



Plant Archives

Journal homepage: <http://www.plantarchives.org>

DOI Url : <https://doi.org/10.51470/PLANTARCHIVES.2026.v26.no.1.257>

FIELD SCREENING OF *G. HIRSUTUM* × *G. BARBADENSE*-DERIVED BT AND NON-BT F₁, F₂, F₃, F₄ GENERATIONS AND PARENTAL COTTON LINES FOR DISEASE TOLERANCE

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(Date of Receiving-27-01-2026; Date of Revision-22-03-2026; Date of Acceptance-07-04-2026)

ABSTRACT

G. hirsutum X *G. barbadense*-derived Bt and Non-Bt F₁, F₂, F₃ and F₄ generations of cotton hybrids, along with *G. barbadense* male parents, were screened for disease tolerance under field conditions against diseases such as Tobacco Streak Virus (TSV), boll rot and Alternaria leaf spot (ALS) while also considering higher yields. Of fifty-six HXB – F₁- non-Bt hybrids, two crosses, namely Suraj X ICB29 and Suraj X ICB258, were found to be free from all diseases. An additional nine crosses were free from all diseases except Alternaria leaf spot. Among the five entries in each of the H X B - F₂ and F₃ non-Bt generations, none showed infection by any disease other than Alternaria leaf spot. Among the 16-H X B- F₄- non-Bt generation crosses, Suraj X ICB1 and MCU5VT X ICB161 were free of all diseases. Of the 50 *G. barbadense* male parents, eight entries, including ICB11A, ICB25, ICB29, ICB86, ICB99, ICB124, ICB200 and V5, were free of all diseases. Among Bt cotton genotypes, only TSV and Alternaria leaf spot diseases were observed. In fifty-one HXB- F₁-Bt hybrids, five crosses, namely PKV081 X ICB207, Rajat Bt X ICB99, GJHV374Bt X CCB141, GJHV374Bt X ICB258 and GJHV374Bt X ICB284, were free from TSV and Alternaria leaf spot diseases. Another seven crosses were free from TSV and infected by Alternaria leaf spot disease. Of eight new H X B – F₁- Bt hybrids, two crosses (GISV 331 X CCH 15-1) X Rajat Bt and (GISV 331 X CCH 15-1) X PKV081 Bt were free from TSV and Alternaria leaf spot diseases. Among seven H X B-F₂-Bt generations, one entry, PKV081 Bt X ICB 39, was free from both diseases. Out of ten H × B-F₃-Bt generations, two entries, such as PKV081Bt × ICB183 and Rajat Bt × ICB99, were free from TSV and infected by Alternaria leaf spot. Of twenty -H X B F₄- Bt generations, GJHV374Bt × ICB194, PKV081 Bt × ICB255 and Suraj Bt × ICB284 were free from TSV and infected by Alternaria leaf spot. Among HXB-F₁-non-Bt hybrids, Suraj X ICB 258, free of diseases, recorded the highest seed cotton yield (3142.8 kg/ha), with good fibre quality. Similarly, Suraj × CCB 29, free of TSV and Boll rot but infected with Alternaria leaf spot, produced the highest yield (3505.7 kg/ha), demonstrating high productivity despite minor pathological constraints. Among HXB-F₁-Bt hybrids, GJHV 374 Bt × ICB 258 recorded the highest yield (3505.7 kg/ha), followed by PKV 018 Bt × ICB 284 and PKV 018 Bt × ICB 207. Importantly, PKV 018 × ICB 207, Rajat Bt × ICB 99, and GJHV 374 Bt × CCB 141 combined to yield moderate to high levels and showed resistance to both TSV and Alternaria leaf spot, making them promising dual-purpose genotypes.

Key words : Disease tolerance, *G. hirsutum*, *G. barbadense*, HXB hybrids, Generations, Bt cotton, High yield.

Introduction

Cotton, the ‘white gold’, is the most important commercial natural fibre crop grown worldwide, including in India. The textile industry depends on lint, a main

byproduct of the ginning process, as a raw material. Cotton is cultivated in 11 states in India, divided into three zones: North, Central and South. It is grown on 110.86 lakh hectares, with a production of 284.88 lakh bales and an average productivity of 448 kg/ha during the 2025-26

