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The Impact of Bt Cotton on Poor Households in Rural India

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ABSTRACT The impact of genetically modified (GM) crops on the poor in developing countries is still the subject of controversy. While previous studies have examined direct productivity effects of *Bacillus thuringiensis* (Bt) cotton and other GM crops, little is known about wider socioeconomic outcomes. We use a microeconomic modelling approach and comprehensive survey data from India to analyse welfare and distribution effects in a typical village economy. Bt cotton adoption increases returns to labour, especially for hired female workers. Likewise, aggregate household incomes rise, including for poor and vulnerable farmers. Hence, Bt cotton contributes to poverty reduction and rural development.

KEY WORDS Genetically modified crops, poverty, rural development, village economy, social accounting matrix

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The Impact of Bt Cotton on Poor Households in Rural India

ABSTRACT The impact of genetically modified (GM) crops on the poor in developing countries is still the subject of controversy. While previous studies have examined direct productivity effects of *Bacillus thuringiensis* (Bt) cotton and other GM crops, little is known about wider socioeconomic outcomes. We use a microeconomic modelling approach and comprehensive survey data from India to analyse welfare and distribution effects in a typical village economy. Bt cotton adoption increases returns to labour, especially for hired female workers. Likewise, aggregate household incomes rise, including for poor and vulnerable farmers. Hence, Bt cotton contributes to poverty reduction and rural development.

I. Introduction

Several recent studies have analysed the impact of genetically modified (GM) crops on farm productivity in developing countries (FAO, 2004; Zilberman et al., 2007; Huang et al., 2008; Krishna and Qaim, 2008). Many of these studies focused on insect-resistant *Bacillus thuringiensis* (Bt) crops, especially Bt cotton, because this technology has been adopted already by millions of small-scale farmers around the world, including in China, India, South Africa, Mexico, and Argentina (James, 2007). The available evidence shows that the concrete impacts vary seasonally and regionally, according to the underlying agro-ecological and socioeconomic conditions (Qaim et al., 2006; Bennett et al., 2006). On average, farmers growing Bt cotton benefit from insecticide savings, higher effective yields through reduced crop losses and net revenue gains, in spite of higher seed prices

(Huang et al., 2002; Morse et al., 2004; Qaim and de Janvry, 2005; Gandhi and Namboodiri, 2006; Crost et al., 2007; Pray and Naseem, 2007; Dev and Rao, 2007). Using partial equilibrium displacement models, different authors also showed that these productivity effects entail significant gains in economic surplus (e.g., Pray et al., 2001; Qaim, 2003).

There are also studies that have analyzed welfare effects of Bt cotton and other GM crops for developing countries from a macroeconomic perspective, using computable general equilibrium (CGE) models (de Janvry and Sadoulet, 2002; Elbehri and Macdonald, 2004; Huang et al., 2004; Anderson et al., 2008). However, hardly any research so far has focused on analysing wider socioeconomic outcomes at the micro level, which is probably also the reason for the ongoing controversy surrounding the poverty and rural development implications of GM crops (Lipton, 2007; World Bank, 2007; Friends of the Earth, 2008).[1] One exception is Subramanian and Qaim (2009), who have examined direct and spillover effects of Bt cotton adoption in India, using a village modelling approach. Building on census data from a particular village in the state of Maharashtra, they developed a micro social accounting matrix (SAM), disaggregating village households by land ownership. Simulation results with a multiplier model showed that small and large farms can benefit from Bt cotton adoption, although household income gains are somewhat bigger for the large farm category.

Here, we extend the approach by Subramanian and Qaim (2009), in order to analyse the impacts of Bt cotton on poor households more explicitly. We use the same data and approach, but in the SAM disaggregate village households by income groups, employing local poverty lines as differentiating criteria. Since this is the first attempt to assess the poverty effects of a GM crop application, the results can add to the academic and public policy debate about the role of agricultural biotechnology for sustainable development.

The rest of the article is organised as follows. In section II, a brief overview of the direct farm level effects of Bt cotton is presented, using representative survey data from different states of India. In section III, the village data and household disaggregation are discussed. In section IV, we describe the general features of the village SAM, while in section V, we run simulations to study the broader socioeconomic impacts of Bt cotton on farm and non-farm households. The last section concludes.

