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Extra-long staple inter-specific cotton hybrid Phule Shubhra (RHB-1623): A genetic and agronomic breakthrough in cotton cultivation

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Abstract

A comprehensive study on Phule Shubhra (RHB-1623), a novel hybrid cotton designed for extra-long staple length (ELS) cotton production, combining the genetic lineage of *Gossypium hirsutum* L. and *Gossypium barbadense* L. Through meticulous genetic characterization and agronomic evaluation, Phule Shubhra emerges as a standout choice for cotton cultivation, boasting high yield potential, superior fibre quality, and enhanced tolerance to sucking pests and bollworms. Notably, Phule Shubhra demonstrates consistent performance in higher seed cotton yield, boll weight and bolls per plant, coupled with ELS, favorable micronaire values, and robust bundle strength, positioning it as a top contender in fibre quality. Additionally, the hybrid exhibits commendable resistance to major diseases such as Alternaria Leaf Spot, Bacterial Leaf Blight, and Grey Mildew, along with varying levels of tolerance to insect pests. Detailed morphological characterization and DNA fingerprinting analysis, including SSR markers, further elucidate Phule Shubhra's distinctiveness and genetic inheritance, offering valuable insights for breeding and selection programs. In summary, Phule Shubhra represents a breakthrough in cotton agriculture, promising sustainable and profitable cultivation practices for growers in the Central zone.

Keywords: Phule Shubhra RHB-1623, cotton hybrid, genetic characterization, agronomic evaluation, high yield, ELS, pest tolerance, disease resistance

Introduction

Cotton stands as a cornerstone crop within the agricultural landscape of the Central zone, playing a pivotal role in both economic prosperity and agricultural sustainability. With its versatile applications ranging from textile production to oil extraction, cotton holds substantial socioeconomic importance for farmers and industries alike. The need for ELS cotton arises from the textile industry's continuous pursuit of superior quality fibre. ELS cotton, renowned for its exceptional length, strength, and fineness, meets the demands of various high-end textile products, including luxury apparel and premium linens. Its longer staple length not only enhances the durability and softness of fabrics but also enables the production of finer yarns, contributing to smoother textures and higher thread counts. Moreover, ELS cotton's distinctive properties offer manufacturers greater versatility in textile design and production, catering to discerning consumer preferences for luxurious, long-lasting textiles. Therefore, as the textile market evolves towards elevated standards of quality and sustainability, the integration of ELS cotton into cotton cultivation becomes increasingly imperative to meet the growing demand for premium textile products.¹Phule Shubhra (RHB-1623) exhibits optimal adaptation within the Central zone of the All India Coordinated Cotton Improvement Project (AICCIP), encompassing the states of Maharashtra, Madhya Pradesh, and Gujarat. This hybrid is particularly well-suited for cultivation under irrigated conditions prevalent in these regions. The Central zone, characterized by its diverse agro-climatic conditions ranging from semi-arid to sub-humid, provides an ideal environment for cotton cultivation under irrigation. Phule Shubhra (RHB-1623) thrives in this production ecology, leveraging its inherent genetic traits to maximize yield potential, enhance fibre quality, and withstand prevalent biotic and abiotic stressors.

With its adaptability to the specific agro-ecological conditions of the Central zone, this hybrid offers a promising solution to cotton farmers seeking sustainable and resilient crop management practices. By targeting the states of Maharashtra, Madhya Pradesh, and Gujarat, Phule Shubhra (RHB-1623) contributes to the advancement of cotton cultivation in key agricultural regions, thereby bolstering the socioeconomic prosperity of farming communities and fostering agricultural sustainability in the Central zone. The Central zone, characterized by its unique agro-climatic conditions and agricultural practices, cotton cultivation forms a vital component of the region's agricultural economy. However, the cultivation of cotton in this region is not devoid of challenges.

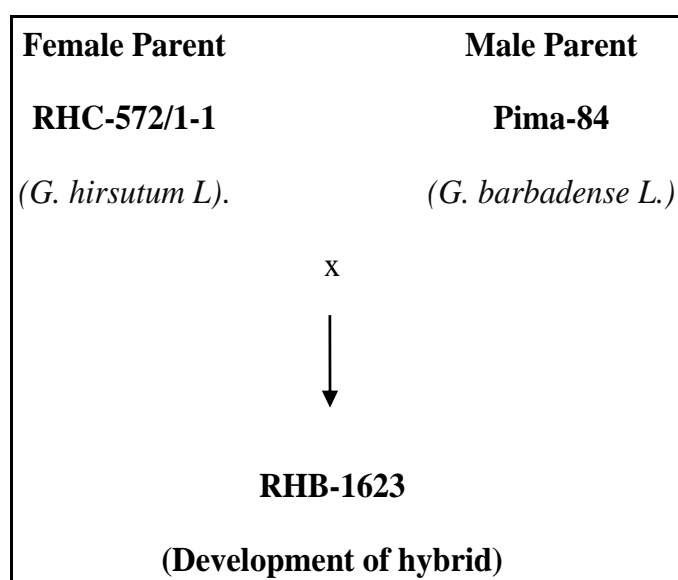
One of the foremost challenges faced by cotton farmers in the Central zone is the pervasive threat of pest infestations. Sucking pests such as aphids, jassids, and whiteflies, along with bollworms like the pink bollworm and American bollworm, pose significant risks to cotton yields by feeding on plant sap, flowers, and bolls, thereby reducing both yield and fibre quality.² These pests not only cause direct damage to cotton plants but also facilitate the transmission of devastating diseases such as cotton leaf curl virus, further exacerbating yield losses.³ Additionally, the textile industry's stringent requirements for high-quality fibre present another challenge for cotton farmers in the region. The demand for cotton with superior fibre properties, including length, strength, and fineness, necessitates the cultivation of varieties that can consistently meet these standards.³ However, achieving such high-quality fibre while simultaneously combating pest pressures remains a formidable task for many farmers in the Central zone. In light of these challenges, the introduction of novel cotton varieties tailored to the specific needs and conditions of the Central zone presents a promising avenue for enhancing productivity, resilience, and profitability for cotton farmers. Among these varieties, Phule Shubhra (RHB-1623) emerges as a beacon of innovation, offering a unique combination of high yield potential, superior fibre quality, and resilience to prevalent pests.

