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The ICAC Recorder

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ICAC Latin American Association
for Cotton Research & Development

INTA, Reconquista, Argentina
8-11 September 2025

The ICAC Recorder

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A SESSION AT THE 15th ALIDA MEETING 8-11 SEPTEMBER 2025 INTA, RECONQUISTA, ARGENTINA

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Editorial

ALIDA -Latin America: The Custodians of Cotton's Past and Architects of Its Future

Cotton *holds immense importance for South America and Mexico, not merely as a commercial crop but as a symbol of cultural continuity and national identity. In regions such as Peru and Mexico, cotton is deeply intertwined with indigenous traditions going back over five millennia. For the ancient Andeans, cotton was not just a fibre but a sacred medium used to weave stories, myths, and societal values into intricate textiles revered by royalty. In Mesoamerica, cotton enjoyed a similar reverence -Aztec and Mayan societies considered it a luxury item and an economic asset, often woven into tribute systems. Even today, in places like Oaxaca and the Peruvian highlands, one can find women working on traditional backstrap looms, upholding a generational craft that binds the past with the present.*

Economically, cotton has evolved into a strategic pillar for the region's trade and industrial sectors. As of 2025, Brazil has emerged as a dominant global exporter, supplying 15% of the world's cotton and surpassing even the United States in international shipments. Meanwhile, Mexico, though reliant on imports, stands as a key textile hub, efficiently transforming raw fibre into finished goods for markets across the globe, particularly North America. Additionally, Peru's prized Pima cotton has carved a niche in the luxury fabric market, thanks to its exceptional quality. What makes this growth even more commendable is the region's commitment to sustainability -Brazil's cotton production is largely certified for eco-social compliance, positioning South America as not just a commercial leader, but a responsible one. Thus, the cotton economy of South America and Mexico represents a fine synergy between heritage, innovation, and sustainability.

Undoubtedly, Latin America holds enormous potential for cotton production and value addition, owing largely to its unique distinction as the center of origin of Gossypium hirsutum and Gossypium barbadense, the two species that together account for about 99% of global cotton area and production. The region is not only an important and emerging textile hub, but also the cradle of a rich artisanal textile heritage. This legacy provides a natural advantage for local communities to sustain traditional textile practices while simultaneously adopting modern technologies and innovations. By doing so, Latin America can position itself as both the custodian of cotton's genetic origins and the guardian of its artisanal textile traditions, generating prosperity through value addition, employment, and inclusive growth. The Latin American Association for Cotton Research and Development (ALIDA) seeks to strengthen regional collaboration so that countries which once enjoyed vibrant cotton production and textile manufacturing can reclaim their prominence. Through shared scientific knowledge, technological innovation, and market intelligence, the ALIDA network aims to promote sustainable cotton textiles as a pathway to renewed competitiveness and long-term prosperity across the region.

The previous edition of the ICAC RECORDER (December 2025) was published as a Special Issue (Part I), featuring articles based on presentations delivered in Sessions 1–3 of the 15th ALIDA Meeting, held from 8–11 September 2025 at INTA Reconquista, Argentina. This Special Issue (Part II) of the ICAC RECORDER (March 2026) presents articles derived from presentations made in Session 4 of the ALIDA Meeting, with a focus on traceability, technological innovations, agricultural engineering, and country reports from eight cotton-producing countries in Latin America.

The Session-4 on innovations, technologies, organization, and territories brought together six presentations that highlighted the diversity and dynamism of the Latin American cotton value chain. Discussions spanned regional cotton production networks, associative organizational models, advances in traceability and fiber quality, and the development of innovative technologies for crop management, harvesting, and post-harvest operations. The strategic role of the FAO-supported +Cotton Project was emphasized for its contributions to capacity building, innovation, and institutional strengthening. Presentations showcased how producer associations such as APPA, AAPA, and ABRAPA have successfully integrated producers, industry, research institutions, and public policy to enhance competitiveness, sustainability, and market access. Advances in standardized fiber classification, certification, and traceability were highlighted as key tools for improving transparency and access to higher-value markets. The session also highlighted the importance of technological innovation from machinery adapted to small-scale farming to drones, sensors, and Agriculture 4.0 solutions, while stressing that effective adoption depends on close collaboration between researchers and farmers, supported by targeted investment, training, and regional cooperation.

I would like to gratefully acknowledge the outstanding contribution of Dr. Marcelo Paytas, who not only coordinated the collection of the manuscripts but also undertook the preliminary editing and translation of the articles from Spanish into English. His dedication and meticulous efforts made my role as Editor remarkably easy in bringing out both Special Issues (Part I and Part II) of the 15th ALIDA meeting. Thank you Marcelo.

– Keshav Kranthi

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Session-4: Introduction
Innovations, Technologies, Organization and Territory

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Introduction

The session on innovations, technologies, organization and territories featured six presentations reflecting the diversity of approaches within the Latin American cotton value chain.

The topics:

- +Cotton in Latin America
- Cotton production networks in Latin America
- Associative models (APPA, AAPA, ABRAPA)
- Advances in traceability, fiber quality, SITC and marketing
- Development and innovation of prototypes and technologies for crop management, harvesting and post-harvest
- Agriculture 4.0 technologies applied to cotton: sensors and drones

Organization and Networks

The strategic role of the +Cotton Project (FAO–ABC/MRE) was highlighted, as it has strengthened technical capacities, promoted cotton roundtables, and generated innovation in seeds, machinery and training. Experiences of production networks were also shared, integrating producers, artisans, designers and technicians to recover local knowledge, add value to cotton fiber, and enhance the visibility of family farming and women within regional economies.

Associative Models

The associations presented their different organizational models:

- **APPA (Santa Fe, Argentina):** public–private articulation, productive innovation and traceability.
- **AAPA (Argentina):** national representation, public policies, sustainability and generational renewal.
- **ABRAPA (Brazil):** represents nearly the entire planted area and export volume, with pillars focused on quality, traceability and sustainability.

All organizations agreed that the integration of producers, industry, science and the State is the foundation of global competitiveness.

Advances in Traceability and Marketing

Experiences related to standardized fiber classification (SITC–HVI), certifications and quality programs were addressed as mechanisms to improve international market insertion. Traceability is consolidating as a tool to ensure transparency and open access to higher-value markets.

Technological Development and Innovation

Advances were presented in machinery adapted to small-scale production (manual harvesters, planters and sprayers), as well as drones and meteorological stations.

It was emphasized that innovation must be linked to joint work between researchers and producers in order to generate effective solutions that improve productivity and sustainability.

Agriculture 4.0 Technologies

The session concluded with a forward-looking perspective on smart cotton, based on digitalization, automation and robotics: variable-rate irrigation and nutrient application, AI-based robots for harvesting and weed control, and integrated real-time data platforms.

Although access and training have increased, investment and local adaptation constraints persist; therefore, technical training and regional cooperation will be key for adoption.

Figure-1. INTA Farm visit

Figure-2. Demonstration of the INTA Mini ginning machine

Figure-3. Visit to the biotech laboratory

Figure-4. Cotton processing training for women entrepreneurs

Figure-5. Demonstration of irrigation water efficiency

Figure-6. Demonstration of soil health technologies

Challenges and Opportunities

The main challenges identified include environmental sustainability, adaptation of technologies to local contexts, generational renewal, cost competitiveness and access to financing. Among the opportunities, regional integration through ALIDA, technological innovation and traceability were highlighted as pathways to consolidate a sustainable, competitive and inclusive cotton sector in Latin America.

General Conclusions

- Network-based organization facilitates the development and appropriation of technological innovations, generating real transformations in contexts of use, as genuine participation of stakeholders imprints specific characteristics on designs and developments, creating practical solutions with high effectiveness and impact.
- Proximity to end users of R&D&I activities constitutes an essential element in co-innovation processes; early interaction between real demand and researchers facilitates access to practical solutions that respond to identified needs.
- Sectoral association strengthens public–private management and advocacy strategies. Collaboration, rather than competition, among different segments of the value chain generates a volume of initiatives and capacity for action that cannot be achieved in isolation. This applies to all links in the cotton value chain, including the science and technology sector.

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+Cotton in Latin America: An Overview

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Abstract

The Latin American cotton sector faces challenges related to territorial weakening and impoverishment affecting different actors, including family farming. This article reviews the experience of the +Cotton Project, a Trilateral South–South Cooperation initiative (FAO/Brazil/Partner Countries) aimed at strengthening the cotton value chain and generating public policies through a horizontal and multisectoral cooperation approach, contributing to sustainable livelihoods. Results include the development of public policy tools, validation of good practices and capacity building. Challenges and opportunities within the cotton value chain are identified, and the importance of articulation networks is highlighted to ensure continuity of innovations and achieve sustainable transformations for cotton in Latin America and the Caribbean.

Introduction

Cotton is one of the 20 most important commodities worldwide in terms of value and industrial development (Beckert, 2014). It involves 28.67 million producers, and it is estimated that 350 million people carry out economic activities related to its value chain. Of the 30.3 million hectares of cotton cultivated globally, 2.7 million are located in Latin America and the Caribbean (USDA, 2025).

By 2019, approximately 131,500 cotton producers were reported in the region, of whom 77% were family farmers (FAO, 2025); currently, it is estimated that the total number of producers in the region does not exceed 18,000. The challenges faced by the Latin American cotton sector—technological, market-related and organizational—have led to a weakening of cotton production in the territories and to impoverishment affecting family livelihoods. In this context, the +Cotton experience reflects recognition of the resilience trajectory of thousands of families for whom cotton has traditionally been a key livelihood. This article reviews the operation and results of the +Cotton Project in Latin America and the Caribbean.

Methodology

The +Cotton Project is a Trilateral South–South Cooperation initiative implemented by the Brazilian Cooperation Agency (ABC/MRE), FAO and seven partner countries in Latin America and the Caribbean, with financial support from the Brazilian Cotton Institute (IBA) and the Government of Brazil. It is the result of technical contributions from Brazilian cooperating institutions such as Embrapa, Abrapa, Asbraer and Empaer-PB, together with their counterparts in partner countries. The project aims to promote and strengthen the cotton value chain, build institutional capacities and contribute to the development of public policies for the cotton sector.

The +Cotton Project is structured around four thematic pillars: Sustainable Technologies; Social Innovation; Strategic Alliances; and Inclusive Markets and integrates three cross-cutting themes: gender and rural youth; Indigenous peoples; and climate change. Project actions are defined through inclusion and articulation with national actors, responding to specific demands through consultation and technical support processes with Brazilian institutions. Mechanisms include diagnostics, training, support for public policy development, and incorporation of demands into promotion, rural extension and research agendas.

Results

Eighteen public policy tools were generated for cotton–food production systems, including cotton development plans and programs in Peru, Bolivia and Paraguay.

The project supported the establishment of networks such as the Latin American Cotton Women's Network, the Regional Cotton Forum and the +Seeds Network, and participated in technical platforms such as ALIDA. More than 126 institutions were involved, and over 100 missions and exchanges were conducted. A total of 157 sectoral studies were completed, and 2,353 professionals and more than 14,000 family farmers, artisans and youth were trained.

A total of 138 technical demonstration units were implemented, 22 national and Brazilian seed varieties were validated, and community seed banks were established. Cold storage facilities were installed in Paraguay and a water cistern in Bolivia, benefiting 100 students. A one-row cotton harvester prototype was developed with Embrapa, and a mini cotton gin was provided to Ecuador, along with machinery kits and equipment adapted for cotton management and processing. Manual harvesters, planters and sprayers were distributed and validated, and fertilizer and NDVI drones were introduced, as well as meteorological stations for risk management and decision-making.

Certification processes and pilots for cotton, digital extension services (ATER), VOIP training methodologies, radio programs such as Mandiyuti: Agriculture for All, Smart Irrigation 4.0 pilots and blockchain traceability initiatives were implemented in coordination with UNECE. More than 2,000 people were trained through virtual courses on home gardens, sustainable cotton production and handicrafts.

The +Cotton Project implemented the Lazos Initiative to foster digital inclusion and the creation of virtual communities for knowledge exchange and management focused on rural populations. Its objective is to connect the Latin American cotton sector, cooperatives and associations, artisans, researchers, public institutions, projects, the textile industry and private companies linked to cotton. By 2025, the initiative had more than 800 active users.

In terms of communication, the project produced 229 audiovisual materials, 1,196 tweets, 462 media articles, 65 YouTube videos and 26 newsletters, among other outputs.

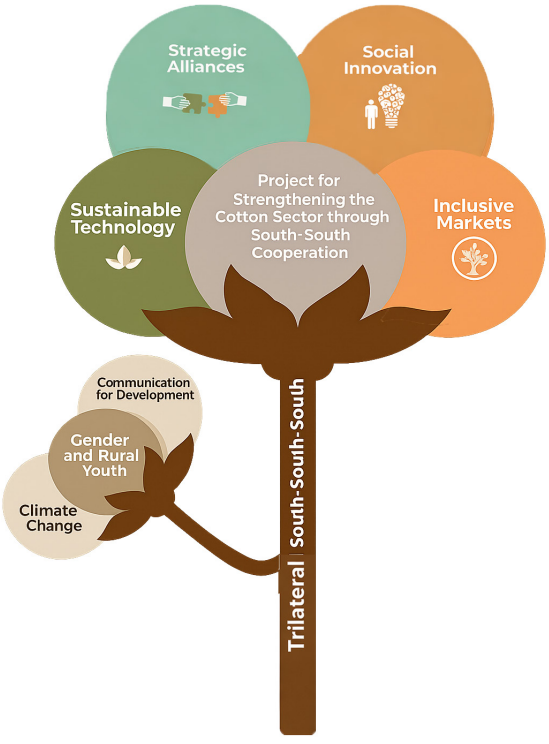

Figure-1 Strategic organization of the +Cotton project

Discussion

The cooperation promoted by +Cotton offers advantages over traditional development models by emphasizing issues fundamental to family farming—which represents 85% of cotton producers in LAC—such as shared institutional management across project life cycles; technical implementation through multi-level actor networks; adoption of trilateral cooperation to share and build knowledge; horizontal, participatory exchange of experiences; neutrality and trust derived from international organization management; and the participation of key public and private actors that expand capacities for differentiated public policy development.

