Journal of Advances in Biology & Biotechnology

Volume 28, Issue 1, Page 346-353, 2025; Article no.JABB.129645
ISSN: 2394-1081

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

S. G. Shamkuwar [a++*], N. V. Kayande [b], A. R. Uike [c++], M. M. Ganvir [d#] and G. R. Shamkuwar [e#]

[a] *Department of Genetics and Plant Breeding, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, 221005, India.*
[b] *Cotton Breeder, Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, 444104, India.*
[c] *Department of Plant Breeding and Genetics, Assam Agricultural University, Jorhat, Assam, 785013, India.*
[d] *AICRP for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, 444104, India.*
[e] *Zonal Agriculture Research Station, Sindewahi, Dr. PDKV, Akola, Maharashtra, 441222, India.*

Authors' contributions

This work was carried out in collaboration among all authors. Author SGS conceptualized the research programme, designed and executed the field experiment, also collected data and prepared manuscript. Author NVK conceptualized the research, designed field experiment and supervised all work. Author ARU collected data and performed literature review. Author MMG performed data analysis and interpretation. Author GRS helped in preparation and revision of manuscript. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/jabb/2025/v28i11888

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/129645

Original Research Article

Received: 07/11/2024
Accepted: 09/01/2025
Published: 14/01/2025

[++] *Research Scholar;*
[#] *Senior Scientist;*
**Corresponding author: E-mail: sahilshamkuwar@gmail.com;*

Cite as: *Shamkuwar, S. G., N. V. Kayande, A. R. Uike, M. M. Ganvir, and G. R. Shamkuwar. 2025. "Comparative Analysis of Yield and Fibre Traits in Newly Developed Bt and Non-Bt Cotton Hybrids". Journal of Advances in Biology & Biotechnology 28 (1):346-53. https://doi.org/10.9734/jabb/2025/v28i11888.*

ABSTRACT

Aims: Cotton is 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_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. While the cross ICAR-CICR 081 *Bt* × ICAR-CICR Rajat *Bt* was found to be most heterotic for fibre parameters.

Conclusion: It was found that the Non-*Bt* × *Bt* crosses performed better 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 threatens 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). It is the first genetically modified (GM) crop 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 and production, and third in export of cotton in the 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 developing and 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. MATERIALS AND METHODS

The experimental material comprised 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. The crosses were randomly made on the basis of *Bt* status and other desirable traits. In the pool of five parents, eight crosses were made (four crosses were Non-*Bt* × *Bt* and four were *Bt* × *Bt*) in *Kharif* 2019-20 as presented in Table 1. Dock and Moll's (1934) method of emasculation was adopted in which the female parents were emasculated in the evening hours between 3 pm to 5 pm using the hand emasculation technique and bagged with butter paper bags 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, five 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 the Central Institute for Research on Cotton Technology (CIRCOT), Mumbai to estimate fibre strength. Standard heterosis was also computed from the selected plants over the checks using a formula

$$\%\,(Standard\ heterosis) = \frac{\bar{F1} - \bar{SC}}{\bar{SC}} \times 100$$

Where,

F_1 = Mean of F_1
SC= Mean of Standard Check

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 hybrids 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 density, resulting in more plants per unit area, which contributes to 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 exhibited early boll bursting. Notably, non-*Bt* × *Bt* hybrids resulted in early boll bursting than the *Bt* × *Bt* hybrids, as presented in Fig. 1.

Yield and its contributing traits always play a 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 performed excellently, 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 crop. The highest heterosis of 9.39% was observed in the AKH 09-

Table 1. Crosses with their names as hybrid and checks

Hybrid name	Crosses		
U*BT* 1	AKH 09-5	×	ICAR-CICR Suraj *Bt*
U*BT* 2	AKH 09-5	×	ICAR 19255 *Bt*
U*BT* 3	ICAR-CICR Rajat *Bt*	×	ICAR-CICR Suraj *Bt*
U*BT* 4	AKH 09-5	×	ICAR-CICR Rajat *Bt*
U*BT* 5	AKH 09-5	×	ICAR-CICR PKV 081 *Bt*
U*BT* 6	ICAR-CICR PKV 081 *Bt*	×	ICAR-CICR Rajat *Bt*
U*BT* 7	ICAR-CICR PKV 081 *Bt*	×	ICAR-CICR Suraj *Bt*
U*BT* 8	ICAR-CICR Rajat *Bt*	×	ICAR-CICR PKV 081 *Bt*
	Checks		
U*BT* 9	PDKV JKAL 116		
U*BT* 10	Ajeet 155		