Background of Phule Shubhra (RHB-1623)

Phule Shubhra (RHB-1623) stands as a remarkable achievement in the realm of cotton breeding, heralding a new era of innovation and resilience in agricultural practices. Developed through meticulous research and breeding efforts under the aegis of the Cotton Improvement Project at Mahatma Phule Krishi Vidhyapeeth, Rahuri, this hybrid represents the culmination of years of dedicated work aimed at addressing the multifaceted challenges faced by cotton farmers in the Central zone. Rooted in a rich genetic lineage, Phule Shubhra (RHB-1623) is a hybrid derived from the cross between *Gossypium hirsutum* L. and *Gossypium barbadense* L., two distinct cotton species renowned for their unique agronomic traits and genetic diversity. The parentage of Phule Shubhra (RHB-1623), specifically RHC-0572/1-1 crossed with Pima-84, underscores the strategic utilization of heterosis breeding techniques to harness the complementary genetic traits inherent in both parental lines. The breeding objective behind the development of Phule Shubhra (RHB-1623) was ambitious yet targeted: to create a hybrid endowed with high and stable yields, excellent fibre properties, and robust resistance or tolerance to prevalent pests, including sucking pests, bollworms, and various diseases. This multifaceted breeding objective reflects a holistic approach aimed at enhancing the overall productivity, sustainability, and profitability of cotton cultivation in the Central zone. In comparison to existing varieties, Phule Shubhra (RHB-1623)

distinguishes itself through its unique combination of agronomic traits and genetic potential. While varieties such as Phule Dhara, Phule Prabha, DCH-32, and Phule-388 share certain general characteristics with Phule Shubhra (RHB-1623), it is the latter's superior performance and adaptability to the specific agro-climatic conditions of the Central zone that set it apart as a pioneering choice for cotton farmers seeking enhanced productivity and resilience. In essence, Phule Shubhra (RHB-1623) represents not only a significant advancement in cotton breeding but also a testament to the unwavering commitment of agricultural scientists and researchers towards addressing the evolving needs and challenges of cotton cultivation in the Central zone. As it takes its place among the ranks of distinguished cotton varieties, Phule Shubhra (RHB-1623) embodies the promise of a brighter, more sustainable future for cotton farming communities across the region.

Details of development of hybrid Phule Shubhra (RHB-1623)



Objectives of developing Phule Shubhra (RHB-1623)

The development of Phule Shubhra (RHB-1623) was driven by a comprehensive set of objectives aimed at addressing key challenges faced by cotton farmers in the Central zone while simultaneously enhancing productivity and sustainability. The primary objectives of developing this hybrid can be summarized as follows, with a strong emphasis on high yield, fibre quality, and pest tolerance:

- 1) **High Yield Potential:** Phule Shubhra (RHB-1623) was specifically bred to exhibit a robust yield potential, aiming to maximize cotton production in the Central zone. By incorporating genetic traits conducive to vigorous vegetative growth, optimized flowering, and bountiful boll development, this hybrid strives to deliver consistently high yields, thereby bolstering farmers' income and overall agricultural productivity.
- 2) **Superior Fibre Quality:** Recognizing the paramount importance of fibre quality in meeting the stringent standards of the textile industry, Phule Shubhra (RHB-1623) places a strong emphasis on producing cotton with exceptional fibre characteristics. Through meticulous breeding efforts, this hybrid aims to produce fibres characterized by their length, strength, fineness, and uniformity, ensuring premium quality output that commands a competitive edge in the market.

3) Pest Tolerance and Resistance: Pest infestations, particularly from sucking pests and bollworms, represent significant threats to cotton yield and quality in the Central zone. Therefore, Phule Shubhra (RHB-1623) was developed with a focus on incorporating genetic traits that confer tolerance or resistance to these prevalent pests. By reducing the susceptibility of the plant to pest damage, this hybrid offers farmers a more resilient and sustainable option for cotton cultivation, minimizing yield losses and the need for excessive pesticide applications.