However, the cooperation also faced technological, organizational and territorial challenges. Sustainability requires ensuring continuity in the use and maintenance of technologies and methodologies by farmers and technicians. Financing constraints, investment and equipment maintenance costs, and the digital divide necessitate sustained training efforts. Organizationally, long-term regional coordination remains a challenge due to the absence of decision-making mechanisms that could sustain synergy. Replicability across countries with different institutional and technological capacities, scalability, and knowledge diffusion into public policies and extension systems are also critical issues. Policy articulation and sustainability across political cycles are vital, as government changes can reverse successful programs. At the territorial level, environmental sustainability demands adaptive management in response to climate change, soil degradation and water scarcity, while rural–urban migration and population aging threaten territorial sustainability.

Opportunities include regional leadership by Brazil and FAO, demonstrating the capacity of Latin American countries to guide development initiatives; the generation of culturally appropriate and technologically flexible solutions; institutional articulation and network building; the potential of digital technologies to improve productivity, management and market access; and the mainstreaming of a gender approach to address inequalities and enhance the visibility of women in family farming.

Conclusion

Under the +Cotton Project framework, good practices focused on Emmanuel South South.pngng productivity, reducing costs and increasing profitability have been validated and adjusted, alongside technological development and capacity strengthening. Interventions respond to demands related to technology, training, social organization, public policies and economic and environmental sustainability, within the framework of Trilateral South–South Cooperation. Networks such as ALIDA represent an opportunity to consolidate post-project cooperation spaces, ensuring continuity of innovations, policies and knowledge, and contributing to territorial transformations with positive impacts on food security, gender equity, environmental sustainability and community resilience.

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Cotton Production Networks in Latin America

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America Gonzalez Sanabria

Abstract

This article brings together contributions from an organizational and economic perspective presented by América González Sanabria (FAO – Paraguay), Ronald Quispe (FAO – Bolivia), Eugenia Zubiarrain and Julieta Rojas (INTA Argentina), within the framework of the panel "Cotton Production Networks in Latin America" at the XV ALIDA Meeting 2025. The analysis addressed the following questions: What are the most relevant organizational aspects at the strategic and operational levels? What challenges are identified for the future?

Strategic & Operational Organizational Priorities

- Network-based work constitutes a collective, interdisciplinary space, integrating different stakeholders along the cotton value chain, including women and men producers, spinners, weavers, textile artisans, market vendors, agricultural and handicraft extension agents, as well as representatives from design and fashion sectors.
- This network approach has its regional precedent in the Latin American Cotton Research and Development Association (ALIDA), which since its inception has promoted technical cooperation and knowledge exchange among Latin American countries, addressing critical issues such as integrated pest management, genetic improvement, fiber quality and sustainability.
- Organizations facilitate capacity strengthening at local, regional and national levels. Through shared management, they enhance the ability to address needs such as access to seeds, recovery and integration of ancestral and technical knowledge into production processes, value addition, market access and organizational development. ALIDA has served as a platform for technology transfer and training, as evidenced by its technical meetings held in countries such as Argentina, Peru, Brazil, Colombia and Paraguay.
- At the strategic level, organizations provide opportunities to enhance the visibility of family farming, peasant and Indigenous sectors, with particular emphasis on women as key actors in local economies. This enables participation in public policies aimed at economic empowerment and strengthens inter-institutional articulation and response capacity. For example, ALIDA, with the support of the International Cotton Advisory Committee (ICAC) and organizations such as FAO, has contributed to positioning cotton as a strategic crop for rural development and employment generation in the region, as reflected in initiatives such as the +Cotton Project.
- At the operational level, agro-food systems based on agroecological models are promoted, including cotton fiber production with both artisanal and industrial value addition and improved market access, addressing logistical aspects to achieve better prices and quality labels. Priority is given to household economies, food sovereignty and biodiversity conservation within agroecosystems. Experiences shared during ALIDA meetings have highlighted the importance of marketing channels, sustainable practices and integrated pest management.
- Active participation of women generates spaces for communication that prioritize values, care of collective experiences, financing opportunities and permanent group building, fostering development and self-recognition of all members, and acknowledging the realities of women and men cotton producers in partner countries.

Identified Challenges

From a political and governmental perspective, production networks must become a priority within public management frameworks in order to strengthen all activities, particularly logistics and market access.

The continuity of platforms such as ALIDA and their articulation with public policies is key to sustaining these efforts.

Figure-1 FAO Regional Network meeting

Figure-2 Interactive session at ALIDA, INTA

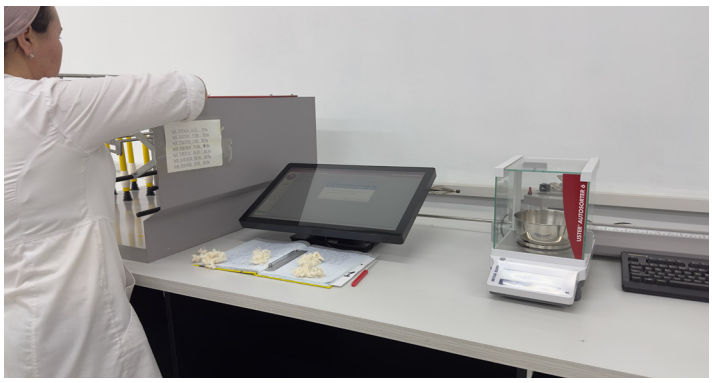

Figure-3 Fibre testing

Figure-4 Cotton value chain -spinning

Figure-5 Skill development training session for women at INTA

Strengthening the Value Chain

In production systems, fiber contamination must be avoided. There is a risk that non-transgenic varieties may be contaminated by transgenic varieties through pollinators, as regulatory distances are often not respected or cannot be enforced. This issue has been addressed in ALIDA meetings, where the expansion of transgenic cotton in the region and its impact on quality and genetic diversity has been discussed.

Organizations require strategic input banks (SIBs) for cotton fibers to ensure continuity in the textile value chain.

Value addition and artisanal-scale industrial processing require specific machinery for ginning, spinning and weaving adapted to low fiber volumes and lower-grade yarn, as family farming systems often cultivate intermediate-fiber varieties with high variability in these parameters.

At the final production stage, access to updated and versatile designs is essential, including collective design processes for garments and other products, ensuring cultural safeguarding of traditional techniques and knowledge.

Regional integration through networks such as ALIDA and other regional projects supported by international organizations remains fundamental to addressing these challenges through a shared and cooperative vision.

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Advances in Traceability, Fiber Quality, SITC and Cotton Marketing

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Marcio Portocarrero

Introduction

Cotton is an essential raw material for the global textile industry. However, its production faces social, environmental and technical challenges.

The growing demand for sustainability and transparency has driven the adoption of traceability and quality systems that ensure fiber origin, authenticity and characteristics.

This article analyzes the current situation, available technologies, strategic challenges and global trends impacting the cotton value chain, with particular reference to Argentina and Brazil. Environmental impacts and international regulations affecting sector competitiveness are also examined.

Key Concepts: Traceability and Transparency

Traceability refers to the ability to track the origin, movement and transformation of products along the value chain, while transparency involves communicating this information to stakeholders.

The cotton value chain is complex and fragmented: production, ginning, spinning and garment manufacturing often occur in different locations and under different actors, making end-to-end traceability difficult.

Three main types are identified: upstream traceability (from the final product back to raw material), process traceability (internal tracking at each production stage), and downstream traceability (from raw material to the consumer).

Each plays a strategic role in quality and sustainability management.

Global Context and Challenges

Traceability systems vary widely by country. The United States and Brazil implement robust systems with permanent bale identification, whereas in West Africa and Tanzania traceability is minimal, with cotton from hundreds of producers mixed into a single bale. At later stages, blending natural and synthetic fibers further complicates tracking. The value chain involves intermediaries and traders, adding complexity and cost, considering that cotton can represent up to 60% of a factory's expenses. Key challenges include lack of technological infrastructure, high costs for small producers, absence of harmonized regulations, and cultural resistance to digitalization.

Traceability Technologies

Various tools aim to ensure cotton traceability: PBI tags, DNA markers, isotopic analysis, blockchain, QR codes and RFID. Each technology presents advantages and limitations. PBI tags are low-cost but vulnerable to damage; DNA markers offer high precision but require specialized equipment; isotopic analysis is non-invasive and relatively low-cost but sensitive to environmental factors; blockchain ensures transparency and decentralization but entails higher costs; QR codes and RFID are easy to implement but depend on reliable infrastructure. Technology selection depends on producer scale, target markets and regulatory requirements.

Figure-1 Cotton bales tagged for the traceability chain

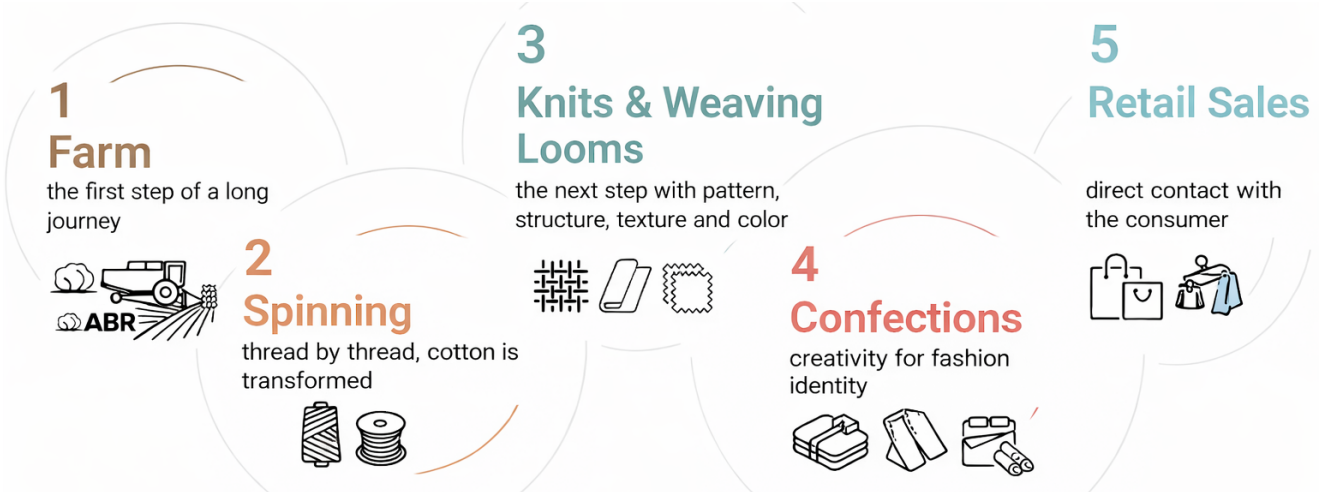

Figure-2 Traceability along the value chain

Argentina: Current Situation

Argentina maintains its own letter-based classification system, coexisting with the internationally accepted Universal Standard, toward which the country is transitioning.

The Association for the Promotion of Cotton Production (APPA) operates the only ICA Bremen-certified laboratory, recognized nationally, supporting the quality and reputation of Argentine cotton.

Challenges remain, including reducing quality variability, standardizing HVI-based classification with audited instruments, improving real-time traceability infrastructure, increasing the number of laboratories (currently 20, with a need for 40), and developing adapted and homogeneous varieties. ICA Bremen certification represents a competitive advantage that should be leveraged through marketing strategies and international trade agreements.

Global Trends and Regulations

The textile sector accounts for approximately 10% of global CO_2 emissions, prompting regulations such as the UN Fashion Industry Charter and the European Green Deal, which promote climate neutrality by 2050 and circular economy principles.

The EU will implement the Digital Product Passport (DPP) between 2027 and 2030, requiring full traceability and verified environmental data. These regulations transform traceability into a non-tariff barrier, compelling producing countries to adapt in order to compete internationally.

Certifications such as Better Cotton, Australian BMP Cotton, Cotton made in Africa and BioRe reinforce this trend by ensuring sustainable practices and decent working conditions. Innovations such as FiberTrace (luminescent pigments) and DNA-based systems (Haelixia) enable real-time verification and strengthen consumer trust.

Brazil: A Reference Model

Brazil implemented the Abrapa Traceability Program in 2001, incorporating data on producer, farm, gin, laboratory and socio-environmental certification. The system extends to garment labeling through a full chain-of-custody, ensuring total transparency. Complementarily, the Sou de Algodão program promotes responsible consumption and circular economy practices, engaging more than 1,800 brands. Brazil has also established offices in Asia to strengthen its presence in international markets, achieving global leadership in exports. The Quality Program monitors laboratories and factors affecting fiber quality, achieving 92% conformity and significant improvements. This model demonstrates that traceability can become a strategic tool for global market positioning.

Environmental and Social Impact

Traceability responds not only to commercial requirements but also to the need to reduce environmental impacts and ensure decent labor conditions. Conventional cotton requires large volumes of water and agrochemicals, exerting pressure on ecosystems and rural communities. Traceability systems enable certification of sustainable practices, promote efficient resource use and ensure compliance with labor regulations, contributing to the Sustainable Development Goals (SDGs).

Conclusions

Traceability in the cotton value chain is an irreversible trend driven by sustainability demands, international regulations and consumer preferences. Argentina has made significant progress in infrastructure and certification but faces challenges in integrating all stages and ensuring reliable real-time data. The Brazilian experience demonstrates that traceability can become a strategic asset for positioning cotton in global markets. Adoption of innovative technologies and alignment with international standards will be key to future competitiveness.

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Associative Models in the Cotton Value Chain APPA, AAPA and ABRAPA

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Zorzón, Cristian

Introduction

The cotton value chain faces global challenges related to competitiveness, sustainability and traceability. In this context, associative models have become key tools to articulate producers, industry, science and the State. This analysis addresses three relevant experiences: APPA (Santa Fe, Argentina), AAPA (Argentina) and ABRAPA (Brazil), highlighting their origins, strategies and future challenges.

Association for the Promotion of Cotton Production (APPA): A 25-Year Public–Private Model

The Association for the Promotion of Cotton Production (APPA) marks 25 years since its creation in 2000. From its inception, it brought together producers, cooperatives, industry, professional associations, provincial and national government bodies, and scientific–technical institutions such as INTA (National Institute of Agricultural Technology). This institutional framework made it possible to sustain the value chain, preserve cotton as a regional economic activity and define a shared development-oriented strategy.

