

Bt COTTON EVALUATION REPORT

Second Year
TRANSGENIC COTTON HYBRIDS WITH
DELTA ENDOTOXIN Cry1A(c) + Cry 2A(b)
(3 Bollgard-II Bt hybrids)

CENTRAL ZONE

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Executive Summary

The All India Coordinated Cotton Improvement Project (AICCIP) undertook the evaluation of three cotton hybrids for central zone. The three Bollgard II hybrids tested in five centres of central zone are MRC.7301 Bt, MRC.7326 Bt and MRC.7160 BG-II. M/S Maharashtra Hybrid Company (MAHYCO) Seeds Pvt. Ltd., Jalna submitted the seeds for the multi-location testing of these three Bollgard II hybrids, possessing the Cry 1A(c) and Cry 2A(b) genes, expressing delta-endotoxin, insecticidal protein from the spores of the soil bacterium strains of *Bacillus thuringiensis var. kurstakii* for the management of cotton bollworms, based on the ICAR letter No. 2(8)/2003-C.C.I. dated 25.4.2003. These hybrids having both **(Cry 1A (c)+ Cry 2A (b))** genes are named as BOLLGARD II (BG II) hybrids.

These were subjected to Breeding (protected against sap sucking insects at their respective threshold levels) and Plant Protection (without any plant protection for insect pests and diseases) evaluations during 2004 *kharif* season. These trials were laid out in accordance with the protocol and following standard package of practices of cotton cultivation, of respective centres, where the evaluations were undertaken. The untreated, acid de-linted seeds of the relevant test hybrids and their non-Bt hybrids were provided by the above said private R&D.

It is found that the bollworm population was very low and the non-Bt hybrids as well as NHH.44 did not have any requirement of plant protection for bollworms. However, all the test hybrids did need protection from sap sucking pests there. In breeding plots (protected against sucking pests), the square damage was found to be the lowest in MRC.7326Bt (0.6%) while the maximum damage was recorded in its non-Bt hybrid (6.8%), more than that in the NHH.44 (5.8%).

While the per cent square damage in Bt Genotypes were six times less than that in their non-Bt counterparts under unprotected condition. NHH.44 recorded as much as 14.7% damage in the zonal average. The BG II genotypes recorded less damage over the Bt (BG I) check hybrids too. The Green boll damage was seen to be 8 times in non-Bt hybrids over their Bt counterparts. NHH.44 recorded 10% green boll damage. The Bt hybrids recorded much less damage over Bt check hybrid too.

The Para wilt incidence up to a maximum of 6.67% at the Khandwa centre. Only at the Nanded centre, there was substantial incidence of Grey mildew ranging from 5.00 percent to 40.00 percent with the maximum grades of three and four. At Nanded, all test BG II hybrids were found to be susceptible to Grey mildew disease.

The seed cotton yield of the three test hybrids under protected condition was higher than NHH.44. The highest seed cotton was harvested from MRC.7160 BGII (1390 kg/ha). However, they were similar to the BG I check hybrids too. MRC.7160 BG II yielded 1390 kg/ha, while under unprotected condition this hybrid yielded 1241 kg/ha seed cotton in this zone. The non-Bt and BG I check hybrids had less seed cotton yield than this hybrid.

The bundle strength (fibre tenacity) of test hybrids during 2004 season does not match with the fibre length of the test entries.

Important observations of two years:

In general, both the years did not have appreciable population of American bollworm and Spotted bollworm in the test plots of the BG II hybrids. All the BG II hybrids did need protection from sap sucking pests there.

During 2003 season, while the per cent square damage in Bt Genotypes were six times less than that in their non-Bt counterparts under unprotected condition, NHH.44 recorded as much as 14.7% damage in the zonal average.

The Green boll damage was seen to be 8 times in non-Bt hybrids over their Bt counterparts. NHH.44 recorded 10% green boll damage. The Bt hybrids recorded much less damage over Bt check hybrid too.

In central zone, the seed cotton yield was not consistent in BG II evaluation due to varying conditions of drought and rains in the test centres during 2003 season. In protected plots, MRC.7301Bt yielded 1042 kg/ha, being the average of five AICCIP centers of this zone. MRC.7326Bt was close to this with 1035 kg/ha while MRC.7160 BG-II yielded 750 kg/ha. However, the data of 2004 evaluations show that there is superiority for BG II hybrids in this respect. During 2004 season, MRC.7160 BG II yielded 1390 kg/ha, while under unprotected condition this hybrid yielded 1241 kg/ha seed cotton in this

zone. The non-Bt and BG I check hybrids had less seed cotton yield than this hybrid under unprotected condition.

The fibre tenacity values of BG II hybrids were not matching with their span length as per CIRCOT and SITRA (South India Textile Research Association – Textile Ministry) norms. The evaluation of these properties under large scale cultivation is required for confirmation.

Introduction

The All India Coordinated Cotton Improvement Project (AICCIP) undertook the evaluation of Sixteen Bt cotton hybrids possessing the Cry 1 A (c) gene (vide ICAR letter No. 2(2)/04 dated 19.04.04) in the five central Zone centres, viz., Central Institute for Cotton Research Institute, Nagpur, Dr.Punjabrao Deshmukh Krishi Vidyapeeth, Akola, Cotton Research Station of Marathwada Agricultural University, Nanded, Cotton Research Station, Khandwa of Jawaharlal Nehru Krishi Vishwa Vidyalaya, and Cotton Research Station, Surat of Navsari Agricultural University for the second year in succession (vide ICAR letter No.2(8)/2003-C.C.I. dated 25.4.2003). The trials were laid out in accordance with standard package of practices of cotton cultivation, followed at respective centers, where the evaluations were undertaken. The untreated, acid de-lined seeds of the relevant test hybrids and their non-Bt counterparts were provided by the above seed companies. The relevant Bt check, local checks were included for comparison and results are furnished below:

Breeding & Plant Protection Evaluations

DESIGN-RBD – No. of treatments :8, 3 REPLICATIONS – 6 ROWS X 6 metre rows

RESULTS OF EVALUATIONS

The Breeding and Plant Protection evaluations of BG II hybrids were undertaken along with their non-Bt counterparts and Bt check hybrid (MECH.162 Bt) and zonal check hybrids, as given above at the designated AICCIP centers, as given above for both central and South zones.

