Picking Cotton

The choice between organic and genetically-engineered cotton for farmers in South India

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Campaigning for sustainable agriculture

"Bt cotton appears to be a pro-poor success because encouraging results have been emphasised, while negative and equivocal ones have been played down."

Dominic Glover, 2009 (STEPS Centre, University Sussex)

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Summary

Poverty and hunger continue to be widespread in India. The majority of these hungry and poor people live in rural areas, with a livelihood dedicated to agriculture. Some 86% of Indian farmers are smallholders, of less than 5 acres (2 hectares). About 65% have rain-fed farms without irrigation facilities.

There is widespread propaganda that genetically-engineered (GE) crops provide the silver bullet for poverty and hunger eradication. On the other hand, recent global analyses have concluded that ecological farming - using low-cost, locally available and agro-ecological technologies – is effectively reaching the same aim.

We compared the economic livelihoods of rain-fed smallholding cotton farmers in South India growing Bt cotton ('Bt cotton': cotton varieties genetically engineered to produced an insecticidal toxin) with those growing non-Bt organic cotton. This study, therefore, is a comparative analysis of two contrasting methods of agriculture: Bt cotton cropping that comes together with chemically intensive agriculture vs. ecological farming in the example of organic cotton farmers.

Our goal is to document the realities of farming taking place right now in the Indian cotton regions, and thus the focus of our analysis is the economic livelihood of the cotton farmers themselves. Our study is not a technical analysis of the performance of the genetically-engineered Bt trait isolated from its surrounding circumstances, but an analysis of what results when farmers grow Bt cotton under the conditions faced by the majority of farmers in India (and other developing countries) - i.e. smallholding farms, rain-fed and poor.

Millions of Indian farmers are dependent on the money brought in by their annual cotton crop. The cotton crop represents by far the largest income for these households, and in nearly all cases is crucial for the farmer's family's survival. In India, cotton represents one of the most economically important commodities in the country and it is central to the livelihood of the many millions of farmers who grow cotton every year. Cotton is one of the major traded commodities worldwide, with a global export value of about $12 billion US dollars, similar to the global export value of a staple grain as important as rice (FAOSTATS 2010). When the cotton fields fail to produce a good crop, as in the dry year of 2009, millions of Indian farmers and their families are left in deep economic distress. This case study shows the economic stability and benefit for Indian farmers of farming cotton organically and without genetic engineering and toxic chemicals.

Greenpeace's research in South India showed that Bt Cotton - a genetically-engineered variety - does not perform as well as traditional and organic cotton.

Our results from detailed interviews with cotton farmers in the South Indian state of Andhra Pradesh show that:

1) The **cost cultivation is almost twice as expensive for Bt cotton farmers than for organic cotton farmers**, both in 2008/09 and 2009/10. The higher expense includes higher costs of seeds, pesticides, fertilisers and interests for loans. Higher loan costs are a direct consequence of higher cost of inputs for cultivation for Bt cotton farmers.

2) **Bt cotton farmers continue to use a large amount and variety of chemical pesticides**, especially insecticides. We recorded in total 26 different chemical pesticides used by Bt farmers. Bt cotton farmers commonly apply pesticides classified by the World Health Organisation as Extremely or Highly Hazardous. **Bt cotton farmers suffer more pest damage than organic farmers**, due to heavy attacks from secondary pests and developing Bt resistance by bollworm. Organic cotton farmers rely exclusively on bio-pesticides and natural pest control, spending very little money on pest control and instead being capable of controlling pests effectively.

3) **Net income from cotton is 200% higher for organic farmers than for Bt cotton farmers in the drought-affected year 2009/10**, while it is not significantly different between Bt and organic cotton farmers in the favourable rainfall year, 2008/09. This difference is mostly due to the much higher cost of cultivation for Bt cotton farmers. Premiums received by organic farmers are relatively small compared to the difference in costs, and thus premiums play a minor role in this difference.

4) **Cotton yields do not differ significantly between Bt and organic cotton farmers**, although in the favourable rainfall year, 2008/09, Bt cotton reached slightly higher yields than organic cotton (a not statistically significant difference). The small yield increase in Bt and chemically-intensive cotton farms does not translate into income benefit for the Bt farmer, due to high cultivation costs. Since non-Bt cotton seed development is neglected, all non-Bt cotton seeds provided to organic farmers during these two years came from old stocks, with unwarranted quality. In the dry year 2009/10, Bt cotton yields fell down drastically, by 50%, while the decrease in non-Bt organic cotton yields was about 30%, despite the presumed lower quality seeds.

5) Organic cotton farmers maintain more than twice the number of crops besides cotton in their farm than Bt cotton farmers. The **net income from the farm as a whole is 90% higher for organic farmers in the dry year 2009/10, and is similar between Bt and organic cotton farmers in the favourable 2008/09 period**.

6) As cost of cultivation is so much higher for Bt cotton farmers, and smallholders in general lack financial security, **Bt cotton farmers incur 65% higher debt –accumulated during 2008/09 and 2009/10–** than non-Bt organic cotton farmers.

7) In the dry year 2009/10 the lower net income for Bt cotton farmers, plus the accumulated debt from higher costs of cultivation, makes Bt cotton farmers very vulnerable to financial insecurity and failure. **In the dry year, the economic livelihood (net return after repaying debts) for Bt cotton farmers is negative; on average, they end up owing Rs. 7,136 (rupees) per acre (€120 per acre).**

8) **Organic farmers, with lower cost of cultivation and thus less debt, end up with a surplus net return of Rs. 5,040 per acre (€85 per acre)**, even after a very bad dry year. This results in higher financial security and a 171% higher value of economic livelihood for non-Bt organic farmers than for Bt farmers.

Our results clearly show that non-Bt organic farmers, by engaging in ecological and economically efficient farming, diversifying their cropping system and relying more on their community, achieve a better, more secure economic livelihood than Bt cotton farmers. Bt cotton farmers, with very high cost of cultivation, high-chemical low-diversity farming and high debt are vulnerable and under high risk of household financial collapse.

Overall, our results indicate that Bt cotton poses a serious financial risk to poor, rain-fed smallholding farmers in India. On the other hand, organic cotton is a clear pro-poor option for improving economic livelihood in rural communities.

Introduction

Poverty and hunger continue to be widespread in India. The country accounts for nearly 50% of the world's hungry (UN WFP, 2010) and about one third of the world's poor (World Bank, 2008). Around 35% of India's population - 380 million - are considered food-insecure (UN WFP, 2010), and 77% of Indians - or 836 million - live on less than Rs. 20 (€0.30) a day (NCEUS, 2007). Strikingly, the majority of these hungry and poor people live in rural areas with a livelihood dedicated to crop production. Although some progress has been made, the World Bank considers that the rate of poverty reduction in India has slowed down during the last 15 years.

India is the second largest producer of cotton in the world after China. It holds 29% of the world's cotton area and accounts for 20% of world production. India is also the second largest exporter of cotton worldwide after the US, as well as the second largest cotton consumer (NCC, 2010). At the same time, India is the largest organic cotton producer in the world since 2008, contributing half of the world's organic cotton supply (Subramani, 2008). Global organic cotton demand is growing rapidly: it grew from $300 million US dollars in 2002 to over $3 billion in 2009 (OE, 2010), and it is expected to exceed $19.8 billion by 2015 (GIA, 2010). At the same time, India also has the largest area of genetically-engineered cotton in the world.

Cotton is the only genetically-engineered crop grown widely in India, after being introduced during the last decade. Genetically-engineered cotton is also grown widely in China, South Africa and the US. These genetically-engineered cotton varieties are known as 'Bt cotton'. Bt cotton plants contain a gene from the soil bacterium *Bacillus thuringiensis*, which produces a toxin designed to kill a group of insect pests, mostly larvae of moths, which are generally called 'bollworm'.

Bt cotton, and in general any genetically-engineered crop, continues to be hailed as the silver bullet for fighting poverty and hunger in the world (Glover, 2009), in spite of the acknowledged low established consensus, scientific research or serious evaluation about the impact of this technology so far (Glover, 2009, Raney, 2006). In particular, the increase in acreage in Bt cotton in India is portrayed often as the 'scientific fact' backing the 'success' of genetically-engineered crops in developing countries . This assumption wipes out the possibility of any informed scientific analysis. It also automatically neglects calls for "an urgent need for further rigorous scientific evaluation of Bt cotton in India before deciding its further promotion" (Arunachalam, 2004).

