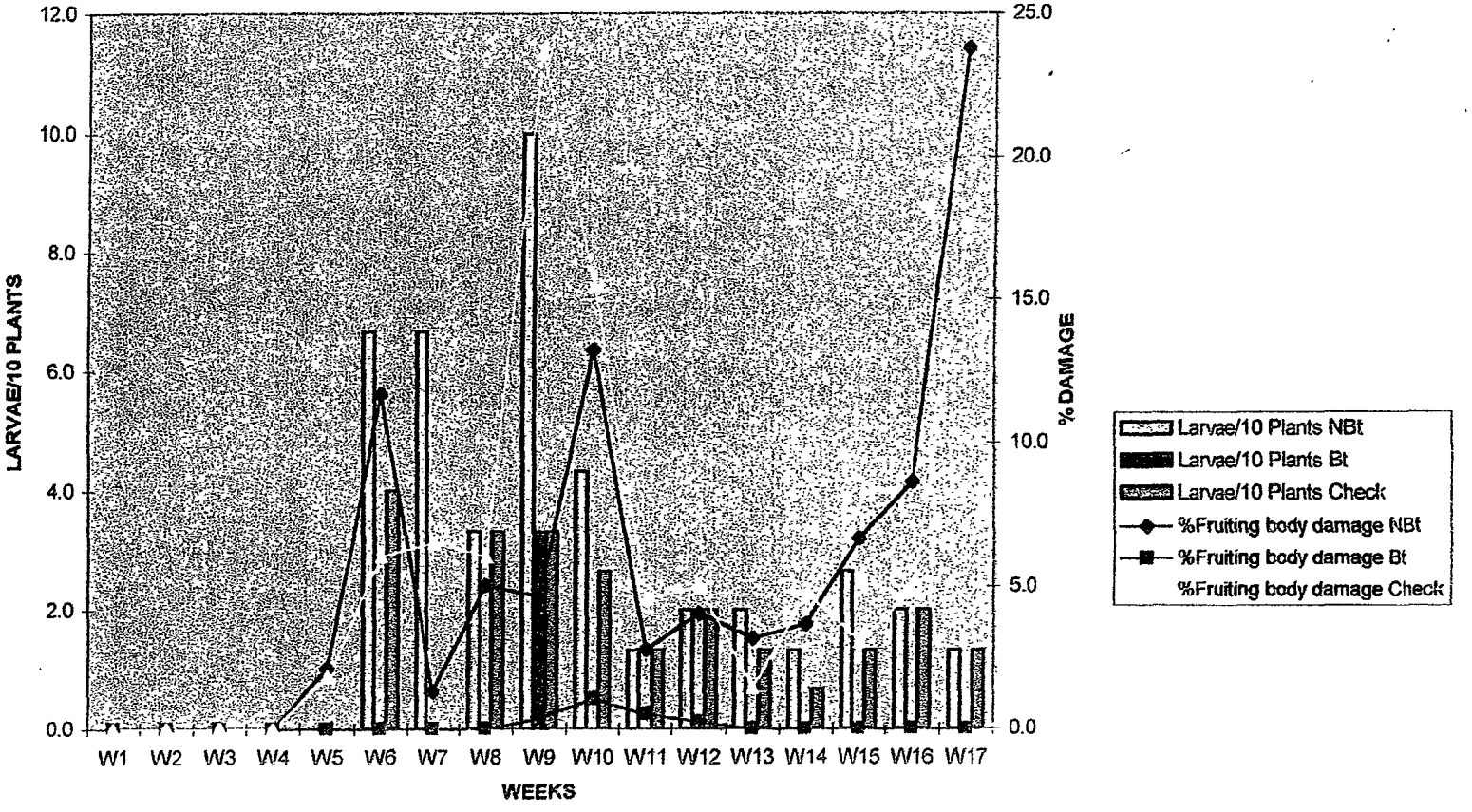


FIG: MS-8 POPULATION OF BOLLWORMS AND % FRUITING BODY DAMAGE ON COTTON AT UMBERKHED JALGAON



PROTOCOL-2 REPORT

GUJRAT

TABLES & FIGURES

TABLE: GJ-1 PERFORMANCE OF Bt OVER NON Bt COTTON HYBRIDS AT PINGARWADA,VADODARA

S.No.	PARAMETERS	NON Bt (MECH-3)	Bt (MECH-3)	CHECK (H-6)
1	PLANT STAND / PLOT	482.0	480.0	480.0
2	WEIGHT OF FIRST PICKING(Kg)	33.0	52.0	31.0
3	WEIGHT OF SECOND PICKING(Kg)	63.0	69.0	60.0
4	WEIGHT OF THIRD PICKING(Kg)	30.0	33.0	30.0
5	YIELD Kg / PLOT	126.0	154.0	121.0
6	YIELD Kg / Ha	2987.0	3802.0	3111.0
7	% YIELD INCREASE OVER NON Bt AND CHE	27.0		22.0
8	NO. OF SPRAYS FOR LEPIDOPTERANS	3.0	0.0	3.0
9	AVERAGE NO. OF BOLLWORMS			
	LARVAE/10 PLANTS			
	a) 0 - 60 DAS	5.7	1.2	2.8
	b) 61 - 90 DAS	1.1	0.4	3.0
	c) 91 - 120 DAS	4.1	1.0	7.7
	d) > 120 DAS	0.0	0.0	0.0
10	AVERAGE %FRUITING BODY			
	DAMAGE			
	a) 0 - 60 DAS	6.4	1.2	6.8
	b) 61 - 90 DAS	6.7	0.6	10.0
	c) 91 - 120 DAS	6.6	3.4	7.2
	d) > 120 DAS	0.0	0.0	0.0
11	AVERAGE NO. OF JASSIDS/30 LEAVES			
	a) 0 - 60 DAS	60.8	47.2	93.9
	b) 61 - 90 DAS	28.8	16.3	19.5
	c) 91 - 120 DAS	51.5	44.5	37.5
	d) > 120 DAS			
12	AVERAGE NO. OF WHITE FLY/30 LEAVES			
	a) 0 - 60 DAS	12.9	16.5	6.8
	b) 61 - 90 DAS	50.3	39.3	41.3
	c) 91 - 120 DAS	264.5	246.0	223.5
	d) > 120 DAS			
13	AVERAGE NO. OF BENEFICIALS/10 PLANTS			
	a) 0 - 60 DAS	34.8	51.7	27.3
	b) 61 - 90 DAS	19.0	23.2	23.2
	c) 91 - 120 DAS	0.0	6.7	3.3
	d) > 120 DAS			

REMARKS :Infestation of bollworms was very low on Bt plots as compare to non - Bt and check plots.

TABLE: GJ-2 PERFORMANCE OF Bt OVER NON Bt COTTON HYBRIDS AT BHUNANA,RAJKOT

S.No.	PARAMETERS	NON Bt	Bt	CHECK
		(MECH-162)	(MECH-162)	H-6
1	PLANT STAND / PLOT	484.0	494.0	469.0
2	WEIGHT OF FIRST PICKING(Kg)	17.3	100.0	33.0
3	WEIGHT OF SECOND PICKING(Kg)	40.0	39.8	29.0
4	WEIGHT OF THIRD PICKING(Kg)	23.5	21.2	40.0
5	WEIGHT OF FOURTH PICKING(Kg)			
6	YIELD Kg / PLOT	80.8	161.0	102.0
7	YIELD Kg / Ha	1995.0	3975.0	2578.0
8	% YIELD INCREASE OVER NON Bt AND CHE	99.0		54 0
9	NO. OF SPRAYS FOR LEPIDOPTERANS	11.0	3.0	11.0
10	PERCENT BAD COTTON	23.7	6.6	20.0
11	PERCENT LOCULE DAMAGE	23.7	6.6	19.3
12	AVERAGE NO. OF BOLLWORMS			
	LARVAE/10 PLANTS			
	a) 0 - 60 DAS	2.5	0.7	2.3
	b) 61 - 90 DAS	7.1	1.1	3.6
	c) 91 - 120 DAS	46.5	9.9	27.2
	d) > 120 DAS	6.3	0.0	7.0
13	AVERAGE %FRUITING BODY			
	DAMAGE			
	a) 0 - 60 DAS	0.9	0.0	0.4
	b) 61 - 90 DAS	12.0	1.4	10.5
	c) 91 - 120 DAS	19.7	3.4	11.0
	d) > 120 DAS	1.8	0.1	2.4
14	AVERAGE NO. OF JASSIDS/30 LEAVES			
	a) 0 - 60 DAS	2.5	3.3	6.5
	b) 61 - 90 DAS	42.3	19.3	37.3
	c) 91 - 120 DAS	31.0	8.0	8.0
	d) > 120 DAS	10.7	9.7	11.7
15	AVERAGE NO. OF WHITE FLY/30 LEAVES			
	a) 0 - 60 DAS	12.8	11.5	22.0
	b) 61 - 90 DAS	51.3	29.3	40.8
	c) 91 - 120 DAS	32.5	38.8	41.8
	d) > 120 DAS	12.0	13.0	13.0
16	AVERAGE NO OF BENEFICIALS/10 PLANTS			
	a) 0 - 60 DAS	8.7	6.8	3.2
	b) 61 - 90 DAS	6.5	5.6	6.1
	c) 91 - 120 DAS	0.9	1.2	0.2
	d) > 120 DAS	0.0	0.0	0.0

REMARKS The incidence of bollworms were very high in this location.Crop was also infested by *Spodoptera* sp

Fig : GJ-1 YIELD OF Bt AND NON Bt COTTON HYBRIDS IN GUJARAT

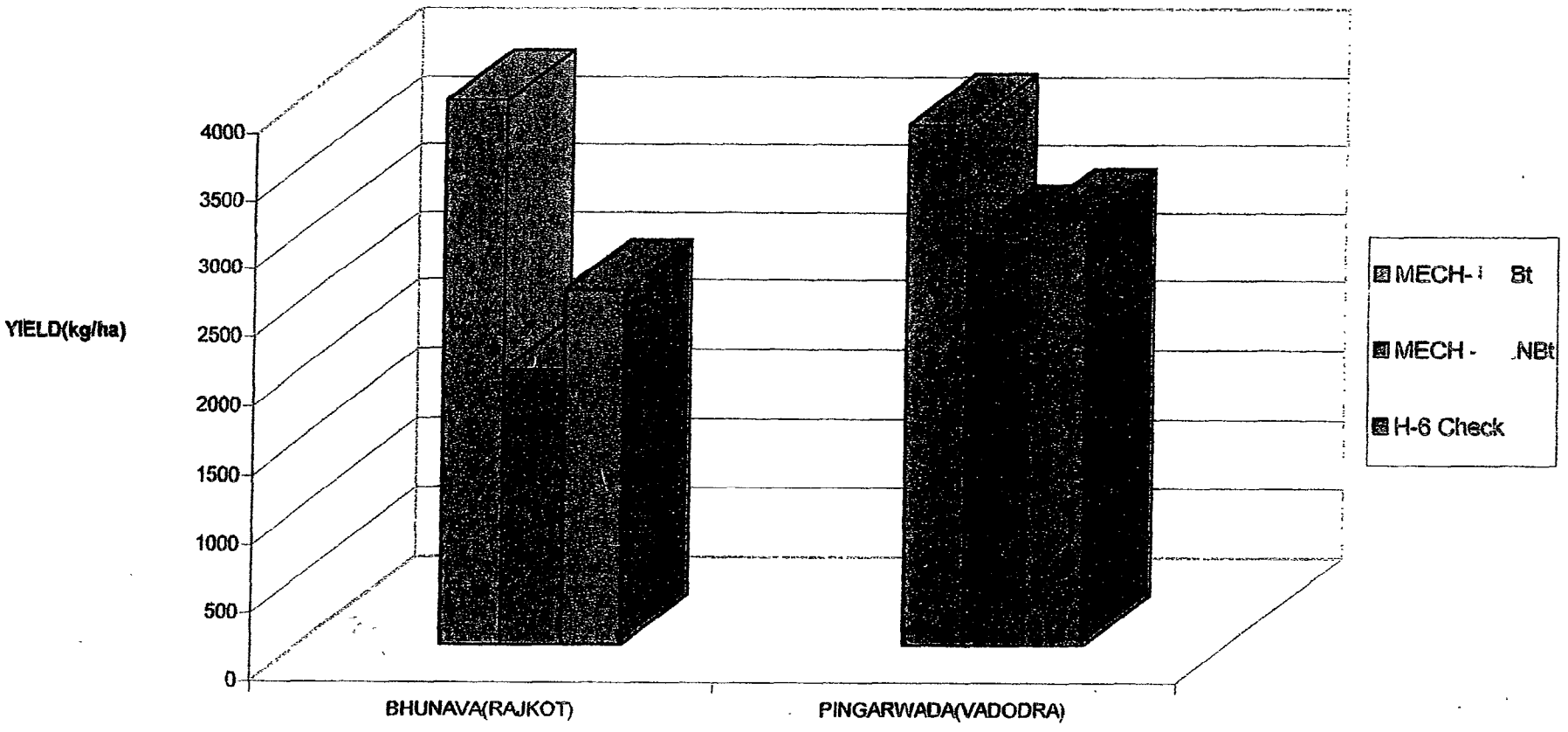


Fig : GJ-2 COMPARATIVE SPRAYING FOR BOLLWORM COMPLEX ON Bt AND NON Bt COTTON HYBRIDS IN GUJARAT

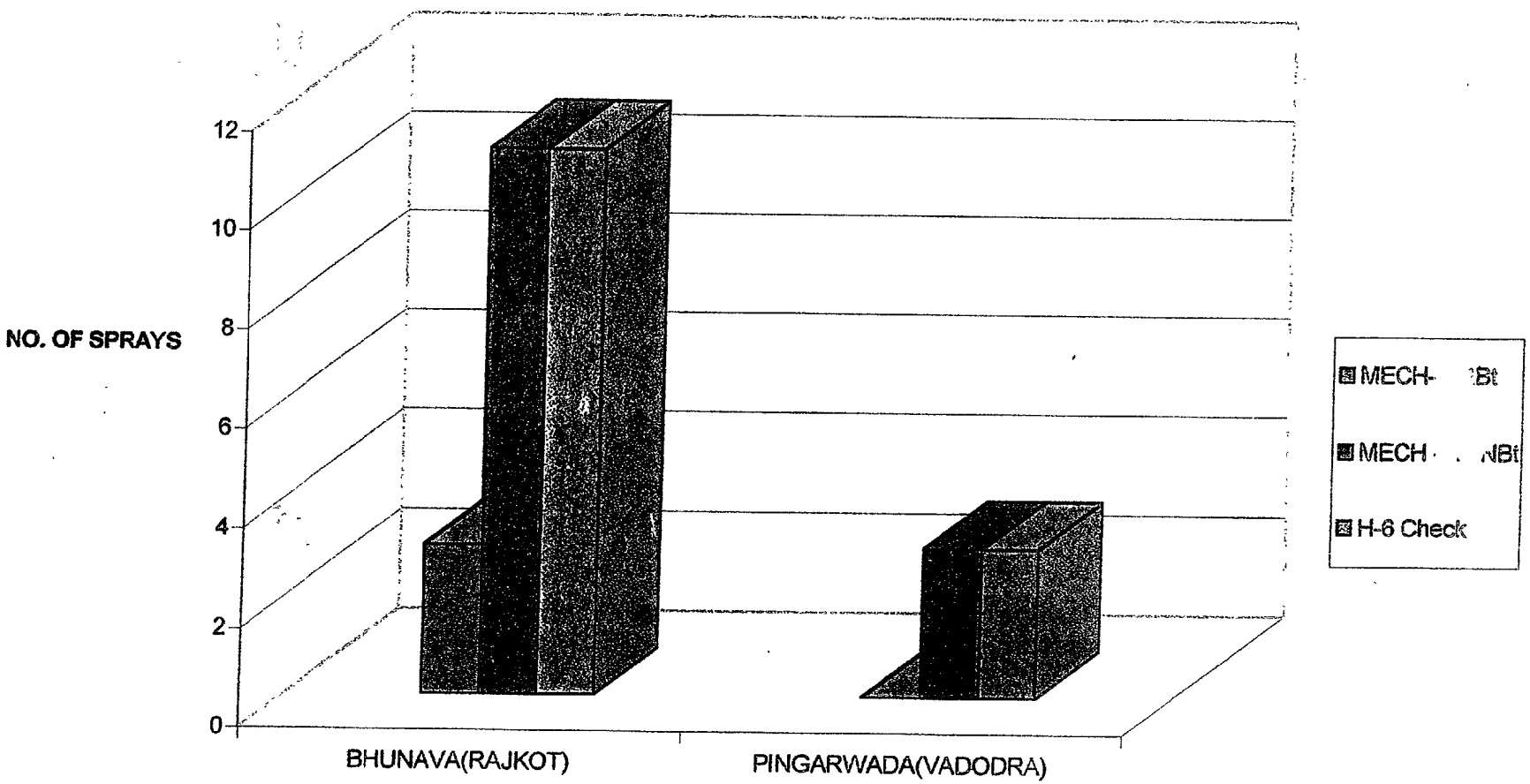


FIG: GJ-3 POPULATION OF BOLLWORMS AND % FRUITING BODY DAMAGE ON COTTON AT PINGARWADA,VADODRA

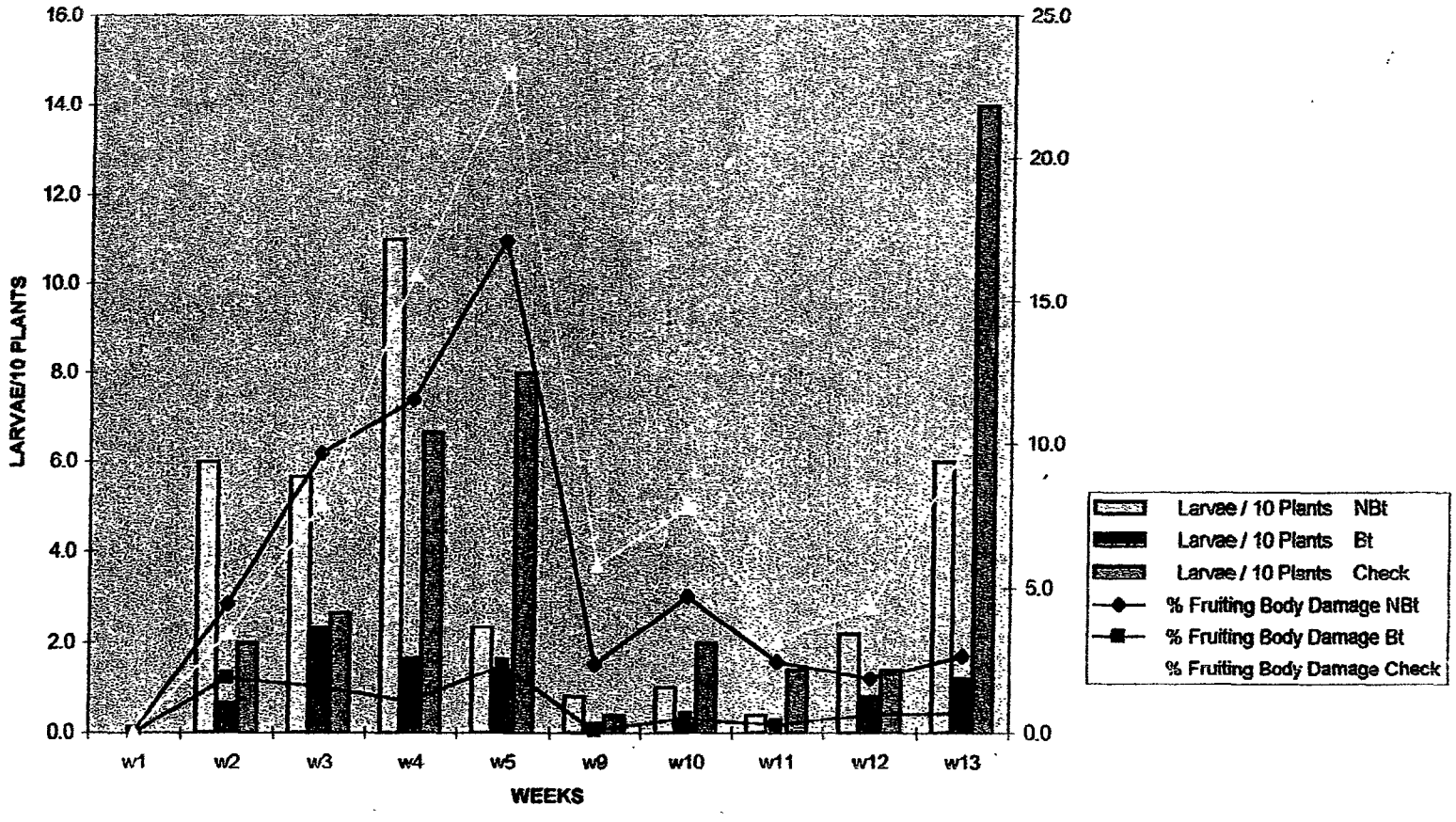
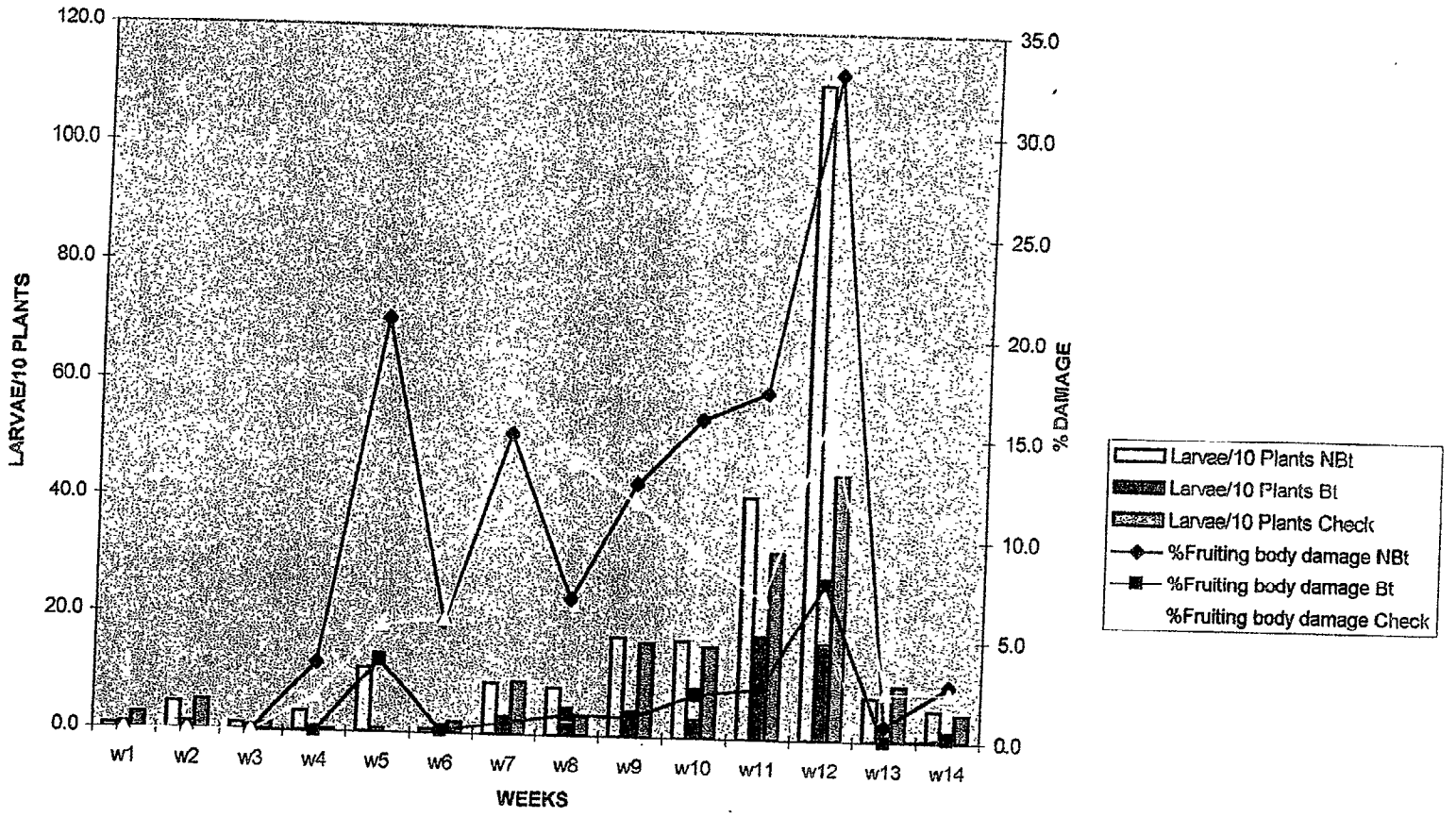


FIG: GJ-4 POPULATION OF BOLLWORMS AND % FRUITING BODY DAMAGE ON COTTON AT BHUNAVA,RAJCOT



PROTOCOL-2 REPORT

KARNATAKA

TABLES & FIGURES

TABLE: KTK-1 PERFORMANCE OF Bt OVER NON Bt COTTON HYBRIDS AT MALADAGUDDA,RAICHUR

S.No.	PARAMETERS	NON Bt (MECH-3)	Bt (MECH-3)	CHECK (NHH-44)
1	PLANT STAND / PLOT	286.0	280.0	290.0
2	WEIGHT OF FIRST PICKING(Kg)	3.6	7.1	4.5
3	WEIGHT OF SECOND PICKING(Kg)	5.0	6.5	5.4
4	YIELD Kg / PLOT	8.6	13.5	9.8
5	YIELD Kg / Ha	212.0	333.0	242.0
6	% YIELD INCREASE OVER NON Bt AND CHEC	57.0		38.0
7	NO. OF SPRAYS FOR LEPIDOPTERANS	3.0	0.0	3.0
8	PERCENT BAD COTTON	7.9	3.2	7.2
9	AVERAGE NO. OF BOLLWORMS			
	LARVAE/10 PLANTS			
	a) 0 - 60 DAS	6.0	1.4	4.2
	b) 61 - 90 DAS	12.8	4.5	12.1
	c) 91 - 120 DAS	4.1	3.1	4.4
	d) > 120 DAS	0.0	0.0	0.0
10	AVERAGE %FRUITING BODY			
	DAMAGE			
	a) 0 - 60 DAS	1.0	0.3	0.8
	b) 61 - 90 DAS	7.8	3.0	7.0
	c) 91 - 120 DAS	8.4	5.7	7.4
	d) > 120 DAS	0.0	0.0	0.0
11	AVERAGE NO. OF JASSIDS/30 LEAVES			
	a) 0 - 60 DAS	15.5	34.8	37.4
	b) 61 - 90 DAS	3.0	3.0	2.2
	c) 91 - 120 DAS	3.1	4.5	3.0
	d) > 120 DAS	0.0	0.0	0.0
12	AVERAGE NO. OF WHITE FLY/30 LEAVES			
	a) 0 - 60 DAS	0.0	0.0	0.0
	b) 61 - 90 DAS	1.9	2.6	2.3
	c) 91 - 120 DAS	1.6	1.0	0.9
	d) > 120 DAS	0.0	0.0	0.0
13	AVERAGE NO. OF BENEFICIALS/10 PLANTS			
	a) 0 - 60 DAS	7.0	8.3	12.3
	b) 61 - 90 DAS	1.8	0.7	0.8
	c) 91 - 120 DAS	1.1	2.2	2.7
	d) > 120 DAS	0.0	0.0	0.0

REMARKS :Crop condition was very poor due to continuous heay rainfall.The field was destroyed by activists after second picking.

TABLE: KTK-2 PERFORMANCE OF Bt OVER NON Bt COTTON HYBRIDS AT BENNIKAL,BELLARY

S.No.	PARAMETERS	NON Bt (MECH-12)	Bt (MECH-12)	CHECK (NHH-44)
1	PLANT STAND / PLOT			
2	WEIGHT OF FIRST PICKING(Kg)	18.8	29.3	17.3
3	WEIGHT OF SECOND PICKING(Kg)	17.3	18.8	12.8
4	YIELD Kg / PLOT	36.0	48.0	30.0
5	YIELD Kg / Ha	889.0	1185.0	740.0
6	% YIELD INCREASE OVER NON Bt AND CHEC	33.0		60.0
7	NO. OF SPRAYS FOR LEPIDOPTERANS	2.0	0.0	2.0
8	PERCENT BAD COTTON	5.1	1.6	6.5
9	AVERAGE NO. OF BOLLWORMS			
	LARVAE/10 PLANTS			
	a) 0 - 60 DAS	5.1	0.0	8.0
	b) 61 - 90 DAS	25.3	2.5	18.2
	c) 91 - 120 DAS	4.7	0.8	3.4
	d) > 120 DAS	0.0	0.0	0.0
10	AVERAGE %FRUITING BODY			
	DAMAGE			
	a) 0 - 60 DAS	2.1	0.4	1.6
	b) 61 - 90 DAS	6.0	2.2	6.2
	c) 91 - 120 DAS	10.3	3.2	10.4
	d) > 120 DAS	0.0	0.0	0.0
11	AVERAGE NO. OF JASSIDS/30 LEAVES			
	a) 0 - 60 DAS	52.5	55.3	44.6
	b) 61 - 90 DAS	22.5	22.1	12.0
	c) 91 - 120 DAS	2.7	3.2	4.5
	d) > 120 DAS	0.0	0.0	0.0
12	AVERAGE NO. OF WHITE FLY/30 LEAVES			
	a) 0 - 60 DAS	15.8	17.4	8.3
	b) 61 - 90 DAS	13.2	10.9	9.4
	c) 91 - 120 DAS	2.4	3.8	5.3
	d) > 120 DAS	0.0	0.0	0.0
13	AVERAGE NO. OF BENEFICIALS/10 PLANTS			
	a) 0 - 60 DAS	11.3	11.9	9.7
	b) 61 - 90 DAS	14.7	13.7	11.8
	c) 91 - 120 DAS	7.1	9.0	8.4
	d) > 120 DAS	0.0	0.0	0.0

REMARKS :Crop condition was very good and bollworm attack was very less on Bt plot as compare to non - Bt and check.The field was destroyed by activists after second picking.

TABLE: KTK-3 PERFORMANCE OF Bt OVER NON Bt COTTON HYBRIDS AT ADUR,DHARWAD

S.No.	PARAMETERS	NON Bt (MECH-162)	Bt (MECH-162)	CHECK (NHH-44)
1	PLANT STAND / PLOT	480.0	485.0	475.0
2	WEIGHT OF FIRST PICKING(Kg)	17.0	41.0	16.0
3	WEIGHT OF SECOND PICKING(Kg)	28.0	29.0	17.0
4	WEIGHT OF THIRD PICKING(Kg)	32.0	34.0	39.0
5	YIELD Kg / PLOT	77.0	104.0	72.0
6	YIELD Kg / Ha	1901.0	2568.0	1778.0
7	% YIELD INCREASE OVER NON Bt AND CHEC	35.0		44.0
8	NO. OF SPRAYS FOR LEPIDOPTERANS	3.0	0.0	3.0
9	PERCENT BAD COTTON	7.4	2.2	10.4
10	PERCENT LOCULE DAMAGE	23.5	1.9	23.7
11	AVERAGE NO. OF BOLLWORMS			
	LARVAE/10 PLANTS			
	a) 0 - 60 DAS	0.3	0.0	0.0
	b) 61 - 90 DAS	0.3	0.3	2.6
	c) 91 - 120 DAS	3.1	0.4	2.3
	d) > 120 DAS	0.0	0.0	0.0
12	AVERAGE %FRUITING BODY			
	DAMAGE			
	a) 0 - 60 DAS	0.0	0.0	0.0
	b) 61 - 90 DAS	5.2	1.2	5.0
	c) 91 - 120 DAS	9.5	2.9	8.9
	d) > 120 DAS	0.0	0.0	0.0
13	AVERAGE NO. OF JASSIDS/30 LEAVES			
	a) 0 - 60 DAS	0.0	0.0	0.0
	b) 61 - 90 DAS	45.1	61.3	73.3
	c) 91 - 120 DAS	165.0	188.7	160.7
	d) > 120 DAS	0.0	0.0	0.0
14	AVERAGE NO. OF WHITE FLY/30 LEAVES			
	a) 0 - 60 DAS	33.2	63.8	34.5
	b) 61 - 90 DAS	0.0	0.0	0.0
	c) 91 - 120 DAS	0.0	0.0	0.0
	d) > 120 DAS	0.0	0.0	0.0
15	AVERAGE NO. OF BENEFICIALS/10 PLANTS			
	a) 0 - 60 DAS	1.1	1.9	1.3
	b) 61 - 90 DAS	0.2	0.0	0.1
	c) 91 - 120 DAS	0.0	0.0	0.0
	d) > 120 DAS	0.0	0.0	0.0

REMARKS :Per cent yield increase in Bt plot was more over check as compare to non - Bt of same hybrid.

