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Research Article

Organic Cotton Cultivation in Saline Soils: A Premium Pathway for Coastal Farmers

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Abstract: Coastal saline regions in India pose serious challenges to conventional agriculture due to high soil salinity, waterlogging, and degraded soil health. However, organic cotton (Gossypium hirsutum L.) offers a promising alternative, given its moderate salt tolerance, ecological benefits, and growing global demand. This study explores the potential of organic cotton as a sustainable livelihood option for smallholders in saline-prone coastal areas. It highlights how organic practices—such as the use of compost, green manures, biofertilizers, and eco-friendly pest management—improve soil structure, microbial activity, and resilience to salinity stress. Case studies from West Bengal, Gujarat, Tamil Nadu, and Telangana demonstrate enhanced yield stability, soil reclamation, and farmer incomes under organic cotton systems. Despite these benefits, key constraints such as the lack of region-specific salt-tolerant varieties, inadequate policy support, certification hurdles, and weak extension services limit large-scale adoption. Addressing these gaps through localized research, input access, institutional training, and targeted policy interventions is essential. Promoting organic cotton in coastal saline zones can play a critical role in transforming degraded lands into climate-resilient, economically viable, and ecologically balanced farming systems.

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1. Introduction

Cotton (Gossypium spp.) is a commercially significant fiber crop cultivated across tropical and subtropical regions, including India, where it makes a substantial contribution to the agricultural economy. Among India's diverse agro-ecological regions, coastal saline zones present unique challenges for conventional agriculture due to soil salinity, waterlogging, and high groundwater salinity, which significantly limit crop productivity and farmer profitability. These saline-affected areas, typically located along the eastern and western coasts, are characterized by electrical conductivity (EC) values often exceeding 4 dS/m, adversely impacting plant growth and nutrient uptake. Despite these constraints, cotton demonstrates moderate salt tolerance, particularly during later stages of growth, making it a viable crop under salinity-stressed conditions. In recent years, the adoption of organic farming practices in these zones has gained attention, offering an ecologically sustainable and economically rewarding alternative. Organic cotton cultivation eliminates the use of synthetic fertilizers and pesticides, instead relying on organic manures, green manuring, biofertilizers, and biocontrol agents that not only enhance soil health but also reduce environmental degradation. Moreover, organic practices can enhance soil structure, stimulate microbial activity, and mitigate the negative effects of salinity. For coastal farmers, the growing global demand for organic cotton—coupled with price premiums and improved soil resilience—positions it as a strategic crop for long-term sustainability. Thus, promoting organic cotton cultivation in coastal saline soils aligns with sustainable agriculture goals while enhancing livelihood security and environmental health in these vulnerable ecosystems.

2. Why Organic Cotton in Saline Soils?

Organic cotton (*Gossypium hirsutum* L.) is emerging as a resilient and economically attractive crop choice for coastal saline regions, where conventional crops often underperform due to high salinity and limited freshwater resources. Cotton exhibits moderate tolerance to salinity and can grow successfully in soils with electrical conductivity levels up to 7–8 dS/m without major yield loss. This makes it a more suitable option than salt-sensitive crops like rice or vegetables, especially during later growth stages. In the coastal districts of West Bengal, varieties such as 'Suravi' and 'Suraj' have shown promise when cultivated in the rabi season following kharif rice, fitting well within the region's crop rotation cycle. Organic cotton farming in these areas reduces reliance on synthetic inputs by encouraging the use of compost, green manures, and beneficial microbes like Azospirillum and phosphate-solubilizing bacteria, which not only improve nutrient cycling and soil structure but also lower input costs—crucial for smallholder farmers in resource-stressed zones.

Cultivating organic cotton on marginal, salt-affected lands promotes sustainable land use and builds climate resilience. The organic inputs enhance soil porosity, microbial activity, and ionic balance, helping to buffer the harmful effects of salinity. As climate change escalates challenges like erratic rainfall and water scarcity, crops like cotton that can endure such conditions become increasingly valuable. For coastal farmers, organic cotton also opens access to high-value niche markets that reward sustainable and ethical production. Certified organic cotton can command a price premium over conventional cotton, offering a significant income advantage. This not only strengthens farmer

livelihoods in low-yielding saline zones but also encourages broader adoption of environmentally sound farming practices.

c

: Healthy crop stand of cotton variety grown in the coastal saline zone of India

3. Benefits for Coastal Farmers from Organic Cotton Cultivation in Saline Soils

a. Access to High-Value Organic Markets

Organic cotton provides coastal farmers with an entry point into premium markets that prioritize environmentally responsible and ethically produced goods. With growing global awareness around sustainability, certified organic cotton fetches 20–30% higher prices than conventional cotton, offering better income potential for farmers operating in saline-prone, low-productivity areas (Textile Exchange, 2022). This premium market access not only ensures stable returns but also encourages the adoption of eco-friendly practices.

