

## Participatory Cotton breeding and cultivar Evaluation for organic smallholders in India

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### Abstract

Stakeholders of the organic cotton sector in India are highly concerned about the overdominance of Bt cotton and the disappearance of non-GM cotton seeds on the market. Organic cotton production can only survive if farmers have access to high quality seeds of suitable cultivars free of GM contamination. With the help of public plant breeders, local cotton grower organisations started on station and on farm trials for the evaluation of cotton cultivars. Moreover, the got engaged in decentralized participatory cotton breeding to develop locally adapted cultivars including traditional Desi cotton species. The close collaboration of breeders, farmers, extension agents, as well as stakeholders of the ginning and spinning industry allows for the identification of cultivars that suit the specific growing conditions of smallholder farmers. Training of farmers in cultivar evaluation and seed propagation restores their seed sovereignty. Participatory breeding is an important tool to get prepared for future challenges.

### Introduction

Up to 80% of world's organic cotton has been produced in India. Now organic cotton production in India is under severe threat (Klaiss et al 2012). Genetically modified F<sub>1</sub> hybrids of the tetraploid upland cotton (*Gossypium hirsutum*) carrying a gene from *Bacillus thuringiensis* (Bt cotton) account for more than 90% of the cotton area in India (Qaim 2013). The non-GM cotton seed market has become completely eroded (Nemes, 2010, Marty 2013) and locally adapted diploid Desi cotton (*G. arboreum*, *G. herbaceum*) getting lost. Fast action is needed to re-establish GM-free seed supply chains and breeding programs to support organic and low input cotton farmers in India. Participatory plant breeding (PPB) offers a great opportunity for developing locally adapted cultivars as well as for maintaining and increasing genetic diversity (Lancon et al. 2004, Ceccarelli et al. 2009). The main aim of the study is to (i) foster collaboration among stakeholders, (ii) introduce participatory breeding approaches for organic cotton (iii) evaluate improved cotton cultivars in smallholders' organic cotton fields and (iv) gain information about the suitability of different types of cotton species and cultivars for organic and low input farming in India.

### Material and methods

The project was initiated in 2011 and is driven by two local organic cotton producer organisations bioRe Association in Madhya Pradesh and Chetna Organic in Orissa and the cotton breeding department of the University of Agricultural Science (UAS) Dharwad, Karnataka and is scientifically supported by the Research Institute of Organic Agriculture (FiBL) Switzerland with expertise in transdisciplinary research. In order to improve the access of organic cotton farmers to high quality non-GM cotton seeds a national workshop on 'Disappearing non-GM cotton – ways forward to maintain diversity, increase availability, and ensure quality of non-GM cotton seed' was organized in Dharwad in June 2011. The goal was to involve the joint expertise and knowledge of breeders, organic farmers, advisors, and representatives of the textile industry along the whole market chain. The resulting Dharwad declaration towards safeguarding the heritage of Indian Desi cotton, maintaining genetic diversity, avoiding GM contamination and supporting the organic farmers with suitable cultivars was important to create public awareness and initiate first projects.

The Cotton Cultivar Evaluation Project has started in 2011 with systematic evaluation of available non GM cultivars and is focusing on the fast identification of suitable cultivars and the reestablishment of a cotton seed supply chain under control of the farmers to safeguard the organic cotton production. Existing non-GM cotton cultivars and breeding lines were evaluated combining on-station and on-farm participatory trials to

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safeguard the threatened organic seed supply. Each year around 50 cultivars including standard hybrids are tested under organic conditions in on station trails with two replications on heavy and light soil and in two geographic regions reflecting the different growing conditions of small holder farmers. In addition, on farm cultivar evaluation trials are conducted by farmer in their own fields after training by the research team. Vegetative growth, plant morphology, health of plant as well as seed cotton yield per plant and acre were assessed for the different pickings. Ginning output and fiber quality parameters (fibre length as Upper half mean Length UhmL (mm), fibre finesse (micronaire), fibre strength (g/tex), Maturity Index (MI), Uniformity Index (UI) and Short Fibre Index (SFI)) were assessed for the first two picking and the last picking. Farmers were highly interested in the project and participated not only in the on farm trials but also in several workshops on identification of ideal genotypes, practical cotton evaluation, training in cross breeding, seed multiplication and single plant selection. Farmers shared their vast experience and knowledge about cotton cultivation.