II. Farm Level Impact of Bt Cotton in India

In India, cotton is mainly grown on relatively small farms with less than 10 acres (Qaim, 2003; Dev and Rao, 2007). Bt cotton was officially commercialised for the first time in 2002, and since then adoption rates have increased rapidly, reaching 15 million acres in 2007 (James, 2007). Before we focus on the particular study village and analyse the socioeconomic impact of Bt cotton for rural households, it is interesting to get an overview of the technology's direct effects from a broader geographic perspective.

Qaim et al. (2006) had analyzed farm level effects of Bt cotton in India in 2002-2003, using stratified random sample data collected in the states of Maharashtra, Karnataka, Andhra Pradesh, and Tamil Nadu. These data are representative for cotton production in central and southern India. Subramanian and Qaim (2009) had surveyed the same farms in 2004-2005, and we conducted a third round of data collection in 2006-2007. A comparison of Bt and conventional cotton plots for all three survey rounds is summarised in Table 1. In the first round in 2002-2003, 341 farmers were surveyed owning 434 main cotton plots – 133 under Bt and 301 under conventional cotton. In the second round, only 318 (93%) farmers from the first round were surveyed due to sample attrition. Yet, 58 additional farmers were randomly sampled, resulting in a total number of 376 farmers with 465 cotton plots. In the third round, 289 farmers from the original sample plus 47 from the additional farmers in the second round were sampled. Since some of them had shifted away from cotton cultivation, additional farmers were randomly added, resulting in a total of 373 cotton plot observations in 2006-2007. Unsurprisingly, the share of Bt plot observations was increasing over time, since adoption rates are rising. Moreover, while in the early years many Bt farmers also maintained a conventional cotton plot, the share of full adopters grew over time.

The results presented in Table 1 are consistent with other studies in India (e.g., Bennett et al., 2006; Gandhi and Namboodiri, 2006; Crost et al., 2007; Dev and Rao, 2007). On average over the three seasons, Bt cotton produced 37 per cent higher yields than conventional cotton, while insecticide amounts were 41 per cent lower.[2] These agronomic effects vary from year to year, which is largely due to seasonal variation in pest pressure. Recently, the widespread adoption of Bt technology seems to have contributed to an overall decline in infestation levels of Bt target pests (especially the American bollworm), so that even conventional cotton farmers had reduced their insecticide sprays significantly in 2006-2007. Between 2002 and 2007, per-acre net revenues were on average 2000-3000 Indian Rupees (Rs.) (US $43-64) higher on Bt than on conventional cotton plots. Sizeable benefits for farmers are also reflected in the rapidly increasing Bt adoption rates, which reached 66 per cent of the total Indian cotton area in 2007-2008 (James, 2007).

(Table 1 about here)

III. Village Census Survey

In order to analyse the wider socioeconomic effects of Bt cotton at the micro level, we use comprehensive data from a census survey that was carried out in one particular village in 2004 (Subramanian and Qaim, 2009). The study village, Kanzara, is located in Akola district of Maharashtra, the state with the largest area under cotton in India. Kanzara can be considered a typical setting for smallholder cotton production in the semi-arid tropics (Walker and Ryan, 1990). The next bigger town is Murtizapur, which is 7 km away from the village.

Interviews with village households captured all household economic activities and transactions for the 12-months period between April 2003 and March 2004. Both transactions within the village and also between village households and the rest of India were considered. Of the total 305 village households, 102 are landless; the other 203 own land suitable for agricultural production. The average farm size of land-owning households in the village is 4.7 acres. All farm households cultivate at least some cotton, mostly next to a number of food and fodder crops for subsistence consumption and for sale.

Of the total village cotton area of 1093 acres in 2003-2004, 33.5 acres were under Bt cotton, involving 15 farmers that had already adopted the technology.[3] This number of Bt adopters had increased from 8 farmers in 2002-2003. Interestingly, some adopters were farm households living below the local poverty line. While especially during the early years of adoption there was also a sizeable black market in India for unapproved Bt hybrids, all adopters in Kanzara cultivated only legal Bt cotton hybrids sold by Mahyco company – namely MECH-12, MECH-162 and MECH-184. During the interviews it became obvious that most farmers in the village believed that illegal cotton hybrids, though cheaper, would perform badly. Indeed, documented evidence shows that legal Bt cotton hybrids often significantly outperform illegal hybrids (Bennett et al., 2005).[4]