Breeding evaluation (Protected from sap sucking pests at ETL)

CENTRAL ZONE

The results on various morphological characters recorded in the hybrids under breeding trial over five locations viz., Cotton Research Station, Nanded, CICR, Nagpur, JNKVV, Khandwa, GAU, Surat and PDKV, Akola are furnished below.

Germination Percentage:

In all the hybrids, germination was good in all locations with 98-100% germination, as given below.

Entry	Nagpur	Akola	Nanded	Surat	Khandwa	Mean
MRC.7160 BG II	98.89	95	100	100	100	99
MRC.7301 BG II	97.78	98	99	99	95	98
MRC.7326 BG II	100.00	99	100	100	95	99
MRC.7160	100.00	99	99	97	95	98
MRC.7301	100.00	97	99	98	90	97
MRC.7326	100.00	96	100	98	100	99
MECH.162Bt (CC)	100.00	100	99	99	100	100
RCH.2Bt(CC)	98.89	97	99	99	100	99
NHH.44 (Check)	98.89	98	100	99	100	99

Number of Sympodia

There was no difference in the number of sympodia between check and non-Bt hybrids with the test Bt hybrids, as can be seen below.

Entry	Nagpur	Akola	Nanded	Surat	Khandwa	Mean
MRC.7160 BG II	16.9	4.5	13.7	20.0	13.0	13.6
MRC.7301 BG II	17.8	5.1	13.9	17.0	14.0	13.6
MRC.7326 BG II	17.5	4.6	13.5	17.0	14.5	13.4
MRC.7160	18.5	5.3	9.6	21.0	13.5	13.6
MRC.7301	18.3	5.6	10.3	20.0	11.5	13.1
MRC.7326	20.0	4.9	10.9	21.0	20.0	15.4
MECH.162Bt (CC)	18.7	6.1	14.4	20.0	12.5	14.3
RCH.2Bt(CC)	17.3	3.8	13.6	15.0	14.2	12.8
NHH.44 (Check)	19.3	4.8	9.2	22.0	13.0	13.6
CD (0.05)	2.6		2.5	6.2		
CV%	8.1		11.7	18.8		

Mean Length of First Sympodium (cm)

The mean length of first sympodium ranged between 24 to 27 cm in test Bt hybrids and was seen to be lower than that in other hybrids, as shown below.

Entry	Nagpur	Akola	Nanded	Mean
MRC.7160 BG II	31.7	20.7	28.0	26.8
MRC.7301 BG II	31.9	16.2	24.1	24.1
MRC.7326 BG II	34.9	21.2	23.8	26.6
MRC.7160	41.2	23.4	27.1	30.6
MRC.7301	34.1	27.8	25.8	29.2
MRC.7326	33.8	28.5	27.8	30.0
MECH.162Bt (CC)	42.2	18.4	28.6	29.7
RCH.2Bt(CC)	28.6	15.7	24.0	22.8
NHH.44 (Check)	44.1	27.6	28.9	33.5
CD (0.05)	9.1		4.2	
CV%	14.6		12.5	

Total number of bolls/plant

The number of bolls per plant was seen to be more in the test Bt hybrids over their non-Bt counterparts. The check Bt hybrids with *cry 1 A(c)* also had similar boll numbers, as seen below.

Entry	Nagpur	Akola	Nanded	Surat	Khandwa	Mean
MRC.7160 BG II	22.8	20.0	14.8	56.0	16.8	26.1
MRC.7301 BG II	19.4	21.5	16.9	29.0	18.0	21.0
MRC.7326 BG II	25.4	27.2	17.4	32.0	22.0	24.8
MRC.7160	13.4	7.0	8.2	31.0	22.8	16.5
MRC.7301	20.0	7.8	8.4	35.0	20.5	18.3
MRC.7326	20.4	10.4	12.6	35.0	20.2	19.7
MECH.162Bt (CC)	19.6	17.3	11.9	59.0	25.3	26.6
RCH.2Bt(CC)	18.2	14.5	11.4	34.0	24.7	20.6
NHH.44 (Check)	21.0	8.9	8.2	65.0	22.2	25.1
CD (0.05)	3.6	5.8	5.9	8.8	2.8	
CV%	10.2	22.6	26.6	12.2	24.4	

Boll weight (g)

The boll weight that was recorded in Bt hybrids was above 3.5 g/plant, as given below.

Entry	Nagpur	Akola	Nanded	Surat	Khandwa	Mean
MRC.7160 BG II	4.2	4.1	3.2	3.1	6.7	4.2
MRC.7301 BG II	4.0	3.4	3.1	3.4	4.9	3.8
MRC.7326 BG II	4.1	4.4	3.3	3.3	4.8	4.0
MRC.7160	4.7	3.3	3.1	3.8	5.0	4.0
MRC.7301	3.9	3.4	3.0	3.1	4.1	3.5
MRC.7326	4.0	3.2	3.1	3.2	4.6	3.6
NHH.44 (Check)	4.2	3.4	2.4	3.0	5.2	3.6
MECH.162Bt (CC)	3.9	3.5	3.2	3.2	5.5	3.8
RCH.2Bt(CC)	4.4	4.2	2.6	3.9	5.2	4.1
CD (0.05)	0.8	0.7	0.5	0.5	1.4	
CV%	11.4	11.3	4.2	9.3	24.4	

Ginning out turn (%)

The percent Ginning out turn (GOT) was quite high in Bt test hybrids over others during 2004-05, as shown below.

Entry	Nagpur	Nanded	Surat	Khandwa	Mean
MRC.7160 BG II	36.9	36	38.7	34.6	36.6
MRC.7301 BG II	33.6	35.9	38.1	37	36.2
MRC.7326 BG II	34.9	36	41	31.6	35.9
MRC.7160	33.6	36.7	36.6	30.95	34.5
MRC.7301	34.3	38.1	37.1	34.5	36.0
MRC.7326	33.6	36.4	35.3	33.7	34.8
MECH.162Bt (CC)	34.4	36.9	36.4	33.5	35.3
RCH.2Bt(CC)	31	35.5	33.9	31.8	33.1
NHH.44 (Check)	32.4	35.2	34.4	31.75	33.4
CD (0.05)	1.31	1.981	1.6	1.38	
CV%	2.23	6.291	2.5	1.8	

Mean Lint Index (g)

The mean lint index was not seen to differ between hybrids during this year, although numerical superiority of MRC.7160 BGII was observed, as seen in the following table.