crop season (caionline.in). Cotton breeding programs aim to improve seed cotton yields and wider adaptability with early maturity (Li *et al.*, 2020), followed by environmental stability (Peng *et al.*, 2021). *G. hirsutum* breeding has focused on maximising yield and wide adaptability, while *G. barbadense* breeding has prioritised fibre quality (Anwar *et al.*, 2022). *G. barbadense* is world-famous for its fineness and fibre length, but its adaptability to different environments is restricted. *G. hirsutum* is mostly drought-tolerant and establishes well in well-drained soils and higher temperatures. When *G. hirsutum* and *G. barbadense* are crossed (HXB), the resulting hybrids have high yields, wider adaptability and superior fibre quality. Heterosis, or hybrid vigour, is the phenomenon in which hybrids surpass their inbred parents in growth, biomass, yield, and fertility (Hochholdinger and Baldauf, 2018). Interspecific hybridisation is crucial for overcoming barriers related to parental genetic diversity (Li *et al.*, 2022). HXB crosses broaden the genetic diversity of the genotypes. Cotton is susceptible to several diseases at different stages of plant growth. Cotton necrosis disease caused by Tobacco Streak Virus (TSV), Boll rot, and Alternaria leaf spot are some of the major diseases responsible for yield losses under favourable weather conditions when susceptible crops are present. Yield losses of 10-30% are typical due to various diseases affecting cotton. The germplasm of *Gossypium barbadense* was surveyed for TSV, and the disease incidence ranged from 1.61% (CCB 140) to 26.60% (ICB 71) (Valarmathi and Dhamayanthi, 2020a). The most common symptoms of TSV include chlorosis and necrosis of young leaves, necrotic spots, purple ring spots on young leaves, necrotic streaks on petioles and stems, floral parts, and square and bud drying and stunted growth (Sampathkumar *et al.*, 2025). Cotton boll rot refers to a complex of symptoms linked to various phytopathogens that damage developing bolls (Bell *et al.*, 2005). Alternaria leaf spot, caused by *Alternaria macrospora* and *Alternaria alternata*, is the primary leaf spot disease affecting all cotton-growing regions in India. Alternaria leaf spot results in a 20-30% loss in seed cotton yield in India (Chauhan *et al.*, 1997).

Although, chemicals can control these diseases, they contribute to ecological pollution. To lower input costs and prevent losses, adopting disease-resistant varieties is crucial. Host plant resistance is a permanent solution for efficient disease management in crops, including cotton and can be combined with other management strategies. Breeding programs benefit from genotypes that combine disease resistance and high yield potential, enabling the development of multiple tolerant varieties

that achieve both high yield and resilience (Bodhke *et al.*, 2019). Discovering new sources of resistance, efficiently screening for resistance, and incorporating them into elite cultivars are essential for future HPR breeding efforts (Egan and Stiller, 2022). The present study was carried out with the following objectives. Evaluation of HXB – Bt and non-Bt hybrids of different generations and parental lines for disease tolerance under natural field conditions. 2. Identification of disease-tolerant HXB-F₁- Bt and non-Bt hybrids with higher yields.

Materials and Methods

The field experiment was carried out at the ICAR-CICR Regional Station, Coimbatore, during the 2023-24 crop season under irrigated conditions to develop HXB hybrids with higher yields, better fibre quality, and improved disease resistance. HXB- Bt and non-Bt -F₁- hybrids, F₂, F₃ and F₄ generations, and *G. barbadense* male parents were evaluated for disease resistance under natural field conditions against TSV, Boll rot and Alternaria leaf spot. Among non-Bt genotypes, 56 HXB-F₁ hybrids, 5 F₂, 5 F₃ and 16 F₄ generations, and 50 *G. barbadense* male parents were evaluated for disease resistance and yield parameters (Table 1). Among Bt genotypes, 51 HXB-F₁ hybrids, 8 new HXB-F₁ hybrids, 7 F₂, 10 F₃ and 20 F₄ generations were evaluated for disease resistance and yield parameters (Table 2). Planting was performed with 10 dibbles per row across four replications, on ridges and furrows spaced 90 x 60 cm apart. A total of 40 plants were maintained for each genotype. Single plant per hill, and gap-filling and thinning were performed as and when required. For disease observations, twenty plants were randomly tagged, and observations were made at monthly intervals. The recommended package of practices was followed for crop management. The yield parameters like number of bolls, single boll weight (g), seed cotton yield (kg/ha), Ginning Out Turn (GOT) were recorded, and fibre quality traits like fibre length (mm), fibre Strength (g/tex) and micronaire (μ) were measured for HXB hybrids. The experiment was conducted in a Completely Randomised Block Design. The average PDI was calculated from four replications, and peak disease incidence was recorded for genotype evaluation. The Per cent Disease Index (PDI) was calculated according to Wheeler (1969)

$$\text{Per cent Disease Incidence (PDI)} = \frac{\text{Number of infected plants} \times 100}{\text{Total number of plants observed}}$$

The following disease grading systems were used for observations

Grading system for Alternaria, Grey mildew and rust

Table 1 : Field screening of HXB-derived (Crosses) – Non-Bt F₁, F₂, F₃, F₄ and parental lines for disease tolerance under field conditions (2023-24) at CICRRS Coimbatore.