The only safe conclusion from the studies carried out so far on Bt cotton in India (and elsewhere) is that the performance and impact of Bt technology are very variable and depend critically upon a wide range of social, institutional, economic and agronomic factors (Glover, 2009, Gruère et al., 2008, Raney, 2006, Smale et al., 2006). Research results about the impacts of Bt cotton coming from econometric field-based studies in India draw a very polarised picture so far: one set of studies claims to demonstrate its complete economical and technical success and another set highlights the failures and farmers' hardships that have accompanied its introduction. Recently, an in-depth evaluation of the studies claiming Bt cotton success, by the STEPS centre at the University of Sussex in the UK, has shown how "methodological and presentational flaws in those studies have created a distorted picture of both the performance and the impacts of GM crops in smallholder farming contexts. This has seriously distorted public debate and impeded the development of sound, evidence-based policy." (Glover, 2009).

Against this background of uncertain evidence and methodology, we wanted to contribute to the discussion on Bt cotton in India with a case study that looks in-depth at the economic realities of poor, rain-fed and smallholding cotton farmers in the state of Andhra Pradesh, taking great care in selecting farmers who represent the majority of Indian cotton farmers.

In light of recent global analyses simultaneously concluding on the effectiveness of ecological farming (i.e. farming based on agro-ecology and organic agriculture, using low-cost, locally available and appropriate technologies) in alleviating poverty and hunger (IAASTD, 2009, Nellemann et al., 2009, UNEP and UNCTAD, 2008), we aim at comparing the economic livelihood of cotton farmers growing Bt cotton with those growing non-Bt organic cotton.

We considered that Andhra Pradesh, the state where 20% of the Indian cotton is produced, with one of the highest cotton yields in India and where non-chemical agriculture is promoted at a large scale, would be a very representative location for this study.

Methodology

We compared farming practices and economic livelihoods of Bt and non-Bt organic cotton farmers in the state of Andhra Pradesh. Currently, the only non-Bt farmers who can be found in the state are organic farmers; all conventional farmers appear to grow Bt cotton. Andhra Pradesh is the third largest producer (both in tonnage and cropping area) of cotton in India, with 20% of the Indian cotton production in 2008/09 (first and second largest producing states are Gujarat and Maharashtra) (CCI, 2010). Andhra Pradesh is the state with the highest yield among the large producers in South India (CCI, 2010).

Andhra Pradesh is also a state where Bt cotton adoption grew very rapidly after its introduction in 2002. Bt cotton adoption went from less than 1% to about 95% of acreage in just seven years (Kuruganti, 2009, Nemes, 2010). Along with the adoption of Bt cotton in the form of Bt hybrids, planting of cotton open-pollinated varieties almost disappeared. It is currently estimated that only 1%, if any, of the cotton grown in Andhra Pradesh is from open-pollinated varietal seeds. We were unable to find farmers growing open-pollinated varieties even in remote tribal areas. Hybrid seeds have taken up the whole cotton seed market in Andhra Pradesh, and mostly in India too.

An organic cotton farmer picks cotton in her field in Kishtapur, Andhra Pradesh, India. Her cotton is certified organic and sold directly to a fashion brand in Europe.

On the other hand, Andhra Pradesh State Government has been supporting NGO initiatives for promoting farming without pesticides (known as Non Pesticide Management – NPM - first spearheaded by the Centre of Sustainable Agriculture – CSA – in Hyderabad (Ramanjaneyulu et al., 2008)). In order to compare farmers' economic livelihoods when growing Bt cotton with those growing organic cotton, we consider that all these characteristics above make Andhra Pradesh the most representative location for our study.

We chose three districts within Andhra Pradesh: Warangal, Karimnagar and Adilabad, the three districts with the largest area of cultivated cotton in 2009/10. In these districts, Bt cotton farmers dominate but there are also about 6,000 organic farmers growing non-Bt organic cotton during 2009/10 (Nemes 2010).

Sampling design

In our comparison between Bt cotton and organic cotton farmers, we wanted to make sure that all parameters, apart from the Bt event in genetically-engineered seeds and agronomic practices, were kept as identical as possible between Bt and organic farmers. For this reason, we sampled farmers in pairs within a given location, to ensure as far as possible that they differed only in the Bt event and agronomic practice.

First, we made sure that Bt and organic farmers shared a number of biophysical characteristics:

1. The sampled farmers are smallholding farmers (average land holding is 5.5 acres (2.2 hectares). Land holdings in this dry-prone region are slightly larger than the Indian average. The average size of the cotton farm for the studied farmers is 2.7 acres (1.1 hectares). The average size of land holdings and cotton farms did not differ between our selected Bt and organic farmers. About 86% of farmers in India have land holding of 5 acres or less (NSSO, 2006).

2. The studied region is dry-prone and all our selected farmers grew cotton without any irrigation at all during 2009/10 (a dry year) and only a small percentage of them with some irrigation during 2008/09 (a normal monsoon year). These resource-poor farmers usually save irrigation, when available, for rice cultivation. Hence, in this study all cotton is grown under rain-fed conditions for both 2009/10 and 2008/09. In India, about 65% of the cotton farms are rain-fed (Sharma et al., 2010). This is the situation when water availability is not deficient, i.e. when irrigation canals and wells carry water. However, in a year with a failing monsoon, as was the case in 2009/10, and with a severe drought, very few farmers could supply any irrigation to their crops in Andhra Pradesh, since irrigation canals were empty, and tanks and wells dry.

3. Climate, weather, soil and other agro-climatic characteristics were minimised by selecting each pair of Bt and organic farmers within close proximity (< 5 km away).

Secondly, within each location, we looked for Bt and non-Bt organic farmers growing the same type of hybrid, but differing only on the Bt trait (i.e. isolines). We selected locations based on where we could find these isoline pairs. At a given location we collected data from a Bt cotton farmer and an organic cotton farmer growing the same hybrid, for example Bt Mallika vs. non-Bt untreated Mallika. On a few occasions this was not possible, since organic farmers have very limited choice of available non-Bt seeds.

We collected data from a total of 27 farmers: 15 Bt cotton farmers and 12 organic cotton farmers (3 Bt cotton farmers did not have an organic pair in a location where non-Bt was completely absent). All of the organic farmers use organic farming practices for all crops they grow, and their cotton is certified organic by the official certification body. All Bt cotton farmers we encountered engage in chemically-intensive agriculture, with high use of pesticide and chemical fertilisers. Our data for each farmer is detailed and exhaustive. Our sample size is small, but by ensuring a detailed random pair-wise design across a large region with very specific selection criteria, we are confident that we have reflected the reality of cotton farmers in the state, and possibly for poor rain-fed smallholder cotton farmers throughout India.

Data collection and analysis

We collected data about all aspects of the economics of cotton farming in rain-fed smallholding farms, in detailed interviews lasting between 2 and 4 hours each. Each farmer was interviewed in his or her cotton farm at the end of the harvest (November/December 2009), with the help of a Telugu interpreter. We recorded each interview for subsequent data quality assurance. We collected information about every aspect of the farm and cultivation process, from farm size and number of crops to every financial aspect of cropping (costs of cultivation, yields, loans and debts, market expenses, etc). A complete list of variables and their definitions is given in Appendix 1. Data was analysed for differences between Bt and organic farmers in a specific statistical tests (t-Test).

In addition to farmers' interviews, we also collected information about seed availability and potential yields under experimental conditions from various seed companies and breeders, research institutions, NGOs and farmers' associations.

Local government institutions, farmer groups, NGOs and individual farmers were fundamental on facilitating this data collection, while they did not have any influence in farmers' selection criteria. Without their support and expertise, we would not have been able to carry out this research. In particular, the farmers' groups and NGOs working with organic farmers do impressive work in supporting them and disseminating a different way of farming (see Table 1).

Table 1. Districts and villages in Andhra Pradesh where we carried out the research, with the help of local farmers' associations and institutions working in the field. Their collaboration was essential to ensure structured data collection that warranted accuracy and especially the honest recording of farmers' statements, both for Bt and organic cotton farmers.

District	Villages	In collaboration with*	Special thanks to
Warangal	Rajula, Chinna-Nagaram, Brahmana-Kothapalli, Vanapathi, Singarapalli and Gopanpalli	PSS, CROPS, MARI	Mr. Kaviraj (PSS), Mr. Vishnu, Mr. R. Lingaiah (CROPS) and Mr. J. Sekhar (MARI)
Karimnagar	Kishpatur, Bijigiri, Nagampet	KVK Jammi Kunta and Chetna	Ms. Karuna Sree (KVK) and Mr. Baji Babu (Chetna)
Adilabad	Kamaipet, Balampur, Devuguda, Gondukosarm	Chetna and Zameen	Mr. B.G. Mahesh, Mr. Jaram, Mr. Gangahar (Chetna) and Mr. Srinivas (Zameen)

**PSS: Pragathi Seva Samithi, CROPS: Centre for Rural Operation Programmes Society, MARI: Modern Architects for Rural India, KVK: Prakasam Krishi Vigyan Kendra in Jammi Kunta, Chetna Organic Farmers Association and Zameen Organic.*

Results and Discussion

1. Cost of cotton cultivation

In both 2008/09 and 2009/10 the total cost of cotton cultivation was about twice as expensive for Bt cotton farmers than for organic farmers (average of Rs. 8,100 per acre for Bt cotton farmers vs. Rs. 4,300 per acre for organic cotton farmers (€137 per acre vs. €73 per acre), see Figure 1)[4]. This reflects major differences in cost of seeds, pesticides, fertilisers and interest of loans, which are all much higher for Bt cotton farmers, both in 2008 and 2009 (see below, and Figure 1).

