Participatory Cotton Breeding for Organic and Low External Input Conditions

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Background
• India has become the second largest cotton producer just after China in 2008
• A success that is largely due to joint efforts of farmers, breeders, agronomists, entomologists, pathologists and physiologists
• A large diversity of Gossypium hirsutum, arboreum and barbadense hybrid and varieties was developed over the years
• Today, Indian farmers grow 90% hirsutum, mainly hybrids, of which 90% is GM cotton
• The genetic diversity has reduced drastically since the introduction of the first GM cotton hybrids; endemic cotton species (desi cotton) are disappearing
• Hybrids are bred for high yield potential soils and depend to a large extent on external inputs (i.e. fertiliser, pesticide, irrigation water) in order to realize maximal yield per acre. These hybrids might be suboptimal under low external input and rainfed farming as different traits are needed under these conditions

• Conversely, over the last two decades India has become the world’s largest organic cotton producer (up to 80% of world’s organic cotton)
• Despite rapid increase of organic cotton markets, the erosion of conventional seed by GM cotton continues to threaten the development of India’s organic cotton sector
• The private seed companies have little interest to invest in non-GM cotton and farmers have lost their traditional knowledge on seed production
• Today, cotton farmers depend on a diminishing supply of non-GM cotton seed of spurious quality
• Risk of physical and genetic contamination of organic cotton with GM cotton and the loss of locally adapted genetic resources increased rapidly
• Therefore, immediate action is needed to improve seed availability, seed access and seed quality of non-GM cotton varieties adapted to organic and low input conditions
→ After continuous yearly increase of 5 -10%, the organic cotton production dropped the first time by 37% in the last season 2011/12 (Market report 2012 Textile exchange)

bioRe - FiBL research partnership

• bioRe partners in an international research programme with the Research Institute of Organic Agriculture (www.systems-comparison.fibl.org)
• Goal: “To enhance know-how on advantages and limitations of different agricultural production systems”
• Expected Outcome 1: “Solid agronomic and socio-economic data on major organic and conventional agricultural production systems in selected project regions are at hand”
• Expected Outcome 2: “New locally-adapted technology innovations for major organic production systems are available and ready for dissemination”

Project location and trial setup

• Location: Central Indian cotton belt (Madhya Pradesh)
• Eco-zone: Semi-arid tropics
• Agricultural system: Annual fibre and food crops (cash crops)
• Crop rotation:

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>Soya</td>
</tr>
</tbody>
</table>

• Treatments: (1) Biodynamic, (2) organic, (3) conventional and (4) GM-cotton
• Trial start: May 2007
• Partners: bioRe India Association
India: Trial site

River Narmada

Yield potential: very good
pH: 8.7
Corg: 0.5%
P(Orison): 7 mg/kg
Clay: 40%
Altitude: 250 masl
Rainfall: 800 mm

Long-term field trial

22°30.28'N, 75°37.48.97'E

Cotton Pre-Trials 2010 due to farmers demand

Objectives & Methodology

To investigate the physiological development, assess yield and cotton fibre quality of available organic, conventional and GM hybrid under low (organic) and high (conventional) external input conditions

Organic, conventional and GM hybrids are tested in an on-station mother trial with a completely randomised block design at different input levels

Cotton hybrid and varieties tested in 2010

<table>
<thead>
<tr>
<th>No</th>
<th>Hybrid/Variety</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>JK DURGA</td>
</tr>
<tr>
<td>B</td>
<td>H12</td>
</tr>
<tr>
<td>C</td>
<td>SURAJ</td>
</tr>
<tr>
<td>D</td>
<td>HY 102</td>
</tr>
<tr>
<td>E</td>
<td>JK DURGA (Bt)</td>
</tr>
</tbody>
</table>

Development of cotton fibre

Cotton is a self pollinator, undetermined growth (perennial plant), diploid and tetraploid species, huge water demand, fibre length and density is very important

Cotton Pre-Trials 2010 (cont.)

Objectives & Methodology

<table>
<thead>
<tr>
<th>Input Level</th>
<th>Low Input</th>
<th>High Input</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compost/acre</td>
<td>8500 kg</td>
<td>2500 kg</td>
</tr>
<tr>
<td>Urea/acre</td>
<td>125 kg</td>
<td>210 kg</td>
</tr>
<tr>
<td>SSP/acre</td>
<td>65 kg</td>
<td></td>
</tr>
<tr>
<td>MOP/acre</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neem extract + cow urine spray</td>
<td>Neem extract + cow urine spray</td>
<td></td>
</tr>
<tr>
<td>Garlic-onion-chili repellent, Top Ten</td>
<td>Garlic-onion-chili repellent, Top Ten</td>
<td></td>
</tr>
<tr>
<td>Pesticide (e.g. Nitrobenzene, Imidachlorprid, Profenofos) + Fungicide</td>
<td>Pesticide (e.g. Nitrobenzene, Imidachlorprid, Profenofos) + Fungicide</td>
<td></td>
</tr>
</tbody>
</table>

Results & discussion

Low Input

High Input

Randomised Complete Block Design (RCBD)

Planting spacing: 1 m x 0.3 m
Results & discussion

Cotton Pre-Trials 2010 (cont.)

