



## Participatory Breeding of Cotton for Organic and Low External Input Conditions

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1

## Content

### Introduction

- Background and problem statement
- bioRe - FiBL research partnership
- Participatory innovation development (PID)

### Cotton Pre-Trials 2010

- Objective & Methodology
- Results and discussion

### Cotton Trials 2011

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- Results and discussion

### Conclusion

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2

## Introduction

### Background and problem statement

- 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
- 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

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3

## Introduction (*cont.*)

- 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
- 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

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4

## Introduction (cont.)

### bioRe - FiBL research partnership



- bioRe partners in an international research programme with the Research Institute of Organic Agriculture ([www.systems-comparison.fibl.org](http://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"

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5

## Introduction (cont.)

### Long-Term Experiment (LTE)



A1	B1	C1	D1
B2	D2	A2	C2
C3	B3	D3	A3
D4	A4	C4	B4

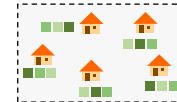
Treatment → Letter  
Replication → Number

### Participatory Innovation Development (PID)

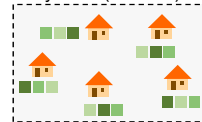
#### Mother trial (on-station)



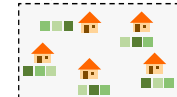
#### Baby trials (on-farm)



#### Baby trials (on-farm)



#### Baby trials (on-farm)



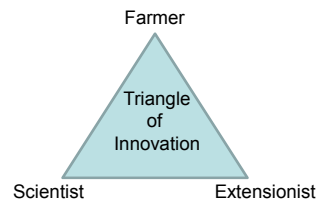
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6

## Introduction (*cont.*)

### Participatory innovation development (PID)



- Participatory innovation development is the triangulation between farmers, breeders and extension agents in management and cultivar improvement
- Participatory plant breeding (PPB) is an opportunity for developing locally adapted cultivars suited to organic and low external input conditions and for increasing genetic diversity by decentralized selection

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7

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8

# Cotton Pre-Trials 2010

## Objectives & Methodology

Objective: 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

Cotton hybrid and varieties tested in 2010			
A	JK DURGA	D	HY 102
B	H12	E	JK DURGA (Bt)
C	SURAJ		

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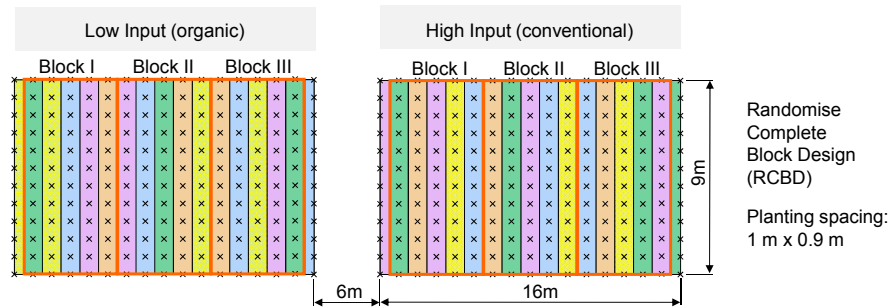
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9

# Cotton Pre-Trials 2010 (cont.)

## Objectives & Methodology

Low Input	High Input
8500 kg compost/acre	2500 kg compost/acre
	125 kg urea/acre, 210 kg SSP/acre, 65 kg MOP/acre
Neem extract + cow urine spray, Garlic-onion-chilli repellent, Top-Ten	Pesticide (e.g. Nitrobenzene, Imidachlorprid, Profenofos) + Fungicide



