

**Original Research Article**

**Comparative Analysis of Yield and Fibre Traits  
in Newly Developed *Bt* and Non-*Bt* Cotton  
Hybrids**

UNDER PEER REVIEW

## ABSTRACT

**Aims:** Cotton as a major fibre crop for textile industry and farmers in the world. Despite its tremendous importance, productivity constraints are still present. To eliminate productivity problem and increase the yield, the present investigation focused on developing new Bt cotton hybrids with better yield and fibre characteristics through estimation of heterosis in different combination of Bt and Non Bt parents.

**Study design:** Randomized block design with three replication was used to conduct the experiment.

**Place and Duration of Study:** The experiment was conducted at Cotton Research Unit, Dr. PDKV, Akola, Maharashtra, during Kharif 2019 & 2020.

**Methodology:** The five diverse parents were crossed with one another as making four crosses of Bt x Bt parents and four crosses of Non-Bt x Bt parents. Eight F<sub>1</sub> hybrids then were evaluated for heterosis performance for different morphological, yield, yield contributing traits and fibre traits with standard checks i.e. PDKV JKAL 116 and Ajeet 155 in Kharif 2020.

**Results:** Results showed that for seed cotton yield (kg/ha), the cross AKH 09-5 × ICAR-CICR Rajat Bt recorded highest 12.30% standard heterosis over the check PDKV JKAL 116. Significant standard heterosis of 35.83% and 34.36% was observed for no. of bolls per plant over both the checks respectively. While the cross ICAR-CICR 081 Bt × ICAR-CICR Rajat Bt was found most heterotic for fibre parameters.

**Conclusion:** It was found that the Non-Bt × Bt crosses performed well for yield and its contributing trait than Bt × Bt crosses, while Bt × Bt crosses did gave good results for fibre quality parameters. Understanding the genetics behind, can be beneficial for the farming community.

*Keywords: Bt cotton, Fiber quality, Heterosis, Non-Bt cotton, Yield components*

## 1. INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is an important fiber crop in the world acquiring half of the textile industry globally (Rajashekar et al., 2023). The well-known fiber crops in world are jute, kenaf, industrial hemp, sun hemp, and flax but still cotton is dominating crop (Atta and Owolarafe, 2023; FAO, 2021). Cotton is sometimes also denoted as oil crop (Cottonseed oil) which is commonly used for cooking in China and other Asian countries and oil of Kinaf is found to have similar properties as cottonseed oil (Ganesan et al., 2018; Atta et al., 2023). Cotton production in India has focused on its utilization in the textile industry for over thousands of years, generating significant employment for both skilled and unskilled labour - thus helping to strengthen the country's economy, (Abdelghany et al., 2024). The historical significance of cotton spans civilizations, and today, it remains a vital plant species for humanity (Wegier et al., 2016).

Despite its economic importance, cotton cultivation faces challenges like drought stress, heat stress, salinity stress, weed competition, diseases and pest infestation during its life cycle (Verma et al., 2024; Lahane et al., 2020). Pests and diseases threaten yield, leading to economic losses for farmers. Among these, the notorious cotton bollworm (*Helicoverpa armigera*) emerges as a major pest, causing substantial damage to cotton crops. In response to this challenge, the introduction of genetically modified (GM) cotton, specifically Bt cotton, revolutionized cotton cultivation. The common soil bacterium *Bacillus thuringiensis* var. *kurstaki* provided the gene *Cry1Ac* making toxic *Cry1Ac* protein which is expressed in cotton and imparts resistance against bollworm complex resulting the Bt cotton (Barwale et al., 2004). In 2002, the first genetically modified (GM) crop which was approved for large scale cultivation in India. India was the world's first country to create the first cotton hybrid, known as "H4", and to commercially exploit cotton heterosis in 1970 (Patel 1981).

India ranks first in terms of area, second in consumption & production and third in export of cotton in world scenario. In India, during 2023-24 the total area was around 125.55 lakh ha. with the production of around 323.11 lakh bales of 170 kg and productivity of 441 kg/ha. (AICRP Annual Report 2024). Previous research has primarily centered on Bt cotton hybrids, leaving a gap in our understanding of Non-Bt × Bt interactions. In this study, we address this gap by comparing developing and Bt × Bt and Non-Bt × Bt cotton hybrids across various traits. Heterosis was the measure to assess the performance of the hybrids for yield, all yield component traits and fibre characters, (Shahzad et al., 2019). Our study bridges the gap by exploring hybrid traits and leveraging heterosis as a powerful tool for cotton breeding.