Entry	Nagpur	Akola	Nanded	Surat	Mean
MRC.7160 BG II	5.6	5.6	4.6	4.8	5.1
MRC.7301 BG II	4.2	5.2	4.0	5.0	4.6
MRC.7326 BG II	4.4	5.7	4.6	4.8	4.9
MRC.7160	5.3	4.9	5.3	4.8	5.1
MRC.7301	4.6	4.7	5.1	4.7	4.8
MRC.7326	4.6	5.4	4.6	4.3	4.7
MECH.162Bt (CC)	4.1	4.4	4.6	4.6	4.4
RCH.2Bt(CC)	4.3	5.2	4.5	5.0	4.7
NHH.44 (Check)	4.1	3.8	4.1	3.8	3.9
CD (0.05)	0.7	0.7	0.7	0.5	
CV%	9.2	7.9	4.3	5.6	

Mean Seed index (g)

The mean seed index was the lowest in check hybrids, NHH.44 and MECH.162Bt hybrids. The Bt test hybrids and their non-Bt counterparts recorded high seed index.

Entry	Nagpur	Akola	Nanded	Surat	Mean
MRC.7160 BG II	9.5	9.3	8.2	7.7	8.7
MRC.7301 BG II	8.3	7.8	7.2	8.2	7.9
MRC.7326 BG II	8.2	8.8	8.2	7.8	8.2
MRC.7160	10.5	8.5	9.1	8.3	9.1
MRC.7301	8.8	7.1	8.2	8.0	8.0
MRC.7326	9.1	8.4	8.1	7.8	8.3
MECH.162Bt (CC)	7.7	7.2	7.8	7.8	7.6
RCH.2Bt(CC)	9.3	8.3	8.2	9.7	8.9
NHH.44 (Check)	8.6	7.0	7.6	7.2	7.6
CD (0.05)	1.4	0.6	0.6	0.7	
CV%	8.8	4.6	7.3	5.0	

Seed cotton yield

The seed cotton yield of the three test hybrids was higher than NHH.44. The highest seed cotton was harvested from MRC.7160 BGII (1390 kg/ha). However, they were similar to the BG I check hybrids too, as can be seen from the following table.

Entry	Nagpur	Akola	Nanded	Surat	Khandwa	Mean
MRC.7160 BG II	877	1063	836	2707	1468	1390
MRC.7301 BG II	852	1093	827	1522	1142	1087
MRC.7326 BG II	923	1052	905	1611	1222	1143
MRC.7160	740	309	266	1820	1042	835
MRC.7301	846	553	228	1554	1005	837
MRC.7326	862	396	500	1823	1071	930
MECH.162Bt (CC)	717	862	590	2850	1250	1254
RCH.2Bt(CC)	879	952	634	2019	1189	1135
NHH.44 (Check)	847	448	448	3006	1214	1193
CD (0.05)	24	119	172	499	160	
CV%	17	9	17	14	6	

Fibre quality parameters

The fibre quality parameters of the three BGII hybrids along with the check hybrids are provided in the following tables. The bundle strength (fibre tenacity) of test hybrids during 2004 season is not the desirable values for the fibre length they are offering.

2.5% span length

Entry	Nagpur	Akola	Surat	Khandwa	Mean
MRC.7160 BG II	26.80	26.0	26.8	27.7	27
MRC.7301 BG II	27.07	28.0	28.4	27.1	28
MRC.7326 BG II	26.23	27.5	27.1	27.6	27
MRC.7160	25.83	25.1	26.3	30.8	27
MRC.7301	25.83	25.1	27.8	27.2	26
MRC.7326	26.13	26.9	25.4	27.1	26
MECH.162Bt (CC)	24.67	24.7	24.6	25.7	25
RCH.2Bt(CC)	30.07	30.7	31.1	32.1	31
NHH.44 (Check)	25.53	24.0	24.9	24.6	25

Bundle strength tenacity

Entry	Nagpur	Akola	Surat	Khandwa	Mean
MRC.7160 BG II	20.5	18.1	17.9	19.7	19
MRC.7301 BG II	19.4	21.2	19.7	20.1	20
MRC.7326 BG II	19.8	21.6	19.0	20.2	20
MRC.7160	19.8	18.4	18.4	21.8	20
MRC.7301	20.8	20.8	19.5	22.0	21
MRC.7326	20.6	21.3	18.7	22.1	21
MECH.162Bt (CC)	19.9	20.9	17.8	19.4	20
RCH.2Bt(CC)	20.8	21.0	18.6	20.6	20
NHH.44 (Check)	19.5	17.9	17.0	17.7	18

Micronaire (10^{-6} g/in)

Entry	Nagpur	Akola	Surat	Khandwa	Mean
MRC.7160 BG II	3.8	3.7	4.9	4.0	4.1
MRC.7301 BG II	3.4	3.4	4.7	3.9	3.9
MRC.7326 BG II	3.5	3.9	4.9	3.9	4.1
MRC.7160	4.3	3.7	4.9	3.5	4.1
MRC.7301	3.3	3.4	4.5	4.1	3.8
MRC.7326	4.0	3.7	5.1	4.3	4.3
MECH.162Bt (CC)	3.3	3.1	4.8	4.3	3.9
RCH.2Bt(CC)	3.1	3.2	4.4	3.7	3.6
NHH.44 (Check)	3.7	3.1	4.8	3.8	3.9

Plant Protection Evaluation

Plant Protection Evaluation - Protected Conditions

The three Bt genotypes were less susceptible to jassid incidence in comparison to their non-Bt hybrids as well as in the check hybrids under protected conditions. The reaction to sap sucking pests is given below. It is found that the BG II hybrids are affected by thrips and whitefly. The data in tables 1 to 3 provide these details.