The Green Cotton Project is a long term project aiming for developing new cotton cultivars, which are specifically suited for organic farming. Here the focus is on networking, capacity building, training farmers in cross breeding and single plant selection. Collaboration among the local cotton growers organisations will foster synergistic effects. The aim is the establishment of decentralized participatory cotton breeding programs that will allow for local adaptation and improve the resilience of organic cotton to counteract the challenges of climate change. Besides the dominating *G. hirsutum* cotton a special focus is put on the traditional Indian Desi cotton (*G. arboreum*) as they have better drought resistance. Specific crosses suitable for low input farming are made by the UAS Dharwad. The progenies were provided to the organic cotton organisations for single plant selection starting from F3 generation (now F5). Phenotypic selection by farmers was compared with selection by researchers and experienced cotton breeders. Final selection in each generation was based on growth habitus, yield potential and fibre quality requirements given by the textile industry. In parallel the farmers are continuously trained in all aspects of plant breeding, seed multiplication and GM testing to obtain a "farmer's breeder curriculum". Female farmers are especially encouraged to participate together with their husbands or in separate groups.

## Results

In the season 2011-2012 in total 49 cultivars of different species and cultivar types received from UAS Dharwad were examined for their suitability under organic and low input farming. *G. arboreum* varietal lines showed good vegetative growth and yield per plant, however on average rather low fiber quality, especially short fibre length. *G. hirsutum* varietal lines showed in general good yield per plant, and seven of these cultivars reached the required fibre quality requirements (Roner 2012).

In the season 2012-2013 we evaluated 50 cotton cultivars, out of which 3 were *G. hirsutum* hybrids, 6 were *G. arboreum* varieties and 41 were *G. hirsutum* varieties. This selection included standard cultivars as well as 8 cultivars that were selected in the previous trial (2011-12). The 50 cotton cultivars were screened at two locations, i.e. at heavy soil with irrigation and light soil with limited irrigation. However, due to severe water logging in the heavy soil trial only few plants survived. Based on the performance on light soil we identified several cultivars with satisfying agronomic performance and fibre quality. The most promising were three *G. arboreum* varieties and five *G. hirsutum* variety which are multiplied by bioRe for pilot cultivation. A total of 21 cultivars were selected to be evaluated again in the present season 2013-14. In addition to these trials, eight on farm trials were performed as well as several farmers' workshops. *G. hirsutum* varieties performed similar to F<sub>1</sub> hybrids. *G. arboreum* varieties performance well under stress conditions like drought, while fibre length was often too short and micronair too high for fine yarn spinning. While yield is highly dependent on location and management, the fiber quality parameters are highly heritable. In general, it was very difficult to meet the fiber quality required by the textile industry. However, the three selected *G. arboreum* varieties can be used for fine yarns and are foreseen for variety release in the state Madhya Pradesh. This season (2013-14) we have included a total of 78 cultivars in the cultivar evaluation trial that had been tested for fiber quality before sowing. In addition 30 new *G. arboreum* lines were screened under heavy soil with drip irrigation and light soil with limited flood irrigation conditions as a stress environment under organic growing conditions. In addition, we have established 24 on farm trials testing the most promising cultivars from last year's trial on farmer's fields. Detailed analysis of the last two seasons (2012-2014) across the different regions and its implementation for the future breeding work will be presented during the meeting.

## Discussion

The close collaboration of breeders, farmers, extension agents, as well as stakeholders of the ginning and spinning industry allows the identification of cultivars that suit the circumstances of resource-poor farmers in

marginal environments. The performance of the cultivars depends strongly on the climatic conditions and the soil type and access to irrigation within region. In addition farmers have different preferences for plant architecture and cotton species. *G. arboreum* genotypes have better drought resistance and can better compensate unfavourable weather conditions due to the longer picking period, but have on average smaller cotton bolls that are more labour intensive for picking compared to the *G. hirsutum* cotton. Under favourable growing conditions the additional effort of hybrid seed production is justified, whereas under less favourable conditions varietal lines show similar performance as hybrids. Therefore a set of 20 to 30 cultivars are needed for each cotton grower organisation so that the farmers have a choice to choose the 3-5 cultivars that fit best to his farming practise. On farm trials offers a great opportunity to keep farmers engaged. Motivated and trained farmers can take up seed production of the cultivar they like best and start small local seed business for the cotton grower organisations. However, special measures need to be taken to avoid GM contamination during seed production. This way seed sovereignty of organic cotton farmers can be restored.

Including farmers in the breeding process not only ensures that cultivars are adopted by farmers, but studies also show that promising lines were selected earlier and were better adapted to local conditions (Ceccarelli et al. 2009). Farmers' selection was efficient and partly different from breeder's selection having different visions of the optimal plant type in mind. Thus, the participatory selection increases the diversity of genotypes. Since breeding is a long term activity the future developments need to be envisioned. On one hand farmers need to prepare themselves on more extreme weather conditions (drought stress, flooding events) but also on changing technologies (hand picking versus mechanical harvest) or new demands from the textile industry (requirements for fiber quality). Regular workshops are needed to discuss the different aspects and scenarios among the stakeholders and to adjust the breeding goals accordingly.

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