Fig : KTK-1 YIELD OF Bt AND NON Bt COTTON HYBRIDS IN KARNATAKA

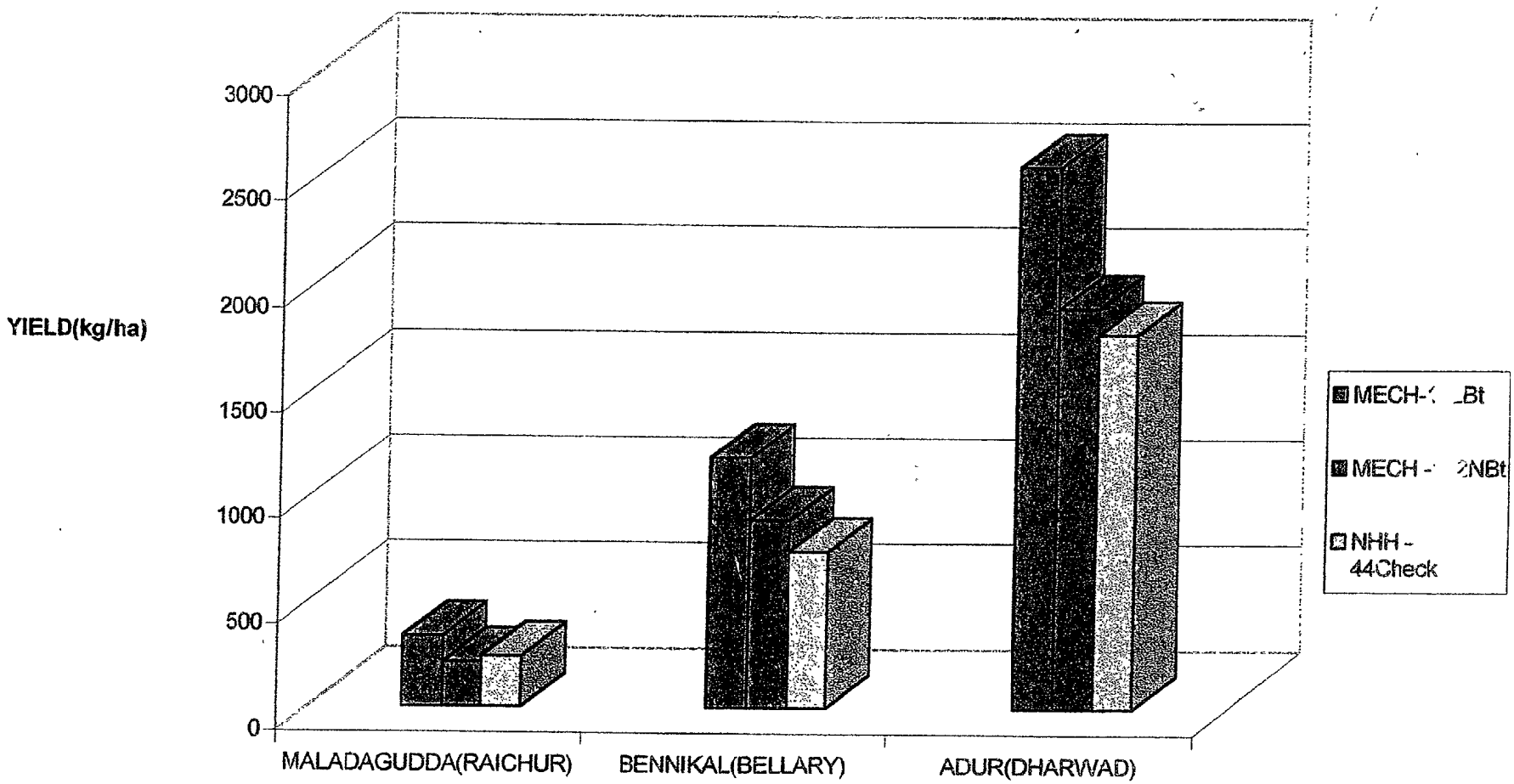


Fig : KTK-2 COMPARATIVE SPRAYING FOR BOLLWORM COMPLEX ON Bt AND NON Bt COTTON HYBRIDS IN KARNATAKA

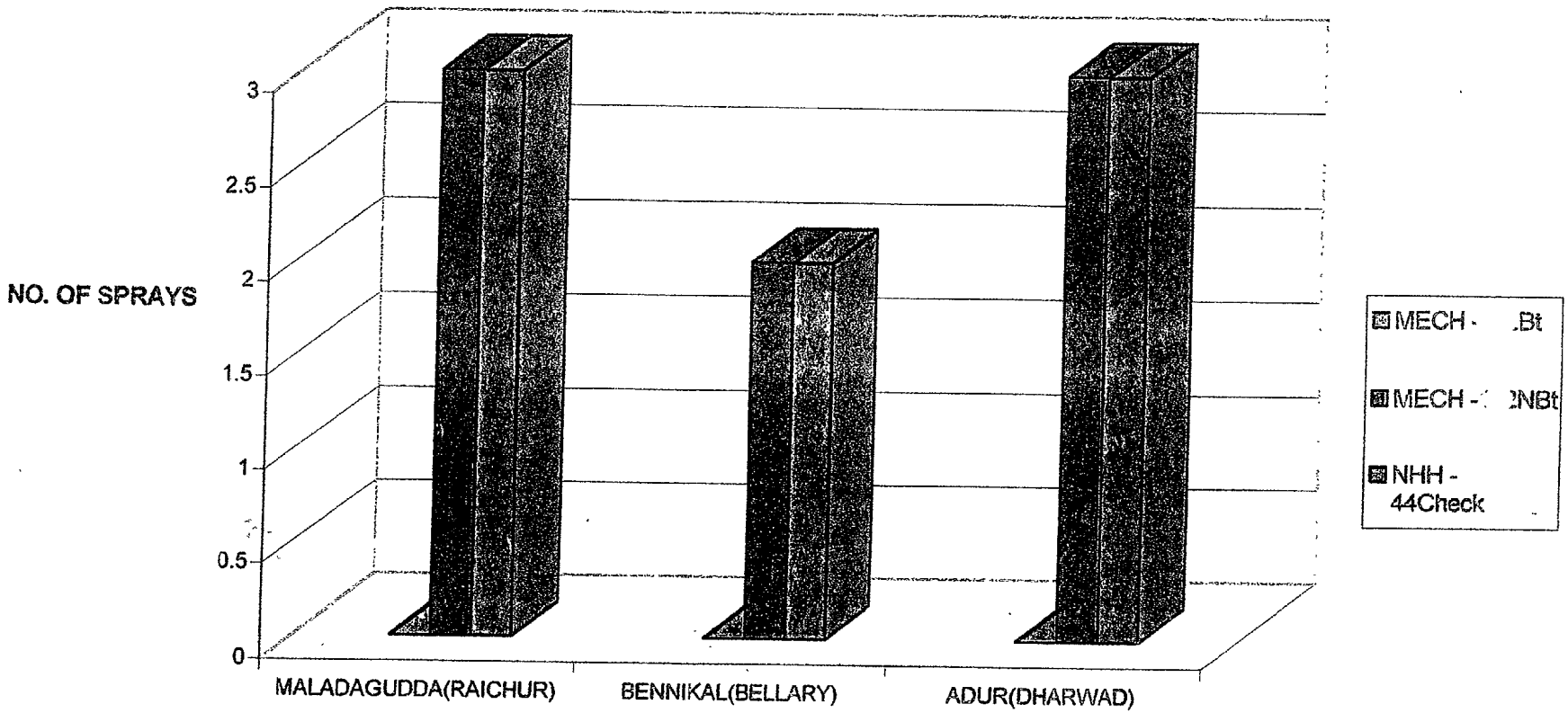


FIG: KTK-3 POPULATION OF BOLLWORMS AND % FRUITING BODY DAMAGE ON COTTON AT MALADAGUDDA,RAICHUR

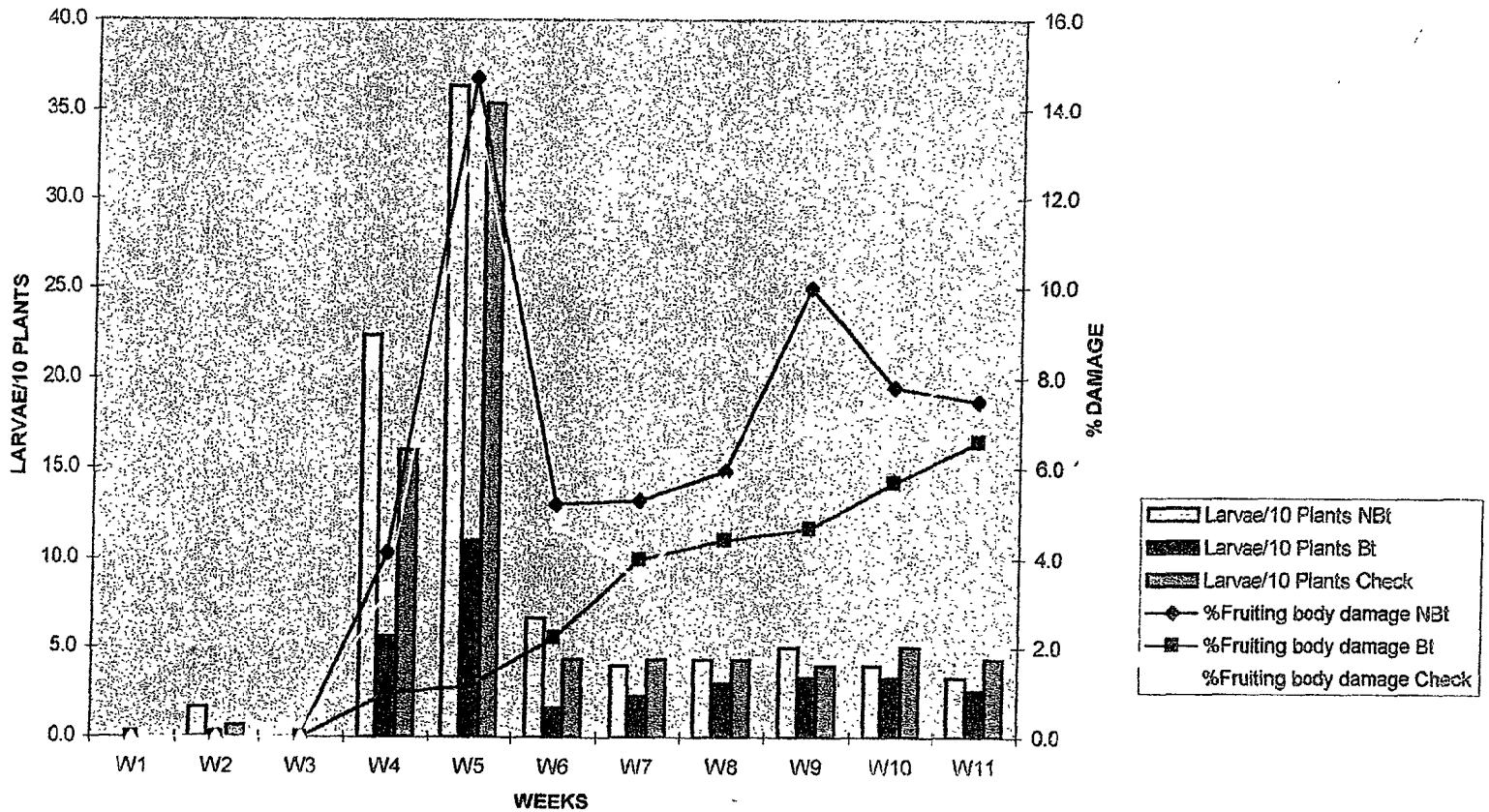


FIG:KTK-4 POPULATION OF BOLLWORMS AND % FRUITING BODY DAMAGE ON COTTON AT BENNIKAL,BELLARY

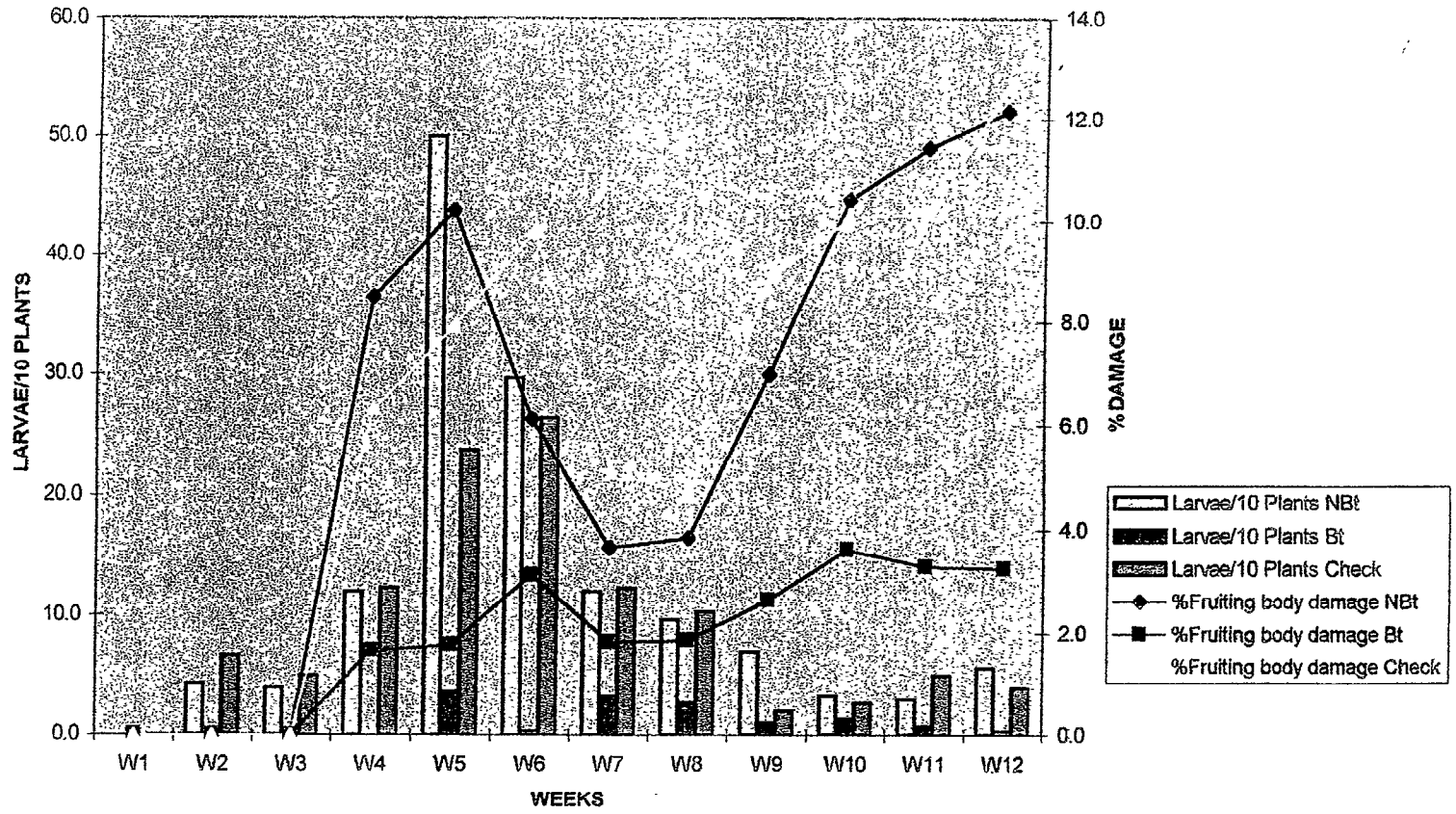
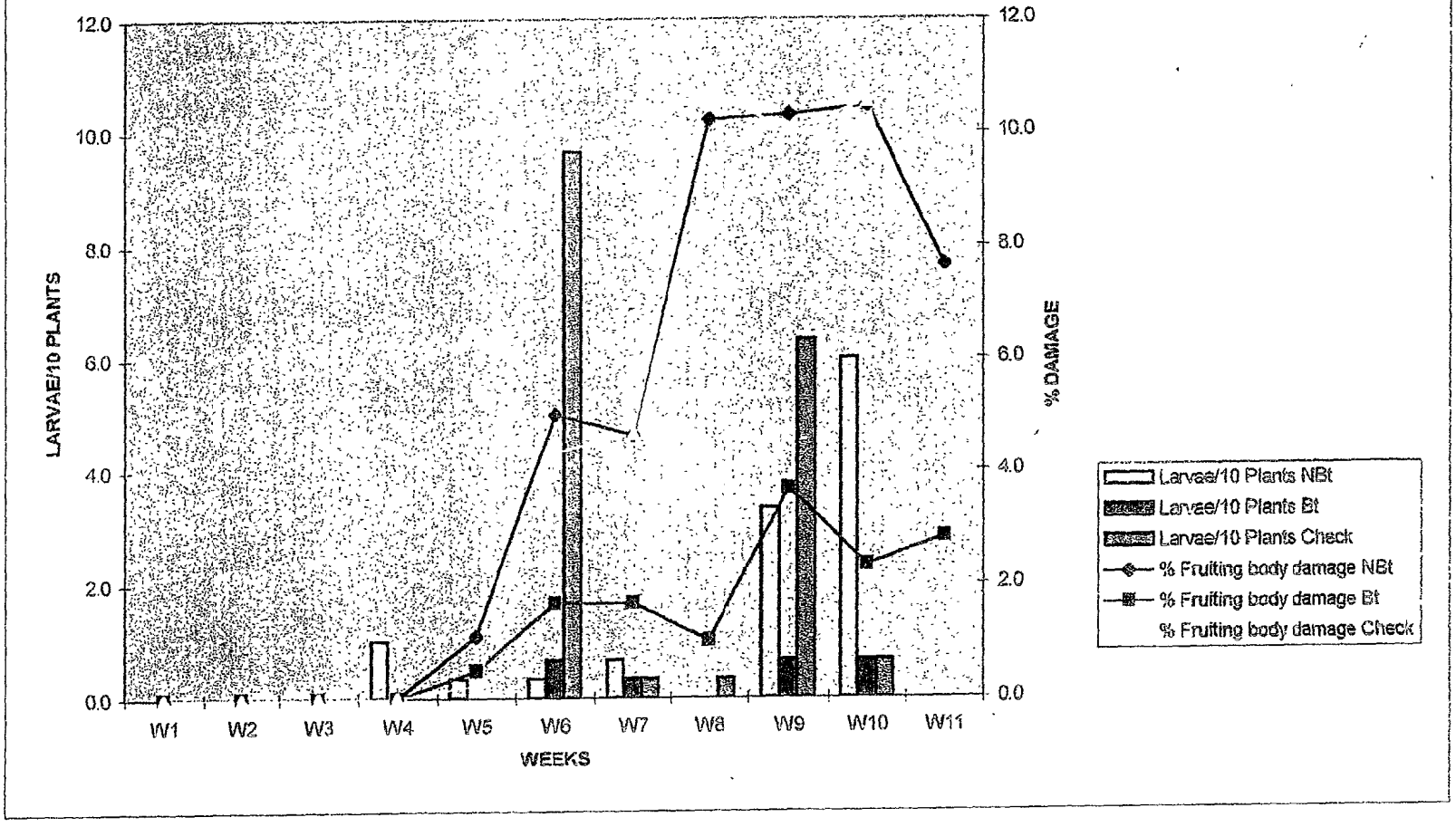


FIG: KTK-5 POPULATION OF BOLLWORMS AND % FRUITING BODY DAMAGE ON COTTON AT ADUR,DHARWAD



PROTOCOL-2 REPORT

HARYANA

TABLES & FIGURES

TABLE: HR-1 PERFORMANCE OF Bt OVER NON Bt COTTON HYBRIDS AT MAYYER,HISSAR

S.No.	PARAMETERS	NON Bt (MECH-915)	Bt (MECH-915)	CHECK (NHH-44)
1	PLANT STAND / PLOT	475.0	448.0	475.0
2	WEIGHT OF FIRST PICKING(Kg)	32.6	58.0	27.0
3	WEIGHT OF SECOND PICKING(Kg)	17.7	6.1	9.6
4	YIELD Kg / PLOT	50.3	64.1	36.7
5	YIELD Kg / Ha	1242.0	1583.0	906.0
6	% YIELD INCREASE OVER NON Bt AND CHEC	27.0		75.0
7	NO. OF SPRAYS FOR LEPIDOPTERANS	4.0	0.0	4.0
8	PERCENT BAD COTTON	1.5	0.2	1.7
9	AVERAGE NO. OF BOLLWORMS			
	LARVAE/10 PLANTS			
	a) 0 - 60 DAS	0.3	0.5	0.7
	b) 61 - 90 DAS	11.2	0.3	9.6
	c) 91 - 120 DAS	11.0	0.2	10.2
	d) > 120 DAS	0.0	0.0	0.0
10	AVERAGE %FRUITING BODY			
	DAMAGE			
	a) 0 - 60 DAS	2.2	0.1	1.3
	b) 61 - 90 DAS	4.6	0.1	4.6
	c) 91 - 120 DAS	2.4	0.1	2.1
	d) > 120 DAS	0.0	0.0	0.0
11	AVERAGE NO. OF JASSIDS/30 LEAVES			
	a) 0 - 60 DAS	57.8	53.8	61.0
	b) 61 - 90 DAS	30.0	33.0	28.3
	c) 91 - 120 DAS	1.7	1.7	1.7
	d) > 120 DAS	0.0	0.0	0.0
12	AVERAGE NO. OF WHITE FLY/30 LEAVES			
	a) 0 - 60 DAS	77.8	89.3	94.5
	b) 61 - 90 DAS	79.0	98.0	105.6
	c) 91 - 120 DAS	11.0	35.8	8.5
	d) > 120 DAS	0.0	0.0	0.0

REMARKS :Per cent yield increase in Bt plot was very high over check hybrid as compare to corresponding non - Bt hybrid.

Fig : HR-1 YIELD OF Bt AND NON Bt COTTON HYBRIDS IN HARYANA

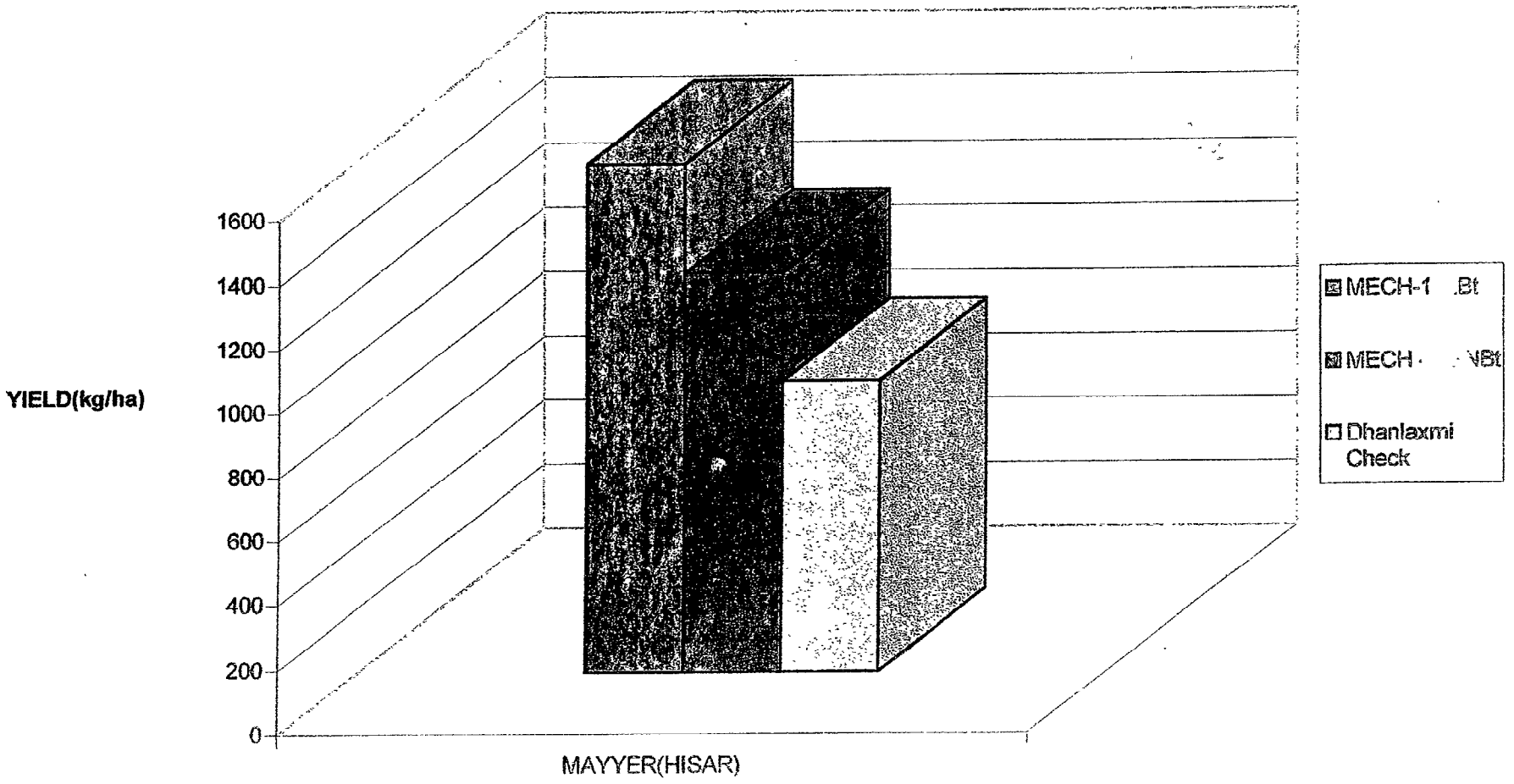


Fig : HR-2 COMPARATIVE SPRAYING FOR BOLLWORM COMPLEX ON Bt AND NON Bt COTTON HYBRIDS IN HARYANA

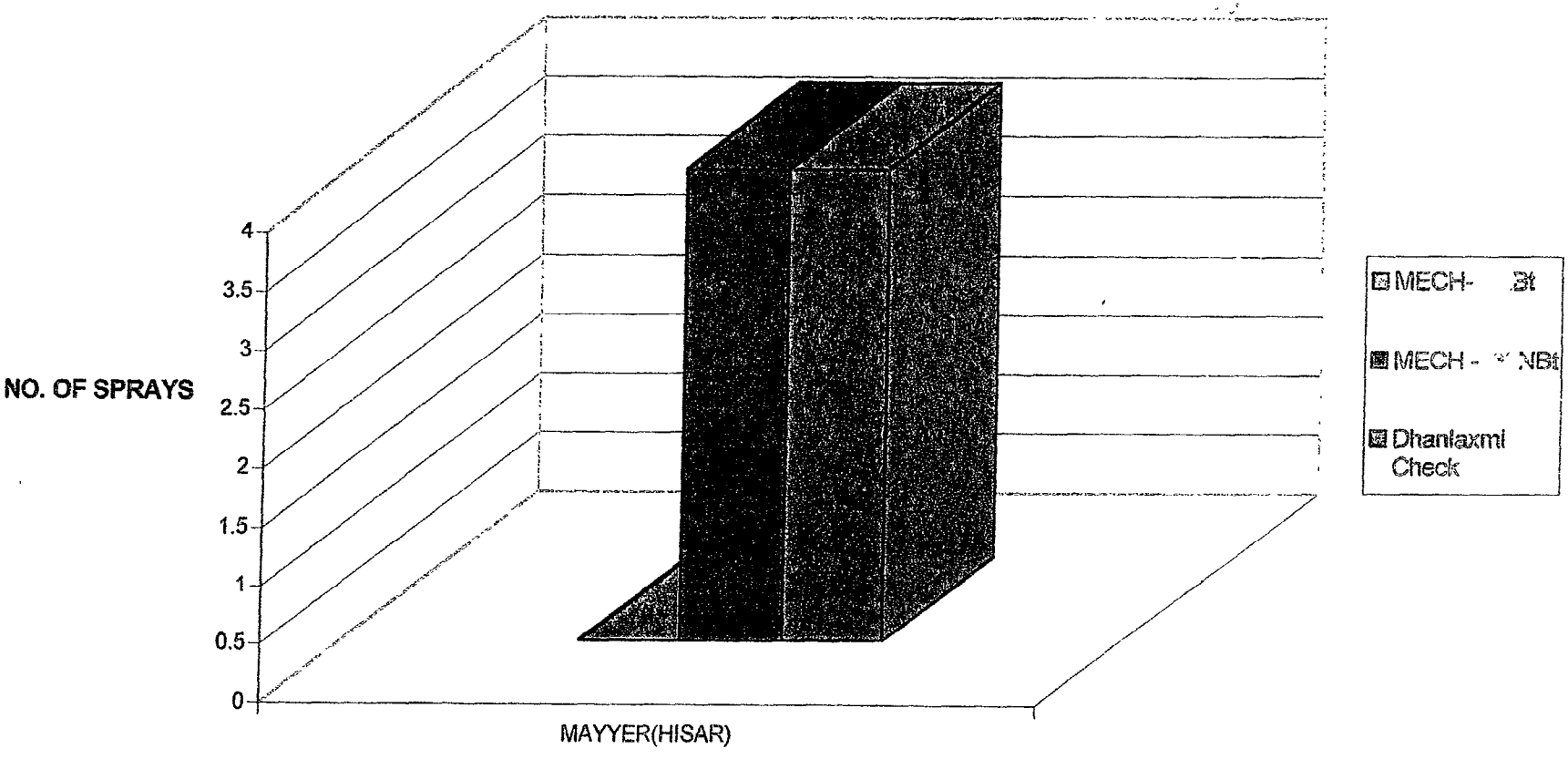
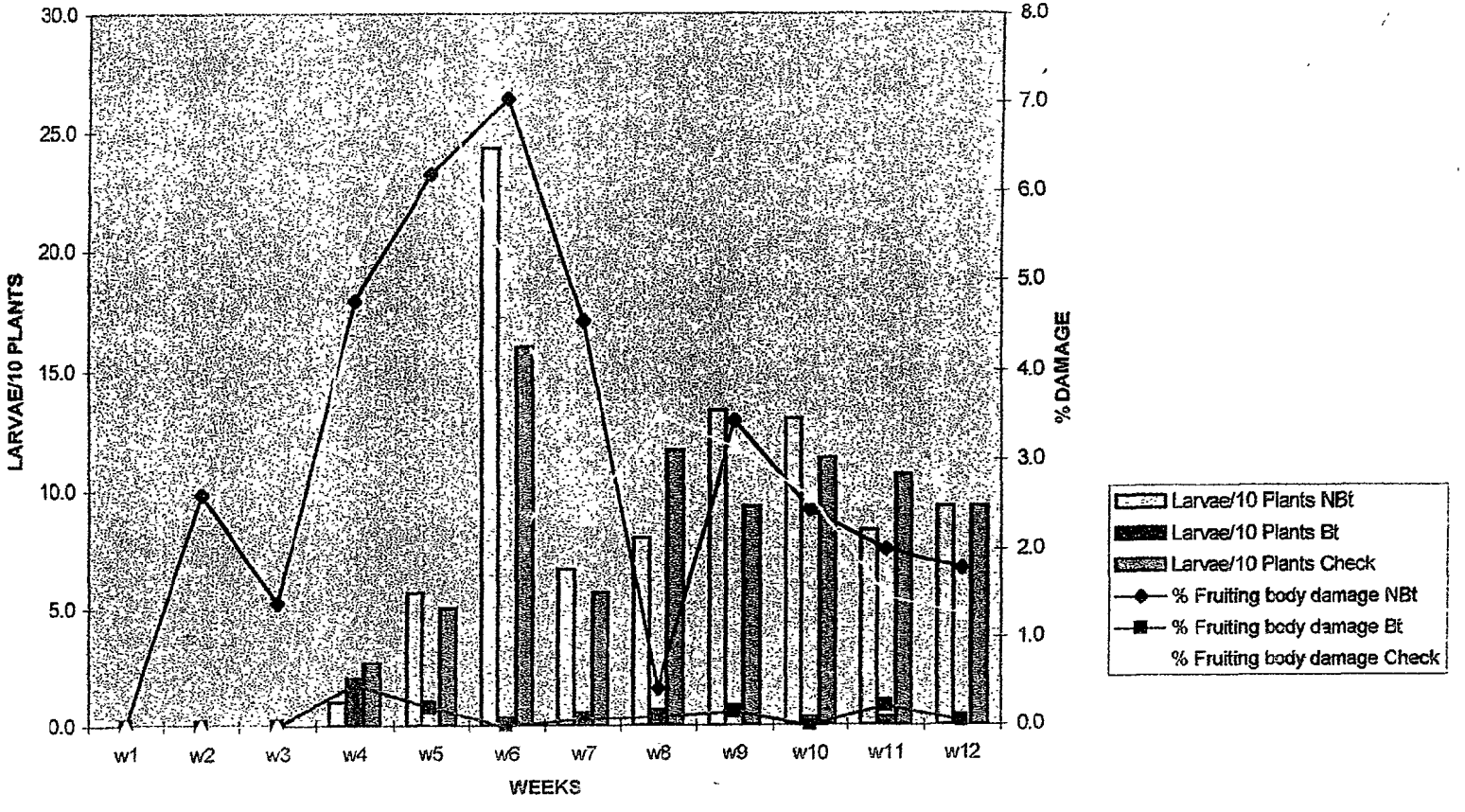


FIG: HR-3 POPULATION OF BOLLWORMS AND % FRUITING BODY DAMAGE ON COTTON AT MAYYER,HISAR



PROTOCOL-2 REPORT

RAJASTHAN

TABLES & FIGURES

TABLE: RJ-1 PERFORMANCE OF Bt OVER NON Bt COTTON HYBRIDS AT SRIGANGANAGAR

S.No.	PARAMETERS	NON Bt (MECH-915)	Bt (MECH-915)	CHECK (NHH-44)
1	PLANT STAND / PLOT	325.0	320.0	345.0
2	WEIGHT OF FIRST PICKING(Kg)			
3	WEIGHT OF SECOND PICKING(Kg)			
4	YIELD Kg / PLOT			
5	YIELD Kg / Ha			
6	% YIELD INCREASE OVER NON Bt AND CHECK			
7	NO. OF SPRAYS FOR LEPIDOPTERANS	1.0	0.0	1.0
8	AVERAGE NO. OF BOLLWORMS			
	LARVAE/10 PLANTS			
	a) 0 - 60 DAS	1.0	0.0	0.9
	b) 61 - 90 DAS	12.4	3.0	13.7
	c) 91 - 120 DAS	1.8	1.0	1.2
	d) > 120 DAS	0.0	0.0	0.0
9	AVERAGE %FRUITING BODY			
	DAMAGE			
	a) 0 - 60 DAS	0.8	0.0	1.0
	b) 61 - 90 DAS	26.7	7.6	28.6
	c) 91 - 120 DAS	7.6	6.7	11.0
	d) > 120 DAS	0.0	0.0	0.0
10	AVERAGE NO. OF JASSIDS/30 LEAVES			
	a) 0 - 60 DAS	63.2	62.6	56.1
	b) 61 - 90 DAS	71.6	63.5	58.6
	c) 91 - 120 DAS	4.7	6.0	3.2
	d) > 120 DAS	0.0	0.0	0.0
11	AVERAGE NO. OF WHITE FLY/30 LEAVES			
	a) 0 - 60 DAS	48.5	49.1	35.1
	b) 61 - 90 DAS	518.3	58.5	343.6
	c) 91 - 120 DAS	27.2	28.5	11.5
	d) > 120 DAS	0.0	0.0	0.0

REMARKS :This trial was sown very late and then severely damaged by heavy rain fall and could not reached to picking stage.