## 2. MATERIALS AND METHOD

The experimental material comprised of five diverse parents, eight F<sub>1</sub> hybrids and two standard checks (PDKV JKAL 116 & Ajeet 155). The five parental lines that were used for crossing includes Bt

parents-ICAR-CICR Rajat *Bt*, ICAR-CICR Suraj *Bt*, ICAR-CICR-PKV 081 *Bt*, ICAR-19255 *Bt* and non-*Bt*-AKH-09-5 (Suvarna Shubhra), having peculiar characteristics. The crosses were randomly made on the basis of *Bt* status and other desirable traits. In the pool of five parents, eight crosses are made (four crosses were Non-*Bt* × *Bt* and four were *Bt* × *Bt*) *Kharif* 2019-20 as presented in Table 1. Dock and Moll's (1934) method of emasculation was adopted in which the females parents were emasculated in the evening hours between 3 pm to 5 pm using hand emasculation technique and bagged with butter paper bag and were pollinated in the next morning between 9 am to 12 pm with the pollens of desirable male parent. The eight experimental hybrids and two standard checks were sown in four rows per genotype with 90cm × 45 cm spacing in Randomized Block Design with three replications during *Kharif* 2020-21 at Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India. All the necessary agronomic practices were followed for better cotton crop growth and cultivation. During flowering, 5 plants were randomly selected and tagged from each plot avoiding border row for recording data on various traits. For fibre traits the samples were sent to Central Institute for Research on Cotton Technology (CIRCOT), Mumbai for estimation of fibre strength. Standard heterosis was also computed from the selected plants over the checks using a formula

$$\% (\text{Standard heterosis}) = \frac{F_1 - SC}{SC} \times 100$$

Where,

F<sub>1</sub> = Mean of F<sub>1</sub>

SC = Mean of Standard Check

Table 1: Crosses with their names as hybrid and checks.

Hybrid name	Crosses	
UBT 1	AKH 09-5	× ICAR-CICR Suraj <i>Bt</i>
UBT 2	AKH 09-5	× ICAR 19255 <i>Bt</i>
UBT 3	ICAR-CICR Rajat <i>Bt</i>	× ICAR-CICR Suraj <i>Bt</i>
UBT 4	AKH 09-5	× ICAR-CICR Rajat <i>Bt</i>
UBT 5	AKH 09-5	× ICAR-CICR PKV 081 <i>Bt</i>
UBT 6	ICAR-CICR PKV 081 <i>Bt</i>	× ICAR-CICR Rajat <i>Bt</i>
UBT 7	ICAR-CICR PKV 081 <i>Bt</i>	× ICAR-CICR Suraj <i>Bt</i>
UBT 8	ICAR-CICR Rajat <i>Bt</i>	× ICAR-CICR PKV 081 <i>Bt</i>
	<b>Checks</b>	
UBT 9	PDKV JKAL 116	
UBT 10	Ajeet 155	

### 3. RESULTS AND DISCUSSION

In cotton, both the positive and negative heterosis are considered desirable. Morphological traits like plant height (cm), *Bt* × *Bt* hybrids consistently exhibited shorter plant heights compared to Non-*Bt* × *Bt* hybrids and checks and none of the hybrid indicated positive standard heterosis over both the checks (Fig.1). These findings are consistent with previous studies (Kumar et al., 2018; Malthi et al., 2019; Solongi et al., 2019). This reduced height and compact canopy structure allow for higher planting densities, resulting in more plants per unit area, which contributes to the higher overall yields (Kumar et al., 2020). Monopodia (non-fruiting branches) per plant were fewer in all hybrids with non-*Bt* parents, showing negative heterosis (desirable for this trait). Specifically, a -13.33% heterosis suggests potential for further improvement through heterosis breeding. Other researchers, including Sivia et al. (2017) and Prakash and Korekar (2017) found similar heterosis results for this trait. For sympodia (fruiting branches) per plant, *Bt* × *Bt* hybrids outperformed non-*Bt* × *Bt* hybrids. The cross ICAR-CICR PKV 081 *Bt* × ICAR-CICR Rajat *Bt* demonstrated significant positive standard heterosis over checks (28.13% and 24.24%) due to diverse parental genetics (Fig.1). These sympodial branches bore more bolls, contributing to overall higher yields. The standard heterosis for 50 % boll bursting ranged from -0.82% to 4.10% over the check variety PDKV JKAL 116 and from -3.20% to 1.60% over Ajeet 155 aligning with Udaya et al. (2022) and Chinchane et al. (2019). Hybrids with AKH 09-5 as a parent predominantly