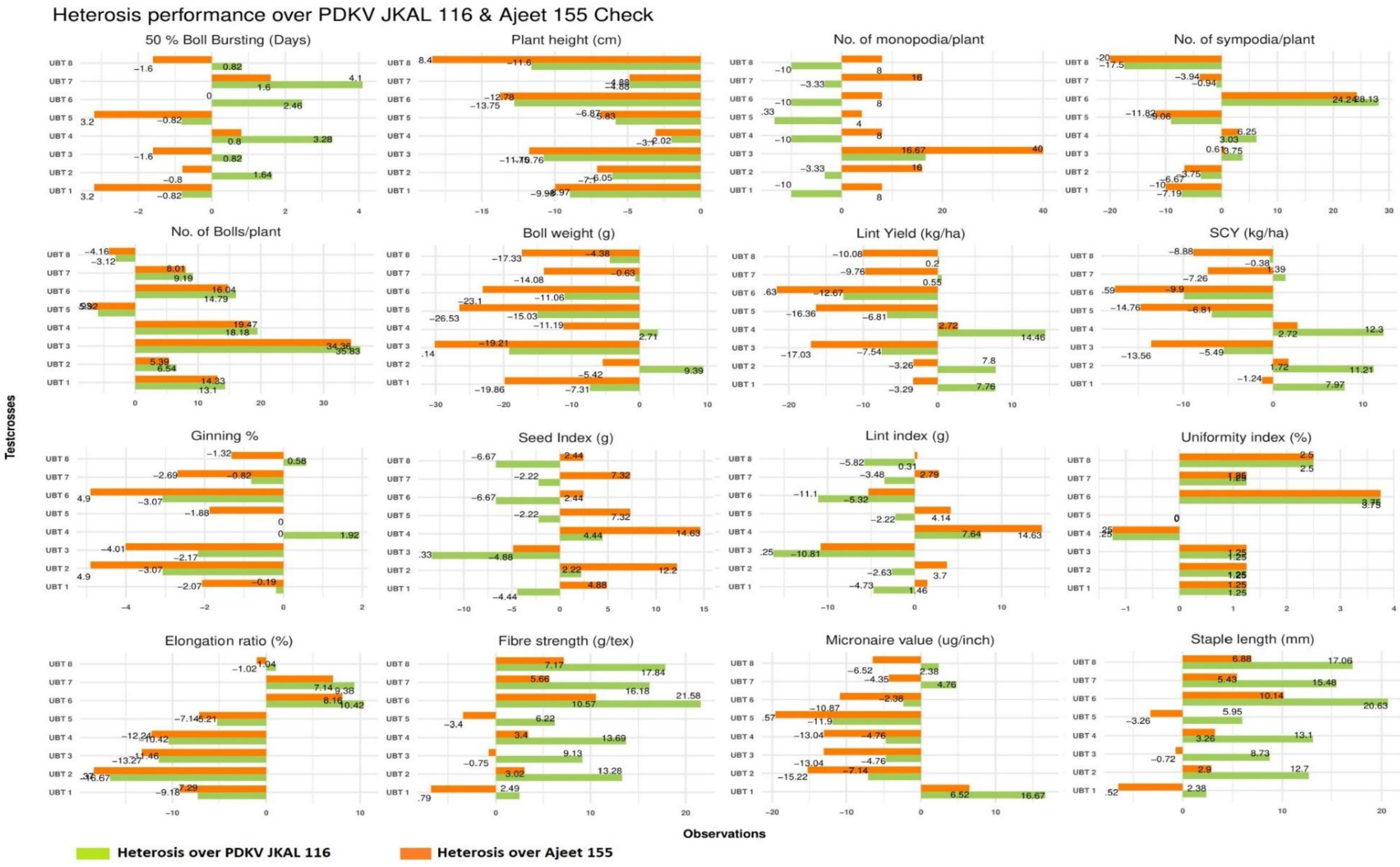

Fig. 1. Heterotic performance of hybrids for various morphological, yield, yield contributing traits and fibre traits over standard checks

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 Fig. 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 was better than the *Bt* × *Bt* hybrids.

Seed index (g), lint index and ginning % are important traits as they are considered as 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 Fig. 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 ratio, staple length and fibre strength are considered for breeding cotton for industrial purposes and for strengthening 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 in 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 ratio, staple length and fibre strength.

4. CONCLUSION

From the present study, it was clear that the performance of non-*Bt* × *Bt* crosses was positive for yield and its contributing traits 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. However, it still needs validation in different locations and the molecular basis must be understood to know the causes of this heterosis performance.

