



Screening and Identification of Disease-tolerant Genotypes of Parental Bt *G. hirsutum*, *G. barbadense* and H×B Hybrid Cotton with Enhanced Yields

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ABSTRACT

Background: Host plant resistance is a durable, permanent solution for effective disease management in cotton. It reduces agrochemical use, is eco-friendly and is durable. Field evaluation is a practical method to identify cotton genotypes with natural resistance to diseases, including H×B hybrids with higher yields.

Methods: Parental Bt *G. hirsutum*, *G. barbadense* and H×B cotton hybrids were screened under field conditions for Alternaria leaf spot (ALS), Tobacco Streak Virus (TSV), grey mildew, external boll rot and rust diseases. Pathological data were recorded at monthly intervals and PDI was calculated. Yield levels were compared with disease-tolerant H×B hybrids for selection.

Result: Of sixty-six *G. barbadense* male parents, 19 entries, namely B1, B3, B8, B12, CCB26, ICB53, ICB58, ICB40(B), ICB183(B), CCB141, CB99, ICB284, CCB143(B), CCB25(B), CCB29(B), CCB11A(B), SM14, ICB86 and CCB64, were free from all diseases. Another 14 entries were disease-free, except for ALS. Five entries were free from all diseases except rust. Five entries were susceptible to most diseases. All four female *G. hirsutum* parents were infected with ALS and rust. Among 18 BG II *G. hirsutum* parents, V3 was free of all diseases. Ten entries were free from TSV and grey mildew but infected with ALS and rust. Seven entries were infected with ALS, TSV and rust. Among 50 H×B hybrids of BG I, six crosses, namely GJHV 374 Bt × ICB 28, GJHV 374 Bt × ICB 174, GJHV 374 Bt × ICB 194, Rajat Bt × CCB 141, Rajat Bt × ICB 75 and PKV 081 Bt × ICB 258, were free from all diseases. Four crosses were free of diseases except rust. ALS, TSV and rust were recorded in 14 crosses. Of the 14 BG entries, one entry, 211-437, was found free of all diseases. The entries 211-445 and GJHV 374 Bt were found disease-free, except for rust. Four entries, including 211-431, PKV 081 Bt, Rajat Bt and Suraj Bt, were infected with ALS, TSV and rust. All seven commercial BG II hybrids were infected with ALS and rust. Hybrids Ankur Anish, RCH659 and US7067 were also infected with TSV. The six H×B-F₁ BG I cotton hybrids that remained free of all the diseases studied and recorded higher seed cotton yields with improved fibre parameters. Hybrids, such as GJHV 374 Bt × ICB 264 and Rajat Bt × CCB 141, were free from ALS and TSV but showed rust incidence, yet maintained reasonably good yields and fibre quality.

Key words: Bt cotton, Disease tolerant, *G. barbadense*, *G. hirsutum*, High yield, H×B hybrids.

INTRODUCTION

Cotton, often called the king of fibres, is an essential commercial crop globally because it supplies natural fibres to the textile industry (Sampathkumar and Prakash, 2026). Cotton is cultivated in 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 in India (caionline.in). Four species are cultivated worldwide for fibre production. Among them, *G. barbadense* is distinctive for its fibre quality, including length, strength and fineness.

In India, it is grown in southern states like Tamil Nadu and Karnataka. However, *G. barbadense* exhibits limited environmental adaptability, thriving only in irrigated lands of arid zones in the Western United States and Lower Egypt (Anwar *et al.*, 2022). *G. hirsutum* produces higher yields and is cultivated in a wide range of environmental conditions. It has moderate fibre length, strength and fineness among cultivated cotton species. *Gossypium hirsutum*, native to Mexico and Central America, is widely grown for its higher fibre yield and decent quality, accounting for over 90% of global cotton cultivation (Orken *et al.*, 2025).

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Crossing of these two species results in H×B hybrids with superior fibre traits, greater adaptability and high yields.