By prioritizing these objectives, Phule Shubhra (RHB-1623) emerges as a multifaceted solution tailored to the specific needs and challenges of cotton farming in the Central zone. With its combination of high yield potential, superior fibre quality, and pest tolerance, this hybrid represents a significant advancement in cotton breeding, promising enhanced profitability, sustainability, and resilience for farmers in the region.

4) Key Features, Field Performance Adoption and Characteristics of Phule Shubhra: Phule Shubhra (RHB-1623) boasts a robust profile characterized by a suite of distinctive agronomic features and superior quality attributes, making it a standout choice for cotton cultivation in the Central zone. Here's a detailed description of the hybrid:

High Yield Potential: Phule Shubhra (RHB-1623)

The coordinated varietal trials conducted over three years (2018-19 to 2020-21) for Phule Shubhra (RHB-1623), a newly introduced cotton hybrid, in the Central zone under irrigated conditions. Across the three-year period, Phule Shubhra consistently demonstrated higher seed cotton yields compared to both the zonal check variety (Phule Dhara, Ck-1) and the local check variety (Ck-2). The mean seed cotton yield for Phule Shubhra over the three years was 1918 kg/ha, whereas the zonal check and local check varieties yielded 1689 kg/ha and 1326 kg/ha, respectively. Additionally, the data reveals Phule Shubhra's percentage increase or decrease in yield compared to the checks and a qualifying hybrid (RHB-1624) for each testing year, as well as its frequency in the top group of performers pooled over the three-year period. Overall, these results underscore Phule Shubhra (RHB-1623) as a genetically and agronomically superior cotton hybrid, exhibiting consistent high yields and competitive performance in the Central zone's irrigated production conditions. (Table 1)

Phule Shubhra (RHB-1623) is renowned for its remarkable yield potential, attributed to its robust genetics and agronomic traits. With consistently high boll weights and an increased number of bolls per plant, this hybrid ensures optimal cotton production per unit area. Through rigorous breeding and selection processes, Phule Shubhra has been developed to maximize yield, providing cotton farmers reliable and lucrative cultivation option. In the comparative analysis of boll weight across different varieties over three years of testing, Phule Shubhra (RHB-1623) consistently demonstrated competitive performance. Across the trials conducted from 2018 to 2021, Phule Shubhra maintained a mean boll weight of 3.00 grams, indicating its stable performance over time. Comparatively, the zonal check variety Phule Dhara exhibited a slightly higher mean boll weight of 3.17 grams, while the mean boll weight of all local check varieties was 2.93 grams. Phule Shubhra's boll weight was similar to that of the hybrid RHB-1624, which recorded a mean of 3.27 grams. When considering the percentage increase or decrease over the checks and qualifying varieties, Phule Shubhra showed minor

fluctuations. However, over the three-year period, Phule Shubhra displayed a slight decrease in boll weight compared to the overall mean, with a decrease of 5.3%.⁴ (Table 2) Despite this decrease, Phule Shubhra remained competitive in boll weight performance compared to other tested varieties.

The number of bolls per plant, a crucial indicator of cotton yield potential, was analyzed across different varieties over three years of testing. Phule Shubhra (RHB-1623) consistently demonstrated a higher number of bolls per plant, with averages of 48.7, 37.9, and 47.4 bolls /plant in 2018-19, 2019-20, and 2020-21 respectively, resulting in an overall mean of 44.67 bolls/plant. In comparison, the zonal check Phule Dhara and the mean of all local checks showed slightly lower averages across the testing period, with overall means of 43.03 and 38.87 bolls/plant, respectively. RHB-1624 also exhibited competitive performance, with an overall mean of 42.33 bolls/plant. These findings highlight Phule Shubhra's superior yield potential compared to standard checks and qualifying varieties, positioning it as a promising option for cotton cultivation due to its consistently higher boll production.⁴ (Table 3)

Superior Fibre Quality

Span Length (SL): A comprehensive analysis of the 2.5% Span Length (SL) of different cotton varieties, with a particular focus on Phule Shubhra (RHB-1623), showcasing its superior fibre quality. Span Length refers to the average length of fibres within the longest 2.5% of fibres in a cotton sample, making it a crucial metric for assessing fibre quality. Across the three years of testing, Phule Shubhra consistently exhibited higher 2.5% SL values compared to the zonal check Phule Dhara and the mean of all local checks as well as RHB-1624. Specifically, in 2018-19, Phule Shubhra demonstrated a 2.5% SL of 36.4 mm, surpassing the other varieties. This trend continued over subsequent years, with Phule Shubhra maintaining its superiority in fibre quality. The overall mean 2.5% SL for Phule Shubhra over the three years was 35.17 mm, indicating its consistent excellence in producing longer and higher-quality fibres. Percentage comparisons reveal consistent increases in 2.5% SL for Phule Shubhra compared to the checks and qualifying varieties, reaffirming its status as a superior choice for cotton cultivation.⁴ These findings underscore Phule Shubhra's remarkable fibre quality attributes, positioning it as a top contender for farmers seeking high-quality cotton varieties with desirable fibre characteristics. (Table 4)

