INTERNATIONAL COTTON RESEARCHERS ASSOCIATION

COTTON

Cotton Innovations Journal Vol 6 - Issue 3

www.cottonicra.org

MAY-2026


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Cotton Innovations Journal

The Cotton Innovations Journal is published twelve times annually. Contributed articles, pictures, cartoons, and feedback are welcome at any time. Please send contributions to the General Editors (see below). The editors reserve the right to edit. The deadline for contributions is one month before the publication date.

Editorial Board

Published by ICRA Secretariat, Pakistan Central Cotton Committee, Multan-Pakistan
http://icra-cotton.org
The newsletter is also available at URL:
http://www.icra-cotton.org/page/cotton-innovations

ISSN 2788-6611

INNOVATION IS OUTREACH TO SMALL HOLDER COTTON FARMERS IN INDIA

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Background

Transfer of knowledge is one of the biggest challenges in agriculture across the globe and is a greater challenge in developing countries. This transfer of technology from lab to land is slow, although the technological advancement is fast, the infrastructure required and the manpower to train farmers in rural remote areas is small. The usefulness of the training depends greatly on the expertise and presentation skills of the trainers (Kranthi 2022).

I have spent over three decades in transferring knowledge to small holder farmers, with various cotton identity programs.I am at present closely associated with a startup Beetle Regen Solutions, an organization working with close to 70K cotton farmers in India in the states of Madhya Pradesh and Maharashtra, promoting Regenerative Agriculture.

In India the total number of educated and trained personnel in the agricultural sector is far too low compared to the size of the sector. There are 4 full time agricultural researchers per 100,000 farmers, implying too few researchers to cater to the demand of the farmers (Anand et al.2021).

Enhancing Cotton Productivity in India:

This article highlights the steps and action that we have taken at Beetle to promote High Density Plantation System (HDPS) and Close Spacing (CS) for increasing cotton productivity.

Productivity of Indian cotton is around 445 kgs of lint per ha which is far below the global average of 775 kgs of lint per ha. To address this gap, ICAR-Central Institute of Cotton Research (ICAR-CICR) Nagpur, India has after several years of research rolled HDPS/CS as a scalable technology for yield enhancement.

Close to 65% of India's cotton is rainfed. Almost 37% of India's area produces around 300 kgs of lint per ha. (ICAR-CICR Technical Bulletin 2023/3). HDPS/CS technologies are being targeted to increase the productivity of cotton in these areas.

The success of HDPS rests on the adoption of its main components by farmers and how organisations and their trainers (to farmers) understand this concept and take the technology to the farmers. The backbone of this is the concept of unit area wise productivity and not plant based productivity, and hence we made a lot of efforts for our field teams to understand this.

The architects of HDPS/CS at ICAR-CICR coined the term `5G' to describe its main components, they are as follows:

- Genotype: Compact, early maturing
- Geography: Soil type (Shallow to medium) and ecosystem (rainfed)
- Geometry: Row to row (90 cm), plant to plant spacing (15 cm for HDPS and 30cm for CS)
- Growth regulation: Canopy management with PGR
- Gain in yield: Integrate IPM, INM, IWM

Let me now briefly elaborate what we at Beetle have done to ensure that all these 5 critical components are properly understood and implemented by the farmers.

Genotype

We contacted several leading cotton seed companies in India and got a list of cultivars that were early maturing (<150days), semi-compact cultivars with synchronous flowering/boll bursting habit. After obtaining the list we reached out to the seed companies again and gave them the locations where the farmers were located to ensure that these cultivars were available with the local seed dealers.

Simultaneously during our training with farmers, we explained the concept of and shared a list of suitable varieties. The recommended seed varieties were shared with farmers in their respective What's app groups as well.

Beetle's team members checking for recommended genotype availability with the local agro dealers.

Geography

The HDPS technology is primarily tailored to light and medium soils with low fertility status. Our teams did a profiling exercise on the villages and grouped the villages according to the predominant soil types. This helped us to target our interventions specifically to those locations where the productivity was lower than the national average of India.