1.1. Seed cost

Seed cost was significantly higher, in both years, for Bt than for organic cotton farmers (Figure 1). The seed cost reflects the rate paid per bag of seed of 450g (plus 125 g refugia in Bt seeds) and also the amount of seeds that each farmer bought per acre. In some cases, farmers bought more than the recommended rate of seeds per acre, hoping that denser sowing would perform better and for occasions when seed germination fails or seeds are washed away by rain. On average, cotton farmers (both Bt and organic) bought about 1.4 ± 0.1 packages of cotton seeds per acre. Hence, our data reflects more than simply the price tag at the seed shop.

The price of Bt cotton seeds at the village shop depends on the hybrid and on the Bt technology: Bt Bollgard I or Bt Bollgard II (with two Bt proteins, introduced in 2009 in the state). In 2008, the official price per packet was Rs. 750, and in 2009, Rs. 750 for Bt Bollgard I, and Rs. 850 for Bt Bollgard II. However, in village shops prices vary slightly around these official values. The price of Bt cotton seeds was much higher until a few years ago, when the State Government intervened to control the maximum retail price per seed package to the current levels. The price of non-Bt seeds, both in 2008 and 2009, was Rs. 460 per package.

Bt cotton farmers buy their seeds at the local seed and agrochemical shop. All village shops we talked to and all interviewed farmers confirmed that, currently, shops in Andhra Pradesh carry Bt cotton seeds exclusively, since seed companies have stopped the development of non-Bt seeds (Nemes, 2010, Tehelka, 2010).

"With regard to cotton seeds, the Government has subjugated its responsibility to the industry. Now we are in the hands of the seed industry."

Senior officer in Society for Elimination of Rural Poverty (SERP), Hyderabad, Andhra Pradesh, October 2009.

Organic farmers can only buy their seeds through special orders placed by farmers' groups and NGOs a year in advance and directly with some companies. In 2009, seed companies in Andhra Pradesh announced that they will stop the development of non-Bt seeds for the next season. This situation obviously limits the seed choice and seed security of farmers (Nemes 2010), but also has serious implications for the economic livelihood of organic farmers - and ultimately for the future of organic farming in India (see section on Yields).

The most popular hybrid among the studied farmers was Mallika, grown by 66% of farmers, both Bt and organic. Farmers also grew Bunny hybrids, and one Bt cotton farmer grew RCH. In 2009, 40% of Bt cotton farmers planted Bollgard II hybrids (Mallika and Bunny).

4 1 acre (a) = 0.405 hectare (ha), 1 quintal (q) = 100 kg, 1 quintal / acre = 250 kg/ha, Rs. 1,000 (Indian Rupees) = €16.5, Rs. 1,000 per acre = €40 EUR per hectare.

The fruit of the Neem tree is used to control pests in organic cotton production.

1.2. Labour and machinery cost

The amount of money that farmers spent on labour and machinery was slightly higher for organic than for Bt cotton farmers, although the difference was not statistically significant (Figure 1). The higher cost of labour on organic farms might relate to the higher labour involved in non-chemical fertilisation and pest protection.

Organic farmers engage in a wide diversity of practices for ecological fertilisation of their soils. These include legume cover crops, intercropping, application of biofertilisers, compost, manure, etc. Similarly, for ecological pest protection, organic farmers apply a diversity of practices that involve more labour but greatly benefit the natural pest protection of their farm (see below). All these practices involve more labour and thus also have the positive effect of more employment of local farm labourers.

1.3. Pesticide cost

Contrary to expectations, Bt cotton farmers continued to use a large amount and variety of chemical pesticides, especially insecticides. We recorded in total 26 different chemical pesticides used by Bt farmers. Each Bt cotton farmer applied about 3 different types of pesticides to their cotton crops, in various applications (see Table 2). Not surprisingly, the money spent by Bt cotton farmers on pesticides was considerably high (around Rs. 1,000 per acre in both 2008/09 and 2009/10), and very significantly higher than the money spent by organic farmers (around Rs. 50 per acre in both years) (Figure 1).

The most common pesticides used by Bt cotton farmers were *Confidor* (Bayer – imidacloprid), used by 60% of Bt farmers, and *Monocrotophos*, used by 53% of Bt farmers. *Monocrotophos* is an organophosphorus insecticide classified as Highly Hazardous by the World Health Organisation (WHO class Ib). Other dangerous pesticides commonly used by Bt cotton farmers were *Methyl parathion* (Extremely Hazardous, WHO class Ia) and *Triazophos* (Highly Hazardous, WHO class Ib). These chemicals are prescribed for control of sucking pests (aphids, mealy bugs, etc). Several Bt cotton farmers stated that they spray chemical pesticides as 'prevention', even at times when they did not have pest attacks in their crops.

We learned from the farmers that "*If you plant Bt cotton, you need to apply all these pesticides for the Bt to work*" was a recommendation by seed vendors that was often heard.

Dr. Kranthi, Director of the Central Institute of Cotton Research (CICR) in Nagpur, recently reported that Bt cotton had increased the use of some dangerous pesticides (Mudur, 2010). This seems to be due to the emergence of new devastating pests, like mealybug, never before seen by Indian farmers. For years, many experts have been warning that sucking pests are becoming a more serious problem on Bt cotton because of a decline in the bollworm population and changes in crop ecology (Wang et al., 2008, Wu et al., 2002, Lu et al., 2010).

Our data shows that Bt cotton farmers did indeed suffer more pest damage than organic farmers (see Table 2). The most commonly used pesticides by Bt farmers are those for managing secondary pests (i.e. sucking pests).

A very high percentage of Bt cotton farmers reported that they have bollworm infestations and damage in their cotton crop, both in 2008 and in 2009 (57% and 36%, respectively, see Table 2). The fact that Monsanto, the company that owns and gets royalty payments for the Bt trait, has just announced that Bt cotton is developing resistance to pink bollworm in some Indian regions, might explain the recorded high incidence of bollworm in Bt farms, although more farm level data is needed (Bagla, 2010, Monsanto, 2010).

Similar to what we found in Andhra Pradesh, it has also been shown in China and South Africa that many Bt cotton farmers continue to spray large amounts of pesticides, including some very hazardous ones (Hofs et al., 2006, Pemsl et al., 2008). Chinese scientists have shown that the initial benefits of Bt cotton in reducing pesticide use, if any, disappear with the higher incidence of secondary pests that quickly follows (Wang et al., 2006, Wang et al., 2008, Wu et al., 2002, Lu et al., 2010). In fact, for these farmers in China, the extra economic burden of heavier pesticides spray, plus the higher costs of Bt cotton seeds, made the Bt technology uneconomical. It has also been established that, in China, Bt technology makes the Bt cotton plants more susceptible to some diseases, for example some fungal root attacks (Li et al., 2009).

On the other hand, organic cotton farmers rely exclusively on bio-pesticides and natural pest control, spending very little money on pest control and being capable of controlling pests effectively. Scientists in China measured a much bigger reduction in pesticide consumption related to training farmers on practices of non-chemical pest control, than related to the Bt cotton adoption per se (Yang et al., 2005). It seems evident that a reduction (or even elimination) of pesticide consumption is achieved by highly effective and economical practices that do not involve uncertain Bt technology.

Fundamental to the ecological control of pests in organic cotton farmers is the Neem tree (*Azadirachta indica*), a native tree that grows naturally all over the Indian cotton regions. The Neem fruit contains very powerful alkaloids with insecticidal properties, and it has been recognised as very effective against a wide range of pests, including those of the cotton crop (UNIDO, 2010).

RENPAP-UNIDO[5], a UN programme in Asia, works extensively in scientific research and dissemination of methods for effective Neem extract application in different crops. Dr. Y.P. Ramdev, from RENPAP-UNIDO considers that the Neem tree *"being locally available throughout the country and having a wide range of pest management activity can replace chemical pesticides and also provide employment opportunities in villages."*

5 Regional Network on Pesticides for Asia and the Pacific (RENPAP) – United Nations Industrial Development Organization (UNIDO).