Micronaire: It is a critical indicator of cotton fibre quality, across different cotton varieties over three years of testing, with a focus on comparing Phule Shubhra (RHB-1623) with other varieties. Micronaire measures the fineness and maturity of cotton fibres, influencing aspects such as spinning performance and fabric quality. Phule Shubhra consistently exhibited favorable Micronaire values compared to the zonal check Phule Dhara, the mean of all local checks, and RHB-1624 (Qual. Var.1) across the testing period. For example, in 2018-19, Phule Shubhra had a Micronaire value of 4.0, which was higher than the other varieties. This trend continued in subsequent years, with Phule Shubhra consistently maintaining higher Micronaire values. The overall mean Micronaire for Phule Shubhra over the three years was 3.6, indicating its superior fibre quality in terms of fineness and maturity. Percentage comparisons reveal consistent increase in Micronaire for Phule Shubhra compared to the checks and qualifying varieties, highlighting its superiority.⁴ these findings underscore Phule Shubhra's exceptional fibre quality attributes, positioning it as an excellent choice for cotton

cultivation, particularly for producers prioritizing high-quality fibre characteristics. (Table 5)

Bundle strength: Cotton fibre quality refers to the capacity of fibre bundles to withstand tension, measured in grams per tex (g/tex). This metric is fundamental in assessing the mechanical properties of cotton fibres, which play a pivotal role in various textile applications. The table presents comprehensive data on bundle strength across different cotton varieties over a three-year testing period, with a primary focus on contrasting Phule Shubhra (RHB-1623) with other varieties. Notably, Phule Shubhra consistently demonstrates superior bundle strength values compared to the zonal check Phule Dhara (Ck-1), the mean of all local checks (Ck-2), and RHB-1624 (Qual. Var.1) throughout the evaluation period. For instance, in 2018-19, Phule Shubhra exhibited a bundle strength of 33.6 g/tex, surpassing its counterparts. This trend persists across subsequent years, with Phule Shubhra consistently maintaining higher bundle strength values. The cumulative average bundle strength for Phule Shubhra over the three-year period stands at 32.5 g/tex, indicative of its robust structural integrity and resilience. Percentage comparisons reveal a consistent ascendancy in bundle strength for Phule Shubhra relative to the reference varieties, accentuating its exceptional fibre quality. ⁴These findings affirm Phule Shubhra's merit as a superior cotton hybrid, particularly favored by growers prioritizing fibres endowed with strength and durability for various textile applications. (Table 6)

Strength/length: Strength/length ratio is a key metric used to evaluate the relationship between fibre strength and length in cotton. It reflects the strength of the fibres relative to their length, providing insights into the overall fibre quality. The table presents data on the strength/length ratio across different cotton varieties over two years of testing, with a particular emphasis on comparing Phule Shubhra (RHB-1623) with other varieties. Throughout the evaluation period, Phule Shubhra consistently demonstrates strength/length ratios comparable to the zonal check Phule Dhara (Ck-1), the mean of all local checks (Ck-2), and RHB-1624 (Qual. Var.1). For instance, in 2019-20 and 2020-21, Phule Shubhra exhibits strength/length ratios of 85.0 and 83.0, respectively, aligning closely with the other varieties. The overall mean strength/length ratio for Phule Shubhra over the two-year period stands at 84.0, indicating a balanced relationship between fibre strength and length. Percentage comparisons reveal minimal fluctuations in the strength/length ratio for Phule Shubhra compared to the reference varieties, with slight increases or decreases over the checks and qualifying varieties. ⁴ These findings underscore Phule Shubhra's commendable fibre quality characteristics, positioning it as a reliable choice for cotton cultivation, particularly favored by growers seeking fibres with a balanced combination of strength and length for textile manufacturing processes. (Table 7)

Disease and Pest Tolerance

The tolerance of the cotton hybrid, Phule Shubhra (RHB-1623), to major diseases across different trial locations and years of testing. This comprehensive assessment is crucial for understanding the hybrid's disease resistance profile, particularly in the Central zone under irrigated conditions, lists three major diseases: Alternaria Leaf Spot (ALB), Bacterial Leaf Blight (BLB), and Grey Mildew, evaluated over the years 2019-20 and 2020-21. Each disease's severity is scored on a scale, with higher numbers indicating greater resistance or reduced severity. For ALB, Phule Shubhra consistently exhibits favorable resistance

scores across trial locations and years, with generally lower scores compared to the zonal check (DCH-32), local checks, and qualifying hybrids/varieties. This suggests that Phule Shubhra demonstrates strong resistance to Alternaria Leaf Spot, making it a reliable choice for growers in areas prone to this disease. Similarly, for BLB, Phule Shubhra maintains commendable resistance scores, particularly in Guntur and Dharwad trial locations. Despite slight variations, its resistance remains notably higher compared to the other varieties tested, indicating robust protection against Bacterial Leaf Blight. Regarding Grey Mildew, the data suggest minimal to no incidence of this disease across trial locations and years for Phule Shubhra, reinforcing its resilience to Grey Mildew infection.