Table:1 Jassids (average of 3 leaves/plant)

Entry	Akola	Nagpur		Nanded		Surat		Khandwa		Mean
	Number	Number	TV*	Number	TV	Number	TV	Number	TV	
MRC.7160 BG II	2.2	1.51	2.17	1.8	2.9	1.3	1.1	0.8	0.6	1.7
MRC.7301 BG II	2.4	1.23	1.17	1.8	2.8	1.3	1.1	0.9	0.8	1.8
MRC.7326 BG II	2.2	1.03	0.67	1.9	3.1	1.4	1.5	1.0	1.0	2.0
MRC.7160	2.1	1.72	2.67	1.4	1.6	1.3	1.2	3.4	11.5	4.1
MRC.7301	3.1	1.49	2.00	1.7	2.5	1.4	1.4	3.8	14.4	5.4
MRC.7326	2.1	1.26	1.33	1.7	2.5	1.2	1.0	3.3	10.8	4.1
NHH.44 (Check)	2.4	1.35	1.50	1.7	2.5	1.2	1.0	3.3	10.6	4.1
MECH.162Bt (CC)	2.9	1.26	1.17	1.8	2.8	1.4	1.5	3.4	11.3	4.7
RCH.2Bt(CC)	4.2	1.56	2.00	1.7	2.4	1.6	1.9	3.6	13.2	5.4

*TV - transformed values

Table:2 Thrips (average of 3 leaves/plant)

Entry	Akola	Nanded		Surat		Khandwa		Mean
	Number	Number	TV*	Number	TV	Number	TV	
MRC.7160 BG II	18.0	5.2	26.6	2.6	6.1	2.3	5.1	14.0
MRC.7301 BG II	22.0	5.6	30.9	2.8	7.6	2.3	5.3	16.4
MRC.7326 BG II	18.4	5.7	31.8	2.6	6.2	2.3	5.1	15.4
MRC.7160	20.7	5.3	28.1	2.9	8.2	2.3	5.1	15.5
MRC.7301	23.6	5.7	32.3	3.2	9.9	2.4	5.7	17.9
MRC.7326	20.3	5.4	29.2	2.6	6.2	2.3	5.2	15.2
NHH.44 (Check)	17.3	5.7	32.0	2.7	6.8	2.3	5.3	15.4
MECH.162Bt (CC)	19.0	5.3	28.4	2.8	7.6	2.3	5.1	15.0
RCH.2Bt(CC)	21.6	5.4	29.2	2.4	5.3	2.3	5.2	15.3

*TV - transformed values

Table:3 Whitefly (average of 3 leaves/plant)

Entry	Akola	Nanded		Surat		Khandwa		Mean
	Number	Number	TV*	Number	TV	Number	TV	
MRC.7160 BG II	1.9	5.3	28.0	1.5	1.7	0.2	0.0	7.9
MRC.7301 BG II	1.5	4.7	21.9	1.2	0.9	0.2	0.1	6.1
MRC.7326 BG II	1.7	5.5	29.3	1.2	1.0	0.3	0.1	8.0
MRC.7160	2.8	5.3	27.9	1.4	1.5	0.2	0.0	8.1
MRC.7301	1.7	5.4	28.7	1.1	0.7	0.3	0.1	7.8
MRC.7326	1.5	5.6	30.8	1.3	1.2	0.2	0.1	8.4
NHH.44 (Check)	1.3	5.6	31.4	1.2	1.0	0.2	0.0	8.4
MECH.162Bt (CC)	1.1	5.2	26.5	1.1	0.7	0.3	0.1	7.1
RCH.2Bt(CC)	1.4	5.4	28.4	1.1	0.8	0.2	0.1	7.7

*TV - transformed values

The pest appeared in such low levels during this season. Hence, there was no difference in the infestation amongst the test hybrids.

Spotted bollworms per plant

Entry	Nagpur		Nanded		Surat		Khandwa		Mean
	TV*	Number	TV	Number	TV	Number	TV	Number	
MRC.7160 BG II	0.7	0.0	1.2	1.0	0.8	0.1	1.5	2.4	0.9
MRC.7301 BG II	0.7	0.0	1.6	2.0	0.7	0.0	0.7	0.5	0.6
MRC.7326 BG II	0.7	0.0	0.9	0.3	0.7	0.0	0.6	0.4	0.2
MRC.7160	0.8	0.2	2.0	3.3	0.8	0.2	1.0	1.0	1.2
MRC.7301	0.7	0.0	1.1	1.0	1.0	0.4	1.5	2.2	0.9
MRC.7326	0.7	0.0	1.1	0.7	0.7	0.0	0.9	0.8	0.4
NHH.44 (Check)	0.7	0.0	1.4	1.7	0.7	0.0	1.0	0.9	0.7
MECH.162Bt (CC)	0.7	0.0	1.3	1.3	0.8	0.2	1.0	1.1	0.6
RCH.2Bt(CC)	0.9	0.3	0.7	0.0	1.0	0.6	1.4	2.0	0.7

*TV - transformed values

The response of BG II hybrids in central zone to American bollworms is given below. It is found that there is substantial reduction of their population in MRC.7160 BGII and MRC.7326 BG II in comparison to their non-Bt counterparts as well as in MECH.162 Bt and in NHH.44.

Number of American bollworms per plant

Entry	Nagpur	Nanded		Surat		Khandwa	Mean
	Number	TV*	Number	TV	Number	Number	
MRC.7160 BG II	0.1	1.9	3.7	0.7	0.0	1.7	2.9
MRC.7301 BG II	0.0	1.7	2.7	0.7	0.0	2.9	1.4
MRC.7326 BG II	0.1	1.5	2.3	0.7	0.0	1.6	2.4
MRC.7160	0.5	2.6	6.3	1.1	0.8	3.2	10.2
MRC.7301	0.6	2.6	6.3	0.7	0.0	3.2	10.4
MRC.7326	0.5	2.0	3.7	0.7	0.0	3.3	11.1
MECH.162Bt (CC)	0.3	1.9	3.3	0.7	0.0	3.2	10.2
RCH.2Bt(CC)	0.3	1.4	1.7	0.7	0.0	1.9	3.4
NHH.44 (Check)	0.8	2.6	6.3	0.8	0.1	3.2	10.3
CD 0.05		0.9		0.1		0.9	
CV %		25.6		16.1		16.8	

*TV - transformed values

The percent locule damage, as depicted in the following table, shows that the BGII hybrids had considerably low locule damage and it was as much as that in BG I check hybrids.

