

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

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Background

- 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)

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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"

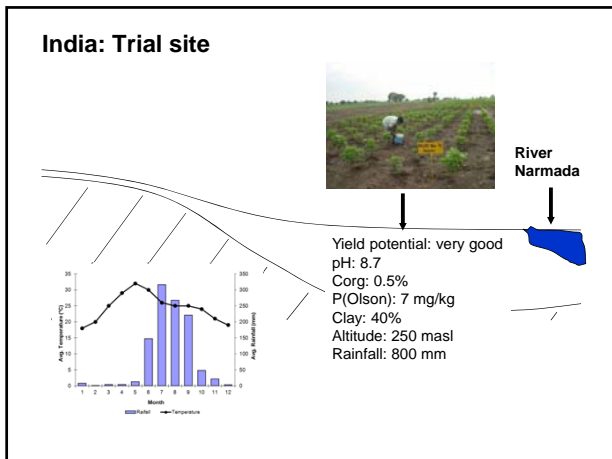
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Project location and trial setup

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

Year 1	Year 2	
Cotton	Soya	Wheat
- › Treatments: (1) Biodynamic, (2) organic, (3) conventional and (4) GM-cotton
- › Trial start: May 2007
- › Partners: bioRe India Association

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Cotton Pre-Trials 2010 due to farmers demand

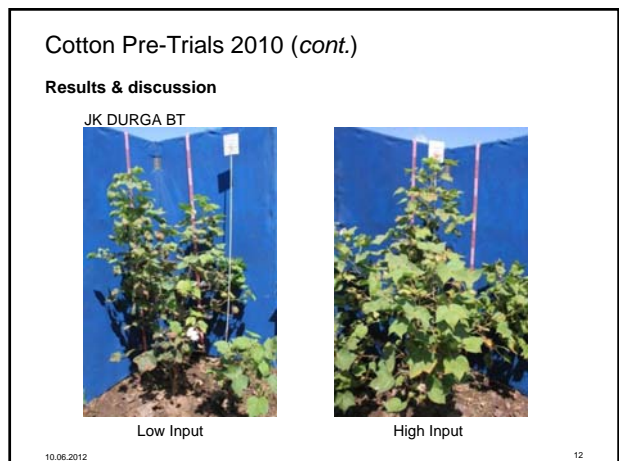
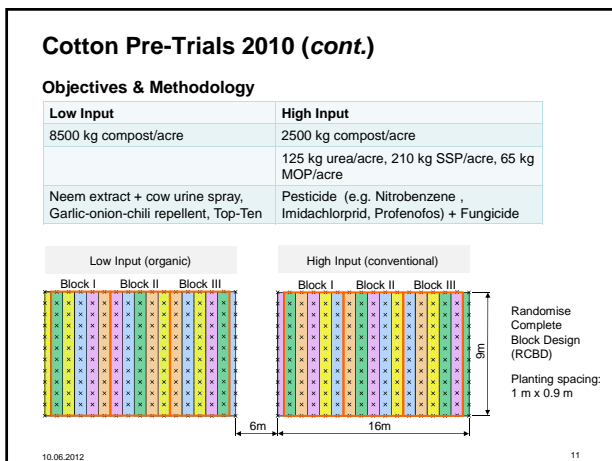
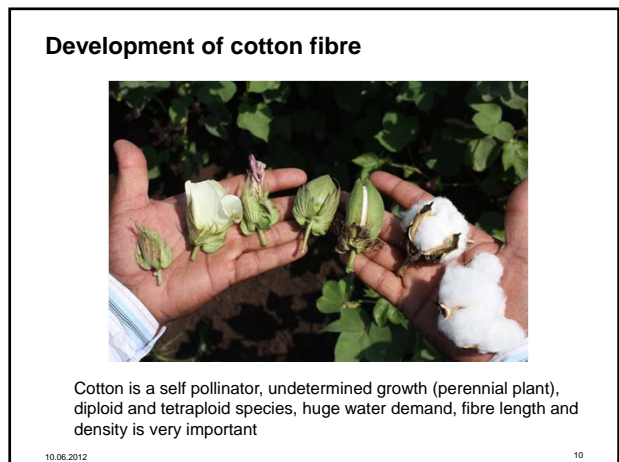
Objectives & Methodology