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.

CONSENT

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

ACKNOWLEDGEMENTS

I would like to thank Cotton Research Unit and Department of Agricultural Botany, Dr. PDKV, Akola for providing the parental lines and allocation of land for conducting the research. No funding was provided.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Abdelghany, A. M., El-Banna, A. A., Lamlom, S. F., El-Sorady, G. A., Salama, E. A., Ren, H., et al. (2024). Combining ability of

Egyptian cotton (*Gossypium barbadense* L.) reveals genetic potential for improved yield and fiber quality. *Journal of Cotton Research*, *7*(12), 1-1.

Adsare, A., Salve, A., & Patil, N. (2017). Heterosis studies for quantitative traits in interspecific hybrids of cotton (*Gossypium hirsutum* L. × *Gossypium barbadense* L.). *Journal of Phytology*, *9*(1), 11-14.

Atta, A. T., & Owolarafe, O. K. (2023). The development and performance evaluation of a small scale kenaf fibre spinning and reeling machine. *Agricultural Engineering*, *27*(1), 163-173.

Atta, A. T., Owolarafe, O. K., Omotosho, O. A., Yahaya, A. I., & Falana, O. B. (2023). Quality ratio comparison of yarn spun from three different varieties of kenaf. *Moor Journal of Agricultural Research*, *24*(1), 101-111.

Barwale, R. B., Gadwal, V. R., Zehr, U., & Zher, B. (2004). Prospects of *Bt* cotton technology in India. *Agricultural Biotechnology Forum*, *7*(1&2), 23-26.

Chinchane, V. N., Duomai, K., & Deosarkar, D. B. (2019). Heterosis studies for qualitative and quantitative characters in cotton (*Gossypium arboreum* L.). *Journal of Cotton Research and Development*, *33*(1), 36-43.

Dock, J. W., & Moll, R. H. (1934). A new technique in cotton hybridization suggested changes in existing method of emasculating and bagging cotton flower. *Journal of Heredity*, *25*(5), 201-204.

FAO. (2021). Recent trends and prospects in the world cotton market and policy developments. FAO. Rome. https://doi.org/10.4060/cb3269en

Ganesan, K., Sukalingam, K., & Xu, B. (2018). Impact of consumption and cooking manners of vegetable oils on cardiovascular diseases-A critical review. *Trends in Food Science & Technology*, *7*(1), 132-154.

Giri, R. K., Verma, S. K., & Yadav, J. P. (2021). Study of heterosis, combining ability, and parental diversity for seed cotton yield and contributing traits using diallel data in cotton (*G. hirsutum* L.). *Indian Journal of Agricultural Research*, *55*(5), 556-562.

Gohil, S. B., Parmar, M. B., & Chaudari, D. J. (2017). Study of heterosis in interspecific hybrids of cotton (*Gossypium hirsutum* L. × *Gossypium barbadense* L.). *Journal of Pharmacognosy and Phytochemistry*, *6*(4), 804-810.

Hugar, A. A., Nidagundi, J. M., Yogesh, L. N., Hosamani, A., & Patil, J. (2020). Detection of high heterotic crosses for seed cotton yield and fibre quality traits in cotton (*Gossypium hirsutum* L.). *Journal of Farm Sciences*, *33*(3), 310-318.

ICAR-AICRP (Cotton). (2024). *Annual Report 2023-24*. ICAR - All India Coordinated Research Project on Cotton, Nagpur.

Keerthivarman, K., Mahalingam, L., Premalatha, N., Boopathi, N. M., Senguttuvan, K., & Manivannan, A. (2022). Combining ability and heterosis studies in cotton (*Gossypium hirsutum* L.) for yield and fibre quality traits. *Electronic Journal of Plant Breeding*, *13*(2), 697-704.

Kumar, A., Sangwan, O., Nirania, K. S., & Bankar, A. H. (2018). Heterosis for seed cotton yield and attributing traits in American cotton (*Gossypium hirsutum* L.). *Journal of Cotton Research and Development*, *32*(1), 63-67.

Kumar, M., Premalatha, N., Mahalingam, L., Sakthivel, N., Senguttuvan, K., & Latha, P. (2020). High density planting system of cotton in India: Status and breeding strategies. In I. Y. Abdurakhmonov (Ed.), *Plant Breeding* (p. 94905). IntechOpen. https://doi.org/10.5772/intechopen.94905

Lahane, P. A., Kolhe, A. V., Mohod, D. N., & Khandare, A. (2020). Effect of different spacing of *Bt* and non-*Bt* cotton hybrid on population of *P. gossypiella* under high density planting. *International Journal of Pure and Applied Biosciences*, *32*(5), 1-4.