Percent Locule damage

Entry	Nagpur		Nanded		Surat		Mean
	TV*	Av 3 lv/pt	TV	Av 3 lv/pt	TV	Av 3 lv/pt	
MRC.7160 BG II	14.7	6.9	11.7	4.1	13.1	5.2	5.4
MRC.7301 BG II	9.3	2.8	10.1	3.2	12.5	4.8	3.6
MRC.7326 BG II	10.9	4.1	8.1	2.0	11.3	3.9	3.4
MRC.7160	25.6	19.7	25.7	19.0	19.5	11.1	16.6
MRC.7301	23.1	16.2	25.2	18.2	13.2	5.2	13.2
MRC.7326	21.6	14.4	22.2	14.4	14.4	6.2	11.7
MECH.162Bt (CC)	16.2	8.3	16.0	7.6	9.8	2.9	6.3
RCH.2Bt(CC)	13.6	5.7	10.4	3.4	16.9	8.5	5.9
NHH.44 (Check)	21.3	13.7	2.5	18.5	14.7	6.5	12.9
CD 0.05	6.5		4.4		2.5		
CV%	31.9		14.8		10.2		

*TV - transformed values

The percent open boll damage was the lowest in BG II hybrids as much as that in BG I hybrids. The gene action reduce the bollworm infestation was evident in the following table.

Percent Open boll damage

Entry	Nagpur		Nanded		Surat		Khandwa	Mean %
	TV*	%	TV	%	TV	%	%	
MRC.7160 BG II	22.5	15.2	12.1	4.4	17.7	9.3	2.2	7.8
MRC.7301 BG II	13.5	6.1	11.8	4.3	16.6	8.2	11.5	7.5
MRC.7326 BG II	16.7	9.6	9.0	2.5	14.6	6.5	4.0	5.6
MRC.7160	36.1	35.1	27.9	22.2	24.7	17.5	3.4	19.6
MRC.7301	31.1	27.5	27.0	20.7	17.5	9.0	3.7	15.2
MRC.7326	29.2	24.4	24.0	16.6	18.0	9.7	3.8	13.6
NHH.44 (Check)	29.8	25.2	27.8	21.8	18.4	10.0	10.5	16.9
MECH.162Bt (CC)	22.9	15.4	15.7	7.6	13.2	5.3	4.3	8.2
RCH.2Bt(CC)	18.6	10.3	10.6	3.4	21.2	13.2	12.4	9.8
CD 0.05	7.4		4.9		2.8		0.2	
CV %	25.9		15.4		9.1		8.8	

*TV - transformed values

The test hybrids had more of sap sucking pests against 2-4 sprayings of insecticides.

The three test hybrids did not have any sprayings against bollworms.

Number of sprayings in different Bt and non Bt genotypes - PROTECTED conditions

Entry	Akola			Nanded			Surat			Khandwa		
	SP	BW	Total	SP	BW	Total	SP	BW	Total	SP	BW	Total
MRC.7160 BG II	4	0	4	2	1	3	1	0	1	0	0	0
MRC.7301 BG II	4	0	4	2	2	4	2	0	2	0	1	1
MRC.7326 BG II	4	0	4	2	1	3	2	0	2	0	0	0
MRC.7160	4	3	7	2	2	4	2	2	4	1	1	2
MRC.7301	4		4	2	2	4	2	1	3	2	1	3
MRC.7326	4	3		2	1	3	1	1	2	1	1	2
MECH.162Bt (CC)	4	3	7	2	3	5	3	1	4	1	1	2
RCH.2Bt(CC)	4	0	4	2	0	2	1	0	1	2		2
NHH.44 (Check)	4	3	7	2	3	5	2	2	4	1	1	2

Plant Protection Evaluation - Unprotected conditions

Under unprotected conditions, the BG II hybrids had less of jassids at Khandwa, as seen from the following table in comparison to other hybrids.

Jassids (average of 3 leaves/plant)

Entry	Nagpur	Akola		Nanded		Surat		Khandwa		Mean
	Number	TV	Number	TV	Number	TV	Number	TV	Number	
MRC.7160 BG II	1.1	2.1	4.9	1.7	2.5	1.3	1.1	0.9	0.7	2.1
MRC.7301 BG II	1.2	2.4	6.8	1.8	2.6	1.4	1.5	1.0	0.9	2.6
MRC.7326 BG II	1.0	2.4	5.7	1.5	2.1	1.3	1.3	0.8	0.7	2.1
MRC.7160	1.5	2.6	6.9	1.3	1.3	1.4	1.4	3.4	11.5	4.5
MRC.7301	1.6	2.8	7.9	1.6	2.0	1.5	1.6	3.6	12.6	5.1
MRC.7326	1.0	2.1	4.7	1.3	1.3	1.4	1.6	3.2	10.2	3.8
MECH.162Bt (CC)	1.1	3.2	10.0	1.4	1.5	1.3	1.2	3.2	10.3	4.8
RCH.2Bt(CC)	1.4	3.2	10.5	1.6	2.1	1.6	2.1	3.5	12.5	5.7
NHH.44 (Check)	1.3	2.3	5.8	1.7	2.3	1.3	1.3	3.3	10.6	4.3
CD 0.05		0.8			NS	0.3		0.4		
CV %		17.1			18.6	12.3		14.4		

The population of thrips and whitefly population were quite high in all entries in central zone, as given in the following two tables. The unprotected condition favoured this in the test entries.

Thrips

Entry	Nagpur	Akola		Nanded		Surat		Khandwa		Mean
	Number	TV	Number	TV	Number	TV	Number	TV	Number	
MRC.7160 BG II	4.1	9.2	85.6	5.0	24.9	2.4	5.3	2.1	4.2	24.8
MRC.7301 BG II	6.3	9.1	84.3	4.6	21.2	2.6	6.4	2.1	4.5	24.5
MRC.7326 BG II	5.8	9.3	87.1	4.4	19.1	2.7	6.9	2.0	4.1	24.6
MRC.7160	4.6	9.2	84.2	4.5	19.5	2.5	6.0	2.1	4.2	23.7
MRC.7301	6.8	9.4	87.8	5.0	24.4	2.7	6.7	2.1	4.3	26.0
MRC.7326	5.0	9.9	99.3	5.1	25.8	2.4	5.5	2.1	4.4	28.0
MECH.162Bt (CC)	8.7	10.9	118.7	5.7	31.7	3.2	9.6	2.1	4.5	34.6
RCH.2Bt(CC)	4.2	9.5	90.0	5.3	27.7	2.3	5.0	2.0	4.1	26.2
NHH.44 (Check)	5.8	10.1	103.3	5.6	31.3	3.1	9.2	2.0	4.1	30.8
CD 0.05		1.4		0.7			0.6			
CV %		8.5		8.5			12.6		16.1	