Ten to 30% yield losses are common in cotton due to various diseases. *Alternaria* leaf spot causes 20-30% seed cotton yield loss in India (Mayee and Mukewar, 2007). Under favourable environmental conditions, it can cause yield losses up to 26.59% (Monga *et al.*, 2013). *Alternaria* leaf spot affects cotton during the boll maturity and bursting stages (Sampathkumar and Raghavendra, 2024). In India, tobacco streak virus (TSV) in cotton has emerged as a significant threat (Rageshwari *et al.*, 2016). During the 2022-23 crop season, the Kurnool and Nandyal districts in Andhra Pradesh experienced a high incidence of TSV in cotton, with PDI ranging from 5.5 to 45.0 (Sampathkumar *et al.*, 2025). The survey revealed that cotton boll rot severity ranged from 5.7 to 11.9 PDI at the boll initiation stage and 22.6 to 31.5 PDI during the boll maturity stage (Nanda and Kulkarni, 2020). Rust caused by *Phakopsora gossypii* resulted in significant yield losses of 30-40% in most Bt cotton hybrids cultivated in the major cotton growing areas of Northern Karnataka during 2009-2010 (Pindikur *et al.*, 2012). Cotton leaf rust poses a significant challenge for cotton farming in the southern region (Valarmathi *et al.*, 2025). Host plant resistance is a durable, permanent solution for managing cotton diseases effectively. It reduces the use of agrochemicals and is eco-friendly. Although the adoption of transgenic Bt cotton has shifted the focus away from insect resistance, host-plant resistance remains vital for managing various diseases and nematodes (Anwar *et al.*, 2022). The present investigation was executed with the following objectives:

1. Evaluation of the parental populations of Bt *G. hirsutum* and *G. barbadense* and their H×B hybrids for disease tolerance under field conditions.
2. Identification of disease-tolerant H×B hybrids with higher yields.

MATERIALS AND METHODS

The field experiment was conducted at the ICAR-CICR Regional Station, Coimbatore, during the 2024-25 crop season under irrigated conditions to develop H×B hybrids with higher yields, superior fibre quality and disease tolerance. Sixty-six *G. barbadense* male parents, four *G. hirsutum* female parents, eighteen *G. hirsutum*-BG II parents, fifty H×B- F1- BG I hybrids (crosses), fourteen *G. hirsutum* BG entries and seven Commercial BG II hybrids (Table 1) were screened. Planting was done at 10 dibbles per row, with four replications, using a spacing of 90×60 cm in ridges and furrows. A total of 40 plants were maintained for each genotype. Twenty plants were randomly tagged and observations were recorded at monthly intervals for *Alternaria* leaf spot (ALS), Tobacco Streak Virus (TSV), Grey mildew (GM), Boll rot (BR) and rust. Gap-filling and thinning were performed after 15 days to maintain a single plant per hill. The experiment was conducted in a completely randomised block design. The yield parameters like

number of bolls, single boll weight (g), seed cotton yield (kg/ha) were recorded and fibre quality traits like fibre length (mm), fibre strength (g/tex) and micronaire (μ) were measured for H×B hybrids. 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).

Per cent disease incidence (PDI)

$$\frac{\text{Number of infected plants}}{\text{Total number of plants observed}} \times 100$$

The following disease grading systems were used for observations.

Grading system for *Alternaria*, Grey mildew and rust diseases (as followed in 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%.

Tobacco streak virus (TSV) - 0 to 4 disease rating scale (as adopted in AICRP on Cotton, 2016).

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%.

RESULTS AND DISCUSSION

In the present investigation, *G. hirsutum*, *G. barbadense* and H×B hybrids were screened for disease tolerance under natural conditions. The genotypes were screened for *Alternaria* leaf spot (ALS), Tobacco Streak Virus (TSV), grey mildew, boll rot and rust diseases. Breeding for disease resistance is more crucial than breeding for pest resistance in most breeding programmes (Meredith, 1980). Interspecies genome merging offers a chance to introduce beneficial alien genes for crop improvement and genetic studies (Anwar *et al.*, 2022). Currently, cultivated cotton varieties are vulnerable to diseases. Resistant crop cultivars are crucial for minimising disease-related losses, as they offer an eco-friendly, straightforward and economical approach to disease control. Field evaluation is a practical method for identifying cotton genotypes with natural resistance against *Alternaria* leaf blight (Chaudhari *et al.*, 2022) and other diseases.