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10

## Cotton Pre-Trials 2010 (cont.)

### Results & discussion

JK DURGA BT



Low Input



High Input

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11

## Cotton Pre-Trials 2010 (cont.)

### Results & discussion

H-12



Low Input



High Input

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12

## Cotton Pre-Trials 2010 (cont.)

### Results & discussion

HY-102



Low Input



High Input

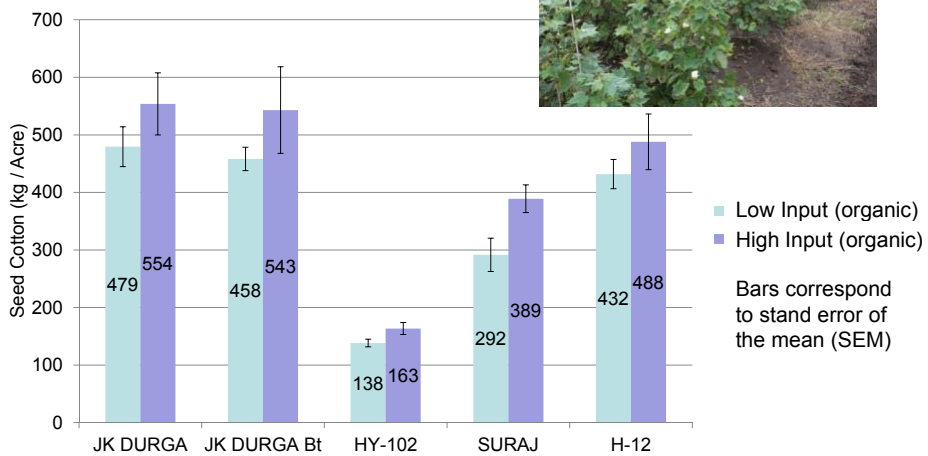
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13

## Cotton Pre-Trials 2010 (cont.)

### Results & discussion



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14

## Cotton Pre-Trial (*cont.*)

### Results & discussion

- 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

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## Cotton Trials 2011

### Objectives & Methodology

Objectives:

- To introduce participatory breeding approaches
- To test improved cotton cultivars in smallholders' organic cotton fields
- To gain information about the suitability of different types of cotton cultivars for organic and low input farming conditions in Central India



Fig. 1 *G. hirsutum*  
4x hybrid



Fig. 2 *G. hirsutum* x  
*barbadense* 4x hybrid



Fig. 3 *G. arboreum*  
2x varietal line

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17

## Cotton Trials 2011 (cont.)

### Objectives & Methodology

Cultivar	Species	Cultivar Type	Mother Trial	Baby Trial	Demo Plots
JK Durga	<i>G. hirsutum</i>	Hybrid	X	X	X
JK Durga (Bt)	<i>G. hirsutum</i>	Hybrid	X		
H-6	<i>G. hirsutum</i>	Hybrid	X	X	X
H-10	<i>G. hirsutum</i>	Hybrid	X	X	X
H-12	<i>G. hirsutum</i>	Hybrid	X	X	X
Ankur-651	<i>G. hirsutum</i>	Hybrid	X	X	X
Rasi 2	<i>G. hirsutum</i>	Hybrid	X		
Rasi 2 (Bt)	<i>G. hirsutum</i>	Hybrid	X		
R-22-(102)	<i>G. hirsutum</i>	Variety	X		
ZCH-8	<i>G. hirsutum</i>	Variety	X		
A-504-48-91	<i>G. arboreum</i>	Variety	X		
B-320-5	<i>G. arboreum</i>	Variety	X		
RAHB-1	<i>G. hirs.</i> x <i>G. barbadense</i>	Hybrid	X		
RAHB-2	<i>G. hirs.</i> x <i>G. barbadense</i>	Hybrid	X		

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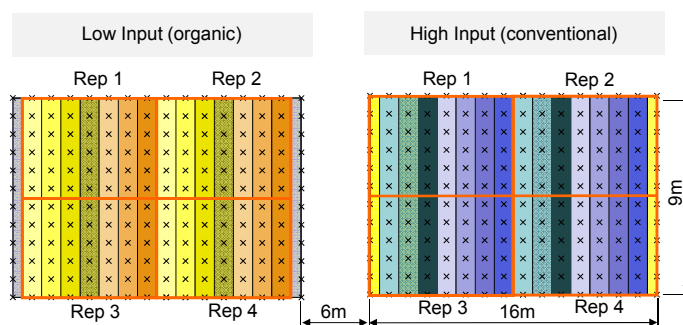
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18

## Cotton Trials 2011 (cont.)

### Objectives & Methodology

Exp. I. tetraploid *G. hirsutum* hybrids are compared with *G. hirsutum* varietal lines, interspecific hybrids, and native diploid *G. arboreum* varieties under high and low input conditions on-station to test for genotype x management interaction



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19

## Cotton Trials 2011 (cont.)

### Objectives & Methodology

Low Input	High Input
8500 kg compost/acre	2500 kg compost/acre
	125 kg urea/acre, 210 kg SSP/acre, 65 kg MOP/acre
Neem extract + cow urine spray, Garlic-onion-chili repellent, Top-Ten	Pesticide (e.g. Nitrobenzene, Imidachlorpid, Profenofos) + Fungicide