Overall, (Table 9) underscores Phule Shubhra's impressive disease resistance profile, particularly against major cotton diseases prevalent in the Central zone under irrigated conditions. This robust resistance trait enhances the hybrid's suitability for cultivation, promising better yield protection and sustainability for cotton growers in the region.

Resistance of the cotton hybrid, Phule Shubhra (RHB-1623), to major insect pests across different trial locations and years of testing the hybrid's susceptibility or resistance to insect damage, particularly in the Central zone under irrigated conditions. For Jassid Injury Grade, Phule Shubhra demonstrates varying levels of susceptibility across trial locations and years. In Banswara during 2018-19, the hybrid exhibited moderate to severe injury grades, similar to the zonal check Phule Dhara, while in Rahuri, the injury grades were generally lower. However, in 2019-20, the severity of Jassid injury increased across all locations for both Phule Shubhra and the reference varieties. In terms of the number of Jassids per 3 leaves, Phule Shubhra generally shows comparable or lower infestation levels compared to the reference varieties, indicating its potential for reduced susceptibility to Jassid infestation. Similarly, for Whitefly and Thrips infestations, Phule Shubhra exhibits varying degrees of susceptibility across locations and years, with infestation levels comparable to or lower than the reference varieties. Regarding Aphids, Phule Shubhra demonstrates a notable reduction in infestation levels compared to the reference varieties, particularly in Banswara during both testing years. For boll damage caused by *P. gossypiella* and locule damage in open bolls, Phule Shubhra generally exhibits lower damage percentages compared to the reference varieties, indicating its potential for reduced susceptibility to these pests. Overall, while Phule Shubhra shows varying levels of susceptibility to major insect pests across different trial locations and years, it generally demonstrates comparable or lower infestation levels compared to the reference varieties. This suggests that Phule Shubhra possesses some degree of resistance or tolerance to these insect pests, making it a promising choice for cultivation in the Central zone under irrigated conditions.

Distinguishing Morphological Characters

The hybrid showcases a range of morphological characteristics, meticulously documented according to the DUS test guidelines, ensuring accurate identification and classification a comprehensive comparison of morphological characteristics among a hybrid (RHB-1623) and its female and male parent lines (RHC-572/1-1 and Pima-84, respectively). These morphological traits are meticulously documented in accordance with the DUS (Distinctiveness, Uniformity, and Stability) test guidelines, ensuring accurate identification and classification. Noteworthy characteristics include hypocotyl pigmentation, leaf color, hairiness, appearance, presence of gossypol glands and

nectaris, petiole pigmentation, leaf shape, stem hairiness and pigmentation, plant height, growth habit, bract type, flowering time, petal color and spot, stigma position, anther filament coloration, pollen color, male sterility, boll bearing habit and traits such as color, shape, surface, prominence of tip, opening, and weight, seed fuzz and fuzz color, seed index, ginning percentage, fibre color, length, strength, fineness (measured by Micronaire value), uniformity, and maturity.

Each characteristic is scored or described for the hybrid and parent lines, allowing for a thorough evaluation of their distinctiveness and similarity. This meticulous documentation ensures accurate identification and classification of the hybrid and facilitates comparisons with its parental lines, aiding in breeding and selection processes for cotton improvement. (Table 8)

DNA fingerprinting analysis using SSR markers

Insights from DNA fingerprinting analysis using SSR markers reveal polymorphism between the parental lines and the hybrid Phule Shubhra (RHB-1623). Specifically, the SSR marker "1091" exhibited allelic variation, with the female parent of Phule Shubhra showing an allele size of approximately 190 bp and the male parent showing an allele size of around 110 bp. Interestingly, both alleles (190/110 bp) were present in the hybrid Phule Shubhra, indicating genetic inheritance from both parental lines. This analysis provides valuable genetic insights into the hybridization process and the inheritance of desirable traits in Phule Shubhra, contributing to a better understanding of its genetic makeup and potential for trait improvement in future breeding programs. (Fig-1)

