Reviving Cotton in North India: High-Tech Regenerative Farming (*Kharif* 2024-25)

A Breakthrough in Regenerative Cotton Farming

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Foreword

Cotton has long been the lifeline of India's textile and agricultural economy, sustaining 70 lakh farm families and driving a vast network of textile industry across North, Central and South cotton growing zones. However, in recent years, cotton cultivation, especially in North India, has been increasingly challenged by declining productivity, mounting pest pressures, climate uncertainties, and unsustainable farming practices. As a scientist deeply committed to the progress of India's cotton sector, I have always believed that the innovation, science-led advancements, and farmer-centric strategies are the pillars of a resilient and profitable cotton farming system. For that matter, I as a director of ICAR-CICR had spearheaded innovative insect resistant Bt cotton and carried out rigorous scientific evaluation for biosafety, efficacy and field performance before it was commercialized in 2002. Subsequently, we standardized the cotton production technology and the opportunity for pan-India stewardship under the aegis of the Technology Mission on Cotton when I became the Agriculture Commissioner, Government of India. Later, I facilitated a pan India program to build confidence amongst farmers to adopt the innovative cotton practices including the high-density planting system (HDPS), organic cotton cultivation, deployment of mating disruption PBKnot technology and scientific outreach for effective management of pink bollworm. Our collective and concerted efforts at ICAR-CICR and South Asia Biotechnology Centre (SABC) resulted in increasing cotton yield from around 300 kg lint per hectare to more than 550 kg lint per hectare and enhancing the supply of cotton from 13 million bales in 2002-03 to 39.8 million bales in 2014-15 before settling it down to 30 million bales by 2024-25.

The high-tech regenerative cotton farming demonstrated by SABC with the help of PI Foundation under technical guidance of ICAR-CICR is a path forward for technology led trajectory of cotton production in India. The publication "**Reviving Cotton in North India: High-Tech Regenerative Farming (*Kharif* 2024-25)**, aptly described as '**A Breakthrough in Regenerative Cotton Farming**', is a landmark effort to address the future need of cotton while tackling pressing climatic challenges. The publication underscores the pivotal role of high-tech regenerative practices in revitalizing cotton farming. By integrating modern solutions such as precision irrigation, integrated pest management, and improved agronomic practices, this publication offers a roadmap to transform cotton production in the North cotton growing zone. Importantly, the insights based on field generated data presented in this publication are not just theoretical but are backed by rigorous scientific validation and extensive on-field experiences.

For India to maintain its leadership in the global cotton industry, the high-tech regenerative cotton innovations must be at the forefront. Enhancing productivity while conserving natural resources is the need of the hour. This publication stands as an invaluable resource for farmers, researchers, and policymakers, providing actionable insights into climate-resilient, technology-driven solutions that can rejuvenate declining production in North India's cotton belt.

My sincere greetings to the authors for their dedication and vision in bringing this critical work to fruition. I am confident that the knowledge shared in this publication on regenerative practices will be imbibed during the implementation of the Technology Mission on Cotton (TMC 2.0) and inspire further breakthroughs in cotton research and empower farmers to adopt progressive, science-based practices, ensuring a prosperous and sustainable future for Indian cotton.

Dr CD Mayee

Former Chairman, Agricultural Scientists Recruitment Board (ASRB) of the Govt of India

&

President of South Asia Biotechnology Centre (SABC), Jodhpur & ISCI, Mumbai

Preface

Cotton, often referred to as the *"white gold"* of India, has played an integral role in shaping North India's agricultural landscape for decades. It has been a primary source of livelihood for millions of farmers and a cornerstone of North India's thriving textile industry clustered around Ludhiana in Punjab, Hisar in Haryana and Bhilwara in Rajasthan. However, in recent decades, cotton cultivation in the region has faced unprecedented challenges, including declining productivity, soil degradation, erratic climatic patterns, and devastating pest infestations - most notably the widespread outbreak of pink bollworm (PBW) and whitefly, and notable incidence of diseases including para wilt, root rot and boll rot. These challenges have been further exacerbated by conventional farming practices, excessive reliance on chemical inputs, and inefficient water management, all of which have led to dwindling profits and increased risks for cotton farmers.

Recognizing the urgent need for a paradigm shift towards scientifically backed, sustainable, and technology-driven solutions, the North India High-Tech Regenerative Cotton Demonstration was launched as part of "Project Bandhan - A Knot of PBW Protection". This pioneering initiative, spearheaded by the South Asia Biotechnology Centre (SABC), Jodhpur, with the support of the PI Foundation and under the technical guidance of the ICAR-Central Institute of Cotton Research (CICR), Nagpur, was implemented during *Kharif* 2024-25 in Gindran village, Sirsa district, Haryana. The large-scale demonstration was designed to introduce and validate regenerative cotton farming practices, ensuring increased productivity while promoting environmental sustainability. Moreover, the introduction of high-tech regenerative cotton farming represents a significant milestone in the sustainability of cotton farming, blending advanced agricultural practices coupled with sustainability measures which are increasingly becoming a prerequisite in the international trade in cotton, by-products and cotton-based textile.

This publication, **"Reviving Cotton in North India: High-Tech Regenerative Farming (*Kharif* 2024-25)"**, tagged as **"A Breakthrough in Regenerative Cotton Farming"** presents the remarkable transformation achieved through modern agronomic interventions under the regenerative farming system. It highlights innovative planting methods approaches and technological breakthroughs such as:

- Precision drip irrigation and fertigation to enhance water and nutrient efficiency

- Integrated pest management (IPM) leveraging pheromone-based PBKnot technology, yellow sticky traps, and biocontrol methods to combat PBW and other pests effectively
- Integrated disease management (IDM) strategies to mitigate para wilt, boll rot, and root rot, using resistant cotton varieties and sustainable practices, and
- Mechanized and scientific approaches to improve plant health, fiber quality, and overall economic returns.

The outcomes of the high-tech demonstration were truly groundbreaking. Not only did the demonstration plots achieve higher yields and superior fiber quality, but they also recorded significant reductions in resource consumption and environmental impact on multiple parameters. The insights presented in this publication serve as a blueprint for policymakers, researchers, extension officers, and farmers striving to adopt climate-resilient, resource-efficient cotton cultivation in North India. By integrating scientific advancements with on-ground evidence, this work underscores the transformative potential of high-tech, sustainable farming solutions in revitalizing cotton farming.

We hope this publication serves as a valuable resource and inspiration for all stakeholders in the cotton value chain. The journey to reviving cotton in North India has begun, and with collaborative efforts and sustained innovation, we can build a more resilient, prosperous, and sustainable future for cotton farmers and the industry.

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Executive Summary

Keeping in view to promote sustainable practices over traditional cotton cultivation methods, the North India high-tech cotton demonstration was laid out by South Asia Biotechnology Centre (SABC), Jodhpur as part of Project Bandhan – A Knot of PBW Protection supported by PI Foundation under the technical guidance of ICAR- Central Institute of Cotton Research (CICR), Nagpur at village Gindran, Rania tehsil of Sirsa district, Haryana in *Kharif*, 2024-25. The high-tech regenerative cotton demonstration focused on enhancing yields in the North cotton growing zone by showcasing regenerative cotton cultivation practices and cutting-edge production technologies. The demonstration integrated advanced cotton crop production and protection strategies to optimize resource use efficiency by incorporating precision drip irrigation and fertigation systems, utilizing the latest water-soluble fertilizers for enhanced nutrient uptake and water conservation, integrated pest management (IPM) techniques, including PBKnot mating disruption technology and pheromone based monitoring traps for effective management of pink bollworm and installing yellow sticky traps for monitoring and managing whitefly and aphid populations. Two conventional cotton farms were established adjacent to the high-tech regenerative cotton demonstration to compare and scientifically evaluate the performance of four different planting methods and technological interventions. Moreover, key stakeholders from public and private sector institutions closely monitored the high-tech regenerative cotton demonstration throughout the season, and collection of scientific data with different parameters was collected and worked out.

Notably, the high-tech regenerative cotton demonstration during *Kharif*, 2024-25 showcased several innovative technological advancements aimed at enhancing sustainability, productivity, and environmental responsibility in cotton production in the North cotton growing zone. The key advancements demonstrated include improved irrigation systems, integrated nutrient management, advanced pest control strategies, and disease management approaches.

1. Advanced Irrigation Method

Efficient water management is crucial for sustainable agriculture, particularly in cotton cultivation, which requires significant water input. The adoption of drip irrigation technology has revolutionized water utilization by delivering moisture directly to the plant roots, thus reducing wastage and adapting to erratic rainfall patterns. The precision irrigation by drip method allows farmers to maintain optimal soil moisture levels, ensure precise fertilizer application and minimize nitrogen leaching and reduces nitrous oxide emissions thus enhancing soil health contributing to climate change mitigation.

2. Integrated Nutrient Management (INM)

Nutrient management plays a pivotal role in improving cotton yield and fiber quality. The integrated nutrient management (INM) strategy demonstrated during the demonstration combines high-quality water-soluble macro and micronutrients from Yara Fertilizers by both placement and foliar application methods to enhance soil fertility and nutrient availability resulting in higher yields and superior fiber quality. The approach minimizes the overuse of chemical fertilizers, thereby reducing environmental risks such as soil degradation and water contamination.

3. Integrated Pest Management (IPM)

Cotton production is highly vulnerable to pest infestations, necessitating sustainable pest management strategies. The integrated pest management (IPM) approach demonstrated at the high-tech cotton demonstration focuses on eco-friendly pest control techniques, including pheromone and sticky traps for timely monitoring of pink bollworm and sucking pests, and mating disruption PBKnot technology to manage pink bollworm.

4. Integrated Disease Management (IDM)

The outbreaks of para wilt, boll rot and root rot have caused severe yield losses in North cotton growing region and therefore the integrated disease management (IDM) approach demonstrated at the high-tech cotton demo emphasizes preventive and sustainable disease control measures including biological control and resistant varieties, cultural practices and effective weed management and targeted and judicious fungicide applications.

By integrating advanced irrigation, nutrient management, pest control, and disease management in the high-tech cotton demonstration, these innovations and best practices collectively contribute to the development of a more resilient and sustainable cotton farming ecosystem. The adoption of high-tech advancements in cotton cultivation provides numerous benefits, including:

- Higher yields and improved fiber quality
- Reduced water and pesticide use
- Lower production costs and increased efficiency
- Environmentally sustainable practices
- Improved farmer profitability

The high-tech regenerative cotton demonstration served as a benchmark for cotton revival in the North cotton growing zone, showcasing that innovative, climate-resilient, and cost-effective solutions can effectively counteract declining cotton production, restore farmer confidence, and drive long-term sustainability in the sector.

The key findings from the high-tech regenerative cotton demonstration are as follows:

- **Enhanced Seed Germination and Optimal Plant Stand**: The high-tech cotton demonstration recorded a significantly higher seed germination rate of 95%, ensuring a robust and uniform plant stand throughout the growing season. In contrast, the control plots exhibited lower germination rates of 78% in plot I (sown one month earlier) and 67% in plot II (sown concurrently with the demonstration field).
- **Efficient Water Utilization through Drip Irrigation**: The implementation of a precision drip irrigation system resulted in substantial water savings, with high-tech cotton cultivation requiring up to 60% less irrigation water compared to conventional flood irrigation practices in control plots.
- **Optimized Fertilizer Efficiency**: Drip fertigation facilitated targeted nutrient delivery, leading to a significant reduction in fertilizer application rates with 54% less nitrogen, 33% less phosphorus and 79% less sulfur compared to conventional cotton farming, without compromising crop performance.
- **Reduced Weed Infestation**: The adoption of drip irrigation minimized surface moisture availability for weed growth, resulting in a lower weed infestation compared to conventional cotton plots subjected to flood irrigation.
- **Lower Sucking Pest Incidence:** A proactive monitoring-based pest management strategy, coupled with threshold-based interventions, effectively mitigated infestations of pink bollworm, whitefly, thrips, and jassid, maintaining significantly lower pest pressure in the demonstration plots relative to the control fields. The seasonal mean and range of different sucking pest population recorded in high-tech cotton demonstration and control plots as mentioned in Table 1.