APPA Silver Jubilee celebrations in Reconquista

Objectives

- Defend cotton production and industry.
- Generate regionally adapted technologies.
- Protect fiber quality and identity.
- Integrate all actors along the value chain.

Strategic Achievements

Productive recovery: technology programs enabled the maintenance and expansion of cultivated area, positioning Santa Fe as the national leader. Through phytosanitary programs, financing and technical assistance, the province recovered planted area. In the following decade, technological innovations consolidated Santa Fe as a national benchmark in area and fiber quality.

International insertion: The Official Fiber Quality Laboratory, certified by ICA Bremen, enabled participation in organizations such as ICAC, FAO and CICCA. This integration facilitated the adoption of global standards and strengthened the competitiveness of Santa Fe cotton.

Institutional articulation: APPA coordinates policies with provincial and national governments, SENASA and the Secretariat of Agriculture, participating in phytosanitary plans, quality regulations and market organization, integrating the entire chain.

Technological innovation: Mechanization, narrow rows, locally adapted varieties and boll weevil control, developed in partnership with INTA were decisive for comprehensive modernization. Key developments include:

- Incorporation of stripper harvesters (Javiyú and HAC 5000) developed jointly with INTA and private companies.
- Adoption of narrow rows and higher planting densities, improving yield and efficiency.
- Development of local varieties with better boll retention, fiber quality and mechanization compatibility.

The science–policy–production articulation became a distinctive feature of the Santa Fe model.

Traceability: Pilot experiences demonstrated traceability from producer to final product, strengthening the identity of Santa Fe cotton.

Training, Information and Communication: Technical workshops and courses generated qualified human capital, integrating students, technicians and producers. Statistical information on area, yield and quality strengthened decision-making and enabled coordination with national and international institutions.

Final Reflection: APPA demonstrates that public–private cooperation can transform crises into opportunities, consolidating a replicable model based on cooperation and strategic planning for other agro-industrial chains. Today, Santa Fe leads Argentine cotton production through a model that combines innovation, integration and quality.

Argentine Cotton Producers Association (AAPA): National Representation and an Integrated Strategy

The Argentine Cotton Producers Association (AAPA), founded in 2019, brings together more than 250 producers from different regions. It emerged inspired by models from Brazil and the United States, where collective action proved essential for productive, economic and regulatory progress.

The so-called "seed crisis" of 2019/20 accelerated the need for a representative entity capable of articulating demands, proposing policies and sustaining a unified voice for the sector.

Objectives

- Represent and defend producers' interests.
- Promote sustainable cotton production with traceability and transparency.
- Participate in the development of regulations and standards.

Most Relevant Strategic Aspects

- **Representation:** AAPA acts as a legitimate interlocutor with public and private institutions, promoting policies that enhance profitability and competitiveness.
- **Public policy influence:** Participation in programs, regulations and financing proposals.
- **Innovation:** Promotion of improved seeds, digital agriculture, integrated pest management and production efficiency.
- **Sustainability:** Through the Argentine Responsible Cotton label (ARA), it promotes environmental and social certifications.
- **Value chain integration:** Links with associations, chambers, INTA, provincial governments and international entities such as ICAC, FAO and ABRAPA.

Most Relevant Operational Aspects

- **Training:** Workshops and technical field days aimed at producer professionalization.
- **Information:** Statistics, market trends and outlooks to support decision-making.
- **Project management:** Participation in initiatives related to genetics, sustainable management and applied research.
- **Legal support:** Assistance in regulatory, environmental and commercial matters.
- **Communication:** Dissemination of updates, phytosanitary alerts and opportunities.

Future Challenges

- **Environmental sustainability:** certification, traceability and footprint reduction.
- **Competitiveness:** production costs, tax pressure and infrastructure.
- **Innovation:** reducing technological gaps and improving access to financing.
- **Climate change:** resilience, adapted varieties and agricultural insurance.
- **International markets:** differentiation, quality and overcoming trade barriers.
- **New generations:** youth incorporation and digital skills training.
- **Public–private articulation:** alliances for research and financing.
- **Communication and positioning:** greater social visibility and recognition.

Final Reflection: AAPA positions itself as a dynamic actor with an integrated vision and strong articulation capacity, while facing challenges that require multisectoral cooperation and proactive leadership.

Brazilian Cotton Producers Association (ABRAPA): Global Leadership and Innovative Governance

Created in 1999, ABRAPA currently brings together 11 state associations, representing 99% of Brazilian cotton production and 100% of exports. Its governance system prohibits presidential re-election and includes an active Advisory Council, consolidating ABRAPA as a global reference.

ABRAPA

ASSOCIAÇÃO BRASILEIRA DOS PRODUTORES DE ALGODÃO

ABRAPA's management principles are based on:

- Listening to market and societal demands.
- Careful short-, medium- and long-term planning.
- Execution within predefined timelines, adapting to market changes.

Four Strategic Pillars

Quality, Traceability, Sustainability and Promotion, with projects coordinated by ABRAPA and implemented by state associations.The Traceability System is the association's longest-running project, enabling individual identification of each cotton bale. It evolved into a full segregation system for cotton used by major Brazilian brands.

The Sustainability Program operates through three protocols:

- **ABR** – Responsible Brazilian Cotton, certifying producing farms.
- **ABR–UBA**, certifying cotton processing units.
- **ABR–Log**, certifying all logistics operations from farm exit to final destination.

ABRAPA operates a Central Reference Laboratory for cotton analysis, verifying all analyses conducted by the 21 laboratories installed across Brazil and serving as a training center for laboratory technicians.

Promotion programs include Sou de Algodão for the domestic market and an international promotion strategy supported by an office in Singapore, operating across ten Asian countries.

Future Challenges for Brazilian Cotton Growth

1. **Carbon monitoring** (CO_2) across production, ginning and industrialization, in partnership with Embrapa Environment and ABIOVE.
2. **Genetic improvement** to develop climate-adapted varieties and new pest-resistant transgenic materials.
3. **Continuous adoption of good agricultural practices**, integrated pest and disease management and increased use of biological controls.
4. **Adoption of new field technologies** through internet connectivity, drones and smart machinery.
5. **Continuous monitoring of water and soil quality**.
6. **Continuous quality improvement** to address contamination issues such as seed coat fragments, stickiness, plastics and impurities.

To address these challenges, ABRAPA implemented Environmental, Social and Governance (ESG) processes in both association management and certified farms.

Key Comparative Lessons

- **Scale and governance:** ABRAPA operates globally with strong institutional capacity; APPA and AAPA operate in more fragmented contexts with locally adapted models.
- **Innovation and sustainability:** All three prioritize traceability and certification, with Brazil leading technological and ESG adoption.
- **Public–private articulation:** APPA exemplifies territorial integration; AAPA consolidates national alliances; ABRAPA coordinates state networks strategically.
- **Shared challenges:** Climate change, competitiveness, international insertion and generational renewal.

General Conclusion

The associative models analyzed demonstrate that cooperation is the foundation for sustaining and projecting the cotton value chain in complex scenarios. APPA contributes territorial experience and resilience; AAPA provides national representation and an integrated vision; ABRAPA delivers global leadership and innovative governance. The future demands deeper articulation, accelerated innovation and strengthened environmental commitments to ensure international competitiveness and sustainability.

The ICAC Recorder

Prototype and Technology Innovations for Cotton Crop Management, Harvest and Post-Harvest

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Introduction

Cotton production in Argentina and other Latin American countries faces structural challenges related to production scale, mechanization, production costs and competitiveness. In this context, the development of technologies adapted to small- and medium-scale production systems has become a strategic priority to sustain cotton activity in regional economies.

This section presents experiences in the design, validation and implementation of prototypes and technologies aimed at improving crop management, harvesting and post-harvest operations, with a strong emphasis on collaborative work between research institutions, producers and private companies.

Context and Objectives

The decline in cotton area and the concentration of production have generated the need for technologies adapted to heterogeneous systems. Large-scale mechanization models are not always economically viable for small and medium producers. Therefore, innovation strategies have focused on developing affordable, efficient and adaptable solutions.

Figure-1. Harvesting operations

The main objectives of technological developments:

- Reduce production and harvesting costs.
- Improve operational efficiency and labor conditions.
- Preserve fiber quality during harvesting and post-harvest stages.
- Facilitate adoption by producers through simplicity and low investment requirements.

Technological Developments

Harvesting Prototypes

Several harvesting prototypes were developed and validated under field conditions, including single-row stripper harvesters designed for small plots. These machines were adapted to narrow-row planting systems and local varieties, enabling mechanized harvesting at lower cost.

Prototypes such as the Javiyú and HAC 5000 harvesters, developed jointly by INTA and private manufacturers, allowed small and medium producers to access mechanization while maintaining fiber quality standards.

Figure-2. A novel harvesting prototype

Figure-3. A spindle type picker for standard row spacing

Figure-4. A stripper type picker for narrow row spacing

Figure-5. Cotton balers in operation

Crop Management Equipment

Technologies were also developed for planting, fertilization and crop protection, including:

- **Precision seeders** adapted to narrow rows.
- **Low-volume sprayers and backpack sprayers** for integrated pest management.
- **Fertilizer application systems** compatible with variable-rate strategies.

These tools improved operational efficiency and reduced input waste, contributing to more sustainable production systems.

Post-Harvest Technologies

Post-harvest innovations focused on preserving fiber quality and reducing losses. These included:

- **Mini cotton gins** adapted to low volumes.
- **Fiber cleaning and handling equipment** designed to minimize contamination.
- **Storage solutions** to protect cotton from moisture and impurities.

Validation and Adoption

All prototypes underwent participatory validation processes involving producers, technicians and researchers. This approach ensured that technologies responded to real needs and local conditions, facilitating adoption and continuous improvement. Field days, on-farm trials and training workshops were key mechanisms for technology transfer, enabling feedback and iterative design adjustments.

Impact and Lessons Learned

The adoption of these technologies contributed to:

- Increased harvesting efficiency and reduced labor dependency.
- Lower production costs and improved profitability.
- Improved fiber quality through reduced contamination.
- Strengthened linkages between research, producers and industry.

A key lesson learned is that successful innovation in cotton requires close interaction between end users and technology developers, ensuring adaptability, affordability and sustainability.

Conclusions

Technological innovation adapted to production scale is essential for sustaining cotton activity in regional economies. The experiences presented demonstrate that locally developed prototypes, validated through participatory processes, can effectively address structural constraints and contribute to a more competitive and sustainable cotton sector.

The ICAC Recorder

From Traditional Cotton to Smart Cotton: Challenges and Perspectives in the Digital Era

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Introduction

The global cotton sector is undergoing a technological transition driven by digitalization, automation and data integration. The concept of "Smart Cotton" encompasses the application of Agriculture 4.0 technologies to improve productivity, sustainability and decision-making throughout the cotton value chain.

This section analyzes current trends, opportunities and challenges associated with the adoption of digital technologies in cotton production systems, with a focus on Latin American contexts.

Agriculture 4.0 Technologies Applied to Cotton

- Smart Cotton systems integrate multiple digital tools, including:
- Sensors for soil moisture, nutrient status and crop growth.
- Meteorological stations for real-time climate monitoring.
- Drones for crop scouting, pest detection and biomass estimation.
- Satellite imagery and NDVI analysis for spatial variability assessment.
- Data platforms for integrated farm management and decision support.

These technologies enable precision agriculture practices such as variable-rate irrigation, fertilization and pest control, optimizing resource use and reducing environmental impacts.

Automation and Robotics

Advances in automation include the development of robotic systems for harvesting, weed control and crop monitoring.

Artificial intelligence algorithms are increasingly used to analyze large datasets, detect patterns and support predictive models for yield, pest outbreaks and climate risks.

While these technologies are advancing rapidly in large-scale systems, their adaptation to small and medium producers remains a key challenge in Latin America.

Benefits and Potential Impacts

Smart Cotton technologies offer multiple benefits:

- Improved productivity through optimized management.
- Reduced input use and production costs.
- Enhanced environmental sustainability.
- Improved traceability & compliance with international standards.
- Greater resilience to climate variability.

Digitalization facilitates transparency, traceability and integration with market and certification systems.

Challenges for Adoption

Constraints for widespread adoption of Agri 4.0 technologies:

- High initial investment costs.
- Limited connectivity and digital infrastructure in rural areas.
- Need for technical training and digital skills development.
- Adaptation of technologies to diverse agroecological and socio-economic contexts.
- Data management, ownership and interoperability issues.