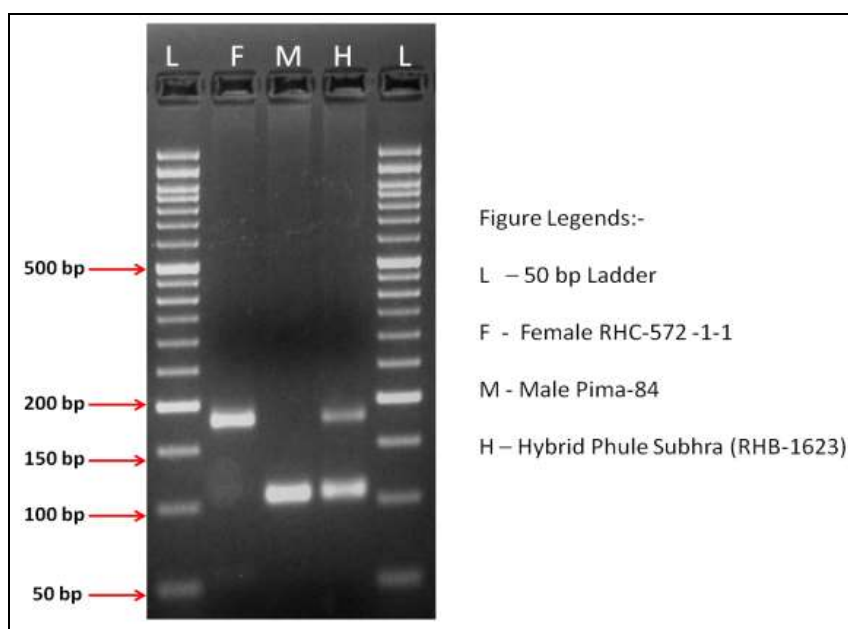


Fig 1: Agarose gel image showing DNA Fingerprinting of cotton Hybrid "PHULE SUBRA" with SSR marker 1091.

Advantages for Farmers in the Central zone

Phule Shubhra (RHB-1623) stands as an extra-long staple interspecific cotton hybrid tailored for cultivation in irrigated conditions across the central zone of India, spanning Maharashtra, Madhya Pradesh, and Gujarat. This hybrid encompasses a suite of advantageous traits that directly address pivotal challenges encountered in cotton farming within the region. Its high yield potential ensures heightened productivity, enabling farmers to reap greater profits from their yields. Complemented by exceptional fibre quality, Phule Shubhra commands premium prices in the textile market, augmenting farmers' income streams. Furthermore, its resilience to sucking pests and bollworms curtails the necessity for extensive pesticide application, thereby trimming production costs and reducing environmental footprint. By fostering stability in yields and safeguarding against pest-related losses, Phule Shubhra fortifies farmers' investments. Its adaptability to the diverse climatic conditions and agronomic practices prevalent in the central zone enhances its suitability for cultivation, furnishing farmers with a dependable and sustainable cotton hybrid. In essence, Phule Shubhra (RHB-1623) emerges as a pivotal solution for cotton farmers, offering prospects for enhanced profitability and sustainability through its amalgamation of high yield potential, superior fibre quality, pest tolerance, and adaptability to regional conditions.

Future Implications and Recommendations

Phule Shubhra (RHB-1623) presents a transformative potential for the cotton industry, particularly in the central zone and beyond. Engineered to combat prevalent pests like aphids, jassids, whiteflies, and bollworms while enhancing fibre quality, this hybrid promises increased yields and reduced pesticide dependency. Its superior fibre attributes align with textile industry standards, ensuring premium market prices. Beyond the central zone, Phule Shubhra sets a benchmark for innovation in cotton breeding globally, contributing to stable global cotton supply chains and sustainable textile production.

Recommendations for further research or adoption strategies to maximize the benefits of this hybrid

- 1. Optimization of Agronomic Practices:** Research precision agriculture techniques tailored to Phule Shubhra, integrating biotechnological tools like remote sensing and drone technology for real-time monitoring and management.
- 2. Refinement of Breeding Techniques:** Utilize biotechnological tools such as marker-assisted selection and genomic editing to expedite the development of Phule Shubhra variants with enhanced traits like pest resistance and fibre quality.
- 3. Assessment of Environmental Impact:** Employ molecular and genetic analyses to evaluate Phule Shubhra's ecological

footprint, including its effects on soil health, water usage, and biodiversity.

4. Stakeholder Collaboration and Knowledge Sharing:

Foster interdisciplinary collaboration between researchers,

policymakers, farmers, and biotech experts to facilitate knowledge exchange and technology transfer, ensuring effective integration of biotechnological approaches in cotton farming practices.

Table 1: Yield Performance Analysis of Phule Shubhra (RHB-1623) in Coordinated Varietal Trials: Central zone, Irrigated Conditions (2018-2021)

	Year of testing	No. of trials	Proposed hybrid RHB-1623	Zonal check Phule Dhara (Ck-1)	Mean of all Local check (Ck-2)	RHB-1624 (Qual. Var.1)
Seed Cotton yield (kg/ha)	2018-19	3	2549.0	2074.0	1351.0	2612.0
	2019-20	3	1672.0	1668.0	1593.0	1599.0
	2020-21	3	1535.0	1325.0	1035.0	1376.0
Overall Mean	3 Years	9	1918	1689	1326	1862
% Increase /decrease over the checks and qualifying varieties	2018-19		-	22.9	88.7	-2.4
	2019-20		-	0.2	5.0	4.6
	2020-21		-	15.8	48.3	11.6
Inc/dec over overall mean of 2 Year				13.6	44.7	3.0
Frequency in the top group (pooled over 3 years)	3 Years		-	7/10	9/10	5/10

Table2: Comparison of Boll Weight among Cotton Varieties.