Geometry

A very critical aspect of the technology, our team simply echoed what has been written in the ICAR-CICR technical bulletin on HDPS. Our message to farmers was, 90x15 cms spacing for light soils (plant population of 74000 plants per ha) and 90x30 cms spacing for medium soils (plant population of 37000 plants per ha). This is a major shift in planting geometry from what farmers were doing earlier (90-120 cm between rows and 30-45 cm between plants in a row). This also meant that the per acre requirement of seed jumped around 4 times from the normal spacing that farmers were used to.

Growth Regulation/Canopy Management

A very new concept and required a lot of work at our end to the convince farmers the need for the same. Canopy management in HDS is required to prevent excess vegetative growth, to enhance light penetration and to regulate plant height. To curtail excessive vegetative growth and retain first formed bolls, plant growth regulator (PGR) like Mepiquat Chloride is applied 2 to 3 times.

Most farmers in India plant hybrids and are accustomed to seeing big/tall plants and consider that as a kind of benchmark and hence regulating plant height is quite antithetical to the general perception.

General perception of what a good cotton plant is in terms of height.

messages, crop 45 days old, crop height was more than 45 cms, crop was at square initiation stage and there should be no drought/excess moisture stress. Farmers were not readily convinced and we did have delays in the 1st spray. Our field teams went on a campaign mode to explain to farmers the importance of canopy management and particularly use of Mepiquat Chloride.

Our Agronomist explaining to farmers on the use of PGR

Farmer with his crop who sprayed PGR on time

The second and third spray of PGR at flowering and later stages, was based on decision criterion based on the internodal distance of the top 5 internodes, if the length is less than 20 cms then there is no need to spray. This is not so easy for farmers and field staff to understand and needs support from experts who understand the plant structure and can explain things in an easy way. Our teams were trained on plant observations by Dr. MV Venugopalan (former principal scientist (Agronomy) ICAR-CICR).

Training on taking observations on cotton plant

Our team taking plant observations.

Gain in yield by incorporating Integrated Nutrient Management (INM), Integrated Pest Management (IPM) & Integrated Weed Management (IWM):

INM

Taking cognizance of the Indian reality of imbalance fertilizer use in India tilting heavily towards use of Nitrogen. The N:P: K ratio has deteriorated to an alarming rate of 10.9:4.4:1 (not limited to cotton alone) from the agronomically recommended 4:2:1 (Gulati & Juneja, 2025).

Further most farmers instead of 3 splits of fertilizers (scientific recommendation) apply the fertilizer in 2 splits. Our messaging to farmers to address this was on the lines that Urea application delays flowering and invites pests (especially when applied in excess in the beginning). This message was well understood by farmers.

The other aspect that we have taken on is intercropping of cotton with legumes, Indian cotton farmers have a host of options to choose from, there are many apprehensions in the minds of farmers about weed control and not being able to perform intercultural operations. These concerns are valid and need to be addressed by showcasing farmers who are practicing the same, with exposure visits to farmers who have planted intercrops on their fields etc.

IPM

We, at Beetle, have been advocating the ICAR-CICR `window-based strategy' (0-60 DAS after sowing, 60 to 90 DAS, 90 to 120 DAS & 120 > DAS). We have been providing positive lists of insecticides with commercial names and WHO ratings. This has empowered farmers who visit agro dealers and specifically ask for insecticides based on the crop stage and pest status.

