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

ABSTRACT

Aims: Cotton is a significant cash crop globally, and its essential for the textile industry and the livelihoods of cotton farmers. The present investigation was aimed to develop new hybrids and estimate heterotic effects on yield, yield components and fibre traits of *Bt* × *Bt* and Non-*Bt* × *Bt* cotton hybrids.
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 ~~each~~ one other as making 4 crosses of Bt x Bt parents and four crosses of Non-Bt x Bt parents. Eight F_1 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 that is grown extensively in many parts of the world (Singh et al 2007). Cotton production in India has focused on its utilization in the textile industry~~s~~ 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 . Despite its economic importance, cotton cultivation has some challenges~~faces~~ challenges. 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 these challenges, 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.

India has emerged as the largest producer of cotton in the world and occupies the first position in terms of both total area (41%) and production (25.59%). In India, during 2022-23 the total area was around 132.27 lakh ha. with the production of around 371 lakh bales of 170 kg and productivity of 487 kg/ha. 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 *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. EXPERIMENTAL DETAILS

The experimental material comprised of five diverse parents, eight F_1 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. In the pool of five parents, eight crosses are made (four crosses were Non-*Bt* × *Bt* and four were *Bt* × *Bt*) as presented in Table 1. Dock and Moll's (1934) method of emasculation was adopted. The experiment was conducted in Randomized Block Design with three replications during *Kharif* 2019-20 & 2020-21 at Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India and all

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necessary practices were followed for better cotton crop cultivation. Standard heterosis was computed over the checks using a formula

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

Where,

F_1 = Mean of F_1

SC= Mean of Standard Check

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

Hybrid name	Crosses		
UBT 1	AKH 09-5	×	ICAR-CICR Suraj *Bt*
UBT 2	AKH 09-5	×	ICAR 19255 *Bt*
UBT 3	ICAR-CICR Rajat *Bt*	×	ICAR-CICR Suraj *Bt*
UBT 4	AKH 09-5	×	ICAR-CICR Rajat *Bt*
UBT 5	AKH 09-5	×	ICAR-CICR PKV 081 *Bt*
UBT 6	ICAR-CICR PKV 081 *Bt*	×	ICAR-CICR Rajat *Bt*
UBT 7	ICAR-CICR PKV 081 *Bt*	×	ICAR-CICR Suraj *Bt*
UBT 8	ICAR-CICR Rajat *Bt*	×	ICAR-CICR PKV 081 *Bt*
	Checks		
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 (2022) and Chinchane et al (2019). Hybrids with AKH 09-5 as a parent predominantly 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).

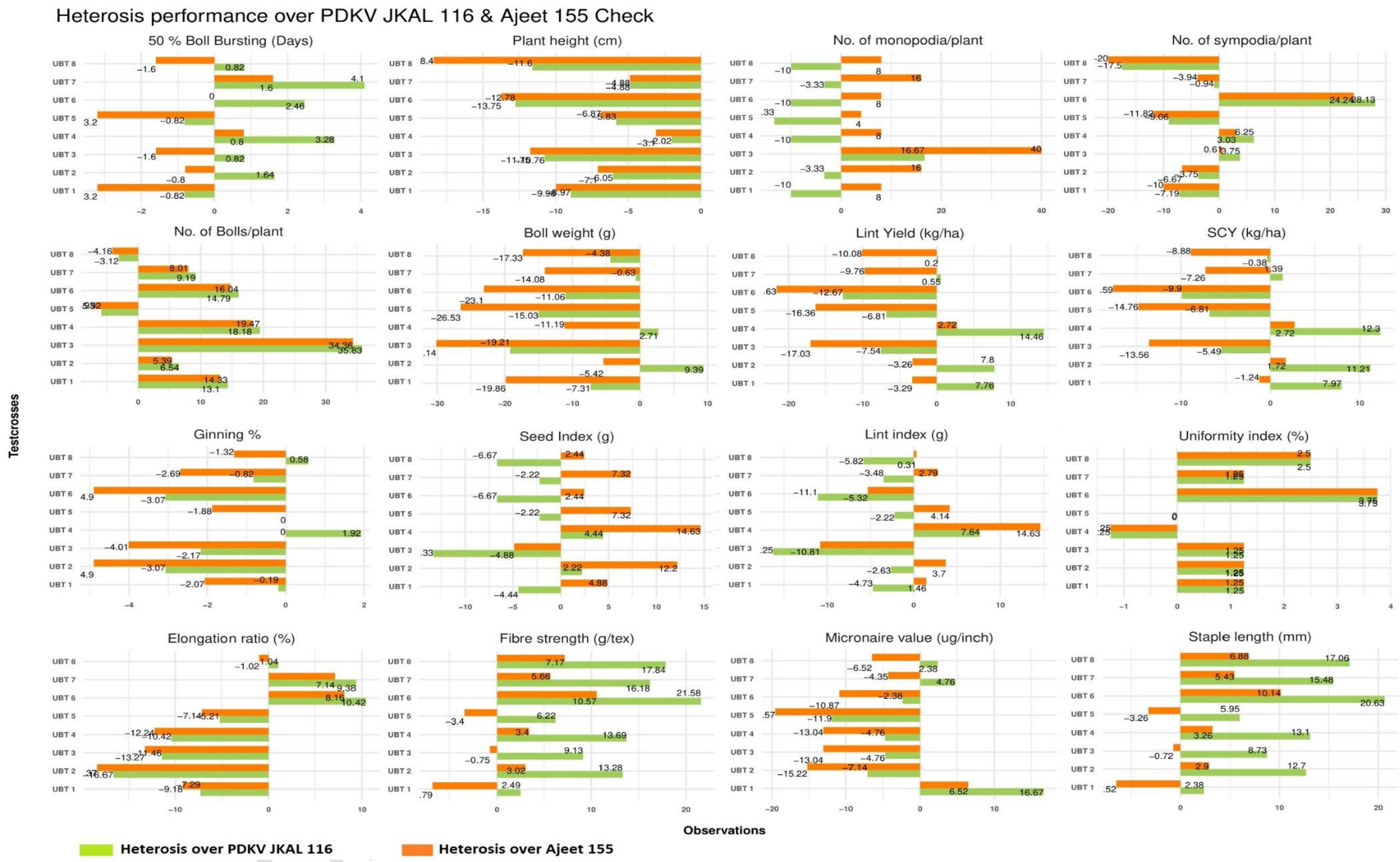

Fig. 1: Heterotic performance of hybrids for various morphological, yield, yield contributing traits and fibre traits over standard checks.

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), Patel et al (2019), 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 Gohil et al (2017) and Lingaraja et al (2017) as presented in figure 1. 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.

CONSENT

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

ETHICAL APPROVAL

Not applicable

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