Fig : RJ-1 COMPARATIVE SPRAYING FOR BOLLWORM COMPLEX ON Bt AND NON Bt COTTON HYBRIDS IN SRIGANGANAGAR

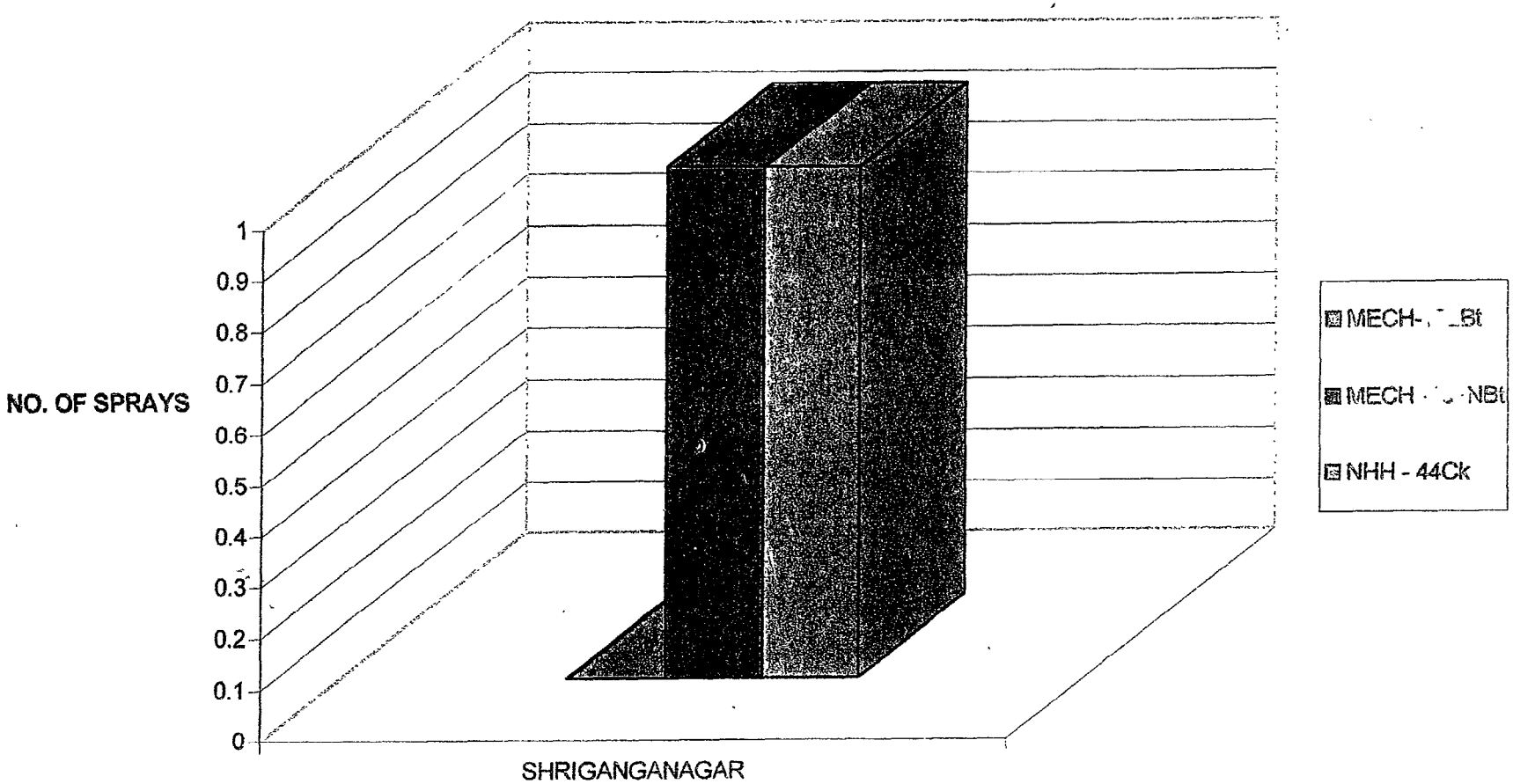
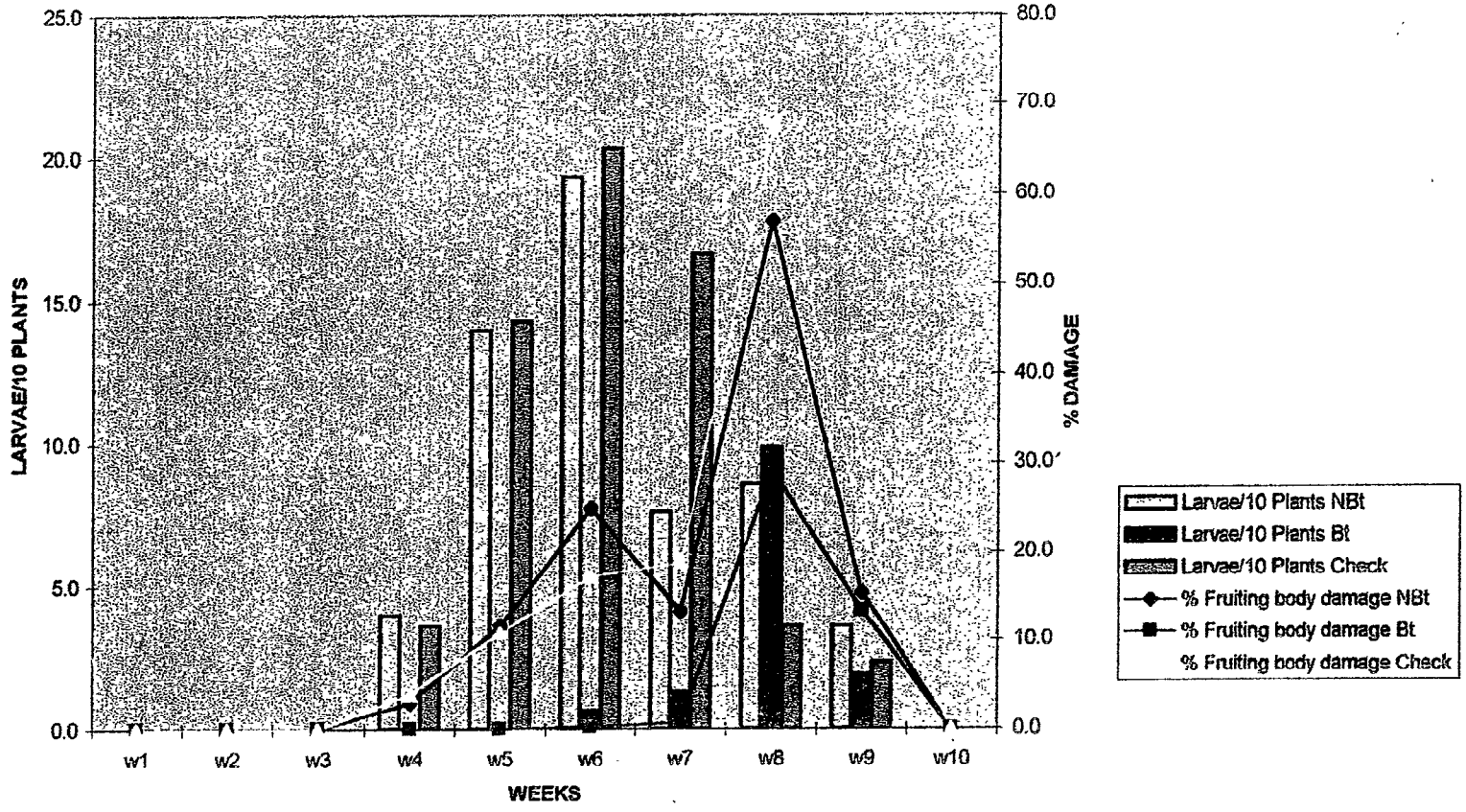


FIG: RJ-2 POPULATION OF BOLLWORMS AND % FRUITING BODY DAMAGE ON COTTON AT SRIGANGANAGAR



PROTOCOL-2 REPORT

TAMIL NADU

TABLES & FIGURES

TABLE: TN-1 PERFORMANCE OF Bt OVER NON Bt COTTON HYBRIDS AT KANNANOOR, DHARMAPURI

S.No.	PARAMETERS	NON Bt (MECH-162)	Bt (MECH-162)	CHECK (NHH-44)
1	PLANT STAND / PLOT	478.0	480.0	480.0
2	WEIGHT OF FIRST PICKING(Kg)	6.0	16.0	8.0
3	WEIGHT OF SECOND PICKING(Kg)	9.0	25.0	10.0
4	WEIGHT OF THIRD PICKING(Kg)			
5	YIELD Kg / PLOT	15.0	41.0	18.0
6	YIELD Kg / Ha	370.0	1012.0	444.0
7	% YIELD INCREASE OVER NON Bt AND CHEC	174.0		128.0
8	NO. OF SPRAYS FOR LEPIDOPTERANS	4.0	0.0	4.0
9	AVERAGE NO. OF BOLLWORMS			
	LARVAE/10 PLANTS			
	a) 0 - 60 DAS	7.1	0.6	5.4
	b) 61 - 90 DAS	9.8	0.0	12.0
	c) 91 - 120 DAS	6.0	0.3	6.2
	d) > 120 DAS	0.0	0.0	0.0
10	AVERAGE %FRUITING BODY			
	DAMAGE			
	a) 0 - 60 DAS	3.2	0.1	3.3
	b) 61 - 90 DAS	6.4	0.0	6.6
	c) 91 - 120 DAS	5.4	0.0	4.3
	d) > 120 DAS	0.0	0.0	0.0
11	AVERAGE NO. OF JASSIDS/30 LEAVES			
	a) 0 - 60 DAS	66.3	65.0	60.0
	b) 61 - 90 DAS	70.0	80.0	75.7
	c) 91 - 120 DAS	45.0	38.5	38.0
	d) > 120 DAS	0.0	0.0	0.0
12	AVERAGE NO. OF WHITE FLY/30 LEAVES			
	a) 0 - 60 DAS	48.5	42.3	44.0
	b) 61 - 90 DAS	59.8	62.3	44.3
	c) 91 - 120 DAS	72.5	78.5	77.0
	d) > 120 DAS	0.0	0.0	0.0
13	AVERAGE NO. OF BENEFICIALS/10 PLANTS			
	a) 0 - 60 DAS	114.8	975.0	100.3
	b) 61 - 90 DAS	144.0	176.0	157.5
	c) 91 - 120 DAS	41.0	405.0	49.0
	d) > 120 DAS	0.0	0.0	0.0

REMARKS :This trial was late sown and final picking is to be done.The present yield is based up to second picking.Per cent yield increase in Bt plot was more as compare to non - Bt plot.

Fig : TN-1 YIELD OF Bt AND NON Bt COTTON HYBRIDS IN TAMILNADU

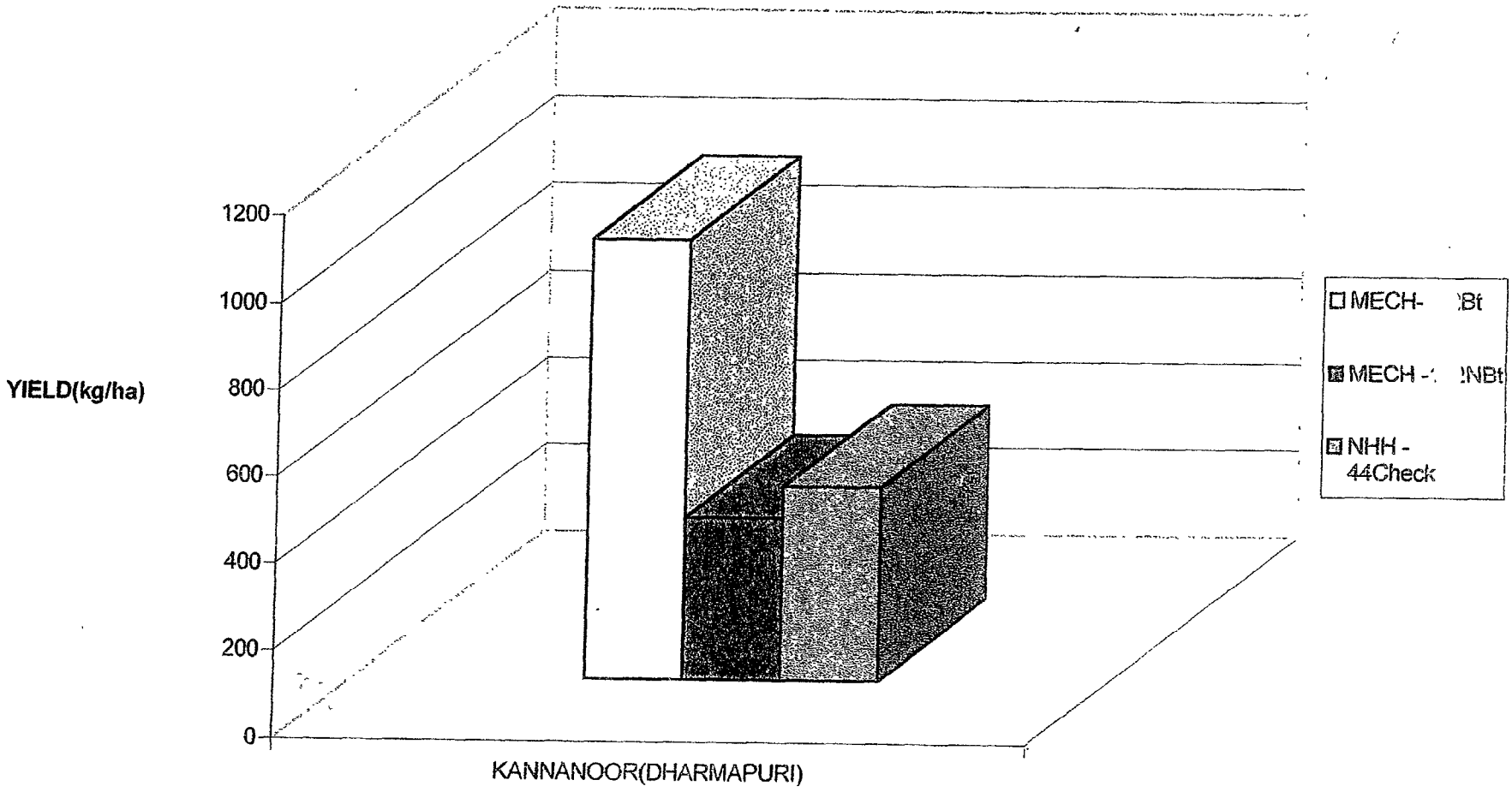


Fig : TN-3 COMPARATIVE SPRAYING FOR BOLLWORM COMPLEX ON Bt AND NON Bt COTTON HYBRIDS IN TAMILNADU

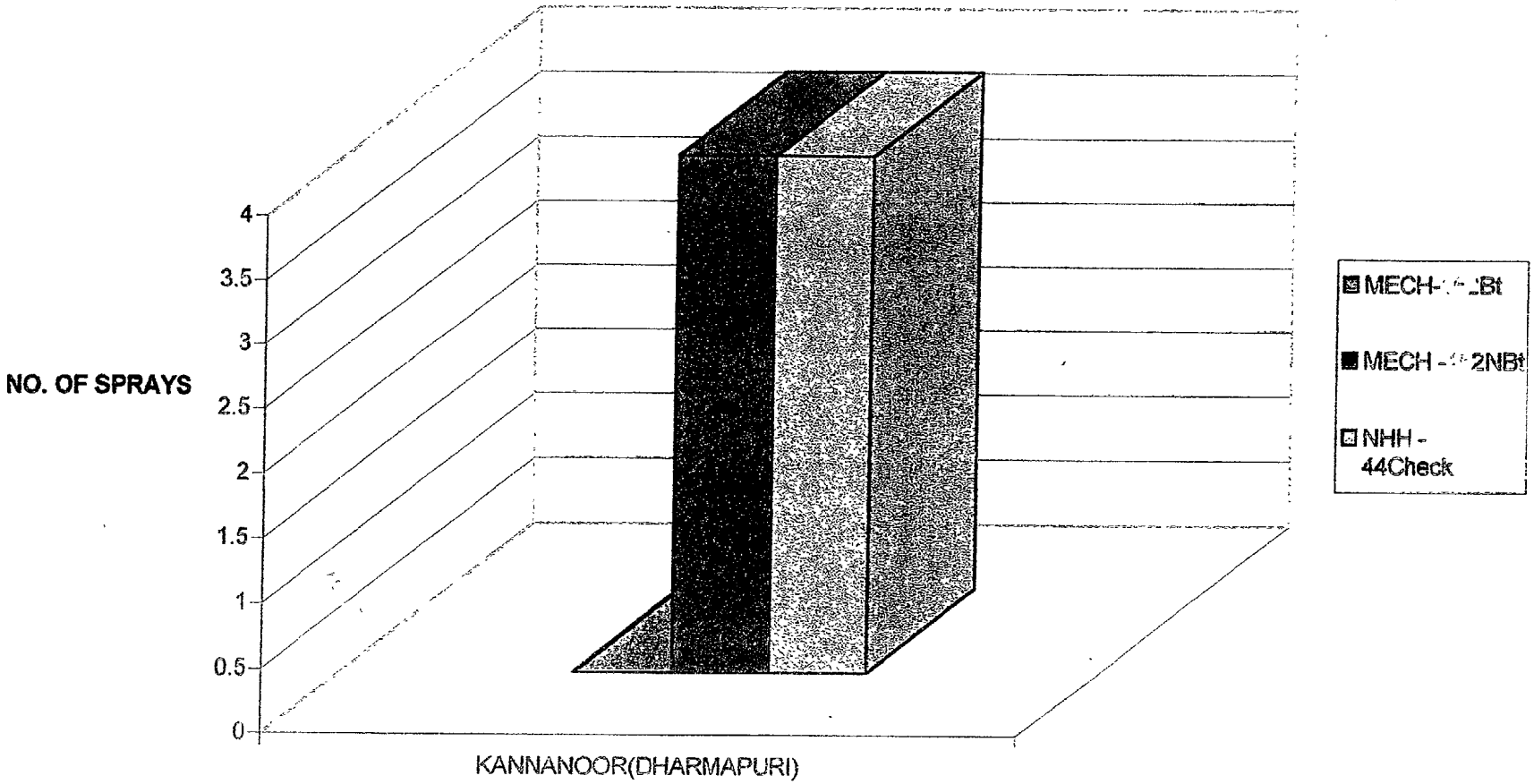
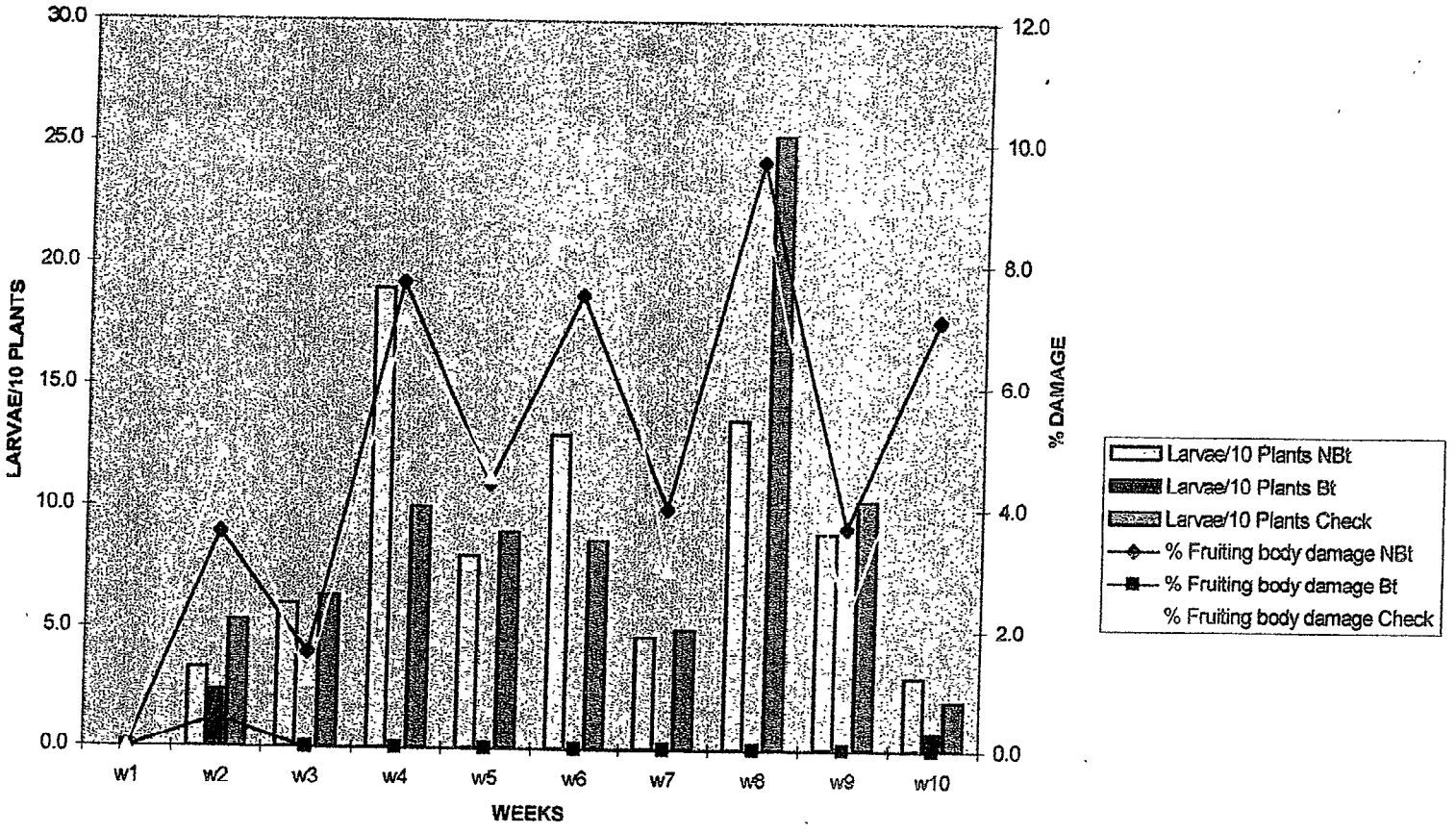


FIG: TN-3 POPULATION OF BOLLWORMS AND % FRUITING BODY DAMAGE ON COTTON AT KANNANOOR,DHARMAPURI



PROTOCOL-2 REPORT

ANNEXURE-1

FIBER QUALITY DATA

ANNEXURE 1

COMPARISON OF FIBER PARAMETERS OF Bt AND NON-Bt COTTON HYBRIDS

MECH-162

LOCATION	NAME OF THE ENTRY	MICRO-NAIR	FIBRE LENGTH MM	UNIFORMIY INDIX(%)	FIBER STRENGTH 1/8TH G GM/TEX	GINNING %
RENTANCHITALA	MECH-162 Bt	4.5	28	79	26.5	35.3
DIST.:GUNTUR	MECH-162 NBt	4.4	28	79	26.3	35.0
STATE : A.P.	NHH-4	4.4	27	78	23.9	33.5
NAGATUR	MECH-162 Bt	4.3	28	79	26.2	34.9
DIST. : KURNOOL	MECH-162 NBt	4.3	28	79	26.0	34.9
AP	NHH-44	4.5	26	78	24.1	34.1
VEREGAON	MECH-162 Bt	4.4	28	80	26.9	34.6
DIST. : *JALNA*	MECH-162NBt	4.5	27	79	25.8	34.8
MAHARASHTRA	NHH-44	4.4	27	79	24.9	34.0
BARAD.	MECH-162 Bt	4.3	27	82	26.8	34.6
DIST. : *NANDED*	MECH-162 NBt	4.4	28	83	27.3	34.6
MAHARASHTRA.	NHH-44	4.2	27	82	24.8	34.1
SOROHAR	MECH-162 Bt	4.4	28	80	26.8	33.7
DIST.: *RAJKOT*	MECH-162 NBt	4.4	30	80	26.8	34.0
GUJARAT	H-6	4.0	28	80	24.8	34.5
ADUR	MECH-162 Bt	4.1	29	81	26.6	34.7
DIST. : *DHARWAD*	MECH-162 NBt	4.0	30	81	27.0	35.1
KARNATAKA	NHH-44	4.2	29	78	25.2	34.2
KANNANOOR	MECH-162 Bt	4.5	28	81	26.2	34.9
DIST. : *DHAMAPURI*	MECH-162 NBt	4.4	28	81	26.0	35.0
TAMILNADU	NHH-44	4.4	26	79	24.2	34.1

AVG.Bt	MECH-162	4.3	28	80	26.6	34.7
AVG.NON-Bt	MECH-162	4.3	28	80	26.5	34.8
AVG.CHECK	NHH-44	4.3	27	79	24.6	34.1

ANNEXURE 1 (continued)

COMPARISON OF FIBER PARAMETERS OF Bt AND NON-Bt COTTON HYBRIDS

MECH-3

LOCATION	NAME OF THE ENTRY	MICRO-NAIR	FIBRE LENGTH MM	UNIFORMIY INDIX(%)	FIBER STRENGTH 1/8TH G GM/TEX	GINNING %
DENDK	MECH-3 Bt	4.5	29	82	27.9	35.4
DIST. : KHAMMAM	MECH-3 NBt	4.6	29	79	27 7	35.9
STATE : A.P.	NHH-44	4.5	27	78	23.5	34.6
KOTHAGADI	MECH-3 Bt	4 3	31	80	27.5	36.2
RENGAREDDY	MECH-3 NBt	4.2	30	80	27.2	36.1
A P	NHH-44	4.4	27	78	24.2	34.2
UMBERKHED	MECH-3 Bt	4.5	31	82	26.9	35.2
DIST. : JALGOAN	MECH-3 NBt	4.7	31	81	26.5	35.3
MAHARASHTRA	NHH-44	4.2	27	80	24.9	34.5
DINGAWADA.	MECH-3 Bt	4.5	31	82	26.9	35.2
VADODARA	MECH-3 NBt	4.6	30	80	25.9	34.5
GUJRAT	NHH-44	4.6	31	79	24.6	33.7
MALAGAUDDA.	MECH-3 Bt	4.6	30	80	25.4	33.2
DIST. RAICHUR	MECH-3 NBt	4.6	30	80	25.4	35.6
KARNATAKA	NHH-44	4.5	26	76	25.6	33.6
AVG.Bt	**MECH-3**	**4.5**	**30**	**81**	**26.9**	**35.0**
AVG.NON-Bt	**MECH-3**	**4.5**	**30**	**80**	**26.5**	**35.5**
AVG. CHECK	**NHH-44**	**4.4**	**27**	**78**	**24.6**	**34.1**

MECH-12

VURURGONDA	MECH-12 Bt	4.4	30	80	26.8	35.5
DIST.: WARANGAL	MECH-12 NBt	4.3	30	80	26.6	35.2
STATE: AP	NHH-44	4.5	27	79	24.1	34.3
KOLHA.	MECH-12 Bt	4.0	29	83	27.8	35.9
DIST. : PARBHANI	MECH-12 NBt	4.1	30	81	28.2	35.8
MAHARASHTRA	NHH-44	4.4	27	80	26.7	34.3
BANIKKAL	MECH-12 Bt	4.4	30	80	26.8	35.3
DIST. : BELLARY	MECH-12 NBt	4.3	30	80	26.5	35.1
KARNATAKA	NHH-44	4.4	27	79	24.5	34.1
AVG.Bt	**MECH-12**	**4.4**	**30**	**81**	**27.1**	**35.5**
AVG.NON-Bt	**MECH-12**	**4.2**	**30**	**80**	**27.1**	**35.4**
AVG. CHECK	**NHH-44**	**4.4**	**27**	**80**	**25.1**	**34.2**

ANNEXURE 1 (continued)

COMPARISON OF FIBER PARAMETERS OF Bt AND NON-Bt COTTON HYBRIDS

MECH-160

	NAME OF THE ENTRY	MICRO-NAIR	FIBRE LENGTH MM	UNIFORMITY INDIX(%)	FIBER STRENGTH 1/8TH G GM/TEX	GINNING %
BOTH	MECH-160 Bt	4.2	31	81	26.9	35.2
DIST. : YAVATAMAL	MECH-160NBt.	3.9	30	81	27.7	35.9
MAHARASHTRA	NHH-44	4.4	28	79	26.4	34.2
LONWADI	MECH-160 Bt	3.9	29	81	27.6	35.7
DIST. : BULDHANA	MECH-160 NBt	4.0	29	80	27.3	35.4
MAHARASHTRA	NHH-44	4.4	27	78	24.9	34.5
AVG.Bt	MECH-160	4.0	30	81	27.2	35.4
AVG.NON-Bt	MECH-160	3.9	29	80	27.5	35.2
AVG. CHECK	NHH-44	4.4	27	78	25.6	34.3

MECH-1

	NAME OF THE ENTRY	MICRO NAIR	FIBRE LENGTH MM	UNIFORMIY INDIX(%)	FIBER STRENGTH 1/8TH G GM/TEX	GINNING %
PANNARI	MECH-1 Bt	3.9	30	80	27.1	36.7
DIST.ADILABAD	MECH-1 NBT	4.1	30	84	26.7	36.5
STATE : A.P.	NHH-44	4.4	28	78	24.5	34.2

MECH-915

	NAME OF THE ENTRY	MICRO NAIR	FIBRE LENGTH MM	UNIFORMIY INDIX(%)	FIBER STRENGTH 1/8TH G GM/TEX	GINNING %
MAYYER	MECH-915 Bt	4.2	31	80	27.9	35.8
DIST. : HISAR	MECH-915NBt	4.3	31	80	27.8	35.8
STATE : HARYANA	DHANLAXMI	4.6	28	81	26.5	35.2

PROTOCOL-2 REPORT

ANNEXURE-2

DETAILS OF INSECT POPULATION DATA FOR ALL LOCATIONS

TABLE: A-1 POPULATION DYNAMICS OF SUCKING PESTS OF COTTON AT RENTACHINTALA,GUNTUR

WEEKS	JASSIDS/30 LEAVES			WHITE FLY/30 LEAVES			APHIDS/30 LEAVES		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	0	0	0	0	0	0	115	65	94
w2	0	0	0	0	0	0	77	62	29
w3	0	0	0	2	8	2	54	52	56
w4	0	0	0	2	1	2	76	74	73
w5	0	0	0	3	4	3	72	71	69
w6	0	0	0	10	12	12	88	138	103
w7	0	0	0	27	31	29	0	0	0
w8	16	19	15	98	102	121	0	0	0
w9	7	8	9	15	17	20	0	0	0
w10	6	8	7	9	11	13	0	0	0
w11	8	9	12	104	85	88	0	0	0
w12	21	10	12	57	54	62	0	0	0
w13	10	9	11	36	38	36	0	0	0
w14	0	0	0	59	58	59	0	0	0

TABLE: A-2 POPULATION DYNAMICS OF BOLLWORMS LARVAE AND % FRUITING BODY DAMAGE AT AT RENTACHINTALA,GUNTUR

WEEKS	Larvae/10 Plants			%Fruiting body damage			% Damage in shed material		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
w2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
w3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
w4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
w5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
w6	9.3	1.0	8.0	5.6	2.3	6.3	0.0	0.0	0.0
w7	4.3	1.0	5.7	5.3	2.1	6.1	0.0	0.0	0.0
w8	6.7	3.7	7.7	20.0	3.6	13.6	24.5	9.5	12.6
w9	6.0	2.7	9.7	16.6	4.0	14.1	39.1	3.6	13.5
w10	4.3	1.3	6.7	9.2	2.9	11.4	7.2	2.9	8.6
w11	4.3	2.3	4.7	4.8	3.4	4.1	7.0	2.9	9.1
w12	4.0	2.0	5.0	7.5	2.1	6.7	8.5	2.6	6.2
w13	3.7	0.0	4.3	7.3	1.7	7.7	7.0	1.7	7.6
w14	6.3	1.3	4.7	3.9	1.9	3.8	3.6	1.5	3.5

TABLE: A-3 POPULATION DYNAMICS OF SUCKING PESTS OF COTTON AT MANGANUR,MEHBOOBNAGAR

WEEKS	JASSIDS/30 LEAVES			WHITE FLY/30 LEAVES			APHIDS/30 LEAVES		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	22	19	0	43	122	29	69	100	94
w2	7	16	0	46	13	98	0	0	0
w3	24	48	25	99	152	275	0	0	0
w4	68	38	2	89	120	245	0	0	0
w5	25	27	22	83	92	70	0	0	0
w6	20	21	18	87	82	60	0	0	0
w7	24	20	23	60	58	63	0	0	0
w8	8	10	12	45	41	43	0	0	0
w9	0	0	0	0	0	0	0	0	0

TABLE: A-4 POPULATION DYNAMICS OF BOLLWORM LARVAE AND % FRUITING BODY DAMAGE AT MANGANUR,MEHBOOBNAGAR

WEEKS	Larvae/10 Plants			%Fruiting body damage			% Damage in shed material		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	9.6	0.0	20.0	35.2	8.3	49.9	0.0	0.0	0.0
w2	17.7	3.0	31.3	56.5	6.1	44.6	43.8	0.0	0.0
w3	5.3	2.0	4.7	24.6	6.7	16.8	46.3	20.0	0.0
w4	3.7	1.0	8.3	49.5	5.9	32.2	47.4	43.0	57.1
w5	3.0	3.0	8.7	41.0	5.7	33.8	51.5	0.0	52.2
w6	6.3	1.3	6.3	37.6	6.7	18.4	0.0	0.0	0.0
w7	10.3	1.3	4.0	26.3	4.5	27.4	0.0	0.0	0.0
w8	5.3	1.0	8.3	21.7	2.7	28.7	40.8	34.2	50.1
w9	1.3	0.0	5.0	12.0	2.5	15.0			

TABLE: A-5 POPULATION DYNAMICS OF SUCKING PESTS OF COTTON AT DENDUKUR, KHAMMAM.