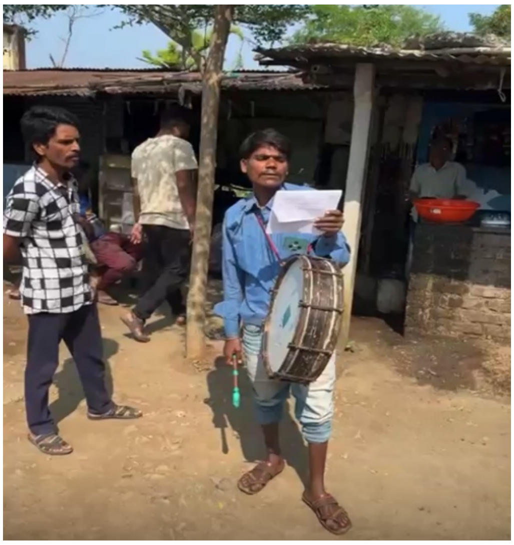
IWM

Farmers do use intercultural operations for weed control and manual weeding is also practiced. However, over the years with labour shortages farmers are resorting to use of weedicides. However, the use of pre-emergence herbicides has been very low. We put in efforts to increase the adoption of the pre-emergent herbicides so that farmers could be encouraged to sow an intercrop with cotton. On the use of post emergence herbicides, we were emphatic that they were effective against younger weeds 10-15 days old or less than 4 inches in height. Conveying this to farmers is essential so that herbicides are not used unnecessarily.

Outcomes

Beetle started to work on HDPS from the cotton season 2024-25, in the first year we got around 250 farmers to follow the technology, these farmers were supported with a subsidy of around ₹16000 per ha, by special project on cotton productivity enhancement, supported by the Indian government (Ministry of Agriculture and Farmers Welfare along with the Ministry of Textiles. In the 2nd year 2025-26 we got close to 2500 farmers growing cotton under HDPS/ CS with no subsidy at all. Preliminary data shows that the farmers got anything between 20 to 25% higher yield as compared to the previous years, this increase is attributed to following the concept of `5G.'

As the cotton season 2025-26 is coming to an end, we are sure that we more farmers would be adopting this technology. Peer to peer learning is an extremely powerful tool, and the best way to convince farmers is to see the crops of fellow farmers. One of the innovative routes we took is to use traditional drum beaters in the village, who gave the names of farmers adopting this technology and generally creating a buzz.



Using the services of drum beater in a village

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FROM 3.2 TO 4.55 TONNES PER HECTARE IN JUST FOUR YEARS: WHAT UZBEKISTAN'S COTTON REVOLUTION TEACHES THE WORLD?

Dr. Venkatesh Kulkarni

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Published in Scientific Reports (Nature Portfolio) | May 2026

Mechanical cotton harvesting at scale — combine harvesters working across intensive-row Uzbekistan cotton fields (2025)

Imagine being told that a country can grow more cotton on less land, spend far less money doing it, and improve the livelihoods of millions of farmers — all within five years. Most would call it wishful thinking. Uzbekistan just made it reality.

Between 2021 and 2025, Uzbekistan's cotton sector underwent one of the most dramatic agricultural transformations in recent global history. A peer-reviewed study just published in *Scientific Reports* — authored by the Council for Cotton Growing under the President of the

Republic of Uzbekistan, in collaboration with the Centre of Genomics and Bioinformatics and the Ministry of Agriculture — documents this transformation with national production data. The findings are extraordinary.

The Numbers That Tell the Story

The headline figure: national average cotton yield rose from **3.24 to 4.55 tonnes per hectare** — a 40.4% improvement. Simultaneously, total cotton production increased by 19.3%, even as the cultivated area was reduced by 15.1% — from about 1.03 million hectares to 875,000 hectares.

In simple terms: Uzbekistan grew significantly more cotton on significantly less land. That freed up over 155,000 hectares — redistributed to food crops and Uzbekistan's youth — directly strengthening food security for the country's 38 million people.

+40.4%	+19.3%	−15.1%	−55.4%
Yield Increase	Production Gain	Area Reduced	Cost per Ha

Three Engines of Change

The transformation was not the result of a single silver bullet. It was powered by three interlocking forces working together:

1. **New-generation cultivars.** Uzbekistan strategically combined domestically developed biotechnology — RNAi and Marker-Assisted Selection (MAS) varieties such as the 'Porloq' and 'Ravnaq' series — with newly introduced Bt/glyphosate-tolerant (Bt/Gt) cultivars. By 2025, advanced technology varieties accounted for nearly 38.5% of the national planted area, with Bt/Gt cultivars alone achieving average yields of 4.85 t/ha, about 9.7% above traditional varieties.
2. **A revolution in how cotton is planted.** Shifting from traditional 90 cm row spacing with flood irrigation to an intensive 76 cm double-row system with drip irrigation cut total production costs per hectare by an estimated 55.4%. Water consumption dropped by 40%. Fertiliser costs fell by 82.8%. Seed requirements shrank by 49%.