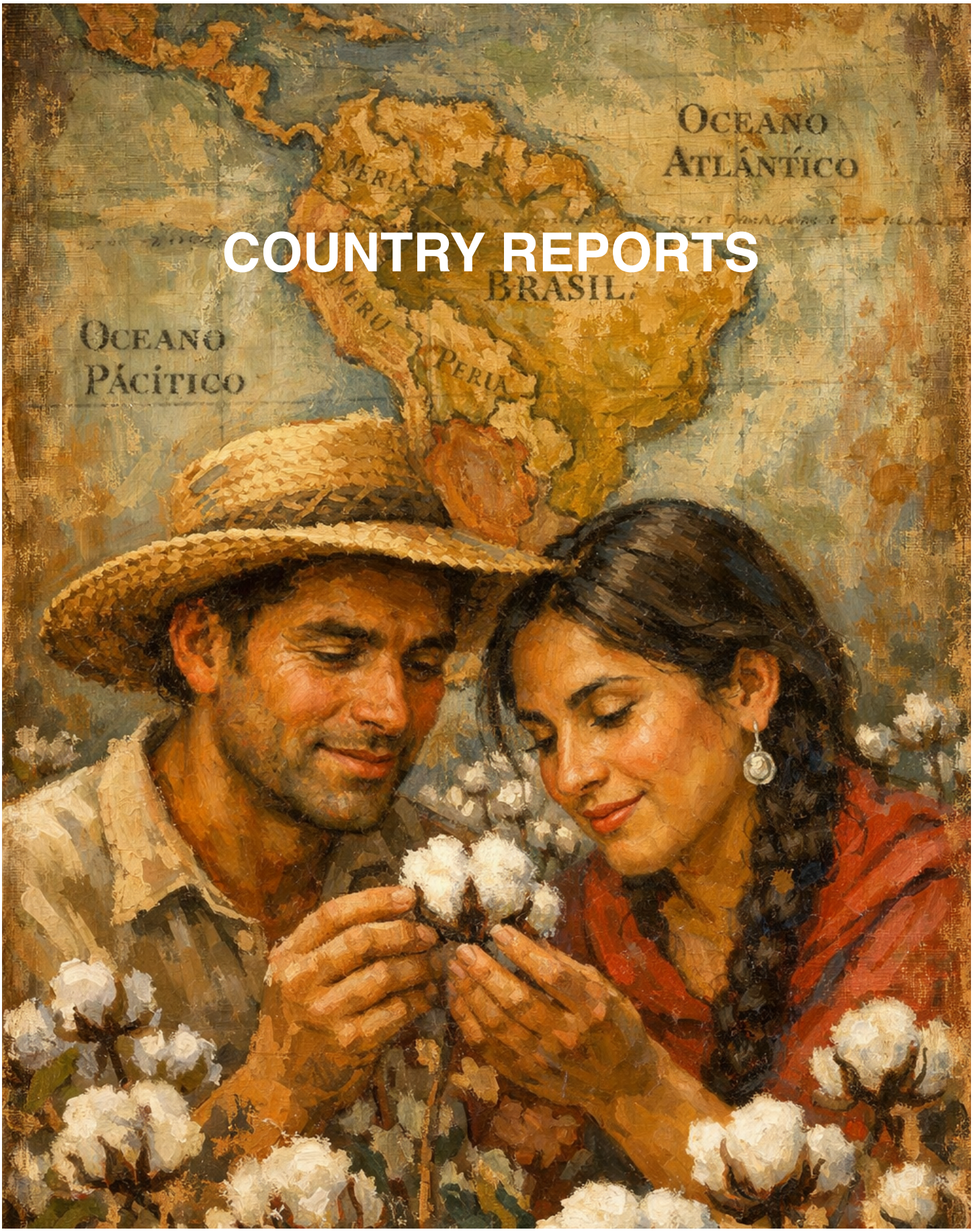
These challenges highlight the importance of public policies, institutional support and regional cooperation.

Future Perspectives

The transition to Smart Cotton requires coordinated efforts among producers, research institutions, private companies and governments. Pilot projects, demonstration units and training programs are essential to validate technologies and promote adoption. Regional platforms such as ALIDA play a strategic role in facilitating knowledge exchange, harmonizing approaches and scaling successful experiences across countries.

Conclusions

Smart Cotton represents an opportunity to transform cotton production systems through innovation, sustainability and digital integration. To fully realize its potential, investments in infrastructure, capacity building and institutional articulation are required. Inclusive strategies that consider the realities of small and medium producers will be essential to ensure that digital transformation contributes to equitable and sustainable development of the cotton sector in Latin America.



COUNTRY REPORTS

The ICAC Recorder

ARGENTINA: Current Status, Innovations and Challenges of the Cotton Sector

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Introduction

Cotton production in Argentina remains a relevant activity for the regional economies of the northern part of the country. Despite its strong geographical concentration, the sector is undergoing a process of transformation driven by technological advances, genetic improvement programs, the adoption of sustainable practices, and increasing articulation between research, extension and production actors. This article summarizes the current status of cotton production in Argentina, recent trends in crop management and technology, the main areas of scientific and technological development, the mechanisms linking research with production systems, and the medium-term strategic challenges for competitiveness and sustainability.

1. Productive structure and territorial distribution

Cotton production in Argentina is highly concentrated in the northern regions of the country, with approximately 600,000 hectares cultivated. The sector is characterized by strong heterogeneity in terms of farm size, access to resources and production capacity. It is estimated that there are around 2,500 cotton producers, which can be grouped into three main categories.

Large producers, representing about 20% of the total number of farmers, account for approximately 77–80% of the cotton-growing area.

These farms are generally highly mechanized, capital-intensive and technologically advanced. Medium-sized producers, who make up around 40%, cultivate about 18% of the total area and are typically defined as those managing between 100 and 300 hectares. Small producers, also close to 40%, occupy only 4% of the cotton area, reflecting structural limitations related to scale, access to technology and competitiveness.

Taken together, small and medium producers represent approximately 85% of all cotton growers, highlighting the importance of innovation strategies and public policies that address the diversity of production systems and levels of technological adoption. This structural configuration strongly influences productivity, efficiency, and the capacity of the sector to respond to climatic, sanitary and market challenges.

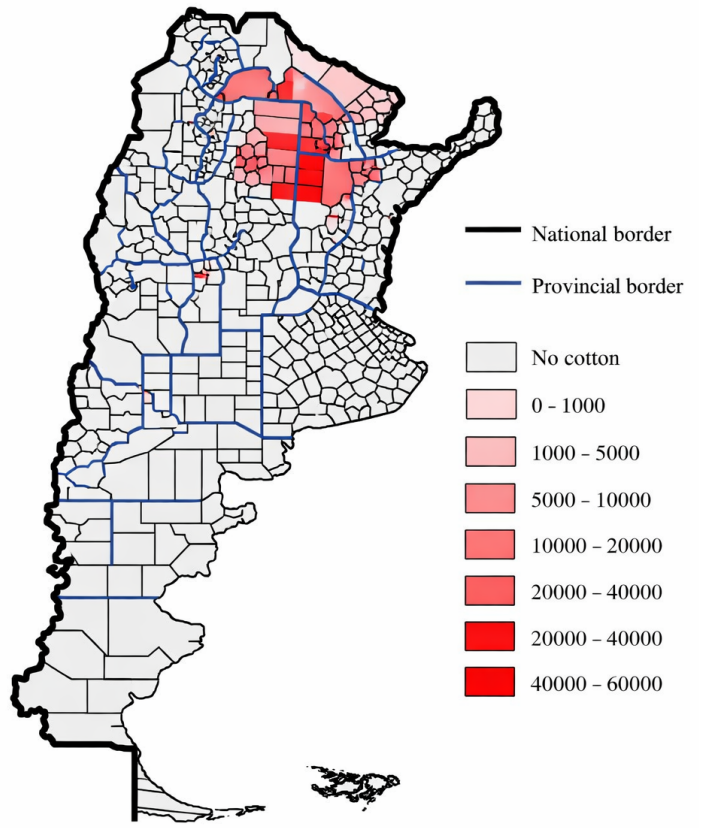

Figure-1 Cotton producing regions in Argentina

2. Technology and crop management

The Argentine cotton sector has made significant progress in the adoption of improved technologies and management practices aimed at increasing yields, optimizing resource use and improving fiber quality.

The most relevant developments include the following:

2.1. Narrow rows and high plant densities

The use of narrow row spacing and high plant densities has been increasingly adopted to improve light interception, shorten crop cycles and facilitate mechanized management. These practices are mainly implemented by medium and large producers with access to precision equipment.

2.2. Full mechanization

Complete mechanization of the production system, including planting, crop management and harvesting, is now common in the main cotton-growing regions. Modern mechanical harvesters and ginning technologies have improved operational efficiency and reduced losses. However, access to such equipment remains limited for smallholders, who often rely on contracted services.

Figure-2 Cotton mechanization in Argentina

2.3. Expansion into new production areas

The expansion of cotton cultivation into new production zones has been supported by improved varieties and advances in agronomic management. Regions with access to irrigation, or with strategies aimed at improving soil water conservation, represent emerging areas with high production potential.

2.4. Transgenic varieties and genetic improvement

Cotton production in Argentina relies largely on transgenic varieties, developed both by INTA and private companies, incorporating traits such as herbicide tolerance (RR) and insect resistance (Bt). These technologies have become key tools for weed and pest management, reducing production costs and supporting integrated management strategies. At the same time, public breeding programs continue to evaluate and develop varieties adapted to local conditions, with emphasis on fiber quality, resource-use efficiency and resistance to biotic and abiotic stresses.

2.5. Sustainable, resilient and regenerative agriculture

Several regional programs promote sustainable, resilient and regenerative agricultural practices in cotton production. These initiatives include crop rotations, integrated pest management, rational use of agrochemicals and soil conservation practices. They aim to improve the environmental performance of the crop while strengthening the competitiveness of small and medium producers and facilitating the adoption of digital technologies.

3. Research and innovation

Argentina has a strong institutional framework supporting research and development (R&D) in cotton production. Key organizations involved include INTA (National Institute of Agricultural Technology); CONICET; INTI; INASE; National universities; National and provincial government agencies.

3.1. Main research areas

The main lines of research include:

- Crop management and ecophysiology, aimed at optimizing productivity and yield stability.
- Genetic improvement, including both conventional and transgenic breeding approaches.
- Plant protection, with a focus on pest and weed management.
- Mechanization and post-harvest technologies, addressing equipment performance and operational efficiency.
- Biotechnology, to incorporate valuable traits and enhance breeding efficiency.
- Cotton value-chain economics, focusing on costs, margins and competitiveness.
- Digital agriculture and Agriculture 4.0, including sensors, geographic information systems and decision-support applications.
- Bioinputs, as alternatives to improve sustainability.

3.2. Funding sources

Cotton R&D programs are supported through the following combination sources:

Public funding at national and provincial levels; Private sector investment, particularly from seed and machinery companies; International cooperation initiatives related to sustainability, genetic improvement and extension.

3.3. Technology transfer

Technology transfer to producers is primarily carried out through the INTA extension system, complemented by producer associations and provincial agencies. Activities include on-farm trials, training programs, technical field days, direct advisory services and the use of digital platforms for information dissemination.

4. Linkages between production and research

The interaction between research institutions and the productive sector is one of the strengths of the Argentine cotton system. The main linkage mechanisms include:

4.1. On-farm trials

Experimental and demonstration trials conducted under real farming conditions allow for the validation of technologies, identification of constraints and adaptation of management practices to specific environments.

4.2. Training and knowledge exchange

Workshops, training courses and technical meetings—both in-person and virtual—provide spaces for dialogue between researchers, extension agents and producers, facilitating knowledge exchange and co-construction of solutions.

4.3. Regional trial networks

Networks of regional trials for variety evaluation and agronomic practices enable the generation of location-specific recommendations and accelerate the adoption of innovations.

4.4. Recently adopted innovations

Recent innovations adopted by the sector include:

- Improved cotton varieties with enhanced fiber quality.
- Advanced machinery and precision agriculture equipment.
- Digital tools and mobile applications for crop monitoring.
- Improved and more sustainable agronomic practices.

4.5. Role of producer associations

Producer organizations, such as APPA, play a key role in bridging producers and research institutions, contributing to the definition of research agendas and supporting technology validation and adoption processes.

5. Future perspectives and challenges

The Argentine cotton sector faces several challenges and opportunities for the next 5–10 years.

5.1. Research priorities

Key research priorities include:

- Developing a more competitive cotton production system, with higher yields, improved fiber quality and greater resilience to climate variability.
- Promoting organizational innovation to strengthen small and medium producers, improve scale and enhance access to technology.
- Fully integrating Agriculture 4.0 concepts, including sensors, digital platforms and data-driven decision-making.

5.2. Value addition strategies

Value addition within the cotton value chain is supported by:

- Producer networks and stronger linkages with ginning and textile industries.
- Traceability systems to enhance market competitiveness.
- Sustainable technologies in production, processing and fiber handling.

5.3. International articulation

Argentina maintains active links with regional and international research networks, including: Universities and research institutes in Brazil, Paraguay, Peru and Colombia; Multilateral organizations such as ICAC, ICRA and FAO.

These connections facilitate access to knowledge, germplasm, biotechnological tools and shared experiences in cotton development policies.

Conclusions

Cotton production in Argentina is undergoing a process of consolidation and modernization. While production remains concentrated in medium and large-scale farms, small producers continue to face structural challenges that require targeted policies and tailored innovation strategies. Technological adoption is high among capitalized producers, with significant advances in mechanization, genetic materials and crop management.

The research system, led by INTA and supported by scientific and academic institutions, sustains a robust agenda in genetics, agronomy, biotechnology and digital agriculture. Effective linkages between research and production have facilitated the transfer of innovations to the field, although adoption gaps persist across different production scales.

Looking ahead, the main challenges relate to climate variability, pest pressure, international competitiveness and the need to strengthen sustainability. Research priorities and value addition strategies aim to promote a more efficient, technologically advanced and environmentally responsible cotton sector.

In conclusion, Argentina has a solid technical foundation and a strong institutional framework to support cotton development. The key challenge lies in deepening the transition toward more resilient, inclusive and innovative production systems that enhance both productivity and sustainability.

The ICAC Recorder

BOLIVIA: Reactivation of the Cotton Sector: Production Systems, Research, and Innovation Pathways

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Abstract

The cotton sector in the Plurinational State of Bolivia has experienced a profound decline over the last three decades, followed by recent initiatives aimed at reactivation through research, innovation, and institutional coordination. From a historical peak of approximately 28,000 tons of lint in the mid-1990s, production fell to less than 500 tons by 2009/2010. Although a moderate recovery has been observed since 2017, the sector remains far below its productive potential.

This article provides a technical overview of the status of cotton production in Bolivia, with emphasis on production systems, technological and management practices, research and development efforts, and linkages between producers and research institutions.

Attention is given to the role of family farming, the conservation of native and naturally colored cottons, and recent initiatives to validate genetically modified (GM) cotton under local conditions.

Finally, perspectives and challenges for the next decade are discussed, including genetic improvement, pest management, and Bolivia's strategic advantage as a country free of the boll weevil.