Table 1. Seasonal Mean and Range of Sucking Pest Population (per 3 Leaves) in High-Tech Cotton Demonstration and Control Plots

Name of insect	High-tech regenerative cotton demonstration		Control plots			
			Conventional cotton farming-I		Conventional cotton farming-II	
	Seasonal Mean	Range	Seasonal Mean	Range	Seasonal Mean	Range
Whitefly/3 leaves	8.20	2.00-16.80	17.36	9.00-40.80	17.49	7.90-43.70
Thrips/3 leaves	7.74	1.70-22.30	13.07	3.70-26.20	14.45	4.20-33.70
Jassid/3 leaves	1.77	0.20-6.50	3.75	0.50-8.90	4.11	0.90-9.70

- **Reduction in Pesticide Application:** Implementation of an integrated pest management (IPM) strategy led to a 18–27% reduction in pesticide usage in high-tech cotton demonstration plots compared to conventional cotton cultivation, minimizing chemical input while maintaining effective pest control.
- **Lower Disease Incidence:** The incidence of para wilt, boll rot, and other cotton diseases was significantly lower in the high-tech demonstration plot compared to control fields, attributed to improved crop management practices and optimized growing conditions.
- **Mitigation of Greenhouse Gases Emissions:** Adoption of solar powered drip irrigation reduced dependence on fossil fuels, thereby decreasing carbon dioxide and other greenhouse gas emissions, enhancing the sustainability of cotton production.
- **Enhanced Yield Performance:** The high-tech regenerative cotton demonstration plot recorded a significantly higher yield of 16.70 quintal per acre (range: 10.23–16.70 q/acre), outperforming the control plots, which yielded 6.53 quintal per acre (control plot I) and 4.21 quintal per acre (control plot II).
- **Superior Economic Returns:** The net profit and benefit cost ratio (BCR) in the high-tech regenerative cotton demonstration were considerably higher than those of the control plots, demonstrating the economic viability and profitability of advanced cultivation techniques. The comparative analysis of net profit and benefit cost ratio for high-tech regenerative cotton demonstration and control plot were presented in Table 2.

Table 2. Comparative Analysis of Net Profit and Benefit Cost Ratio (BCR) for High-Tech Regenerative Cotton Demonstration vs. Control Plots

Items	High-tech regenerative cotton demonstration (Indian Rupee)	Control plots	
		Conventional cotton farming-I (Indian Rupee)	Conventional cotton farming-II (Indian Rupee)
Net profit	79097	25462	10478
Benefit cost ratio (BCR)	2.99	2.21	1.54

Status of Cotton Production in North India

Cotton is a crucial crop in the *Kharif* season, particularly in the key cotton growing districts of Punjab (Mansa, Bathinda, Fazilka, Abohar), Haryana (Bhiwani, Hisar, Fatehabad, Sirsa), and Rajasthan (Hanumangarh, Sriganganagar) of North cotton growing zone. However, cotton cultivation in North India, particularly in Punjab, Haryana, and Rajasthan, has been facing a significant decline in recent years due to multiple agronomic and environmental challenges. One of the most pressing concerns is the infestation of pink bollworm (*Pectinophora gossypiella*), which has caused severe yield losses and reduced farmer profitability. Additionally, the region has been grappling with whitefly attacks, infection of cotton leaf curl virus (CLCuV), thrips & disease such as wilting and boll rots, soil degradation, water scarcity, and overuse of chemical pesticides, which have led to increased input costs and environmental concerns.

Since 2021, cotton farmers in North region have experienced a steady decline in cotton production and have been struggling to deal with multiple sustainability challenges including pink bollworm (PBW) resistance to *Bt* cotton, requiring a shift towards integrated pest management (IPM) strategies and advanced agricultural techniques and sustainable cotton production practices. Addressing these challenges is crucial to reviving cotton productivity, improving farmer livelihoods, and ensuring sustainable cotton cultivation.

For the *Kharif* 2024-25 season, the situation has worsened significantly, with a sharp drop in cotton acreage (Fig. 1 & Fig. 2). Farmers are increasingly shifting away from cotton cultivation, favoring other crops such as paddy (rice) due to economic uncertainties, pest infestations, and climate-related challenges. This shift not only threatens the cotton value chain, including ginning and textile industries, but also exacerbates water scarcity issues, as paddy is a highly water-intensive crop.

Currently, no concrete action plan is in place to reverse this trend. If left unaddressed, the declining cotton acreage could have long-term implications on farmer livelihoods, regional economies, and the textile sector. Urgent interventions—such as sustainable farming practices, integrated pest management, and farmer support programs—are essential to revitalize cotton cultivation in North India.

Punjab:

- **Production Trend:** Due to considerable reduction in the area under cotton cultivation, Punjab witnessed a nose-dive in production of cotton to barely 59,500 tons in a recent season of 2024-25.
- **Acreage Decline:** The area dedicated to cotton farming has decreased significantly, from 7.58 lakh hectares in the 1980s and 1990s to just 97,000 hectares in 2024-25.

Haryana:

- **Production Estimate:** Haryana produced 10,23,000 bales in the current season of 2024-25, a decline from 15,38,129 bales in the previous *Kharif* season.
- **Pest Infestation:** Farmers in Haryana have been severely affected by pink bollworm attacks, leading many to abandon cotton cultivation in favor of other crops like paddy.

Rajasthan:

- **Production Estimate:** Rajasthan produced 20,42,000 bales in current season of 2024-25, a decline from 26,21,000 bales in pervious *Kharif* season
- **Pest Impact:** The pink bollworm infestation has been particularly severe, with reports indicating that up to 90% of the cotton crop was affected in certain areas of Hanumangarh and Sriganganagar.

Fig.1: Trend of cotton area under cultivation in North cotton growing zone during last five years

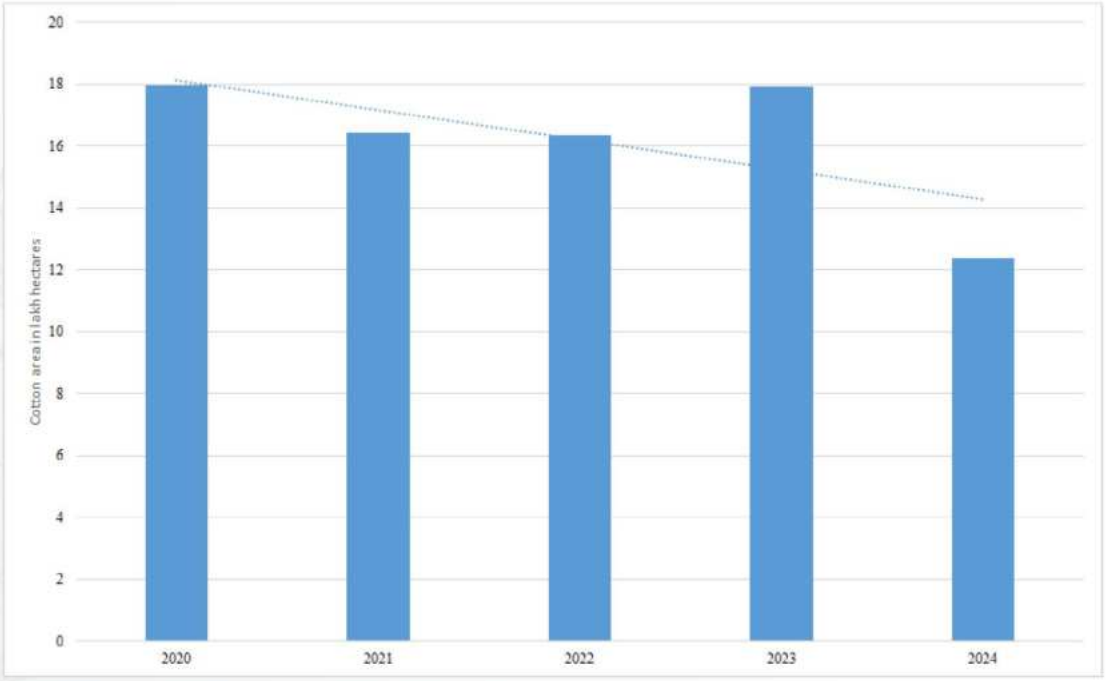
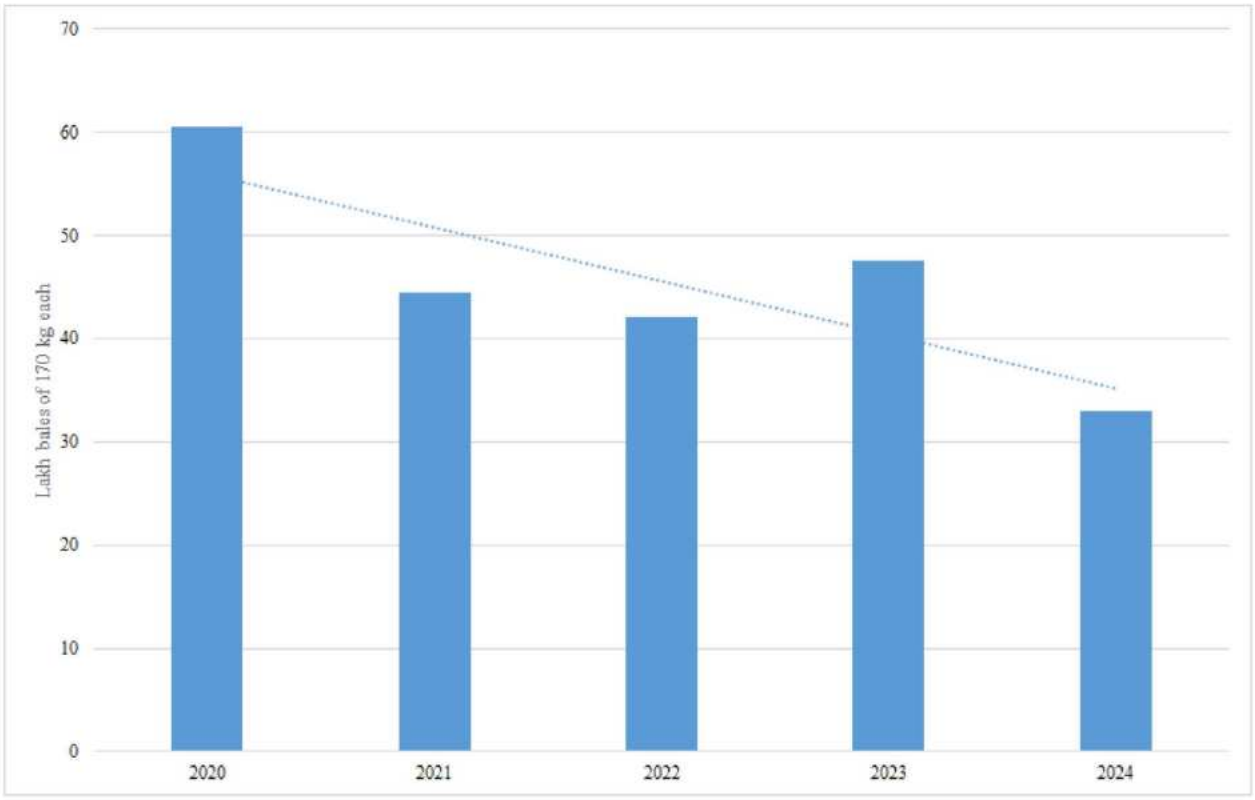


Fig 2. Trend of cotton production in North cotton growing zone during the last five years



Source: Minsitry of Agriculture and Farmers Welfare, 2020 to 2025

Key Sustainability Challenges in Cotton Farming in North India

The reliability of traditional cotton cultivation practices has led to numerous challenges for smallholder cotton farmers in North India. High pest infestations, particularly pink bollworm and sucking pests like whitefly, thrips, and leafhopper have significantly affected the crop health and yields. The widespread disease outbreaks, including cotton leaf curl virus (CLCuV), boll rot, and wilting (root rot and para wilt), also affected productivity and climate induced challenges such as rising temperatures, erratic & excessive precipitation led to stagnant yields and declining productivity of cotton. Moreover, the excessive use of chemical fertilizers and pesticides not only pose a financial burden on farmers but also increases environmental risks resulting in serious health hazards due to pesticide exposure. Smallholder cotton farmers in North India face several sustainability challenges, leading to reduced productivity and economic uncertainty. These concerns are crucial for ensuring a sustainable and productive cotton farming system in the region.