Table 2. Pest incidence and practices for pest control in Bt and organic cotton farmers in Andhra Pradesh. Values are averages across Bt and organic farmers and values in brackets indicate standard errors of the mean.

	Bt cotton	Organic cotton	Notes
Number of pest attacks in 2009	3.5 (0.7)	1.8 (0.5)*	(Similar in 2008, omitted for brevity)
Worst pest in 2009	Mealy bug	Aphids	
Farms with bollworm damage in 2009	36%	62%	
Farms with bollworm damage in 2008	57%	62%	All organic farmers said they control bollworm effectively, both in 2008 and 2009.
Number of different chemical pesticides applied per farmer	2.8 (0.5)	0*	Organic farmers only apply farm-preparations and some biopesticides.
Most common pesticides used	*Confidor, Monocrotophos, Methyl parathion* and *Triazophos*	Neem tree extract, cow dung and urine preparation.	*Methyl parathion* is WHO class Ia – Extremely Hazardous and *Monocrotophos* and *Triazophos* are Class Ib – Highly Hazardous
Money spent on pesticides in 2009 (Rs/a)	1,119 (409)	26 (18)*	
Money spent on pesticides in 2008 (Rs/a)	973 (379)	54 (29)*	

**Denotes that difference of mean between Bt and organic cotton farmers is statistically significant (t-Test with $\alpha < 0.05$).*

1.4. Fertiliser cost

Bt cotton farmers spent about seven times more money on fertilisers than organic cotton farmers (Rs. 2,657 per acre vs. Rs. 344 per acre, respectively, in 2009, see Figure 1). This difference is mostly due to expenditure on chemical fertilisers made by Bt cotton farmers (some Bt cotton farmers also apply manure in some years).

Organic farmers rely for fertilisation mostly on legume intercrops, manure and compost application and in some cases biofertilisers. For some farmers, manure costs include buying cartloads of farmyard manure (costs included here). When used effectively, all these can provide enough nutrients for a healthy fertile soil at a fraction of the cost of chemical fertilisers.

Organic fertilisers are also proved to increase organic matter content in the soil, and to contribute to resistance against drought conditions (Lal, 2008). This fact might explain why yields in organic cotton farms did not decrease as much as in Bt cotton farms during the drought of 2009 (see section on Yields).

1.5. Animal feed cost

Both Bt and organic cotton farmers spent similar amount of money on buying feed for their cattle animals, with no significant differences between them in either year (see Figure 1).

Farmers spray Bt cotton crops with chemical pesticides, as advised by Bt cotton seed companies and dealers.

1.6. Interest on loans cost

Bt cotton farmers spent about 80% more money for paying the cost of loans than organic cotton farmers (74% more in 2009, 84% more in 2008; see Figure 1). This higher cost of loans is a direct consequence of the much higher cost of cultivation (seeds, pesticides and fertilisers) for Bt cotton farmers. As their cost of cultivation is much higher, Bt cotton farmers take loans for between 80% and 60% higher amounts than organic farmers (for 2009 and 2008 respectively, see Table 3). Consequently, due to much higher loan amounts and subsequence higher frequency of payment defaulting, Bt cotton farmers are not given more favourable loans by banks and microcredit groups. Thus Bt cotton farmers depend mostly on private moneylenders for their loans, and this explains the higher interest rates paid by Bt cotton farmers (see Table 3).

Organic farmers tend to associate among themselves in *sangam* (societies) and many of them, or their wives, participate in microcredit schemes within a village society to get crop loans (27% of them, compared to 7% of Bt cotton farmers, see Table 3). These cooperative schemes benefit in lower interest rates (3% annual interest rate for women's self-help groups), especially compared with the rates charged by banks (around 12%) and particularly local moneylenders (around 30% but often up to 50% annual interest rates). The much higher amount of loans taken by Bt cotton farmers make their participation in microcredit schemes difficult.

Bt cotton farmers, the majority of whom (53%) take large loans from private moneylenders, and subsequently paying very high interest rates, have a much higher cost of loan interest than organic farmers. This is a direct consequence of their higher expenditure on seeds, pesticides and fertilisers. As we will show in section 5, this also has drastic consequences for the amount of debt Bt farmers accumulate.

Table 3. Loans and interest paid by cotton farmers in Andhra Pradesh in 2009 and 2008. Interest paid and loan givers are for 2009; 2008 values are very similar and have been omitted for brevity. Values are averages across Bt and organic farmers and values in brackets indicate standard errors of the mean.

District	Bt cotton farmers	Organic cotton farmers
Total loan taken 2009 (Rs/a)	6,255.0 (1,542.5)	1,206.5 (417.5)*
Total loan taken 2008 (Rs/a)	5,586.8 (1,257.2)	2,047.9 (789.6)*
Interest rate paid for loan 2009 (%)	23.1 (5.6)	11.6 (3.1)*
% Farmers taking loan from:		
Local private moneylender	**53%**	**27%**
Bank	27%	18%
Microcredit group	**7%**	**27%**
No loans	**13%**	**27%**

**Denotes that difference of mean between Bt and organic cotton farmers is statistically significant (t-Test with $\alpha < 0.05$).*

Cost of inputs needed for cotton cultivation

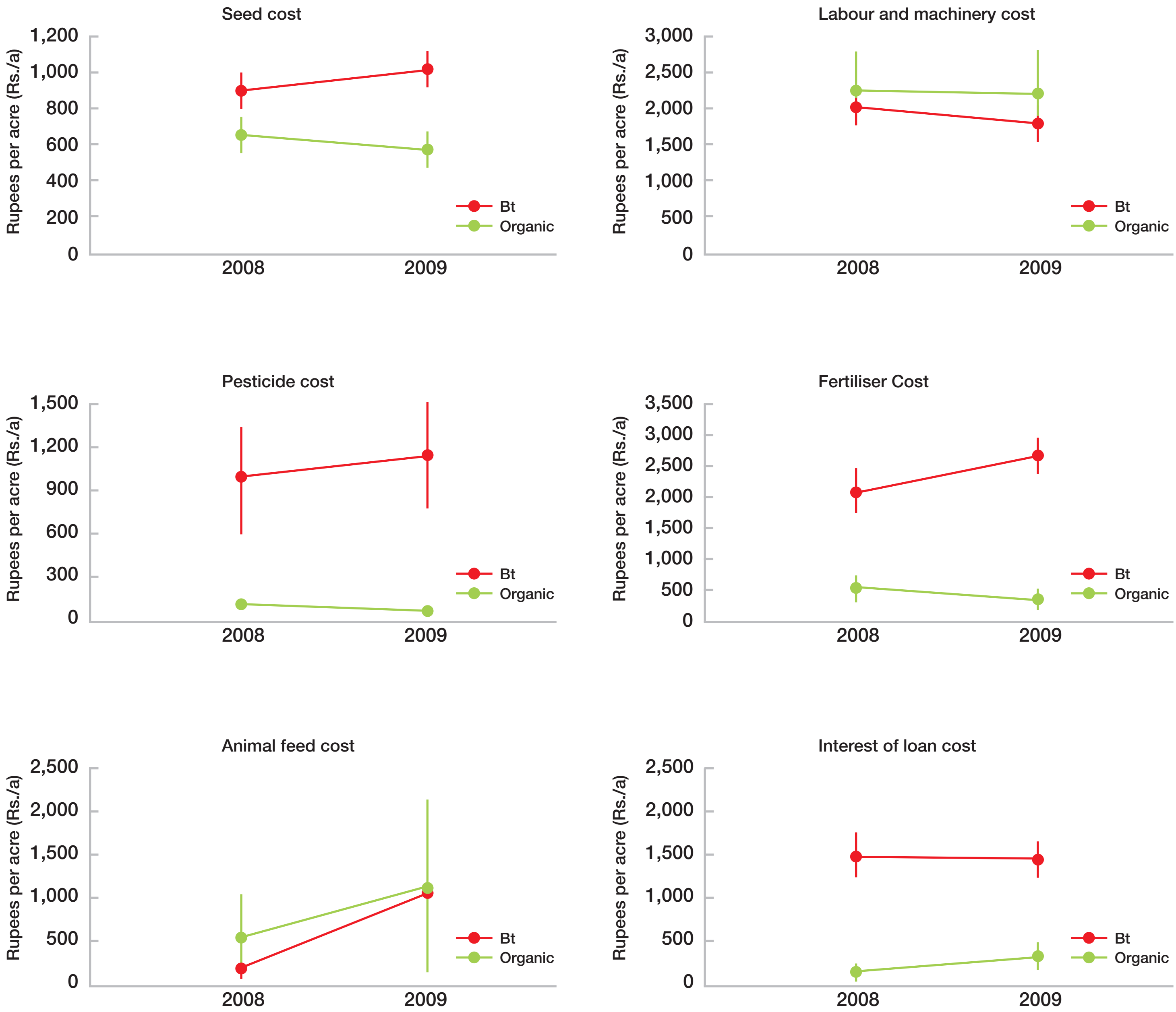
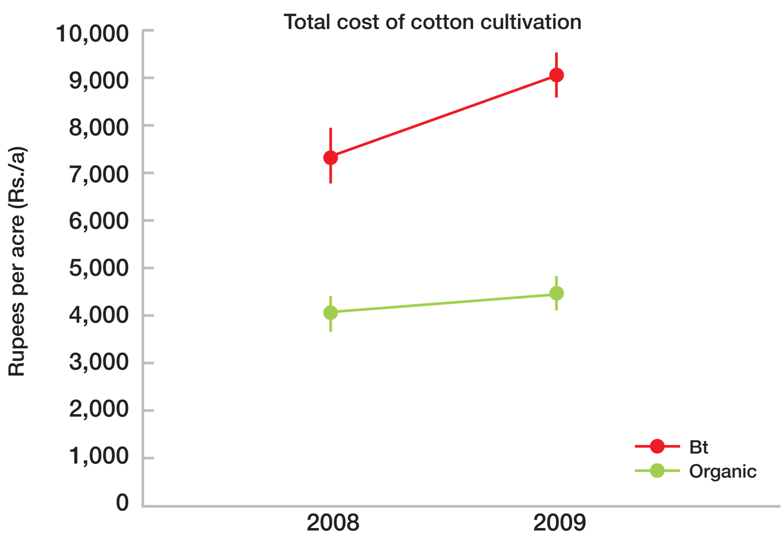