Of the 66 *G. barbadense* male parents, 19 entries were found to be free of all diseases. The PDI of ALS ranged from 3.5 to 8.0, TSV from 1.2 to 8.3, boll rot from 2.0 to 3.0 and rust from 3.0 to 6.0 among the genotypes. Another fourteen entries were found to be free from all diseases except *Alternaria* leaf spot. Five entries were free from all diseases except rust. Another five entries were susceptible to most diseases (Fig 1 and Table 2). In cotton breeding programmes, lint yield remains the primary objective (Zeng *et al.*, 2018),

Table 1: Genotypes of non-Bt *G. barbadense*, *G. hirsutum* parents, BGII *G. hirsutum* parents, HxB-F1- BG I hybrids (crosses), Bt *G. hirsutum* genotypes and commercial BGII hybrids (Check) of cotton used for screening against diseases in field conditions.

G. barbadense male parents				G. hirsutum- BG II parents		HxB- F1-BG I hybrids (crosses)		G. hirsutum-BG I entries			
S.no	S.no	S.no	S.no	S.no	S.no	S.no	S.no	S.no	S.no		
1	B1	26	ICB 46 (B)	51	ICB 273	1	V1	1	Rajat Bt×ICB 176	1	211-81
2	B2	27	ICB 53	52	ICB 284	2	V2	2	Suraj Bt×CCB 141	2	211-135
3	B3	28	ICB 58	53	ICB 290	3	V3	3	Suraj Bt×ICB 284	3	211-201
4	B4	29	ICB 61	54	CCB 26	4	V4	4	GJHV 374Bt×Suvin	4	211-212
5	B5	30	ICB 75	55	CCB 11A(B)	5	V5	5	GJHV 374Bt×ICB 194	5	211-280
6	B6	31	ICB 86	56	CCB 25 (B)	6	V6	6	PKV 081Bt×Suvin	6	211-385
7	B7	32	ICB 99	57	CCB 29	7	V7	7	PKV 081Bt×ICB 199	7	211-406
8	B8	33	ICB 99 (B)	58	CCB 29 (B)	8	V8	8	PKV 081Bt×ICB 255	8	211-431
9	B9	34	ICB 124	59	CCB 64	9	V9	9	Rajat Bt×Suvin	9	211-437
10	B10	35	ICB 124 (B)	60	CCB 129	10	V10	10	Rajat Bt×CCB 11	10	211-445
11	B11	36	CCB 143 (B)	61	CCB 141	11	V11	11	Rajat Bt×ICB 194	11	PKV 081 Bt
12	B12	37	ICB 176	62	CCB 143 (B)	12	V12	12	Suraj Bt×ICB 194	12	Rajat Bt
13	B13	38	ICB 176 (B)	63	SM 10	13	V13	13	Suraj Bt×ICB 264	13	GJHV 374 Bt
14	B14	39	ICB 183	64	SM 14	14	V14	14	Suraj Bt×ICB 199	14	Suraj Bt
15	B15	40	ICB 183 (B)	65	EA 15	15	V15	15	GJHV 374 Bt×CCB 28	Commercial BGII hybrids (Check)	
16	B16	41	ICB 194	66	EA 69	16	PH1	16	GJHV 374 Bt×CCB 29	S.no	
17	ICB 13	42	ICB 200			17	PH2	17	GJHV 374 Bt×ICB 207	1	RCH971
18	ICB 16	43	ICB 220			18	PH3	18	GJHV 374 Bt×ICB 220	2	RCH659
19	ICB 28	44	ICB 244			G. hirsutum- Female parents					
20	ICB 28(B)	45	ICB 255			S.no			PKV 081 Bt×ICB 284	3	Ankur Anish
21	ICB 34	46	ICB 258			1	Surabhi	20	PKV 081 Bt×ICB 96	4	Ankur 888
22	ICB 39	47	ICB 258 (B)			2	Suraj	21	Rajat Bt×ICB 174	5	Bahubali
23	ICB 40	48	ICB 262			3	MCU5VT	22	Rajat Bt×ICB 75	6	Puli
24	ICB 40(B)	49	ICB 264			4	CCB15-1	23	Rajat Bt×ICB 199	7	US7067
25	ICB 46	50	ICB 264 (B)					24	Suraj Bt×ICB 174		
								25	Suraj Bt×ICB 194		