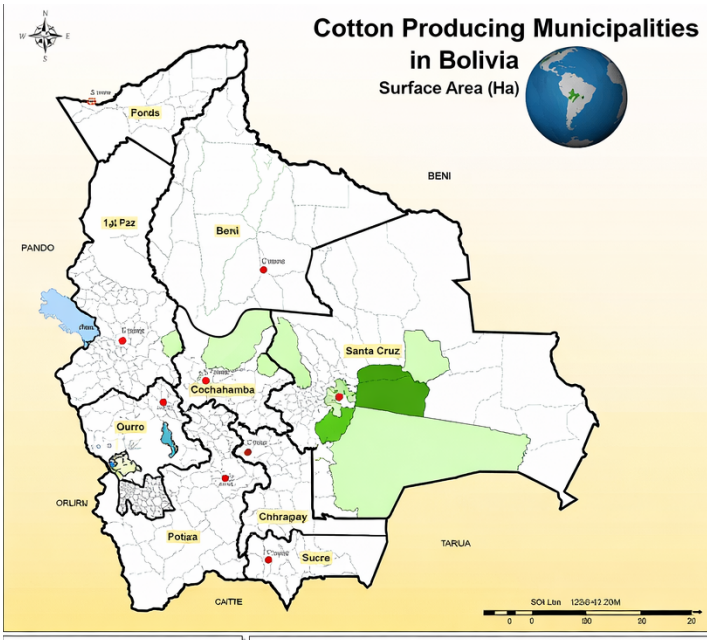
Introduction

Cotton has historically played a significant role in Bolivia's agricultural and rural economy, particularly in the eastern lowlands of the Department of Santa Cruz. During the 1990s, the crop reached its maximum development, supported by favorable prices, public policies, and access to improved varieties.

However, a combination of factors—including high production costs, pest pressure, limited access to technology, and weak institutional support—led to a sustained contraction of the sector. In recent years, renewed interest in cotton has emerged through national programs and international cooperation initiatives, seeking to strengthen family farming, recover local genetic resources, and introduce technological innovations adapted to Bolivian conditions.

Within this context, cotton production in Bolivia today represents a heterogeneous system, ranging from indigenous family-based production of naturally colored cottons to medium and large-scale commercial farms exploring GM technologies.

This article synthesizes available information from recent programs and field experiences to provide a comprehensive technical perspective suitable for the ICAC Recorder.



COTTON PRODUCTION SURFACE AREA (HECTARES)

#	Municipality	Department	Surface Area (Ha)
1	Lagunillas	Santa Cruz	6,220
2	Saipina	Santa Cruz	3,214
3	Cabezas	Santa Cruz	2,998
4	Cuetro Canadas	Santa Cruz	1,960
5	Pailón	Santa Cruz	1,364
6	Minero	Santa Cruz	1,083
7	Charagua	Santa Cruz	1,043
8	Peta Grande	Santa Cruz	891
	Total		**18,311**

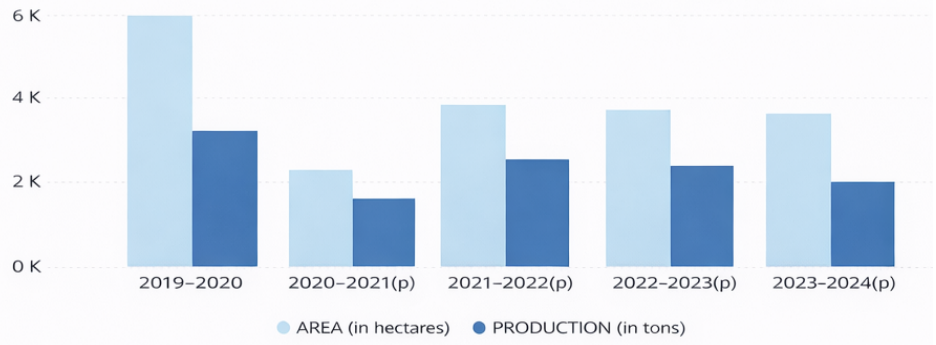
Figure-1 Cotton producing Municipalities in Bolivia

Production Systems and Current Status

Cotton production in Bolivia is currently concentrated in the Department of Santa Cruz, where agroecological conditions are most suitable. According to recent records, approximately 57 producers are formally registered, including small, medium, and large-scale farmers. Small producers represent the majority and play a central role in the conservation of traditional production systems and native cotton varieties. Family farming systems include indigenous communities of Guaraní, Guarayo, and Chiquitano origin, cultivating cotton on communal lands, typically on areas of up to five hectares. These systems rely primarily on family labor and are strongly associated with the production of naturally colored cottons (*Gossypium barbadense*), which are valued for artisanal and cultural uses. Other small-scale producers, mainly of mestizo origin, manage areas of up to 50 hectares, with limited mechanization and restricted access to modern inputs.

Medium-scale producers, often migrants from Andean regions, cultivate between 11 and 50 hectares of cotton, with moderate mechanization and better access to technology. Large-scale producers, including Bolivian, Brazilian, Argentine, and Mennonite farmers, operate on areas exceeding 100 hectares and are characterized by high levels of mechanization, access to capital, and interest in advanced technologies such as GM cotton.

BOLIVIA: COTTON AREA AND PRODUCTION EVOLUTION, 2019–2024(p)



CROP LOCATION

	Cotton	AREA (ha)	PRODUCTION (t)	YIELD (kg/ha)
2019–2020	6,000,00	6,000,00	2,925,23	487,54
2020–2021(p)	2,196,26	1,143,26	1,143,26	520,54
2021–2022(p)	2,771,04	2,576,48	2,576,48	693,23
2022–2023(p)	3,859,71	2,481,25	2,481,25	642,86
2023–2024(p)	3.732,39	2,003,33	2,003,33	536,74

Source: Instituto Nacional de Estadistica – Ministerio de Desaarrollo Rural y Tierras (Observatorio Agroambiental y Productivo)

Figure-2 Cotton area and production in Bolivia (2019-2024)

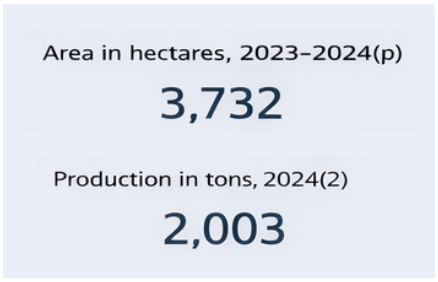


Figure-2a Cotton area & production

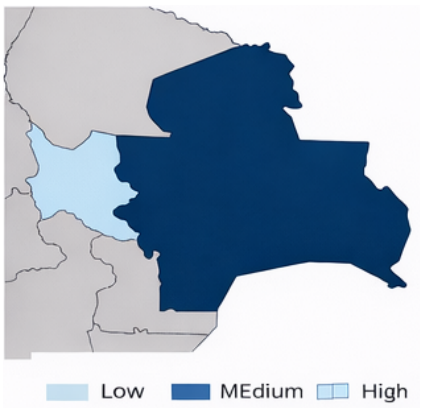


Figure-3 Cotton growing regions

Technology and Crop Management Practices

The technological base of cotton production in Bolivia is heterogeneous and, in many cases, outdated. A historical overview of varietal use highlights the limited renewal of genetic material. Conventional varieties imported from the United States dominated production in the 1970s. In 2002, the national conventional variety CCA-348 "Mandiyuti" was released, representing a milestone in local breeding efforts.

Since 2008, transgenic cotton—primarily Deltapine 444—has been introduced, although its use has largely occurred through informal channels. Currently, an estimated 95% of the cotton area is planted with degenerated transgenic seed, while only 5% uses the conventional Mandiyuti variety. This situation has resulted in yield instability and increased vulnerability to pests and diseases.

Crop management practices typically include nitrogen fertilization based on urea, adjusted when soil analysis is available. Irrigation is limited and generally restricted to areas with low rainfall or off-season production.

Pest control remains predominantly chemical, contributing to high production costs. However, initiatives promoting Integrated Pest Management (IPM) and biological control have gained relevance, particularly in indigenous systems producing naturally colored cotton without agrochemicals.

Figure-4 Field visit and training session on cotton production in Bolivia

Research and Innovation Framework

Research and development in the Bolivian cotton sector have been driven mainly by public institutions and international cooperation. Between 2017 and 2022, the +Algodón Project—implemented by the Ministry of Rural Development and Lands (MDRyT), FAO, and the Brazilian Cooperation Agency—focused on rescuing and improving the Mandiyuti variety, as well as conserving native cotton germplasm.

From 2021 to 2025, the National Program for the Support of Cotton Production in Bolivia (PNAPAB), led by the National Institute of Agricultural and Forestry Innovation (INIAF), expanded research efforts and established the first national cotton germplasm bank. These actions aimed to increase genetic variability and lay the foundation for future breeding programs. More recently, in 2025, the Departmental Center for Agricultural Research (CIAT) in Santa Cruz initiated field trials with GM cotton (MON 531 x MON 1445), focusing on resistance to key pests and tolerance to herbicides. These trials represent a significant step toward evaluating advanced biotechnological options under local agronomic and socio-economic conditions.

Linkages Between Research and Production

Strengthening the connection between research institutions and producers has been a central objective of recent initiatives.

The +Algodón Project established 71 demonstration and seed multiplication plots, trained more than 150 municipal technicians, and implemented a network of Technical Assistance and Rural Extension (ATER).

These actions facilitated the production of certified Mandiyuti seed, enabling the planting of approximately 1,600 hectares in 2022. Participatory approaches were key to the project's success, with research agendas validated by municipal governments and indigenous authorities.

Adoption rates were high, particularly among family farmers involved in seed production and demonstration plots. Subsequent programs under PNAPAB have emphasized technology transfer and genetic diversification, although measurable adoption outcomes are still emerging. The ongoing GM cotton trials conducted by CIAT involve direct collaboration with medium and large producers, highlighting a complementary innovation pathway oriented toward commercial-scale production systems.

Perspectives and Challenges

Despite recent progress, significant challenges remain. High costs of pest and weed control, low yields of conventional varieties, and dependence on foreign genetic material continue to constrain competitiveness. At the same time, Bolivia holds a strategic phytosanitary advantage as a country recognized by the Andean Community as free of the Mexican boll weevil (*Anthonomus grandis*). Future research priorities over the next 5–10 years include expanding genetic variability through systematic collection and characterization of native and conventional cottons, strengthening breeding programs, and validating GM technologies to improve yields and profitability while reducing agrochemical use. Preserving and valorizing naturally colored cottons also offers opportunities for niche markets, artisanal value chains, and rural development.

Conclusions

The reactivation of the cotton sector in Bolivia requires an integrated strategy that recognizes the diversity of production systems and leverages both traditional knowledge and modern technologies. Recent research, innovation, and extension efforts have laid a foundation for recovery, particularly through genetic conservation, participatory approaches, and institutional coordination. Sustained investment, regulatory clarity, and regional cooperation will be essential to consolidate these advances and position Bolivia as a competitive and sustainable cotton producer in the coming decade.

The ICAC Recorder

BRAZIL: Cotton Report

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Abstract

Following the 2023/24 cotton harvest, Brazil became the world's largest exporter of cotton fiber. Approximately 70% of the fiber produced was exported to Asian countries, and 30% was destined for the domestic textile industry. In the 2025/26 crop season, 2,052,000 hectares of cotton will be cultivated, with an estimated production of 3,830,000 tons. To achieve these numbers, the cotton production chain in Brazil has undergone significant changes in the last 40 years, notably with the migration of production areas to the Brazilian Cerrado, with its well-defined rainy season. The organization of producers into associations has also strengthened the sector in its constant demands for public policies and in the solid construction of the quality of Brazilian cotton to compete in the global market, improving the image of Brazilian cotton in terms of quality, sustainability and traceability. Finally, agricultural research has allowed the adaptation of the crop to this new biome (Cerrado) and has achieved enviable levels of quality, both in the development of genetic materials and in the improvement of the production system.

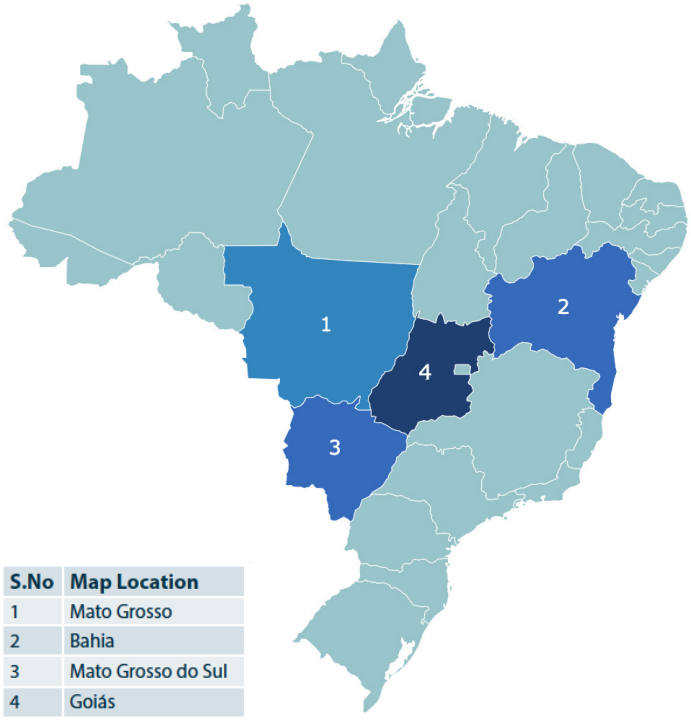
Cotton production and business structure

In Brazil, the area cultivated with cotton in the 2024/2025 crop season was 2.14 million hectares, with a production of 3.934 million tons of cotton fiber. The cultivation is geographically concentrated in the cerrado biome, central Brazil, which represents more than 95% of the cultivated area.

Brazil is the world's largest fiber exporter, with shipments of 2.83 million tons, representing approximately US$ 5.5 thousand. The producers of the Cerrado biome are predominantly large, with cotton farms greater than 1,000 hectares. A smaller portion of the planted surface (less than 5%) is located in the Caatinga biome (semi-arid zone), composed of small and medium-sized producers.

Technology and production management

Cotton varieties available in Brazil are predominantly transgenic, nationally developed. There is also a small amount of conventional cotton in the Caatinga biome. All cotton grown in the Cerrado biome is managed using chemical fertilizers, growth regulators, chemical and biological pest control, chemical weed control and diseases control. At the end of the cycle, defoliants and harvest-aids are also used. Cotton defoliation is the artificial induction of leaf drop, a natural process that occurs as plants mature, to prepare for mechanical harvesting; it's managed by applying hormonal defoliants that trigger ethylene production, causing mature leaves to form an abscission layer and fall, allowing easier picker access, better lint quality, and simultaneous boll opening. Harvesting in all producing areas is mechanized using picker-type harvesters.. The majority of cultivation areas are raifed. However, the installation of center pivot irrigation systems for water supply during critical periods has increased significantly, especially in the state of Bahia.