Figure 1. Cost of cotton cultivation, including all expenses involved. Values are averages and bars standard errors of the mean.



Harvested cotton.

2. Cotton yields

Cotton yields were higher in 2008 (normal monsoon) than in 2009 (poor monsoon) for both Bt and organic cotton farmers (see Figure 2). As has been shown in many regions, yields of cotton in general remain low when there is lack of irrigation (Fok et al., 2008, Witt et al., 2006). In order to put the yield results from our studied farms into context, we also present yield results from the two main cotton research stations in South India. Research shows that potential for high yields in non-Bt hybrids is significantly higher than the yields obtained by currently available Bt hybrids (Figure 2).

Yields were not statistically significantly different between Bt and organic cotton, although Bt cotton yields in 2008 were higher than organic cotton yields (Figure 2). Cotton yields were highly variable within each type of farm and even within each type of cotton hybrid planted. There is no relationship between higher yield and specific hybrids, nor between yields and Bollgard II hybrids. If anything, Bollgard II hybrids seem to yield less than Bollgard I hybrids in 2009/10 (3.6 vs. 4.5 quintals per acre, respectively). It is important to remember that any yield advantage of Bt cotton should be expected as a reduction in crop losses due to pests (less pest damage), since the Bt trait is not a technology that enhances productivity as such.

Within our data, the small yield increase for Bt and chemically-intensive cotton farms in 2008 does not seem to be related to the Bt trait in those hybrids; as we can reason from two pieces of evidence from the present study:

1) Both Bt and organic cotton farmers reported the same level of bollworm damage in 2008/09, thus a potential ‘enhanced’ pest protection with the Bt trait cannot be the cause of that yield increase.

2) In 2009/10, Bt cotton farmers reported less bollworm damage than organic farmers. However, this ‘enhanced’ pest protection was not translated into higher yields, which are similar between Bt and organic farmers in this year. Organic farmers reported higher pest damage in 2009/10 than Bt cotton farmers, but still managed the same yield. (This presumed ‘pest protection’ with the Bt trait is also not translated into low pesticide use, as we have seen in section 1, Figure 1 and Table 2).

The few companies still offering non-Bt cotton seeds in 2008 announced in August 2009 that they have not produced any new non-Bt seeds in the past years and that they will soon stop any commercialisation and development of non-Bt seeds (Nemes 2010). They also acknowledged that all non-Bt seeds recently being sold were from old stocks, meaning seeds developed and multiplied years before. This can obviously have detrimental effects for the quality of seeds and potential yields (Nemes 2010, Nuziveedu Seeds, personal communication). This fact might explain the slightly higher yield of Bt cotton in 2008. The higher quality of the hybrids *per se* - but unrelated to the Bt event - has also been argued to be one of the causes for the increase in total cotton production in India in the last years (Kuruganti, 2009).

It is remarkable, however, that in spite of this difference in the quality of the seed stock available for Bt and organic cotton farmers, irrespective of the Bt event, organic farmers managed to get the same yield as Bt farmers in 2009, when they all struggled with a very dry year. In spite of massive investment in seed development for Bt hybrids, organic farmers, completely neglected by breeders, reached the same yield as Bt cotton farmers.

Yields of Bt and non-Bt cotton in the studied farms and in Research Stations in South India

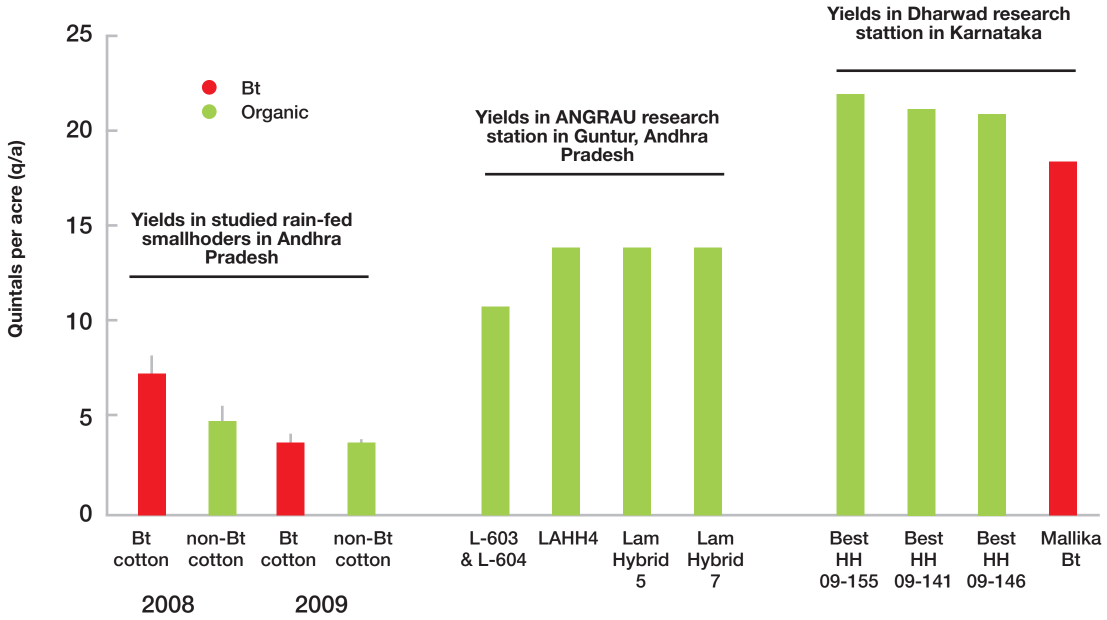


Figure 2. **Cotton yield achieved by Bt and organic cotton in 2008 and 2009 in Andhra Pradesh, and yields from the two main cotton breeding research institutes in South India (ANGRAU: Acharya N.G. Ranga Agricultural University in Guntur and Dharwad: University of Agriculture Sciences). Values are averages and bars, where available, standard errors of the mean. Within our study results, differences in 2008 are only marginally statistically significant, with t-Test *P*=0.12 (α<0.05). See details and sources for research stations data in Appendix 2.**

In Andhra Pradesh, there is de facto minimal public sector development and no public distribution of non-Bt seeds. All cotton seed development is currently in the hands of private companies commercialising the seeds (which have royalty agreements with Monsanto on the Bt trait) (Nemes, 2010). Companies selling Bt cotton seeds acknowledge that they are developing better hybrids for Bt seeds, which are not available for non-Bt farmers (Nemes 2010, Nuziveedu Seeds 2009, personal communication). Hence, it could be expected that non-Bt cotton yields might be lower than Bt cotton yields due to the low quality of non-Bt seeds. However, a brief look at the public sector breeding programmes in South India indicates a significant potential for non-Bt cotton yields, if enough support was given to the public sector non-Bt breeders and promotion of non-Bt seeds would be resumed by the public sector (Figure 2).