Xinjiang-model intensive planting: high-density double rows with plastic mulch and drip irrigation lines — the agronomy revolution that cut costs by 55%

3. **Coordinated policy and market reform.** Targeted subsidies for drip irrigation systems, advanced seed access, and modern machinery. Extension system modernisation. Quality-based price premiums that rewarded better fibre, not just higher volume. Smart investments designed to change farmer behaviour permanently.

The Hidden Engine: Science-Led Governance and the Cartagena Protocol Advantage

Behind the yield numbers lies a story rarely told in agricultural transformation case studies: the critical role of **a scientist in the decision-maker's chair**. **Dr. Ibrokhim Y. Abdurakhmonov**, lead author and head of the Council for Cotton Growing under the President of Uzbekistan, placed scientific reasoning at the very centre of national policy.

Uzbekistan, a signatory to the **Cartagena Protocol on Biosafety**, completed its full biosafety evaluation rigorously and issued commercial GM approval **from day one of the review process being concluded** — without shortcuts on safety, but without bureaucratic delay either.

Scientists and policy leaders evaluating cotton trials in the field — Uzbekistan

Technology adoption time was reduced by 100% vs. the global norm. Where other countries take 5 years for GM approval, Uzbekistan moved from approval to 30.82% national area coverage in a single growing season.

This is the governance lesson that deserves the most attention. GMO regulation is often discussed as a binary choice between precaution and progress. Uzbekistan demonstrated a third path: **science - informed, farmer - centred, protocol-compliant speed**. Farmers did not wait years for a technology proven elsewhere in the world. They received it when they needed it, and the harvest data confirmed it was the right call.

Broad Adaptability: The Science Behind the Success

One of the study's most reassuring findings is the **consistency of cultivar performance across all five agro-climatic zones** — from the fertile Fergana Valley to the arid deserts of Karakalpakstan. Statistical analysis showed that genotype-by-environment interaction accounted for only 12.9% of yield variance and was not statistically significant. Cultivars behaved reliably across regions — the hallmark of sound breeding work.

What This Means Beyond Uzbekistan

Cotton occupies just 2.5% of the world's arable land yet accounts for approximately 16% of global insecticide use. The Uzbekistan story demonstrates that **sustainable intensification is not a theoretical concept** — it is achievable at national scale, within a decade, in an irrigated dryland system facing serious water stress.

The model is not a template to copy blindly. It depends on seed system capacity, irrigation infrastructure, and governance. But the lesson is clear: when genetic innovation, agronomic practice, and policy reform move together — not in isolation — transformation accelerates.

Looking to 2030

Dense boll set on Bt/Gt cultivar — peak yield potential

The projections of national average yield could reach **approximately 6.0 t/ha by 2030** under an accelerated adoption scenario — assuming full-area Bt/Gt coverage and at least 80% adoption of intensive agronomy including high-density planting, plastic mulching, and drip irrigation. A backcrossing programme is already under way in Public-Private Sector Collaborations to incorporate Bt/Gt traits into locally adapted Uzbek cultivars. New initiatives include Introduction of new plant types that can potentially tolerate Salinity and Moisture stress. Developing new Gene Stakes to attain sustainability. High boll retention in high temperatures and higher density of planting. Compact plant types that require less growth regulators spray.

"For those of us working in seed R&D, agronomy, and agricultural policy — this is not just Uzbekistan's story. It is a proof of concept for what becomes possible when science, economics, and governance align. Which cotton-growing regions will write their own version of this story next?"

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