1) High Pest Infestation Pressure:

Cotton is highly vulnerable to severe pest infestations, causing significant yield losses and increased cultivation costs.

- **Pink Bollworm (PBW):** The pink bollworm (*Pectinophora gossypiella*) has become a persistent and destructive pest in India, particularly affecting Punjab, Haryana, and Rajasthan. It significantly damages lint quality and can reduce yield by 35-90%. The pest has also developed resistance to *Bt* cotton, weakening its effectiveness.
- **Whitefly**: A major pest causing Cotton Leaf Curl Virus (CLCuV), whiteflies affect plant health by sucking sap, leading to premature boll and leaf drop. The honeydew they excrete promotes black sooty mold, further reducing photosynthesis and fiber quality.
- **Thrips and Jassids**: Thrips thrive in dry conditions, damaging young cotton plants by feeding on leaves, flowers, and bolls, while jassids inject toxic saliva into plant tissues, stunting growth and causing leaf curling and defoliation.

Pink Bollworm

Thrips

Whitefly

Jassid

2) High Disease Infestation Pressure:

Cotton crops are increasingly affected by diseases, further reducing yield and fiber quality.

- **Cotton Leaf Curl Virus Disease (CLCuD):** Spread by whiteflies, this virus causes leaf curling, vein thickening, and stunted plant growth, leading to yield losses of 10.5-87.4% depending on the infection stage.
- **Boll Rot:** Fungal and bacterial infections cause boll rot, leading to fiber discoloration, premature boll dropping, and reduced market value.
- **Root Rot & Parawilt:** Cotton plants experience wilting and root rot, often due to waterlogging, nutrient imbalances, and extreme temperatures, resulting in plant death.

Cotton Leaf Curl Virus Disease (CLCuD)

Boll Rot

Root Rot

Parawilt

3) Climate Change & Environmental Factors:

Climate variability poses a significant threat to cotton cultivation, affecting yields and fiber quality in the North cotton growing zone.

- **Extreme Temperatures:** Higher temperatures during flowering and boll development increase heat stress, reducing photosynthesis and causing boll drop.

- **Water Scarcity & Erratic Rainfall:** Droughts and irregular rainfall patterns disrupt cotton growth, making irrigation management difficult and leading to fluctuating yields.
- **Extreme Weather Events:** Hailstorms, floods, and strong winds cause physical damage to cotton crops, further lowering production.

Effect of Extreme Temperature on Cotton Crop

4) Closure of Ginning & Textile Industries:

Decline in cotton production in North India poses significant challenges to both the ginning and textile industries, affecting operational efficiencies, closure of large numbers of ginning factories, financial stability, unemployment, and the overall competitiveness of India's textile sector.

5) Rising Costs & Environmental Risks

The increased reliance on chemical pesticides and fertilizers has:

- Raised input costs, making cotton farming less profitable.
- Caused environmental degradation due to excessive pesticide use.
- Harmed farmer health due to exposure to toxic agrochemicals.

Notably, the world is moving towards regenerative production and sustainability practices - a climate resilient and nature positive approach which efficiently utilizes natural resources employed in various production activities without adversely affecting the natural ecosystem - with the tripartite goals of ensuring social equity, economic profitability, and environmental health.

In this context, the sustainability challenges underscore the need for integrated pest management strategies, adoption of high-tech based regenerative cotton production system, deployment of cotton hybrid showing tolerance to PBW, surveillance and monitoring of pests and diseases, timely information sharing, coordination with stakeholders and supportive policies to revitalize cotton cultivation in North India.

Need for High-Tech Regenerative Solution in Cotton Farming

The declining profitability and increasing pest and climate-related risks are discouraging farmers from growing cotton, leading to a shift toward water-intensive crops like paddy. Collectively, Punjab, Haryana, and Rajasthan have seen a reduction in cotton acreage from 19.5 lakh hectares to 10.95 lakh hectares, contributing to increased cotton prices due to reduced supply. To sustain cotton production, integrated pest and disease management, climate-resilient practices, and sustainable resource use must be promoted.

In order to put the concept in practice, the South Asia Biotechnology Centre has laid out North India's most advanced and high-tech cotton demonstration for regenerative cotton production in *Kharif* 2024-25 at village Gindran, Rania tehsil of Sirsa district, Haryana.

The high-tech regenerative cotton demonstration focused on enhancing yields in North cotton growing zone under the aegis of Project Bandhan, which was supported by PI Foundation and implemented by South Asia Biotechnology Centre (SABC) across India, in technical collaboration with ICAR- Central Institute of Cotton Research (CICR), Nagpur.

Key Objectives of High-Tech Regenerative Cotton Demonstration, *Kharif* 2024-25.

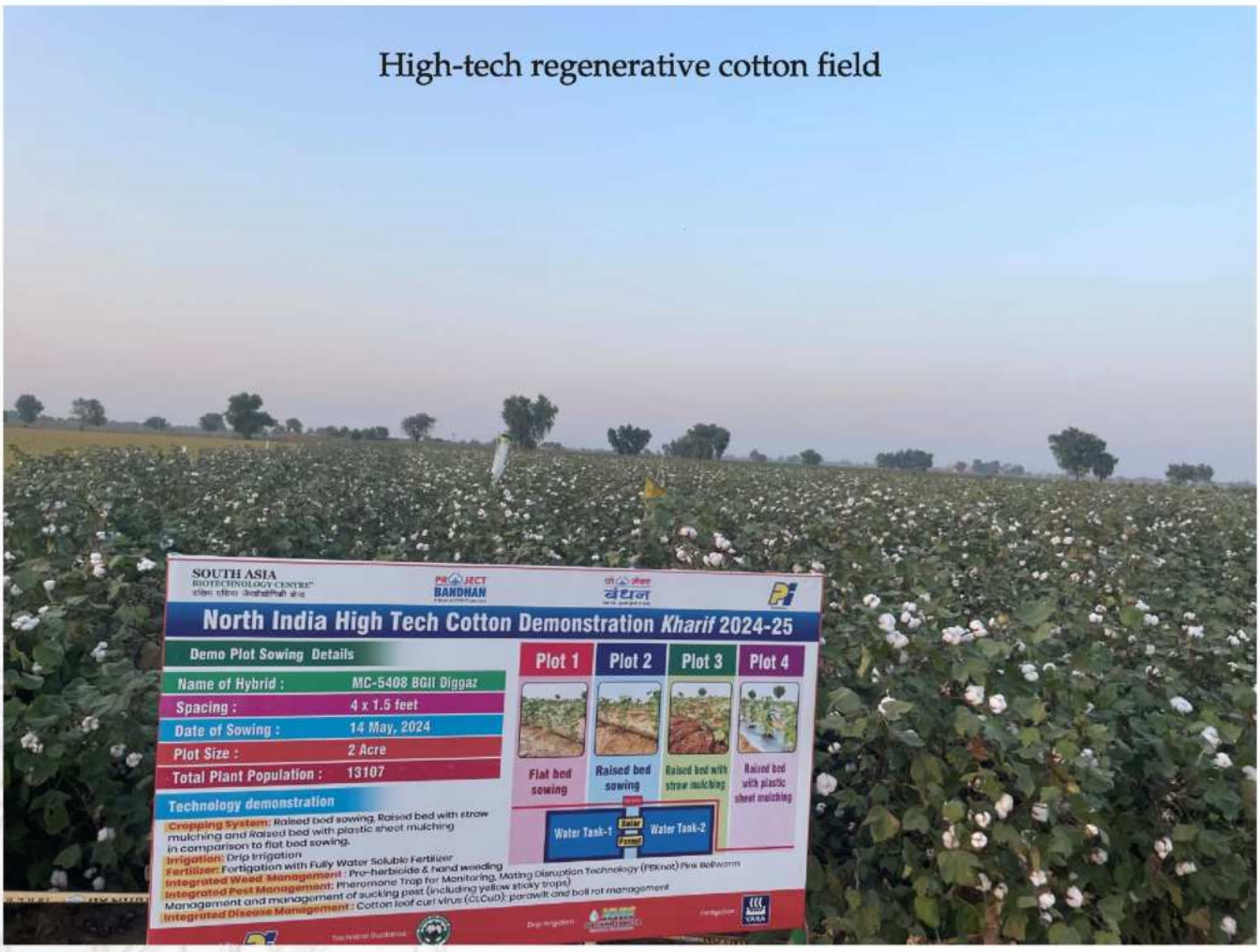
The North India high-tech regenerative cotton demonstration is strategically designed with the following technical objectives:

- Demonstration of advanced cotton production technologies, including evaluation and validation of various planting methods including flat bed, raised bed, raised bed with rice straw mulch, and raised bed with polyethylene mulch to optimize soil moisture retention, weed suppression, and crop establishment.
- Implementation of precision drip irrigation and fertigation systems, employing state-of-the-art water-soluble fertilizers to enhance water and nutrient use efficiency, with a focus on site-specific nutrient management (SSNM) and minimizing input losses.
- Deployment of integrated cotton production and pest management strategies, incorporating IPM modules with emphasis on PBKnot-based mating disruption for pink bollworm suppression, pheromone trap-based monitoring for pink bollworm incidence, and sticky trap-based monitoring for whitefly populations.
- Promotion of solar powered drip irrigation systems to reduce reliance on conventional motorized pumps and integrating renewable energy solutions with advanced fertigation for environmentally sustainable cotton cultivation.
- Systematic pest and disease surveillance, involving real-time field monitoring to assess pest dynamics and emerging challenges, with specific focus on pink bollworm, sucking pests (whitefly, thrips), and key diseases (root rot, boll rot, and parawilt) that enables timely intervention and adaptive management practices.

Excessive weed growth

Acute symptoms
of para wilt

Conventional cotton field



High-tech regenerative cotton field

Overview of High-Tech Regenerative Cotton Demonstration

The North India high-tech regenerative cotton demonstration was established over a 2-acre area as a collaborative initiative by the South Asia Biotechnology Centre (SABC) under Project Bandhan – A Knot of PBW Protection, supported by the PI Foundation. This demonstration, conducted during *Kharif* 2024 at Gindran village, Tehsil Rania, Sirsa district, Haryana, aimed to showcase regenerative cotton cultivation practices and cutting-edge production technologies. The demonstration integrated advanced cotton crop production and protection strategies to optimize resource use efficiency by incorporating precision drip irrigation and fertigation systems, utilizing the latest water-soluble fertilizers for enhanced nutrient uptake and water conservation, integrated pest management (IPM) techniques, including PBKnot mating disruption technology and pheromone traps for effective pink bollworm control and installing yellow sticky traps for monitoring and managing whitefly and aphid populations. A detailed analysis of the demonstration findings is presented below in Table 3.