The only public centre doing research in non-Bt cotton seeds in Andhra Pradesh is the Acharya N.G. Ranga Agricultural University (ANGRAU), with its research stations in Guntur and Warangal. A principal cotton scientist in Andhra Pradesh and a cotton breeder of ANGRAU working in Guntur explained that, in the last 15 years, due to a lack of interest from the government, his research on non-Bt seeds has not reached the farmers (Appendix 2).

About 600 different non-Bt hybrids and open-pollinated varieties have been screened in Guntur during the last 11 years, but none of them have been authorised for release. The best-resulting hybrid (WGHH41) is now grown at all research stations in the state and considered to be the highest yielding cotton. **However, this non-Bt seed will not be released for farmer cultivation, since the Approval Committee[6] only accepts Bt hybrids and varieties in the state.**

In South India, public sector research in non-Bt seeds is better developed in the neighbouring state of Karnataka. One of the most important research centres on cotton breeding in India is based at the University of Agriculture Sciences (UAS) in Dharwad. Scientists at UAS Dharwad have been breeding new open-pollinated variety and hybrid seeds of cotton for the past few years, with very promising results so far (Figure 2, see details in Appendix 2 on results of cotton seed breeding carried out by Dr. S. S. Patil). Data from ANGRAU and Dharwad confirms that the potential for high yields in non-Bt cotton seeds is very significant, up to 22 quintals per acre under rain-fed conditions (see Figure 2 and Appendix 2).

6 Variety Release Committee (in Hyderabad, Andhra Pradesh).

Workers at a cotton factory in Asifabad, Adilabad district, Andhra Pradesh.

Public research from the best cotton research centres in South India is not currently reaching the farmers in Andhra Pradesh, who are losing out considerably from the unavailability of good quality non-Bt cotton seeds. If the Government of India wants to continue promoting organic agriculture (as stated in its latest 5-year plan) and further wants to maintain the economic benefits of being the largest exporter of organic cotton in the world, it is necessary that it starts supporting and distributing non-Bt seeds in the country as soon as possible.

In this context of lack of support for non-Bt cotton breeding, NGOs and farmers' organisations in the country have initiated a common effort to facilitate community-based participatory non-Bt cotton breeding among farmers, in particular organic farmers. For the last three years, the Centre of Sustainable Agriculture (CSA) in Andhra Pradesh has been working on making parental lines available to NGOs and farmers who want to collaborate in 'home breeding' of non-Bt cotton seeds. This community-based effort, albeit with limited resources and reach, seems to have great potential for high yields and increased seed security (Nemes, 2010).

As reflected in Figure 2, potential yields achieved in research stations are about one order of magnitude higher than average yields achieved by poor smallholding farmers in their fields. This reflects a large yield gap, occurring not only in cotton, and which is a common feature in many developing countries but especially significant in India (Aggarwal et al., 2008, Lobell et al., 2009). Scientists and agronomists have been arguing about the causes and solutions for this yield gap intensively for the last several decades. However, the gap – and hunger - still persist. What seems clear, as it was concluded by 400 scientists debating the future of agriculture globally, is that biotechnology - and in particular, genetic engineering - does not seem to be a significant tool for closing this yield gap, especially for the poor smallholding farmers who represent the great majority of farmers in the world (IAASTD 2009).

3. Net revenue from cotton

The net revenue, or net income, for cotton farmers after taking into account all costs and profit from cotton production is similar for Bt and organic farmers in a good (normal monsoon) year, but it is higher for organic farmers in a dry year (see Figure 3). The disadvantage for Bt cotton farmers in the dry year 2009/10 is a 63% decrease in net revenue when compared to organic farmers.

On average, Bt cotton farmers sold their cotton at Rs. 2,900 per quintal, in both 2008 and 2009. Organic farmers, thanks to premiums, sold their cotton at Rs. 3,250 per quintal in 2009 and Rs. 3,050 per quintal in 2008. The much higher cost of cultivation for Bt cotton farmers has a higher influence on net income than this relatively small difference in cotton selling price.

In spite of a small yield increase in Bt and chemically-intensive cotton farms in 2008, the overall economic return is still better for non-Bt organic farmers, due to much higher costs of cotton cultivation and the large yield decrease in Bt cotton under dry conditions.

The dry conditions under which organic cotton has an income advantage are expected to be more common in the future (Brown and Funk, 2008), and Bt cotton farmers, achieving a much lower net revenue, appear to increase their vulnerability under these conditions. It has been shown in South Africa that Bt cotton increased production risks for smallholders, due to the lack of benefits in unfavourable years (Shankar et al., 2007). This has dramatic consequences for the overall economic viability of Bt cotton farmers (see section 5).

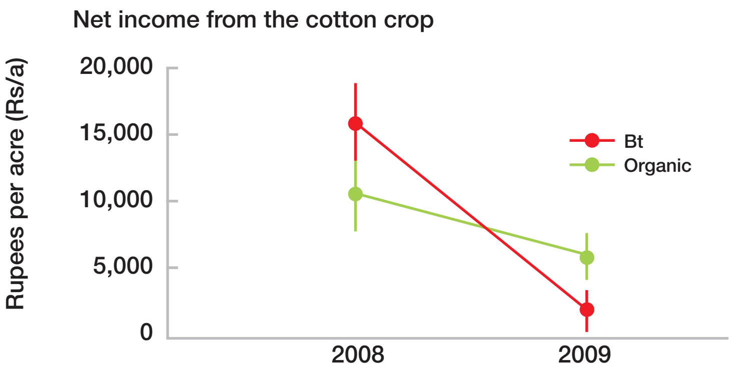


Figure 3. **Net revenue from the cotton crop for Bt and non-Bt organic farmers in Andhra Pradesh during 2008 and 2009. Values are averages and bars standard errors of the mean. Differences in 2008 are not statistically significant, but net revenue in 2009 is significantly higher for non-Bt organic farmers (t-Test α<0.05).**

4. Other crops: diversity and income

Smallholding farmers, in spite of very limited resources and productive land, tend to avoid monocultures in their farms. The majority of Bt cotton farmers (11 out of 15) and almost all organic farmers (12 out of 13) grow other crops in addition to cotton on their farms. However, the trend is for **higher crop diversity within non-Bt organic cotton farmers, as the number of crops besides cotton is more than double on organic farms than on Bt cotton farms** (1.5 vs. 3.5 other crops, respectively, see Table 4). It has been pointed out that these two groups of farmers might be pursuing a different kind of livelihood strategy, with non-Bt farmers relying more on agriculture as a whole but less on cash-crops, in this case cotton (Glover 2009).

Some Bt cotton farmers who grow mostly cotton worried about their food security after a bad year. *"I used to grow crops that I could feed my family with, but now, with only cotton and this drought, I will get very little cash and will struggle to feed my family"* Katakuri Rajayya, Bt cotton farmer from Bijigiri village in Karimnagar (Andhra Pradesh).

Growing a variety of crops on a farm is an insurance against the failure of one particular crop or a bad weather year. Scientists have shown that crop diversity improves soil fertility, reducing the need to use chemical inputs while maintaining high yields (Smith et al., 2008).

The income generated from growing crops besides cotton are not different between Bt and organic farmers in either 2008 or 2009, and it was lower in the dry year 2009 than in 2008. Although not statistically significant, in 2008 organic farmers got about Rs. 2,000 more on average from these crops than Bt cotton farmers, due to higher production from the diversity of crops they grow (eg pulses grown as intercrops). The larger decrease in income from other crops from 2008 to 2009 for organic farmers relates to them having slightly less access to irrigation water than Bt cotton farmers, and thus many of them were unable to grow rice - a high value crop - in the dry year. However, in terms of food security, organic farmers produce more quantity and diversity of legume crops, which although having less market cash value do have a higher nutrition security.

Table 4. **Diversity of crops, besides cotton, grown in Bt and organic cotton farms in Andhra Pradesh (India). Values are averages across Bt and organic farmers and values in brackets indicate standard errors of the mean.**

	Bt cotton farmers	Organic cotton farmers
Diversity of crops, besides cotton, 2009	1.5 (0.2)	3.5 (0.4)*
Income from other crops, 2009	2,900 (787)	2,735 (716)
Diversity of crops, besides cotton, 2008	1.6 (0.2)	3.3 (0.5)*
Income from other crops, 2008	4,570 (1,477)	6,599 (2,099)

**Denotes mean difference between Bt and organic cotton farmers is statistically significant (t-Test with $\alpha < 0.05$).*

Cotton picking on a farm in Andhra Pradesh.