- Cultivars performed slightly better under conventional treatment
- JK Durga & H-12 both achieved higher yield than the Suraj & Hy-102
- Overall JK Durga performed best
- JK Durga non-GM performed better than JK Durga GM in both low input & high input treatments
- Selection of JK Durga for long-term experiment, cropping season 2011-12

Organisation of National Cotton workshop to join forces among organic cotton stakeholders

- bioRe organized with the support of the University of Dharwad and FiBL a national workshop on disappearing non-GM cotton
- Invited stakeholders:
  - Organic cotton producer organisations
  - Center of Indian Cotton Research Institutes
  - Cotton Breeding & Organic Farming Institutes
  - Public and private Seed companies
  - Public Institutes for Testing fibre quality
  - Cotton spinners, retailers, and producers
  - Ministry of agriculture
  - NGOs involved in organic cotton, seed exchange, GMO free regions

Dharwad Declaration 21th June 2011

Disappearing non-GM cotton – ways forward to maintain diversity, increase availability and ensure quality of non-GM cotton

- Collaboration and exchange
  - Facilitating exchange of information, techniques, genetic material
  - Pooling volume of producers seed demand
  - Promoting private public partnership in prebreeding, breeding, multiplication of cotton
  - Forming a multistakeholder forum for policy advocacy

- Desired policy changes
  - Focusing policy and public research on non-GM cotton
  - Installing board for organic cotton with financial & implementation power
  - Continuous dialog with policy makers
  - Safeguarding organic cotton farmers from GM contamination
  - Declare ecologically sensitive zones GM-free

Evaluation & Multiplication of cotton cultivars under organic and low input conditions

- Local testing & multiplication on station and on farm under various conditions
- Maintaining & utilizing genetic diversity of non-GM cotton in situ, especially of endemic Desi cotton

Establish and optimize non-GM cotton seed value chain

- Implement measures to avoid physical and genetic GM contamination
- Identify specific non-GM areas for seed production
- Installing seed quality testing
- Database on availability of seeds, results from cultivar trials
- Training farmers in seed multiplication, processing, storage
- Empowering farmers and farmer groups to set up own seed business
- Bringing valuable germplasm from public institution into farmers fields

Follow up of Dharwad declaration

- Workshop on organisation and action that need to be done
  - Initiation of Indian Organic Cotton Initiative
  - Working group on political lobbying
  - Working group on plant breeding
  - Working group on seed chain development incl. Varietal trials
  - Working group on quality assessment of fibre and GM contamination
  - Develop concept note
  - Identify leader and participants for each working group
  - Define objectives and tasks per working group
  - Determine time line and overall budget needed
Cotton Trials 2011 (cont.)

Objectives & Methodology

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Species</th>
<th>Cultivar Type</th>
<th>Mother Trait</th>
<th>Baby Trait</th>
<th>Demo Plot</th>
</tr>
</thead>
<tbody>
<tr>
<td>JK Durga (Bt)</td>
<td>G. hirsutum (4x)</td>
<td>Hybrid</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>H-6</td>
<td>G. hirsutum</td>
<td>Hybrid</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>H-10</td>
<td>G. hirsutum</td>
<td>Hybrid</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Ankur-651</td>
<td>G. hirsutum</td>
<td>Hybrid</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Raj-2</td>
<td>G. hirsutum</td>
<td>Hybrid</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Raj-2 (Bt)</td>
<td>G. hirsutum</td>
<td>Hybrid</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>R-22-102 (G)</td>
<td>G. hirsutum</td>
<td>Varietal line</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>ZSH-8</td>
<td>G. hirsutum</td>
<td>Varietal line</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>A-596-84 (R)</td>
<td>G. arboreum (2x)</td>
<td>Varietal line</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>B-330-5</td>
<td>G. arboreum</td>
<td>Varietal line</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>RAHB-1</td>
<td>G. hirsutum x G. barbadense</td>
<td>Hybrid</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>RAHB-2</td>
<td>G. hirsutum x G. barbadense</td>
<td>Hybrid</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Follow up of Dharwad declaration

Participatory Cotton Trials on station 2011/12

Objectives & Methodology

Objectives:

• To gain information about the suitability of different types of cotton cultivars for organic and low input farming conditions in Central India

Comparison of:

• different cotton species (2x vs. 4x)
• different cultivar types (hybrid vs. Inbred lines)
• Different plant morphology
• Response to different input level & pest management
Harvest data of on station trial 2011/2012

Cotton Trials 2011 (cont.)
Additional 36 cotton cultivars (5 hirsutum hybrids, 5 interspecific hybrids, 7 arboresum lines, 20 hirsutum lines, 8 barbadense lines and 5 compactum hirsutum lines and five F2 populations) provided by Prof. Patil from the University of Dharwad are examined on BioRe farm with two replications.