For investigating income distribution effects, we have to classify village households in a meaningful way. Unlike Subramanian and Qaim (2009), who used a categorisation by land ownership, for the analysis here we classify village households according to their consumption expenditures, using the local rural poverty line of 10.62 Rs. per day (Planning Commission, 2001). This corresponds to US $1.15 in terms of purchasing power parity (PPP), which is close to the $1.08 a day figure used by the World Bank to classify extreme poverty at the international level (Chen and Ravallion, 2007). Forty-eight per cent of the households in Kanzara fall below this poverty line. A second threshold of 21.24 Rs. per day ($2.30 PPP) is used to classify vulnerable households.[5] While vulnerability is a dynamic concept, we use it based on cross-section data, as we reasonably assume that households that are just above the poverty line are highly susceptible to negative shocks. According to this definition, 38 per cent of the village households are vulnerable, that is, they fall in-between the Rs. 10.62-21.24 range.

IV. Features of the Micro Social Accounting Matrix

The SAM we use is based on Subramanian and Qaim (2009), but with a different household categorisation, as detailed above. Village SAMs have been developed and used previously in different contexts (Adelman et al., 1988; Subramanian and Sadoulet, 1990; Parikh and Thorbecke, 1996). Yet, this SAM is distinct in two respects. First, unlike previous SAMs, which are based on sample surveys, this SAM builds on a village census. Since a SAM by construction requires both receipts and payments of all transactions, availability of census data reduces the problem of unbalanced markets and thus of biased results. Second, this SAM explicitly considers Bt and conventional cotton as two different activities, which allows us to evaluate both technologies' distributional impacts.

The SAM used here captures all economic transactions that were undertaken by households and other institutions within the village as well as with the rest of India (ROI). The survey questionnaire that was used to construct the SAM included details on land and other assets owned, area under each crop, revenues and production costs for crop and livestock activities, individual incomes from different off-farm activities, and labour market participation. Moreover, household transactions in consumer and producer durables, financial assets, borrowing, lending, and consumption expenditures on food and non-food were captured. Since households reported the source and destination of each transaction – including labour income and transfer receipts from ROI – it was not difficult to identify the sources (destinations) even if they were outside the village.

An aggregate version of the SAM is presented in the appendix (Tables A1-A5). Apart from the different household categorisation, one other difference to Subramanian and Qaim (2009) is that the payments by institutions to factors are obviated by introducing two new activities – financial services and construction. This was necessary to make the SAM sparse enough for a multiplier model. The detailed SAM has 156 agricultural and non-agricultural activities, 119 commodities, 8 factors, and six household categories. Agricultural activities include the cultivation of cotton and numerous other crop and livestock enterprises. Non-agricultural activities include agricultural services (for example, hiring out machinery), village production (for example, construction and small-scale manufacturing), retail trade, private services (for example, barber, doctor), government services (for example, ration shop, post office), and transportation.

Apart from each activity having its own commodity, many activities produce more than one commodity. In other cases more than one activity produces the same commodity under different technologies, as is the case for Bt and conventional cotton. The SAM figures for both technological alternatives in cotton are shown in the first two columns of Table A1. As indicated above, the panel data summarized in Table 1 were used to update yield and insecticide use differences between Bt and conventional cotton in the SAM. Given that the number of Bt observations in Kanzara village was still quite small in 2003-2004, use of these more representative data helped to improve the reliability of the results. All other details in the SAM are based on the village census.

In terms of household categorisation, we first subdivided all village households into landless and landowners, and then each of these into the three different poverty groups – poor, vulnerable, and rich, according to their consumption expenditures, as previously described. In the village, 57 per cent of the landless households are poor, while 30 per cent are vulnerable. Among the landowners, 42 per cent are poor and another 42 per cent are vulnerable. Vulnerable farm households received the highest share of the village income (34 per cent), even higher than that of the rich farm households. A large part of this income of vulnerable farmers accrues from factor earnings, accounting for about Rs. 2.2 million (see appendix Table A3).