	Year of testing	No. of trials	hybrid RHB-1623	Zonal check Phule Dhara (Ck-1)	Mean of all Local check (Ck-2)	RHB-1624 (Qual. Var.1)
Boll wt.(g)	2018-19	3	3.4	3.5	3.1	3.8
	2019-20	3	2.9	3.0	2.6	3.1
	2020-21	3	2.7	3.0	3.1	2.9
Overall Mean	3 Years	9	3.00	3.17	2.93	3.27
% increase /decrease over the checks and qualifying varieties	2018-19			-2.9	9.7	-10.5
	2019-20			-3.3	11.5	-6.5
	2020-21			-10.0	-12.9	-6.9
Inc/dec over overall mean 3 Year	3 Years			-5.3	2.3	-8.2

Table 3: Comparative Analysis of Boll Yield across Cotton Varieties: Assessing Phule Shubhra's Superiority in Yield Potential

Bolls/Plant	Year of testing	No. of trials	Hybrid RHB-1623	Zonal check Phule Dhara (Ck-1)	Mean of all Local check (Ck-2)	RHB-1624 (Qual. Var.1)
No. of Bolls/plant	2018-19	3	48.7	46.5	41.2	46.5
	2019-20	3	37.9	42.0	37.2	38.5
	2020-21	3	47.4	40.6	38.2	42.0
Overall Mean	3 Years	9	44.67	43.03	38.87	42.33
% increase /decrease over the checks and qualifying varieties	2018-19			4.7	18.2	4.7
	2019-20			-9.8	1.9	-1.6
	2020-21			16.7	24.1	12.9
Inc/dec over overall mean 3 Years	3 Years			3.8	14.9	5.5

Table 4: Assessment of Span Length Fibre Quality Across Cotton Varieties: Highlighting Phule Shubhra's Superiority

	Year of testing	No. of trials	RHB-1623	Zonal check Phule Dhara (Ck-1)	Mean of all Local check (Ck-2)	RHB-1624 (Qual. Var.1)
2.5% Span Length (mm)						
2.5% SL	2018-19	3	36.4	35.5	35.9	36.4
	2019-20	3	35.8	35.0	35.7	34.6
	2020-21	3	33.3	32.4	33.0	33.2
Overall Mean	3 Years	9	35.17	34.30	34.87	34.73
% increase /decrease over the checks and qualifying varieties	2018-19			2.5	1.4	0.0
	2019-20			2.3	0.3	3.5
	2020-21			2.8	0.9	0.3
Inc/dec over overall mean	3 Years			2.5	0.9	1.3

Table 5: Comparative Analysis of Micronaire Fibre Quality Across Cotton Varieties: Evaluating Phule Shubhra's Superiority

	Year of testing	No. of trials	RHB-1623	Zonal check Phule Dhara (Ck-1)	Mean of all Local check (Ck-2)	RHB-1624 (Qual. Var.1)
Micronaire	2018-19	3	4.0	3.7	3.9	3.5
	2019-20	3	3.6	3.6	3.4	3.2
	2020-21	3	3.1	3.2	2.8	3.0
Overall Mean	3 Years	9	3.6	3.5	3.4	3.2
% increase /decrease over the checks and qualifying varieties	2018-19			8.1	2.6	14.3
	2019-20			0.0	5.9	12.5
	2020-21			-3.1	10.7	3.3
Inc/dec over overall mean	3 Years			1.7	6.4	10.0

Table 6: Comparative Analysis of Bundle Strength in Cotton Varieties: Evaluating Phule Shubhra's Superior Fibre Integrity

	Year of testing	No. of trials	RHB-1623	Zonal check Phule Dhara (Ck-1)	Mean of all Local check (Ck-2)	RHB-1624 (Qual. Var.1)
Strength	2018-19	3	33.6	32.3	33.3	33.5
	2019-20	3	33.9	33.4	36.0	33.8
	2020-21	3	30.0	29.7	28.7	29.0
Overall Mean	3 Years	9	32.5	31.8	32.7	32.1
% increase /decrease over the checks and qualifying varieties	2018-19		-	4.0	0.9	0.3
	2019-20		-	1.5	-5.8	0.3
	2020-21		-	1.0	4.5	3.4
Inc/dec over overall mean	3 Years		-	2.2	-0.1	1.3

Table 7: -Comparative Analysis of Strength/ length ratio in Cotton Varieties: Evaluating Phule Shubhra's Superior Fibre Integrity

	Year of testing	No. of trials	RHB-1623	Zonal check Phule Dhara (Ck-1)	Mean of all Local check (Ck-2)	RHB-1624 (Qual. Var.1)
Strength/ length ratio	2019-20	3	85.0	85.0	85.0	85.0
	2020-21	3	83.0	82.0	84.0	84.0
Overall Mean	2 Years	6	84	83.5	84.5	84.5
% increase /decrease over the checks and qualifying varieties	2019-20			0.0	0.0	0.0
	2020-21			1.2	-1.2	-1.2
Inc/dec over overall mean	2 Years			0.6	-0.6	-0.6

Table 8: Distinguishing morphological characters of hybrid and parents.