Fig 1: Different disease symptoms observed in *G. barbadense* genotypes.

followed by environmental stability and early maturity. All these characteristics can be attained from *G. hirsutum* cultivars. The unique fibre qualities of *G. barbadense* make it an attractive option for adding genetic diversity to improve the fibre quality of *G. hirsutum* cotton (Anwar *et al.*, 2022). *G. barbadense* is generally considered vulnerable to Alternaria leaf spot, whereas *G. hirsutum* exhibits resistance.

Among the four female *G. hirsutum* parents, namely Surabhi, Suraj, MCU5VT and CCB15-1, all were found to be infected with Alternaria leaf spot and rust. MCU5VT was also found to be infected by TSV. The PDI ranged from 4.0 to 7.0 for ALS, 0.0 to 2.1 for TSV, 0.0 to 3.0 for boll rot and 4.0

to 8.0 for rust across four genotypes (Table 2). Among the various varieties/genotypes tested against *A. macrospora* under natural conditions, thirteen entries exhibited resistance, 25 showed moderate resistance or tolerance and 12 were moderately susceptible. None of the entries was highly susceptible at 120 DAS (Chaudhari *et al.*, 2022).

Out of the 18 Bt-BG II *G. hirsutum* parents, one entry, V3, was found to be free of all diseases. Ten entries were free of TSV and Grey mildew but infected by ALS and Rust. Seven entries were susceptible to ALS, TSV and Rust. Among the diseases, ALS showed a PDI ranging from 3.0 to 9.0, TSV from 0.2 to 8.3, grey mildew from 0.0 to 3.0 and

Table 2: Screening of non-Bt *G. barbadense* and *G. hirsutum* parents for disease tolerance under field conditions (2024-25) at CICR RS Coimbatore.

Entry	No. of entries screened	No. of replications	*Diseases observed-PDI				Disease-resistant/tolerant entries
			ALS	TSV	Boll rot	Rust	
<i>G. barbadense</i> -male parents	66	3	3.5-8.0	1.2-8.3	2.0-3.0	3.0-6.0	19 entries -B1, B3, B8, B12, CCB26, ICB53, ICB58, ICB40(B), ICB183(B), CCB141, CB99, ICB284, CCB143(B), CCB25(B), CCB29(B), CCB11A(B), SM14, ICB86 and CCB64 - free from all diseases. 14 entries-B2, B4, B9, B10, CCB11, SM10, ICB16, ICB34, ICB258(B), ICB176(B), ICB46(B), ICB258, ICB244 and ICB290-free from all diseases except ALS5 entries-B15, CCB129, EA69, SM10 and ICB75-free from all diseases except rust. 5 entries-B13, B14, EA15, ICB200 and ICB273-susceptible to most diseases. Surabhi, Suraj, MCU5VT and CCB15-1 - infected by ALS and rust. MCU5VT infected by TSV also.
<i>G. hirsutum</i> -Female parents	4	10	4.0-7.0	0.0-2.1	0.0- 3.0	4.0-8.0	

*Mean of four replications

Table 3: Screening of BG II *G. hirsutum* parents and HxB-F1-BG I hybrids (crosses) for disease tolerance under field conditions (2024-25) at CICR RS Coimbatore.