Whitefly

Entry	Nagpur	Akola		Nanded		Surat		Khandwa		Mean
	Number	TV	Number	TV	Number	TV	Number	TV	Number	
MRC.7160 BG II	2.63	1.73	3.22	1.87	23.3	1.28	1.14	0.28	0.08	6.07
MRC.7301 BG II	2.13	1.67	2.44	5.1	25.8	1.12	0.75	0.17	0.03	6.23
MRC.7326 BG II	2.77	2.04	3.67	4.88	23.5	1.08	0.67	0.28	0.08	6.14
MRC.7160	2.10	2.86	8.22	4.95	24.2	1.37	1.38	0.17	0.03	7.19
MRC.7301	2.33	1.52	1.89	5.43	29.1	1.08	0.67	0.26	0.07	6.81
MRC.7326	1.43	1.53	1.89	5.5	29.9	1.09	0.69	0.24	0.06	6.79
MECH.162Bt (CC)	1.77	1	0.67	5.1	25.7	1.09	0.69	0.22	0.05	5.78
RCH.2Bt(CC)	2.27	2.07	4.33	5.28	27.5	1	0.5	0.24	0.06	6.93
NHH.44 (Check)	1.90	1.7	2.45	5.31	27.9	1	0.5	0.2	0.04	6.56
CD 0.05		1.14		NS			0.31			
CV %		36.43		8.5			15.84		13.25	

There was very poor population of Spotted bollworm in this season in central zone. Hence, the results on their infestation in BG II hybrids are inconclusive.

Spotted bollworms

Entry	Akola		Nanded		Surat		khandwa		Mean
	TV*	Number	TV	Number	TV	Number	TV	Number	
MRC.7160 BG II	0.7	0.0	0.9	0.3	0.8	0.1	2.1	4.5	1.0
MRC.7301 BG II	0.7	0.0	1.3	1.3	0.7	0.0	2.9	8.2	1.9
MRC.7326 BG II	0.7	0.0	1.2	1.0	0.7	0.0	1.6	2.5	0.7
MRC.7160	1.9	3.3	1.5	2.0	0.8	0.1	2.4	5.9	2.3
MRC.7301	1.3	1.3	1.5	1.7	0.8	0.2	2.5	6.3	1.9
MRC.7326	1.2	1.0	0.7	0.0	0.8	0.3	1.8	3.2	0.9
MECH.162Bt (CC)	0.8	0.0	1.6	2.0	0.8	0.1	1.8	3.1	1.0
RCH.2Bt(CC)	0.7	0.0	0.9	0.3	0.7	0.0	3.1	9.5	2.0
NHH.44 (Check)	1.8	2.7	1.6	2.3	0.9	0.4	3.0	9.1	2.9
CD 0.05	0.4		0.6			0.3		0.3	
CV %	18.7		26.2			20.9		12.4	

*TV - transformed values

The American bollworm infestation was low in general during this season in this zone. However, the BG II had less larvae than other hybrids in this evaluation.

American bollworms

Entry	Nagpur	Akola		Nanded		Surat		Khandwa		Mean
	Number	TV*	Number	TV	Number	TV	Number	TV	Number	
MRC.7160 BG II	0.0	0.7	0.3	1.1	0.7	0.3	0.9	2.2	5.0	1.4
MRC.7301 BG II	0.1	0.7	0.0	1.2	1.0	0.0	0.7	2.0	4.2	1.2
MRC.7326 BG II	0.0	0.9	0.1	1.1	0.7	0.0	0.7	2.2	5.0	1.3
MRC.7160	0.5	1.9	2.2	2.0	6.9	0.2	0.8	2.2	5.0	3.1
MRC.7301	0.4	1.5	1.2	2.7	7.0	0.0	0.7	2.2	4.8	2.8
MRC.7326	0.3	1.8	1.5	2.5	5.7	0.3	0.9	1.8	3.3	2.3
MECH.162Bt (CC)	0.1	1.2	0.4	1.2	1.0	0.2	0.8	2.2	4.8	1.4
RCH.2Bt(CC)	0.1	1.2	0.3	1.3	1.3	0.0	0.7	2.9	8.5	2.2
NHH.44 (Check)	0.5	1.0	0.9	2.8	7.3	0.8	1.1	2.9	8.4	3.6
CD 0.05		1.0		0.6		NS		0.2		
CV %		49.2		17.8		30.9		8.2		

*TV - transformed values

The percent locule damage also followed similar trend as much as that of the number of American bollworms per plant. The BG I check hybrids had also lower locule damage over non-Bt BG II counterparts.

Locule damage (%)

Entry	Nagpur		Akola		Nanded		Surat		Khandwa		Mean %
	TV*	%	TV	%	TV	%	TV	%	TV	%	
MRC.7160 BG II	10.7	3.8	0.0	0.0	11.7	4.1	25.0	18.0	12.7	4.8	6.1
MRC.7301 BG II	9.8	3.6	0.0	0.0	10.1	3.2	23.8	17.9	20.6	12.4	7.4
MRC.7326 BG II	11.6	4.9	0.0	0.0	8.1	2.0	22.8	15.0	12.0	4.3	5.3
MRC.7160	26.4	20.4	37.5	37.2	25.7	19.0	29.9	25.1	12.1	4.4	21.2
MRC.7301	24.3	17.1	31.3	27.1	25.2	18.2	28.7	23.3	11.1	3.7	17.9
MRC.7326	23.0	15.8	31.2	27.5	22.2	14.4	26.3	19.8	11.7	4.1	16.3
MECH.162Bt (CC)	9.8	3.1	3.5	1.1	16.0	7.6	25.1	18.4	11.1	3.7	6.8
RCH.2Bt(CC)	10.4	3.8	3.5	1.1	10.4	3.4	25.2	19.0	21.8	13.8	8.2
NHH.44 (Check)	21.8	14.0	24.7	19.0	2.5	18.5	26.0	19.9	21.8	13.8	17.0
CD 0.05	5.7		9.1		4.4		NS		0.3		
CV %	30.0		35.9		14.8		23.2		10.8		

*TV - transformed values

The percent Open boll damage also followed similar trend as much as that of the open boll damage over non-Bt BG II counterparts.