As can be seen in Table A1, in 2003-2004 the gross domestic product of the village was about Rs. 24.91 million (US $0.53 million). Subtracting the commodity imports shown in Table A2 from the exports shown in Table A5 reveals that Kanzara is a net exporter of commodities such as cotton, cereals, pulses and fodder. The local economy is characterised by extreme openness, with only 28 per cent of total crop production within the village being for subsistence purposes. In terms of factor services, comparison of Tables A3 and A5 shows that the village is a net importer. The total village value added is Rs. 10.90 million (Table A3). Rs. 1.9 million worth of hired labour are earned in Kanzara by outside village households (Table A3), while Rs. 1.5 million are earned by village households working as hired labourers outside the village (Table A5).

V. Simulations

The SAM as such is a static representation of the village economy. It does not allow statements about the backward and forward linkage effects of individual activities like Bt cotton, which can significantly influence income distribution. This requires simulations with a SAM multiplier model. The idea of a SAM multiplier simulation is to introduce an exogenous shock to the village economy and then observe how factor returns and household incomes change in comparison with the status quo. We use the multiplier model described by Subramanian and Qaim (2009), which largely builds on Pyatt and Round (1979).

Before discussing the concrete simulations, several limitations of this model, which result from the restrictive assumptions imposed, need to be stressed. First, prices are fixed. This is realistic for a single village, because the village economy is small, that is, when the cost of transacting with outside markets is low, the village is likely to be a price taker for most goods and factors. However, when extrapolating the findings to a larger region, this assumption has to be questioned.[6] Second, the supply of factors and resources is perfectly elastic. Yet, in a village economy resource constraints can generate high shadow prices that guide scarce resources to their most productive use inside and outside the village. This cannot be captured with this particular approach. Third, since absolute factor usage is not modelled explicitly, it is difficult to distinguish changes in employment and returns to labour. But in this respect, the other assumptions help in interpretation: increased income accruing to labour can only come about through increased employment, since labour markets are assumed to be unconstrained and wages fixed.

For the analysis of Bt cotton impacts, we run two scenario simulations, both considering an expansion in the village cotton area by 10 acres. The first scenario assumes that the additional 10 acres are cultivated with Bt cotton, while the second assumes that the additional area is grown with conventional cotton.[7] Accordingly, differences between the two scenarios can be interpreted as the net impacts of Bt technology adoption. The 10 acres in each scenario are additional to the crop area already cultivated in Kanzara, and – as is common in SAM multiplier analyses – it is assumed that there are no constraints in the availability of other production factors. It should be noted that the magnitude of the area expansion does not matter for the essence of the results, as long as it is the same in both scenarios. Based on the existing structure of the village economy, the multiplier model simply simulates the direct and spillover effects resulting from the increase in a specific economic activity, in our case either Bt or conventional cotton production. All the resulting effects are proportional to the assumed area expansion, such that income distribution is not influenced by the choice of the concrete acreage.

We first discuss the Bt scenario separately, in order to explain the socioeconomic mechanisms underlying the results. Figure 1 demonstrates that 10 additional acres of Bt cotton would entail sizeable aggregate returns to labour, which would rise by Rs. 39 thousand. Especially the returns to hired female labour would increase. In the manual cotton production systems, hired women workers carry out most of the sowing, weeding, and harvesting operations, while men are mostly responsible for tillage, irrigation, and pest control. But also returns to non-agricultural labour would increase through employment effects in other village sectors that are linked to cotton production, such as transportation, trade, and other services.

(Figure 1 about here)

Aggregate household incomes in the Bt scenario increase by Rs. 106 thousand (Figure 2). This is the result of changes in the returns to the factors of production labour, capital, and land employed within the village. In addition, multiplier effects through spillovers to outside village markets and feedbacks are included. These are particularly important for a cash crop like cotton. For instance, higher cotton production and rising incomes within the village induce growth also in outside village sectors, which again leads to new employment opportunities, including for village households. Figure 2 demonstrates that most of the aggregate income effects resulting from an increase in Bt cotton production are captured by farm households, although landless village households also benefit to some extent.

(Figure 2 about here)

Yet, income gains would also result from an increase in conventional cotton production. Therefore, the second scenario simulation assumes that the additional 10 acres are cultivated with conventional cotton. The effects on labour and household incomes are similar to those in the Bt scenario (Figures 1 and 2), as one would expect given that both alternatives involve an increase in village cotton production. Nonetheless, there are also noteworthy differences, and these differences are particularly relevant for the comparative evaluation of both technological choices.