S. no.	HXB - F ₁	S. no.	HXB - F ₁	S. no.	HXB - F ₁	S. no.	H × B - F ₄	S. no.	G. <i>barbadense</i> male parents	S. no.	G. <i>barbadense</i> male parents
1	CCH15-1XICB99	26	SurajXICB99	51	MCUVT5XICB174	7	MCUVT5XICB1	15	ICB86	40	CCB25
2	MCUVT5XICB46	27	MCUVT5XICB99	52	SurajXICB258	8	MCUVT5XCCB64	16	ICB96	41	CCB29
3	CCH15-1XCCB11A	28	CCH15-1XICB46	53	SurajXCCB143B	9	MCUVT5XICB46	17	ICB99	42	CCB39
4	SurabhiXICB161	29	CCH15-1XICB284	54	SurajXICB264	10	Suraj X Suvin	18	ICB124	43	CCB64
5	SurajXCCB11A	30	SurabhiXICB264	55	CCH15-1XICB258	11	Surabhi X CCB64	19	ICB161	44	CCB141
6	MCUVT5XICB124	31	MCUVT5XICB258	56	CCH151XCCB143B	12	Surabhi X ICB 46	20	ICB174	45	CCB143
7	SurabhiXICB124	32	Suraj X Suvin	S.no	HXB - F2	13	CCH15-1 X Suvin	21	ICB176	46	CCB143B
8	SurajXCCB29	33	MCUVT5XCCB143B	1	Suraj X ICB 161	14	Suraj X ICB 1	22	ICB183	47	B1
9	SurajXICB124	34	CCH15-1XICB176	2	CCH15-1XCCB11A	15	CCH15-1 X CCB64	23	ICB194	48	B2
10	MCUVT5XCCB29	35	SurabhiXCCB143B	3	Suraj X ICB 99	16	MCUVT5 X ICB 53	24	ICB198	49	V5
11	SurajXCCB25	36	CCH15-1XICB264	4	MCUVT5XCCB25	S. no	G. barbadense male parents	25	ICB199	50	Suvin
12	SurabhiXCCB11A	37	SurabhiXICB174	5	Suraj X ICB 176	1	ICB1	26	ICB200		
13	MCUVT5XCCB11A	38	SurajXICB174	S.no	HXB - F3	2	ICB13	27	ICB206		
14	SurabhiXCCB29	39	MCUVT5XICB176	1	Suraj X ICB 264	3	ICB16	28	ICB207		
15	CCH15-1XCCB25	40	MCUVT5XICB284	2	MCUVT5XICB176	4	ICB28	29	ICB220		
16	CCH15-1XICB161	41	MCUVT5XICB264	3	Suraj X CCB 143 B	5	ICB34	30	ICB244		
17	CCH15-1XCCB29	42	SurabhiXICB284	4	Suraj X Suvin	6	ICB35	31	ICB255		
18	SurajXICB46	43	SurabhiXICB258	5	CCH15-1XICB284	7	ICB39	32	ICB257		
19	MCUVT5XCCB25	44	SurajXICB284	S.no	HXB - F4	8	ICB40	33	ICB258		
20	SurabhiXCCB25	45	CCH15-1 X Suvin	1	MCUVT5XICB161	9	ICB46	34	ICB262		
21	CCH15-1XICB124	46	Surabhi X Suvin	2	MCUVT5 X Suvin	10	ICB53	35	ICB264		
22	SurajXICB161	47	SurabhiXICB176	3	Surabhi X Suvin	11	ICB58	36	ICB273		
23	SurabhiXICB46	48	CCH15-1XICB174	4	CCH15-1XICB290	12	ICB61	37	ICB284		
24	SurabhiXICB99	49	MCUVT5XSuvin	5	Surabhi XICB290	13	ICB75	38	ICB290		
25	MCUVT5XICB161	50	SurajXICB176	6	CCH15-1 X ICB46	14	ICB77	39	CCB11A		

Table 2 : Field screening of H × B -derived (Crosses) – Bt F₁, F₂, F₃, F₄ and parental lines for disease tolerance under field conditions (2023-24) at CICRRS Coimbatore.