SN	Characteristics	Hybrid RHB-1623		Female parent RHC- 572/1-1		Male Parent Pima-84	
1.	Hypocotyl : Pigmentation	9	Present	9	Present	9	Present
2.	Leaf : Colour	2	Green	2	Green	1	Light Green
3.	Leaf : Hairiness	2	Medium	2	Medium	1	Sparse
4.	Leaf : Appearance	1	Cup	2	Flat	1	Cup
5.	Leaf : gossypol glands	9	Present	9	Present	9	Present
6.	Leaf : Nectaris	9	Present	9	Present	9	Present
7.	Leaf : Petiole Pigmentation	9	Present	9	Present	9	Present
8.	Leaf : Shape	2	Semi digitate (Semi Okra)	1	Palmate (Normal)	2	Semi digitate (Semi Okra)
9.	Plant : Stem Hairiness	3	Sparce	2	Medium	1	Smooth
10.	Plant : Stem Pigmentation	9	Present	9	Present	9	Present
11.	Plant : Height	9	Very Tall	7	Tall	5	Medium Tall
12.	Plant : Growth Habit	7	Spreading	5	Semi Spreading	5	Semi Spreading
13.	Bract : Type	3	Normal	3	Normal	3	Normal
14.	Flower: Time of 50% Flowering	7	Late	5	Medium	7	Late
15.	Flower : Petal colour	2	Yellow	1	Cream	3	Deep Yellow
16.	Flower : Petal Spot	9	Present	1	Absent	9	Present
17.	Flower : Position of Stigma	5	Exerted	3	Embedded	5	Exerted
18.	Flower : Anther Filament Colouration	1	Absent	1	Absent	1	Absent
19.	Flower : Pollen colour	4	Deep Yellow	3	Yellow	4	Deep Yellow
20.	Flower: Male sterility	1	Absent	1	Absent	1	Absent
21.	Boll : Bearing habit	1	Solitary	1	Solitary	1	Solitary
22.	Boll : Colour	3	Green	3	Green	3	Green
23.	Boll : Shape Longitudinal Section	7	Elliptic	5	Ovate	7	Elliptic
24.	Boll : Surface	9	Pitted	1	Smooth	9	Pitted
25.	Boll : Prominence of Tip	9	Pointed	9	Pointed	9	Pointed
26.	Boll : Opening	9	Open/semi-open	5	Open	3	Semi-Open
27.	Boll : Weight	3	Small	5	Medium	3	Small
28.	Seed: Fuzz	5	Medium	7	Dense	1	Naked
29.	Seed : Fuzz Colour	3	Green	2	Gray	3	Green

30.	Seed Index	7	Bold	7	Bold	7	Bold
31.	Ginning %	1	Very low	5	Medium	3	Very Low
32.	Fibre : Colour	1	White	1	White	1	White
33.	Fibre : Length (SL)	9	Extra Long	7	Long	9	Extra Long
34.	Fibre : Strength S (3.2m)	7	Strong	5	Medium	7	Strong
35.	Fibre : Fineness (MIC) (Micronaire Value)	7	Fine	7	Fine	9	Very Fine
36.	Fibre: Uniformity (%)	5	Good	7	Good	5	Average
37.	Fibre: Maturity (%)	9	Very Good	7	Good	9	Very Good

Table 9: Comparison of Disease Resistance RHB-1623 Levels in Cotton Varieties Across Trial Locations and Years of Testing

Year of Testing	Trial Locations	hybrid RHB-1623	Zonal Check DCH-32	Local Checks	Quality. hybrid RHB-1624	Quality. hybrid / DHB-1002
A. ALB (Alternaria Leaf Spot)						
2019-20	Guntur	1	1	1	2	1
	Dharwad	4	4	4	4	4
	Coimbatore	1	1	1	1	1
2020-21	Dharwad	22.5	22.5	22.5	22.3	--
	Coimbatore	11.5	11.4	11.4	11.5	--
B. Bacterial Leaf Blight (BLB)						
2019-20	Guntur	3	1	1	1	1
	Dharwad	4	3	3	4	4
	Coimbatore	0	0	0	0	0
2020-21	Dharwad	23.3	19.4	22.5	18.4	-
C. Grey Mildew						
2019-20	Guntur	1	2	2	2	1
	Dharwad	0	0	0	0	0
	Coimbatore	-	-	-	-	-
2020-21	Dharwad	0	0	0	0	0

Conclusion

Phule Shubhra (RHB-1623) emerges as a pivotal solution for cotton farmers in the central zone, offering prospects for enhanced profitability and sustainability. Tailored for cultivation in irrigated conditions across Maharashtra, Madhya Pradesh, and Gujarat, this extra-long staple interspecific cotton hybrid directly addresses pivotal challenges encountered in the region's cotton farming. With its high yield potential and exceptional fibre quality, Phule Shubhra enables farmers to reap greater profits while reducing environmental impact through decreased pesticide application. Its resilience to sucking pests and bollworms fortifies farmers' investments, fostering stability in yields. Additionally, Phule Shubhra's adaptability to diverse climatic conditions enhances its suitability for cultivation, promising sustainable and profitable cotton farming practices. The thorough documentation of Phule Shubhra's traits and DNA analysis provides valuable insights into its genetic makeup, contributing to future breeding efforts. Encouraging farmers to adopt Phule Shubhra is essential for unlocking its potential to enhance productivity and sustainability in cotton cultivation, positioning it as a transformative solution in the agricultural landscape.

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