Table 3. Technical Interventions Implemented in the North India High-Tech Regenerative Cotton Demonstration

S.No	Technical interventions	Details
1.	Total area (in acre)	2 Acre
2.	Land preparation details	Deep ploughing; cultivator and planking
3.	Previous season crop	Wheat
4.	Methods of sowing	Flatbed; Raised bed; Raised bed with rice straw mulch; Raised bed with poly mulch
5.	Name of Bt- hybrid variety	MC 5408 BG-II (Tata Diggaz)
6.	Date of sowing	14 May, 2024
7.	Seed rate	1.2 Packet/Acre
8.	Spacing	4 ft x 1.5 ft.
9.	Source of irrigation water	Canal water & groundwater stored in the water tank
10.	Method of irrigation	Drip irrigation
11.	Size of drip	16 mm (16-2-2-40-A)

12.	Irrigation management	Adopt proper soil moisture management
13.	Source of power for water pump	Solar energy
14.	Type of nutrient used	Use only high-water soluble fertilizer
15.	Method of nutrient application	Fertigation & foliage application
16.	Nutrient management	Follow the 4R principles during the whole cropping season following the right source, right dose, right place, and right time.
17.	Method of weed control	Manual & mechanical weeding along with herbicide application
18.	Sucking pest management	• Regular monitoring of the cotton crop during the whole season. • Yellow sticky traps for monitoring and management of sucking pests. • Insecticide application as per ETL.
19.	Bollworm management	• Regular monitoring of the cotton crop during the whole season. • Used pheromone traps for regular monitoring of pink bollworm inside the trap. • Used PBKnot mating disruption technology for pink bollworm management.
20.	Disease management	• Regular monitoring of the cotton crop during the whole season. • Done need based fungicides application.
21.	Other intercultural operations	• Maintained proper plant canopy through de-topping & use of growth retardant

Outcomes of High-Tech Regenerative Cotton Demonstration

Comparison of North India High-Tech Cotton Demonstration with Conventional Cotton Farming

To scientifically evaluate the performance of the North India high-tech regenerative cotton demonstration, comparative assessments were conducted against conventional cotton farming systems. For this purpose, two control plots were identified: conventional cotton farming-I, sown on April 14, 2024, and conventional cotton farming-II, sown on May 14, 2024, aligning with the date of demonstration plot establishment. The inclusion of an additional control plot with an earlier sowing date allowed for a comprehensive comparison across the full range of farmer sowing practices in the region. Throughout the crop growth period, the demonstration and both control plots were subjected to rigorous monitoring by a team of technical experts. Systematic data collection was carried out following scientific protocols, with ten plants randomly tagged in each treatment for recording biometric observations and pest dynamics. The comparative results, capturing crop growth, pest incidence, and yield parameters between the high-tech regenerative cotton demonstration and conventional farming practices in control plots are presented in Table 4.

Table 4. Comparative Performance of North India High-Tech Regenerative Cotton Demonstration and Conventional Cotton Farming (control plots)

Technological interventions	North India high-tech regenerative cotton demonstration	Control plots	
		Conventional cotton farming-I	Conventional cotton farming-II
Land preparation details	Deep ploughing, cultivator & planking	Deep ploughing, cultivator & planking	Deep ploughing, cultivator & planking
Outcome	Land preparation process kept the same in both high-tech demo and control plot		
Bt Cotton Hybrid	MC 5408 BG-II	MC 5408 BG-II	MC 5408 BG-II
Outcome	MC 5408 BG-II (Diggaz) Bt cotton hybrids were used for sowing in high-tech demo and control plots		
Date sowing	14 May	14 April	14 May

Outcome	Control plot-I (conventional cotton farming-I) was sown one month early than high-tech regenerative cotton demo along with the control plot-II		
Spacing	4 x 1.5 ft.	3.16 x 1.5 ft.	3.16 x 1.5 ft.
Outcome	Control plots were planted at a closer spacing compared to the high-tech regenerative cotton demonstration		
Seed rate	1.2 Packet	1.5 Packet	2 Packet
Outcome	During sowing of the high-tech plot, fewer seeds were required as compared to the control plot		
Germination (%) 30 DAS	95%	78%	67%
Outcome	Germination of cotton in the high-tech plot was better as compared to that in the control plot. No impact of high temperature in May 2024 was observed on the germination of cotton plants in all three plots		
Plant stand (poor/ average/good/ excellent)	Excellent	Good	Poor
Outcome	In the high-tech plot, the cotton plants exhibited robust growth throughout the season, and reported very low incidence of pests and diseases as compared to the control plots		
Total plant population	Flat bed: 7060	7282	6255
treatment wise/acre	Raised bed: 7023 Raised with rice straw mulch: 6986 Raised bed with poly mulch: 6678		
Outcome	Due to good germination of cotton plants, despite having more spacing as compared to the control plot, the number of plants was seen to be higher in the high-tech plot as compared to the control plots		
Total number of irrigations	43 (drip irrigation)	4	5
Outcome	In the high-tech plot, irrigation was applied through drip irrigation; hence the total number of irrigations required was much more as compared to the control plot. Despite a higher number of irrigations, the high-tech plot consumed considerably lower water and much higher water saving		
Average water uses per irrigation	7000-8000 liters	2-2.3 lakh liters	2-2.3 lakh liters
Outcome	Due to drip irrigation in the high-tech plot, less water was required per irrigation as compared to the control plot where water was applied through flood irrigation		
Total water consumption during the season	3-3.5 lakh liters	10-11.5 lakh liters	8-9.2 lakh liters
Outcome	Despite the higher number of irrigations, water savings were much higher in high-tech plots as compared to control plot		
Source of power for irrigation	Solar energy	Diesel/Electricity	Diesel/Electricity
Outcome	Solar energy was supplied as a source of power for irrigation and spray, whereas in the control plot, electricity and diesel were used instead of solar energy as a power source		

Total nutrient applied throughout the season (Kg/acre)	Nitrogen: 15.17 Phosphorus: 15.80 Potassium: 17.1 Sulphur: 1.25 Magnesium: 0.87 Zinc: 0.1	Nitrogen: 33 Phosphorus: 24 Potassium: 1.8 Sulphur: 6 Calcium: 9	Nitrogen: 33 Phosphorus: 24 Potassium: 1.8 Sulphur: 6 Calcium: 9
Outcome	The high-tech regenerative cotton demo consumed 54% less nitrogenous fertilizer, 34% less phosphoric fertilizer, and 79.16% less sulphur fertilizer as compared to control plots. Significant reduction in chemical fertilizer application without affecting yield can help in improved soil structure, enhanced microbial activity, and decreased greenhouse gas emissions		
Weed population throughout the season (low/medium/high)	Low	Medium	High
Outcome	By using drip irrigation at high-tech regenerative cotton demo, a low weed density was observed as compared to control plots, where flood irrigation was given		
Total number of manual weeding	2	1	2
Outcome	For weed control, hand weeding was done twice in the high-tech plot and the control plot II		
Total number of mechanical weeding	1	2	2
Outcome	In the high-tech plot, weeding was carried out once with a power weeder to control weeds, whereas in the control plot, weeding was done twice with a tractor to control weeds		
Mean population and range of sucking pest during the growing season			
Whitefly/3 leaves Thrips/3 leaves Jassids or Leafhopper/ 3 leaves	8.20 (2.00-16.80) 7.74 (1.70-22.30) 1.77 (0.20-6.50)	17.36 (9.00-40.80) 13.07 (3.70-26.20) 3.75 (0.50-8.90)	17.49 (7.90-43.70) 14.45 (4.20-33.70) 4.11 (0.90-9.70)
Outcome	Due to the adoption of a proper IPM practices in high-tech regenerative cotton demonstration, whitefly (Fig.1), thrips (Fig.2), and Jassids (Fig.3) infestations were very low as compared to control plots throughout the season		
Mean damage percent and range of pink bollworm during the growing season			
Pink bollworm (green boll damage %)	0.48 (0.00-5.00)	4.05 (0.00-20.00)	3.81 (0.00-25.00)
Outcome	In 2024 season, the outbreak of pink bollworm was reported only at the beginning & end of the season, however observed below ETL in control plots due to heavy insecticidal sprays. The incidence of pink bollworm in the high-tech plot observed negligible as compared to the control plots due to adoption of IPM management practices		
Total number of insecticides applied for sucking pest and bollworm management	5	5	5

Outcome	The number of pesticides used in the high-tech cotton plot and the control plot is the same, but there is a huge difference observed in the amount of pesticides spray in compared plots		
Pesticide application in form of single or mixture*	Single	Mixture	Mixture
Outcome	The high-tech plot avoided spray of pesticide in combination whereas in the control plot, a combination of two or more pesticides were applied, and hence higher dose and cost to farmers escaping recommended dosages		
Total pesticide applied (weight/volume) throughout per acre	1.73 (litre/kg)	2.37 (litre/kg)	2.12 (litre/kg)
Outcome	By adopting a proper IPM approach, the weight/volume of pesticide recorded 18 to 27% lower in high-tech regenerative cotton demonstration as compared to conventional cotton cultivation		
Root Rot	Nil	Low	Medium
Para wilt	Nil	Nil	Nil
Boll Rot	Low	Low	Low
Outcome	In *Kharif* 2024, conventional cotton plots affected due to wilting of plants at maturity, but effective crop management in the high-tech demo plot prevented the problem of wilting. Moreover, the incidence of other diseases was observed lower in the high-tech demo comparison to the control plot		
Total number of fungicide application applied during the season**	2	2	2
Outcomes	Fungicide applied in high-tech demo same as control plot		
Method of fungicide application (spray/ drenching)	Spray + drenching	Spray	Spray
Outcome	Both methods of drenching and spraying of fungicide in the high-tech plot, whereas only spraying was undertaken in the control plots		
Total fungicide used (weight/volume) throughout the season in acre	1 (litre/kg)	1 (litre/kg)	1 (litre/kg)
Outcome	Both high-tech demo and control plots received similar amount and numbers of sprays, however, the spraying was as prophylactic measure in the high-tech cotton demonstration		

*Pesticide Use Pattern:

1. In high-tech regenerative cotton farming: Spinetoram 11.7% SC; Profenophos 50% EC; Dinotefuran 20% SG; Thiamethoxam 25% WG; Ethion 50% EC
2. In control plots - Dinotefuran 20% SG+Emamectin benzoate 5% SG; Profenophos 40%+Cypermethrin 4% EC+Thiamethoxam 25% WG; Pyriproxyfen 10% EC+Emamectin benzoate 5% SG+Thiamethoxam 25% WG; Diafenthiuron 50% WP+Emamectin benzoate 5% SG+Thiamethoxam 25% WG

**Fungicide Use Pattern in high-tech regenerative cotton demonstration and control plots: Propineb 70% WP and Carbendazim 12%+Mancozeb 63% WP

Figure 3: Whitefly Population Dynamics in High-Tech Regenerative Cotton Demonstration vs. Control Plots