S. no.	H × B – F ₁	S. no.	H × B – F ₁	S. no.	H × B – F ₁	S. no.	H × B – F ₃
1	Rajat BtXCCB141	26	Suraj BtXICB183	51	GJHV374BtXICB258	7	GJHV 374 BtXCCB141
2	GJHV374BtXCCB141	27	Rajat BtXICB258	S. no.	H × B – F₁ (New Crosses)	8	GJHV 374 BtXICB 264
3	Suraj BtXCCB141	28	Suraj BtXICB284	1	(GISV 331XCCH 15-1) XGJHV374 Bt	9	Rajat BtXICB 176
4	Rajat BtXICB39	29	Suraj BtxCCB143B	2	(GISV 331X CCH 15-1) XRajat Bt	10	Suraj BtXICB 284
5	PKV081xICB28	30	GJHV374BtXICB264	3	(GISV 331XCCH 15-1) XPKV018 Bt	S. no.	H X B – F₄
6	GJHV374BtXICB183	31	Rajat BtXICB284	4	(GISV 331XCCH 15-1) X Suraj Bt	1	GJHV 374 BtXICB194
7	GJHV374BtXICB99	32	GJHV374BtxCCB143B	5	(GISV 323 x DCH 1716) X GJHV374 Bt	2	PKV 081 BtXICB 255
8	PKV081XICB183	33	PKV081XICB176	6	(GISV 323 x DCH 1716) XRajat Bt	3	Suraj BtXICB 284
9	PKV081XICB39	34	PKV081XICB264	7	(GISV 323 x DCH 1716) XPKV018 Bt	4	Rajat Bt X Suvin
10	GJHV374BtxICB28	35	Rajat BtXICB174	8	(GISV 323 x DCH 1716) XSuraj Bt	5	PKV 081 BtXICB 199
11	PKV081XICB207	36	PKV081XSUVIN	S. no.	H X B – F₂	6	GJHV 374 BtXSuvIn
12	Rajat BtXICB34	37	Rajat Bt X Suvin	1	GJHV 374 Bt X CCB 143 B	7	Rajat BtXICB 194
13	GJHV374 BtXICB34	38	Rajat BtxCCB143B	2	GJHV 374 Bt X ICB 284	8	Rajat BtXCCB 11
14	GJHV374BtXICB207	39	GJHV374 BtXICB176	3	Rajat Bt X CCB 141	9	PKV 081 BtXSuvIn
15	Suraj BtxICB28	40	Suraj BtXICB176	4	GJHV 374 Bt X ICB 183	10	Suraj BtXICB 199
16	Rajat BtXICB183	41	GJHV374BtXICB174	5	PKV 081 Bt X ICB 28	11	Suraj BtXICB 194
17	PKV081XICB34	42	GJHV374BtXICB284	6	PKV 081 Bt X ICB 39	12	PKV 081 BtXICB 284
18	Suraj BtXICB207	43	Rajat BtXICB264	7	PKV 081 Bt X ICB 258	13	PKV 081 BtXICB 96
19	PKV081XCCB141	44	GJHV374BtXSUVIN	S. no.	H X B – F₃	14	GJHV 374 BtXCCB 28
20	PKV081XICB99	45	PKV081XICB258	1	PKV 081 Bt X ICB 183	15	GJHV 374 BtXICB 220
21	Rajat BtXICB28	46	PKV081XCCB143B	2	Rajat Bt X ICB 99	16	Rajat BtXICB 75
22	GJHV374BtXICB39	47	PKV081XICB284	3	GJHV 374 Bt X ICB 99	17	Rajat BtXICB 174
23	Rajat BtXICB99	48	Suraj BtXICB264	4	PKV 081 Bt X ICB 99	18	GJHV 374 BtXCCB 29
24	Rajat BtXICB207	49	Rajat BtXICB176	5	GJHV 374 Bt X ICB 39	19	GJHV 374 BtXICB 207
25	Suraj BtXICB39	50	Suraj BtXICB258	6	Suraj Bt XCCB 141	20	Rajat BtXICB 199

diseases (AICRP on Cotton)

0 - Plants completely free from infection;

1 - Leaf area covered less than 5%;

2 - Leaf area covered 6-20%;

3 - Leaf area covered 21-40%;

4 - Leaf area covered >40%.

Grading system for external boll rot (fungal) incidence=

$$\frac{\text{Number of bolls infected}}{\text{Total number of bolls observed}}$$

Grading system for Tobacco Streak Virus (TSV)

Tobacco streak virus (TSV) – 0 to 4 disease rating scale (AICRP on Cotton, 2016)

Scale Description

0 - Free from the disease

1 - Few upper leaves showing chlorosis or necrosis; up to 5%

2 - Moderate square drying and a few branches affected; 6-10%

3 - Severe burning of squares and more branches affected; 11-25%

4 - Severe stunting, inclusive of the above symptoms; >25%

$$\text{Average Grade} = \frac{\text{Sum of all grades}}{\text{Total no. of plants}}$$

$$\text{PDI} = \frac{\text{Average grade}}{\text{Maximum grade}} \times 100$$

Results and Discussion

In the current study, HXB – F₁ – Bt and non-Bt hybrids, F₂, F₃, F₄ generations and *G. barbadense* male parents were screened for disease tolerance under natural field conditions. The hybrids and advanced generations were screened for Tobacco Streak Virus (TSV), Boll rot and Alternaria leaf spot (ALS) (Figs. 1 and 2). Identification of disease-tolerant hybrids with high yields was our main objective to deploy host plant resistance at the field level. Lint percentage, a component of lint output, was likely among the earliest traits selected during domestication and initial breeding, and remains the most valued characteristic (Zhao *et al.*, 2022). *Gossypium hirsutum* is widely grown for its higher fibre yield and decent quality, accounting for over 90% of global cotton cultivation (Teodoro *et al.*, 2019). Fibre quality traits can be incorporated into *G. hirsutum* through crossing with *G. barbadense*. Further, screening for disease tolerance will enhance the quality of the genotypes. Field screening is the best method to identify disease-tolerant genotypes for cultivation.

