Seeding the Green Future
Participatory breeding for Securing Organic Cotton and Genetic Diversity

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Meeting Point Organic right from the start! biofach Messe Nürnberg organic breeding exhibition
Nürnberg, 15th February 2019
Challenges of organic cotton in India

• India has been the largest organic cotton producer, 10 years ago India supplied 80% but dropped now to 56%, with a decrease of 20% from 2014/15 to 2015/16!!!

• Organic cotton in India is less than 2%, while genetically modified Bt cotton reached 95% in less than 10 years

• Public breeding and seed multiplication were neglected

• Local non-GM seed supply were eroded

• Commercial seed companies have limited interest in non GM cotton (higher production risks, risk of Bt contamination, small demand)

• High dependency on global seed company holding Bt licence resulting in high seed price and concentration on high input agriculture (high level of fertilizer, pesticide, irrigation)

• Breeder’s seed is already contaminated with Bt, causing Bt contamination throughout the cotton value chain
Area under GMO cotton of main producing countries

Reference: www.transgen.de
Organic Cotton Production on global level

Global Fiber Production Trend (MT)

Challenges and Research Gaps of Organic Cotton

• Limited genetic improvement of non-GM cotton after introduction of Bt-cotton
• Missing public breeding programs for organic and low input conditions and nationwide cultivar testing under organic conditions
• Loss of genetic diversity: the more resilient traditional desi cotton (G. arboreum) disappeared from production
## Cultivated cotton species in India

<table>
<thead>
<tr>
<th>Species</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Gossypium hirsutum</em></td>
<td>Upland cotton tetraploid</td>
<td>Pima / Egyptian cotton tetraploid</td>
</tr>
<tr>
<td><em>Gossypium barbadense</em></td>
<td></td>
<td>Desi cotton diploid</td>
</tr>
<tr>
<td><em>Gossypium arboreum</em></td>
<td></td>
<td>Desi cotton diploid</td>
</tr>
<tr>
<td><em>Gossypium herbaceum</em></td>
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</table>
Change of cultivation area in different cotton species in the last decades in India

1947
- G. arboreum: 64%
- G. herbaceum: 28%
- G. hirsutum: 8%

1995
- G. barbadense: 1.2%
- G. arboreum: 24.4%
- G. herbaceum: 13%
- G. hirsutum hybrids, 32%

2000
- G. barbadense: 2.58%
- G. hirsutum hybrids: 40%
- G. hirsutum varieties: 33.34%
- G. herbaceum: 9.46%

2012
- G. barbadense: 0.95%
- G. arboreum A.B.: 0.95%
- G. hirsutum hybrids: 85.5%
- G. herbaceum: 4.75%
- G. hirsutum varieties: 5%

Prof. Dr. R. W. Bharud, Mahatma Phuke Agricultural University Rahuri, MA
All Indian Cotton Improvement Project

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First Steps: The Dharwad Declaration

National Workshop June 21st 2011: «Disappearing non-GM cotton - ways forward to maintain diversity, increase availability and ensure quality of non-GM cotton seed» Dharwar Declaration

Jointly organized by bioRe India Ltd., FiBL Switzerland, University of Agricultural Sciences Dharwad including main stakeholders

To combine forces for immediate action and support of:

- Collaboration & Exchange, e.g. private public partnership
- Desired Policy Changes, e.g. establishing GM-free zones
- Evaluation and multiplication of existing cotton cultivars under organic and low-input conditions
- Establishing and optimizing the non-GM seed chain
- Continuous improvement of non-GM cultivars
GREEN COTTON

Decentralized Participatory Cotton Breeding for Organic and Marginal Growing Conditions in India

In collaboration with Partner Organisations:
- bioRe Association
- Chetna Organic
- University of Agricultural Science Dharwad

Timeframe: 2013 – 2016 (option for prolongation)

Supported by Mercator Foundation Switzerland

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Goals and Objectives of Green Cotton

➤ Safeguarding the future seed supply of non-GM cotton crucial for the organic cotton production and textile industry
   ➤ Improving yield stability & fibre quality and adaptation to local growing conditions by decentralized selection on non GM cotton in the target environment

➤ Promoting genetic diversity in the field with special focus on the utilization of tradition Desi cotton germplasm to get prepared for climate change
   ➤ Performaning specific crosses with desi cotton for organic and marginal growing conditions

➤ Enabling farmers and farmer organisations to retain seed sovereignty to become more independent from high input costs
   ➤ Initiation of participatory breeding involving farmers in selection
   ➤ Training of farmers → certified farmer breeders for selection & seed propagation
Partners

FiBL  Chetna Organic

Supporters:

STIFTUNG MERCATOR SCHWEIZ  OCA ORGANIC COTTON ACCELERATOR  FONDATION Carrefour

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Objectives:

• Continuation of participator breeding initiatives and upscaling of the activities in different States in India

• Secure non GM seed supply chain of adapted cultivars for organic cotton farmers

• Develop a broad portfolio of new cotton cultivars of American and traditional Desi cotton with

• Improve integrity of organic cotton by capacity building and close collaboration of actors among the supply chain

• Improve livelihood of small holder cotton farmers

• Empower female and male farmers to manage their own seed supply free of GMO and adjusted to local conditions and climate change
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Local partners

Organic cotton growers organisations:
• Chetna Organic: involved in Green Cotton participatory breeding since 2013
• Pratibha Synthex: started with on station organic breeding
• Cotton Connect: link to many organic growers associations on farm trials
• Action for Social Advancement (ASA): on farm trials
• Center for Sustainable Agriculture (CSA): on farm trials

Public institutions and universities:
• RVSKV Gwalior university – Khandwa College: testing for truthfully labeled seed under organic conditions, seed multiplication, crosses
• JN Agric. University Jabalpur: interested to support organic cotton farmers
• Akola university: running breeding programs of G. hirsutum and G. arboreum cotton
• MKV Parbhani University: breeding of long fibre arboreum cotton

Commercial seed companies providing non GM seed on contract basis: Dafthari seeds, Green Gold Seeds, JK Seeds, Nirmal Seeds, Bloom biotech, Krishidhan seeds, Nuziveedu seeds, Ankur Seeds Ltd
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Methodology:

• Scale up participatory cotton breeding by empowering farmers through collaboration with researchers, breeders, seed companies, advisors, textile industry

• Utilizing full potential of genetic cotton resources in India
  – Explore potential of traditional diploid desi cotton (G. arboretum) in order to combine drought resistance, tolerance to sucking pest, nutrient use efficiency with fiber quality (>28mm)
  – Explore the potential of tetraploid G. hirsutum cotton varietal lines bred and selected under organic condition

• Training of trainers & farmers and implementation of
  – organic on-station and on-farm trials for cultivar testing and selection
  – cross breeding and single plant selection
  – Maintenance breeding, seed multiplication, seed quality and GMO testing
Breeding Scheme

P1 x P2

F1

F2

Phenotypic screening

Plants space-planted in rows for individual plant selection

F3

F4

Families grown in progeny rows for selection.

F5

F6

Preliminary yield trials. Select single plants.

F7

F8 – F12

Multi-location testing, licensing, seed increase and cultivar release

F8 – F12

Green Cotton

Phase I

2013-2016/17

2017

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Future Phase II

2018-2022

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Future Phase III

2022-2026
Participatory Cultivar Evaluation and Participatory Breeding as a viable Alternative to Seed Monopoly

Formal plant breeding and seed supply

- Society
- Public & Private Breeding
- Variety release
- Seed Propagation
- Seed traders
- Farmers

One Way Information: Scientist

Extension Service

Farmer

Participatory plant breeding and seed multiplication

- Society
- Politics
- Customer
- Farmer
- Breeder
- Seed producer
- Trader
- Agronomist
- Social Scientist
- Ecologist
- Molecular biologist
- Economist
- Climatologist

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Methodologies and Tools for Participatory Research

Participatory rapid appraisal
Mother - Baby Trial
Farmer field schools
Farmer research committees
Participatory technology development
Action research

21 cultivars x 2 replication

Best 5 cultivars tested in 10 on-farm trials
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Start of on farm trial and training

Capacity building in
- Varietal Testing
- Seed multiplication
- Seed processing & cleaning
- Germination Testing
- Seed Health
- Storage
- Crossing techniques
- Selection techniques

Regular Workshops with all Stakeholders
Farmers Field Days and Demo Trials

Ceccarelli 2010

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Spreading of on farm trials

Village 1
Village 2
Village 3

Ceccarelli 2010

Stage 1
Stage 2
Stage 3
Stage 4
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Breeding material from different breeders or seed companies

Start participatory breeding at two cotton growers organisation: Selection of early and advanced generation

Two seed producer provide organic non-GM cotton seed for ALL organic farmers

On-station & On-farm baby trials of best lines

MLT in different pedoclimatic regions
Capacity building
Involve farmers in selection criteria, cultivar testing & selection, breeding activity

Cultivar selection

Single plant selection

<table>
<thead>
<tr>
<th>Priority of Traits for Farmers</th>
<th>Male (%)</th>
<th>Female (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Many Branches</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Boll size</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4-5 compartments</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Deep root</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Boll opening</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Easy picking</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Easy cotton release</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Continuous flowering</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hairy leaves</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Earliness</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No Wilting</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Germination</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fiber quality</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Disease tolerant</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Creating new diversity of traditional cotton

- Collection of traditional Indian cotton *G. arboreum*
- Crosses of traditional Indian cotton and modern cotton species
- Multiplication of offspring
- Single plant selection in early generations (F2 - F5)
- Testing advanced generations (F6-F9)
Development and implementation of new cultivars

- **Multilocation trials of 20 to 50 lines with replication in organic farms** for yield stability, resistance, fiber quality in 3 different States under irrigated fertile soil and rainfed under sandy soil.