### Heterosis performance over PDKV JKAL 116 & Ajeet 155 Check

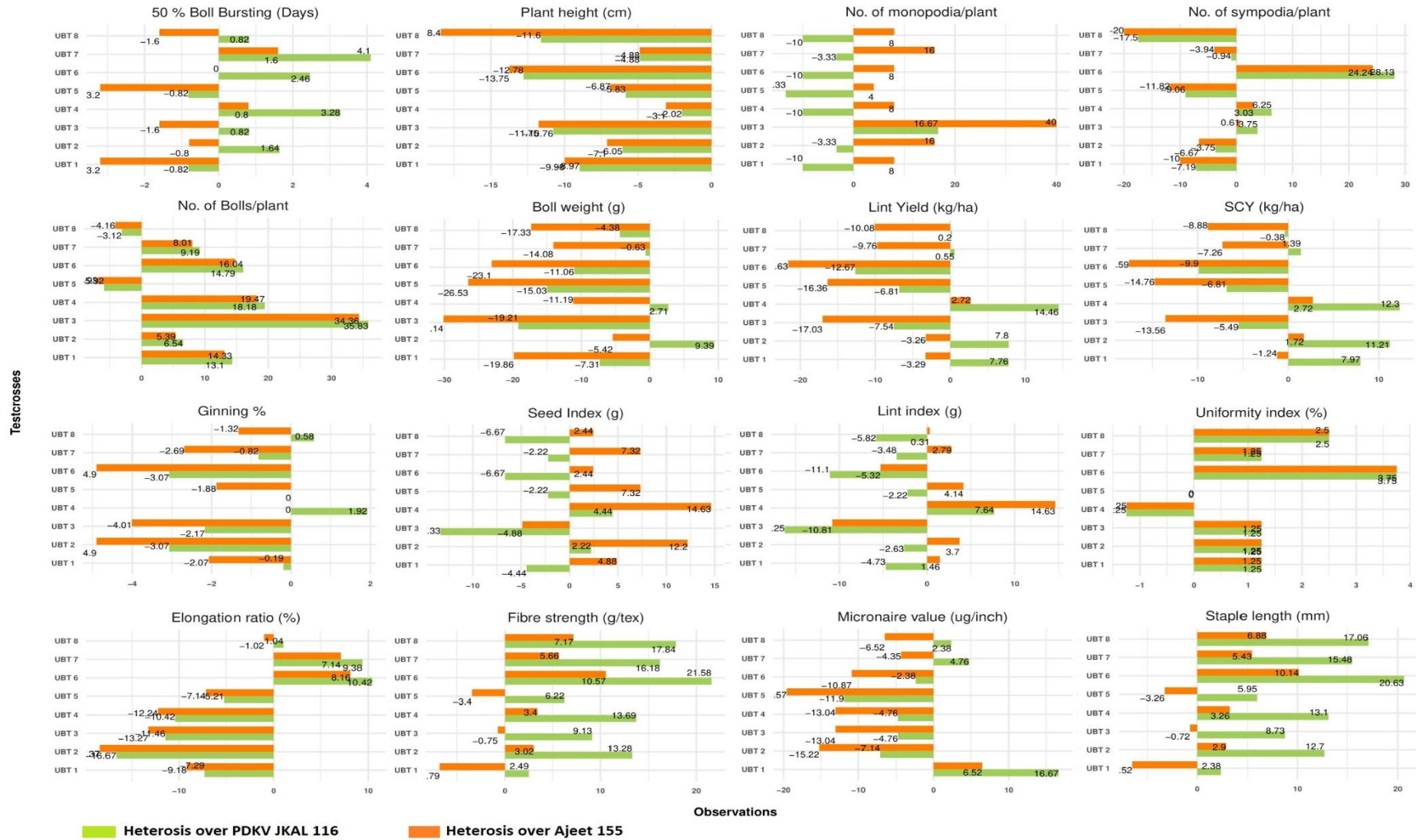


Fig. 1: Heterotic performance of hybrids for various morphological, yield, yield contributing traits and fibre traits over standard checks.

exhibited early boll bursting. Notably, non-*Bt* × *Bt* hybrids resulted in early boll bursting that the *Bt* × *Bt* hybrids as presented in Figure 1.