S.No	Map Location
1	Mato Grosso
2	Bahia
3	Mato Grosso do Sul
4	Goiás

Figure-1 Cotton producing regions in Brazil

ABRAPA (Brazilian Association of Cotton Producers) coordinates the programs Responsible Brazilian Cotton (ABR), Responsible Brazilian Cotton for Processing Units (ABR-UBA) and Responsible Brazilian Cotton for Retro Port Terminals (ABR-LOG). The ABR program operates in Brazil in collaboration with Better Cotton Initiative (BCI). The programs together promote sustainable management through the progressive development of good social, environmental and economic practices, based on criteria that encompass health, safety and well-being of workers up to the protection of water sources and the preservation of biomes, water and soil.

Figure-2 BRS 700 FL B3RF Variety with premium fibre quality

Research and innovation

Public (Universities and EMBRAPA) and private national institutions (TMG, IMA, IGA, Foundation Bahía), as well as international private research institutions: BASF, Bayer (Deltapine) work on cotton in the country. Furthermore, large groups of producers (more than 100,000 hectares) have research departments for applied tests and final validation of varieties and chemicals and biological inputs. The main scope of research is genetic improvement, plant protection and sustainable production systems.

The majority of the financing of cotton research and innovation comes from private funds. A small part comes from public funds. A large part of technology transfer today is carried out through private consultancies and research institutes of producers' associations.

Relationship between production & research

Since a large part of research funding in Brazil is private, there is a close relationship between research and the productive sector. Rural extension programs offer diverse educational opportunities, experimentation services, and consulting for farmers, agronomists, and agricultural technicians. These mechanisms exist to connect researchers and producers. As a result, many innovations have been adopted in the country. Among them, we can highlight the no-till farming system, the use of cover crops for carbon sequestration and reduction of soil pathogen populations, new varieties of transgenic cotton, and high-quality fiber varieties (long staple). Almost all cotton produced in Brazil is grown using a no-till farming system. In defining research priorities, producers and state associations rely on their own research institutions or foundations to define their agendas, and there is constant contact with producers to align the objectives of the breeding programs for the development of new cultivars.

Challenges, opportunities & future perspectives

Forty years after the boll weevil arrived in Brazil, this pest continues to be the main limiting factor for cotton cultivation in the country. Climatic instability also contributes to increasing crop risk, especially rainfall, since the vast majority of planted areas are rainfed. To mitigate these risks, irrigated areas for cotton cultivation have increased significantly in recent years.

Cotton production costs have also increased significantly in the last decade, mainly due to increased costs for chemical inputs, fertilizers, and biotechnology fees. Despite high production costs, Brazilian cotton maintains its competitiveness globally. Over the next five to10 years, efforts should be made to develop transgenic cotton cultivars resistant to boll weevil, as well as to develop biological control methods for the pest.

Several strategies are underway to add value to crop products: fiber and seeds. Upland cotton cultivars with high fiber quality, such as the recently launched BRS 700FL B3RF, offer superior quality and satisfactory productivity. This could allow Brazil to reach a new level of fiber quality, meeting the demands of the most discerning markets in terms of quality. Still on the topic of fiber quality, in the coming years we will have available varieties of Pima cotton adapted to the Brazilian Cerrado, to meet a specific niche of very high fiber quality. Finally, the development of gossypol-free cotton cultivars is in its final stages. Gossypol-free cotton seeds can be used for human consumption and for non-ruminant animals, mainly in the aquaculture and poultry industries.

In terms of regional or international coolaboration with cotton research networks, Brazil participates in Sur-Sur cooperation (Mercosur); the Cotton-4 project in Africa (Burkina Faso, Chad, Mali and Togo); and cooperates with some American institutions such as Texas Tech University, Texas A&M, The University of Georgia and USDA.

The ICAC Recorder

COLOMBIA: Status of the Cotton Sector, Challenges, and Strategic Pathways Forward

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Abstract

This article provides a comprehensive overview of the Colombian cotton sector, analyzing its recent evolution, current productive structure, predominant management practices, and research and innovation ecosystem. It highlights key challenges such as climate variability, high production costs, and producer heterogeneity, alongside strategic priorities and opportunities for value addition and enhanced international engagement to position Colombian cotton within the global context.

Introduction

Cotton cultivation in Colombia has undergone a significant transformation in recent decades. From a widely extensive crop in the 1970s and 1980s, with areas exceeding 400,000 hectares, it experienced a drastic reduction due to political, economic, and biophysical factors. However, in recent years, the sector has shown signs of recovery, driven by supportive policies, technology adoption, and the concerted efforts of guilds and research institutions. This article describes the current situation, highlighting progress, persistent challenges, and the path forward for a more resilient and competitive cotton sector.

Cotton Regions and Production

Cotton production in Colombia is concentrated in two main regions with distinct characteristics. The Coastal Zone, which includes departments such as Córdoba, Cesar, Bolívar, and Sucre, contributes 45.97% of national production and is characterized by an average yield of 0.76 tonnes of fibre per hectare. The Interior Zone, comprised of the departments of Tolima, Huila, and Valle del Cauca, not only contributes the majority of production (54.02%) but is also the most productive region, achieving significantly higher yields of 1.11 tonnes of fibre per hectare (Conalgodón, 2024).

The Caribbean region has a main rainy season (August-December) with 900-1000 mm of precipitation, while the interior region (Tolima) has a bimodal rainfall regime with 1000-1500 mm annually. This variability, coupled with the occurrence of phenomena such as El Niño and La Niña, generates critical water deficits, especially during flowering, and is exacerbated by sandy soils with low water retention capacity. Historical trends show a sharp contraction in the planted area, which fell from 400,000 hectares in 1977 to approximately 70,000 in 1982, due to economic liberalization, the elimination of subsidies, and falling international fibre prices (Ministerio de Agricultura, 2005). Cotton areas were displaced by crops such as rice, corn, oil palm, and pastures for livestock.

Nevertheless, since 2020, the sector has begun a recovery process. Recent data (Conalgodón, 2024) indicate a total area of around 12,000-18,000 hectares, with fibre production between 11,000 and 19,000 tonnes. Yields have shown constant improvement, exceeding 900 kg/ha in many seasons and even projected to surpass 1,100 kg/ha by 2025, thanks to increased technification (Conalgodón, 2024).

Productive Structure and Economic Aspects

The Colombian cotton sector is heterogeneous. Small and medium-sized producers with family farms of less than 10 hectares predominate in both the Coastal and Interior zones. Concurrently, large technified farms have emerged in new agricultural frontiers like the Altillanura and in departments such as Córdoba and Tolima, which utilize mechanization, supplemental irrigation, and intensive management, explaining the wide variation in yields.

Although cotton is not a crop of significant relative weight in the agricultural GDP compared to coffee or oil palm, it is a major generator of rural employment. Direct production generates between 15,000 and 18,000 jobs, while the entire value chain contributes approximately 500,000 jobs (Inexmoda, 2018). Colombia is currently a net importer of fibre, and its exports of raw cotton are modest in the global context.

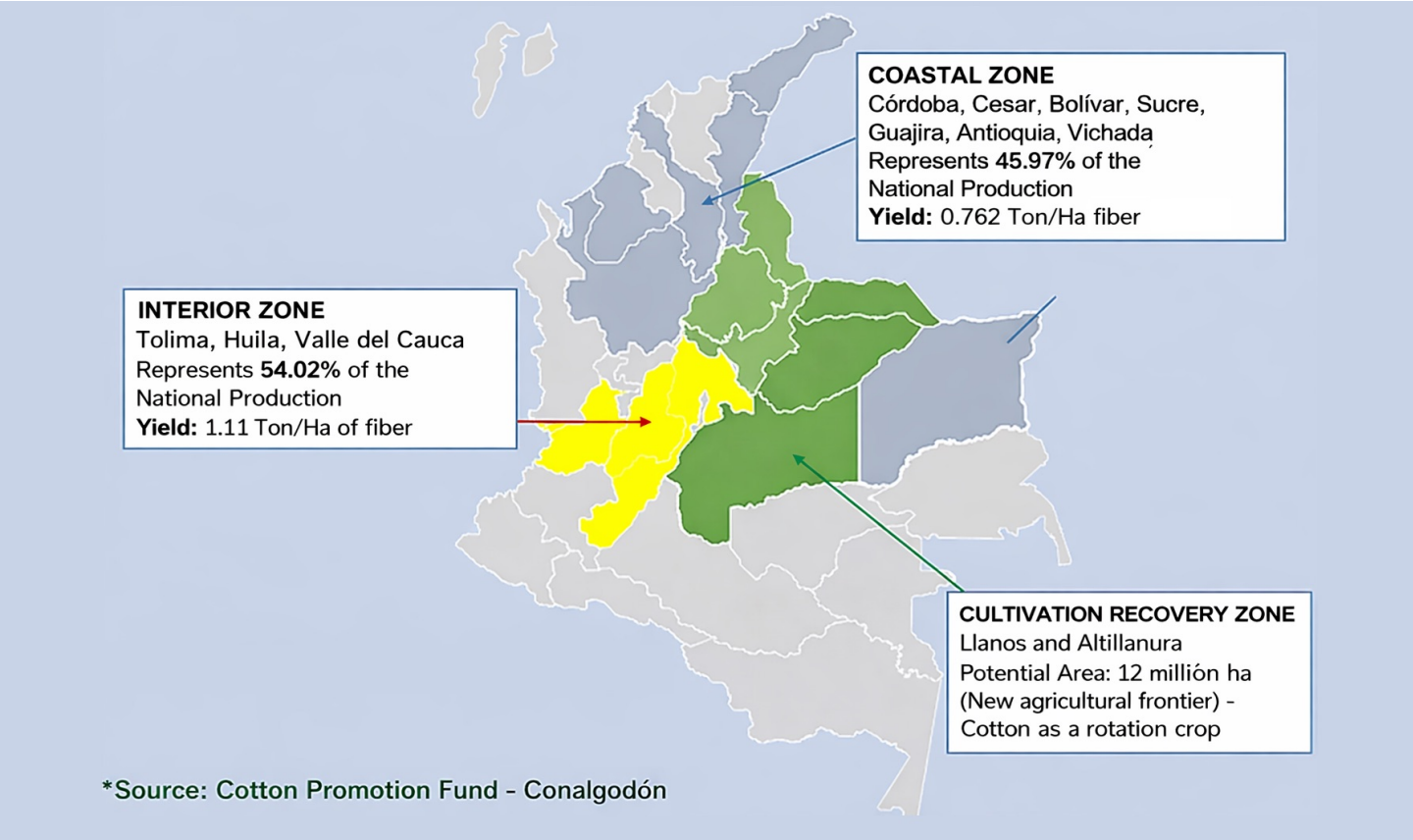

Figure-1 Regional Distribution of Cotton Production in Colombia

Production costs have shown an upward trend, driven primarily by inputs. The total cost per hectare increased from approximately 6.3 million Colombian pesos (COP) in 2019 to 8.7 million COP in 2022 (Conalgodón, 2024). Despite this, net income per hectare has remained positive, thanks to improved yields and fibre prices.

Varieties, Biotechnology & Management Practices

The phytotechnical landscape of Colombian cotton reflects a constant pursuit of competitiveness and sustainability. This effort materializes in a dual approach: the development of locally adapted genetic material and the implementation of management practices that optimize resources and minimize environmental impact. Genetic breeding, led by AGROSAVIA, has developed national varieties such as Gaitana M-109 and Caribeña M-129 (AGROSAVIA, 2024). Concurrently, Colombia has adopted transgenic technologies since the early 2000s. The most cultivated technologies include Bollgard (insect resistance) and Roundup Ready (herbicide tolerance), with stacked events such as Bollgard II + Roundup Ready Flex being common in varieties like FM 910 B2RF and FM 911 B2RF.

The adoption of biotechnology must be accompanied by responsible agronomic management to ensure its longevity and effectiveness. In Colombia, practices have evolved towards a model of sustainable intensification (Ouazaa et al., 2022):

- **Fertilization:** Based on soil analysis and applied in split applications.
- **Irrigation:** Supplemental irrigation (furrow, drip, sprinkler) is used in areas with water availability.
- **Integrated Pest Management (IPM):** Combines biological, cultural, and chemical control, with an emphasis on refuge strategies to delay resistance in Bt crops.
- **Sustainable Programs:** Initiatives such as "+Algodon" and packages from AGROSAVIA/Conalgodón promote good practices for soil conservation and integrated management (FAO, 2021).

Research, Innovation & Linkages

The Research, Development, and Innovation (R&D&I) ecosystem in cotton is the engine of the sector's technical progress. However, the gap between generated knowledge and its widespread adoption in the field remains a major bottleneck. A network of public and private institutions drives knowledge generation. AGROSAVIA, as the backbone of national agricultural research, works in conjunction with the Colombian Agricultural Institute (ICA) – the regulatory body – universities such as the National University of Colombia, and the leading guild, Conalgodón. Priority research lines include ecophysiology, IPM, precision agriculture, genetic improvement, and post-harvest management.

Linkage between research and production is strengthened through participatory research and demonstration plots on producer farms, modernized extension programs in collaboration with AGROSAVIA and CIAT, and networks and guilds like Conalgodón, which articulate sector demands and facilitate technology transfer.

Despite these efforts, the adoption rate of many locally developed technologies remains low. AGROSAVIA's Social Balance reports, which measure the impact of its technologies, have not yet recorded significant adoptions specific to cotton cultivation. The most notable exception is transgenic seeds, which peaked in adoption (49,000 ha) in the 2000-2010 decade, stabilizing at an average of 10,000 ha in the last decade, reflecting fluctuations in the total planted area.

Challenges & Future Opportunities

The path to a prosperous and sustainable Colombian cotton sector requires confronting a series of structural challenges and defining a clear agenda of priorities.