Entry	No. of entries screened	No. of replications	*Diseases observed-PDI				Disease-resistant/tolerant entries
			ALS	TSV	GM	Rust	
BG II- <i>G. hirsutum</i> parents	18	2	3.0-9.0	0.2-8.3	0.0-3.0	4.0-10.0	Entry V3- free from all diseases. Ten entries V1, V2, V4 to V9, V14 and PH2- free from TSV and GM and infected by ALS and rust. Seven entries -susceptible to ALS, TSV and rust
HxB-F1-BG I hybrids (crosses)	50	4	3.0-7.0	1.2-8.5	Nil	3.0-9.0	Six crosses-GJHV 374 Bt × ICB 28, GJHV 374 Bt × ICB 174, GJHV 374 Bt × ICB 194, Rajat Bt × CCB 141, Rajat Bt × ICB 75 and PKV 081 Bt × ICB 258-free from all diseases. Four crosses-GJHV 374 Bt × ICB 264, Rajat Bt × CCB 141, Rajat Bt × CCB 11 and Rajat Bt × ICB 194 - free from all diseases except rust. Fourteen crosses-susceptible to ALS, TSV and rust.

*Mean of four replications.



Fig 2: Different disease symptoms observed in *G. hirsutum* genotypes.

rust from 4.0 to 10.0 (Fig 2 and Table 3). In recent years, diseases associated with Bt cotton in northern Karnataka have increased significantly, leading to a cotton boll rot complex due to favourable environmental conditions (Nanda and Kulkarni, 2020).

Among 50 H×B- F1- BG I hybrids, six entries, such as GJHV 374 Bt × ICB 28, GJHV 374 Bt × ICB 174, GJHV 374 Bt × ICB 194, Rajat Bt × CCB 141, Rajat Bt × ICB 75 and PKV 081 Bt × ICB 258, were found to be free from all diseases. PDI of ALS recorded from 3.0 to 7.0, TSV from 1.5 to 8.5 and rust from 3.0 to 9.0. Four crosses, such as GJHV 374 Bt × ICB 264, Rajat Bt × CCB 141, Rajat Bt × CCB 11 and Rajat

Bt × ICB 194, were found to be free from all diseases except rust. Another fourteen crosses were found to be susceptible to ALS, TSV and rust (Table 3). As TSV is an emerging disease in India, identifying tolerant genotypes against TSV is more important than other diseases. Early-season diseases like TSV, boll rot, grey mildew and ALS should be given higher priority than late-season rust. Valarmathi and Amutha (2025) screened 300 *G. barbadense* germplasms under natural field conditions for TSV resistance. Among them, 14 were categorised as resistant, 22 as moderately resistant, 168 as moderately susceptible and 94 as susceptible. At RARS Warangal, fifty-two germplasm lines and thirteen Bt hybrids were

screened, with HYPS-152, H-1250, RAH-4 and eleven Bt hybrids exhibiting resistance to TSV (Vijaya Bhaskar, 2023).

Several workers worldwide, including in India, have reported various genotypes with resistance to Alternaria leaf spot. Cia *et al.* (2016) found that among 18 Upland cotton genotypes, TMG 81 WS, IAC 08-2031, IAC 26 RMD, NUOPAL and IMA 09-474 showed resistance to *A. macrospora* under field conditions in Brazil. Infection by pathogenic Alternaria causes premature defoliation in cotton and severe defoliation results in yield losses. Rajesha *et al.* (2021) evaluated 39 cotton genotypes for Alternaria leaf blight resistance under natural field conditions and found that 21 were resistant, 11 were moderately resistant and 5 were moderately susceptible. Only two genotypes were highly vulnerable to leaf blight.

In the present study, of the 14 *G. hirsutum* BG entries, one, namely 211-437, was found to be free of all diseases. Two entries, namely 211-445 and GJHV 374 Bt, were found to be free from all diseases except rust. Four entries were found to be susceptible to ALS, TSV and rust. ALS observed from 4.0 to 9.0, TSV from 1.2 to 5.7 and rust from 4.0 to 12.0 PDI (Table 4). Like ALS and TSV, grey mildew disease also devastates cotton yield under favourable environmental conditions. Many researchers have reported the presence of resistant/tolerant genotypes for grey mildew in cotton. Eighty-nine cotton germplasms were evaluated for grey mildew resistance in the field using infector row methods, including local, high-yielding varieties and hybrids in Odisha. Among these, GSHV-159 and GISV-272 remained disease-free. Additionally, 22 entries demonstrated stable resistance over three years. While 32 genotypes exhibited only moderate resistance, 24 were susceptible to grey mildew and nine germplasms proved highly sensitive to the fungus. Resistant genotypes can serve as donors for breeding grey mildew-resistant cotton (Boblina *et al.*, 2023).