Additional 36 cotton cultivars (5 hirsutum hybrids, 5 interspecific hybrids, 7 arboresum lines, 20 hirsutum lines, 8 barbadense lines and 5 compactum hirsutum lines and five F2 populations) provided by Prof. Patil from the University of Dharwad are examined on BioRe farm with two replications.

Objectives:
• To compare farmers and breeders selection
• To compare farmer’s perception with yield and fibre quality data

Methodologies:
• Engage 20 farmers in four different villages trained in PTD and highly interested in seed issue
• Interview of farmers
• Instruction of farmers on farm field trial installation, labelling, sampling
• Farmers’ workshops on
• Farmer’s cultivar selection of best cultivar in own field
• Farmer’s cultivar selection of best cultivar on station
• Farmer’s single plant selection in segregating populations on station

Participatory Cotton Trials on farm 2011/12

On farm trials in six villages

Participatory cotton trials on farm 2011/12
• Visit of farmers group already involved in participative technology development (PTD network)

• Common decision which cultivars shall be tested
  → five G. hirsutum hybrids tested in 4 villages by 22 farmers
  → five G. hirsutum varietal lines in 2 villages by 4 farmers according to farmer’s practice in commercial field
Participatory cotton trials on farm 2011/12

- Regular visits of bioRe researcher and extensionist to on farm trials
- Interview of farmers about soil properties, irrigation, crop management, sowing time
- Group meetings to instruct harvesting procedure
- Distribution of marked bags for the harvest (Sept. – Feb.) of each cultivar, one assistant per village during harvest and yield assessment
- Farmer select best cultivar(s) in his field (distributing 3 colour ribbons among the five cultivars) and describes why he chose them

- First selection workshop on bioRe farm with 18 farmers:
  - Grouping according to irrigation facility
  - Definition & prioritization of important cotton traits
  - Evaluation of 20 hirsutum varietal lines by distributing 5 ribbons for the cultivars he would like to cultivate on his farm
  - Group discussion to select the best 4-5 cultivars out of the 20
  - Visit also other cotton types and discuss their suitability

Participatory cotton trials on farm 2011/12

- Second selection workshop on bioRe farm with 5 most enthusiastic farmers:
  - More detailed introduction into cotton breeding
  - Every farmer presented his own trial
  - Definition & prioritization of important cotton traits
  - Evaluation of 5 segregating populations (F3) of intraspecific hirsutum crosses, 50 rows a 20 plants per cross, 5'000 single plants
  - Two groups, evaluating 2 and 3 populations,
  - Selection of bioRe researcher/master student, farmer and cotton breeder from Dharwad had different coloured ribbons to mark plants independently

- Harvest of selected plants, assessment of single plant yield and quality analysis of the one with above average yields
- Total 19 selected F3 lines, farmers’ selection were more successful in selecting for high fibre length than cotton breeder

Final group session

- Presentation of results from on station and on farm trials
- Interpretation of results within groups of similar growing conditions (irrigated or rainfed)
- Comparison of farmers perception with yield and quality data
- Acknowledgement of farmers, certificate for participating and small gift

Reasons for the selection of the 3 best cultivars

- Good growth
- Good germination
- Deep roots
- More branches
- Good flowering
- Less flower shedding
- Regular flash
- Good second flash
- Good size
- Good height

Figure 22: Farmers’ reasons for preferring cultivar H-10, H-12 and Ankur-651
On farm selection by farmers

On land with good irrigation

On sandy soil without irrigation

Summary

- General high interest of farmers to participate in on-station and on-farm testing of cotton varietal lines and hybrids
- On-station mother trials are managed by the researchers, while on-farm baby trials are managed by the farmer
- A network of interested farmers need to be established, who are regularly trained in on-farm research and supported by extension agents
- Farmers, researchers and extension agents together monitor the on-station and on-farm trials and evaluate cotton varieties and hybrids
- However, the extension agents and farmers need to be introduced into plant breeding by the researcher to support and profit from decentralized participatory breeding efforts
- Farmers are highly motivated to find new genotypes as they are in great need for good seed sources

Thanks you for your attention!