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

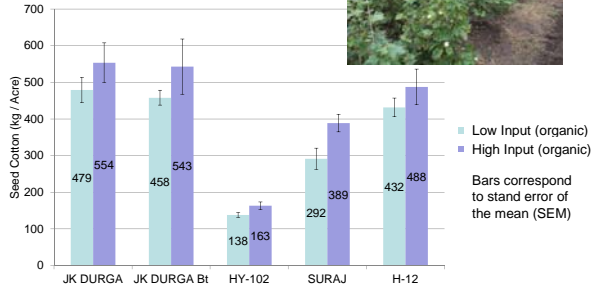
Block	Hybrid/Variety
A	JK DURGA
B	H12
C	SURAJ
D	HY 102
E	JK DURGA (Bt)

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Cotton Pre-Trials 2010 (cont.)

Results & discussion



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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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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 of 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, end producers
 - Ministry of agriculture
 - NGOs involved in organic cotton, seed exchange, GMO free regions



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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

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Dharwad Declaration 21th June 2011

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

- **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



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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



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Follow up of Dharwad declaration



Deliverables in chronological order (compile from outcomes)

1. Demand of organic and non-GM cotton producers assessed for season 2011/12 and for 2012/13 (July 2011)
2. Negotiation with breeders and seed producers completed (July 2011)
3. Promising cotton cultivars for organic production identified in close agreement with breeders (July 2011)
4. Supply of breeders seed for multiplication and on station and on-farm trials completed (July 2011)
5. Training workshop on non-GM cotton successfully attended by xxxx farmers in yyy locations
6. Suitable areas for non-GM seed production identified and reserved/recommended for GM-free areas (in close collaboration with policy, breeder and quality group)
7. Demand of organic and non-GM cotton producers assessed for season 2012/13 and for 2013/14 (Dec. 2011)
8. Negotiation with breeders and seed producers completed (Jan. 2012)
9. On farm and on station field data of cultivar trials assessed (yield, pest, quality, ...) and analysed (March 2012)
10. Promising cotton cultivars for organic production identified in close agreement with breeders (April 2012)
11. Supply of breeders seed for multiplication and on station and on-farm trials completed (April 2012)
12. Supply of (certified) non-GM free cotton seed to farmer's organisations (May 2013)
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Participatory Cotton Trials on station 2011/12

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. 2. *G. arboreum* x *barbadense* hybrid

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

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Cotton Trials 2011 (cont.)

Objectives & Methodology

Cultivar	Species	Cultivar Type	Mother Trial	Baby Trial	Demo Plots
JK Durga	<i>G. hirsutum</i> (4x)	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>	Varietal line	X		
ZCH-8	<i>G. hirsutum</i>	Varietal line	X		
A-504-48-91	<i>G. arboreum</i> (2x)	Varietal line	X		
B-320-5	<i>G. arboreum</i>	Varietal line	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		

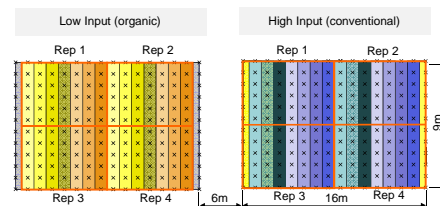
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Cotton Trials 2011 (cont.)

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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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

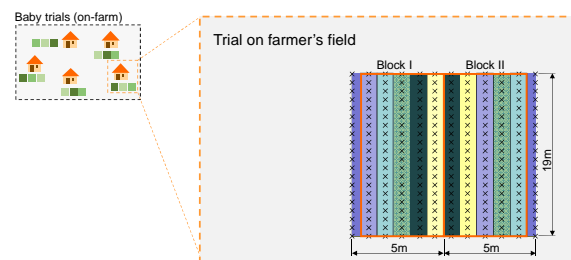
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Cotton Trials 2011 (cont.)

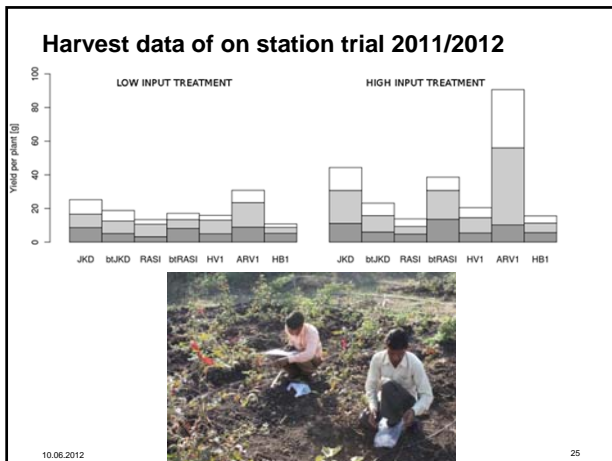
Objectives & Methodology

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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Cotton Trials 2011 (cont.)