5. Economic livelihood and debt

The net revenue from the farm, including the income from other crops besides cotton, was significantly lower - about 90% lower profit - for Bt cotton farmers than for non-Bt organic farmers during the dry year, 2009, and not significantly different in 2008 (Table 5, Figure 4). The net income of these farmers, both Bt and organic, is below the poverty line set by the World Bank ($1.25 US dollars a day = Rs. 55 a day), both in 2008 (around Rs. 50) and especially in 2009 (Rs. 13 a day vs. Rs. 25 a day in Bt and organic cotton farmers, respectively). All these farmers have very little financial security or savings, but it is especially alarming for Bt cotton farmers in the dry year.

To understand the overall economic situation of farm households it is important to also look at the debts originating from crop loans. As we showed in section 1, the amount of loans and interest paid by Bt cotton farmers are much higher than those paid by organic farmers, due to the very high cost of cultivation endured by Bt cotton farmers. Smallholding farmers are cash limited and rely on loans to afford inputs at the beginning of every season. The amount of loans and interests that farmers were unable to pay in 2008/09 added to the loans taken in 2009/10 represents the accumulated debt that will have to be paid with 2009/10 income. This accumulated debt after the 2009/10 cropping year, was 65% higher for Bt cotton farmers than for organic farmers (see Table 5).

Since net farming revenue in 2009 is lower for Bt farmers than for organic farmers, and since debt is so much higher for Bt farmers, the final net return for Bt farmers, after repaying debts -what we call here net economic livelihood - is a negative amount of Rs. 7,136 per acre for Bt cotton farmers compared to a positive return of Rs. 5,040 per acre for organic farmers (see Table 5). This last figure represents the instant situation of farmers after the cotton harvest of 2009/10, at the time of the largest annual cash entry in their households. It shows that Bt cotton farmers will face a dire economic situation during 2010, with high amounts of debt and having to take more crop loans for the next cotton season.

Net economic livelihood for organic farmers is positive, and although offering a very low income still below poverty line levels, organic farmers are able to live with less pressure from debts compared to Bt cotton farmers. The much lower cost of cultivation in organic farmers will also ease the pressure on crop loans next season.

A similar advantageous situation for organic cotton farmers has been shown in the central India state of Madhya Pradesh, where organic farmers achieved an average net return 30-40% higher than Bt cotton farmers (Eyhorn et al., 2007). Indeed, a recent World Bank-funded project in Andhra Pradesh aimed at scaling up the non-chemical community-based agriculture first promoted by NGOs (e.g. Centre for Sustainable Agriculture) has shown that ecological farming is a very efficient, ecological and economical way of poverty eradication (Vijay Kumar et al., 2009).

Organic farmer Ms. Gullapalli Rajeswari in Kishtapur, Karimnagar, stores her cotton harvest at home. Working with organic farmers' associations, she gets a fair, better price and improved marketing directly to organic cotton brands in Europe.

Table 5. **Economic livelihood of Bt cotton farmers and non-Bt organic cotton farmers in Andhra Pradesh, resulting from the total cost of cotton cultivation, net incomes from cotton and other crops, and accumulated debt during 2008/09 and 2009/10. Values are averages across Bt and organic farmers and values in brackets indicate standard errors of the mean. *Difference for organic* is the percentage difference between averages for Bt and non-Bt organic cotton farmers. (Averages of different variables do not necessarily add up to exact totals, since each variable is calculated from individual farmer data and then averaged. Raw data is available upon request.)**

	2009			2008		
	Bt cotton farmers	**Organic cotton farmers**	Difference for organic	**Bt cotton farmers**	**Organic cotton farmers**	Difference for organic
Total cotton cultivation cost (Rs/a)	8,764 (826)	4,624 (867)*	- 47%	7,450 (815)	4,074 (736)*	- 45%
Net income cotton (Rs/a)	2,069 (1,524)	6,199 (1,913)*	+ 200%	16,093 (2,890)	10,734 (2,421)[n.s.]	- 33%
Net income other crops (Rs/a)	2,900 (787)	2,735 (716)[n.s.]	- 6 %	4,570 (1,477)	6,599 (2,099)[n.s.]	+ 44%
Net income whole farm (Rs/a)	4,775 (1,929)	8,934 (1,910)*	+ 87%	20,054 (4,270)	17,333 (3,791)[n.s.]	- 14%
Accumulated debt 2008/09 – 2009/10 (Rs)	9,934 (2,855)	3,463 (966)*	- 65%			
Economic livelihood (Income - Debt) 2009/10 (Rs/a)	**-7,136 (3,695)**	**5,040 (2,374)***	**+ 171%**			

**Denotes that the difference of mean between Bt and organic cotton farmers is statistically significant (t-Test with α < 0.05).*

Organic cotton farmer Gullapalilli Rajeswari and her husband have been growing organic cotton for 4 years while building ecological pest protection with natural methods.

Economic livelihood of cotton farmers

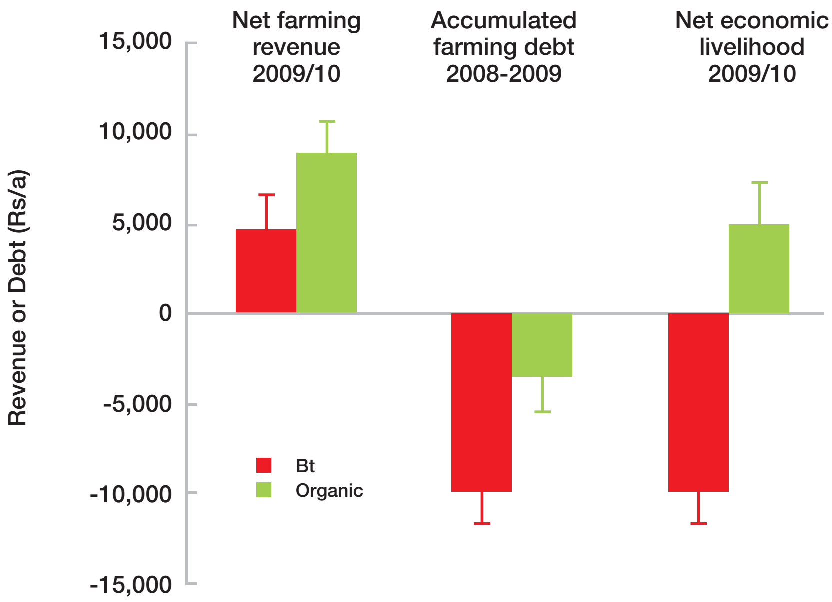


Figure 4. Economic livelihood of cotton farmers, as calculated from the net farming revenue in 2009/10 minus the accumulated debt after two years (2008/09 and 2009/10). Differences are statistically significant (t-Test $\alpha<0.05$).

Organic cotton farming also benefits the future of these rural communities.

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The Chetna association of organic farmers in Karimnagar organises vocational training workshops for young women in the village.

In addition to a better, less risky economic livelihood, our studied organic farmers also enjoy additional non-economic benefits from their way of farming. In terms of their farming environment, they create and work in a non-toxic and high biodiversity environment, as compared to the heavy on pesticide and less biodiverse environment in Bt cotton farms.

Organic farmers seem to engage in a different kind of livelihood, less dependent on cash crops and more dependent on their association with other farmers. The collective of organic farmers within a village help each other in procuring seeds, share experiences and organise trainings, and in some cases create additional services for the community. The farmers' association of Chetna in Karimnagar, for example, is responsible for organising vocational training for young women in the village, so that the young daughters of cotton farmers are learning to be tailors and at the same time helping to sew the sacks for cotton marketing. In addition, they also organise childcare facilities, so that children do their homework and are cared for until their parents return from the cotton fields at sunset. In working for a more ecological way of farming, these poor rain-fed smallholders are also creating a better future for their families and a better future for our natural environment.

Conclusion

Results clearly show that non-Bt organic farmers, by engaging in economical and ecological farming, and by diversifying their cropping system and relying more on their community, achieved a better, more secure economic livelihood than Bt cotton farmers. Bt cotton farmers, with very high cost of cultivation, high-chemical low-diversity farming, and high debt, are under high vulnerability and risk of household financial collapse.

In an era of growing risk and uncertainty, the high variability in the performance of Bt cotton, even when looking at only two years, represents in itself a threat to the livelihood of these small-scale farmers. In an unfavourable year, Bt farmers made only a quarter of the income they could expect in a normal year, while organic farmers' income only decreased by half. This inherent variability resulting from the non-adaptable Bt technology, added to the background of high debt and unpredictable weather, clearly endangers the subsistence of the rain-fed smallholding cotton farmers in India. It seems clear that single technological interventions are a narrow, expensive and ineffective approach to solve any aspect of the profound problems that India and other developing countries are facing in the context of diverse and complex farming systems.