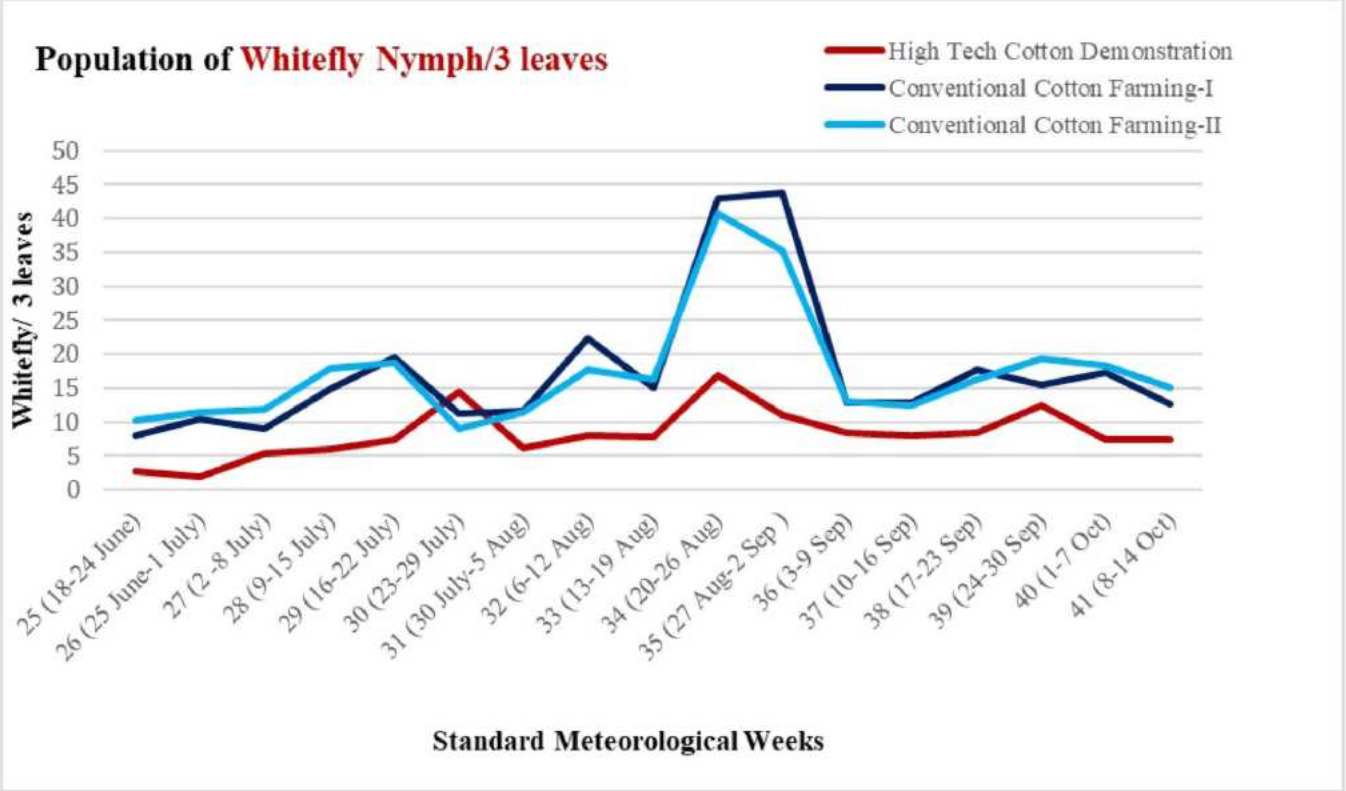


Figure 4. Comparative Thrips Infestation in High-Tech Regenerative Cotton Demonstration and Conventional Farming Plots

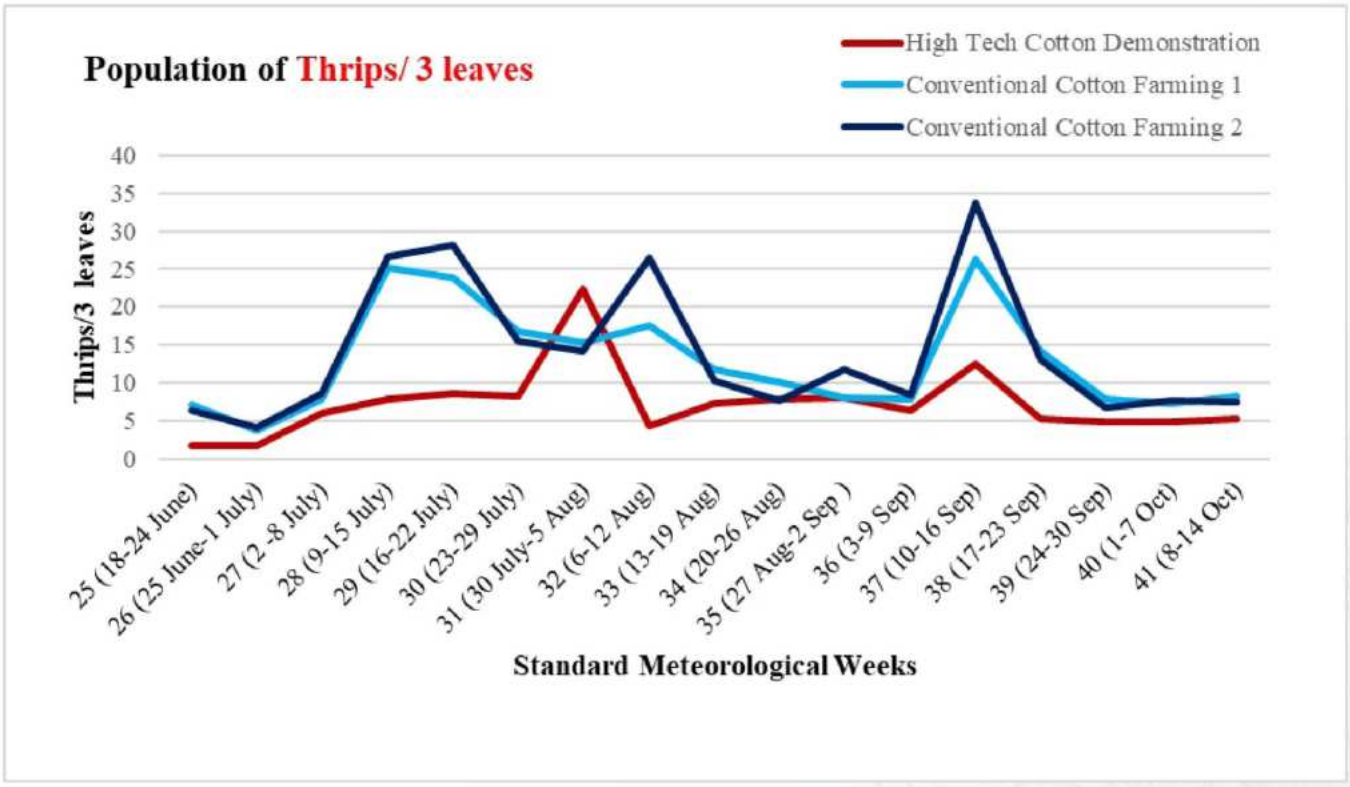
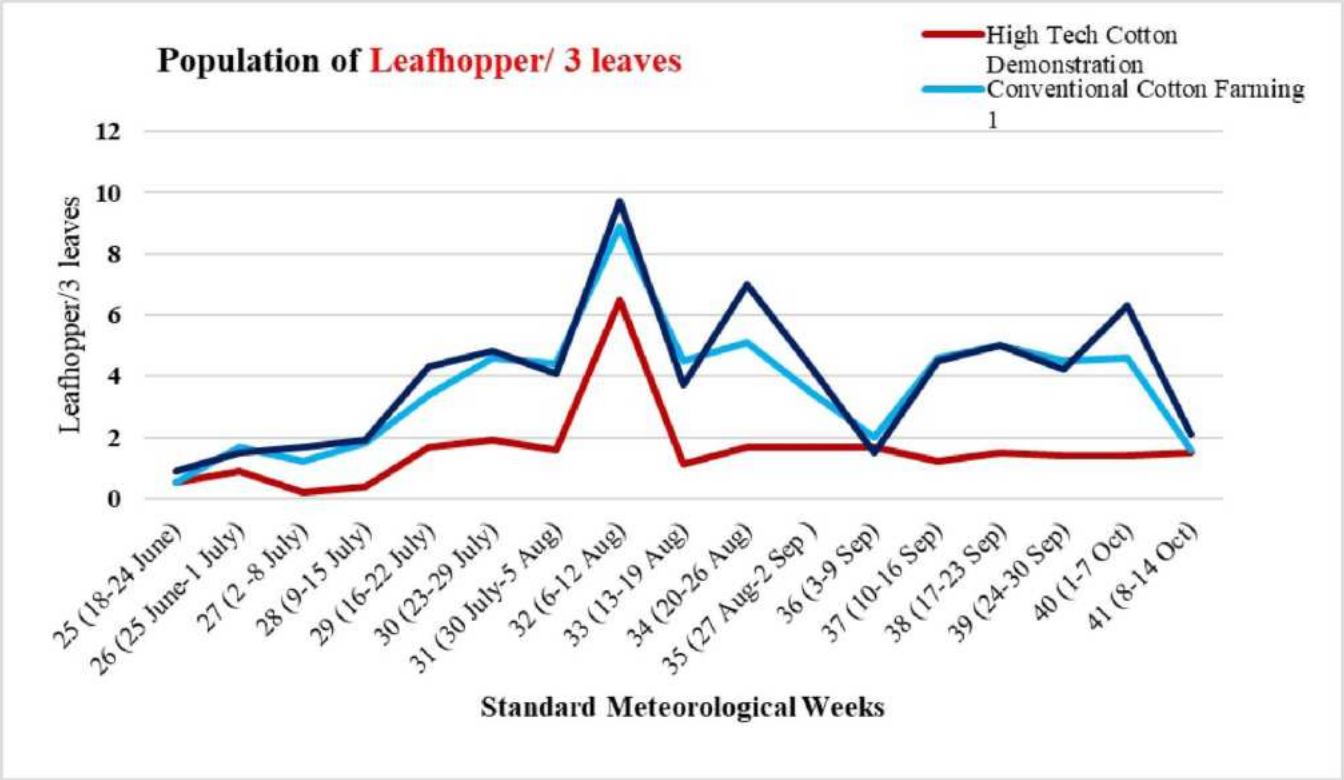


Figure 5. Comparative Leafhopper Infestation in High-Tech Regenerative Cotton Demonstration and Conventional Farming Plots



Cotton Seed Yield

The cotton seed yield data from various technical interventions adopted under the high-tech regenerative cotton demonstration are presented in Table 5. Among the different treatments, the highest seed cotton yield of 16.70 quintals per acre was recorded in the flat bed with mechanical detopping and drip fertigation treatment, followed by raised bed with poly mulch, drip fertigation, and canopy management with detopping, which recorded 15.97 quintals per acre, and flat bed with drip fertigation combined with Mepiquat Chloride application, yielding 15.25 quintals per acre. In contrast, the raised bed with straw mulch and drip fertigation treatment recorded the lowest yield of 10.23 quintals per acre among all interventions.

The conventional cotton farming control plots exhibited significantly lower yields, with conventional plot-I (DAS: 14 April) recording 6.53 quintals per acre and conventional plot-II (DAS: 14 May) recording only 4.21 quintals per acre. The superior yield performance of the high-tech regenerative cotton demonstration, particularly the yield of 16.70 quintals per acre, underscores the effectiveness of these advanced production technologies in the North cotton growing zone during *Kharif* 2024. This outcome suggests a promising direction for cotton productivity enhancement and potential revival in states like Haryana, Punjab, and Rajasthan.

The substantial yield advantage observed under high-tech interventions compared to conventional practices can be attributed to the regulated water supply through drip irrigation, precise fertigation with water-soluble fertilizers leading to improved nutrient use efficiency and better crop establishment. Additionally, drip irrigation played a critical role in mitigating the adverse effects of high temperature. The adoption of mechanical detopping and Mepiquat Chloride applications contributed positively to canopy management, boll retention, and overall yield improvement presented in Table 5.

Table 5. Average Green Boll Count, Number of Pickings, and Seed Yield in North India High-Tech Regenerative Cotton Demonstration and Control Plots

Technological interventions	Average number of green bolls	Total number of pickings	Total yield (Q/acre)
North India high-tech regenerative cotton demonstration			
Flat Bed			
Canopy management with mepiquat chloride	51.1	4	15.25
Canopy management with detopping	54.1	4	16.70
Control plot	45.5	4	12.73

Raised bed			
Canopy management with mepiquat chloride	45.9	4	12.56
Canopy management with detopping	51.4	4	13.20
Control plot	39.1	4	10.79
Raised with rice straw mulch			
Canopy management with mepiquat chloride	40.3	4	10.61
Canopy management with detopping	41.4	4	10.58
Control plot	40.1	4	10.23
Raised bed with poly mulch			
Canopy management with mepiquat chloride	48.8	3	14.52
Canopy management with detopping	49.5	3	15.97
Control plot	40.1	3	13.79
Control plots			
Conventional cotton farming-I	39.5	2	6.53
Conventional cotton farming-II	21.4	1	4.21

Cost of Cultivation

The cultivation of cotton requires substantial investment, comprising expenditures on quality seed, fertilizers, pesticides, labour for key operations such as sowing, weeding, and harvesting, as well as costs associated with irrigation and land preparation (Table 6). In the North India high-tech regenerative cotton demonstration, the cost of cultivation was meticulously calculated for the treatment plot utilizing flat bed with mechanical detopping, which recorded the highest seed cotton yield. The primary objective of this demonstration is to scientifically determine the most efficient and productive cotton cultivation approach and to facilitate its dissemination among farmers.