WEEKS	JASSIDS/30 LEAVES			WHITE FLY/30 LEAVES			APHIDS/30 LEAVES		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	18	7	9	0	0	0	800	385	963
w2	4	2	2	0	0	0	370	216	131
w3	9	7	5	0	0	0	107	112	155
w4	26	17	26	0	0	0	112	112	128
w5	154	159	47	12	7	74	0	0	0
w6	35	34	38	77	69	84	0	0	0
w7	22	20	33	53	39	35	0	0	0
w8	17	12	18	32	29	37	0	0	0
w9	5	6	6	8	6	7	0	0	0
w10	45	36	34	33	26	29	0	0	0
w11	11	18	26	17	19	28	0	0	0
w12	0	0	0	0	0	0	0	0	0

TABLE: A-6 POPULATION DYNAMICS OF BOLLWORMS LARVAE AND % FRUITING BODY DAMAGE AT DENDUKUR,KHAMMAM

WEEKS	Larvae/10 Plants			%Fruiting body damage			% Damage in shed material		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
w2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
w3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
w4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
w5	16.0	2.0	5.0	3.6	0.7	4.3	0.0	0.0	0.0
w6	0.0	0.0	0.0	1.9	0.4	0.6	0.0	0.0	0.0
w7	3.0	1.0	15.0	11.4	1.0	10.2	0.0	0.0	0.0
w8	13.0	5.0	15.7	41.8	5.8	38.7	0.0	0.0	0.0
w9	22.0	6.0	26.0	34.1	3.9	39.8	0.0	0.0	0.0
w10	2.3	2.0	5.3	26.8	3.3	21.1	0.0	0.0	0.0
w11	3.0	1.0	6.0	26.1	7.0	18.6	0.0	0.0	0.0
w12	0.0	0.0	0.0	12.7	14.5	20.2	0.0	0.0	0.0

TABLE: A-7 POPULATION DYNAMICS OF SUCKING PESTS OF COTTON AT NAGATUR,KURNOOL

WEEKS	JASSIDS/30 LEAVES			WHITE FLY/30 LEAVES			APHIDS/30 LEAVES		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	10	3	60	1	4	2	60	107	110
w2	8	15	6	10	12	5	160	146	292
w3	19	15	21	26	98	26	267	455	674
w4	26	9	10	5	8	3	65	104	94
w5	11	8	8	22	7	32	51	127	115
w6	4	20	3	25	35	29	2	31	51
w7	6	22	7	28	11	22	0	270	43
w8	3	6	3	16	26	22	0	10	8
w9	12	9	7	50	32	47	12	0	0
w10	22	16	19	36	33	67	0	6	0
w11	0	18	0	3	35	58	0	0	0
w12	5	5	0	93	82	128	0	29	0
w13	12	32	19	121	109	132	0	0	0
w14	4	9	39	142	41	74	0	0	0
w15	16	26	48	122	92	135	0	112	43
w16	5	15	1	146	41	86	0	0	0
w17	0	0	0	115	76	78	14	10	22

TABLE: A-8 POPULATION DYNAMICS OF BOLLWORMS AND % FRUITING BODY DAMAGE AT NAGATUR,KURNOOL

WEEKS	Larvae/10 Plants			% Fruiting body damage			%Damage in shed material		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	0.7	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
w2	2.7	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
w3	1.3	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0
w4	0.0	0.0	0.3	1.6	0.8	0.0	0.0	0.0	0.0
w5	1.0	0.0	1.7	0.0	0.0	0.4	16.6	0.0	0.0
w6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
w7	9.0	0.3	2.7	3.6	0.5	10.1	10.8	9.9	39.1
w8	2.0	0.0	1.3	3.1	0.0	4.4	39.6	0.8	41.8
w9	0.7	0.3	0.3	2.0	0.0	0.8	29.8	1.6	18.1
w10	22.0	0.3	28.0	8.4	0.0	11.3	61.4	0.0	69.4
w11	8.0	1.3	1.7	6.4	0.2	7.2	80.0	33.3	53.7
w12	2.3	1.7	1.7	1.6	0.0	4.4	47.0	17.0	18.7
w13	10.3	2.7	12.7	3.0	0.6	3.5	31.6	1.3	7.1
w14	13.7	0.0	17.7	9.9	0.0	6.8	50.0	24.0	61.0
w15	4.0	0.0	4.3	9.1	0.3	2.8	0.0	0.0	0.0
w16	22.3	0.0	10.0	15.6	0.0	12.0	36.1	40.3	43.1
w17	11.0	0.3	3.7	38.4	14.0	34.2	51.4	46.3	45.4
w18	26.3	0.7	41.7	28.8	0.0	38.7	0.0	0.0	0.0

TABLE: A-9 POPULATION DYNAMICS OF SUCKING PESTS OF COTTON AT VURUGONDA,WARANGAL

WEEKS	JASSIDS/30 LEAVES			WHITE FLY/30 LEAVES			APHIDS/30 LEAVES		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
W1	73	45	35	8	3	3	81	154	194
W2	10	1	12	0	0	0	100	227	225
W3	46	58	37	8	3	9	128	150	142
W4	35	39	16	0	0	0	95	94	92
W5	6	5	6	57	61	68	107	8	23
W6	40	43	32	51	39	44	82	84	66
W7	18	17	16	53	57	55	83	78	74
W8	31	31	39	44	54	65	68	74	75
W9	58	55	27	46	54	39	78	66	79
W10	102	105	95	189	183	239	737	767	135
W11	47	80	90	142	187	193	6	6	2
W12	122	137	84	67	87	142	0	0	0
W13	121	128	99	71	71	136	0	0	0

TABLE: A-10 POPULATION DYNAMICS OF BOLLWORMS AND % FRUITING BODY DAMAGE AT VURUGONDA,WARANGAL

WEEKS	Larvae/10 Plants			% Fruiting bodies damage			%Damage in shed material		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
W1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W3	4.0	0.0	6.0	9.1	0.0	16.7	0.0	0.0	0.0
W4	2.6	0.0	4.0	8.3	3.8	13.6	0.0	0.0	0.0
W5	4.0	0.0	5.0	4.8	0.0	5.9	0.0	0.0	0.0
W6	7.0	0.0	8.3	8.4	0.2	8.9	10.8	0.0	20.3
W7	6.0	1.0	6.6	5.3	0.2	10.2	20.8	0.0	20.6
W8	8.0	0.7	10.0	3.8	0.4	8.9	18.6	0.0	13.8
W9	12.0	0.3	9.0	4.8	0.8	11.5	10.5	1.5	16.1
W10	12.0	0.3	16.0	10.3	1.0	18.0	30.0	5.0	38.2
W11	12.7	0.3	22.3	15.7	0.5	20.8	46.6	5.4	63.0
W12	7.6	1.3	10.6	4.3	0.5	11.4	65.3	3.0	49.3
W13	11.0	2.7	25.1	3.4	0.2	7.3	17.7	2.1	30.1

TABLE: A-11 POPULATION DYNAMICS OF SUCKING PESTS AT KOTHAGADI,RANGAREDDY

WEEKS	JASSIDS/30 LEAVES			WHITE FLY/30 LEAVES			APHIDS/30 LEAVES		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
W1	23	27	20	0	0	0	0	0	0
W2	28	37	16	0	0	0	0	0	0
W3	17	36	29	12	13	9	6	0	5
W4	11	10	11	21	13	19	0	0	0
W5	2	2	3	12	17	15	0	0	0
W6	9	6	9	20	18	17	0	0	0
W7	24	25	12	19	10	20	21	21	20
W8	55	61	172	43	43	78	63	68	60
W9	28	30	32	21	19	24	0	0	0
W10	44	32	0	80	68	45	0	0	0
W11	0	0	0	0	0	0	0	0	0

TABLE: A-12 POPULATION DYNAMICS OF BOLLWORMS AND % FRUITING BODY DAMAGE AT KOTHAGADI,RANGAREDDY

WEEKS	Larvae/10 Plants			%Fruiting body damage			%Damage in shed material		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
W1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W2	2.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0
W3	0.0	0.0	5.3	0.0	0.0	32.6	0.0	0.0	0.0
W4	0.3	0.0	1.7	6.3	2.3	2.3	0.0	0.0	0.0
W5	1.0	0.0	1.3	3.3	1.9	3.0	21.1	0.0	68.6
W6	4.0	1.0	5.3	11.1	1.2	7.7	0.0	9.7	21.9
W7	4.3	0.0	6.7	4.6	2.1	3.9	37.8	34.0	40.6
W8	2.7	0.0	7.3	1.9	0.5	2.7	55.0	43.1	50.0
W9	7.0	1.0	7.3	6.9	0.5	11.9	41.0	24.4	50.5
W10	3.3	0.0	8.7	7.7	0.0	3.3	25.6	0.0	38.4
W11	0.0	0.0	8.0	6.2	2.8	6.3	0.0	0.0	0.0

TABLE: A-13 POPULATION DYNAMICS OF SUCKING PESTS OF COTTON AT PONNARI,ADILABAD

WEEKS	JASSIDS/30 LEAVES			WHITE FLY/30 LEAVES			BENEFICIALS/10 PLANTS		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	34	31	13	0	0	0	1	4	8
w2	16	21	5	0	0	0	5	4	4
w3	23	21	12	0	0	0	6	7	7
w4	20	22	11	0	0	0	9	8	8
w5	47	30	13	0	0	0	16	11	12
w6	47	49	27	0	0	0	14	17	7
w7	54	47	20	0	0	0	15	16	9
w8	39	47	6	0	0	0	19	20	14
w9	36	39	19	0	0	0	12	18	14
w10	35	35	20	0	0	0	15	19	15
w11	73	62	17	3	4	7	9	7	5
w12	78	71	18	13	9	17	0	0	0
w13	79	71	39	20	13	27	0	0	0
w14	81	72	30	21	18	22	0	0	0
w15	73	69	65	37	44	45	0	0	0
w16	71	78	74	53	65	54	0	0	0
w17	81	83	69	68	65	63	0	0	0

TABLE: A-14 POPULATION DYNAMICS OF BOLLWORMS AND % FRUITING BODIES DAMAGE AT PONNARI,ADILABAD

WEEKS	Larvae/10 Plants			%Fruiting Body Damage			% Damage in shed material		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
w2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
w3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
w4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
w5	6.0	0.0	4.3	2.3	0.6	1.4	0.0	0.0	0.0
w6	8.3	0.0	8.3	6.4	0.6	6.6	0.0	0.0	0.0
w7	8.3	0.0	8.6	7.4	0.8	4.6	0.0	0.0	0.0
w8	8.6	0.0	13.6	8.0	0.8	5.5	0.0	0.0	0.0
w9	9.0	0.0	11.6	8.9	0.8	4.8	0.0	0.0	0.0
w10	12.3	0.0	17.0	9.2	0.6	6.0	0.0	0.0	0.0
w11	14.0	0.0	17.0	9.3	0.3	9.4	53.5	3.9	56.6
w12	14.0	0.0	18.0	9.7	0.4	9.8	49.6	3.2	60.0
w13	17.0	0.0	25.0	9.8	0.3	12.4	54.0	2.7	52.6
w14	23.3	0.0	22.0	10.1	0.3	12.8	58.6	2.7	63.3
w15	20.6	0.0	28.0	8.7	0.5	9.1	0.0	0.0	0.0
w16	15.0	0.0	22.0	8.2	0.0	6.2	0.0	0.0	0.0
w17	18.0	0.0	18.3	6.1	0.0	6.6	0.0	0.0	0.0

TABLE: A-15 POPULATION DYNAMICS OF SUCKING PESTS OF COTTON AT BOTH,YEOTMAL

WEEKS	Jassids/30 Leaves			White Fly/30 Leaves			Aphids/30 Leaves		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	7	6	6	30	37	39	101	97	86
w2	3	2	3	39	33	41	105	203	159
w3	20	13	38	79	73	105	303	521	340
w4	6	6	11	6	5	9	15	16	18
w5	43	27	34	201	181	185	59	62	45
w6	2	3	13	68	60	82	92	72	88
w7	37	46	39	162	139	163	0	0	0
w8	105	101	81	649	558	511	72	60	52
w9	72	114	108	129	81	74	33	41	47
w10	35	30	29	99	58	64	4	0	1
w11	0	2	1	116	115	91	32	6	0
w12	1	1	3	114	73	110	0	1	0
w13	27	18	9	118	98	101	3	0	0
w14	188	169	181	594	384	443	0	0	0
w15	36	28	25	107	97	77	11	21	2
w16	35	31	47	80	53	71	0	0	0
w17	6	10	11	29	35	32	0	0	0
w18	8	2	23	49	29	47	0	0	0

TABLE: A-16 POPULATION DYNAMICS OF BOLLWORMS AND % FRUITING BODY DAMAGE AT BOTH, YEOTMAL

WEEKS	Larvae/10 Plants			%Fruiting body damage			% Damage in shed material		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
w2	1.6	0.3	1.3	0.0	0.0	0.0	0.0	0.0	0.0
w3	1.2	0.7	1.7	0.0	0.0	0.0	0.0	0.0	0.0
w4	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
w5	0.1	0.0	1.3	2.5	0.0	1.7	0.0	0.0	0.0
w6	5.7	0.3	0.9	5.4	0.2	5.8	6.6	2.0	12.2
w7	2.3	0.3	2.7	2.7	0.1	4.5	8.3	0.3	9.8
w8	1.7	0.3	2.0	2.6	0.0	3.4	8.1	0.0	10.4
w9	1.3	0.0	1.3	0.7	0.0	0.2	6.6	0.0	8.1
w10	0.3	0.0	1.3	0.4	0.1	0.7	11.6	0.0	21.5
w11	2.0	0.0	2.7	1.5	0.1	1.2	28.8	0.0	26.8
w12	8.0	0.7	6.7	10.7	0.1	6.5	50.9	5.9	40.3
w13	4.7	0.3	2.7	4.4	0.1	3.4	55.6	0.0	20.7
w14	8.3	1.0	7.3	7.8	1.3	6.8	34.5	0.0	34.2
w15	4.7	0.7	3.3	2.8	0.9	3.3	79.2	0.0	76.2
w16	6.0	0.7	4.7	8.5	0.6	7.3	43.8	8.3	33.3
w17	4.7	2.0	5.0	4.0	0.4	1.4	29.5	13.3	58.8
w18	5.7	2.0	4.0	5.6	1.4	4.8	32.4	22.2	47.8

TABLE: A-17 POPULATION DYNAMICS OF SUCKING PESTS OF COTTON AT VIREGAON,JALNA

WEEKS	Jassids/30 Leaves			White Fly/30 Leaves			Beneficials/10 Plants		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	50	39	51	60	60	58	37	47	13
w2	3	11	2	14	12	6	27	33	13
w3	0	6	21	42	37	55	27	73	50
w4	0	4	3	39	33	31	150	83	93
w5	15	27	13	87	59	113	80	113	47
w6	2	2	3	25	28	19	23	60	37
w7	43	69	14	130	143	106	23	60	10
w8	1	1	0	21	33	34	20	40	30
w9	4	7	3	79	66	64	23	63	47
w10	1	5	6	89	113	84	43	90	60
w11	6	0	4	92	31	103	13	63	17
w12	2	1	1	112	170	149	10	60	13
w13	0	0	0	39	27	26	10	17	10

TABLE: A-18 POPULATION DYNAMICS OF BOLLWORMS AND % FRUITING BODY DAMAGE AT VIREGAON,JALNA

WEEKS	Larvae/10 Plants			%Fruiting body damage			% Damage in shed material		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
w2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
w3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
w4	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
w5	1.3	0.0	0.0	2.4	0.3	2.4	0.0	0.0	0.0
w6	12.7	0.0	12.0	15.1	0.4	14.3	0.0	0.0	0.0
w7	14.3	0.0	13.3	11.0	0.0	24.3	0.0	0.0	0.0
w8	12.7	0.0	8.0	7.5	0.6	7.0	0.0	0.0	0.0
w9	12.0	0.7	14.0	7.0	1.4	6.1	0.0	0.0	0.0
w10	11.3	9.3	16.0	7.2	1.3	8.0	0.0	0.0	0.0
w11	15.0	0.0	13.3	5.7	0.5	0.1	0.0	0.0	0.0
w12	11.7	1.7	12.0	6.0	0.5	5.5	0.0	0.0	0.0
w13	0.0	0.0	2.0	1.7	0.1	1.0	0.0	0.0	0.0
w14	3.3	1.1	3.3	2.2	0.3	1.4	0.0	0.0	0.0

TABLE: A-19 POPULATION DYNAMICS OF SUCKING INSECT PESTS OF COTTON AT KOLHA, PARBHANI

WEEKS	Jassids/30 Leaves			White Fly/30 Leaves			Beneficials/10 Plants		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	41	43	25	0	0	0	0	0	4
w2	89	86	53	9	18	8	3	6	2
w3	28	36	28	58	58	37	9	12	6
w4	28	30	14	23	34	23	17	15	1
w5	76	78	68	25	22	14	8	9	6
w6	34	34	36	21	12	16	6	11	6
w7	34	34	36	25	18	18	4	7	7
w8	76	85	67	23	22	33	2	0	3
w9	28	30	29	17	13	48	0	0	0
w10	38	36	30	56	52	64	0	0	0
w11	91	90	68	65	59	72	0	0	0
w12	20	31	15	29	23	21	7	3	7
w13	14	13	12	22	31	20	1	5	4
w14	17	14	13	31	17	14	9	10	12
w15	26	29	13	16	14	16	10	15	11

TABLE: A-20 POPULATION DYNAMICS OF BOLLWORMS AND % FRUITING BODY DAMAGE AT KOLHA,PARBHANI

WEEKS	Larvae/10 Plants			%Fruiting body damage			% Damage in shed material		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	1.3	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0
w2	2.3	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0
w3	16.0	0.0	15.0	18.4	0.0	24.7	7.9	0.0	12.2
w4	8.7	0.0	10.0	9.2	0.0	16.1	3.7	0.0	15.4
w5	17.3	4.3	24.3	9.0	2.5	23.2	25.8	0.0	21.8
w6	13.7	8.7	19.7	23.8	6.7	28.8	20.1	0.0	24.7
w7	4.3	1.3	3.3	4.7	0.3	4.5	15.8	6.5	28.8
w8	2.6	0.0	3.3	4.9	0.7	4.7	32.3	19.3	50.1
w9	11.0	5.6	10.3	11.0	5.3	8.2	15.7	7.6	10.9
w10	8.7	6.7	6.7	5.6	1.5	4.9	27.8	0.0	30.4
w11	4.0	0.6	4.3	2.9	0.6	3.2	45.5	29.3	34.8
w12	7.0	0.0	8.7	4.8	4.4	5.5	15.4	21.8	20.5
w13	2.0	0.6	3.0	1.5	0.7	2.7	18.3	4.5	16.5
w14	6.0	0.0	8.6	4.8	4.4	5.5	21.0	5.6	23.1
w15	2.0	0.7	3.0	1.5	0.7	2.7	17.4	10.2	18.3
w16	0.0	0.0	0.7	0.9	0.0	0.0	7.8	0.0	2.4

TABLE: A-21 POPULATION DYNAMICS OF SUCKING INSECT PESTS OF COTTON AT BARAD, NANDED

WEEKS	JASSIDS/30 LEAVES			WHITE FLY/30 LEAVES			APHIDS/30 LEAVES		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	26	26	32	0	0	0	71	48	70
w2	21	22	24	0	0	0	79	65	66
w3	61	69	77	18	9	12	127	114	119
w4	14	9	7	25	15	12	34	11	9
w5	21	18	10	36	22	21	51	41	24
w6	5	14	10	15	23	20	14	13	13
w7	74	82	92	23	46	34	13	16	16
w8	17	28	26	33	24	25	5	6	11
w9	27	33	69	20	24	45	0	0	0
w10	34	46	39	29	30	29	0	0	0
w11	68	65	64	49	50	45	0	0	0
w12	27	23	26	44	40	43	0	0	0
w13	15	20	20	35	30	38	0	0	0
w14	17	15	20	30	31	34	0	0	0
w15	16	12	14	20	27	31	0	0	0

TABLE: A-22 POPULATION DYNAMICS OF BOLLWORMS LARVAE AND PER CENT FRUITING BODY DAMAGE AT BARAD,NANDED

WEEKS	Larvae/10 Plants			%Fruiting body damage			% Damage In shed material		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	2.3	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0
w2	1.7	0.3	2.0	0.0	0.0	0.0	0.0	0.0	0.0
w3	2.7	0.7	1.3	0.0	0.0	0.0	0.0	0.0	0.0
w4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
w5	1.7	0.0	2.3	0.9	0.0	1.3	0.0	0.0	0.0
w6	2.3	0.0	2.7	2.6	0.0	2.0	0.0	0.0	0.0
w7	4.0	0.3	3.7	5.0	0.2	3.0	0.0	0.0	0.0
w8	7.0	0.3	5.7	6.0	0.3	5.2	25.6	3.1	30.7
w9	3.3	0.7	2.0	2.7	0.2	2.6	18.1	2.3	17.0
w10	2.0	0.3	1.7	2.9	0.4	2.3	17.0	2.3	15.6
w11	4.0	1.3	4.7	3.3	1.0	3.2	50.0	12.5	50.0
w12	5.3	1.3	5.3	8.4	0.4	7.2	0.0	0.0	0.0
w13	2.7	0.7	3.3	1.9	0.4	2.0	28.0	2.0	25.0
w14	1.3	0.3	1.7	0.9	0.3	1.2	1.6	2.3	2.0
w15	0.7	0.0	2.0	0.8	0.1	2.6	13.8	0.0	1.9

TABLE: A-23 POPULATION DYNAMICS OF SUCKING INSECT PESTS OF COTTON AT LONAWADI, BULDANA

WEEKS	JASSIDS/30 LEAVES			WHITE FLY/30 LEAVES			BENEFICIALS/10 PLANTS		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	24	15	12	149	126	177	7	9	4
w2	5	7	13	32	76	59	3	8	3
w3	13	11	21	78	78	91	3	3	1
w4	42	64	32	414	446	347	6	10	4
w5	6	14	16	92	62	93	32	37	13
w6	9	8	8	79	67	31	4	2	1
w7	15	14	37	57	54	53	3	7	1
w7	6	17	31	37	25	30	7	7	0
w8	10	13	18	32	12	14	3	3	2
w9	15	14	11	14	18	10	1	2	2
w10	27	28	31	25	20	27	2	4	2
w11	31	29	35	37	34	36	2	4	3
w12	66	57	59	67	71	82	5	3	2
w13	18	20	15	21	19	24	2	3	2
w14	13	10	12	31	24	32	2	2	1
w15	17	15	18	28	25	37	1	0	1

TABLE: A-24 POPULATION DYNAMICS OF BOLLWORMS LARVAE AND PER CENT FRUITING BODY DAMAGE AT LONWADI,BULDANA

WEEKS	Larvae/10 Plants			%Fruiting body damage			% Damage in shed material		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	1.3	0.3	1.7	0.0	0.0	0.0	0.0	0.0	0.0
w2	2.7	0.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0
w3	3.3	0.3	3.7	3.8	0.3	3.4	0.0	0.0	0.0
w4	11.0	1.0	13.3	9.7	0.2	14.4	0.0	0.0	0.0
w5	2.3	0.3	2.0	4.4	0.2	4.2	0.0	0.0	0.0
w6	5.7	1.0	6.3	7.8	0.3	5.9	3.3	1.4	8.1
w7	2.0	0.7	2.3	4.4	0.3	4.2	7.8	1.3	12.6
w8	7.7	1.3	6.3	6.2	0.4	6.7	42.6	1.2	56.3
w9	2.0	0.7	2.7	3.2	0.3	3.3	38.2	4.0	38.7
w10	3.3	0.7	3.7	2.4	0.4	2.6	41.8	6.3	41.3
w11	2.7	0.0	7.3	1.8	0.1	2.5	39.1	2.1	50.7
w12	2.0	1.3	5.3	1.5	0.4	1.6	37.6	5.6	25.9
w13	1.7	0.3	2.5	2.2	0.4	2.4	41.3	4.2	34.9
w14	3.3	1.3	4.0	4.9	0.6	4.7	32.8	3.7	41.5
w15	10.0	2.3	8.3	6.2	2.7	7.7	25.9	4.8	35.5
w16	2.3	1.3	3.7	3.2	1.3	4.2	10.6	1.7	12.2

TABLE: A-25 POPULATION DYNAMICS OF SUCKING PESTS OF COTTON AT UMBERKHED, JALGAON.

WEEKS	JASSIDS/30 LEAVES			WHITE FLY/30 LEAVES			BENEFICIALS/10 PLANTS		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
W1	107	98	98	0	0	0	0	0	0
W2	27	26	18	0	0	0	10	0	7
W3	128	103	120	2	1	0	40	30	7
W4	20	22	13	33	31	32	13	30	13
W5	54	63	54	39	46	49	10	20	7
W6	28	50	35	193	229	237	30	23	7
W7	35	42	32	217	189	197	20	13	0
W8	67	71	76	119	113	119	20	3	0
W9	83	79	53	104	112	83	3	23	7
W10	4	7	1	104	100	113	7	10	10
W11	13	25	15	147	160	135	0	0	0
W12	44	40	35	177	0	153	0	7	0
W13	19	24	27	25	33	20	0	3	0
W14	23	29	25	58	50	70	3	0	0
W15	17	9	13	2	12	18	0	3	0
W16	10	9	10	13	11	3	0	0	0
W17	10	11	1	13	10	18	0	0	3

TABLE: A-26 POPULATION DYNAMICS OF BOLLWORMS LARVAE AND PER CENT FRUITING BODY DAMAGE AT UMBERKHED JALGAON

WEEKS	Larvae/10 Plants			%Fruiting body damage			% Damage in shed material		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
W1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W5	0.0	0.0	0.0	2.1	0.0	1.8	0.0	0.0	0.0
W6	6.7	0.0	4.0	11.7	0.0	6.1	3.1	0.0	0.0
W7	6.7	0.0	0.0	1.3	0.0	6.6	9.4	0.0	8.1
W8	3.3	0.0	3.3	5.1	0.0	6.1	26.9	1.0	30.8
W9	10.0	3.3	3.3	4.7	0.4	23.6	14.9	1.6	17.1
W10	4.3	0.0	2.7	13.3	1.1	15.5	10.4	2.2	10.6
W11	1.3	0.0	1.3	2.8	0.5	4.6	13.0	0.6	13.2
W12	2.0	0.0	2.0	4.1	0.3	5.0	14.5	0.0	17.3
W13	2.0	0.0	1.3	3.2	0.0	1.4	10.8	0.0	8.7
W14	1.3	0.0	0.7	3.7	0.0	4.8	8.0	0.0	5.2
W15	2.7	0.0	1.3	6.7	0.0	3.1	12.9	0.0	6.0
W16	2.0	0.0	2.0	8.7	0.0	4.9	8.9	0.0	8.7
W17	1.3	0.0	1.3	23.8	0.0	17.6	8.9	0.0	11.1

TABLE: A-27 POPULATION DYNAMICS OF SUCKING PESTS OF COTTON AT PINGARWADA,VADODRA

WEEKS	JASSIDS/30 LEAVES			WHITEFLY / 30 LEAVES			BENEFICIALS /10 PLANTS		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	48	21	21	3	5	2	16	30	13
w2	128	128	231	12	25	9	60	107	26
w3	44	27	29	27	22	9	20	20	17
w4	23	13	13	9	13	7	43	50	53
w5	47	39	21	23	19	17	66	76	83
w6	12	14	24	52	42	44	7	13	7
w10	8	10	26	38	43	42	3	13	3
w11	34	2	7	88	53	62	0	0	0
w12	62	52	37	254	228	178	0	3	7
w13	41	37	38	275	264	269	0	10	0

TABLE: A-28 POPULATION DYNAMICS OF BOLLWORMS LARVAE AND PER CENT FRUITNG BODY DAMAGE AT PINGARWADA , VADODRA

WEEKS	Larvae / 10 Plants			% Fruiting Body Damage			% Damage in shed material		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
w2	6.0	0.7	2.0	4.5	1.9	3.5	0.0	0.0	0.0
w3	5.7	2.3	2.7	9.7	1.6	7.9	0.0	0.0	0.0
w4	11.0	1.7	6.7	11.5	1.1	16.0	43.3	0.0	30.4
w5	2.3	1.3	8.0	17.2	2.4	23.0	33.5	0.0	32.0
w9	0.8	0.2	0.4	2.4	0.1	5.8	20.6	16.6	26.8
w10	1.0	0.2	2.0	4.7	0.5	7.8	24.4	10.6	27.7
w11	0.4	0.0	1.4	2.5	0.3	3.2	7.7	0.0	3.9
w12	2.2	0.8	1.4	1.9	0.7	4.4	9.8	0.0	3.7
w13	6.0	1.2	14.0	2.7	0.7	9.9	13.1	0.0	24.1

TABLE: A-29 POPULATION DYNAMICS OF SUCKING PESTS OF COTTON AT BHUNAVA, RAJKOT.

WEEKS	JASSIDS/30 LEAVES			WHITE FLY/30 LEAVES			BENEFICIALS/10 PLANTS		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	0	0	11	0	0	30	0	1	0
w2	3	6	7	3	4	5	5	3	4
w3	0	3	2	30	26	24	22	17	8
w4	7	4	6	18	16	29	8	5	1
w5	18	15	4	35	20	42	2	1	0
w6	8	1	5	76	70	75	22	19	22
w7	60	28	84	62	6	24	1	0	2
w8	83	33	56	32	21	22	1	2	1
w9	18	18	27	30	37	43	1	1	0
w10	106	14	5	82	99	95	2	3	0
w11	0	0	0	18	19	29	1	0	0
w12	0	0	0	0	0	0	0	0	1
w13	0	0	0	0	0	0	0	0	0
w14	32	29	35	36	39	39	0	0	0
w14	0	0	0	0	0	0	0	0	0

TABLE: A-30 POPULATION DYNAMICS OF BOLLOWORMS LARVAE AND PER CENT FRUITING BODY DAMAGE AT BHUNAVA,RAJKOT

WEEKS	Larvae/10 Plants			%Fruiting body damage			% Damage in shed material		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	0.7	0.6	2.6	0.0	0.0	0.0	0.0	0.0	0.0
w2	4.6	1.3	5.0	0.0	0.0	0.0	0.0	0.0	0.0
w3	1.3	1.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0
w4	3.3	0.0	0.3	3.5	0.0	1.7	58.0	0.0	0.0
w5	11.0	0.7	0.0	20.6	3.6	5.4	96.5	13.6	89.2
w6	0.7	0.3	2.0	5.6	0.2	5.7	97.3	16.3	71.3
w7	8.7	1.3	9.0	15.0	0.6	17.2	89.7	42.7	90.3
w8	8.0	2.0	3.3	6.8	1.1	13.6	79.0	34.3	87.3
w9	17.0	2.0	16.0	12.6	1.0	11.7	89.6	11.9	91.0
w10	16.6	3.2	15.6	15.9	2.2	8.9	55.5	13.8	87.2
w11	41.3	17.6	32.0	17.3	2.6	7.0	80.0	14.0	74.5
w12	111.2	16.6	45.3	33.0	7.8	16.3	95.7	62.5	85.7
w13	7.3	0.0	9.3	0.8	0.0	2.4	100.0	4.3	100.0
w14	5.3	0.0	4.7	2.8	0.2	2.4	77.8	20.0	100.0

TABLE: A-31 POPULATION DYNAMICS OF SUCKING PESTS OF COTTON AT MALADAGUDDA, RAICHUR.

WEEKS	Jassids/30 Leaves			White Fly/30 Leaves			Beneficials/10 Plants		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
W1	4	3	5	0	0	0	26	20	33
W2	26	67	97	0	0	0	2	13	16
W3	27	65	43	0	0	0	0	0	0
W4	5	4	5	0	0	0	0	0	0
W5	2	3	0	3	3	1	0	0	0
W6	4	3	3	4	4	4	0	0	0
W7	5	1	3	0	2	0	0	0	0
W8	2	5	4	1	2	4	7	3	3
W9	4	6	2	3	0	1	0	7	4
W10	3	6	4	1	3	1	3	0	4
W11	3	2	3	1	0	1	0	0	0

TABLE: A-32 POPULATION DYNAMICS OF BOLLOWORMS LARVAE AND PER CENT FRUITING BODY DAMAGE AT MALADAGUDDA,RAICHUR

WEEKS	Larvae/10 Plants			%Fruiting body damage			% Damage in shed material		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
W1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W2	1.7	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0
W3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W4	22.3	5.7	16.0	4.1	1.0	3.3	0.0	0.0	0.0
W5	36.3	11.0	35.3	14.7	1.2	13.9	17.2	4.8	15.4
W6	6.7	1.7	4.3	5.2	2.2	4.8	20.3	9.1	18.4
W7	4.0	2.3	4.3	5.3	4.0	3.6	8.6	7.7	8.6
W8	4.3	3.0	4.3	5.9	4.4	5.7	8.1	6.5	9.0
W9	5.0	3.3	4.0	10.0	4.7	6.9	8.5	7.1	7.7
W10	4.0	3.3	5.0	7.8	5.7	7.3	7.9	7.6	8.3
W11	3.3	2.6	4.3	7.5	6.6	8.1	8.0	8.1	8.4

TABLE: A- 33 POPULATION DYNAMICS OF SUCKING PESTS OF COTTON AT BENNIKAL, BELLARY.