Yield and its contributing traits always play the key role in development of better and improved hybrids in crops and cotton is highly amenable for heterosis breeding. The number of bolls per plant is the key trait responsible for yield in cotton. *Bt* × *Bt* hybrids demonstrated excellent performance, achieving a standard heterosis of 35.83%. Non-*Bt* × *Bt* hybrids also performed well, yielding approximately 19.46% standard heterosis (Fig. 1). Crosses with diverse genetic backgrounds (e.g., ICAR-CICR Rajat *Bt* × ICAR-CICR Suraj *Bt* and AKH 09-5 × ICAR-CICR Rajat *Bt*) exhibited the highest significant heterosis over both PDKV JKAL 116 and Ajeet 155, endorsing their potential for crop improvement and hybrid breeding (Lekshmi et al., 2023). Boll weight (g) is also a peculiar character to determine the yield of the cotton. The highest heterosis of 9.39% was observed in the AKH 09-5 × ICAR 19255 *Bt* cross, aligning with results of Giri et al. (2021) and Rani et al. (2020). Parent AKH 09-5's large boll size contributed significantly to boll weight in hybrids. Seed cotton yield (kg/ha) is the major character for adaptation of variety by the farmers. The cross AKH 09-5 × ICAR-CICR Rajat *Bt* achieved a remarkable heterosis of 12.30% over the commercial check variety PDKV JKAL 116 as presented in Figure 1. Other promising crosses included AKH 09-5 × ICAR 19255 *Bt* and AKH-09-5 × ICAR-CICR Suraj *Bt*. However, over check Ajeet 155, the maximum heterosis observed was only 2.72%. Non-*Bt* × *Bt* crosses consistently outyielded *Bt* × *Bt* crosses, aligning with previous research findings of Adsare et al. (2017), Revanasiddayya and Patil (2019). For Lint yield (kg/ha), standard heterosis over PDKV JKAL 116 and Ajeet 155 varied, and only few hybrids resulted positive standard heterosis. AKH 09-5 × ICAR-CICR Rajat *Bt* reported highest standard heterosis over both the checks proving the results of Lodam et al. (2017). The performance of the Non-*Bt* × *Bt* hybrids is far better than the *Bt* × *Bt* hybrids.

Seed index (g), lint index & ginning % are important traits as they are considered as an economic traits to benefit the farmers. The cross AKH 09-5 × ICAR-CICR Rajat *Bt* exhibited maximum standard heterosis for both seed index and lint index. Conversely, the cross ICAR-CICR Rajat *Bt* × ICAR-CICR Suraj *Bt* showed the least heterotic effect. Notably, non-*Bt* × *Bt* hybrids consistently outperformed *Bt* × *Bt* hybrids for seed index and lint index, with seven out of eight crosses displaying positive heterosis over the check variety Ajeet 155 as presented in figure 1. These results were in accordance with results of Gohil et al. (2017) and Lingaraja et al. (2017). The cross ICAR-CICR PKV 081 *Bt* × ICAR-CICR Rajat *Bt* recorded maximum heterosis for ginning (%). This trait is crucial for economic considerations, as higher ginning (%) directly impacts the profitability of cotton production.

Fibre parameters like micronaire value, uniformity index, elongation ration, staple length and fibre strength are considered for breeding cotton for industrial purpose and to strengthen the economy of developing nations. Negative heterosis was observed for micronaire value in six crosses over PDKV JKAL 116 and seven crosses over AJEET 155. Negative heterosis is desirable for micronaire value, indicating finer fiber quality suitable for ginning and textile industries. The cross AKH-09-5 × ICAR-CICR PKV 081 *Bt* displayed the maximum negative heterosis of -11.90% and -19.57%, emphasizing its potential for fine fiber production (Fig. 1). The results were accordance with Hugar et al. (2020) and Keerthivarman et al. (2022). A single cross ICAR-CICR PKV 081 *Bt* × ICAR-CICR Rajat *Bt* outperformed for four fibre quality parameters viz. uniformity index, elongation ration, staple length and fibre strength.

## CONCLUSION

From the present study it was clear that the performance of non-*Bt* × *Bt* crosses was positive for yield and its contributing trait than *Bt* × *Bt* crosses, while *Bt* × *Bt* crosses performed good for fibre quality parameters and can be utilized further for improvement of these traits by proper selection of parents for achieving greater heterosis. But it still need validation in different location and molecular basis must be understood to know the causes of this heterosis performance.

## CONSENT

All the authors have no conflict of interest and given consent to publish the research finding in Journal of Advances in Biology & Biotechnology

## Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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