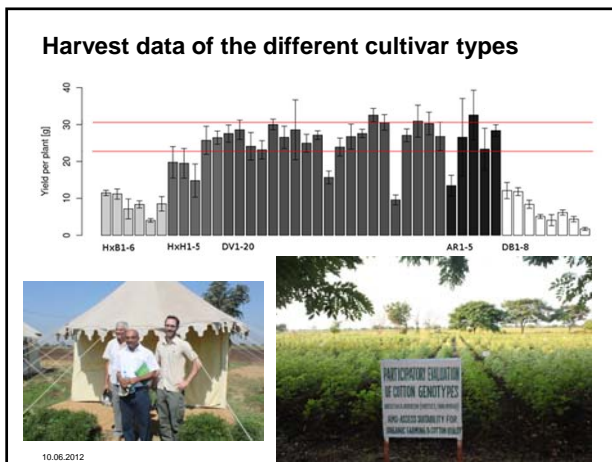
Additional 36 cotton cultivars (5 hirsutum hybrids, 5 interspecific hybrids, 7 arboreum lines, 20 hirsutum lines, 8 barbadesse lines and 5 compactum hirsutum lines and five F2 populations) provided by Prof. Patil from the University of Dharwad are examined on bioRe farm with two replications

Plot D

DEMO 1	DEMO 2	DEMO 3	DEMO 4	DEMO 5	JK DURGA
CONTRACT VARIETAL TRIAL 1.5	CONTRACT VARIETAL TRIAL 1.5	HIB HYBRIDE TRIAL 1.5	HIB HYBRIDE TRIAL 1.5		
ARBOREUM VARIETAL TRIAL 1.5	ARBOREUM VARIETAL TRIAL 1.5	HIB HYBRIDE TRIAL 1.5	HIB HYBRIDE TRIAL 1.5		
ARBOREUM 100-40-01	ARBOREUM 100-40-01	F2:BXB 6 LINES	F2:KOH 5 LINES	F2:BXB 6 LINES	F2:KOH 5 LINES
HIRSATUM VARIETAL LINE R2-105-120	BARBADENSE R2-105-120	HIRSATUM VARIETAL LINE R2-105-120	BARBADENSE R2-105-120		
HIRSATUM VARIETAL LINE R2-105-120	BARBADENSE R2-105-120	HIRSATUM VARIETAL LINE R2-105-120	BARBADENSE R2-105-120		
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BioRe Farm

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- ### Participatory Cotton Trials on farm 2011/12
- 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 cultivars on station
 - Farmer's single plant selection in segregating populations on station
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- ### 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
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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 there suitability

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Group meetings & instructions



Farmer's selection on station



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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

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Participatory cotton trials on farm 2011/12

- **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 preception with yield and quality data
 - Comparison between farmers
 - Acknowledgement of farmers, certificate for participating and small gift

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Reasons for the selection of the 3 best cultivars

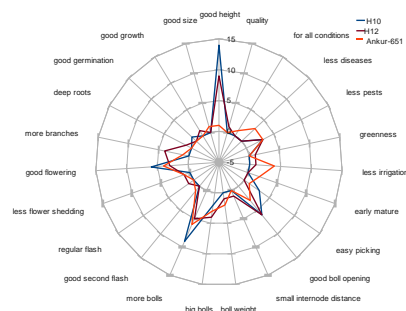


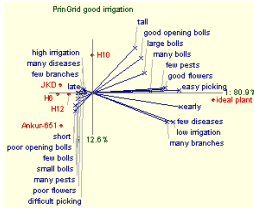
Figure 22: Farmers' reasons for preferring cultivar H-10, H-12 and Ankur-651

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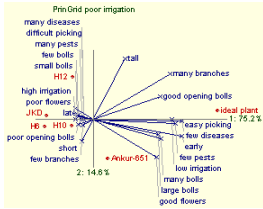
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On farm selection by farmers

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