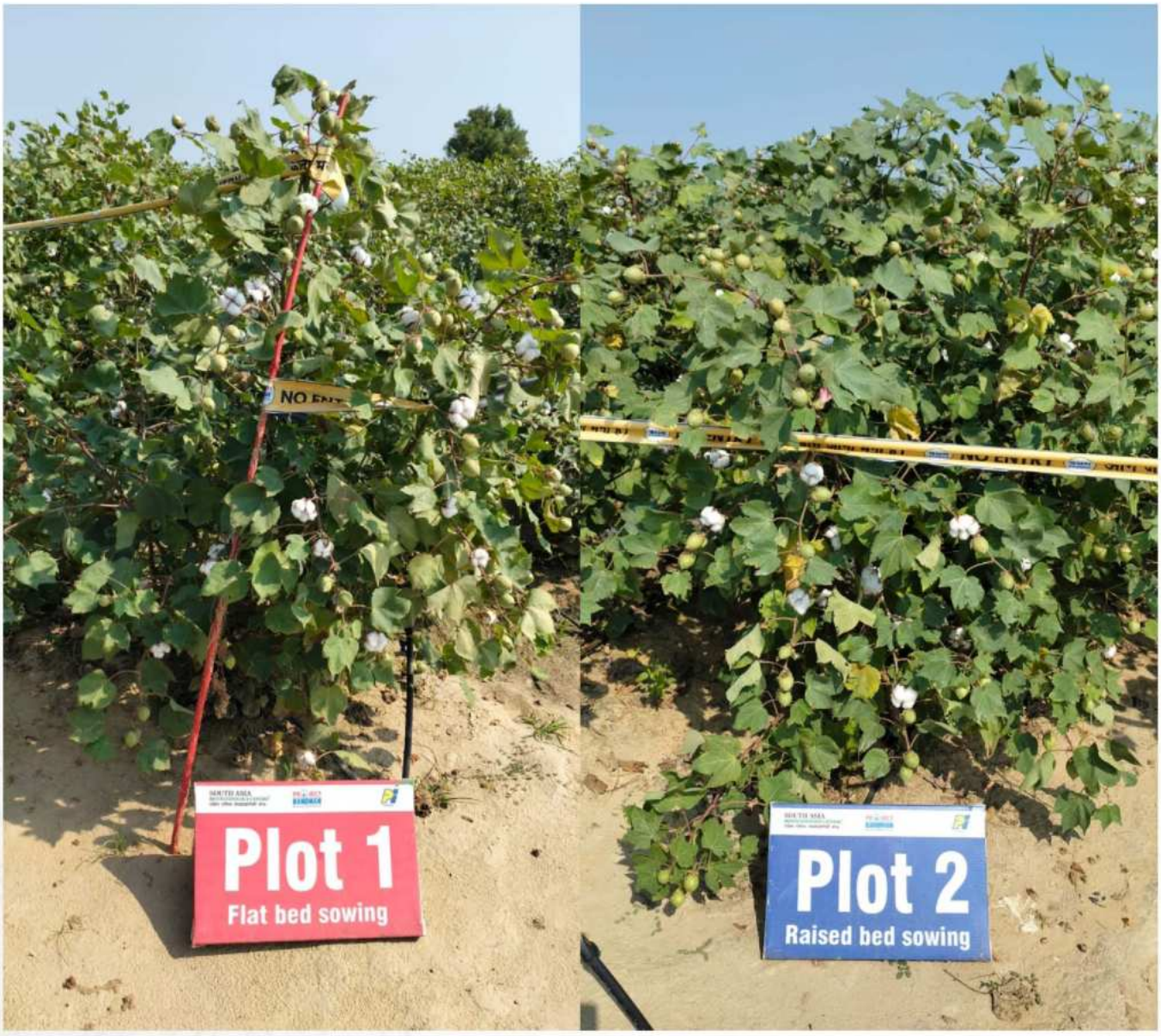
By adopting these advanced practices, farmers in the North Indian cotton belt can significantly enhance their productivity and contribute to the revival and sustainability of cotton production in states such as Haryana, Punjab, and Rajasthan.

Table 6. Cost of Cultivation, Net Profit and Benefit Cost Ratio (BCR) of North India High-Tech Cotton Demonstration and Conventional Cotton Farming Control Plots

Technological interventions	High-tech cotton demonstration (flat bed sowing) (Indian Rupee)	Control plots Conventional cotton farming-I (Indian Rupee)	Conventional cotton farming-II (Indian Rupee)
Land preparation & sowing	4300	2300	2300
Seed	1044	1305	1740
Fertilizer	6000	3400	3600
Mechanical weeding	1000	400	800
Manual weeding	500	1000	1000
Yellow stick trap	900	–	–
Pheromone trap	500	500	500
Insecticide	3060	2800	2780
Fungicide	650	650	650
Canopy management cost	1000	–	–
Post harvest management	2500	1500	1500
Total cost without picking charges	21454	13855	14870
Cotton picking cost	18370	7183	4631
Total cost of cultivation	**39824**	**21038**	**19501**
Total income	**118921**	**46500**	**29979**
Net profit	**79097**	**25462**	**10478**
Benefit cost ratio	**2.99**	**2.21**	**1.54**

The net profit realized from the high-tech regenerative cotton demonstration was substantially higher compared to the conventional control plots. Analysis of the benefit-cost ratio (BCR) revealed that for every rupee invested, a return of 2.21 rupees was obtained under conventional cotton farming-I, while conventional cotton farming-II

yielded a lower return of 1.54 rupees per rupee invested. In contrast, the high-tech regenerative cotton demonstration, following advanced management practices, achieved the highest BCR of 2.99, indicating significantly greater economic efficiency and profitability. This clearly demonstrates that the adoption of precision interventions and regenerative cotton practices can substantially enhance farm profitability in the North Indian cotton belt.




NO ENTRY
Plot 3
Raised bed with
straw mulching


Plot 4
Raised bed with
plastic sheet mulching


SOUTH ASIA
BIOTECHNOLOGY CENTRE
PROJECT
BANDHAN
बंधन
North India High Tech Cotton Demonstration Kharif 2024-25
Demo Plot Sowing Details
Name of Hybrid : MC-5408 BGII Diggaz
Spacing : 4 x 1.5 feet
Date of Sowing : 14 May, 2024
Plot Size : 2 Acre
Total Plant Population : 13107
Plot 1
Plot 2
Plot 3
Plot 4
Flat bed sowing
Raised bed sowing
Raised bed with straw mulching
Raised bed with plastic sheet mulching
Water Tank-1
Solar
Water Tank-2
Technology demonstration
Cropping System: Raised bed sowing, Raised bed with straw mulching and Raised bed with plastic sheet mulching in comparison to flat bed sowing.
Irrigation: Drip Irrigation
Fertilizer: Fertigation with Fully Water Soluble Fertilizer
Integrated Weed Management : Pre-herbicide & hand weeding
Integrated Pest Management: Pheromone Trap for Monitoring, Mating Disruption Technology (PBKnot) Pink Bollworm
Management and management of sucking pest (including yellow sticky traps)
Integrated Disease Management : Cotton leaf curl virus (CLCuD): parawilt and boll rot management

Strengthening the Capacity of Key Cotton Stakeholders & Value Chain Partners

The South Asia Biotechnology Centre (SABC) spearheaded a series of impactful scientific programs at the North India high-tech regenerative cotton demonstration as part of Project Bandhan – A Knot to PBW Protection. Supported by the PI Foundation and guided by the technical expertise of ICAR-CICR, these initiatives aimed to promote awareness of high-tech cotton cultivation and revitalize cotton production in North India.

During the *Kharif* 2024-25 season, approximately 2,500 cotton farmers from 12 key cotton-growing districts across Haryana, Punjab, and Rajasthan visited the state-of-the-art regenerative cotton demonstration facility. They were joined by teams of scientists, policymakers, and stakeholders from both public and private institutions, fostering collaboration and knowledge exchange to drive regenerative innovation in cotton farming.

Textile Industry Commits to Reviving Cotton Production in North India

The rapid decline in cotton farming over the past three years in Punjab, Haryana, and Rajasthan—reducing from 19 lakh hectares to 10 lakh hectares, has placed the cotton textile industry in North India at serious risk. The shrinking supply of raw cotton has led to the closure of numerous ginning plants, threatening the survival of key textile hubs such as Ludhiana, Hisar, and Bhatinda. Alarmed by the crisis, the Ginners Associations of Punjab, Haryana, and Rajasthan have voiced concerns about the industry's future, warning of impending collapse if cotton production is not revived urgently.

Recognizing the gravity of the situation, a large contingent of industry stakeholders, including members of Indian Cotton Association Limited (ICAL), North India Textile Mills Association (NITMA), Punjab-Haryana-Rajasthan Ginners Associations, and the Cotton Corporation of India Ltd. (CCI), convened on August 8, 2024, at High-Tech R&D Station at Gindran village, Sirsa district of Haryana to witness cutting-edge cotton cultivation practices and discuss urgent solutions to the industry's ongoing crisis.

Textile Industry to Scale up High-Tech Regenerative Cotton Production: A Roadmap for Cotton Revival

Witnessing the foresightedness of the North India high-tech regenerative cotton production which aimed at providing practical solutions to address emerging pest threats, climate variability, and declining yields, the North India textile industry champions vowed to focus on combating pink bollworm (PBW) infestation, whitefly, thrips, root rot, boll rot, and para wilt, while integrating regenerative agricultural practices to mitigate the adverse effects of climate change. Spanning two acres of farmer-owned land, the textile industry champions witnessed following regenerative technology components and precision-driven cotton farming techniques, including:

- Drip irrigation & fertigation using advanced water-soluble fertilizers.
- Integrated Pest Management (IPM), featuring the large-scale deployment of PBKnot mating disruption technology for pink bollworm control.
- Pest monitoring through pheromone traps for PBW and sticky traps for whitefly.
- Four innovative cropping systems integrating raised-bed, poly mulch, and rice straw mulch techniques to improve soil health and water efficiency.

Textile Industry Leaders Call for Urgent Action:

Concerns Over Cotton Quality & Industry Survival

- **Sh. Brijesh Kasana, Chief General Manager, CCI Sirsa,** highlighted concerns over the deteriorating quality of cotton due to PBW and whitefly infestation. He stressed the need for an integrated approach - such as the one demonstrated by SABC to revive North India's cotton sector.

- **Sh. Susil Mittal, President, Haryana Cotton Ginners Association,** pointed out that Bt cotton's effectiveness against PBW has weakened over the past three years, leading to widespread infestation. He urged the Central and State Governments to fast-track the approval of new-generation cotton technologies, including next-generation Bt cotton resistant to PBW and BG-II RRF cotton to address labor shortages.

- **Sh. Aditya Chitlangia, President, Rajasthan Ginners Association,** called for collective action among stakeholders to scale up pheromone-based PBW management technologies.

Leveraging Global Best Practices

- **Sh. Mahesh Sharda, Past President, ICAL,** emphasized the need for an enhanced cotton value chain and market-driven strategies. Drawing parallels to the USA's successful PBW eradication program, he advocated for technologies such as Bt cotton advancements and male-sterile PBW moth releases.

- **Sh. Vivek Kaushal, CEO, DCM Nouvelie Textile Mills, Hisar,** emphasized the importance of collaboration to strengthen cotton production and equip farmers with better pest and disease management strategies amid climate change challenges.