WEEKS	JASSIDS/30 LEAVES			WHITE FLY/30 LEAVES			BENEFICIALS/10 PLANTS		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
W1	3	2	2	2	3	2	0	0	0
W2	17	19	25	8	7	9	10	9	9
W3	88	86	71	10	3	5	18	19	12
W4	102	114	80	43	57	17	18	18	17
W5	61	70	25	37	29	21	23	17	18
W6	8	3	1	3	3	1	19	16	13
W7	13	8	11	7	6	6	8	11	9
W8	8	7	12	6	6	9	8	11	8
W9	3	2	3	2	2	0	4	6	5
W10	4	4	3	4	4	10	6	7	8
W11	4	3	6	4	4	6	6	10	12
W12	0	3	5	0	5	6	11	13	9

TABLE: A-34 POPULATION DYNAMICS OF BOLLOWORMS LARVAE AND PER CENT FRUITING BODY DAMAGE AT BENNIKAL,BELLARY

WEEKS	Larvae/10 Plants			%Fruiting body damage			% Damage in shed material		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
W1	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
W2	4.3	0.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0
W3	4.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0
W4	12.0	0.0	12.3	8.5	1.7	6.3	0.0	0.0	0.0
W5	50.0	3.7	23.7	10.2	1.8	7.9	0.0	0.0	0.0
W6	29.7	0.3	26.3	6.1	3.1	9.8	0.0	0.0	0.0
W7	12.0	3.3	12.3	3.7	1.8	5.1	12.0	8.1	17.7
W8	9.7	2.7	10.3	3.9	1.9	4.7	16.3	6.2	8.2
W9	7.0	1.0	2.0	7.0	2.6	8.9	13.5	6.4	21.0
W10	3.3	1.3	2.7	10.4	3.6	10.1	21.1	4.2	19.7
W11	3.0	0.7	5.0	11.5	3.3	10.2	24.9	7.3	24.8
W12	5.6	0.3	4.0	12.2	3.3	12.6	26.3	7.9	27.2

TABLE: A-35 POPULATION DYNAMICS OF SUCKING PESTS OF COTTON AT ADUR,DHARWAD

WEEKS	JASSIDS/30 LEAVES			APHIDS/30 LEAVES			BENEFICIALS/10 PLANTS		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
W1	0	0	0	30	50	30	0	0	0
W2	0	0	0	103	205	108	4	7	4
W3	0	0	0	0	0	0	0	0	1
W4	0	0	0	0	0	0	0	0	0
W5	0	0	0	0	0	0	0	0	0
W6	0	0	0	0	0	0	1	0	0
W7	0	0	0	0	0	0	0	0	0
W8	180	245	293	0	0	0	0	0	0
W9	229	246	254	0	0	0	0	0	0
W10	266	320	228	0	0	0	0	0	0
W11	0	0	0	0	0	0	0	0	0

TABLE: A-36 POPULATION DYNAMICS OF BOLLWORMS LARVAE AND % FRUITING BODY DAMAGE AT ADUR,DHARWAD

WEEKS	Larvae/10 Plants			% Fruiting body damage			% Damage in shed material		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
W1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W4	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W5	0.3	0.0	0.0	1.1	0.5	0.2	0.0	0.0	0.0
W6	0.3	0.7	9.7	5.0	1.7	4.3	46.3	21.7	52.7
W7	0.7	0.3	0.3	4.6	1.7	4.7	46.2	21.7	52.6
W8	0.0	0.0	0.3	10.2	1.0	10.7	55.6	5.8	21.7
W9	3.3	0.7	6.3	10.3	3.7	10.0	0.0	0.0	0.0
W10	6.0	0.7	0.7	10.5	2.3	10.6	29.3	5.7	28.0
W11	0.0	0.0	0.0	7.7	2.8	6.0	26.5	6.5	20.4

TABLE : A-37 POPULATION DYNAMICS OF SUCKING INSECT PESTS OF COTTON AT MAYYER, HISAR.

WEEKS	JASSIDS/30 LEAVES			WHITE FLY/30 LEAVES			APHIDS/30 LEAVES		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	78	85	77	47	29	33	0	0	0
w2	36	29	38	89	96	74	0	0	0
w3	94	85	113	130	153	190	0	0	0
w4	23	16	16	45	79	81	0	0	0
w5	47	25	18	38	64	105	0	0	0
w6	25	50	37	71	85	82	0	0	0
w7	26	33	34	83	99	90	0	0	0
w8	22	24	24	124	144	144	0	0	0
w9	6	6	6	38	141	34	0	0	0
w10	1	1	1	6	2	0	0	0	0
w11	0	0	0	0	0	0	0	0	0
w12	0	0	0	0	0	0	0	0	0

TABLE: A-38 POPULATION DYNAMICS OF BOLLWORM COMPLEX AND PER CENT FRUITING BODY DAMAGE AT MAYYER, HISSAR

WEEKS	Larvae/10 Plants			% Fruiting body damage			% Damage in shed material		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
w2	0.0	0.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0
w3	0.0	0.0	0.0	1.4	0.0	0.0	2.9	0.0	0.0
w4	1.0	2.0	2.7	4.8	0.5	5.3	11.1	1.5	11.3
w5	5.7	0.0	5.0	6.2	0.2	7.4	13.8	4.5	17.8
w6	24.3	0.3	16.0	7.1	0.0	5.1	1.1	1.7	13.3
w7	6.7	0.0	5.7	4.6	0.1	2.4	7.3	2.0	7.9
w8	8.0	0.7	11.7	0.4	0.1	3.5	8.6	0.1	9.2
w9	13.3	0.0	9.3	3.4	0.2	3.1	11.0	0.0	14.8
w10	13.0	0.3	11.3	2.5	0.0	2.6	11.8	0.0	11.8
w11	8.3	0.3	10.7	2.0	0.2	1.5	25.0	0.0	26.0
w12	9.3	0.0	9.3	1.8	0.1	1.3	46.5	0.0	55.0

TABLE : A-39 POPULATION DYNAMICS OF SUCKING PESTS OF COTTON AT SRI GANGANAGAR.

WEEKS	JASSIDS/30 LEAVES			WHITE FLY/30 LEAVES			APHIDS/30 LEAVES		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	84	85	75	0	0	0	0	0	0
w2	31	59	32	38	90	45	0	0	0
w3	45	37	34	131	74	72	0	0	0
w4	93	70	83	25	33	23	0	0	0
w5	233	205	209	56	47	59	0	0	0
w6	21	20	15	773	754	465	0	0	0
w7	2	2	2	1118	1120	795	0	0	0
w8	31	27	9	126	153	55	0	0	0
w9	7	10	3	45	53	19	0	0	0
w10	2	2	3	9	4	4	0	0	0

TABLE: A-40 POPULATION DYNAMICS OF BOLLOWORMS LARVAE AND PER CENT FRUITING BODY DAMAGE AT SRI GANGANAGAR.

WEEKS	Larvae/10 Plants			% Fruiting body damage			% Damage in shed material		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
w2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
w3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
w4	4.0	0.0	3.6	3.0	0.0	4.0	0.0	0.0	0.0
w5	14.0	0.0	14.3	11.6	0.0	10.8	0.0	0.0	0.0
w6	19.3	0.7	20.3	25.0	0.3	17.2	33.6	0.0	48.2
w7	7.7	1.3	16.7	13.2	0.7	18.7	26.8	1.9	56.8
w8	8.6	9.9	3.6	57.0	29.2	67.5	33.3	32.6	68.5
w9	3.6	1.9	2.3	15.3	13.3	21.9	0.0	0.0	0.0
w10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
w11	Crop destroyed by heavy rain fall in the region								

TABLE: A-41 POPULATION DYNAMICS OF SUCKING PESTS OF COTTON AT KANNANOOR, DHARMAPURI

WEEKS	JASSIDS/30 LEAVES			WHITE FLY/30 LEAVES			APHIDS/30 LEAVES		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	65	65	49	2	3	3	6	2	5
w2	113	96	92	127	100	106	196	195	152
w3	26	36	39	10	13	15	55	48	50
w4	61	63	60	55	53	52	202	145	194
w5	39	46	61	43	54	31	154	177	197
w6	114	133	130	87	92	83	198	156	155
w7	32	54	55	9	9	8	30	61	59
w8	95	87	57	100	94	55	194	310	219
w9	44	32	42	15	16	15	35	37	45
w10	46	45	34	130	141	139	47	44	53

TABLE: A-42 POPULATION DYNAMICS OF BOLLOWORMS LARVAE AND PER CENT FRUITING BODY DAMAGE AT KANNANOOR, DHARMAPURI

WEEKS	Larvae/10 Plants			% Fruiting body damage			% Damage in shed material		
	NBt	Bt	Check	NBt	Bt	Check	NBt	Bt	Check
w1	0.0	0.0	0.0	0.0	0.0	0.0	0,0	0.0	0.0
w2	3.3	2.3	5.3	3.6	0.5	4.9	60.0	16.0	91.1
w3	6.0	0.0	6.3	1.6	0.0	1.1	80.0	0.0	94.0
w4	19.0	0.0	10.0	7.7	0.0	7.1	71.7	0.0	82.5
w5	8.0	0.0	9.0	4.4	0.0	4.5	61.5	0.0	69.2
w6	13.0	0.0	8.7	7.5	0.0	10.0	82.0	0.0	80.9
w7	4.7	0.0	5.0	4.0	0.0	3.0	33.3	0.0	60.0
w8	13.6	0.0	25.3	9.7	0.0	9.0	73.4	0.0	62.5
w9	9.0	0.0	10.3	3.7	0.0	2.1	96.0	0.0	97.0
w10	3.0	0.7	2.0	7.1	0.0	6.5	96.2	0.0	98.2

Protocol-2 Report Supplement

Location Based Differences in Results

Trail locations in Protocol-2 involved only single Bt cotton hybrids (and non-Bt checks) for each site. Entry replications were not randomized, and no statistical inferences were attempted. However, substantial trends were observed for yield increases in Bt cotton hybrids, as compared to non-Bt checks, at all research trial locations. *Supplemental Table S2* summarizes differences among locations for yield expression from these Protocol 2 trials. Yield increases for Bt hybrids as compared to their non-Bt counterparts were present for all locations, and were measured as greater than 10% increase at 17 of 19 locations. Overall increases ranged from 6% to 174%, considering all hybrids and locations. Decreases in Bt hybrids for Bollworm larvae count and fruiting body damage due to larvae feeding were also observed at the majority of locations, along with substantial decreases in insecticide application requirements (*reference Protocol-2 Report, Table 1*).

SUPPLEMENTAL TABLE S2: Protocol 2 - Summary of Location Data for Yield Among Bt and Non-Bt Cotton Hybrids for Trials Conducted in India, 1998-1999.

HYBRID COMPARISON	Number of Locations Showing Yield Difference > 10% (Bt vs. Non-Bt Hybrids)	Range of Yield Increase Among Locations (% Increase: Bt vs. Non-Bt Hybrids)	Average Yield Among All Locations: Yield Average (Kg/ha)	Average Yield Among All Locations: % Increase in Yield (Bt versus Non-Bt Hybrids)
MECH-1 Bt **MECH-1 Non-Bt**	1 of 1	58%	1210 765	58%
MECH-3 Bt **MECH-3 Non-Bt**	3 of 4	6% – 57%	1569 1377	14%
MECH-12 Bt **MECH-12 Non-Bt**	2 of 3	8% – 33%	1405 1203	17%
MECH-160 Bt **MECH-160 Non-Bt**	3 of 3	18% – 72%	2256 1491	51%
MECH-162 Bt **MECH-162 Non-Bt**	7 of 7	21% – 174%	2140 1349	59%
MECH-915 Bt **MECH-915 Non-Bt**	1 of 1	27%	1583 1242	27%
Mean: Bt Hybrids **Mean: Non-Bt Hyb.**	17 of 19	6% – 174%	1694 1238	37%

ATTACHMENT 2

Protocol – 1 Report
Replicated Research Trials of Bt Cotton

Replicated Research Trials of Bt Cotton

Protocol-1 Report

Assessment of Yield and Bollworm Complex Load among Bt and Non-Bt Cotton Hybrids in Replicated Research Trials in India, 1998-1999

Submitted to RCGM
February 8, 1999

MAHARASHTRA HYBRID SEEDS COMPANY, LTD
Resham Bhavan, 4th Floor, 78 Veer Nariman Road, Mumbai 400 020, India

PREAMBLE

A technological breakthrough in control of Lepidopteran pests in cotton, such as the Bollworm complex, was achieved in the early 1990's by the Monsanto Company. This technology involved the incorporation of an expressed gene from *Bacillus thuringiensis* (Bt) for the production of the Cry1Ac protein in cotton plants. Maharashtra Hybrid Seeds Company, Ltd. (Mahyco) perceived the importance of this technology for control of Lepidopteran (Bollworm) pests and its clear value to the Indian farmer through reduction in use of environmentally damaging pesticides, and associated costs, as well as through increased yield potentials. It was therefore decided to undertake a breeding program to incorporate the Bt gene into elite Indian cotton lines for development of value-added hybrid cotton seeds. The following is a chronological narrative of research activities related to development of Bt cotton hybrids in India, and the corresponding regulatory process. At all stages of these activities, the duly constituted Institutional Bio-Safety Committee (IBSC) of Mahyco and the Department of Biotechnology (DBT) were kept updated on progress through documentation and discussion.

Import of Bt Cotton Seeds: As per Government of India regulations, an application was made by the Mahyco IBSC to the DBT for permission to import Bt cotton seeds from Monsanto Co., USA. DBT then granted permission, vide Permit No. BT/BS/01/004/91-Vol II dated March 10, 1995, for the import of 100g of Bt cotton seeds. These seeds were received for plant quarantine on January 23, 1996 and were released from quarantine on March 30, 1996.

Green House Operations: Upon receipt of the aforementioned seeds, the Research and Development division of Mahyco took up a fully green-house contained breeding program, as per DBT guidelines. The objective of this program was to incorporate the Bt gene into Mahyco's elite cotton inbred lines. The corresponding breeding work was accelerated by adopting embryo culture from immature bolls, thus it became possible to complete three plus generations per year. A small quantity of hybrid seeds were made by the Kharif 1997 cotton crop season. At the beginning of the 1998 Kharif season, sufficient amount of experimental hybrid seeds had been generated to take up larger area and multi-location trials. With the intention to ascertain the risk (or the lack of risk) of Bt gene transfer into related Gossypium species, inter-specific crosses were attempted. However these consistently failed to set seed. As per DBT guidelines, the staff involved in these experiments were regularly medically checked by specialists and their health status was shown to be normal.

Field Studies to Assess Pollen Escape: In July 1996, permission was received from DBT to conduct a limited field trial in Jalna (MS) to assess the extent of out-crossing

from Bt cotton to a non-transgenic pollen trap at distances starting from 5 meters to 50 meters (Permit No. BT/BS/01/004/91-Vol.III, dated July 16, 1996). The result of this study was submitted to DBT on March 18, 1997, and it was shown that there was no detectable out-crossing even as close as 5 meters, *i.e.* the nearest distance tested. A more detailed and multi-location testing of the probability of out-crossing from Bt cotton was then undertaken. An application was made to RCGM for permission to conduct further pollen-trap studies in four additional locations. The permission was received in November 1997 (Permit No. BT/17/02/94-PID/MS6/IBMAHYCO, dated November 10, 1997). In these studies, the first five pollen-trap rings were kept between 1 and 5 meters from the Bt pollen source, and another nine rings at 5 meter intervals, up to a distance of 50 meters. The results of these experiments, which involved detailed sampling and Polymerase Chain Reaction (PCR) amplification of DNA related to the Bt gene, were submitted to DBT for the first location on April 27, 1998, for the second and third locations on May 24, 1998, and for the fourth location on August 31, 1998. The proposed fifth location experiment was not conducted due to seasonal limitations. The results were as per expectations based on cotton floral part development and pollen characteristics, *i.e.* the effective distance of out-crossing from Bt cotton was only up to 2 meters, at a frequency ranging from 1% to 6% only. As bees are considered to be the predominant agents of cross-pollination in cotton, honey bee hives were provided at all corners of these trials and in three geographical locations (Karnataka, Andhra Pradesh and Tamil Nadu). Normal bee activity, development of colonies and honey production in the hives were noted at all the locations.

Bt Cotton Aggressiveness and Persistence: Natural shed of Bt cotton seeds were compared with the non-transgenic counterparts for potential weediness properties. A study of the difference of germination rate between these two types was also done. It was shown that there is no difference in these attributes between Bt cotton and conventional, non-transgenic cotton. These experiments clearly indicated that Bt cotton crops do not pose as an aggressor on the natural flora/habitat.

Biochemical and Toxicological Studies: In 1998, comparative chemical analysis, for protein, oil, ash, carbohydrate and total gossypol content were done. No difference was found between Bt and non-Bt cottonseed, which is used for oil extraction and as animal feed. Detailed studies were undertaken on the toxicity and allergenicity of Bt cotton. The toxicological study was conducted by Indian Toxicological Research Center, Lucknow, in the year 1998. The final report, which indicates that Bt cotton is not toxic to goats (as a model for ruminant mammals), has been recently submitted. This further supports earlier studies on avian and mammalian models, which have been reported in the literature. Allergenicity studies were also conducted on Brown Norway Rats and shown to pose no threat in this regard. The guinea pig model was not compatible with

cottonseed-based feeding and therefore had to be substituted with the above Brown Norway Rat model.

Multi-Location Field Trials: On the basis of the aforementioned studies, application was made and permission received from RCGM and DBT for conducting extensive multi-location field trials in the Kharif season of 1998. Permission was granted vide Permit No. BT/17/02/94-PID/MS6/IBMAHYCO dated 27.07.1998 and 5.8.1998. These experiments consisted of replicated research trials in small plot size at 15 locations, and trials of large plot size at 25 locations grown under typical farm conditions. The results of these trials are reviewed in the attached documents. Results from the replicated research trials at 15 locations are referred to as Protocol-1 Report, and results from the large plot trials at 25 locations are referred to as Protocol-2 Report.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ANNEXURE TABLES

LIST OF ABBREVIATIONS

Bt	*Bacillus thuringiensis*
Bt Cotton	Hybrid cotton with Bt gene insert
CRBD	Completely Randomized Block Design
DAS	Days After Sowing
Kg	Kilogram
ha	Hectare
LSD	Least Significant Difference
N	Nitrogen
Non-Bt	Hybrid cotton without Bt gene insert
P	Phosphorous
K	Potassium

Protocol -1 Report

EXECUTIVE SUMMARY

Under the guidance of the Department of Biotechnology, Government of India, research trials of Bt cotton hybrids were conducted at 15 locations representing seven states of India in 1998-1999. Objectives of these trials included:

1) Comparison of yield and fiber quality among Bt cotton hybrids and their non-Bt counterparts.

2) Comparison of Lepidopteran pest load (Bollworm Complex) among Bt cotton hybrids and their non-Bt counterparts, as well as effects on adjacent non-Bt field plantations.

3) Assessment of effects of Bt cotton hybrids on non-Lepidopteran (sucking) pests of cotton.

Each location trial consisted of 10 cotton hybrid entries randomized in four replications. Entries consisted of four Indian cotton hybrids containing a Bt (*Bacillus thuringiensis*) gene, the same four cotton hybrids but without the Bt gene, and two national hybrids as additional non-Bt checks.

In a separate but adjacent field block, all six non-Bt hybrids mentioned above were also planted in four replications. A five-meter distance was maintained around both field blocks in order to study possible effects of Bt cotton fields on adjacent non-Bt cotton plantations. Agronomic data related to yield and other morphological traits were taken at appropriate intervals during the crop growth cycle. Data related to Bollworm Complex (American Bollworm, Spotted Bollworm, Pink Bollworm) and other pests of cotton were taken at 15 day intervals through boll formation. Application of pesticides for control of Bollworm Complex was not employed at any of the trial locations in this study. All other standard cotton cultivation and management practices were used at each location.

Data were collected and analyzed from 10 locations for yield-related characters, and 9 locations for insect reaction characters. Data from some trial locations were unavailable due to damaging rains resulting in inconsistent collection of data.

Results from this study indicated that cotton hybrids containing the Bt gene provided significantly increased yield and/or yield component as compared to their non-Bt counterparts at each location tested. Pooled data over all locations indicated average yield increase of 37% to 60% when comparing individual Bt versus non-Bt

hybrid versions, while mean yield performance of all Bt hybrids was 40% higher in comparison to mean performance of all hybrids which did not carry the Bt gene (Table 1).

Results also indicated that Bt hybrids provided for significantly reduced Bollworm Complex activity as compared to their non-Bt counterpart hybrids. Significant decreases were measured for Bollworm larvae count and percentage fruiting body (flower/square/boll) damage on Bt hybrids. The percentage of fruiting body damage for Bt cotton hybrids averaged 2.5% for both intervals of 0 to 60 and 61 to 90 days after sowing, while figures for all non-Bt hybrids averaged 8.7% and 11.4%, respectively (Table 1).

No significant change was noted in mean yield or Bollworm Complex activity among non-Bt hybrids of Block-1 (plantation containing both Bt and non-Bt hybrids) and Block-2 (plantation containing only non-Bt hybrids) (Table 1). Other pests of cotton (Aphids, Jassids, Whitefly) did not significantly vary among Bt and non-Bt hybrids. Beneficial insects were also observed to be active on all hybrids. Fiber quality characters were measured for all hybrids, and were not found to significantly vary among Bt and non-Bt types.

This study clearly indicates that incorporation of a Bt gene into Indian hybrid cotton germplasm holds promise to substantially improve cotton production through control of Bollworm infestation, while also maintaining fiber quality. Control of Bollworm infestation through use of Bt cotton hybrids does not appear to influence behaviour of the same insects in adjacent fields, nor have any substantial effect on activity of sucking pests or beneficial insects of cotton. It is apparent that Bt cotton hybrids will have substantial value as a major component in integrated pest management (IPM) systems for cotton production in India.

TABLE 1. Summary of Pooled Data for Yield and Bollworm Complex Traits from Bt and Non-Bt Cotton Hybrid Trials in India, 1998-1999.

BLOCK 1: Bt & Non-Bt Hybrids

HYBRID	Yield Measurement [1]		Bollworm Complex Reaction [2]			
	Yield	% Increase in Yield:	Bollworm Larvae (Count per 10 Plants)		% Fruiting Body Damage [3]	
	(Kg/ha)	Bt versus Non-Bt Hybrids	0 – 60 Days After Sowing	61 - 90 Days After Sowing	0 - 60 Days After Sowing	61 – 90 Days After Sowing
MECH-1 Bt	* 1164	46 %	* 0.9	* 1.5	* 1.8	* 2.5
MECH-1 Non-Bt	795		4.3	5.1	7.8	11.6
MECH-3 Bt	* 1456	44 %	* 1.0	* 1.8	* 2.2	* 3.3
MECH-3 Non-Bt	1014		5.9	5.3	8.3	12.8
MECH-12 Bt	* 1623	37 %	* 1.3	* 1.6	* 2.2	* 1.3
MECH-12 Non-Bt	1187		5.3	6.2	7.0	10.9
MECH-162 Bt	* 1611	60 %	* 1.5	* 2.0	* 3.6	2.9
MECH-162 Non-Bt	1004		6.6	6.9	8.8	9.6
NHH-44	1078		7.5	7.8	11.1	11.9
H-8	1189		7.0	7.2	8.9	11.8
Mean: Bt Hybrids	* 1464	40 %	* 1.2	* 1.7	* 2.5	* 2.5
Mean: Non-Bt Hyb.	1045		6.1	6.4	8.7	11.4
LSD (0.05)	214		2.5	2.4	4.5	7.2

BLOCK 2: Non-Bt Hybrids

MECH-1	894		5.2	6.1	7.7	10.7
MECH-3	957		4.4	7.7	6.9	11.6
MECH-12	1137		5.3	7.2	7.6	11.0
MECH-162	1176		6.3	6.9	6.5	11.7
NHH-44	1111		4.8	6.9	7.1	9.3
H-8	1118		5.1	7.0	8.8	12.2
Mean: Non-Bt Hyb.	[NS] 1066		[NS] 5.2	[NS] 7.0	[NS] 7.4	[NS] 11.1
LSD (0.05)	178		2.0	1.2	2.8	3.4

* = Bt cotton hybrid significantly different from the non-Bt counterpart for components related to yield or Bollworm Complex.

[NS] = Mean of non-Bt hybrids in Block 2 (non-Bt plantation) Not Significantly Different from mean of non-Bt hybrids in Block 1 (Bt & non-Bt plantation).

[1] Yield data averaged over 10 locations, representing 5 States.

[2] Bollworm Complex data averaged over 9 locations, representing 5 States.

[3] Damage to fruiting bodies involved either flower parts, squares, or bolls.

Protocol-1 Report

Assessment of Yield and Bollworm Complex Load among Bt and Non-Bt Cotton Hybrids in Replicated Research Trials in India, 1998-1999

OBJECTIVES

1) Comparison of Yield and fiber quality among Bt cotton hybrids and their non-Bt counterparts.

2) Comparison of Lepidopteran pest load (Bollworm Complex : American Bollworm, Spotted Bollworm, Pink Bollworm) among Bt cotton hybrids and their non-Bt counterparts, as well as effects on adjacent non-Bt field plantations.

3) Assessment of effects of Bt cotton hybrids on non-Lepidopteran pests of cotton.

MATERIALS AND METHODS

Protocol-1 consisted of replicated trials of Bt and non-Bt cotton hybrids in two blocks grown at 15 locations in seven states of India. These states (locations) were Andhra Pradesh (4), Maharashtra (4), Karnataka (2), Gujarat (1), Haryana (2), Punjab (1) and Tamil Nadu (1). In Block-1, treatments include four Bt hybrids with their corresponding four non-Bt version, and two non-Bt notified hybrids. Block-2 treatments included the same six non-Bt hybrids as in Block-1.

These trials were conducted in rainy season (Kharif) in 1998-1999. Normal cultural practices prevalent in the region were followed. However, spraying for Lepidopteran pests (referred to as Bollworm Complex) was not undertaken in order to assess the pest resistance efficacy of Bt cotton. Data were recorded for insect pest reaction, yield and morphological characters. Fiber quality properties of length, strength, fineness and elongation were measured with HVI-3000 (Motion Control, Inc., USA) and HVI-900A (Zellweger Uster, Inc., USA) machines in the Mahyco cotton fiber testing laboratory by using standard protocols.

A. Description Of Field Plots

1. **Block-1 :** Four Bt hybrid and their 4 corresponding non-Bt versions, along with two notified hybrids, were grown in a complete randomized block design (CRBD) with four replications. Corresponding Bt hybrids and their non-Bt versions were randomized in pairs through out the experiment.

2. **Block- 2 :** The same four non-Bt Hybrids and two non-Bt hybrid checks were grown in the second block, in four replications of a CRBD. The detail of spacing, plot size are given below:

Design-CRBD	BLOCK-1	BLOCK-2
Treatments	10 (4 Bt hybrids + 4 non-Bt versions + 2 notified hybrids)	6 (same non-Bt hybrids used in Block-1)
Replications	Four	Four
Gross Plot (3.6m X 9m)	32.4 Sq. Mt	32.4 Sq. mt
Rows per plot	Four	Four
Row length	9 m.	9 m.
Spacing between rows	90 cm	90 cm
Spacing between plants	90 cm	90 cm
Gross experimental area	(36x38.7m) = 1394 Sq.m.	(36x38.7m) = 1394 Sq.m.
Isolation between blocks	5 m	5 m

B. Description of Treatment Assignments

Hybrid Entry	Treatment Designation	
	Block-1	Block-2
MECH-1 (Bt))	T1	
MECH-1 (Non Bt)	T2	T1
MECH-3 (Bt)	T3	
MECH-3 (Non Bt)	T4	T2
MECH-12 (Bt)	T5	
MECH-12 (Non Bt)	T6	T3
MECH-162 (Bt)	T7	
MECH- 162 (Non Bt)	T8	T4
NHH-44 Check	T9	T5
H-8 Check	T10	T6

C. Field Layout Details

BLOCK-1: (36m x 38.7m)

Plot Rep 1	101 T3	102 T4	103 T1	104 T2	105 T7	106 T8	107 T10	108 T5	109 T6	110 T9
0.9m										
Plot Rep 2	120 T5	119 T6	118 T10	117 T1	116 T2	115 T3	114 T4	113 T9	112 T8	111 T7
0.9m										
Plot Rep 3	121 T4	122 T3	123 T8	124 T7	125 T6	126 T5	127 T9	128 T10	129 T2	130 T1
0.9m										
Plot Rep 4	140 T1	139 T2	138 T9	137 T3	136 T4	135 T6	134 T5	133 T10	132 T7	131 T8

Space 5m ▲▼

BLOCK-2: (21.6m x 38.7m)

Plot Rep 1	201 T5	202 T6	203 T1	204 T2	205 T4	206 T3
0.9m						
Plot Rep 2	212 T4	211 T3	210 T5	209 T1	208 T6	207 T2
0.9m						
Plot Rep 3	213 T2	214 T5	215 T3	216 T6	217 T1	218 T4
0.9m						
Plot Rep 4	224 T3	223 T4	222 T2	221 T5	220 T6	219 T1

An isolation of 5m was maintained surrounding each Block.

D. Location Details

Trials were organized with approval of the Department of Biotechnology at 15 Locations in 7 States of India as listed below:

Locations of Replicated Bt-Cotton Trials:

State	District	Tehsil	Village	Survey No.	Farmer Name
Andhra Pradesh (AP)	Prakasham	Addanki	Gopalpuram	74/1	Yerra Hanumantha Rao
	Karimnagar	Vemulawada	Pushpanagar	428	Katakam S. Reddy
	Ranga Reddy	Ranga Reddy	Medchal/ Jedimetia	93RU/ 93LU	Kailash Charan/ Mahyco
	Ranga Reddy	Shamshabad	Kavvaguda	467	Mahyco
Maharashtra (MS)	Latur	Udgir	Lohara	434	Chandrarao, H. Sontake
	Amravati	Warud	Warud	2	Rambhau H. Hole
	Jalna	Jalna	Jamwadi	198	Mahyco
	Akola	Telhara	Chittalwadi	29	Vijay A. Ingle
Gujrat (GJ)	Mehsana	Gozaria	Parsa	82	Harshadbhai B. Patil
Karnataka (KTK)	Chitradurga	Harihar	Duggavati	115	B. Chandrappa & S. Ramappa
	Haveri	Ranibennur	Kunbev	98	Mahyco
Haryana (HR)	Sirsa	Mandi Dabwali	Alika	-	Harpal Singh
	Gurgaon	Farrukhnagar	Sewari	76	Mahyco
Punjab (PJ)	Ferozpur	Abohar	Rajowali	6/21	Surinder Singh
Tamilnadu (TN)	Coimbatore	Valampalayam	Kondayam-Palayam	119	Mahyco

E. Crop Management

Trials were planted on ridge-and-furrow, as well as on flat beds depending on the resources available and prevalent cotton production practices in the region. Basal dose fertilizer of 30N-30P-20K was applied. The second dose in the same ratio was given at 40 days after sowing (DAS). At 70 DAS, 20 kg N was added as a top dressing.

A summary of cultural practices at each location is given below in tabular form.

Crop Management Practices at Bt Trial Locations

State	Location	Bt Trial Sowing Date	N-P-K	Irrigation	Weeding	Insecticides
AP	Prakasham	Aug 7, 98	100-60-60 three split	Three	Six	Metasystox@ 2ml/l
AP	Kavvaguda Ranga Reddy	Aug 7, 98	100-75-40	Three	Six	Basal-Phorate Metasystax@2ml/l 3 sprays confidor @ 0.5 ml/l
AP	Ranga Reddy	Aug 8, 98	90-60-30	Three	Six	Metasystax@2ml/l Monocrotophos@1.5ml/l, 3 sprays confidor @ 0.5 ml/l
AP	Karimnagar	Aug 7, 98	100-60-60	Nil	Six	Three sprays. Acephate and three spray of Confidor @ 0.5 ml/l.
MS	Latur	Aug 8, 98	107-62-40	Two	Five	Metasystax@2ml/l =2 Confidor @ 0.5 ml/l =3
MS	Amravati	Aug 9, 98	100-62-40	Two	Five	Metasystax@2ml/ =2l Monocrotophos@1.5ml/l, Confidor @ 0.5 ml/l=2
MS	Jalna	Aug 8, 98	100-62-40	Two	Five	Metasystax@2ml/l Confidor @ 0.5 ml/l
MS	Akola	Aug 9, 98	100-62-40	Nil	Five	Metasystax@2ml/l =2 Confidor @ 0.5 ml/l =3
GJ	Mehsana	Aug 9, 98	120-60-0	One	Five	Metasystax@2ml/l =2 Confidor @ 0.5 ml/l =3
KTK	Duggavati	Aug 12, 98	100-40-40	Two	Rain	Metasystax@2ml/l =2 Confidor @ 0.5 ml/l =3
KTK	Haveri	Aug 12,98	100-40-40	Two	Four	Metasystax@2ml/l =2 Confidor @ 0.5 ml/l =2
HR	Sirsa	Aug 8, 98	100-50-50	Two	Heavy rain	Poor germination
HR	Gurgaon	Aug 9, 98	40-40-30	Two	Heavy rain	Metasystax@2ml/l =2 Confidor @0.5 ml/l =3
PJ	Ferozpur	Aug 10 , 98	40-40-30	Two	Heavy rain	Metasystax@2ml/l =2 Confidor @ 0.5 ml/l =3
TN	Coimbatore	Aug 17, 98	100-40-40	Five	Five	Metasystax@2ml/l =2 Confidor @ 0.5 ml/l =3

As Bt cotton does not provide protection against sucking insects, need based sprayings were recommended to control Aphids, Jassids and Whitefly. Minimum 4 to 5 sprayings were undertaken using Acephate @ 2g/l water, Metasystax @ 2ml/l water, and Confidor @ 0.5ml/l water, *i.e.* 100 ml/ha.