Among non-Bt genotypes, of the 56 HXB-F₁ hybrids, two entries, namely Suraj × ICB29 and Suraj × ICB258, were found to be free of all diseases. An additional 8 entries, such as Surabhi × ICB161, Surabhi × ICB258,

Table 3 : Field screening of HX B-derived (Crosses) – Non-Bt F₁, F₂, F₃, F₄ and parental lines for disease tolerance under field conditions (2023-24) at CICR RS Coimbatore.

S. no.	Entry	No. of entries screened	No. of replications	*Diseases observed - PDI			Boll rot	Disease-resistant/ tolerant entries
				Alternaria	TSV			
1	H × B-F ₁ – New crosses	56	4	3.00 - 10.00	1.25 - 27.5 (Most entries infected)	3.00 - 10.00 (Most entries affected)	Suraj × ICB29 and Suraj × ICB258 were found to be free from all the diseases. CCB15-1 × ICB161, Surabhi × ICB161, Surabhi × ICB258, CCH15-1 × CCB11A, Suraj × CCB29, Surabhi × ICB124, Suraj × ICB264, Surabhi × ICB264 and MCU5VT × CCB143B were found to be free from all diseases except Alternaria leaf spot	
2	F ₂	5	4	4.50 - 15.50	0.0	0.0	All entries were infected only by Alternaria leaf spot	
3	F ₃	5	4	5.00 - 12.00	0.0	0.0	All entries were infected only by Alternaria leaf spot	
4	F ₄	16	4	4.00 - 8.00	7.5 - 15.00	0.0	Suraj X ICB1 and MCU5VT X ICB161 were free from all diseases	
5	<i>G. barbadense</i> Male parents	50	4	4.00 - 15.00	4.50 - 15.00 (few entries infected)	0.0	ICB11A, ICB25, ICB29, ICB86, ICB99, ICB124, ICB200 and V5 were free from all diseases	

*Mean of four replications.

CCH15-1 × CCB11A, Suraj × CCB29, Surabhi × ICB124, Suraj × ICB264, Surabhi × ICB264 and MCU5VT × CCB143B, were free of all diseases except *Alternaria* leaf spot (Table 3). Among the cotton diseases, Tobacco Streak Virus is an emerging disease that causes significant yield loss, particularly in the South Zone of India.

In India, cotton necrosis disease caused by tobacco streak virus (TSV) is a significant concern, with reports of up to 62.7% yield loss (Rageshwari *et al.*, 2017). TSV incidence in cotton has been rising recently, particularly in southern India. During the 2022-23 crop season, districts such as Kurnool and Nandyal in Andhra Pradesh experienced severe disease levels, with PDI values ranging from 5.5 to 45.0 (Sampathkumar *et al.*, 2025). Screening entries for TSV resistance is crucial in cotton breeding programmes. Previous researchers surveyed major cotton-growing areas for TSV incidence and screened breeding material for TSV resistance in cotton, groundnut and sunflower. Vemana *et al.* (2016) screened 62 groundnut genotypes, including Spanish and Virginia types, using the Parthenium infector border row technique under field conditions and Kadiri 7, a bold cultivar, recorded the maximum yield. Screening of sunflower cultivars for resistance to TSV has also been reported. Twenty-three sunflower hybrids were tested across multiple trials over five years in Australia. Among them, two hybrids, NH2201 and Hysun 304, showed good tolerance to TSV under natural infection conditions (Sharman *et al.*, 2016). In the present investigation, a few entries were completely free from TSV incidence, which will play an important role at the field level.

In this study, the F₂ and F₃ generations were free of TSV and Boll rot but were infected with *Alternaria* leaf spot. Among 16 F₄ genotypes, Suraj × ICB1 and MCU5VT × ICB161 were free from all diseases. Out of 50 *G. barbadense* male parents, 8 entries-ICB11A, ICB25, ICB29, ICB86, ICB99, ICB124, ICB200 and V5-were free from all diseases (Table 3). *Alternaria* leaf spot is a common disease that occurs in the late season, particularly when plants are stressed by moisture or nutrient deficiencies. Weather conditions, such as cooler temperatures and sufficient moisture, significantly influence *Alternaria* incidence. *Alternaria* leaf spot is primarily caused by two species, *viz.*; *A. macrospora* and *A. alternata*. Among the foliar diseases affecting cotton, *Alternaria* blight, caused by *A. macrospora*, is a severe, annual disease that poses a significant threat to cotton production and yield (Chattannavar *et al.*, 2001). *Alternaria macrospora* was the most prevalent pathogen during the early growing season of cotton, while

Alternaria alternata was more prevalent towards the end of the cotton growing season (Bhuiyan *et al.*, 2007). Under favourable environmental conditions, *Alternaria* leaf spot disease can result in yield losses of up to 26.59% (Monga *et al.*, 2013) and 38.23% (Bhattiprolu and Prasada Rao, 2009). Chattannavar *et al.* (2009b) evaluated 196 cotton cultivars under field conditions for *Alternaria* blight resistance during the June 2007 kharif season. Of these, nine cultivars, namely DCH 32, RAMSHH 7, GSHB 895, CCHB 2628, CCCHB 07-2, DHB 0782, NSPL 414, Ajeet 999 and HAGHB 12, were identified as the most resistant. In recent times, Boll rot has become more significant, especially in Central India. Fully grown bolls are vulnerable to both external and internal boll rot during favourable weather conditions. During the survey, the incidence of inner boll rot and disease was higher in Maharashtra during the main rainy-season months (August–September). In August 2018, the lowest incidence of inner boll rot was observed in boll samples from the Yavatmal district, at 7.46%. However, in September 2018, the disease incidence was 23.64%, 20.75% and 22.50% in samples from the Jalgaon, Buldhana and Jalgaon districts, respectively (Nagrle *et al.*, 2020).