Unanimous Textile Industry Pledge for Revival of Cotton in North India:

The "Seeing is Believing" study tour of textile industry veterans to high-tech regenerative cotton demonstration concluded with unanimous support from stakeholders, reaffirming a collaborative commitment to reviving cotton production in North India. Industry leaders, farmers, and policymakers pledged to:

- Expand pheromone-based PBW control solutions
- Adopt next-generation cotton technologies and best agronomic practices
- Strengthen the cotton value chain & textile ecosystem
- Encourage knowledge-sharing & capacity-building among farmers

The Indian cotton and textile industry now has a blueprint for sustainable growth, resilience and revival of cotton production in North India.

Multiple Stakeholder Engagement to Accelerate Regenerative Cotton Production in North India

Recognizing the decline in cotton production, the South Asia Biotechnology Centre (SABC), in collaboration with PI Foundation, organized a "Key Stakeholder Engagement to Accelerate Regenerative Cotton Production" on August 28, 2024 at the SABC's High-Tech R&D Station, South Asia Biotechnology Centre at Gindran village, Sirsa district of Haryana. As part of Project Bandhan, which spans seven clusters across Punjab, Haryana, and Rajasthan, this initiative aims to revitalize cotton cultivation with the support of PI Foundation and technical guidance from ICAR-CICR.

The event witnessed participation from prominent agricultural scientists and policymakers, including Prof. B.R. Kamboj, Vice Chancellor of CCS Haryana Agricultural University (CCSHAU), Dr. Rajvir Garg, Director of Research at CCSHAU, and various experts from ICAR, PAU, and the State Agriculture Department. Dr. Dilip Monga, Technical Advisor at SABC, and Dr. Bhagirath Choudhary, Founder Director of SABC, led discussions on Project Bandhan's objectives, while Dr. Rajvir Garg emphasized subsidy benefits for drip irrigation and solar systems. Dr. K.S. Sekhon from PAU highlighted the challenges of shifting cotton acreage to paddy cultivation and the need for sustainable solutions such as crop residue management. Meanwhile, Dr. Vijay Kumar discussed integrated pest management (IPM) strategies, particularly for pink bollworm (PBW), through mating disruption tools and off-season management.

Chief Guest Prof. Kamboj underscored the importance of enhanced extension services and farmer engagement, calling for structured strategies to support cotton revival in North India. The event concluded with a field visit to the high-tech regenerative cotton

demonstration, where participants, led by Dr. Rishi Kumar of ICAR-CICR, reviewed advanced cotton growing practices, drip irrigation methods, and precision agriculture techniques.

Accelerating engagement with Govt officials, Dr. P.K. Singh, Agriculture Commissioner, Ministry of Agriculture & Farmers Welfare, visited the high-tech regenerative cotton demonstration at Sirsa, Haryana on 30 August 2024, accompanied by key stakeholders from ICAR-CICR and SABC. He assessed four innovative cotton planting methods poised to transform production in North India and launched a brochure detailing these advancements. Dr. Singh also examined an exhibition showcasing PBKnot technology, pheromone traps, and insect resistance management protocols, commending the research and applied laboratory setup at SABC's High-Tech R&D Station, South Asia Biotechnology Centre at Gindran village, Sirsa district of Haryana.

Simultaneously, a Farmers' Mela was held, attracting 150 progressive farmers from Haryana, Punjab, and Rajasthan. Dr. Singh engaged directly with farmers, stressing the importance of purchasing certified agro-inputs, avoiding pesticide mixing, and collaborating with government initiatives for cotton revival. Progressive farmers shared insights on PBKnot technology and experiences with high-tech demonstrations. The event concluded with a field tour led by Dr. Rishi Kumar of ICAR-CICR RRS Sirsa and Dr. Bhagirath Choudhary of South Asia Biotechnology Centre, who detailed innovations such as drip irrigation, raised bed farming, and mulching techniques.

On 16 September 2024, another milestone event—the Farmers-Scientists Interaction—was conducted under Project Bandhan, with the participation of 130 farmers and top agricultural experts, including Dr CD Mayee, former Chairman of ASRB, and Dr YG Prasad., Director of ICAR-CICR. The session focused on transitioning to climate-smart cotton cultivation, with Dr. Prasad urged farmers to adopt high-tech practices for improved resilience against climate change. Dr. Mayee hailed the demonstration as a model for reviving cotton in North India, advocating for wider adoption of scalable technologies.

A comprehensive field tour followed, featuring real-time demonstrations of innovative cotton production techniques, PBKnot solutions, and integrated pest management strategies. The event concluded with a visit to the high-tech R&D station's applied laboratory, where experts showcased soil and water testing capabilities supporting regenerative cotton production.

Through these strategic engagements, Project Bandhan continues to drive forward high-tech regenerative cotton cultivation, promoting sustainability, resilience, and productivity in North India's cotton sector.


दिनांक: 28 अगस्त 2024
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सुस्वागतम्
दिनांक: 28 अगस्त 2024


North India High Tech Cotton Demonstration Kharif 2024-25
Plot 1
Plot 2
Plot 3
Plot 4
Flat bed sowing
Raised bed sowing
Raised bed with straw mulching
Raised bed with plastic sheet
Water Tank-1
Water Tank-2


High
Tech
&D
tation


सुस्वागतम्
सुस्वागतम्







सुस्वागतम्


Plot 1
Flat bed sowing


सुस्वागतम्


High
Tech
R&D
Station
SOUTH ASIA


सुस्वागतम्


सुस्वागतम्

Private Sector Participation in high-tech Regenerative Cotton Demonstration

The high-tech regenerative cotton demonstration in North India witnessed active engagement from key private sector stakeholders, including leading seed companies, agrochemical firms, and research institutions. These visits provided critical evaluations, expert insights, and validation of innovative cotton farming practices. Throughout the Kharif 2024-25, the experts from ICAR-CICR, RRS Sirsa; CCSHAU, Hisar; PAU Ludhiana and South Asia Biotechnology Centre (SABC), Jodhpur and leading agronomists conducted field visits, thoroughly assessing crop performance and offering guidance on refining agronomic practices in consultation with private sector institutions. They emphasized the need for farmer-centric validation of new technologies. In addition, the senior teams from Rasi Seeds, Mahyco Company Limited, Bayer CropScience Limited, Mahyco Monsanto Biotech Pvt Ltd and ALPGIRI Seeds evaluated the demonstration plots, commending plant health, fruiting patterns, and agronomic excellence. They

recognized the initiative as a game-changer for boosting per-acre cotton yields in North India. Moreover, the representatives from the leading agrochemical and fertilizer industry including PI Industries, TATA Rallis and Yara Fertilizers praised the initiative's advanced pest management strategies, PBKnot technology, and sustainable farming approaches which are indispensable for the revival of cotton production and improving farmer profitability. Notably, the experts described the demonstration as "impressive, farmer-centric, and highly effective", emphasizing its role in educating farmers on modern cotton cultivation techniques, in scaling up best practices, improving adoption rates among farmers and ensuring sustainable cotton production in North India. The initiative was recognized for its potential to restore confidence in cotton farming and enhance productivity in the North India cotton belt.


High
Tech
R&D
Station
SOUTH ASIA


North India High Tech Cotton Demonstration Kharif 2024-25
Plot 1
Plot 2
Plot 3
Plot 4


Scientific Outreach


High Tech R&D Station
SOUTH ASIA
BIOTECHNOLOGY CENTRE

Summary of Farmers' Experience at North India High-Tech Regenerative Cotton Demonstration

Around 2,500 farmers from Punjab, Haryana, and Rajasthan convened at the high-tech regenerative cotton demonstration for multiple events under Project Bandhan during *Kharif* 2024-25 mentioned in Table 7. These exposure visits and on-farm training programs were designed to enhance farmers' awareness of high-tech cotton cultivation, equipping them with innovative techniques and scientifically proven practices to boost cotton production in North India. These on-farm training programs covered advanced planting methods, drip fertigation, and proactive pest and disease monitoring, ensuring farmers to adopt sustainable and efficient farming strategies. Each on-farm event was tailored to specific modern technologies, with a strong focus on PBKnot (pheromone-based pest control), drip fertigation, and pink bollworm management. Farmers participated in live demonstrations of PBKnot technology, pheromone traps, and sticky traps, gaining hands-on experience in their installation and effective use.

Additionally, women farmers and farm workers played a key role by participating in on-farm training sessions focused on clean cotton picking, proper storage, transportation, and their crucial contributions to the cotton production and textile industry. The initiative underscored the importance of empowering farmers through technology and knowledge-sharing, paving the way for a revitalized and resilient cotton farming sector in North India.

The initiative had a significant impact on smallholder cotton farmers by enhancing their knowledge and adoption of integrated pest management (IPM) and integrated disease management (IDM) techniques, enabling more effective control of pests and diseases. Through hands-on training, farmers gained practical exposure to precision farming techniques, including high-tech cotton cropping systems, drip fertigation, and

pheromone-based pest management, improving resource efficiency and crop productivity. Additionally, the initiative empowered farmers with scientific agronomic interventions, boosting their confidence in modernized, data-driven cotton cultivation to enhance yield potential, fiber quality, and economic returns. By leveraging technological innovations and capacity-building programs, this effort marks a crucial step toward revitalizing North India's cotton sector, fostering sustainable and resilient cotton production.

Table 7. District wise Farmers' Participation in High-Tech Regenerative Cotton Demonstration

Month	Total number of intensive farmer's field visits	Farmer field location (name of Districts only)
July	90	Sirsa
August	1450	Haryana: Sirsa, Fatehabad, Hisar, Bhiwani Punjab: Fazilka, Abohar, Bathinda and Mansa Rajasthan: Hanumangarh and Rajasthan
September	790	Haryana: Sirsa, Fatehabad, Hisar, Bhiwani Punjab: Fazilka, Abohar, Bathinda and Mansa Rajasthan: Hanumangarh and Rajasthan
October	170	Sirsa and Bhiwani
Total	**2500**	




High
Tech
R&D














Plot 4

Social Media Outreach of High-Tech Regenerative Cotton Demonstration

In *Kharif* 2024, the South Asia Biotechnology Centre (SABC) spearheaded high-tech cotton demonstrations to promote advanced cultivation techniques among smallholder farmers. These demonstrations were a key component of *Project Bandhan*, an initiative dedicated to enhancing cotton production across North India's cotton-growing regions. Throughout the season, SABC

organized a series of on-field programs, group discussions, and farmers' fairs, engaging key stakeholders from the cotton value chain. These events showcased groundbreaking technological advancements implemented in the high-tech regenerative cotton demonstration at Gindran village, Sirsa district, Haryana. A remarkable 2,500 farmers from Punjab, Haryana, and Rajasthan actively participated in these initiatives, attending exposure visits as part of *"Seeing is Believing"* tours. Additionally, four individuals were honoured for their exceptional contributions to advancing high-tech cotton production in North cotton growing zone:

- **Dr Rishi Kumar** - Recognized as the *Best Cotton Scientist* for his unwavering support of smallholder cotton growers
- **Sh Rajvir Rathi** - Awarded *Best Industry Champion* for his advocacy efforts on behalf of smallholder farmers
- **Sh Subhash Thete** - Commended for successfully implementing *"Project Bandhan – A Knot of PBW Protection"*
- **Sh Deepak Jakhar** - Honoured as the *Best SABC Employee* for his dedication to executing *Project Bandhan* in the North cotton-growing zone during *Kharif* 2024-25.

Notably, SABC has a strong tradition of leveraging digital platforms to share visual content from its field projects, including *Project Bandhan*. Every event and exposure visit to the high-tech regenerative cotton demonstration was meticulously recorded in high-quality short video formats and disseminated across various social media platforms such as YouTube, LinkedIn, Facebook, and Twitter. These efforts amplified awareness of advanced cotton farming techniques among a wider audience including smallholder farmers of North cotton growing zone.


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दिनांक: 16 सितम्बर 2024

For a comprehensive collection of multimedia content and detailed insights from the Kharif 2024-25 cotton demonstrations, visit SABC's official website and social media channels. A summary of relevant videos capturing key moments from the high-tech regenerative cotton demonstration with access to selected multimedia content is highlighted in table 8.