Open boll damage (%)

Entry	Nagpur		Akola		Nanded		Surat		Khandwa		Mean %
	TV*	%	TV	%	TV	%	TV	%	TV	%	
MRC.7160 BG II	15.5	8.3	0.0	0.0	12.1	4.4	29.3	24.3	8.5	2.2	7.8
MRC.7301 BG II	13.3	6.7	0.0	0.0	11.8	4.3	31.2	28.5	19.8	11.5	10.2
MRC.7326 BG II	17.0	11.0	0.0	0.0	9.0	2.5	28.7	23.2	11.5	4.0	8.1
MRC.7160	36.9	36.4	77.4	87.5	27.9	22.2	38.1	38.3	10.6	3.4	37.6
MRC.7301	31.8	27.9	53.4	64.4	27.0	20.7	36.3	35.2	11.1	3.7	30.4
MRC.7326	30.9	27.2	45.6	51.1	24.0	16.6	33.6	30.9	11.2	3.8	25.9
MECH.162Bt (CC)	13.5	6.2	7.1	4.4	15.7	7.6	31.1	27.0	12.0	4.3	9.9
RCH.2Bt(CC)	15.1	8.7	5.0	2.2	10.6	3.4	31.8	28.7	20.6	12.4	11.1
NHH.44 (Check)	29.0	24.0	50.6	51.1	27.8	21.8	32.6	29.7	18.9	10.5	27.4
CD 0.05	8.1		24.8		4.9		NS		0.2		
CV %											

*TV - transformed values

All the hybrids had only spraying against sap sucking pests as given below. There was no difference in the number of sprayings between these hybrids.

Number of sprayings for sucking pest - Unprotected Conditions

Entry	Akola	Nanded	Surat	Khandwa	Mean
MRC.7160 BG II	4	2	2	1	2.3
MRC.7301 BG II	5	2	2	3	3.0
MRC.7326 BG II	5	2	3	2	3.0
MRC.7160	5	2	2	1	2.5
MRC.7301	5	2	2	2	2.8
MRC.7326	5	2	2	1	2.5
NHH.44 (Check)	5	2	3	1	2.8
MECH.162Bt (CC)	5	2	2	2	2.8
RCH.2Bt(CC)	5	2	2	3	3.0

The highest seed cotton yield in central zone under UNPROTECTED condition was in MRC.7160 BG II (1241 kg/ha) followed by MRC.7326 BG II (1182 kg/ha). The BG I check hybrids yielded better than NHH.44.

Seed cotton yield (Kg/ha) (Unprotected)

Entry	Nagpur	Akola	Nanded	Surat	Khandwa	Mean
MRC.7160 BG II	881	1194	518	3051	563	1241
MRC.7301 BG II	513	1225	555	1936	529	952
MRC.7326 BG II	639	1386	707	2395	785	1182
MRC.7160	815	70	467	1679	468	700
MRC.7301	700	239	295	1967	462	733
MRC.7326	611	294	327	1874	623	746
MECH.162Bt (CC)	688	776	451	2367	547	966
RCH.2Bt(CC)	515	1079	371	2580	435	996
NHH.44 (Check)	1043	156	321	2179	395	819
CD (0.05)	NS	146	371	454	156	
CV%	28.6	11.89	33.2	11.56	16.99	

Plant Pathology Evaluation

During 2003 - 04, there was very little disease incidence, hence the hybrids could not be evaluated for their reaction to various diseases. However, during 2004 – 05 may foliar diseases viz., Bacterial leaf blight (BLB), Grey mildew, Alternaria leaf spot and Myrothecium leaf spot and also Para wilt appeared and the hybrids could be evaluated for their reaction during this year. Among these diseases, significant incidences of bacterial leaf blight at Surat and Akola, Grey mildew at Nanded and Parawilt at Khandwa and Akola have been noticed.

Bacterial leaf blight

Bacterial leaf blight (BLB) disease has been observed at all the five centres where the Bt hybrids were tested, but as the incidence Nagpur, Nanded and Khandwa was negligible in all three hybrids, BG II (hybrids) viz., MRC.7160 BG II, MRC.7301 BG II and MRC.7326 BG II were found to be Susceptible at Akola. At other centres there was less incidences of BLB, the percent disease incidence (PDI) values are given below.

Bacterial Leaf Blight Disease Incidence (Percent disease incidence)

Entry	Nagpur	Surat	Nanded		Khandwa		Akola
			Pro tected	Un protected	Pro tected	Un protected	
MRC.7160 BG II	0.00	0.57	0.00	0.00	1.80	1.90	36.42 (34.96)
MRC.7301 BG II	0.57	7.23	3.00	5.00	2.10	2.30	41.36(39.17)
MRC.7326 BG II	0.00	9.06	3.00	3.58	2.20	2.00	24.08 (28.78)
MRC.7160	0.00	6.23	0.00	0.00	2.10	2.20	17.29 (24.31)
MRC.7301	0.45	5.65	0.00	0.00	2.80	2.40	18.52 (25.13)
MRC.7326	0.13	5.25	3.05	5.00	2.10	2.20	19.75 (26.20)
MECH.162Bt (CC)	0.33	7.62	2.00	5.00	1.90	2.00	30.25 (32.96)
RCH.2Bt (CC)	0.69	16.39	2.00	4.00	2.20	2.20	33.95(35.36)
NHH.44 (Check)	0.00	2.27	3.25	5.00	2.00	2.20	39.58 (38.85)
C.D (0.05)		8.39					7.63
CV%		118.07					13.89

*Values in the parentheses are arcsine transformed values

Alternaria leaf spot

This disease was observed only at Nagpur and Nanded. All the three hybrids viz., MRC.7160 BG II, MRC.7301 BG II and MRC.7326 BG II, had 6.95 to 15.0 PDI whereas their non Bt counter parts had 10.0 – 15.0 PDI.

Alternaria leaf spot (Per cent Disease Incidence)

Entry	Nagpur	Nanded	
		Protected	Unprotected
MRC.7160 BG II	0.94	8.10	15.00
MRC.7301 BG II	0.86	5.90	10.00
MRC.7326 BG II	0.62	5.30	5.95
MRC.7160	1.58	10.00	15.00
MRC.7301	0.98	6.04	10.00
MRC.7326	1.06	6.00	10.00
MECH.162Bt (CC)	1.09	5.90	9.00
RCH.2Bt(CC)	1.04	8.00	10.00
NHH.44 (Check)	1.14	4.05	8.08

Grey mildew

Only at the Nanded centre, there was substantial incidence of Grey mildew ranging from 5.00 percent to 40.00 percent with the maximum grades of three and four.