Morphological Assessments	Quality Assessments
Stem diameter, Leaf shape, Hairyness, Plant height, Pest and Diseases	Diameter of cotton ball, Seed and Lint index
Homogeneity within cultivar	Uniformity and Maturity
Monopodia/Sympodia, Harvesting time, No. of cotton balls per plant, Weight of cotton balls per plant	Length, Strength, and Finesse of Fibre

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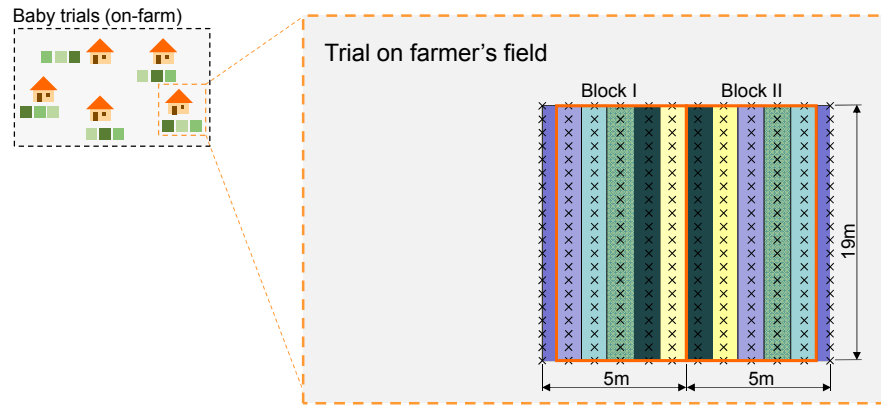
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20

## Cotton Trials 2011 (cont.)

### Objectives & Methodology

Exp. II. five *G. hirsutum* hybrids are tested by 20 organic cotton farmers of the PID network at different soil fertility levels



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21

## Cotton Trials 2011 (cont.)

### Objectives & Methodology

Exp. III & IV. 36 cotton cultivars and five F2 populations are examined on the bioRe farm

Plot D

DEMO 1	DEMO 2	DEMO 3	DEMO 4	DEMO 5	JK DURGA
COMPACT VARIETAL TRIAL, 1-5	COMPACT VARIETAL TRIAL, 5-1	HXH HYBRIDE TRIAL 5-1	HXB HYBRIDE TRIAL 6-1		
ARBOREUM VARIETAL TRIAL, 1-5	ARBOREUM VARIETAL TRIAL, 5-1	HXB HYBRIDE TRIAL 1-6	HXH HYBRIDE TRIAL 1-5		
ARBOREUM 504-48-91	ARBOREUM 320-5	F2.BXB 6 LINES	F2.HXH 5 LINES	F2.BXB 6 LINES	F2.HXH 5 LINES
9 FEET GAP					
HIRSUTUM VARIETAL LINE R1-101-120	BARBADENSE R1-101-108	HIRSUTUM VARIETAL LINE R2-201-220	BARBADENSE R2-201-208		
9 FEET GAP					
HIRSUTUM VARIETAL LINE R2-201-220	BARBADENSE R2-201-208	HIRSUTUM VARIETAL LINE R1-101-120	BARBADENSE R1-101-108		
9 FEET GAP					
INDO-AMERICAN INDAM-206					

BioRe Farm

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22

## Cotton Trials 2011 (*cont.*)

### Preliminary Results

- During plant development the *G. hirsutum* hybrids were more homogeneous and showed better growth than the other cultivar types
- Interspecific *G. hirsutum* x *barbadense* hybrids were short in growth and heavily attacked by pest and diseases, while the *G. arboreum* varietal lines were very inhomogenous in the on-station trial (Exp. I)
- Also on-farm (Exp. III) *G. hirsutum* varietal lines showed best plant development and early flowering, while the *G. barbadense* varietal lines were most infested by pests and diseases
- The *G. arboreum* varietal lines were very healthy but yielded comparatively small cotton balls

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23

## Conclusion

- 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

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24



24.06.2014

R. Baruah, M. Messmer, D. Forster, R. Verma, S.S. Patil

25

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24.06.2014

R. Baruah, M. Messmer, D. Forster, R. Verma, S.S. Patil

26