Lekshmi, A. L., Kumar, M., Rajeswari, S., Raveendran, M., Uma, D., & Manickam, S. (2023). Assessment of heterotic potential and association analysis in direct and reciprocal hybrids for seed cotton yield and fiber quality traits involving lintless–fuzzless genotypes in upland cotton (*Gossypium hirsutum* L.). *Electronic Journal of Plant Breeding*, *14*(2), 410-418.

Lingaraja, L., Sangwan, R. S., Nimbal, S., Sangwan, O., & Singh, S. (2017). Heterosis studies for economic and fibre quality traits in line × tester crosses of upland cotton (*Gossypium hirsutum* L.). *International Journal of Pure and Applied Biosciences*, *5*(2), 240-248.

Lodam, V. A., Pathak, V. D., Patil, S. S., & Faldu, G. O. (2017). Improvement in lint yield and fibre quality traits in inter and intra-specific hybrids in American cotton. *Journal of*

Cotton Research and Development, *31*(2), 171-179.

Malathi, S., Patil, R. S., & Saritha, H. S. (2019). Heterosis studies in interspecific cotton hybrids (*G. hirsutum* L. × *G. barbadense* L.) under irrigated condition. *Electronic Journal of Plant Breeding*, *10*(2), 852-861.

Patel, C. T. (1981). Evolution of hybrid-4 cotton. *Current Science*, *50*(8), 343–346. http://www.jstor.org/stable/24083260

Prakash, G., & Korekar, S. L. (2017). Impact of planting density and growth regulators on *Bt* cotton (*Gossypium hirsutum* L.) hybrid yield and component traits. *Journal of Biosciences*, *5*(5), 1273-1278.

Rajashekar, J., Rajashekar, K., Lakshmi, K. V., & Chauhan, S. (2023). Studies on performance of *Bt* cotton hybrids against jassids (*Amrasca bigutulla bigutulla* Ishida) during summer season. *International Journal of Environmental and Climate Change*, *13*(12), 864-868.

Rani, S., Chapara, M., & Satish, Y. (2020). Heterosis for seed cotton yield and yield contributing traits in cotton (*Gossypium hirsutum* L.). *International Journal of Chemical Studies*, *8*(3), 2496-2500.

Revanasiddayya, & Patil, S. S. (2019). Extent of heterosis for seed yield and its contributing traits under full diallel mating of naked seeded types of cotton (*Gossypium hirsutum* L.). *Journal of Farm Sciences*, *32*(4), 393-396.

Shahzad, K., Li, X., Qi, T., Guo, L., Tang, H., Zhang, X., et al. (2019). Genetic analysis of yield and fiber quality traits in upland cotton (*Gossypium hirsutum* L.) cultivated in different ecological regions of China. *Journal of Cotton Research*, *12*(14).

Sivia, S. S., Siwach, S. S., Sangwan, R. S., Sangwan, O., & Nimbal, S. (2017). Genetic improvement through standard heterosis for seed cotton yield in upland cotton (*Gossypium hirsutum* L.). *Journal of Cotton Research and Development*, *31*(2), 164-170.

Solongi, N., Jatoi, W. A., Baloch, M. J., Siyal, M., Solangi, A. H., & Memon, S. (2019). Heterosis and combining ability estimates for assessing potential parents to develop F1 hybrids in upland cotton. *Journal of Animal and Plant Sciences*, *29*(5), 1362-1373.

Udaya, V., Saritha, H. S., & Patil, R. S. (2022). Heterosis studies for seed cotton yield and fibre quality traits in upland cotton (*Gossypium hirsutum* L.). *Indian Journal of Agricultural Research*, *57*(2), 150-154.

Verma, S. K., Kimar, R., Sain, S. K., Singh, A., Bagri, S., & Paul, D. (2024). Emerging challenges in cotton cultivation and strategies for improving productivity in the north zone of India. *Journal of Cotton Research and Development*, *38*(1), 7-18.

Wegier, A., Alavez, V., & Piñero, D. (2016). Cotton: Traditional and modern uses. In R. Lira, A. Casas, & J. Blancas (Eds.), *Ethnobotany of Mexico: Ethnobiology* (pp. 439-456). Springer. https://doi.org/10.1007/978-1-4614-6669-7_18

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/129645