Current challenges:

- Increasing pressure from pests and diseases and the risk of resistance.
- High production costs and limited access to financing.
- Climate variability and extreme weather events.
- Structural heterogeneity that hinders the scaling of technologies among small producers.

Research priorities: To overcome these challenges, the R&D&I agenda must focus on:

- Genetic improvement for water resilience and pest resistance.
- Applied ecophysiology and crop modeling.
- Adaptation of precision agriculture technologies.
- IPM strategies and resistance management.
- Supply chain economics and financing models for local value addition.

Strategies for adding value and international articulation: The long-term sustainability of the sector depends not only on producing more but on producing better and capturing greater value. Key strategies include:

- Progressing towards reliable production with sustainability and traceability certifications.
- Exploiting market niches such as Pima, organic, or specialty-coloured cottons.
- Fostering industrial innovation in ginning, local spinning, and the use of sustainable dyes.
- Strengthening international articulation through active participation in the ICAC, ALIDA, and technical cooperation with organizations such as the FAO and the APC, as well as with peer institutions like Embrapa (Brazil) and INTA (Argentina).

Conclusion

The Colombian cotton sector is in a phase of reactivation and transformation. Although it faces significant structural and environmental challenges, it has a solid foundation of research institutions, organized guilds, and a mix of producers with growth potential.

The future of cotton in Colombia will depend on its ability to integrate technological innovation with inclusive business models, improve its cost and quality competitiveness, and position itself strategically in international markets through sustainability and differentiation. Continuous collaboration at the national and international levels will be a fundamental pillar for this cotton revival.

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The ICAC Recorder

ECUADOR: Cotton Conservation of Genetic Resources, Research Advances & Strategic Perspectives in a Center of Diversity

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Abstract

Ecuador occupies a unique position in the global cotton sector as part of the center of diversity for Gossypium barbadense and other related species. While commercial cotton production has declined significantly, the country has made substantial progress in the conservation, characterization, and utilization of cotton genetic resources. Led by the National Institute of Agricultural Research (INIAP), Ecuador has implemented systematic collection, ex situ and in situ conservation, and advanced morphological and molecular characterization of native and cultivated cotton accessions. This article provides a technical overview of the current situation of cotton in Ecuador, with emphasis on genetic resource conservation, research and innovation frameworks, and international cooperation initiatives. Perspectives and challenges are discussed in relation to biodiversity conservation, climate resilience, and the potential role of Ecuadorian cotton germplasm in regional and global breeding programs, in line with the objectives of the ICAC Recorder.

Introduction

Cotton has deep historical, cultural, and biological significance in Ecuador. The country forms part of the primary center of diversity for *Gossypium barbadense*, one of the most important species for high-quality and extra-long staple cotton worldwide. Although Ecuador no longer plays a major role in global cotton production, its relevance lies in the conservation of native, wild, and cultivated cotton genetic resources that represent a valuable asset for future breeding and adaptation strategies. Recognizing this strategic importance, Ecuador has prioritized the conservation and scientific characterization of cotton germplasm through national research programs coordinated by INIAP. These efforts contribute not only to national biodiversity conservation goals but also to regional and international initiatives aimed at safeguarding and utilizing plant genetic resources for food and agriculture. This article synthesizes recent advances in cotton research and conservation in Ecuador to provide a comprehensive technical perspective suitable for the ICAC Recorder.

Cotton Genetic Resources in Ecuador

Unlike other cotton-producing countries in Latin America, Ecuador's cotton sector is currently characterized by limited commercial production and a strong focus on genetic resource conservation. Native cottons, particularly *G. barbadense*, are distributed across diverse agroecological zones and are associated with traditional farming systems and cultural practices. INIAP maintains the national cotton germplasm bank, which conserves a broad collection of accessions representing cultivated, semi-wild, and wild materials.

Recent collection campaigns conducted between 2018 and 2021 covered three continental regions of Ecuador, significantly strengthening the representativeness of the national collection. The germplasm bank currently conserves more than 120 accessions, including predominantly Ecuadorian *G. barbadense*, national *G. hirsutum*, and a limited number of international reference accessions. These resources constitute a strategic reservoir of genetic diversity, particularly for traits related to fiber quality, adaptation to biotic and abiotic stresses, and morphological variability.

Table-1 Cotton germplasm accessions conserved in the INIAP genebank, Ecuador

Species	Ecuador	
Source of collections*	**Natl**	**Intl**
Cultivated	-	-
***G. hirsutum* L.**	-	-
Cultivars (breeding materials)	-	154
***G. barbadense* L.**	-	
Cultivars (breeding materials)		3
Landraces	168	
Unclassified	4	-
Primary gene pool	-	-
G. darwinii Watt	1	-
Secondary gene pool	-	-
G. klotzschianum Andersson	0	-
Subtotal	173	157

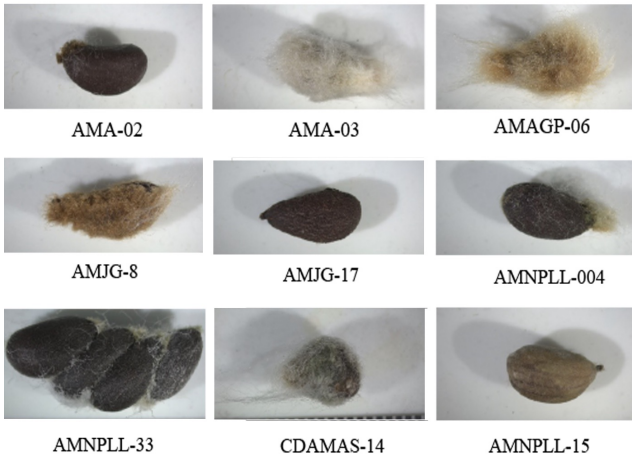

Figure-1 Seed morphological variability

Figure-2 The germplasm morphological-characterization team

Research and Innovation Framework

Research on cotton in Ecuador is led by INIAP, with a clear emphasis on genetic resource conservation, characterization, and documentation. The research framework integrates field collection, ex situ conservation, in situ characterization, and laboratory-based molecular analysis.

Morphological characterization has been conducted using internationally recognized descriptors, including those developed by the International Board for Plant Genetic Resources (IBPGR) and the International Union for the Protection of New Varieties of Plants (UPOV). These standardized descriptors allow for consistent evaluation of plant architecture, reproductive traits, seed characteristics, and fiber attributes.

In parallel, molecular characterization using simple sequence repeat (SSR) markers has provided deeper insights into genetic diversity and population structure. Recent analyses employed 30 SSR markers, of which 17 were polymorphic, enabling the assessment of genetic relationships among Ecuadorian and international accessions. Cluster analyses, principal component analysis, and dendrograms confirmed a high level of genetic diversity within Ecuadorian *G. barbadense*, encompassing both cultivated and wild forms.

Linkages, Cooperation & Knowledge Generation

Cotton research in Ecuador is closely linked to national and international cooperation initiatives. Projects such as "Más Algodón" and "BioBridge" have supported germplasm collection, capacity building, and methodological strengthening. These initiatives have facilitated knowledge exchange and reinforced Ecuador's role within regional and global networks focused on plant genetic resources.

Scientific outputs from these efforts include peer-reviewed publications, such as the submitted article on the genetic diversity of the Ecuadorian national cotton collection assessed by SSR markers. Such contributions enhance the international visibility of Ecuadorian research and provide valuable data for breeding programs beyond national borders.

At the national level, in situ characterization activities and collaboration with local communities help to document traditional knowledge and maintain the dynamic conservation of cotton diversity in farmers' fields.

Perspectives and Challenges

Despite significant progress, several challenges remain. Additional collection efforts are required in the Galápagos Islands to conserve endemic species such as *G. darwinii* and *G. klotzchianum*, which are of exceptional evolutionary and scientific importance.

Long-term funding and institutional support are also essential to ensure the sustainability of germplasm conservation and research activities.

Looking ahead, priorities for the next 5–10 years include expanding molecular characterization, integrating phenotypic and genotypic data, and exploring the potential use of Ecuadorian germplasm in breeding programs aimed at improving fiber quality, stress tolerance, and climate resilience.

Strengthening regional and international collaboration, particularly within Latin America and through ICAC-related networks, will be critical to maximizing the impact of Ecuador's genetic resources.

Conclusions

Ecuador's contribution to the global cotton sector lies primarily in its rich genetic heritage and the scientific efforts dedicated to its conservation and characterization.

Through the leadership of INIAP, the country has established a solid foundation for safeguarding cotton genetic resources of global importance.

Continued investment in research, conservation, and international cooperation will be essential to ensure that this diversity remains available to support future cotton improvement and sustainability worldwide.

The ICAC Recorder

MEXICO: Cotton Technological Intensification, Phytosanitary Management, and Research Priorities in a Center of Origin

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Abstract

Mexico is one of the leading cotton-producing countries in Latin America and plays a strategic role in the regional cotton economy due to its high productivity, advanced phytosanitary management, and strong institutional organization of the value chain. Cotton production is concentrated in irrigated systems managed by large, medium, and small-scale producers, with widespread adoption of genetically modified (GM) cultivars, narrow-row planting systems, and integrated pest management. Mexico has also achieved notable success in the eradication of key pests such as the pink bollworm and maintains active programs against the cotton boll weevil. At the same time, the country faces unique challenges related to biodiversity conservation, as Mexico is a recognized center of origin for Gossypium species. This article provides a technical overview of the Mexican cotton sector, focusing on production systems, technology and management practices, research and innovation frameworks, value chain organization, and future challenges, in line with the scope of the ICAC Recorder.

Introduction

Cotton has long been a strategic crop in Mexico, underpinning rural economies in irrigated agricultural regions and supporting a well-established textile and manufacturing industry. Over recent decades, Mexico has undergone a significant transformation in cotton production, characterized by technological intensification, strong phytosanitary programs, and institutional coordination through producer organizations and government agencies.

Today, Mexican cotton production combines high-yield commercial systems with increasing attention to sustainability, regenerative agriculture, and biodiversity conservation. The presence of genetically modified cotton, advanced irrigation systems, and coordinated pest eradication programs has positioned Mexico among the most productive cotton-producing countries in the region. This article synthesizes current information on the Mexican cotton sector to provide a comprehensive technical overview suitable for dissemination through the ICAC Recorder.

Production Systems and Sector Structure

Cotton production in Mexico is geographically concentrated in well-defined irrigated regions, particularly in northern states such as Chihuahua, Baja California, Sonora, Coahuila, and Durango. These regions benefit from favorable climatic conditions, irrigation infrastructure, and proximity to processing and export channels.

The sector is composed of a mix of large commercial producers, medium-scale farmers, and smaller producers integrated into organized value chains. Cotton area and production have remained relatively stable in recent years, supported by consistent yields and efficient production systems. According to national statistics, average cotton yields in Mexico are among the highest in Latin America, reflecting the intensive use of technology and inputs. Institutional organization is a defining feature of the Mexican cotton sector. The "Sistema Producto Algodón" provides a formal framework for coordination among producers, ginners, researchers, input suppliers, and government agencies, facilitating collective decision-making and strategic planning across the value chain.

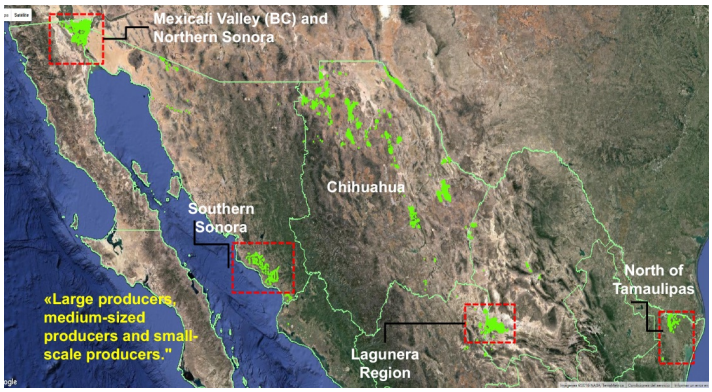

Figure-1 Cotton producing regions in Mexico

Technology and Crop Management Practices

Mexican cotton production is characterized by high levels of technological adoption. Genetically modified cotton cultivars are widely used, providing resistance to key insect pests and tolerance to herbicides. These technologies have contributed significantly to yield stability, reduced pest pressure, and lower production risks.

Crop management practices commonly include narrow-row planting systems, precise fertilization, and the use of advanced irrigation technologies. Irrigated agriculture is the dominant production system, allowing for greater control over crop development and input efficiency.

Phytosanitary management is a cornerstone of the Mexican cotton model. The successful eradication of the pink bollworm (*Pectinophora gossypiella*) represents a major milestone, achieved through coordinated regional programs involving producers and government agencies. Ongoing efforts to control and suppress the cotton boll weevil (*Anthonomus grandis*) further enhance productivity and sustainability. In parallel, regenerative agriculture practices are gaining attention, with initiatives aimed at improving soil health, enhancing biodiversity, and reducing the environmental footprint of cotton production.

Research and Innovation Framework

Research and innovation in the Mexican cotton sector are supported by strong public–private collaboration. Government agencies, research institutions, universities, and the private sector jointly contribute to the development and dissemination of new technologies.

Key research lines include genetic improvement, pest and disease management, irrigation efficiency, agronomic optimization, and sustainable production systems. Significant investment has been made in developing and refining integrated pest management (IPM) strategies, combining GM technologies with monitoring, biological control, and rational pesticide use.

Innovation efforts also address the need for adaptive management in response to climate variability and water scarcity, particularly in irrigated regions where competition for water resources is increasing.

Figure-2 Regenerative agricultural practices in Mexico

Linkages Between Research and Production

The linkage between research and production in Mexico is facilitated through institutional platforms such as the Sistema Producto Algodón, which promotes dialogue and coordination among stakeholders.

Field trials, demonstration plots, and extension activities play a central role in validating and disseminating new technologies.

Producers actively participate in defining research priorities, particularly in areas related to pest management, varietal performance, and production efficiency. This participatory approach ensures that innovation remains closely aligned with sector needs and enhances adoption rates.

Capacity building and training programs are also essential components of technology transfer, supporting the professional development of technicians, extension agents, and producers.