It is clear from our data that Bt cotton goes irremediably hand-in-hand with high use of agrochemical inputs. As a consequence of government policies to promote hybrid seeds and the aggressive marketing techniques of the seed companies, the Bt cotton farmer is reliant on the shop vendor in his village for advice on how to maximise yields. This clearly promotes higher use of chemical fertilisers and pesticides by Bt cotton farmers. Given these realities, Bt cotton in India will always be input-intensive and can never be ecologically or economically sustainable.

Rain-fed smallholding farmers face very complex problems that cannot be addressed with single-minded commercial technological solutions. Alternative solutions exist that are locally available, economical and ecological with a ready experience of success under different scenarios (organic farming systems increasing food security of farmers in Africa, for example (UNEP and UNCTAD, 2008)). In the case of continuous growth of cotton production in a highly food-insecure country, options must include the reduction of cotton cultivation all together, moving instead towards a farming system with higher crop diversity and nutritional intensity. India is a major exporter of cotton to international markets, while at the same time it has to import a growing amount of legumes - pulses, the main protein source for million of Indians - at increasingly volatile international prices.

Greenpeace believes that agriculture should move towards an ecological farming system that ensures healthy farming and healthy food for today and tomorrow. An ecological farming system that protects soil, water and climate, promotes biodiversity, and does not contaminate the environment with chemical inputs or genetic engineering.

Greenpeace demands that the Indian government:

1. Bans Bt cotton cultivation, in light of the high financial risk involved in Bt cotton cultivation by small-scale farmers in India, in addition to other uncertainties in its health and environmental impacts.

2. Takes up an active role in supplying sufficient quantity and quality of non-Bt seeds, supporting public sector research institutes to do more research for improved varieties and hybrids of non-Bt cotton.

3. Supports organic cotton and ecological farming, focusing agriculture research and development on ecological alternatives that ensure future food security and livelihood security to farmers and farm labourers.

Appendix 1

Components of economic livelihood

The different variables used to estimate economic livelihood of farmers are defined below.

1. Cost of cotton farming

1.1. **Seed cost** is the total money spent per farmer per acre in buying cotton seeds for the cotton field.

1.2. **Labour and machinery cost** is the total money spent per farmer per acre in labour (including all events of cotton cultivation: soil preparation, sowing, spraying, manuring, weeding, picking, etc) and any machinery rental (tractor for soil preparation is the most common one). This includes only the external labour that the farmer needs to pay for. It does not include the non-financial labour supplied by the farmer and his or her family, as all farmers interviewed, and their families, supplied as much work as possible to their own farm. Family labour was not different between Bt and organic cotton farmers.

1.3. **Pesticide cost** is the total money spent per farmer per acre in buying chemical pesticides for cotton. Usually, Bt cotton farmers buy pesticides from the same shop where they buy Bt seeds and the shop vendors give them recommendations on what pesticides to spray.

1.4. **Fertiliser cost** is the total money spent per farmer per acre in buying nutrients for the cotton crop, both chemical and/or organic. Organic farmers do not use any chemical fertilisers. Organic fertilisers are applied in a variety of ways: farm yard manure, livestock temporal 'rental' in their farm, chicken manure from chicken industrial facilities and others.

1.5. **Animal feed cost** is the total money spent per farmer per acre in buying feed for animals. Most farmers keep some animals in their farm, both for farm work and manure supply and for milk production. In good years, farm products (e.g. straw from paddy) supply enough for feeding the animals. But in dry years, many farmers have to buy additional feed to keep their animals alive. As animals form an integral part of the cotton cultivation process, we have included this expense here.

1.6. **Interest of loan cost** is the total money spent per farmer per acre in paying interests from crop loans. In general, smallholding farmers are very cash limited and need to take a loan every year in order to buy farm inputs at the beginning of the season. Only some farmers are able to take bank loans at official rates. Many can only rely on moneylenders from their village, who normally charge interest up to 50% per year. Some farmers are associated with self-help groups and societies (sangam) that facilitate microcredits at much lower rates.

1.7. **Total cost of cotton farming** is the sum of all these expenses. Each variable was calculated for every farmer and then averaged across Bt and organic cotton farmers.

All figures are given in Rupees (Rs) per acre (a). As we want to keep this study meaningful for farmers, we have kept the unit system used by farmers in India (i.e. acres instead of hectares and quintals instead of kilograms or tonnes)[7]. Conversions are given in the footnotes of the Results section.

2. Yield of cotton is the production of cotton at farm level (raw cotton including lint and seed) expressed in quintals per acre (1 q/a = 250 kg/ha).

3. Net revenue from cotton is the total revenue from selling the cotton harvest, based on the total yield and the price at which the farmer sold the cotton total, minus the cost of cultivation (1.7).

The selling cotton price is quite variable, depending mostly on the time and point of transaction. The official support price for cotton is around 3000 Rupees per quintal, but actually varies widely depending on cotton quality and demand. From the price at which each farmer sold, we subtracted any market expenses charged by the buyer (middlemen or market). Farmers sell to private local buyer or directly to cotton processing units managed by the Government Cotton Corporation of India. Local buyers -middlemen- buy from farmers in villages at a lower price and then sell, for a profit, to the cotton processing units. Organic farmers generally, but not always, sell their cotton to their association or NGO, who usually give a premium for the organic certification and does not charge any market expenses.

4. Other crops: diversity and income

Diversity of other crops is the number of crops, besides cotton, that the farmer is growing in his or her landholding. These crops might be grown in the same season as cotton (usually from May/June to November/December, coinciding with the monsoon wet months, i.e. kharif), or in other season (rabi).

Income from other crops is the net revenue from selling these crops in the market.

5. Economic livelihood and debt

5.1. **Economic livelihood or net farm profit** is the total monetary income in the farm after paying for all cultivation costs. It includes the revenue from selling other crops in addition to cotton.

5.2. **Accumulated debt** is the unpaid crop loans and interests for 2008/09 and 2009/10, calculated at the end of 2009, after the main yearly cash input into the household.

All values are given as average of farmer group (Bt or organic cotton farmer), accompanied by the standard error of the mean.

7 1 acre (a) = 0.405 hectare (ha), 1 quintal (q) = 100 kg, 1 quintal / acre = 250 kg/ha
1,000 Rs (Indian Rupees) = 16.5 EUR, 1,000 Rs/a = 40 EUR/ha

Appendix 2

Cotton yields from open-pollinated varieties and hybrids developed by research institutes in South India

Table A1. **Yields of cotton seeds released from ANGRAU (all non-Bt). It does not include the 'best hybrid' according to the researcher (WGHH41) because it has not been approved for release. (OP variety stands for open-pollinated variety).**

Seed ID	Seed type	Year of release	Yield* (q/a)	Remarks
LK-861	OP variety	1993	10	Immune to whitefly
LPS-141	OP variety	1987	10	Resistant to whitefly
L-603	OP variety	1997	11	Tolerant to jassids
L-604	OP variety	1997	11	Tolerant to jassids
LAHH4	Hybrid	1997	14	Wider adaptability
Lam Hybrid 5	Hybrid	2002	14	Resistant to Cercospora
Lam Hybrid 7	Hybrid	2006	14	Resistant to jassids

Source: ANGRAU, http://www.cicr.org.in/aiccip/aiccipCenters/Guntur.html

**Yield reflects average yield measure during 3 years in trials taking place at the research station, under rain-fed conditions and with supply of chemical fertilisers and pesticides.*

Table A2. **Yield data for 2009/10 for cotton seeds developed by Dr. S. S. Patil at University of Agricultural Science in Dharwad, Karnataka. These five hybrids are consistently the best performing ones during 2009/10. The data also include the yields achieved by the best performing Bt hybrid (*Mallika*) [grown by the majority of Bt cotton farmers studied in Andhra Pradesh in the present report].**

Seed ID	Seed type	Plant type	Yield* (q/a)
Best HH 09-115	Non-Bt hybrid	**Stay green X Robust High RGR**	22.2
Best HH 09-141	Non-Bt hybrid	**High HI(R) X Stay Green (Moderate Green)**	21.4
Best HH 09-146	Non-Bt hybrid	**Robust RGR X**	21.2
Best HH 09-152	Non-Bt hybrid	**High HI X Robust + RGR**	20.9
Best HH 09-103	Non-Bt hybrid	**Robust Green + Rob X Rob + High RGR**	20.8
Mallika Bt	Bt hybrid	**Best Bt check**	18.6

Source: Dr. S.S. Patil, UAS, Dharwad, March 2010. Data generated under Council of Scientific and Industrial Research's New Millenium India Technology Leadership Initiative (1st phase: 2008-2011) (NMITLI) project.

**Yield reflects average yield measure during 2009/10 in trials taking place at the research station, under rain-fed conditions and with supply of chemical pesticides and both chemical and organic fertilisers.*

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