In this protocol, spraying for the Bollworm complex (American Bollworm, Pink Bollworm, Spotted Bollworm) was not undertaken for any treatment in order to ensure equal opportunity for infestation throughout.

F. Data Recording

The following data were recorded on 10 randomly selected plants in each experimental plot.

1) Insect count was recorded at a regular interval of 15 days on Bt hybrids and non-Bt hybrids in Block -1 and Block-2.

2) Percent fruiting body damage (flower parts, squares and bolls) was recorded on the same randomly selected plants.

3) Days to flowering, yield (cotton with seed in Kg/ha) and morphological characters.

4) Fiber quality characters.

G. Data Analysis

Analyses of variance were conducted for each location, and treatment means were compared using the least significant difference at the $\pm$ 0.05 level of significance. Treatment means for each character were also calculated and compared using pooled data over all locations.

Insect data recorded up to 60 days after sowing, and 61 to 90 days after sowing were reported as an average for the respective period. These are presented as 60 DAS, and 90 DAS throughout this report.

H. Status of Location Trials and Data

Of the 15 locations sown, four trials were damaged by rain and reliable data was not obtained. These trials were Prakasham (AP), Sirsa and Gurgaon (HR) and Duggavati (KTK). Data from Ferozpur in Punjab was available for insect resistance, but not for yield due to damaging late rains. Insect pest reaction was not assessed at the Jalna (MS) and Coimbatore (TN) locations.

RESULTS

Summary data for each trial location are presented in the following pages (Table 2 to Table 20). The summary of pooled data over all trials was previously presented in Table 1.

Data for yield characters were obtained for 10 of 15 trial locations, as follows:

1. Kavvagudda, Ranga Reddy (AP)
2. Srinath Farm, Ranga Reddy (AP)
3. Pushpanagar, Karimnagar (AP)
4. Lohara, Latur (MS)
5. Warud, Amrawati (MS)
6. Jamwadi, Jalna (MS)
7. Chittalwadi, Akola (MS)
8. Ranebennur, Haveri (KTK)
9. Parsa, Mehshana (GJ)
10. Kondayampalayam, Coimbatore (TN)

Data for insect reaction were obtained for 9 of 15 trial locations, as follows:

1. Kavvagudda, Ranga Reddy (AP)
2. Srinath Farm, Ranga Reddy (AP)
3. Pushpanagar, Karimnagar (AP)
4. Lohara, Latur (MS)
5. Warud, Amrawati (MS)
6. Chittalwadi, Akola (MS)
7. Ranebennur, Haveri (KTK)
8. Parsa, Mehshana (GJ)
9. Rajowali, Ferozpur (PJ)

Laboratory analyses of fiber quality were collected using bolls from four locations. Data tables for fiber quality are listed in the Annexure (Tables A1 to A9).

Data from these trials represent hybrids with different growth duration. Hybrid entries MECH-1, MECH-3, and MECH-12 are typically around 150 to 160 days in duration with 2 to 3 boll pickings. Hybrids MECH-162, NHH-44 and H-8 are typically around 180 to 190 days in duration with 3 or more boll pickings. These differences tend to provide for varying baseline yield potentials, which should be kept under consideration when making comparisons in resulting data.

LOCATION : Kauvagudda, Ranga Reddy (AP)

A. Yield and Morphological Traits

Block-1: Table 2

Significant differences were noted in the yield of Bt hybrid and the non-Bt ranging from 60% (MECH-12 Bt) to 91% (MECH 1 Bt). Number of bolls in MECH-12 Bt and MECH-162 Bt were higher by 36% and 54%, respectively, over the check H-8. Numbers of bolls in Bt hybrids were also significantly higher than the non-Bt hybrid.

Block-2: Table 2

The data for yield and other morphological characters were similar to those of the non-Bt hybrids in Block-1. However, MECH-12 recorded a higher yield in this Block.

B. Insect Reaction

Block-1: Table 3

The mean Bollworm Complex count up to 60 DAS ranged from 0.5 on MECH-12 Bt to 3.0 on MECH-162 Bt. On non-Bt hybrids including checks, it ranged from 2.0 to 9.0. The Bollworm Complex counts at 90 DAS range from 0.0 to 1.0 in Bt and 2 to 5 in non-Bt hybrids. The fruiting body damage (%) in Bt hybrids range from 1.3 to 3.8 at 60 DAS; and 0.3 to 0.4 at 90 DAS. In non-Bt hybrids fruiting body damage (%) range from 7.3 to 15.2 at 60 DAS; 0.9 to 1.1 at 90 DAS.

Average aphids count at 60 DAS ranges from 0.0 to 19 for MECH 162 and MECH-12 Bt, respectively. The low aphid count was also recorded at 90 DAS. Jassids count was also low in this trial ranging from 0.0 to 17. Whitefly count was reported at 16 to 30 at 60 DAS and 21 to 41 at 90 DAS. Differences were not noted between Bt and non-Bt hybrids for these pests.

Block-2: Table 3

This Block had higher sucking pests, Bollworm Complex count and fruiting body damage (%) than Block-1 at 60 DAS and 90 DAS.

TABLE 2. Kavvaguda, RangaReddy (AP): Summary of Yield and Morphological Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

BLOCK 1: Bt & Non-Bt Hybrids

HYBRID	Yield (Kg/ha)	Yield (Kg/Plot)			Ave. Bolls/ Pl.	Ave. Pl./ Plot	Days to 1st Flower	Days to 1st Boll Burst
		1st Pick	2nd Pick	3rd Pick				
MECH-1 Bt	* 1152	0.81	* 2.53	0.39	* 21	36	45	95
MECH-1 Non-Bt	601	0.63	0.99	0.33	10	39	45	95
MECH-3 Bt	1068	0.65	2.31	0.50	* 28	37	47	95
MECH-3 Non-Bt	926	0.68	1.81	0.51	18	39	47	95
MECH-12 Bt	* 1763	* 1.36	* 3.89	0.46	* 30	35	45	95
MECH-12 Non-Bt	1102	0.77	2.35	0.45	18	38	45	95
MECH-162 Bt	* 1500	1.14	* 3.18	0.54	* 34	37	49	95
MECH-162 Non-Bt	753	0.63	1.22	0.59	15	39	49	95
NHH-44	867	0.56	1.62	0.63	15	32	50	103
H-8	1052	0.92	1.97	0.52	22	38	53	103
Mean: Bt Hybrids	* 1371	1.00	* 2.97	0.47	* 28	36	47	95
Mean: Non-Bt Hy.[1]	883	0.65	1.66	0.51	16	38	48	98
LSD (0.05)	348	0.57	0.93	0.17	9	4	1	1

BLOCK 2: Non-Bt Hybrids

MECH-1	892	1.11	1.44	0.34	19	36	45	95
MECH-3	1159	1.89	1.44	0.41	20	40	47	95
MECH-12	1632	2.83	2.07	0.39	22	37	45	95
MECH-162	1518	2.89	1.33	0.70	15	38	47	95
NHH-44	1293	2.41	1.23	0.55	16	36	48	95
H-8	1635	2.82	1.94	0.54	29	38	44	103
Mean: Non-Bt Hy.[1]	1354	2.33	1.57	0.49	20	38	46	96
LSD (0.05)	246	1.19	0.75	0.16	11	3	3	1

* = Bt Cotton Hybrid Significantly Different from non-Bt Counterpart for Yield Related Components.

[1] Mean Value for All Conventional Cotton Hybrids under Trial, within the Block of Interest.

TABLE 3. Kavvaguda, RangaReddy (AP): Summary of Insect Reaction Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

BLOCK 1: Bt & Non-Bt Hybrids

HYBRID	Bollworm Complex				Sucking Pests					
	Bollworm Larvae /10 Pl.		% Fruit Body Damage		Aphids (30 Leaves)		Jassids (30 Leaves)		Whitefly (30 Leaves)	
	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS
MECH-1 Bt	1.4	* 0.0	* 2.2	* 0.4	15	12	13	11	23	37
MECH-1 Non-Bt	5.3	2.3	7.5	0.9	9	18	10	13	26	35
MECH-3 Bt	2.0	* 0.5	* 2.0	* 0.3	11	19	10	9	22	32
MECH-3 Non-Bt	6.9	3.8	7.3	0.9	10	6	17	12	16	39
MECH-12 Bt	0.5	* 1.0	* 1.3	* 0.3	19	0	7	14	16	41
MECH-12 Non-Bt	2.0	3.5	7.8	0.9	10	14	17	11	18	25
MECH-162 Bt	3.0	* 0.5	* 3.8	* 0.5	0	0	0	6	26	36
MECH-162 Non-Bt	9.1	3.3	13.2	1.1	6	0	1	5	30	33
NHH-44	8.3	5.3	15.3	1.1	6	0	1	11	22	35
H-8	5.9	3.0	11.7	1.1	0	0	1	10	17	21
Mean: Bt Hybrids	1.7	* 0.6	* 2.3	* 0.4	15	16	10	10	22	37
Mean: Non-Bt Hy.[1]	6.3	3.5	10.5	1.0	8	13	8	10	22	31
LSD (0.05)	6.3	2.2	4.0	0.4	20	16	12	10	13	23

BLOCK 2: Non-Bt Hybrids

MECH-1	9.0	4.5	2.0	4.8	75	29	15	14	32	32
MECH-3	4.0	3.8	1.3	5.8	13	37	25	18	31	38
MECH-12	11.0	5.0	2.2	5.3	28	32	13	16	31	36
MECH-162	8.1	4.5	1.6	4.1	28	5	12	10	33	35
NHH-44	6.1	4.3	2.9	2.3	32	5	10	8	31	20
H-8	2.9	4.5	1.6	1.8	25	13	10	12	30	15
Mean: Non-Bt Hy.[1]	6.9	4.4	2.0	4.0	34	20	14	13	32	29
LSD (0.05)	8.0	2.3	1.5	4.2	25	22	11	6	11	11

* = Bt Cotton Hybrid Significantly Different from non-Bt Counterpart for Bollworm Reaction Traits.

[1] Mean Value for All Conventional Cotton Hybrids under Trial, within the Block of Interest.

Note: Fruit Body Damage (%) Includes Flowers, Squares and Green Bolls.

LOCATION: Srinath Farm, Ranga Reddy (AP)

A. Yield and Morphological Traits

Block-1: Table 4

The yield increase in Bt hybrids over non-Bt hybrid ranges from 30% (MECH-162 Bt) to 46% (MECH-3 Bt). The Bt hybrid yields were higher than the best check (NHH-44) by 16% and 43% for MECH-3 Bt and MECH-12 Bt, respectively. The numbers of bolls per plant were significantly higher in Bt as compared to the non-Bt hybrids.

Block-2: Table 4

The yield of all hybrids was lower in Block-2 as compared to Block-1. The number of bolls per plant was also lower in this Block.

B. Insect Reaction

Block-1: Table 5

Bollworm Complex count was low in this trial (0 to 0.6 at 60 DAS, and 0 to 0.9 at 90 DAS). Lower fruiting body damage (%) was observed in this Block ranging from 0.4% to 0.9% at 60 DAS as compared to 2.0% to 3.0% of Bt and non-Bt hybrids, respectively. At 90 DAS fruiting body damage in Bt hybrids ranged from 0.3% to 1.2%, as against non-Bt hybrid range of 2.0% to 5.0%.

Aphid count at 60 DAS ranged from 17 to 56, and at 90 DAS 0.8 to 159; Jassids count ranged from 8 to 98 at 60 DAS; 4 to 9 at 90 DAS. Whitefly count ranged from 7 to 16 at 60 DAS and 10 to 17 at 90 DAS. Differences were not noted between Bt and non-Bt hybrids for these pests.

Block-2: Table 5

Fruiting bodies damage in this Block was similar to that of Block-1 for the non-Bt hybrids ranging from 2% to 5% at 60 DAS and 2% to 4% at 90 DAS.

TABLE 4. Srinath Farm, RangaReddy (AP): Summary of Yield and Morphological Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

BLOCK 1: Bt & Non-Bt Hybrids

HYBRID	Yield (Kg/ha)	Yield (Kg/Plot)			Ave. Bolls/ Pl.	Ave. Pl./ Plot	Days to 1st Flower	Days to 1st Boll Burst
		1st Pick	2nd Pick	3rd Pick				
MECH-1 Bt	895	2.1	0.4	0.4	* 26	29	NA	NA
MECH-1 Non-Bt	741	1.6	0.5	0.3	15	36		
MECH-3 Bt	* 1080	* 2.4	0.6	0.5	* 31	37		
MECH-3 Non-Bt	741	1.5	0.5	0.4	14	34		
MECH-12 Bt	* 1327	* 3.2	0.6	0.5	* 38	31		
MECH-12 Non-Bt	1049	2.4	0.6	0.4	24	37		
MECH-162 Bt	* 1049	* 2.3	0.7	0.4	27	32		
MECH-162 Non-Bt	803	1.7	0.6	0.3	21	34		
NHH-44	926	1.8	0.8	0.4	29	36		
H-8	926	2.1	0.6	0.3	30	36		
Mean: Bt Hybrids	* 1088	* 2.5	0.6	0.5	31	32		
Mean: Non-Bt Hy.[1]	864	1.9	0.6	0.4	22	36		
LSD (0.05)	204	0.6	0.3	0.2	10	7		

BLOCK 2: Non-Bt Hybrids

MECH-1	494	1.0	0.4	0.2	7	38	NA	NA
MECH-3	524	1.1	0.3	0.3	11	36		
MECH-12	679	1.6	0.3	0.3	9	40		
MECH-162	771	1.6	0.6	0.3	15	39		
NHH-44	617	1.2	0.5	0.3	13	38		
H-8	679	1.6	0.4	0.2	11	35		
Mean: Non-Bt Hy.[1]	627	1.4	0.4	0.3	11	38		
LSD (0.05)	309	0.8	0.3	0.1	7	4		

* = Bt Cotton Hybrid Significantly Different from non-Bt Counterpart for Yield Related Components.

NA = Data Not Available.

TABLE 5. Srinath Farm, RangaReddy (AP): Summary of Insect Reaction Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

BLOCK 1: Bt & Non-Bt Hybrids

HYBRID	Bollworm Complex				Sucking Pests					
	Bollworm Larvae /10 Pl.		% Fruit Body Damage		Aphids (30 Leaves)		Jassids (30 Leaves)		Whitefly (30 Leaves)	
	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS
MECH-1 Bt	0.0	0.0	0.5	0.3	23	0	98	9	12	11
MECH-1 Non-Bt	0.0	0.4	2.1	2.0	33	0	46	9	16	14
MECH-3 Bt	0.0	0.4	* 0.9	* 1.0	17	8	98	8	12	12
MECH-3 Non-Bt	0.4	0.9	3.0	5.0	47	5	18	7	13	15
MECH-12 Bt	0.0	0.0	* 0.4	* 0.5	20	5	39	9	8	13
MECH-12 Non-Bt	0.0	0.4	2.0	4.0	20	12	36	7	12	10
MECH-162 Bt	* 0.0	0.4	0.4	* 1.2	38	159	13	5	13	13
MECH-162 Non-Bt	0.6	0.0	1.3	3.0	37	133	8	4	9	11
NHH-44	0.3	0.0	3.0	3.4	56	117	16	4	7	13
H-8	0.3	0.0	2.3	2.0	42	109	37	9	10	17
Mean: Bt Hybrids	0.0	0.2	* 0.6	* 0.8	25	43	62	8	11	12
Mean: Non-Bt Hy.[1]	0.3	0.3	2.3	3.2	39	63	27	7	11	13
LSD (0.05)	0.6	0.8	1.7	1.8	31	82	93	6	8	9

BLOCK 2: Non-Bt Hybrids

MECH-1	0.6	0.6	2.3	2.5	14	20	19	12	8	8
MECH-3	0.0	0.0	3.3	2.4	16	5	20	6	12	21
MECH-12	0.0	0.0	2.1	1.8	13	0	26	7	10	9
MECH-162	0.0	0.0	4.9	3..0	39	5	10	4	13	11
NHH-44	0.3	0.0	3.9	3.9	49	13	10	4	11	15
H-8	1.1	0.0	5.3	3.3	18	0	8	4	16	16
Mean: Non-Bt Hy.[1]	0.3	0.1	3.6	2.8	25	7	16	6	12	13
LSD (0.05)	0.9	0.6	2.1	2.1	29	16	9	6	7	8

* = Bt Cotton Hybrid Significantly Different from non-Bt Counterpart for Bollworm Reaction Traits.

[1] Mean Value for All Conventional Cotton Hybrids under Trial, within the Block of Interest.

Note: Fruit Body Damage (%) Includes Flowers, Squares and Green Bolls.

LOCATION : Pushpnagar, Karimnagar (AP)

A. Yield and Morphological Traits

Block-1: Table 6

Yields of Bt hybrids were significantly higher than the non-Bt hybrids and the checks (H-8 and NHH-44) in all the cases. The yield advantage ranged from 12% (MECH-162 Bt) to 22% (MECH-1 Bt). The number of bolls retained on the Bt hybrids is higher by 26% to 19% as compared to the non-Bt counterparts.

Block-2: Table 6

In general, bolls/plant and yield in this Block for each hybrid was lower than Block-1. MECH-162 and MECH-3 recorded significantly higher yield than other hybrids. Differences in yield can be due to micro-environmental variation.

B. Insect Reaction

Block-1: Table 7

In Bt hybrids, the Bollworm Complex count and fruiting body damage (%) was significantly lower than the non-Bt hybrid and check, both at 60 DAS and 90 DAS.

There was heavy attack of sucking pests on all the hybrids both at 60 DAS and 90 DAS, except in the case of MECH-3 and MECH-12 Bt where the number of insects compared to their other counterparts hybrids were much higher. This appears to be variation not due to Bt or non-Bt material.

Block-2: Table 7

In general, Bollworm Complex count and fruiting body damage (%) was higher in Block-2 than in Block-1.

TABLE 6. **Pushpanagar, Karimnagar (AP): Summary of Yield and Morphological Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.**

BLOCK 1: Bt & Non-Bt Hybrids

HYBRID	Yield (Kg/ha)	Yield (Kg/Plot)		Ave. Bolls/ Pl.	Ave. Pl./ Plot	Days to 1st Flower	Days to 1st Boll Burst
		1st Pick	2nd Pick				
MECH-1 Bt	* 1848	* 3.51	2.48	* 37	37	45	82
MECH-1 Non-Bt	1515	2.73	2.18	31	38	45	81
MECH-3 Bt	* 1691	* 3.32	2.16	* 45	37	45	83
MECH-3 Non-Bt	1466	2.59	2.16	37	39	45	83
MECH-12 Bt	* 2148	* 3.78	* 3.18	* 42	37	49	84
MECH-12 Non-Bt	1805	3.25	2.60	36	38	48	83
MECH-162 Bt	1583	* 2.98	2.15	* 58	38	55	87
MECH-162 Non-Bt	1416	2.38	2.21	46	38	55	85
NHH-44	1320	2.43	1.85	51	38	55	88
H-8	1361	2.53	1.88	49	39	45	80
Mean: Bt Hybrids	* 1818	* 3.39	2.49	* 45	37	49	84
Mean: Non-Bt Hy.[1]	1481	2.65	2.15	42	38	49	83
LSD (0.05)	172	0.48	0.49	2	3	1	2

BLOCK 2: Non-Bt Hybrids

MECH-1	1084	2.00	1.51	29	37	45	81
MECH-3	1228	2.62	1.36	39	37	45	81
MECH-12	1076	1.99	1.50	33	37	50	84
MECH-162	1277	2.69	1.45	45	38	55	86
NHH-44	1038	1.84	1.52	42	36	55	87
H-8	1089	2.21	1.32	43	37	45	80
Mean: Non-Bt Hy.[1]	1132	2.23	1.44	39	37	49	83
LSD (0.05)	168	0.32	0.32	5	3	1	1

* = Bt Cotton Hybrid Significantly Different from non-Bt Counterpart for Yield Related Components.

TABLE 7. Pushpanagar, Karimnagar (AP): Summary of Insect Reaction Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

BLOCK 1: Bt & Non-Bt Hybrids

HYBRID	Bollworm Complex				Sucking Pests					
	Bollworm Larvae /10 Pl.		% Fruit Body Damage		Aphids (30 Leaves)		Jassids (30 Leaves)		Whitefly (30 Leaves)	
	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS
MECH-1 Bt	* 0.6	1.5	* 2.0	* 0.7	114	46	40	71	47	45
MECH-1 Non-Bt	3.3	3.2	5.0	7.5	107	44	49	70	35	10
MECH-3 Bt	* 0.3	* 0.8	* 2.3	* 0.7	112	41	46	72	36	11
MECH-3 Non-Bt	4.3	8.2	8.0	7.2	115	188	52	60	27	10
MECH-12 Bt	* 0.5	* 1.5	1.9	* 0.6	442	322	47	83	29	25
MECH-12 Non-Bt	4.1	9.8	4.0	7.2	89	43	72	70	29	17
MECH-162 Bt	* 1.0	* 2.0	2.2	* 1.2	133	33	43	39	48	66
MECH-162 Non-Bt	4.5	7.6	3.6	9.4	95	36	66	28	59	66
NHH-44	3.0	10.5	4.6	13.2	191	37	38	12	68	62
H-8	4.8	9.2	4.4	10.9	127	31	30	22	58	78
Mean: Bt Hybrids	* 0.6	* 1.4	* 2.1	* 0.8	200	110	44	66	40	36
Mean: Non-Bt Hy.[1]	4.0	8.1	4.9	9.2	120	63	51	43	46	40
LSD (0.05)	1.4	2.3	2.5	3.6	44	23	19	26	30	20

BLOCK 2: Non-Bt Hybrids

MECH-1	8.7	8.8	6.5	11.2	51	35	82	112	68	30
MECH-3	6.2	9.3	6.8	11.8	82	26	90	85	36	37
MECH-12	5.4	11.7	14.7	10.1	78	31	72	84	33	39
MECH-162	6.8	11.6	8.0	11.9	82	17	55	50	59	72
NHH-44	7.2	10.7	8.1	13.2	103	19	32	48	75	74
H-8	7.3	13.0	8.0	12.4	95	20	43	50	225	82
Mean: Non-Bt Hy.[1]	6.8	10.8	8.7	11.7	81	24	62	71	82	56
LSD (0.05)	2.3	3.7	11.4	3.2	34	20	24	26	190	23

* = Bt Cotton Hybrid Significantly Different from non-Bt Counterpart for Bollworm Reaction Traits.

[1] Mean Value for All Conventional Cotton Hybrids under Trial, within the Block of Interest.

Note: Fruit Body Damage (%) Includes Flowers, Squares and Green Bolls.

LOCATION : Lohara, Latur (MS)

A. Yield and Morphological Traits

Block-1: Table 8

This trial was affected due to heavy rainfall, which resulted in heavy pressure from sucking pests and reduced yield. Even under these adverse circumstances, significant differences in yield between Bt and non-Bt hybrids were observed. In general Bt hybrid yields were higher than non-Bt hybrid counterparts in the range from 24% to 33%. Bt hybrids also recorded higher yield than the best check (H-8), varying from 25% to 46%.

Block-2: Table 8

This Block recorded lower yield than the Block-1. Highest yield was noticed in MECH –162, which was better than both all checks. No difference in other characters, except DAS to first boll opening, was observed. H-8, MECH-3 and NHH-44 were late in boll bursting.

B. Insect Reaction

Block-1: Table 9

The Bollworm Complex counts and fruiting body damage (%) were lower in Bt hybrids than the non-Bt counterparts and checks at both 60 and 90 DAS. The Bollworm Complex count up to 90 DAS ranged from 2 to 3 in Bt hybrids, as against 4 to11 in non-Bt hybrids. Percent fruiting body damage was lower in Bt hybrids than in non-Bt hybrids.

There was low Aphid infestation up to 90 DAS in this trial. However, Jassids and Whitefly population was comparatively high. Bt and non-Bt hybrids were similar for overall sucking pest infestation.

Block-2: Table 9

No significant differences were seen for sucking pests between Block-1 and Block-2. Percent fruiting body damage was lower in Block-2 as compared to Block-1.

TABLE 8. Lohara, Latur (MS): Summary of Yield and Morphological Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

BLOCK 1: Bt & Non-Bt Hybrids

HYBRID	Yield (Kg/ha)	Yield (Kg/Plot) 1st Pick	2nd Pick	3rd Pick	Ave. Bolls/ Pl.	Ave. Pl./ Plot	Days to 1st Flower	Days to 1st Boll Burst
MECH-1 Bt	* 561	* 0.47	* 0.67	* 0.68	NA	31	48	99
MECH-1 Non-Bt	435	0.40	0.49	0.52		36	48	100
MECH-3 Bt	* 567	* 0.48	* 0.69	* 0.67		29	49	105
MECH-3 Non-Bt	456	0.40	0.55	0.53		36	49	106
MECH-12 Bt	* 543	* 0.44	* 0.68	* 0.64		34	49	99
MECH-12 Non-Bt	408	0.35	0.50	0.47		35	50	100
MECH-162 Bt	* 632	* 0.55	* 0.77	* 0.73		36	49	107
MECH-162 Non-Bt	481	0.39	0.59	0.58		35	48	105
NHH-44	435	0.34	0.52	0.55		38	49	102
H-8	429	0.35	0.52	0.52		35	49	103
Mean: Bt Hybrids	* 576	* 0.48	* 0.70	* 0.68		33	49	103
Mean: Non-Bt Hy.[1]	441	0.37	0.52	0.52		36	49	103
LSD (0.05)	76	0.03	0.03	0.02		4	3	5

BLOCK 2: Non-Bt Hybrids

MECH-1	423	0.33	0.52	0.54	NA	40	47	99
MECH-3	435	0.33	0.54	0.54		38	49	104
MECH-12	422	0.30	0.53	0.53		38	48	97
MECH-162	510	0.35	0.58	0.58		34	47	109
NHH-44	419	0.30	0.51	0.54		38	51	111
H-8	424	0.30	0.53	0.54		37	46	101
Mean: Non-Bt Hy.[1]	439	0.31	0.54	0.55		38	48	104
LSD (0.05)	56	0.01	0.02	0.01		5	4	5

* = Bt Cotton Hybrid Significantly Different from non-Bt Counterpart for Yield Related Components.

NA = Data Not Available.

TABLE 9. Lohara, Latur (MS): Summary of Insect Reaction Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

BLOCK 1: Bt & Non-Bt Hybrids

HYBRID	Bollworm Complex				Sucking Pests					
	Bollworm Larvae /10 Pl.		% Fruit Body Damage		Aphids (30 Leaves)		Jassids (30 Leaves)		Whitefly (30 Leaves)	
	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS
MECH-1 Bt	2.3	* 2.2	7.9	* 6.9	9	16	57	22	41	40
MECH-1 Non-Bt	5.3	6.5	7.5	12.9	2	12	58	18	41	28
MECH-3 Bt	* 2.5	* 2.8	5.9	* 3.3	15	8	45	17	67	34
MECH-3 Non-Bt	8.5	3.8	5.2	13.4	10	7	46	14	48	29
MECH-12 Bt	* 2.0	* 2.3	* 3.9	* 3.2	3	6	63	18	38	39
MECH-12 Non-Bt	11.3	7.5	13.4	16.5	2	1	50	17	36	35
MECH-162 Bt	2.5	* 2.0	1.9	* 2.7	8	2	50	16	45	31
MECH-162 Non-Bt	5.6	8.5	5.9	11.4	2	19	45	17	37	40
NHH-44	8.9	11.3	9.3	12.9	13	28	47	19	41	42
H-8	6.9	9.9	7.3	14.1	5	10	45	17	45	35
Mean: Bt Hybrids	2.3	* 2.3	4.9	* 4.0	9	8	54	18	48	36
Mean: Non-Bt Hy.[1]	7.8	7.9	8.1	13.5	6	13	49	17	41	34
LSD (0.05)	5.16	1.92	4.2	3.09	8	21	12	6	15	6

BLOCK 2: Non-Bt Hybrids

MECH-1	11.1	10.3	9.7	11.1	3	2	49	19	36	31
MECH-3	9.9	12.0	9.1	13.1	1	1	40	20	43	36
MECH-12	11.8	10.0	10.4	14.7	4	0	40	20	38	38
MECH-162	15.5	11.3	8.3	13.7	1	3	39	20	38	40
NHH-44	12.0	11.8	9.5	13.9	18	0	37	17	35	31
H-8	14.3	13.5	9.9	12.6	22	3	36	19	35	33
Mean: Non-Bt Hy.[1]	12.5	11.5	9.5	13.2	8	1	40	19	38	35
LSD (0.05)	6.3	3.4	2.8	3.7	31	2	9	3	10	5

* = Bt Cotton Hybrid Significantly Different from non-Bt Counterpart for Bollworm Reaction Traits.

[1] Mean Value for All Conventional Cotton Hybrids under Trial, within the Block of Interest.

Note: Fruit Body Damage (%) Includes Flowers, Squares and Green Bolls.

LOCATION : Warud, Amaravati (MS)

A. Yield and Morphological Traits

Block-1: Table 10

Bolls/plant were higher in Bt hybrids than in non-Bt hybrids. Bt hybrids were higher in yield over their counterpart non-Bt hybrids, ranging from 11% to 43%. Only MECH-12 Bt and MECH-162 Bt were better than the check by 54% and 16%, respectively.

Block-2: Table 10

MECH-12 and H-8 hybrids gave the highest yield in Block-2. In general, high yield was recorded in all hybrids of this Block.

B. Insect Reaction

Block-1: Table 11

Hybrids MECH-3 Bt, MECH-12 Bt. and MECH-162 Bt. had very low Bollworm Complex population for 90 DAS as compared to their non-Bt counterparts. Fruiting body damage was lower in Bt hybrids than in non-Bt hybrids.

Aphid infestation was high up to 60 DAS. At 90 DAS, moderate Jassid and Whitefly populations were recorded. Differences were not noted between Bt and non-Bt hybrids for these pests.

Block-2: Table 11

Mean Bollworm Complex count in this Block up to 60 DAS was 6.3, and for 90 DAS 6.0. The fruiting body damage was high in MECH-3 up to 60 DAS, similar to that observed in Block-1.

TABLE 10. Warud, Amravati (MS): Summary of Yield and Morphological Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

BLOCK 1: Bt & Non-Bt Hybrids

HYBRID	Yield (Kg/ha)	Yield (Kg/Plot) 1st Pick	2nd Pick	3rd Pick	Ave. Bolls/ Pl.	Ave. Pl./ Plot	Days to 1st Flower	Days to 1st Boll Burst
MECH-1 Bt	* 2080	2.12	2.31	* 2.31	50	38	47	95
MECH-1 Non-Bt	1870	2.00	2.13	1.93	54	38	50	95
MECH-3 Bt	* 2382	2.18	2.67	* 2.87	72	38	49	98
MECH-3 Non-Bt	2129	2.06	2.47	2.37	64	39	49	100
MECH-12 Bt	* 3836	* 4.18	* 4.62	* 3.63	45	39	47	95.
MECH-12 Non-Bt	2947	3.15	3.31	3.09	31	38	48	95
MECH-162 Bt	* 2873	* 2.23	* 3.06	* 4.02	62	39	50	117
MECH-162 Non-Bt	2003	1.62	1.87	3.00	45	39	52	120
NHH-44	1771	1.50	1.93	2.31	38	39	54	122
H-8	2481	2.81	2.75	2.48	48	39	50	100
Mean: Bt Hybrids	* 2793	2.67	* 3.16	* 3.20	57	39	48	101
Mean: Non-Bt Hy.[1]	2200	2.19	2.41	2.53	47	39	51	105
LSD (0.05)	168	0.51	0.22	0.23	NA	NA	3	2

BLOCK 2: Non-Bt Hybrids

MECH-1	1753	1.93	1.97	1.78	55	39	50	95
MECH-3	1972	1.95	2.33	2.11	38	38	47	101
MECH-12	2277	2.46	2.61	2.31	50	39	51	96
MECH-162	1848	1.68	1.8	2.51	43	38	50	120
NHH-44	1836	1.75	2.12	2.08	42	37	55	122
H-8	2324	2.61	2.71	2.21	51	38	52	100
Mean: Non-Bt Hy.[1]	2001	2.06	2.25	2.16	46	38	51	106
LSD (0.05)	145	0.05	0.20	0.22	NA	NA	3	2

* = Bt Cotton Hybrid Significantly Different from non-Bt Counterpart for Yield Related Components.

NA = Data Not Available for LSD Calculation. Data for Bolls/ Plant and Plants/ Plot were Reported as Replication Means.