Perspectives and Challenges

Despite its technological strength, the Mexican cotton sector faces several challenges. Conservation of biodiversity is a major concern, as Mexico is a center of origin for cotton and home to wild Gossypium relatives that require protection from genetic erosion.

Additional challenges include the need to train a new generation of researchers, extensionists, and technical advisors, ensuring generational renewal and continuity of expertise. Strengthening research and extension capacity in integrated pest management remains a priority, requiring sustained public–private collaboration.

Looking ahead, continued investment in sustainable and regenerative practices, efficient water use, and innovation-friendly regulatory frameworks will be critical to maintaining competitiveness while safeguarding environmental and genetic resources.

Conclusions

Mexico's cotton sector represents a technologically advanced and well-organized production model within Latin America.

The integration of GM technologies, robust phytosanitary programs, and strong institutional coordination has delivered high productivity and resilience.

At the same time, Mexico's unique status as a center of origin for cotton underscores the importance of balancing intensification with biodiversity conservation.

Continued collaboration between public and private actors, along with investment in human capital and sustainable practices, will be key to the long-term sustainability of the sector.

The ICAC Recorder

PARAGUAY: Family Farming, Technology Adoption, and Pathways for Sectoral Revitalization of Cotton

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Abstract

Cotton has historically been one of the most important industrial and social crops in Paraguay, closely linked to rural livelihoods and family farming systems. Although the cultivated area and national production have declined markedly over recent decades, cotton remains a strategic crop for smallholders and a priority within rural development and food security policies. In recent years, renewed efforts led by national institutions and international cooperation—particularly through FAO-supported initiatives such as the +Algodón Program—have focused on improving productivity, strengthening seed systems, promoting sustainable management practices, and enhancing linkages between research and producers. This article provides a technical overview of the current status of the Paraguayan cotton sector, addressing production structure, technology and crop management, research and innovation frameworks, and mechanisms for technology transfer. Perspectives and challenges for the coming decade are discussed, with emphasis on family farming, sustainability, and value chain development.

Introduction

Cotton has played a central role in Paraguay's agricultural history, serving as a key source of income for rural households and contributing to the development of local textile and oilseed value chains.

For decades, the crop was widely cultivated by small-scale farmers, providing employment and supporting rural economies. However, structural changes in agriculture, market volatility, pest pressure, and limited access to modern technologies have led to a sustained decline in cotton production.

Despite these challenges, cotton continues to be recognized as a strategic crop for family farming and rural development. National policies and international cooperation programs have increasingly emphasized the need to revitalize the sector through improved technologies, stronger institutional coordination, and sustainable production models. This article synthesizes available information from recent initiatives to present a comprehensive technical overview of cotton production in Paraguay for the ICAC Recorder.

Production Systems and Sector Structure

Cotton production in Paraguay is predominantly based on family farming systems. The majority of producers are smallholders cultivating limited areas, often integrated into diversified farming systems that include food crops and livestock.

Cotton remains particularly important in regions where few alternative cash crops are available, contributing to household income and employment.

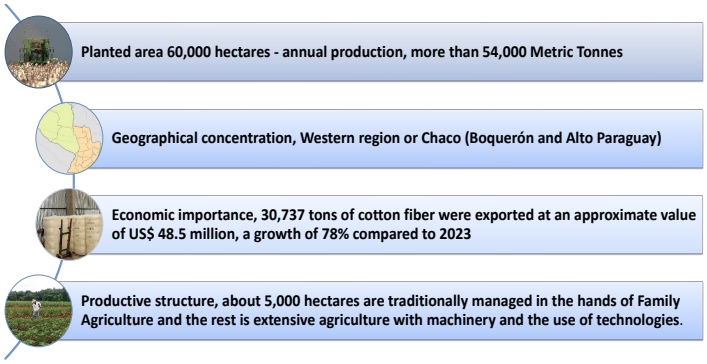

Figure-1 Production systems & structure of the cotton sector

The sector is characterized by low levels of mechanization, high reliance on family labor, and strong sensitivity to climatic variability.

While medium and large-scale cotton production exists to a limited extent, the Paraguayan cotton sector is primarily oriented toward social and developmental objectives rather than large-scale commercial exports.

Given this structure, productivity levels are generally below regional and global averages, highlighting the importance of access to quality seed, appropriate crop management practices, and effective extension services tailored to smallholder conditions.

Figure-2 Mechanized harvesting in Paraguay

Technology and Crop Management Practices

Cotton production technologies in Paraguay reflect the predominance of small-scale systems. Conventional varieties are widely used, and seed quality has historically been a limiting factor. Recent programs have placed strong emphasis on strengthening local seed systems, promoting the use of improved varieties, and ensuring seed availability at the community level.

Crop management practices focus on basic agronomic principles, including timely planting, adequate plant density, soil fertility management, and weed control.

Pest management represents one of the main constraints, as insect pressure can significantly reduce yields and increase labor requirements. In response, integrated pest management (IPM) approaches are increasingly promoted, combining cultural practices, biological control, and rational use of chemical inputs.

Sustainable agriculture practices, such as crop rotation, soil conservation, and reduced reliance on agrochemicals, are particularly relevant in Paraguayan cotton systems due to environmental considerations and limited access to external inputs.

Research and Innovation Framework

Research and innovation in the Paraguayan cotton sector are driven primarily by public institutions, national research organizations, and international cooperation. Programs supported by FAO, including the +Algodón initiative, have played a key role in revitalizing research activities, strengthening institutional capacities, and promoting innovation adapted to family farming systems.

Research priorities include varietal improvement, seed multiplication, agronomic management, and pest control strategies suitable for smallholders. Innovation efforts also emphasize participatory approaches, ensuring that technologies respond to producer needs and local conditions. Funding for research and development is largely based on public resources and international cooperation, reflecting the sector's social importance and limited capacity for private investment. This context underscores the need for efficient coordination among institutions and long-term policy support.

Linkages Between Research & Production

Strengthening the linkage between research and production has been a central objective of recent cotton initiatives in Paraguay. Extension and technology transfer activities are implemented through training programs, demonstration plots, and close collaboration with producer organizations and rural communities.

Participatory methodologies are widely used, enabling producers to engage actively in technology evaluation and adaptation. This approach enhances adoption and facilitates the dissemination of improved practices within farming communities.

International cooperation programs have also contributed to capacity building for technicians and extension agents, reinforcing local extension systems and improving the flow of information between researchers and producers.

Perspectives and Challenges

The Paraguayan cotton sector faces multiple challenges, including low productivity, pest pressure, climate variability, and limited market incentives. Additionally, competition from alternative crops and migration from rural areas threaten the continuity of cotton-based livelihoods.

Looking ahead, priorities for the next 5–10 years include strengthening seed systems, improving varietal performance, expanding the adoption of IPM and sustainable practices, and enhancing value addition through local processing and market integration. Cotton also offers opportunities for linking agricultural production with social policies aimed at poverty reduction and rural development. Continued engagement with regional and international networks, including FAO-supported platforms and Latin American cooperation initiatives, will be essential to share experiences, access knowledge, and reinforce Paraguay's position within the regional cotton sector.

Conclusions

Cotton remains a crop of high social and economic relevance in Paraguay, particularly for family farming systems. While the sector faces persistent structural challenges, recent efforts in research, innovation, and extension provide a foundation for gradual revitalization. An integrated approach that combines improved technologies, institutional coordination, and sustained policy support will be critical to strengthening the resilience and sustainability of cotton production in Paraguay in the years to come.

The ICAC Recorder

PERU: Cotton Production, Innovations, Current Status, Research Capacities, and Future Pathways

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Abstract

Peru has a long-standing tradition in cotton production and is internationally recognized for the quality of its extra-long staple fibers, particularly Pima and Tanguis cotton. In recent decades, the sector has undergone structural changes characterized by reduced cultivated area, predominance of family farming systems, and increasing pressure from pests, production costs, and climate variability. At the same time, Peru has consolidated a strong institutional framework for research, innovation, and sustainable management, supported by public policies, legal restrictions on genetically modified organisms, and active engagement in integrated pest management and digital agriculture initiatives. This article provides a technical overview of the Peruvian cotton sector, focusing on production systems, technological and management practices, research and innovation efforts, and mechanisms linking research with producers. Perspectives and challenges for the next decade are discussed, highlighting genetic improvement, sustainability, and value addition within the cotton-textile value chain.

Introduction

Cotton plays a strategic role in Peru's agricultural and agro-industrial economy, underpinning one of the most emblematic textile and apparel industries in Latin America. The country is historically known for its native and improved cotton varieties with exceptional fiber quality, which have positioned Peruvian cotton in premium international markets. Despite this comparative advantage, cotton cultivation has declined in area and profitability, reflecting competition from alternative crops, rising production costs, and persistent phytosanitary challenges.

Currently, cotton production in Peru is characterized by a predominance of small-scale family farming systems, complemented by medium and a limited number of large producers. Public institutions, led by the National Institute of Agrarian Innovation (INIA), have played a central role in sustaining research, varietal development, and technology transfer. This article synthesizes recent information on the Peruvian cotton sector to provide a comprehensive and up-to-date technical perspective suitable for dissemination through the ICAC Recorder.

Production Systems and Sector Structure

In 2024, the cotton cultivated area in Peru reached approximately 10,536 hectares, with an annual production of 23,234 metric tons of seed cotton and a national average yield of about 2.2 tonnes per hectare. Significant yield gaps persist, as northern coastal zones have demonstrated potential yields between 4.1 and 4.6 tonnes per hectare under improved management conditions.

Cotton production is geographically concentrated along the coastal regions, including Ica, Piura, Lambayeque, Lima, Arequipa, and Áncash, with smaller production areas in the Amazonian regions of San Martín and Ucayali. The sector supports approximately 8,400 farming families and generates an estimated 67,000 direct jobs per cropping season, excluding employment associated with textile and garment manufacturing.

The productive structure is dominated by family farming systems, which account for nearly 90% of producers, typically cultivating between three and five hectares. Medium-scale producers represent around 10%, generally operating less than ten hectares, while large producers are relatively few. This structure underscores the importance of extension services, access to quality seed, and collective action through associations and cooperatives.

Technology & Crop Management Practices

Peru's cotton sector operates under a distinctive technological framework shaped by legal and environmental considerations. The cultivation of transgenic cotton is currently prohibited due to biosafety and conservation policies established under national legislation, including Law No. 29811 (2011) and its extension through Law No. 31111 (2021). As a result, cotton production relies exclusively on conventional, national, and imported non-GM varieties.

Key varieties cultivated include Pima, Tanguis, and Del Cerro, alongside nationally developed cultivars such as INIA 803 (Del Cerro), INIA 801 and 802 (Áspero), and INIA 804 "La Colorina," a native colored cotton. Limited use of imported hybrid seed, such as Hazera hybrids from Israel, has also been reported in specific production zones.

Core management practices emphasize the use of quality seed, balanced fertilization, efficient irrigation systems, plant growth regulation, and Integrated Pest Management (IPM). Biological control is a cornerstone of pest management strategies, particularly for key pests such as the pink bollworm (*Pectinophora gossypiella*), with strong institutional support from INIA, SENASA, MIDAGRI, and FAO.

Research and Innovation Framework

Research and innovation in the Peruvian cotton sector are led primarily by INIA, in coordination with regional governments, universities, producer organizations, and international partners. Public funding constitutes the main source of support for research and development, complemented by cooperation initiatives such as the +Algodón Project.

Major research lines include genetic improvement, agronomic management, pest and disease control, and conservation of native cotton germplasm. Breeding programs focus on enhancing yield potential, fiber quality—particularly extra-long staple characteristics—and resistance to biotic and abiotic stresses.

Advanced but non-transgenic techniques, such as marker-assisted selection and induced mutations, are increasingly incorporated within the legal framework.

Innovation efforts also extend to sustainable and digital agriculture. Initiatives such as the "Perú Smart Agro 4.0" project integrate sensors, meteorological stations, big data analytics, and decision-support tools to optimize irrigation and crop management, with reported productivity gains of up to 70% per hectare and water savings of approximately 25%.

Linkages Between Research & Production

Multiple mechanisms facilitate interaction between researchers and producers in Peru. These include on-farm trials and demonstration plots, training programs, extension services led by regional agricultural agencies, and participatory platforms such as ad hoc commissions, roundtables for native cotton, and national research networks.

A notable example of capacity building is the modular, face-to-face theoretical and practical training program on integrated cotton management, organized by the National Program for Regional Crops and INIA in collaboration with water user boards and professional associations. These initiatives strengthen the technical capacities of extension agents and farmers alike.

Specialized services, such as INIA's biocontrol laboratories, further reinforce technology transfer. Facilities like the Vista Florida Experimental Station produce beneficial insects and entomopathogenic organisms, including *Trichogramma* spp., *Chrysoperla* spp., *Orius insidiosus*, and entomopathogenic nematodes, providing producers with effective alternatives to chemical control.

Figure-1 Technology transfer training for producers

Perspectives and Challenges

The Peruvian cotton sector faces persistent constraints related to pest pressure, high production costs, climate variability, and market competition. Nonetheless, strong institutional capacities and accumulated technical knowledge provide a solid foundation for future development.

Research priorities for the next 5–10 years include the development of highly competitive varieties with superior yield and fiber quality, expansion of genetic variability through germplasm rescue and introduction, and enhanced resistance to biotic and abiotic stresses. Greater integration of meteorological, physiological, and sanitary data into predictive management systems is expected to improve decision-making and resilience.

Value addition strategies encompass strengthening linkages with the textile industry, promoting native and colored cottons for differentiated markets, and fostering innovation in bioproducts and sustainable textiles. Active participation in regional and international research networks, including ICAC and Latin American cooperation platforms, will be essential to maintain competitiveness and visibility.

Conclusions

Peru's cotton sector combines a rich genetic heritage with a robust institutional framework for research and innovation. While structural and economic challenges persist, continued investment in genetic improvement, sustainable management, and technology transfer offers significant opportunities for revitalization. By aligning family farming systems with advanced agronomic practices and value chain integration, Peru is well positioned to strengthen its role as a producer of high-quality cotton in the global market.