Table 8. Summary of relevant multimedia videos capturing key moments from the high-tech regenerative cotton demonstration, Kharif 2024-25

	**The Revival of Cotton in North India - High Tech Cotton Demonstration Farm in Kharif 2024-25** 20 July 2024 https://www.youtube.com/watch?v=LOdQB3J9uuA
	**CICR reviews & guides the execution of High-Tech Cotton Demonstration in Haryana** 28 July 2024 https://www.youtube.com/watch?v=XCghBE5mgGY&t=10s
	घर बैठें देखिए कपास की सबसे हाई-टेक खेती☞ कपास की हाई टेक खेती में कम खर्च ले पाएंगे ज्यादा पैदावार 27 Sept 2024 https://www.youtube.com/watch?v=oBftCPiHV1I
	ਨਰਮੇ ਦੇ ਵੱਧ ਉਤਪਾਦਨ ਲਈ ਵੱਡਾ ਟਰਾਇਲ **cotton 2024 : Big demo for future farming** 09 August 2024 https://www.youtube.com/watch?v=-nGaIRXFkfU
	**High-tech regenerative cotton practice reaps bountiful quality harvest in North cotton growing zone** 21 Oct 2024 https://www.youtube.com/watch?v=mfEXCS2HLUg
	अब आप भी कपास की हाई-टेक खेती कर ले पाओगे १३ से १५ क्विंटल तक कपास उत्पादन ☞ किसानों के लिए खुशखबरी 05 Nov 2024 https://www.youtube.com/watch?v=OBxPM4kj4vg&t=10s

Conclusion and Recommendations

The high-tech regenerative cotton demonstration conducted during the *Kharif* 2024 season at the North India High-Tech R&D Station, South Asia Biotechnology Centre at Gindran village, Sirsa district of Haryana, has provided compelling evidence that technological interventions can significantly enhance cotton productivity, resource efficiency, and sustainability.

Key Findings of the high-tech Regenerative Cotton Demonstration

- **Improved Germination & Plant Stand**: The adoption of drip fertigation systems ensures higher germination rates and optimal plant stand, contributing to better crop establishment and yield potential.
- **Water Conservation**: Farmers utilizing micro-irrigation techniques such as drip systems can achieve up to 60% savings in irrigation water, compared to conventional cotton farming.
- **Enhanced Fertilizer Use Efficiency**: Drip fertigation leads to significant improvements in nutrient uptake efficiency, with 54% for nitrogenous fertilizers, 33% for phosphoric fertilizers, and 79% for sulphur fertilizers, ensuring better crop nutrition and reduced input wastage.
- **Yield Improvement through Technology**: The integration of drip fertigation with advanced agronomic practices demonstrated substantial yield advantages, with:
    - Drip fertigation + mechanical detopping at 75 DAS (flat bed sowing): 16.70 quintal/acre
    - Drip fertigation + raised bed + polymulch + mechanical detopping: 15.97 quintal/acre
    - Drip fertigation + flat bed + canopy management with Mepiquat Chloride: 15.25 quintal/acre
    - Control plots (conventional methods): 4.21–6.53 quintal/acre
- **Economic Viability**: The net profit ratio from high-tech regenerative cotton demonstration plots was 2.99, significantly higher than in conventional control plots, which recorded 2.21 (control plot-I) & 1.54 (control plot-II), highlighting the economic benefits of adopting advanced regenerative farming technology.

Strategic Recommendations

- Drip fertigation should be widely promoted as a standard agronomic practice to improve water and nutrient efficiency in cotton farming.
- Integrated Pest Management (IPM), including mating disruption technology (PBKnot) and pheromone traps for monitoring, should be scaled up to reduce pesticide usage, minimize pest incidence, and ensure environmental protection.
- Adoption of water storage tanks and solar-powered irrigation systems alongside drip fertigation can play a crucial role in climate change mitigation and sustainable water management.
- The success of these technology-driven demonstrations serves as a pathway for increased adoption across the cotton-growing belt, offering a ray of hope for farmers, ginners, spinners and textile industry of North India.

By embracing precision agriculture, resource-efficient practices, and modern pest management strategies, the North cotton growing zone can revitalize cotton cultivation, enhance productivity, and ensure long-term sustainability for both farmers and the industry. In summary, the successful demonstration of these innovative technologies can become a ray of hope for farmers and cotton value chain partners of the North cotton growing region which results in the increase of area, productivity and production of cotton through technology adoption".

Annexure 1-6: Detailed Summary of Events and Participant Attendance

This section provides a comprehensive list of events conducted, along with the corresponding number of participants for each event held at the high-tech regenerative cotton production in *Kharif* 2024-25 at Gindran village, Sirsa district of Haryana.

Annexure 1: Seeing is believing program for cotton-textile partners

Total number of participants: 30		
S.No.	**Name of key stakeholder**	**Name of Institution/organization/company**
1.	Sh. Brijesh Kasana	Chief General Manager of The Cotton Corporation of India Ltd. (CCI), Sirsa
2.	Sh. Sushil Mittal	President of Haryana Cotton Ginners Association
3.	Sh. Aditya Chitlangia	President of Rajasthan Ginners Association
4.	Sh. Mahesh Sharda	Former President, Indian Cotton Association Limited (ICAL)
5.	Sh. Vivek Kaushal	CEO, DCM Nouvelie Textile Mills, Hisar
6.	Sh. Ramandeep Singh	General Manager, Louis Dreyfus Company, Bhatinda
7.	Sh. Bhola Singh	General Mills, Vardhman Textiles
8.	Dr. Dilip Monga	Technical Advisor of SABC & Ex Head and Principal Scientist ICAR-CICR RRS Sirsa
9.	Dr. Bhagirath Choudhary	Founder & Director of South Asia Biotechnology Centre

Annexure 2: Key stakeholder engagement to accelerate regenerative cotton production

Total Number of participants:50		
S No.	**Name of key stakeholder**	**Name of institution/organization/company**
1.	Prof. BR Kamboj	Vice Chancellor, Chaudhary Charan Singh Haryana Agricultural University, Hisar (CCS-HAU)
2.	Dr. Rajvir Garg	Director Research, Chaudhary Charan Singh Haryana Agricultural University, Hisar (CCS-HAU)
3.	Dr. JS Sandhu	Ex DDG (Crop Science) of Indian Council of Agricultural Research (ICAR) and Ex-Vice Chancellor of Sri Karan Narendra Agriculture University, Jobner
4.	Dr. Sain Dass	Ex-Director of ICAR- Indian Institute of Maize Research
5.	Dr. Rishi Kumar	Head of ICAR-CICR Regional Centre, Sirsa

6.	Dr KS Sekhon	Head of Punjab Agricultural University's Regional Research Station (RRS), Bathinda
7.	Dr. Vijay Kumar	Chief Entomologist of Punjab Agricultural University (PAU), Ludhiana
8.	Dr. Dilip Monga	Technical Advisor of SABC & Ex Head and Principal Scientist ICAR-CICR, RRS, Sirsa
9.	Dr. Bhagirath Choudhary	Founder & Director of South Asia Biotechnology Centre, Jodhpur
10.	State Agriculture Department Haryana teams, and progressive farmers participated in the key stakeholders meeting	

Annexure 3: Farmers' Mela showed the way forward for cotton cultivation in North India

Total Number of participants:150		
S.No.	**Name of key stakeholder**	**Name of Institution/organization/company**
1.	Dr. PK Singh	Agriculture Commissioner, Ministry of Agriculture & Farmers Welfare, Govt of India
2.	Dr. Rishi Kumar	Head & Principal Scientist ICAR-CICR, RRS, Sirsa
3.	Dr. Dilip Monga	Technical Advisor of SABC & Ex Head and Principal Scientist ICAR-CICR RRS Sirsa
4.	Dr. Bhagirath Choudhary	Founder & Director of South Asia Biotechnology Centre, Jodhpur
5.	Sh. Sandeep Kumar	PI Foundation
6.	150 progressive farmers from major cotton growing district of Haryana, Punjab and Rajasthan participated in the key stakeholders meeting	

Annexure 4: Cotton farmers at North India high-tech cotton demonstration

A group of progressive cotton farmers from different cotton-growing districts of north India assembled at the high-tech cotton demonstration to learn and adopt new cotton cultivation technologies.

Total number of participants: 240		
S.No.	**Name of key stakeholder**	**Name of institution/organization/company**
1.	Dr. Deepak Jakhar	Fellow Scientist of South Asia Biotechnology Centre, Sirsa
2.	Sh. Sanjeev Gupta	Tata Rallis Pvt. Ltd
3.	Sh. Sanjeev Deshwal	Tata Rallis Pvt. Ltd
4.	Sh. Sachin Parihar	Tata Rallis Pvt. Ltd
5.	240 progressive farmers from major cotton growing district of Haryana, Punjab and Rajasthan participated in the key stakeholders meeting	

Annexure 5: Farmers-Scientists interaction to promote high-tech cotton cultivation

Total number of participants:140		
S.No.	**Name of key stakeholder**	**Name of institution/organization/company**
1.	Dr. Charudatta Mayee	Ex-chairman ASRB and President of South Asia Biotechnology Centre
2.	Dr. Y G Prasad	Director ICAR-CICR, Nagpur
3.	Dr. Rishi Kumar	Head & Principal Scientist of CICR, RRS, Sirsa
4.	Dr. SK Sain	Principal Scientist of CICR, RRS, Sirsa
5.	Dr. Dilip Monga	Technical Advisor of SABC & Ex Head and Principal Scientist ICAR-CICR RRS Sirsa
6.	Sh. Abhijit Tathe	PI Industries Ltd
7.	Sh. Gagandeep Singh	PI Industries Ltd
8.	Sh. Rajvir Rathi	Vice Chairman of Federation of Seed Industry of India (FSII) and Bayer Crop Science Ltd
9.	Sh. Aashish Pradhan	Mahyco Monsanto Limited (MMB)
10.	Sh. Pankaj Sharda	Indian Cotton Association Limited (ICAL)
11.	Dr. Bhagirath Choudhary	Founder & Director of South Asia Biotechnology Centre
12.	140 progressive farmers from major cotton growing district of Haryana, Punjab and Rajasthan participated in the key stakeholders meeting	

Annexure 6: Key stakeholder exposure visits at high-tech cotton demonstration

Total number of visitors:500		
S.No.	**Name of key stakeholder**	**Name of institution/organization/ company**
1.	Dr. Rishi Kumar and Dr. Amarpreet Singh	ICAR-CICR Regional Research Station, Sirsa
2.	Sh Rajesh Malik, Sanjeev Lakra, JP Beniwal and Rajpal Singh	Rasi Seed Pvt. Ltd
3.	Sh Aashish Pradhan and Shivpal Singh	MMB
4.	Dr. Anil Kumar	Dy. Director Agri., ATC Hanumangarh Town
5.	Dr. Rajvir Garg (Dean Research), Dr. Suresh Kumar (Joint Director)	CCS Haryana Agricultural University, Hissar
6.	Sh. Yuvraj Singh, Sh. Anand Singh Rathore, Sh. Pawan Sharma, Sh. Rajesh Dakha, Dr. P.M Bhardwaj, Sh. Ajaypal Singh, Sh. Bajrang Bagria, Sh. Sunil Goyat, Sh. Avinash Mishra, Sh. Vijay Kumar, Sh. Gurmeet Singh and Sh Rai Singh	Mahyco Pvt Ltd
7.	Sh. Ajay Sentil and Sh. Rajesh Suthar	Yara Fertilizer
8.	Sh. Girish Patel and Sh. Virendra Singh Tanwar	ALPGIRI Seed
9.	Sh. Sanjeev Kumar, Sh. Sachin Parihar and Sh. Subash Chander	Rallis India Ltd
10.	Progressive farmer from different cotton growing districts of Haryana, Punjab and Rajasthan.	

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