TABLE 11. Warud, Amravati (MS): Summary of Insect Reaction Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

BLOCK 1: Bt & Non-Bt Hybrids

HYBRID	Bollworm Complex				Sucking Pests					
	Bollworm Larvae /10 Pl.		% Fruit Body Damage		Aphids (30 Leaves)		Jassids (30 Leaves)		Whitefly (30 Leaves)	
	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS
MECH-1 Bt	* 2.5	* 0.1	1.4	0.5	59	7	4	7	34	23
MECH-1 Non-Bt	8.0	3.5	2.5	0.7	63	3	10	7	50	30
MECH-3 Bt	* 1.1	2.1	* 0.3	0.9	63	14	4	7	60	23
MECH-3 Non-Bt	10.8	3.9	2.1	1.3	38	7	3	9	55	24
MECH-12 Bt	6.3	1.5	0.8	0.1	56	4	7	6	38	25
MECH-12 Non-Bt	7.3	3.3	1.0	1.3	50	9	5	5	43	29
MECH-162 Bt	* 0.8	* 1.1	0.1	* 0.5	71	34	15	12	57	33
MECH-162 Non-Bt	7.8	5.5	1.3	2.0	58	3	3	9	49	35
NHH-44	12.5	4.1	3.9	1.9	94	13	2	5	62	32
H-8	13.3	4.5	0.2	1.7	59	3.5	3	6	56	36
Mean: Bt Hybrids	* 2.8	1.2	3.2	* 0.6	62	15	8	8	47	26
Mean: Non-Bt Hy.[1]	9.9	4.1	3.7	1.5	60	6	4	7	53	31
LSD (0.05)	4.7	3.2	1.3	0.9	38	23	13	5	21	8

BLOCK 2: Non-Bt Hybrids

MECH-1	1.7	4.8	1.1	2.7	97	10	4	12	65	21
MECH-3	12.0	8.8	4.1	2.7	57	18	4	10	52	34
MECH-12	4.8	8.8	11.9	1.4	49	22	3	15	38	39
MECH-162	9.8	5.8	8.7	1.8	59	20	4	7	38	38
NHH-44	0.9	5.5	0.1	1.8	52	15	4	5	39	27
H-8	8.8	2.5	21.4	1.9	69	11	2	7	43	34
Mean: Non-Bt Hy.[1]	6.3	6.0	7.9	2.1	64	16	3.5	9	46	32
LSD (0.05)	4.5	4.6	2.2	1.4	32	19	2	9	27	12

* = Bt Cotton Hybrid Significantly Different from non-Bt Counterpart for Bollworm Reaction Traits.

[1] Mean Value for All Conventional Cotton Hybrids under Trial, within the Block of Interest.

Note: Fruit Body Damage (%) Includes Flowers, Squares and Green Bolls.

LOCATION : Jamwadi, Jalna (MS)

A. Yield and Morphological Traits

Block-1: Table 12

Yield of Bt hybrids was higher than the non-Bt hybrids and checks. MECH-162 Bt recorded highest yield, followed by MECH-3 Bt and MECH-1 Bt. The yield difference between non-Bt and Bt hybrids was significantly higher in the favour of Bt hybrids.

Block-2: Table 12

All non-Bt hybrids and checks recorded low yield in this Block due to high rainfall resulting in water logging in this part of the field.

B. Insect Reaction

Insect reaction data for this location were not available.

TABLE 11. Warud, Amravati (MS): Summary of Insect Reaction Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

BLOCK 1: Bt & Non-Bt Hybrids

HYBRID	Bollworm Complex				Sucking Pests					
	Bollworm Larvae /10 Pl.		% Fruit Body Damage		Aphids (30 Leaves)		Jassids (30 Leaves)		Whitefly (30 Leaves)	
	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS
MECH-1 Bt	* 2.5	* 0.1	1.4	0.5	59	7	4	7	34	23
MECH-1 Non-Bt	8.0	3.5	2.5	0.7	63	3	10	7	50	30
MECH-3 Bt	* 1.1	2.1	* 0.3	0.9	63	14	4	7	60	23
MECH-3 Non-Bt	10.8	3.9	2.1	1.3	38	7	3	9	55	24
MECH-12 Bt	6.3	1.5	0.8	0.1	56	4	7	6	38	25
MECH-12 Non-Bt	7.3	3.3	1.0	1.3	50	9	5	5	43	29
MECH-162 Bt	* 0.8	* 1.1	0.1	* 0.5	71	34	15	12	57	33
MECH-162 Non-Bt	7.8	5.5	1.3	2.0	58	3	3	9	49	35
NHH-44	12.5	4.1	3.9	1.9	94	13	2	5	62	32
H-8	13.3	4.5	0.2	1.7	59	3.5	3	6	56	36
Mean: Bt Hybrids	* 2.8	1.2	3.2	* 0.6	62	15	8	8	47	26
Mean: Non-Bt Hy.[1]	9.9	4.1	3.7	1.5	60	6	4	7	53	31
LSD (0.05)	4.7	3.2	1.3	0.9	38	23	13	5	21	8

BLOCK 2: Non-Bt Hybrids

MECH-1	1.7	4.8	1.1	2.7	97	10	4	12	65	21
MECH-3	12.0	8.8	4.1	2.7	57	18	4	10	52	34
MECH-12	4.8	8.8	11.9	1.4	49	22	3	15	38	39
MECH-162	9.8	5.8	8.7	1.8	59	20	4	7	38	38
NHH-44	0.9	5.5	0.1	1.8	52	15	4	5	39	27
H-8	8.8	2.5	21.4	1.9	69	11	2	7	43	34
Mean: Non-Bt Hy.[1]	6.3	6.0	7.9	2.1	64	16	3.5	9	46	32
LSD (0.05)	4.5	4.6	2.2	1.4	32	19	2	9	27	12

* = Bt Cotton Hybrid Significantly Different from non-Bt Counterpart for Bollworm Reaction Traits.

[1] Mean Value for All Conventional Cotton Hybrids under Trial, within the Block of Interest.

Note: Fruit Body Damage (%) Includes Flowers, Squares and Green Bolls.

LOCATION : Jamwadl, Jalna (MS)

A. Yield and Morphological Traits

Block-1: Table 12

Yield of Bt hybrids was higher than the non-Bt hybrids and checks. MECH-162 Bt recorded highest yield, followed by MECH-3 Bt and MECH-1 Bt. The yield difference between non-Bt and Bt hybrids was significantly higher in the favour of Bt hybrids.

Block-2: Table 12

All non-Bt hybrids and checks recorded low yield in this Block due to high rainfall resulting in water logging in this part of the field.

B. Insect Reaction

Insect reaction data for this location were not available.

TABLE 13. Chittalwadi, Akola (MS): Summary of Yield and Morphological Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

BLOCK 1: Bt & Non-Bt Hybrids

HYBRID	Yield (Kg/ha)	Yield (Kg/Plot) 1st Pick	2nd Pick	3rd Pick	Ave. Bolls/ Pl.	Ave. Pl./ Plot	Days to 1st Flower	Days to 1st Boll Burst
MECH-1 Bt	* 820	1.03	0.72	* 0.91	NA	NA	45	115
MECH-1 Non-Bt	509	0.70	0.51	0.44			45	114
MECH-3 Bt	*1811	2.00	* 2.25	* 1.62			51	122
MECH-3 Non-Bt	849	1.63	0.59	0.53			51	122
MECH-12 Bt	* 1203	1.62	1.19	* 1.09			49	118
MECH-12 Non-Bt	885	1.47	0.82	0.58			49	117
MECH-162 Bt	* 2058	* 2.60	* 2.10	* 1.97			54	121
MECH-162 Non-Bt	876	1.22	0.92	0.70			54	121
NHH-44	1515	2.70	1.74	0.47			55	124
H-8	1320	3.00	0.84	0.44			48	116
Mean: Bt Hybrids	* 1473	1.81	* 1.57	* 1.39			50	119
Mean: Non-Bt Hy.[1]	992	1.78	0.90	0.52			50	119
LSD (0.05)	210	0.55	0.42	0.28			NA	NA

BLOCK 2: Non-Bt Hybrids

MECH-1	520	1.30	0.62	0.39	NA	NA	45	115
MECH-3	805	1.78	0.87	0.60			51	122
MECH-12	802	1.02	1.06	0.52			49	118
MECH-162	1062	0.90	1.98	0.56			54	122
NHH-44	1488	2.18	1.83	0.81			55	124
H-8	1392	2.32	1.23	0.39			47	117
Mean: Non-Bt Hy.[1]	881	1.58	1.26	0.54			50	120
LSD (0.05)	164	0.67	0.21	0.10			NA	NA

* = Bt Cotton Hybrid Significantly Different from non-Bt Counterpart for Yield Related Components.

NA = Data Not Available. Data Taken at One Replication for Dates of Flowering and Boll Burst.

TABLE 14. Chittalwadi, Akola (MS): Summary of Insect Reaction Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

BLOCK 1: Bt & Non-Bt Hybrids

HYBRID	Bollworm Complex				Sucking Pests					
	Bollworm Larvae /10 Pl.		% Fruit Body Damage		Aphids (30 Leaves)		Jassids (30 Leaves)		Whitefly (30 Leaves)	
	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS
MECH-1 Bt	* 0.0	2.0	* 0.0	* 2.6	134	NA	62	15	68	18
MECH-1 Non-Bt	3.0	2.1	4.3	10.6	80		61	5.0	50	13
MECH-3 Bt	* 0.5	1.0	* 0.1	8.5	129		47	18	45	16
MECH-3 Non-Bt	2.7	2.1	5.8	11.7	96		45	12	40	9
MECH-12 Bt	* 0.2	* 0.0	2.6	* 1.5	123		61	17	36	8
MECH-12 Non-Bt	2.5	3.0	3.9	11.8	109		60	12	56	7
MECH-162 Bt	* 0.5	1.7	* 0.1	6.4	100		33	16	44	4
MECH-162 Non-Bt	3.0	2.7	3.8	7.0	100		37	6.0	75	5
NHH-44	4.0	5.7	4.4	9.5	116		43	5.0	55	3
H-8	3.5	3.2	4.2	6.6	146		44	7	57	10
Mean: Bt Hybrids	* 0.3	1.2	* 0.7	4.7	122		51	17	48	12
Mean: Non-Bt Hy.[1]	3.1	3.1	4.4	9.5	107		48	8	56	8
LSD (0.05)	1.0	2.3	2.3	7.3	34		10	9	20	9

BLOCK 2: Non-Bt Hybrids

MECH-1	3.8	3.1	7.1	11.2	110	NA	63	15	47	9
MECH-3	4.3	6.2	6.9	16.0	121		61	15	37	9
MECH-12	4.0	4.2	6.1	13.6	114		42	15	33	5
MECH-162	3.9	5.2	5.7	15.1	102		46	8	45	5
NHH-44	3.8	5.2	5.0	15.7	95		24	7	30	0
H-8	4.2	3.5	4.9	10.1	89		34	7	26	0
Mean: Non-Bt Hy.[1]	4.0	4.6	6.0	13.6	105		45	11	36	5
LSD (0.05)	1.6	2.2	2.4	5.8	37		18	4	22	6

* = Bt Cotton Hybrid Significantly Different from non-Bt Counterpart for Bollworm Reaction Traits.

NA = Data Not Available.

[1] Mean Value for All Conventional Cotton Hybrids under Trial, within the Block of Interest.

Note: Fruit Body Damage (%) Includes Flowers, Squares and Green Bolls.

LOCATION : Parsa, Mehsana (GJ)

A. Yield and Morphological Traits

Block-1: Table 15

All Bt hybrids were higher in yield as compared to non-Bt hybrids, however differences were not significant and data was limited due to only a single boll picking. The yield gain for Bt hybrids ranging from 2% to 14%. MECH-162 Bt was higher in yield than the best check, NHH-44.

Block-2: Table 15

No significant differences were seen in all non-Bt hybrids for yield in this Block. MECH-162 recorded highest yield and was better than the best check, NHH-44. Yields in Block-1 and Block-2 for all non-Bt hybrids were similar.

B. Insect Reaction

Block-1: Table 16

Bt hybrids had lower Bollworm Complex count than non-Bt hybrids and checks. Fruiting body damage was also low in Bt hybrids as compared to that seen in the non-Bt hybrids and checks. Sucking pest reaction was high both at 60 DAS and 90 DAS in Bt as well as non-Bt hybrids.

Block-2: Table 16

Bollworm Complex count and fruiting body damage was variable compared to Block 1. The Bollworm count was similar to non-Bt hybrids in Block-1. However, fruiting body damage was higher at 60 DAS and lower at 90 DAS than was observed in Block 1. Sucking pest infestation was similar in both the Blocks.

TABLE 15. Parsa, Mehsana (GJ): Summary of Yield and Morphological Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

BLOCK 1: Bt & Non-Bt Hybrids

HYBRID	Yield (Kg/ha)	Yield (Kg/Plot) (Cumulative)			Ave. Bolls/ Pl.	Ave. Pl./ Plot	Days to 1st Flower	Days to 1st Boll Burst
MECH-1 Bt	1157	3.75	NA	NA	* 48	28	48	100
MECH-1 Non-Bt	1111	3.60			36	29	48	102
MECH-3 Bt	1404	4.55			* 52	32	48	104
MECH-3 Non-Bt	1234	4.00			35	34	50	97
MECH-12 Bt	1419	4.60			* 49	34	50	102
MECH-12 Non-Bt	1388	4.50			34	30	47	105
MECH-162 Bt	1728	5.60			* 56	35	47	108
MECH-162 Non-Bt	1512	4.90			48	33	48	104
NHH-44	1666	5.40			46	32	48	110
H-8	1604	5.20			43	30	48	110
Mean: Bt Hybrids	1427	4.63			* 52	32	48	103
Mean: Non-Bt Hy.[1]	1419	4.60			40	31	48	104
LSD (0.05)	232	0.75			7	4	NA	NA

BLOCK 2: Non-Bt Hybrids

MECH-1	1235	4.00	NA	NA	42	28	48	111
MECH-3	1235	4.00			39	30	47	113
MECH-12	1203	3.90			52	29	52	117
MECH-162	1759	5.70			58	32	45	122
NHH-44	1604	5.20			52	32	46	116
H-8	1574	5.10			49	34	47	116
Mean: Non-Bt Hy.[1]	1435	4.65			49	31	48	116
LSD (0.05)	252	0.82			6	NA	NA	NA

* = Bt Cotton Hybrid Significantly Different from non-Bt Counterpart for Yield Related Components

NA = Data Not Available. Data for Yield (Kg/Plot) Reported as Cumulative Sum for All Pickings.

TABLE 16. Parsa, Mehsana (GJ): Summary of Insect Reaction Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

BLOCK 1: Bt & Non-Bt Hybrids

HYBRID	Bollworm Complex				Sucking Pests					
	Bollworm Larvae /10 Pl.		% Fruit Body Damage		Aphids (30 Leaves)		Jassids (30 Leaves)		Whitefly (30 Leaves)	
	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS
MECH-1 Bt	* 0.0	* 3.8	* 0.1	* 2.2	92	0	82	96	116	153
MECH-1 Non-Bt	4.9	12.5	8.5	11.4	92	30	101	84	114	135
MECH-3 Bt	* 0.8	* 3.5	* 4.2	* 1.2	89	3	82	64	124	112
MECH-3 Non-Bt	5.0	8.8	8.8	13.4	84	5	79	69	91	129
MECH-12 Bt	* 0.5	* 3.0	* 0.4	* 0.8	85	13	87	79	102	126
MECH-12 Non-Bt	4.0	8.3	6.7	10.2	101	19	98	85	109	141
MECH-162 Bt	* 0.5	* 3.0	* 0.2	* 2.9	78	4	85	70	110	102
MECH-162 Non-Bt	3.8	8.8	7.8	12.2	82	23	89	77	100	127
H-6	5.8	7.8	9.4	7.3	89	16	87	68	115	119
H-8	5.8	9.5	9.2	9.7	87	26	89	60	107	81
Mean: Bt Hybrids	* 0.4	* 3.3	* 1.2	* 1.8	86	5	84	77	113	123
Mean: Non-Bt Hy.[1]	4.9	9.2	8.4	10.7	89	19	90	73	106	122
LSD (0.05)	1.5	4.9	3.0	3.4	27	19	22	15	31	36

BLOCK 2: Non-Bt Hybrids

MECH-1	5.3	10.0	11.3	9.0	83	12	93	84	110	121
MECH-3	5.8	10.2	12.1	9.0	81	11	77	74	114	105
MECH-12	4.8	9.2	8.0	8.4	78	0	88	76	110	121
MECH-162	5.0	8.5	7.1	7.6	86	16	91	90	118	110
H-6	5.8	10.0	9.5	11.3	78	4	72	57	115	98
H-8	4.5	9.2	8.2	8.5	86	5	83	62	118	108
Mean: Non-Bt Hy.[1]	5.2	9.5	9.3	9.0	82	8	84	73	114	110
LSD (0.05)	1.4	2.8	4.8	2.7	13	6	16	21	18	20

* = Bt Cotton Hybrid Significantly Different from non-Bt Counterpart for Bollworm Reaction Traits

[1] Mean Value for All Conventional Cotton Hybrids under Trial, within the Block of Interest. .

Note: Fruit Body Damage (%) Includes Flowers, Squares and Green Bolls.

LOCATION : Kunbev, Haveri (KTK)

A. Yield and Morphological Traits

Block-1: Table 17

All four Bt hybrids were significantly higher yielding than the non-Bt hybrids. Bt hybrids MECH-3 Bt, MECH-12 Bt and MECH -162 Bt were better than the check H-8 by 42%, 52% and 57%, respectively.

Block-2: Table 17

MECH 12 recorded highest yield over all other hybrids, including the best check H-8 by 3%.

B. Insect Reaction

Block-1: Table 18

Bt hybrids had lower Bollworm Complex count than the non-Bt hybrids. Fruiting body damage was also low in Bt hybrids compared to non-Bt hybrids. The sucking pest pressure was similar in both groups.

Block-2: Table 18

Fruiting body damage ranged from 3.9% in MECH-12 to 7.4% in H-8. In general, Bollworm Complex count was negligible up to 60 DAS, and the damage was comparable to that seen in Block-1.

TABLE 17. Kunbev, Haveri (KTK): Summary of Yield and Morphological Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

BLOCK 1: Bt & Non-Bt Hybrids

HYBRID	Yield (Kg/ha)	Yield (Kg/Plot) 1st Pick	Yield (Kg/Plot) 2nd Pick	Ave. Bolls/ Pl.	Ave. Pl./ Plot	Days to 1st Flower	Days to 1st Boll Burst
MECH-1 Bt	1022	1.83	1.48	NA	NA	NA	NA
MECH-1 Non-Bt	419	0.84	0.52				
MECH-3 Bt	* 2277	* 3.17	* 4.20				
MECH-3 Non-Bt	1076	1.71	1.78				
MECH-12 Bt	* 2440	* 4.14	* 3.77				
MECH-12 Non-Bt	1374	2.53	1.92				
MECH-162 Bt	* 2518	* 4.03	* 4.12				
MECH-162 Non-Bt	1140	2.09	1.50				
NHH-44	823	1.68	0.98				
H-8	1601	2.74	2.44				
Mean: Bt Hybrids	* 2064	3.29	* 3.39				
Mean: Non-Bt Hy.[1]	1072	1.93	1.52				
LSD (0.05)	712	1.44	1.12				

BLOCK 2: Non-Bt Hybrids

MECH-1	740	1.22	1.17	NA	NA	NA	NA
MECH-3	845	1.52	1.23				
MECH-12	1522	2.68	2.11				
MECH-162	1066	1.34	2.10				
NHH-44	955	1.93	1.16				
H-8	1473	2.38	2.40				
Mean: Non-Bt Hy.[1]	1100	1.85	1.70				
LSD (0.05)	245	0.68	0.45				

* = Bt Cotton Hybrid Significantly Different from non-Bt Counterpart for Yield Related Components

NA = Data Not Available.

TABLE 18. Kunbev, Haveri (KTK): Summary of Insect Reaction Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

BLOCK 1: Bt & Non-Bt Hybrids

HYBRID	Bollworm Complex				Sucking Pests					
	Bollworm Larvae /10 Pl.		% Fruit Body Damage		Aphids (30 Leaves)		Jassids (30 Leaves)		Whitefly (30 Leaves)	
	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS
MECH-1 Bt	NA	0.3	NA	3.8	120	1	48	2	7	0
MECH-1 Non-Bt		1.8		4.8	102	0	18	2	13	2
MECH-3 Bt		1.0		3.0	146	2	12	0	10	1
MECH-3 Non-Bt		2.9		3.8	139	0	12	0	11	0
MECH-12 Bt		0.8		3.4	83	0	16	2	6	0
MECH-12 Non-Bt		2.9		3.7	141	0	16	2	7	1
MECH-162 Bt		1.5		4.9	152	3	9	2	19	2
MECH-162 Non-Bt		4.5		4.8	101	0	9	1	13	2
NHH-44		2.8		4.6	113	0	6	0	15	1
H-8		2.3		4.0	75	3	7	1	10	1
Mean: Bt Hybrids		0.9		3.8	125	2	21	1	11	1
Mean: Non-Bt Hy.[1]		2.8		4.3	112	0.5	11	1	12	1
LSD (0.05)		4.0		3.1	1	9	7	6	8	3

BLOCK 2: Non-Bt Hybrids

MECH-1	NA	1.0	NA	5.8	1	6	9	2	8	1
MECH-3		3.8		4.3	29	5	6	2	12	5
MECH-12		2.1		3.9	41	12	8	5	6	0
MECH-162		2.9		4.8	79	11	3	4	10	2
NHH-44		3.3		5.2	121	5	2	2	9	1
H-8		1.1		7.4	72	6	4	1	6	4
Mean: Non-Bt Hy.[1]		2.4		5.2	57	8	5	3	9	2
LSD (0.05)		4.0		3.1	1	9	7	6	8	3

* = Bt Cotton Hybrid Significantly Different from non-Bt Counterpart for Bollworm Reaction Traits

NA = Data Not Available.

[1] Mean Value for All Conventional Cotton Hybrids under Trial, within the Block of Interest.

Note: Fruit Body Damage (%) Includes Flowers, Squares and Green Bolls.

LOCATION : Rajowali, Ferozpur (PJ)

A. Yield and Morphological Traits

Block-1 & Block-2

Yield data could not be recorded due heavy crop damage by the rain.

B. Insect Reaction

Block-1: Table 19

Bollworm Complex count and fruiting body damage (%) were significantly lower in Bt hybrids than their non-Bt counterparts. High population of sucking pests were recorded on both Bt and non-Bt hybrids.

Block-2: Table 19

High pressure of sucking pest was recorded in this Block. Bollworm count and fruiting body damage was similar for all the hybrids.

TABLE 19. Rajowali, Ferozpur (PB): Summary of Insect Reaction Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

BLOCK 1: Bt & Non-Bt Hybrids

HYBRID	Bollworm Complex				Sucking Pests					
	Bollworm Larvae /10 Pl.		% Fruit Body Damage		Aphids (30 Leaves)		Jassids (30 Leaves)		Whitefly (30 Leaves)	
	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS
MECH-1 Bt	1.2	* 3.9	* 5.4	* 5.1	NA	17	76	26	220	283
MECH-1 Non-Bt	4.9	12.6	24.2	53.6		22	77	32	257	324
MECH-3 Bt	* 0.6	* 4.3	* 3.2	* 11.1		8	75	32	205	428
MECH-3 Non-Bt	7.6	13.3	25.7	59.2		5	85	32	226	495
MECH-12 Bt	* 1.3	* 5.1	* 5.8	* 2.1		38	78	35	252	355
MECH-12 Non-Bt	11.9	16.6	17.9	42.5		29	86	34	236	335
MECH-162 Bt	* 3.3	* 5.8	* 9.8	* 5.7		13	71	26	213	203
MECH-162 Non-Bt	18.1	21.9	33.3	35.5		8	85	33	232	514
NHH-44	16.9	22.5	38.9	54.4		4	71	33	225	251
H-8	16.4	23.1	32.1	57.9		5	79	26	237	400
Mean: Bt Hybrids	*1.6	* 4.8	* 6.1	* 6.0		19	75	30	222	317
Mean: Non-Bt Hy.[1]	12.6	18.3	28.7	50.5		12	81	32	236	387
LSD (0.05)	4.3	5.9	10.5	9.7		23	15	10	46	104

BLOCK 2: Non-Bt Hybrids

MECH-1	6.5	11.1	26.6	34.2	NA	3	80	37	234	368
MECH-3	6.7	15.1	19.3	39.1		1	70	34	248	485
MECH-12	5.6	15.0	22.5	39.9		5	88	33	220	358
MECH-162	6.7	12.1	15.3	43.2		3	76	35	257	451
NHH-44	8.0	12.6	23.4	16.5		1	68	33	237	254
H-8	6.3	13.7	35.4	41.8		1	89	31	227	448
Mean: Non-Bt Hy.[1]	6.6	13.3	23.7	35.8		2	79	34	237	394
LSD (0.05)	1.7	3.6	10.6	17.3		6	19	6	18	170

* = Bt Cotton Hybrid Significantly Different from non-Bt Counterpart for Bollworm Reaction Traits

NA = Data Not Available.

[1] Mean Value for All Conventional Cotton Hybrids under Trial, within the Block of Interest.

Note: Fruit Body Damage (%) Includes Flowers, Squares and Green Bolls.

LOCATION : Coimbatore (TN)

A. Yield and Morphological Traits

Block-1: Table 20

Bt hybrids MECH-1 Bt, MECH-3 Bt, and MECH-162 Bt were significantly higher in yield than their non-Bt counterpart. Bt hybrids were superior as compared to their non-Bt counterparts by 39% for MECH -12 Bt and 84% for MECH –1 Bt. Overall yield performance for most Bt hybrids was higher than the better check, NHH-44.

Block-2: Table 20

This Block had better plant stand and yield level than the non-Bt hybrids in the Block-1. The check hybrid NHH-44 recorded the highest yield.

B. Insect Reaction

Insect data for this location were not available.

TABLE 20. Kondayampalayam, Coimbatore (TN): Summary of Yield and Morphological Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

BLOCK 1: Bt & Non-Bt Hybrids

HYBRID	Yield (Kg/ha)	Yield (Kg/Plot) 1st Pick	2nd Pick	3rd Pick	Ave. Bolls/ Pl.	Ave. Pl./ Plot	Days to 1st Flower	Days to 1st Boll Burst
MECH-1 Bt	* 1152	* 2.08	* 1.66	NA	NA	NA	49	105
MECH-1 Non-Bt	626	1.08	0.95				52	101
MECH-3 Bt	* 1336	* 2.69	* 1.64				48	100
MECH-3 Non-Bt	972	1.91	1.24				47	96
MECH-12 Bt	892	2.15	* 0.74				48	96
MECH-12 Non-Bt	641	1.83	0.25				48	102
MECH-162 Bt	* 1170	* 2.27	* 1.52				48	101
MECH-162 Non-Bt	790	1.38	1.18				52	104
NHH-44	1083	1.87	1.64				51	97
H-8	889	2.08	0.80				47	104
Mean: Bt Hybrids	* 1137	2.29	1.39				48	100
Mean: Non-Bt Hy.[1]	833	1.69	1.01				49	101
LSD (0.05)	276	0.78	0.39				3	11

BLOCK 2: Non-Bt Hybrids

MECH-1	953	2.04	1.05	NA	NA	NA	NA	NA
MECH-3	880	1.83	1.02					
MECH-12	1075	2.39	1.09					
MECH-162	1216	2.28	1.66					
NHH-44	1333	2.18	2.14					
H-8	1123	2.38	1.26					
Mean: Non-Bt Hy.[1]	1096	2.18	1.37					
LSD (0.05)	233	0.36	0.39					

* = Bt Cotton Hybrid Significantly Different from non-Bt Counterpart for Yield Related Components

NA = Data Not Available.

SUMMARY OF RESULTS AND OBSERVATIONS

Relative to yield and Bollworm Complex reaction of Bt cotton hybrids, the results of this study can be summarized as follows:

- Cotton hybrids containing the Bt gene provided significant increase in yield and/or yield component as compared to their non-Bt counterpart hybrids at each location tested. Pooled data averaged over all locations indicated yield increases from 37% to 60% when comparing individual Bt versus non-Bt hybrid versions; while mean yield performance of all Bt hybrids was 40% higher in comparison to mean performance of all non-Bt hybrids (including notified hybrid checks).

- Cotton hybrids containing the Bt gene provided significantly reduced Bollworm Complex activity as compared to their non-Bt counterpart hybrids. Significant decrease was measured for Bollworm count and percentage fruiting body damage on Bt hybrids. Bollworm counts (per 10 plants) on Bt hybrids averaged 1.2 and 1.7 at 60 DAS and 90 DAS, respectively. Bollworm counts on non-Bt hybrids averaged 6.1 and 6.4 at 60 DAS and 90 DAS, respectively. Percentage fruiting body damage for Bt cotton hybrids averaged 2.5% for both 60 DAS and 90 DAS, while figures for non-Bt hybrids averaged 8.7% and 11.4%, respectively.

- No significant change was noted between Block-1 (plantation containing both Bt and non-Bt hybrids) and Block-2 (plantation containing only non-Bt hybrids) in mean yield of non-Bt hybrids averaged over all locations. No significant differences were detected between Block-1 and Block-2 plantations for Bollworm count and percentage fruiting body damage, averaged over all locations.

Summary of results of other data and general observations are as follows:

- Fiber quality characters did not significantly vary among Bt and non-Bt hybrids (see Annexure Tables).

- Sucking pest reaction (Aphids, Jassids, Whitefly) did not significantly vary among Bt and non-Bt hybrids.

- Beneficial insects (Lady Bird Beetle, Green Lacewing Bug, Spiders) were also observed to be active on both Bt and non-Bt hybrids.

- In general, Bollworm Complex infestation and resulting damage was observed to be less than normal in most cotton growing areas in the 1998/1999 cotton cropping season. Despite this fact, Bt cotton hybrids showed substantial yield advantage over non-Bt hybrids under conditions of no pesticide application targeted for Bollworm Complex.

- Non-Bt hybrids are observed to be taller than Bt hybrids after first flush of boll formation. This appears to be the result of Bt hybrids having greater retention of bolls, and thus greater partitioning of energy toward reproductive rather than vegetative growth. Non-Bt hybrids, with greater loss of bolls, have a longer phase of vegetative growth as a reaction to Bollworm induced pruning.

- Later than normal sowing and non-seasonal heavy rain affected overall yield of the trials.

- Experiment treatments were a mixture of long and shorter duration hybrids. As a result, those with a tendency for longer duration (MECH-162, NHH-44, H-8) may show cumulative higher yield over the entire season. Therefore, this trend should be taken into consideration when making baseline comparisons of seasonal yield potential among these hybrids.

CONCLUSIONS

- Based on results of this study, incorporation of the Bt gene into Indian hybrid cotton germplasm holds promise to significantly improve cotton production through control of bollworm infestation, while also maintaining fiber quality.

- Control of bollworm infestation through Bt cotton hybrids does not influence behavior of the same insects in adjacent non-Bt fields.

- Bt cotton hybrids appear to have no substantial effect on activity of sucking pests of cotton, nor on other insects which may be beneficial in nature.

- Bt cotton hybrids also can be useful as a major component of an overall integrated pest management (IPM) approach to cotton production in India.

Protocol-1 Report

ANNEXURE TABLES

Fiber Quality Characteristics of Bt and non-Bt Cotton

ANNEXURE TABLE A1. Summary of Pooled Data for Fiber Quality from Eight Locations of Bt and Non-Bt Cotton Hybrid Trials in India, 1998-1999.

HYBRID	Fiber Fineness (Micronaire)	Fiber Length (mm)	Uniformity Index (%)	Fiber Strength ($1/8^{th}$ G. g/tex)	Ginning Out Turn (%)
BLOCK 1: Bt & Non-Bt Hybrids					
MECH-1 Bt	4.1	30	80	27.0	35.4
MECH-1 Non-Bt	4.2	30	81	26.9	35.4
MECH-3 Bt	4.2	29	81	26.8	35.5
MECH-3 Non-Bt	4.2	30	81	26.5	35.5
MECH-12 Bt	3.9	30	80	26.9	35.7
MECH-12 Non-Bt	4.1	30	80	26.8	35.6
MECH-162 Bt	4.0	29	81	26.5	34.9
MECH-162 Non-Bt	4.0	28	81	26.5	34.9
NHH-44	4.2	27	78	24.6	34.2
H-8	3.9	28	80	25.0	34.5
Mean: Bt Hybrids	4.1	30	80	26.8	35.4
Mean: Non-Bt Hy.[1]	4.1	30	81	26.7	35.3
LSD (0.05)	0.3	1	2	0.6	0.6
BLOCK 2: Non-Bt Hybrids					
MECH-1	4.2	30	81	26.9	35.5
MECH-3	4.2	30	81	26.2	35.4
MECH-12	4.1	30	80	27.0	35.4
MECH-162	4.1	28	80	26.3	35.2
NHH-44	4.4	27	79	25.0	34.2
H-8	4.0	28	80	25.5	34.6
Mean: Non-Bt Hy.[1]	4.2	30	81	27	35.4
LSD (0.05)	0.3	1	2	1.2	0.8

[1] Mean Value for Non-Bt Versions of Bt Hybrids, within each Block.

ANNEXURE TABLE A2. Kavvaguda, RangaReddy (AP): Summary of Fiber Quality Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

HYBRID	Fiber Fineness (Micronaire)	Fiber Length (mm)	Uniformity Index (%)	Fiber Strength ($1/8^{th}$ G. g/tex)	Ginning Out Turn (%)
BLOCK 1: Bt & Non-Bt Hybrids					
MECH-1 Bt	4.0	30	78	28.0	36
MECH-1 Non-Bt	4.2	30	82	28.2	35
MECH-3 Bt	4.3	29	83	26.9	36
MECH-3 Non-Bt	4.1	30	80	27.0	36
MECH-12 Bt	3.1	31	82	28.1	36
MECH-12 Non-Bt	3.5	31	81	28.0	36
MECH-162 Bt	3.4	30	81	27.7	35
MECH-162 Non-Bt	3.6	29	81	26.8	35
NHH-44	4.0	28	78	25.8	35
H-8	3.0	28	82	24.8	35
Mean: Bt Hybrids	3.7	30	81	27.6	36
Mean: Non-Bt Hy.[1]	3.8	30	81	27.5	36
BLOCK 2: Non-Bt Hybrids					
MECH-1	3.1	30	80	27.1	35
MECH-3	3.3	30	81	26.8	36
MECH-12	3.0	29	81	26.8	36
MECH-162	4.0	28	77	25.7	35
NHH-44	3.7	28	82	26.9	35
H-8	3.3	28	81	26.3	35
Mean: Non-Bt Hy.[1].	3.4	29	80	26.6	36

[1] Mean Value for Non-Bt Versions of Bt Hybrids, within each Block.

Note: Fiber Quality Sampling was Performed on One Replication per Block.