Figure 1 demonstrates that Bt cotton generates higher returns to labour than conventional cotton in the local economy. The difference is especially notable for hired female agricultural labourers, which is due to significantly higher yields to be harvested in Bt cotton. While yields are gender-neutral in general, picking cotton is an operation for which primarily hired women are employed in India. Hence, Bt cotton adoption clearly increases the employment opportunities for women in the local setting.[8]

For male members of the farm families, returns to labour are also higher in Bt than in conventional cotton, although this is largely driven by indirect effects. With reduced insecticide applications in Bt, labour demand for pest control in cotton decreases. Since in India male family members are mostly responsible for pest scouting and spraying of insecticides, their workload is reduced through Bt adoption. This is what Subramanian and Qaim (2009) referred to as saved management time. However, the simulations suggest that this management time saved in Bt cotton production can be reallocated to other agricultural and non-agricultural activities, such that the overall returns to family male labour increase. Most of this opportunity income is realised in self-employed activities.[9] In contrast, the returns to hired male agricultural labour are lower in Bt than in conventional cotton, suggesting that there are fewer alternative employment opportunities for this category of workers.

Total household income increases are 82 per cent higher under Bt than under conventional cotton (Figure 2). This implies a remarkable gain in overall economic welfare through Bt technology adoption at the village level. For landless households, the effects are relatively small. Especially the poorer landless households derive most of their income from employment as hired agricultural labourers, and the higher returns for female workers in Bt cotton are almost offset by the lower returns for male workers. However, all types of farm households – including those below the poverty line – benefit considerably more from Bt than from conventional cotton. Strikingly, vulnerable farm households are the main beneficiaries, with additional income gains in a magnitude of 134 per cent.

Beyond the direct impacts on cotton profits, labour market effects are an important component of the income changes caused by Bt technology. For poor and vulnerable farmers, higher returns to labour are due to more employment of female household members as hired workers on other farms, as well as higher returns to agricultural family labour in alternative employments. For rich farmers, hiring out female labour is rare, so that the increase is almost exclusively from higher returns to family male labour employed in alternative activities. Thus, the observed differences in household income increases between different types of farmers can largely be explained by different opportunity incomes. Poor farm households are dominant in non-agricultural village production activities such as construction and small-scale manufacturing (Figure 3), where positive spillover effects through Bt cotton adoption are relatively weak. Spillovers are more felt by vulnerable farm households, who receive a higher proportion of the village income from agricultural production and non-agricultural services, and for rich farm households, who account for the largest share of agricultural services (for example, hiring out machinery) and retail trade within the village.

(Figure 3 about here)

VI. Conclusion

In this article, we have analysed the direct and spillover effects of Bt cotton on poor households in rural India. The results demonstrate that technology adoption entails important positive socioeconomic effects in the small farm sector. More specifically, we have shown that Bt cotton adoption raises the returns to rural labour with interesting gender implications. Compared to conventional cotton, Bt cultivation increases aggregate labour returns by 42 per cent, while the returns for hired female agricultural workers even increase by 55 per cent. Likewise, total household incomes rise considerably, including for poor and vulnerable farm families that constitute the largest proportion of rural dwellers. Strikingly, the main beneficiaries are vulnerable farmers, whose household income gains are 134 per cent higher under Bt than under conventional cotton. This disproves the often heard argument that only wealthy farmers could benefit from GM crops.

While the exact findings presented here are specific to the study village, the social structure of the local economy is typical for the semi-arid tropics, comprising cotton production in central and southern India. So it is reasonable to conclude that Bt cotton produces important benefits in large parts of rural India. The technology is net employment generating and causes income gains for all types of households, including those below the poverty line. This highlights that Bt cotton contributes to poverty reduction and rural development.

Hardly any previous research has been carried out on the wider socioeconomic outcomes of GM crops at the micro level in developing countries. The resulting knowledge gap has contributed to uncertainty and to overly precautious attitudes in research and regulatory policies. Our results for Bt cotton in India cannot simply be generalised to other examples, because impacts always depend on the concrete technology and institutional framework. Nonetheless, the fact that GM crop applications can help reduce poverty as such has wider implications and might further the debate about the role of agricultural biotechnology for sustainable development.