Among Bt genotypes, out of the 51 HXB-F₁ hybrids, five crosses-PKV081 × ICB207, Rajat Bt × ICB99, GJHV374Bt × CCB141, GJHV374Bt × ICB258 and GJHV374Bt × ICB284-were free from both diseases, such as TSV and *Alternaria* leaf spot. Another seven crosses-GJHV374Bt × ICB174, Rajat Bt × ICB264 and PKV081 Bt × ICB284, Suraj Bt × ICB284, Rajat Bt × ICB176, GJHV374Bt × ICB264 and PKV081 Bt × ICB258-were free from TSV but infected by *Alternaria* leaf spot (Table 4). Moreover, *G. hirsutum* cultivars are generally more resistant to *Alternaria* leaf spot than *G. barbadense* genotypes. Field evaluation is a practical and accessible method for identifying cotton genotypes that naturally resist *Alternaria* leaf spot. *Alternaria* spp. infects crops predisposed by some form of stress (Hillocks, 1991). Infection by pathogenic *Alternaria* leads to premature defoliation in cotton (Rajesha *et al.*, 2012), which causes severe yield losses. Bhattiprolu and Rao (2013) reported that, among 376 cotton genotypes tested for ALS resistance from 2003 to 2010 under natural outbreak conditions, TCH 1717 and RAJHH 783 showed no visible infections and 47 genotypes were resistant. In 2016, 168 entries, including 8 Pima and 125 Upland cotton cultivars and lines, were tested across six replicated trials for *Alternaria* leaf spot resistance. In 2017, 98 entries, with 74 Upland and 18 Pima cultivars and lines, were evaluated. Of the 197 lines screened, 133 from 2016 and

Table 4 : Field screening of H × B -derived (Crosses) – Bt F₁, F₂, F₃, F₄ and Nagpur lines for disease tolerance under field conditions (2023-24) at CICR RS Coimbatore.

S. no.	Entry	No. of entries screened	No. of replications	*Diseases observed-PDI		Disease-resistant/ tolerant entries
				Alternaria	TSV	
1	H × B -F ₁ (Crosses)	51	4	3.00 - 10.00	1.25 - 15.00	PKV081 Bt X ICB207, Rajat Bt X ICB99, GJHV374Bt X CCB141, GJHV374Bt X ICB258 and GJHV374Bt X ICB284 were free from TSV and Alternaria leaf spot GJHV374 Bt X ICB174, Rajat Bt X ICB264, PKV081 Bt X ICB284. Suraj Bt X ICB284, Rajat Bt X ICB176, GJHV374 Bt X ICB264 and PKV081 Bt X ICB258 were free from TSV and infected by Alternaria leaf spot
3	H × B – F ₁ (New Crosses)	8	4	5.00 - 8.00	0.75 - 5.50	(GISV 331 X CCH 15-1) X Rajat Bt and (GISV 331 X CCH 15-1) X PKV081 Bt were free from TSV and Alternaria leaf spot
4	F ₂	7	4	4.00-10.00	0.60 – 4.00	PKV081 Bt X ICB 39 was free from TSV and Alternaria leaf spot
5	F ₃	10	4	4.00 - 9.00	1.75 – 4.50	PKV081Bt X ICB183 and Rajat Bt X ICB99 were free from TSV and infected by Alternaria leaf spot
6	F ₄	20	4	4.00 - 8.00	5.60 – 10.25	GJHV374Bt X ICB194, PKV081 Bt X ICB255 and Suraj Bt X ICB284 were free from TSV and infected by Alternaria leaf spot

*Mean of four replications.

Table 5 : Performance of HXB-F₁ - non Bt Cotton Genotypes for Seed cotton yield, Yield components and Fibre Quality traits along with Variability Parameters.