ANNEXURE TABLE A3. Srinath Farm, Ranga Reddy (AP): Summary of Fiber Quality Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

HYBRID	Fiber Fineness (Micronaire)	Fiber Length (mm)	Uniformity Index (%)	Fiber Strength ($1/8^{th}$ G. g/tex)	Ginning Out Turn (%)
BLOCK 1: Bt & Non-Bt Hybrids					
MECH-1 Bt	3.4	29	80	25.9	35
MECH-1 Non-Bt	3.2	29	80	26.5	36
MECH-3 Bt	3.5	29	81	26.7	35
MECH-3 Non-Bt	3.6	29	81	26.2	35
MECH-12 Bt	3.6	28	80	26.5	36
MECH-12 Non-Bt	4.0	29	82	26.1	36
MECH-162 Bt	3.5	27	83	26.5	34
MECH-162 Non-Bt	3.2	26	80	27.0	35
NHH-44	4.3	27	79	24.6	34
H-8	3.6	28	80	25.8	35
Mean: Bt Hybrids	3.5	28	81	26.4	35
Mean: Non-Bt Hy.[1]	3.5	28	81	26.4	35
BLOCK 2: Non-Bt Hybrids					
MECH-1	3.0	29	80	27.7	36
MECH-3	3.5	29	81	26.7	35
MECH-12	3.0	29	80	26.5	36
MECH-162	3.8	28	79	26.9	35
NHH-44	4.2	28	78	24.3	34
H-8	2.7	28	81	25.1	35
Mean: Non-Bt Hy.[1].	3.3	29	80	27.0	36

[1] Mean Value for Non-Bt Versions of Bt Hybrids, within each Block.

Note: Fiber Quality Sampling was Performed on One Replication per Block.

ANNEXURE TABLE A4. Pushpanagar, Karimnagar (AP): Summary of Fiber Quality Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

HYBRID	Fiber Fineness (Micronaire)	Fiber Length (mm)	Uniformity Index (%)	Fiber Strength ($1/8^{th}$ G. g/tex)	Ginning Out Turn (%)
BLOCK 1: Bt & Non-Bt Hybrids					
MECH-1 Bt	4.4	30	80	27.5	36
MECH-1 Non-Bt	4.4	30	80	27	35
MECH-3 Bt	4.3	30	81	26.7	35
MECH-3 Non-Bt	4.4	30	81	26.2	36
MECH-12 Bt	3.8	30	81	26.5	35
MECH-12 Non-Bt	4.2	30	82	26.1	35
MECH-162 Bt	4.3	29	83	26.5	35
MECH-162 Non-Bt	4.2	29	82	27.0	35
NHH-44	4.5	26	79	24.6	34
H-8	4.1	27	80	25.8	34
Mean: Bt Hybrids	4.2	30	81	26.8	35
Mean: Non-Bt Hy.[1]	4.3	30	81	26.5	35
BLOCK 2: Non-Bt Hybrids					
MECH-1	4.3	30	81	27.0	35
MECH-3	4.5	30	80	26.5	35
MECH-12	4.4	30	80	26.1	35
MECH-162	4.2	29	81	26.4	35
NHH-44	4.4	27	78	24.5	34
H-8	4.2	27	79	25.6	35
Mean: Non-Bt Hy.[1].	4.4	30	81	26.5	35

[1] Mean Value for Non-Bt Versions of Bt Hybrids, within each Block.

Note: Fiber Quality Sampling was Performed on One Replication per Block.

ANNEXURE TABLE A5. Jamwadi, Jalna (MS): Summary of Fiber Quality Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

HYBRID	Fiber Fineness (Micronaire)	Fiber Length (mm)	Uniformity Index (%)	Fiber Strength ($1/8^{th}$ G. g/tex)	Ginning Out Turn (%)
BLOCK 1: Bt & Non-Bt Hybrids					
MECH-1 Bt	4.1	31	81	27.0	36
MECH-1 Non-Bt	4.4	31	82	26.8	36
MECH-3 Bt	4.2	30	80	26.5	36
MECH-3 Non-Bt	4.5	30	80	26.1	36
MECH-12 Bt	4.1	31	79	27.1	36
MECH-12 Non-Bt	4.1	31	82	27.2	36
MECH-162 Bt	4.2	28	81	26.8	35
MECH-162 Non-Bt	4.1	28	82	27.0	35
NHH-44	4.4	27	78	24.4	34
H-8	4.0	28	80	24.6	34
Mean: Bt Hybrids	4.1	30	80	26.8	36
Mean: Non-Bt Hy.[1]	4.2	30	81	26.7	36
BLOCK 2: Non-Bt Hybrids					
MECH-1	4.5	30	80	27.0	36
MECH-3	4.2	30	82	26.0	36
MECH-12	4.2	31	81	27.0	36
MECH-162	4.2	30	80	28.0	36
NHH-44	4.5	27	78	24.1	34
H-8	4.2	27	81	24.9	34
Mean: Non-Bt Hy.[1].	4.3	30	81	27.0	36

[1] Mean Value for Non-Bt Versions of Bt Hybrids, within each Block.

Note: Fiber Quality Sampling was Performed on One Replication per Block.

ANNEXURE TABLE A6. Chittalwadi, Akola (MS): Summary of Fiber Quality Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

HYBRID	Fiber Fineness (Micronaire)	Fiber Length (mm)	Uniformity Index (%)	Fiber Strength ($1/8^{th}$ G. g/tex)	Ginning Out Turn (%)
BLOCK 1: Bt & Non-Bt Hybrids					
MECH-1 Bt	4.5	30	80	26.9	36
MECH-1 Non-Bt	4.5	31	80	26.7	36
MECH-3 Bt	4.4	30	80	26.8	35
MECH-3 Non-Bt	4.5	30	81	25.8	35
MECH-12 Bt	4.1	30	80	27.6	36
MECH-12 Non-Bt	4.4	30	79	26.7	36
MECH-162 Bt	4.1	31	79	27.1	35
MECH-162 Non-Bt	4.1	29	80	27.1	35
NHH-44	4.4	26	76	24.5	34
H-8	4.0	28	80	24.8	34
Mean: Bt Hybrids	4.3	30	80	27.1	35
Mean: Non-Bt Hy.[1]	4.4	30	80	26.5	35
BLOCK 2: Non-Bt Hybrids					
MECH-1	4.4	30	81	26.5	36
MECH-3	4.5	30	82	26.0	36
MECH-12	4.1	30	80	27.6	35
MECH-162	3.2	28	79	25.9	36
NHH-44	4.6	26	79	24.9	34
H-8	3.5	27	79	25.0	35
Mean: Non-Bt Hy.[1].	4.1	29	80	26.5	36

[1] Mean Value for Non-Bt Versions of Bt Hybrids, within each Block.

Note: Fiber Quality Sampling was Performed on One Replication per Block.

ANNEXURE TABLE A7. Parsa, Mehsana (GJ): Summary of Fiber Quality Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

HYBRID	Fiber Fineness (Micronaire)	Fiber Length (mm)	Uniformity Index (%)	Fiber Strength ($1/8^{th}$ G. g/tex)	Ginning Out Turn (%)
BLOCK 1: Bt & Non-Bt Hybrids					
MECH-1 Bt	4.2	30	82	27.5	35
MECH-1 Non-Bt	4.3	30	81	27.3	35
MECH-3 Bt	4.4	30	81	26.9	36
MECH-3 Non-Bt	4.4	30	82	27.1	35
MECH-12 Bt	4.3	31	80	26.5	36
MECH-12 Non-Bt	4.4	31	79	26.8	35
MECH-162 Bt	4.4	28	80	25.9	35
MECH-162 Non-Bt	4.4	28	81	26.0	35
NHH-44	4.5	27	79	24.9	34
H-8	4.2	28	81	24.6	35
Mean: Bt Hybrids	4.3	30	81	26.9	35
Mean: Non-Bt Hy.[1]	4.4	30	81	26.8	35
BLOCK 2: Non-Bt Hybrids					
MECH-1	4.4	30	82	26.9	35
MECH-3	4.2	30	81	26.8	35
MECH-12	4.2	31	80	26.5	35
MECH-162	4.4	28	80	25.8	35
NHH-44	4.5	27	78	24.5	34
H-8	4.1	28	81	24.5	35
Mean: Non-Bt Hy.[1].	4.3	30	81	26.5	35

[1] Mean Value for Non-Bt Versions of Bt Hybrids, within each Block.

Note: Fiber Quality Sampling was Performed on One Replication per Block.

ANNEXURE TABLE A8. Kunbev, Haveri (KTK): Summary of Fiber Quality Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

HYBRID	Fiber Fineness (Micronaire)	Fiber Length (mm)	Uniformity Index (%)	Fiber Strength ($1/8^{th}$ G. g/tex)	Ginning Out Turn (%)
BLOCK 1: Bt & Non-Bt Hybrids					
MECH-1 Bt	4.1	31	80	27.0	35
MECH-1 Non-Bt	4.4	31	79	26.5	36
MECH-3 Bt	4.3	30	81	26.8	36
MECH-3 Non-Bt	4.4	30	81	26.5	36
MECH-12 Bt	4.2	30	80	26.3	36
MECH-12 Non-Bt	4.3	30	78	26.9	36
MECH-162 Bt	4.2	28	82	25.8	36
MECH-162 Non-Bt	4.4	28	80	25.7	35
NHH-44	4.5	27	78	24.1	34
H-8	4.2	28	81	25.1	34
Mean: Bt Hybrids	4.2	30	81	26.4	36
Mean: Non-Bt Hy.[1]	4.3	30	80	26.4	36
BLOCK 2: Non-Bt Hybrids					
MECH-1	4.5	31	81	26.9	37
MECH-3	4.3	30	82	26.0	35
MECH-12	4.4	30	80	26.8	35
MECH-162	4.2	28	80	25.5	35
NHH-44	4.6	27	78	24.1	34
H-8	4.1	28	81	25.9	35
Mean: Non-Bt Hy.[1].	4.3	30	81	26.3	35

[1] Mean Value for Non-Bt Versions of Bt Hybrids, within each Block.

Note: Fiber Quality Sampling was Performed on One Replication per Block.

ANNEXURE TABLE A9. Kondayampalam, Coimbatore (TN): Summary of Fiber Quality Data for Replicated Trials of Bt and Non-Bt Cotton Hybrids.

HYBRID	Fiber Fineness (Micronaire)	Fiber Length (mm)	Uniformity Index (%)	Fiber Strength ($1/8^{th}$ G. g/tex)	Ginning Out Turn (%)
BLOCK 1: Bt & Non-Bt Hybrids					
MECH-1 Bt	3.9	30	80	26.9	35
MECH-1 Non-Bt	4.2	30	81	26.2	35
MECH-3 Bt	4.3	30	81	27.1	35
MECH-3 Non-Bt	4.3	30	82	27.3	35
MECH-12 Bt	4.2	30	81	26.5	35
MECH-12 Non-Bt	4.3	30	80	26.8	35
MECH-162 Bt	4.4	28	80	25.7	35
MECH-162 Non-Bt	4.4	28	79	25.6	35
NHH-44	4.4	27	79	24.2	35
H-8	4.1	28	80	24.6	34
Mean: Bt Hybrids	4.2	29	80	26.5	35
Mean: Non-Bt Hy.[1]	4.3	29	80	25.4	35
BLOCK 2: Non-Bt Hybrids					
MECH-1	4.3	30	80	26.1	35
MECH-3	4.4	30	81	27.0	35
MECH-12	4.2	31	81	27.1	35
MECH-162	4.5	29	80	26.6	35
NHH-44	4.5	27	79	25.5	35
H-8	4.2	28	81	24.4	34
Mean: Non-Bt Hy.[1].	4.3	30	80	26.7	35

[1] Mean Value for Non-Bt Versions of Bt Hybrids, within each Block.

Note: Fiber Quality Sampling was Performed on One Replication per Block.

Protocol-1 Report Supplement

Location Based Differences in Results

Protocol-1 involved a replicated randomized design for analysis of differences among Bt hybrids and their non-Bt counterparts, for multi-location trials grown in India during 1998-1999. *Supplemental Table S1.1* summarizes differences among locations for yield expression from these Protocol 1 trials. All Bt cotton hybrids expressed statistically significant and higher yield as compared to their non-Bt versions at the majority of locations tested. When contrasting the mean yield of the two groups of hybrids (Bt vs. Non-Bt), nine out of ten locations showed significantly higher yield for Bt cotton hybrids. For the single location (Gujrat) where significantly higher yield was not measured in Bt hybrids, environmental conditions prevented more than one boll picking and therefore limited data availability. The range of significant yield increase for Bt cotton hybrids over their non-Bt counterparts was 11% to 273%, considering all hybrids and locations. Yield increases on a per hybrid basis averaged over those locations showing significant yield differences ranged from 41% to 78%, with the mean yield of all Bt hybrids showing a 46% increase over non-Bt versions for such locations. Yield increases on a per hybrid basis averaged over all locations ranged from 37% to 60%, with the mean of all Bt hybrids showing 40% yield increase over the mean of non-Bt hybrids *(reference also Protocol-1 Report, Table 1)*.

For measurements involving bollworm larvae count and fruiting body damage due to larvae feeding, statistically significant decreases were noted at a majority of locations tested *(Supplemental Table S1.2)*. For those locations showing significant differences, decreases in mean Bollworm larvae count on Bt hybrids ranged from 4-fold to 6-fold, while decreases in fruiting body damage also ranged from 4-fold to 6-fold for Bt hybrids as compared to their non-Bt counterparts.

SUPPLEMENTAL TABLE S1.1: Protocol 1 – Summary of Location Data for Yield Among Bt and Non-Bt Cotton Hybrids for Trials Conducted in India, 1998-1999.

			Average Yield Among Locations Showing Significant Yield Difference		Average Yield Among All Locations	
	Number of Locations Showing Significant Yield Difference [a]	Range of Yield Increase Among Locations Showing Significant Yield Difference	Yield Average	% Increase in Yield	Yield Average	% Increase in Yield
HYBRID COMPARISON	(Bt vs. Non-Bt Hybrids)	(% Increase: Bt vs. Non-Bt Hybrids)	(Kg/ha)	(Bt versus Non-Bt Hybrids)	(Kg/ha)	(Bt versus Non-Bt Hybrids)
MECH-1 Bt **MECH-1 Non-Bt**	7 of 10	11% – 273%	1214 828	47%	1164 795	46%
MECH-3 Bt **MECH-3 Non-Bt**	8 of 10	12% – 191%	1510 1001	51%	1456 1014	44%
MECH-12 Bt **MECH-12 Non-Bt**	8 of 10	19% – 133%	1738 1231	41%	1623 1187	37%
MECH-162 Bt **MECH-162 Non-Bt**	8 of 10	31% – 200%	1600 897	78%	1161 1004	60%
NHH-44 **H-8**	Both Non-Bt Checks	Both Non-Bt Checks	1078 [b] 1189 [b]	Both Non-Bt Checks	1078 1189	Both Non-Bt Checks
Mean: Bt Hybrids **Mean: Non-Bt Hyb.**	9 of 10	23% – 234%	1466 [c] 1003 [c]	46%	1464 1045	40%

[a] Number of locations out of 10 total.

[b] Average of Non-Bt check hybrids NNH-44 and H-8 calculated over all 10 trial locations.

[c] Mean yield of Bt and Non-Bt hybrids (including Non-Bt hybrids NNH-44 and H-8) calculated over the 9 trial locations which showed significant mean yield difference between these two groups

SUPPLEMENTAL TABLE S1.2: Protocol 1 – Summary of Location Data for Bollworm Complex Reaction and Fruiting Body Damage Among Bt and Non-Bt Cotton Hybrids for Trials Conducted in India, 1998-1999.

HYBRID COMPARISON	Number of Locations Showing Significant Differences Between Bt & Non-Bt Hybrids		Average Value Over Locations Showing Significant Differences Between Bt & Non-Bt Hybrids		Average Value Over All Locations	
	0 – 60 Days After Sowing	61 - 90 Days After Sowing	0 – 60 Days After Sowing	61 - 90 Days After Sowing	0 – 60 Days After Sowing	61 - 90 Days After Sowing
BOLLWORM LARVAE COUNT (PER 10 PLANTS)						
Mean: Bt Hybrids	5 of 8	5 of 9	1.1	2.5	1.2	1.7
Mean: Non-Bt Hyb.			6.9	9.4	6.1	6.4
FRUITING BODY DAMAGE (%)						
Mean: Bt Hybrids	6 of 8	7 of 9	2.2	2.1	2.5	2.5
Mean: Non-Bt Hyb.			9.9	12.8	8.7	11.4

Study to generate data on the stability of Cry 1Ac gene

Chapter III

Annexure 2

Title of Study : **F2 segregation analysis to confirm stability of the *Cry1Ac* gene in Mahyco Bt Cotton Derivatives.**

Purpose : To ascertain gene stability by analysing the F2 segregation pattern of the Bt *Cry1Ac* gene in the F2 generation, derived from representative F-1 cotton hybrids that were in turn derived by test cross of non-transgenic cotton parents with transgenic Bt cotton converted Mahyco parents (true-breeding for the Bt positive trait).

Methods : Three independently generated F-1 populations, each a result of a different Bt converted Mahyco parent line, were taken for this experiment. The F2 generation was produced by growing these F-1 hybrids in the transgenic green house. From each population, 720 seeds were germinated in paper towel in the laboratory and the seedlings were tested individually for expression of the Bt gene, by way of a standard Cry1Ac specific Elisa (Enzyme Linked Immuno-Sorbent Assay). The dominant phenotype (Elisa positive) and the recessive phenotype (Elisa negative) individuals were counted and the ratio analysed by Chi Square test for goodness of fit to the expected 3:1 ratio.

Results : The observed numbers of Elisa positive, i.e., individuals containing the Bt *Cry1Ac* gene, and Elisa negatives, along with their Chi square analysis are given below.

Chi Square Test for Goodness of Fit (Ratio 3 :1)

Population-1:

Observed Value	Expected Value	Chi^2	Significance at 5%
Elisa Positive: 532	540	0.119	Not Significant
Elisa Negative: 188	180	0.474	Not Significant

The value of X^2 is non-significant, it justifies the agreement between the observed fact and the expected fact or value. Here the observed value of X^2 is 0.119 and 0.474 which are less than the 5.991, the value of X^2 at 5% level of significance for 2 degrees of freedom. It proves that this observed value is non-significant and hence, the agreement with the theoretical ratio is proved to be quite satisfactory.

Population-2:

Observed Value	Expected Value	Chi^2	Significance at 5%
Elisa Positive: 524	540	0.474	Not Significant
Elisa Negative:196	180	1.422	Not Significant

The value of X^2 is non-significant, it justifies the agreement between the observed fact and the expected fact or value. Here the observed value of X^2 is 0.474 and 1.422 which are less than the 5.991, the value of X^2 at 5% level of significance for 2 degrees of freedom. It proves that this observed value is non-significant and hence, the agreement with the theoretical ratio is proved to be quite satisfactory.

Population-3:

Observed Value	Expected Value	Chi^2	Significance at 5%
Elisa Positive: 561	540	0.817	Not Significant
Elisa Negative:159	180	2.450	Not Significant

The value of X^2 is non-significant, it justifies the agreement between the observed fact and the expected fact or value. Here the observed value of X^2 is 0.817 and 2.450 which are less than the 5.991, the value of X^2 at 5% level of significance for 2 degrees of freedom. It proves that this observed value is non-significant and hence, the agreement with the theoretical ratio is proved to be quite satisfactory.

Conclusion : The observed segregation of the Bt (*Cry1Ac*) gene in all the three tested F2 populations conform to the expected 3:1 ratio. This establishes the fact that the transgene in question is behaving consistently as a single dominant Mendelian factor, indicating stable inheritance of the gene. It may be noted that the generation tested in this experiment was the seventh generation from the first crossing of the particular Mahyco recurrent parent. Unambiguous behaviour of the Cry1Ac positive trait as a consistent single dominant Mendellian factor confirms beyond doubt that the transgene in question, incorporated into Mahyco Bt cotton lines, is a stable nuclear incorporated gene.

Expression levels of Cry 1Ac insect control protein found in Bt cotton hybrids during the 2000 growing season

Chapter V

Annexure 1

Expression levels of Cry1Ac Insect Control Protein found in *Bt* cotton hybrids during the 2000 growing season

1. Purpose of the study :

During the growing season of 2000, MAHYCO field-tested some *Bt* cotton hybrids at a number of locations in India. This current study aims at quantitating the *in planta* expressed *Bt* insecticidal protein, Cry1Ac in various tissues like terminal leaf, square, boll and first-pick seed in three *Bt* hybrids and one non-*Bt* hybrid (as check) grown in five locations during 2000. The Cry1Ac expression was profiled for three tissues of each hybrid at five time points and the first-pick seed at 135 days after sowing.

2. Time of study : Field season of 2000

3. Field locations :

Kallakal, AP
Harpanhalli, Kar
Yeotmal, Mah
Barwah, MP
Guntur, AP

4. Hybrids under study :

Mech 12 *Bt*
Mech 162 *Bt*
Mech 184 *Bt*
Mech 12 Non-*Bt*

5. Replications :

Each hybrid, at each field location, was replicated twice (R1 & R2).

6. Tissues studied :

i. Fully opened terminal leaf (about the size of one rupee coin)
ii. Pre-candle square (bud), two to three nodes below the terminal
iii. First position boll, two to three nodes below the uppermost white bloom
iv. First-pick seeds

7. Field sampling :

The *Bt* cotton hybrids, represented by Mech 12 Bt, Mech 12 Non-Bt, Mech 162 Bt and Mech 184 Bt were sampled at 60, 74, 90, 104 and 118 days after sowing (DAS). At each sampling time, the three specific tissue types mentioned above were collected.

Each sample consisted of tissues (Terminal leaf / square / boll) taken from 5 randomly selected plants within the plot and pooled. Both replications of a treatment were sampled and pooled separately. The pooled tissues were processed together for evaluation, and thus each data point represents a pooled mean. The sample plots had received no insecticide sprays for lepidopteran control. The samples were transported to the laboratory in pre-labeled plastic bags packed in ice.

Seeds from only the first-pick (approximately 135 DAS) were sampled from the hybrids across the field locations and transported to the laboratory for analysis.

NOTE:

The seeds were coated with an Imidachloprid formulation named "Gaucho" before sowing for initial control of sucking pests. In addition, need-based spraying for control of sucking pests was effected in all locations. In the event of spray for sucking insects, a time gap of ten days was given between spray and sampling. The plant-protection protocol also included spraying for bollworm control based on population reaching economic threshold level (ETL) of 20 larvae/20 plants. Economic threshold for bollworm control was never reached in any of the five locations.

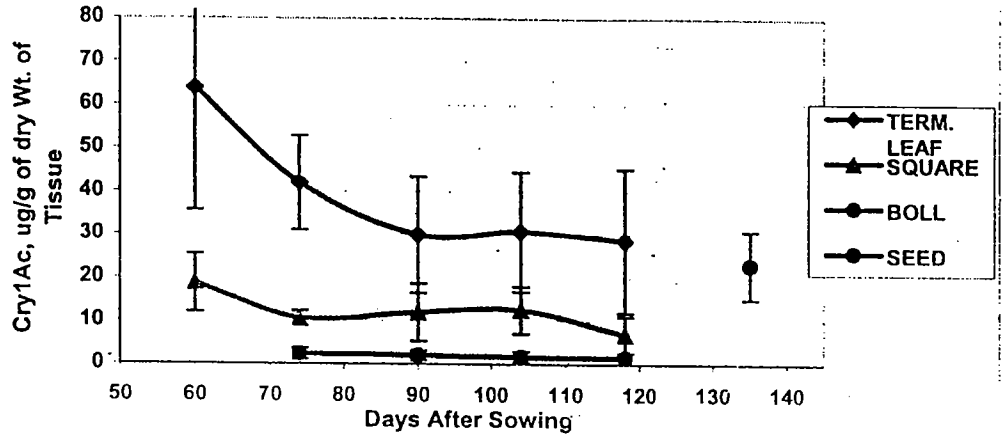
8. Laboratory evaluation :

Sample processing and evaluation for Cry1Ac was performed after a sensitive quantitative bioassay method previously described (Greenplate, 1999). Accordingly, plant tissue samples were frozen and subsequently lyophilized in a Virtis Genesis 12ES freeze dryer (Virtis Company, Gardiner, NY, USA). Cotton seeds were delinted and split into halves before freeze-drying. After complete lyophilization, the dried samples were ground into a fine powder using a mortar and pestle and stored in sealed containers in a -80° freezer. For testing, powder samples were diluted 1000 to 25000 times, depending upon the tissue type, in a 0.2% agar solution in order to achieve an even suspension. These diluted powder samples were applied as an overlay on synthetic insect diet in the wells (50 µL/well) of 96-well microtiter plates normally used for immunoassay work. One plate of 96 wells was used for each plant sample. Concurrent with this, a separate set of plates was similarly surface treated with 8 dilutions (ranging from 5.55 to 0.484 ng/mL) of a standard Cry1Ac formulation (MVP®II powder, a commercial product of Mycogen Corporation, San Diego, USA. This formulation contains delta endotoxin of *Bacillus thuringiensis* variety *kurstaki*, at 19.7 % w/w of Cry1Ac, encapsulated in killed *pseudomonas fluorescens*. Two plates, designated untreated controls, were treated with 0.2% agar only. The plates were allowed to surface dry in an aerated incubator at 30° C. Upon drying, a suspension of eggs (in 0.2% agar) of the Cry1Ac-sensitive spotted bollworm (*Earias vittella*) was pipetted onto the treated wells (25 µL/well). The eggs were within 12 hours of hatching and were in a suspension that resulted in about 3 eggs per well. The egg slurry was also surface dried. A thin sheet of mylar film was heat sealed over the wells and an insect pin (#0) was used to perforate the mylar over each well to provide aeration. The plates were incubated at 30° C for 8 days or until 90% of the wells in the untreated control plates contained 3rd instar larvae. At this time every treatment was evaluated by counting the number of treated wells that contained 3rd instar larvae. The values for the purifed Cry1Ac standard dilutions were compiled and graphed as % 3rd instars *vs* Cry1Ac concentration. This became a "standard curve" from which the amount of Cry1Ac present in the diluted plant samples could be estimated based on their respective values for % 3rd instars; these numbers were subsequently corrected to account for the original dilution factors of the sample powders and final estimates of Cry1Ac content in tissue samples were expressed as µg/g dry weight.

9. **Results:**

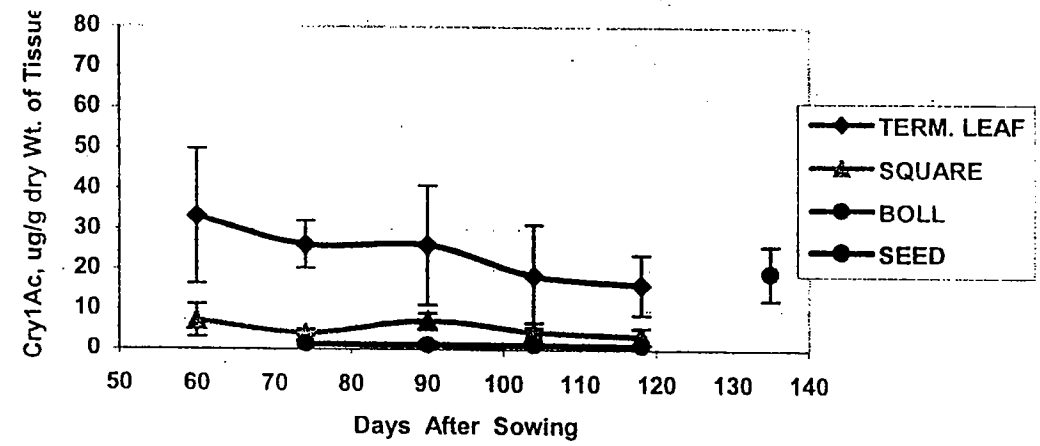
(i) The levels of Cry1Ac in the *Bt* cotton hybrid Mech 12 (terminal leaf, square, bolls and first-pick seed) at five time points across five field locations are shown in Fig. 1

Fig.1 Mean Expression (with SD) of Cry1Ac in tissues of Hybrid Mech 12 Bt across five locations



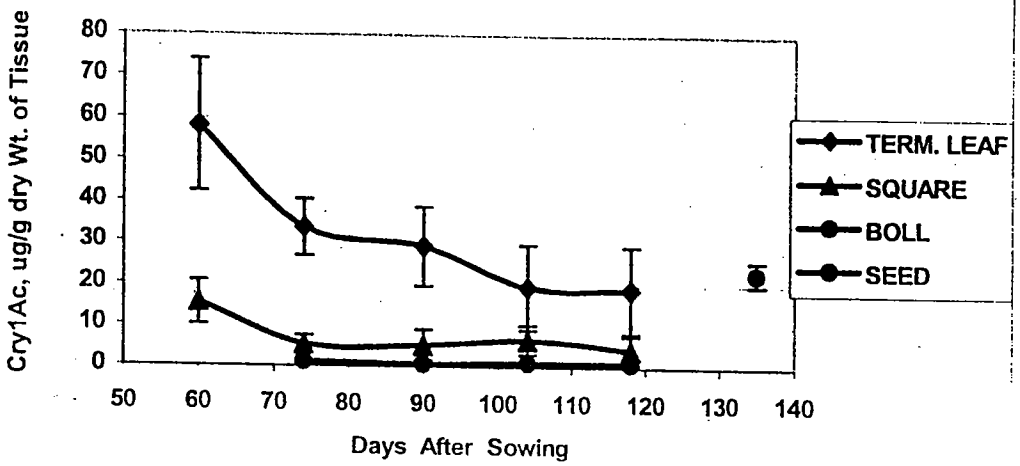
ii) The expression levels of Cry1Ac seen in *Bt* cotton hybrid Mech 162 (terminal leaf, square, bolls and first-pick seeds) at five time points across five field locations are shown in Fig. 2

Fig.2 Mean Expression (with SD) of Cry1Ac in tissues of Mech 162 Bt across five locations



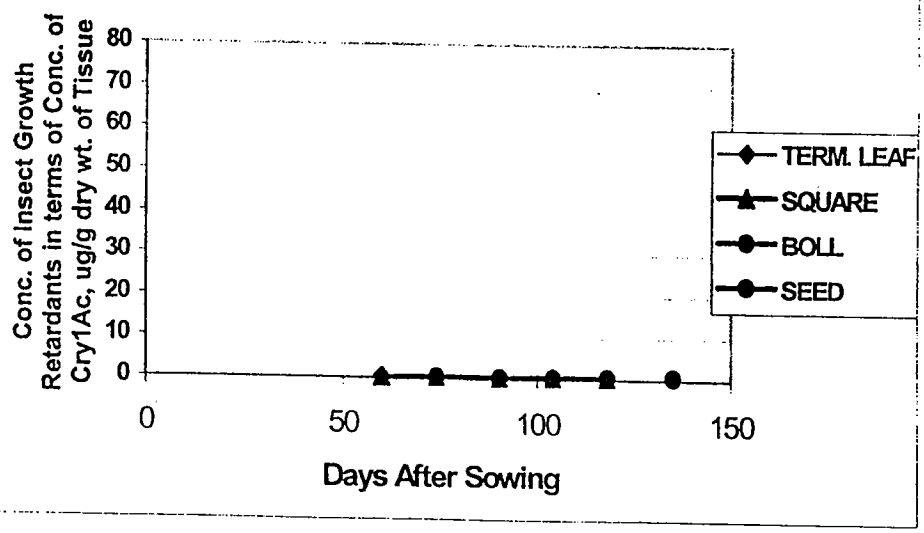
iii) The expression levels of Cry1Ac seen in *Bt* cotton hybrid Mech 184 (terminal leaf, square, bolls and first-pick seeds) at five time points across five field locations are shown in Fig. 3

Fig.3 - Mean Expression (with SD) of Cry1Ac in tissues of Hybrid Mech 184 Bt across five locations



iv) Background values obtained in the assay with the tissues of the non-transgenic hybrid Mech 12 Non-*Bt* is shown in Fig. 4

Fig.4 Background Values Obtained with Tissues of Hybrid Mech 12 Non-Bt across five locations



10. DISCUSSION

The validity and specificity of this insect-based bioassay for quantitation of Cry1Ac in tissues is clear on comparing the expression in the Bt hybrids and the absence of any insect-retardation effect in the Non-Bt tissues.

The expression of Cry1Ac in the various tissues across the three hybrids was characteristic of Bt cotton as seen earlier (Greenplate, 1999). The terminal leaf had the highest expression in all the three hybrids and could represent high level of Cry1Ac in the shoot region of cotton. This observation bears significance because the spotted bollworm, *Earias vittella* and American bollworm, *Helicoverpa armigera* predominantly lay eggs in the shoot region of the plant and the neonates feed on the tissue in this region. The concentration of Cry1Ac strongly suggests good control .

Among the reproductive tissues, the concentration of Cry1Ac varied between 5 and 20 ug in all the hybrids in the window period of 60 to 110 DAS. This period is characterized by appearance of plenty squares on the plant and also coincides with the peak infestation by spotted and american bollworms on cotton. The Bt protein concentration seen could translate into effective protection of bollworms on the squares.

Expression of Cry1Ac in first-pick seeds (approximately 135 days after sowing) across the hybrids ranged from 19 to 30 ug/g dry wt. of tissue. The relatively high content of Cry1Ac seen in seeds of all hybrids could offer effective protection against the Pink Bollworm (PBW) which feeds on seeds on entering the bolls and secondly, PBW is the most sensitive to Cry1Ac among the cotton bollworms.

In order to get a holistic picture of the bollworm-tolerance trait introduced in the hybrids, the expression profiles of the various hybrids across field locations generated in this study needs to be complemented with plant damage and other entomological observations obtained from these fields in future studies.

REFERENCE :

1) Greenplate, J.T., 1999. Quantification of *Bacillus thuringiensis* insect control protein Cry1Ac over time in Bollgard® cotton fruit and terminals. J. Econ. Entomol. 92: 1377-1383.