b. Declining Input Costs and On-Farm Resource Use

Over time, organic cotton cultivation becomes more cost-efficient as farmers rely increasingly on farm-generated inputs like compost, farmyard manure, green manures, and bio-fertilizers such as Azospirillum and Rhizobium. These inputs improve soil health and reduce dependence on costly external inputs, lowering production expenses in the long run (Ghosh et al., 2013). This makes organic farming particularly suitable for smallholders managing saline and degraded lands with limited financial resources.

c. Better Adaptation to Climate Variability

Cotton's deep-rooting system and tolerance to moderate salinity and dry spells make it more resilient under changing coastal climates. Under organic management, improved soil structure and organic matter content enhance water retention and reduce the crop's susceptibility to drought and salt stress. Organic practices build soil resilience and buffer against extreme weather, helping farmers maintain crop stability despite environmental uncertainties.

d. Enhanced Soil Quality in Saline Ecosystems

Continuous application of organic inputs like compost and crop residues helps restore soil organic carbon and microbial life in salt-affected soils (Farooqi et al., 2023). This

improves nutrient availability, root development, and overall plant vigor. Studies have shown that organic amendments reduce salinity toxicity, enhance soil enzymatic activity, and support biological reclamation of saline soils paving the way for sustainable land regeneration.

e. Foundation for Crop Diversification and Sustainability

By rejuvenating soil health and increasing soil fertility, organic cotton creates a productive base for introducing crop rotations and diversified farming systems in coastal areas. Improved soil conditions support other high-value or salt-tolerant crops, encouraging more diversified, climate-resilient, and economically viable farming models. This transition not only sustains cotton yields but also broadens farmers' livelihood options over time.

4. Best Practices for Successful Organic Cotton Cultivation on Saline Soils

Adopting organic cotton in coastal saline regions requires a holistic and site-specific approach that addresses both salinity management and the principles of organic agriculture. The following practices are essential for improving crop establishment, enhancing soil health, and ensuring sustainable yields in salt-affected environments:

a. Soil Enrichment and Reclamation Methods

Improving the soil's structure and chemical balance is essential for cultivating organic cotton in saline conditions. Organic amendments like compost, farmyard manure (FYM), and green manure help increase organic carbon, stimulate microbial activity, and reduce the harmful effects of excess salts. Deep-rooted green manure species such as Sesbania aculeata are highly effective in adding nitrogen and biomass to the soil. In cases of saline-sodic soils, applying gypsum ($CaSO_4 \bullet 2H_2O$) helps displace sodium ions from soil particles, replacing them with calcium to improve water infiltration and reduce electrical conductivity. A synergistic application of FYM (10–15 t/ha), gypsum (2–4 t/ha), and green manure crops can significantly improve soil health and create favorable conditions for organic cotton cultivation (Qadir et al., 2006).

b. Application of Beneficial Microorganisms

In organic systems, salt-tolerant plant growth-promoting rhizobacteria (PGPR) and mycorrhizal fungi are key tools for enhancing crop performance under saline stress. Microbial strains such as Azospirillum brasilense, Azotobacter chroococcum, and Glomus species can enhance root growth, improve nitrogen fixation, increase phosphorus availability, and support osmotic stress tolerance. These bio-inoculants, when applied during seed treatment or directly to the soil at sowing, promote better seedling establishment and plant vigor in saline-prone soils.

c. Eco-Friendly Pest and Disease Control

Salinity-affected regions often witness shifts in pest and disease profiles, necessitating adapted organic protection methods. Neem-based products like 5% neem seed kernel

extract or 1–2% neem oil are effective against common cotton pests such as whiteflies and jassids. Pheromone traps serve as efficient monitoring tools for bollworms, while botanical mixtures such as garlic-chili extract or cow urine-based solutions help suppress disease pathogens (Roychoudhury., 2016). Intercropping cotton with crops like marigold (Tagetes spp.) or legumes such as green gram and cowpea not only helps in pest deterrence but also supports soil fertility through nitrogen fixation and enhanced biodiversity.

By following these integrated practices, farmers in coastal saline areas can transform degraded lands into productive zones for organic cotton. These strategies not only boost yield and fiber quality but also contribute to long-term ecological sustainability and economic resilience.