S. no.	Genotypes	NB	SBW (g)	SCY (kg/ha)	GOT (%)	UHML (mm)	FS (g/tex)	Mic (µg/inch)
1	CCH15-1 X CCB 11 A	45.70	4.70	2284.80	35.20	34.70	31.80	3.00
2	CCH15-1 X ICB 161	58.30	3.50	3084.60	30.00	34.20	32.00	2.60
3	Surabhi X ICB 124	25.70	5.10	1961.00	36.30	36.50	35.00	3.10
4	Surabhi X ICB 161	55.30	3.90	2685.00	31.70	34.70	31.00	2.10
5	Suraj X CCB 29	57.30	4.90	3505.70	26.10	36.50	35.50	2.40
6	MCUVT5 X CCB 143 B	43.30	4.30	2185.00	32.30	35.80	35.10	2.90
7	Surabhi X ICB 258	56.70	3.30	2284.80	32.30	36.80	34.00	2.60
8	Surabhi X ICB 264	32.00	4.20	2084.80	30.20	40.20	37.80	2.40
9	Suraj X ICB 258	59.300	3.50	3142.80	29.30	36.20	32.20	2.40
10	Suraj X ICB 264	45.30	2.30	1804.30	30.20	35.60	32.40	2.80
	Check	33.30	3.80	1513.20	34.80	35.10	34.00	2.70
	Mean	47.89	3.97	2502.28	31.36	36.12	33.68	2.63
	SD	10.86	0.88	555.03	3.02	1.68	2.12	0.30
	SE	3.44	0.28	175.56	0.96	0.53	0.67	0.09
	CV (%)	22.67	22.17	22.19	9.63	4.65	6.30	11.41
	CD (0.05)	7.78	0.63	397.10	2.17	1.20	1.52	0.21
	CD (0.01)	11.18	0.91	570.07	3.12	1.73	2.18	0.31

NB- Number of Bolls, SBW- Single Boll weight, SCY-Seed Cotton Yield, GOT- Ginning Out Turn, UHML-Upper Half Mean Length, FS- Fiber Strength, Mic- Micronaire.

Table 6 : Performance of HXB-F1- Bt Cotton Genotypes for Seed Cotton Yield, Yield Components and Fibre Quality Traits along with Variability Parameters.

S. no.	Genotypes	NB	SBW (g)	SCY (kg/ha)	GOT (%)	UHML (mm)	FS (g/tex)	Mic (µg/inch)
1	GJHV 374 Bt X CCB 141	45.70	4.70	2284.80	35.20	34.70	31.8	3.00
2	PKV 018 Bt X ICB 207	58.30	3.50	3084.60	30.00	34.20	32.0	2.60
3	Rajat Bt X ICB 99	25.70	5.10	2001.00	36.30	36.50	35.0	3.10
4	GJHV 374 Bt X ICB 174	55.30	3.90	2685.00	31.70	34.70	31.0	2.10
5	GJHV 374 Bt X ICB 258	57.30	4.90	3505.70	26.10	36.50	35.5	2.40
6	GJHV 374 Bt X ICB 264	43.30	4.30	2056.00	32.30	35.80	35.1	2.90
7	GJHV 374 Bt X ICB 284	56.70	3.30	2284.80	32.30	36.80	34.0	2.60
8	PKV 018 Bt X ICB 258	32.00	4.20	2167.00	30.20	40.20	37.8	2.40
9	PKV 018 Bt X ICB 284	59.30	3.50	3142.80	29.30	36.20	32.2	2.40
10	Rajat Bt X ICB 176	45.30	2.30	1998.60	30.20	35.60	32.4	2.80
11	Rajat Bt X ICB 264	45.70	4.70	2284.80	35.20	34.70	31.8	3.00
12	Suraj Bt X ICB 284	58.30	3.50	3084.60	30.00	34.20	32.0	2.60
	Check	52.70	3.70	1998.20	35.40	32.80	34.1	2.80
	Mean	48.06	4.06	2549.12	31.40	35.91	33.38	2.66
	SD	10.55	0.88	499.18	3.00	1.68	2.06	0.32
	CV (%)	21.95	21.67	19.58	9.55	4.68	6.17	12.03
	SE	3.05	0.25	144.05	0.87	0.49	0.6	0.09
	CD (5%)	6.71	0.55	317.00	1.91	1.08	1.32	0.20

NB- Number of Bolls, SBW- Single Boll weight, SCY-Seed Cotton Yield, GOT- Ginning Out Turn, UHML-Upper Half Mean Length, FS- Fiber Strength, Mic- Micronaire.

92 from 2017, with 28 overlapping and 6 tested twice in 2017, most showed susceptibility similar to the check, Acala 1517-08. However, the resistant check, NuMex COT 15 GLS, and several other glandless lines, demonstrated the highest resistance (Zhu *et al.*, 2018).

In this research, among eight new HXB-F1 hybrids, two entries-(GISV 331 × CCH 15-1) × Rajat Bt and (GISV 331 × CCH 15-1) × PKV081 Bt-were free from TSV and Alternaria leaf spot. Of the seven F₂ entries, PKV081 Bt × ICB 39 was free from both TSV and Alternaria leaf spot. Among ten F₃ entries, PKV081Bt × ICB183 and Rajat Bt × ICB99 were free of TSV, but infected with Alternaria leaf spot. Out of twenty F₄ generations, three entries—GJHV374Bt × ICB194, PKV081 Bt × ICB255, and Suraj Bt × ICB284-were free from TSV and infected by Alternaria leaf spot (Table 4). The survey showed that TSV incidence was highest in Telangana, with a mean PDI of 25.31, followed by Andhra Pradesh, with a mean PDI of 16.47. In Warangal, RCH 659 BG II hybrid had the highest incidence at 51.11. Tamil Nadu's Annur (KDCHB-407 hybrid) recorded a maximum PDI of 32.39. Maharashtra's mean incidence was lowest at 6.22 PDI. TSV was highest in MCU 12 (21.67) in Coimbatore and 16.78% in Suraj, Nagpur (Vinodkumar *et al.*, 2017).