- **150 on farm baby trials of best candidates** including traditional cotton and open pollinated cotton in 6 States and growing conditions.

- **18 pilot trials** in farmers field to compare with hybrid cultivars.

- **Seed multiplication** of best candidates in isolated areas.

- Registration of cultivars.

- Commercialization of truthfully labelled seed.
Results highlight the need for agro-ecological zone specific cultivar development for different soil and water dynamics.
SGF Trial Sites (2018-19)
150 on farm trials

1. Madhya Pradesh
2. Maharashtra
3. Rajasthan
4. Odisha
5. Gujarat
6. Andhra Pradesh
Plan for conservation - multiplication

<table>
<thead>
<tr>
<th>Farmer name</th>
<th>Low land</th>
<th>Low land conservation</th>
<th>Multiplication</th>
<th>Up land</th>
<th>Upland conservation</th>
<th>Multiplication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deepu</td>
<td>1</td>
<td>2 rows 5 var paddy</td>
<td>0.1 acre 2 var paddy</td>
<td>2</td>
<td>10 var millets</td>
<td>0.2 acre 2 var redgram</td>
</tr>
<tr>
<td>Dhano</td>
<td>2</td>
<td>2 rows 10 var paddy</td>
<td>1 acre 5 var paddy</td>
<td>2</td>
<td>1 Var of upland crops like oils seeds, cotton</td>
<td>1 var cotton seed multipl</td>
</tr>
</tbody>
</table>

Village: Bhimdonga
Manikeswari group
Ma lakmi seed bank

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Farmers own seed

Commercia F1 Hybrids
Farmers own selections
Varietal lines
Desi Varietal lines

Chetna Cooperatives & Seed banks
Procure 400 kg of varietal seed cotton & gin

200 kg of locally suitable varieties stocked
for 100 certified organic farmers.

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Farmer needsto buy each year

Farmers can use their farm saved seed
Example for cross-sector promotion of organic cotton breeding

Poolfunding of organic breeding:
- 50% Foundation Mercator Switzerland
- 50% Organic Cotton Accelerator

Project Governance, Activities & Partners

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Importance of International Cooperation

Textile Exchange:
• annual Organic Cotton Market Report
• established 2012 Organic Cotton Round Table
• with annual meetings the task force Seed & Soils

Organic Cotton Accelerator:
Pooling resources of international textile brands to support
• cotton breeding projects in India
• develop business models and sourcing practices that secure the integrity of organic cotton supply chain
First Results on Participatory Breeding and Conclusion

• Engagement of all actors of the value chain allow a targeted selection of cultivars that are best suited for their growing conditions and meet demand of market.

• Traditional desi cotton are more tolerant against sucking pest, more tolerant towards drought and flooding and morphological distinctly from GM-cotton, and do not cross with them

• Empowerment of female farmer and involvement in breeding improves adoption of new cultivar types

• Training, capacity building, farmers organisations and shared decision power is important as well as a neutral facilitator fostering collaboration between cooperations

• Linking farmers with textile industry is needed to develop a supply chain partnership with mutual benefit and secure supply of high quality organic cotton fiber

• Breeding is part of the value chain and needs support from the textile industry
Outlook
Linking Seed & Breeding Initiatives on global scale

• Capacity building to empower organic farmer organisations
• Sharing of information, knowledge, practices, testing protocols
• common R&D projects
• Status quo analysis of available species and cultivars
• Focus on biodiversity and adaptation to climate change
• Exchange of seeds: among partners, between countries? Open source seeds, farmer owned seeds
• Maintenance breeding with quality system to avoid GMO contamination
• Scholarship, Training, institutional exchange
• Political lobbying for organic cultivar testing
• Linking stakeholders, partner recruitment
• Develop business plan for breeding and seed production
• Common fundraising to approach different brands, Crowd funding
Outlook for 2019

**Organic Cotton Exhibition and sustainable textile consumption**

**Botanical garden Univ. Zürich** 10\(^{th}\) August – 29\(^{th}\) September 2019

Thanks to all partners, supporters and for your attention

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