Table 1: Case Studies on Organic Cotton Cultivation in Coastal/Saline Zones of India

Region/ Location	Implementing Agency	Key Interventions	Outcomes / Impact
Tirunelveli & Tuticorin, Tamil Nadu (coastal saline belt)	Tamil Nadu Agricultural University (TNAU) – Organic Farming Research Centre	Use of FYM + gypsum + green manures (Sesbania), bio-inoculants, non-GM cotton seeds	Soil EC reduced by ~20% over 3 seasons; 25% higher net returns than conventional cotton
Bhavnagar & Junagadh, Gujarat	Gujarat Organic Farming Board (GOFB) in partnership with local cooperatives	Farmer trainings, input kits (compost, neem oil, Rhizobium), drip irrigation with saline-tolerant cotton	30% higher income; improved soil structure and water use efficiency
Nimpith KVK, Sundarbans, West Bengal	Ramakrishna Ashram Krishi Vigyan Kendra (Nimpith), ICAR-ATARI Kolkata	Organic cotton trials on reclaimed saline polders using FYM, Azospirillum, and neem-based biopesticides	Cotton yield reached 1.2–1.5 t/ha under moderate salinity (EC 6–8 dS/m); enhanced livelihood of marginal farmers
Adilabad, Telangana	Chetna Organic Farmers Association (NGO-led contract farming)	Organic certification, fair trade pricing, direct market linkage with textile brands	Farmers received 25–35% premium; crop diversification and community empowerment

5. Limitations and Strategic Recommendations for Organic Cotton in Coastal Saline Regions

a. Monoculture Dependency and Biodiversity Loss

Over-reliance on cotton as a sole crop reduces on-farm biodiversity, depletes specific soil nutrients, and increases vulnerability to pest outbreaks such as bollworms and sap-feeding insects. So we can promote intercropping with legumes or trap crops (e.g., marigold) and integrate organic cotton within diverse crop rotations. This not only supports soil fertility and pest management but also enhances ecological stability.

b. Certification Complexity and Market Volatility

The organic certification process is lengthy (2–3 years), expensive, and difficult for smallholders to maintain, especially in remote coastal zones. Furthermore, market returns are tied to fluctuating international demand and trade dynamics. For this introduce targeted financial support for certification costs, training, and infrastructure through government schemes like PKVY. Strengthen local certification systems (e.g., Participatory Guarantee Systems) and build stable market linkages via cooperatives, FPOs, and fair-trade partnerships.

c. High Water Demand During Critical Growth Stages

While cotton tolerates moderate salinity, it still requires significant water during flowering and boll formation—posing challenges in saline belts with limited freshwater access. So we can promote water-efficient practices like drip irrigation and rainwater harvesting. Provide incentives for water-saving technologies, and develop saline-tolerant cotton varieties adapted to local agro-ecological conditions.

d. Limited Access to Quality Inputs

Farmers often struggle to access certified organic seeds, compost, and bio-inputs in a timely and affordable manner. So establish decentralized organic input banks and mobile delivery services in coastal areas is recommended. Strengthen linkages with agricultural universities and NGOs for input production and distribution, tailored to saline conditions.

e. Inadequate Extension Support in Coastal Zones

Conventional extension services often lack region-specific knowledge on saline agriculture and organic practices. That's why development of specialized Organic Cotton Resource Centers within coastal KVKs to offer soil testing are done, pest management training, and demonstrations. Utilize digital tools (apps, SMS alerts, helplines) for remote advisory support.

6. Future Research and Policy Gaps

Despite the growing recognition of organic cotton as a sustainable and profitable option for coastal farmers dealing with saline soils, several research and policy-level challenges hinder its widespread adoption. A concerted focus on the following areas is critical to scaling up this promising pathway:

- The lack of region-specific, salt-tolerant organic cotton varieties is a major barrier. Most current varieties are not suited to organic systems or the unique conditions of areas like the Sunderbans or Kutch. There is a strong need for non-GMO, organically breedable varieties developed through local trials.
- There is limited long-term data on how organic cotton performs in saline soils. Without multi-year studies, it's hard to evaluate benefits like yield stability, soil improvement, or climate resilience compared to conventional cotton.
- Policy support is inadequate. Although schemes like PKVY and NMSA exist, organic farmers in saline zones lack proper insurance, MSP coverage, market access, and support for certification, making them vulnerable.

- Extension services are weak. Many field workers are not trained in organic practices suited to saline soils. Farmers also lack access to localized training, demo plots, and technical guidance.

A focused national initiative tailored to saline zones—covering breeding, long-term research, policy support, and extension is essential to scale up organic cotton farming sustainably.

7. Conclusions

Organic cotton offers a sustainable and eco-friendly solution for farming in coastal saline regions of India. Its ability to improve soil health, reduce chemical use, and support biodiversity makes it ideal for these fragile ecosystems. However, its widespread adoption is limited by the lack of salt-tolerant, organically-suited varieties, insufficient long-term research, weak extension support, and policy gaps. With focused breeding, improved data, better training, and targeted policies, organic cotton can transform saline-affected areas into resilient and productive agricultural landscapes. This shift can enhance farmer income, restore degraded lands, and position India as a global leader in sustainable cotton production.

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