Tobacco Streak Virus symptoms in *G. hirsutum*



Boll rot symptoms in *G. hirsutum*



Alternaria leaf spot and leaf blight symptoms in *G. hirsutum*

Among HXB-F₁-non-Bt hybrids, Suraj × ICB 258, free of diseases, recorded the highest seed cotton yield (3142.8 kg/ha) (Table 5), with good fibre quality, found to be best for stable performance under field conditions. Similarly, Suraj × CCB 29, free of TSV and Boll rot but infected with Alternaria leaf spot, produced the highest yield (3505.7 kg/ha), demonstrating high productivity despite minor pathological constraints. CCH15-1 × ICB 161 also expressed high yield potential (3084.6 kg/ha) but was susceptible to Alternaria leaf spot, suggesting that its field performance may be slightly compromised under disease pressure. In contrast, Surabhi × ICB 124 and MCVT5 × CCB 143B, though showing moderate yield levels, were also affected only by Alternaria, indicating relatively better resistance to other major diseases. Overall, genotypes like Suraj × ICB 258 combine high yield with complete resistance to Alternaria leaf spot, whereas most other crosses, despite good performance, exhibit susceptibility to the disease, highlighting the need for targeted resistance breeding against this disease. Among HXB-F₁-Bt hybrids, seed cotton yield ranged from 1998.6 to 3505.7 kg/ha, with a mean of 2549.12 kg/ha and substantial variation among genotypes. Among them, GJHV 374 Bt × ICB 258 recorded the highest seed cotton yield (3505.7 kg/ha), followed by PKV 018 Bt × ICB 284 and PKV 018 Bt × ICB 207, demonstrating superior yield potential. Importantly, PKV 018 × ICB 207, Rajat Bt × ICB 99 and GJHV 374 Bt × CCB 141 combined to yield moderate to high levels (Table 6) and showed resistance to both TSV and Alternaria leaf spot, making them promising dual-purpose genotypes. In contrast, genotypes such as GJHV 374 Bt × ICB 174 and Suraj Bt × ICB 284, although free from TSV, were susceptible to Alternaria leaf spot, which might limit their field performance under disease pressure. Overall, genotypes showing both higher yields and dual disease resistance can be prioritised for selection and further breeding programmes.

Conclusion

Of fifty-six HXB – F₁ - non-Bt hybrids, two crosses, namely Suraj × ICB29 and Suraj × ICB258, were found to be free from all diseases. An additional nine crosses were free from all diseases except Alternaria leaf spot. Among the five entries in each of the H X B - F₂ and F₃ non-Bt generations, none showed infection by any disease other than Alternaria leaf spot. Among the 16-H × B- F₄ - non-Bt generation crosses, Suraj × ICB1 and MCV5VT × ICB161 were free of all diseases. Of the 50 *G. barbadense* male parents, eight entries were free of all diseases. Among Bt cotton genotypes, of 51 HXB- F₁- Bt hybrids, five crosses were free from TSV and

Alternaria leaf spot. Out of eight new H × B – F₁- Bt hybrids, two crosses were free from TSV and Alternaria leaf spot. Among seven H × B-F₂-Bt generations, one entry was free from both diseases. Out of ten H × B-F₃- Bt generations, two entries were free from TSV and infected by Alternaria leaf spot. Of twenty -H × B F₄- Bt generations, 3 entries were free from TSV and infected by Alternaria leaf spot. Among HXB-F₁-non-Bt hybrids, Suraj × ICB 258, free of diseases, recorded the highest seed cotton yield (3142.8 kg/ha), with good fibre quality. Similarly, Suraj × CCB 29, free of TSV and Boll rot but infected with Alternaria leaf spot, produced the highest yield (3505.7 kg/ha), demonstrating high productivity despite minor pathological constraints. Among HXB-F₁- Bt hybrids, GJHV 374 Bt × ICB 258 recorded the highest yield (3505.7 kg/ha), followed by PKV 018 Bt × ICB 284 and PKV 018 Bt × ICB 207. Importantly, PKV 018 × ICB 207, Rajat Bt × ICB 99 and GJHV 374 Bt × CCB 141 combined to yield moderate to high levels and showed resistance to both TSV and Alternaria leaf spot, making them promising dual-purpose genotypes.

Acknowledgement

This research was supported by the Indian Council of Agricultural Research, Department of Agricultural Research and Education, Government of India.

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