At Nanded, the three BG II hybrids viz., MRC 6160 BG II, MRC 6301 BG II and MRC 6326 BG II as well as their non Bt counterparts and also MECH 162 Bt and NHH 44 were found to be susceptible both under protected and unprotected conditions. Only RCH 2Bt had 4.90 to 10.00% incidence, as given below.

Grey mildew (*Percent Disease Incidence)

Entry	Nanded					
	Protected			Unprotected		
	PDI*	Max. grade	Yield (kg/ha)	PDI	Max. grade	Yield (Kg/ha)
MRC.7160 BG II	20.90	4	518	35.00	4	836
MRC.7301 BG II	15.00	3	555	30.35	4	828
MRC.7326 BG II	20.50	4	707	20.35	4	906
MRC.7160	30.00	4	467	40.00	4	266
MRC.7301	25.32	4	295	35.00	4	229
MRC.7326	20.22	4	327	35.95	4	501
MECH.162Bt (CC)	30.95	4	451	40.00	4	590
RCH.2Bt(CC)	4.90	1	371	10.00	2	634
NHH.44 (Check)	25.00	4	321	30.00	4	449

Parawilt

In the trial with BG II hybrids, the Para wilt incidence varied from 0.00% to 6.67% under protected and 0.00% to 4.00% under unprotected conditions at the Khandwa centre, as given below.

Reaction of BG II hybrids to Parawilt (Per cent Disease Incidence)

Entry	Khandwa			
	Protected	Yield (Kg/ha)	Unprotected	Yield (Kg/ha)
MRC.7160 BG II	6.67	562.61	0.00	1468
MRC.7301 BG II	2.50	528.73	4.00	1142
MRC.7326 BG II	4.17	784.89	0.00	1222
MRC.7160	5.00	467.65	2.22	1042
MRC.7301	3.34	462	2.45	1005
MRC.7326	0.00	623.19	4.44	1071
MECH.162Bt (CC)	0.00	546.7	0.00	1250
RCH.2Bt(CC)	0.00	435.31	2.78	1189
NHH.44 (Check)	2.50	394.75	2.78	1214
C.D (0.05)	NS	156.57	4.71	160.43
CV%	43.62	16.99	34.81	5.93

Myrothecium leaf spot

This disease was noticed only at Nagpur with a very low incidence ranging from 0.00% to 1.61 % in the Bt I trial and 0.13 to 1.08 % in the BG II trial.

Reaction of BG II hybrids to Myrothecium Leaf Spot (Percent Disease incidence)

Entry	Nagpur
MRC.7160 BG II	0.39
MRC.7301 BG II	0.96
MRC.7326 BG II	1.08
MRC.7160	0.21
MRC.7301	0.30
MRC.7326	0.13
MECH.162Bt (CC)	0.77
RCH.2Bt(CC)	0.35
NHH.44 (Check)	0.13

Combined report for two years (2003 & 2004 seasons)

Central zone

In CENTRAL ZONE, The three BG II hybrids tested in this are MRC.7301 Bt, MRC.7326 Bt and MRC.7160 BG-II. MECH.162Bt and NHH.44 were the checks in 2003 while in 2004 season, MECH.162Bt, RCH.2Bt and NHH.44 were the checks.

In breeding plots (protected against sucking pests), the square damage was found to be the lowest in MRC.7326 BGII (0.6%) while the maximum damage was recorded in its non-Bt hybrid (6.8%), more than that in the NHH.44 (5.8%). In unprotected plots, while the per cent square damage in Bt Genotypes were six times less than that in their non-Bt counterparts under unprotected condition, NHH.44 recorded as much as 14.7% damage in the zonal average. The Bt Genotypes recorded less damage over the Bt check hybrid. Similarly, the green boll damage was seen to be 8 times in non-Bt hybrids over their Bt counterparts. NHH.44 recorded 10% green boll damage. The Bt hybrids recorded much less damage over Bt check hybrid too.

The seed cotton yield was not consistent in BG II evaluation due to varying conditions of drought and rains in the test centres during 2003 season, as can be seen from the following table. However, MRC.7160 BGII yielded 1390 kg/ha in protected condition as against 1241 kg/ha under unprotected conditions during 2004 season. Similar trend was seen in MRC.7326 BGII.

CENTRAL ZONE Entry	Seed cotton yield (kg/ha)			
	2003 season		2004 season	
	Protected	Unprotected	Protected	Unprotected
MRC.7160 BG II	751	846	1390	1241
MRC.7301 BG II	401	913	1087	952
MRC.7326 BG II	1042	727	1143	1182
MRC.7160	634	520	835	700
MRC.7301	1035	466	837	733
MRC.7326	420	389	930	746
MECH.162Bt (CC)	747	519	1254	966
RCH.2Bt(CC)	-	-	1135	996
NHH.44 (Check)	435	519	1193	819

The fibre quality parameters of the three BGII hybrids along with the check hybrids are provided in the following table. The fibre tenacity values are not matching with the span length in accordance with the CIRCOT and SITRA (South Indian Textile research Association, Textile Ministry) norms. The evaluation of these properties under large scale cultivation is required for confirmation.

Fibre quality parameters of two years

Genotypes	2.5% span length (mm)		Bundle strength tenacity (g/tex)		Micronaire	
	2003	2004	2003	2004	2003	2004
MRC.7160 BG-II	27.6	27	21.9	19	4.4	4.1
MRC. 7160	29.2	28	21.1	20	3.6	3.9
MRC.7301 BG-II	27.6	27	20.1	20	4.5	4.1
MRC. 7301	27.1	27	20.5	20	4.2	4.1
MRC. 7326 BG-II	26.8	26	21.1	21	4.0	3.8
MRC. 7326	25.8	26	19.7	21	4.5	4.9
MECH. 162 (CC)	25.7	25	19.5	20	4.5	3.9
RCH.2Bt (CC)	-	31	-	20	-	3.6
NHH. 44 (ZC)	27.2	25	19.6	18	4.6	3.9