In the current study, all seven commercial BG II hybrids were found to be infected with ALS and rust. Three hybrids, such as Ankur Anish, RCH659 and US7067, were identified as susceptible to ALS, TSV and rust. The per cent disease index ranged from 3.0 to 10.0 for ALS, 1.3 to 6.2 for TSV, 3.0 to 7.0 for grey mildew and 3.0 to 10.0 for rust (Table 4). Boll rot disease is more common during cloudy, mild rain conditions when mature bolls are present in the lower canopy and ready to open. Cotton rust normally appears late in the season; recently, symptom development at early stages has also been reported. The estimated avoidable loss due to rust disease was approximately 21.7% in Bunny Bt and notably higher at 34.1% in RCH 2 BG II (Monga *et al.*, 2013). The identified disease-tolerant parental genotypes, as well as H×B hybrids, will play a crucial role in the effective cotton disease management in field conditions.

The main aim of this study was to improve the yields of H×B hybrids with better fibre quality and disease resistance. The six H×B-F₁ BG I cotton hybrids that remained free of all the studied diseases (ALS, TSV, boll rot and rust) also recorded higher seed cotton yields and improved fibre

Table 4: Screening of Bt (BG I) *G. hirsutum* genotypes and Commercial BG II hybrids (Check) for disease tolerance under field conditions (2024-25) at CICR RS Coimbatore.

Entry	No. of entries screened	No. of replications	*Diseases observed-PDI				Disease-resistant/tolerant entries
			ALS	TSV	GM	Rust	
<i>G. hirsutum</i> BG I entries	14	2	4.0-9.0	1.2 - 5.7	Nil	4.0-12.0	Entry 211-437- free from all diseases. Two entries, 211-445 and GJHV 374- free from all diseases except. Rust four entries -211-431, PKV 081 Bt, Rajat Bt and Suraj Bt - susceptible to ALS, TSV and rust.
Commercial BG II hybrids (Check)	7	4	3.0-10.0	1.31-6.2	3.0-7.0	3.0-10.0	All seven hybrids- RCH659, Ankur Anish, Ankur 888, Bahubali, Puli and US7067 -infected by ALS and rust. Three hybrids -Ankur Anish, RCH659 and US7067 - susceptible to ALS, TSV and rust.

*Mean of four replications.

parameters. Notably, GJHV 374 Bt × ICB 174 (4074 kg ha⁻¹) and Rajat Bt × ICB 75 (4064 kg ha⁻¹) produced the highest yields, along with optimal fibre length and strength. Some hybrids, such as GJHV 374 Bt × ICB 264 and Rajat Bt × CCB 141, were free from ALS and TSV but showed rust incidence, yet still maintained reasonably good yields and fibre quality. Conversely, the other crosses were susceptible to ALS, TSV and rust, generally resulting in lower yields and variable fibre traits. Overall, disease-free hybrids tended to exhibit better productivity and fibre quality than susceptible hybrids.

CONCLUSION

Among 66 *G. barbadense* male parents, 19 entries were free from all diseases (ALS, TSV, GM and Rust). Of the 18 *G. hirsutum* BG II parents, one entry, V3, was found free of all diseases. Among 50 H×B- F₁-BG I hybrids (crosses), six were found free from all diseases. Four were free from all diseases except Rust. The six H×B-F₁ BG I cotton hybrids that remained free of all the studied diseases (ALS, TSV, boll rot and rust) also achieved higher seed cotton yields and improved fibre parameters. Hybrids, such as GJHV 374 Bt × ICB 264 and Rajat Bt × CCB 141, were free from ALS and TSV but showed rust incidence, yet still maintained reasonably good yields and fibre quality.

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Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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