Endnotes

[1] Especially for India, there have been reports by biotech critics that Bt cotton ruins rather than helps smallholder farmers. However, such reports do not build on representative data. Gruère et al. (2008) clearly showed that the occasional claim of a link between Bt cotton adoption and farmer suicides cannot be substantiated.

[2] These representative results on yield and insecticide use differences between Bt and conventional cotton are also used to update the village SAM, as further explained below.

[3] 2003-2004 was only the second season in which Bt cotton was officially commercialised in India. As pointed out above, the number of adopting farmers in India has increased significantly over time, including in Kanzara village.

[4] Especially in the Indian state of Gujarat, there are also reports about farmers who benefited significantly more from illegal than from legal Bt cotton hybrids (Roy et al., 2007). A plain comparison is difficult, because the exact nature of illegal Bt hybrids is not always clear; they comprise F1 seeds, farmer-reproduced F2 seeds, but sometimes also spurious seeds that do not actually carry Bt genes (Herring, 2007). Moreover, different hybrids are adapted to different agroecological environments. Our own survey data from four central and southern states of India, including Maharashtra, show that illegal F1 seeds were sold at about 800-1000 Rs. per packet (enough to plant one acre) during the first years of adoption, as compared to 1600 Rs. for legal Bt cotton seeds. Due to more recent government price caps in the legal market, mean official Bt seed prices are now at about 800 Rs., while illegal F1 seeds are sold at about 600 Rs. (Sadashivappa and Qaim, 2009). One advantage of legal Bt seeds for cash-constrained farmers is that they can sometimes buy them on credit from the input dealers – an option which is usually not available in illegal markets.

[5] The World Bank uses a $2.15 (PPP) a day value as a second threshold. This is considered to be more representative of what poverty means in middle-income countries (Chen and Ravallion, 2007).

[6] For instance, with higher yields in Bt cotton across villages and regions, the price of cotton can decline, which would lower the benefits for technology adopters and would even result in negative implications for non-adopting conventional cotton farmers.

[7] Technically, this is implemented as an exogenous increase in cotton demand by the value produced on the additional 10 acres. In SAM jargon, this is called the initial injection. Since yields in Bt are higher than in conventional cotton, the value of the injection is also proportionally higher in the Bt cotton scenario.

[8] This result is based on the assumption that production patterns and gender roles do not change through Bt cotton adoption. Given the evidence so far, this is a realistic assumption for India.

[9] The alternative employment opportunities available to family male workers in the village are in other crop and livestock enterprises, agricultural services (for example, hiring out machinery), village production activities (for example, construction and small-scale manufacturing), retail trade (for example, grocery shop, laundry), private services (for example, barber, doctor, electrician) and transport services (for example, bullock cart, tractor). Figure 3 shows the distribution of these opportunities for each of the farm household categories. The assumption that these other activities can absorb additional labour is not unrealistic, because, as mentioned above, the village is a net importer of factor services, including labour. Hence, the saved family labour in cotton can substitute for some of the imported labour. Moreover, most sectors in the village operate at less than full capacity.

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Table 1. Comparison of mean insecticide use, yields, and net revenues between Bt and conventional cotton plots in India

	2002-2003		2004-2005		2006-2007	
	Bt	Conventional	Bt	Conventional	Bt	Conventional
Insecticide use in kg/acre	2.07*** (2.65)	4.17 (3.37)	2.05*** (2.68)	4.19 (10.48)	1.22* (1.41)	1.55 (1.51)
Yield in kg/acre	658.82*** (393.64)	490.86 (335.88)	742.94*** (327.62)	550.52 (291.22)	841.65*** (356.00)	589.93 (335.09)
Net revenue in Rs./acre	5294.22*** (8117.19)	3132.99 (6773.89)	4921.83*** (6290.90)	2152.08 (5476.80)	7120.82*** (7654.80)	4181.26 (7563.07)
Number of observations	133	301	165	300	317	56

Sources: Qaim et al. (2006) for 2002-2003, Subramanian and Qaim (2009) for 2004-2005, and authors' calculations for 2006-2007.

Notes: Standard deviations are shown in parentheses.

*, **, *** Mean values are different from those of conventional cotton in the same year at a 10 per cent, 5 per cent, and 1 per cent significance level, respectively.

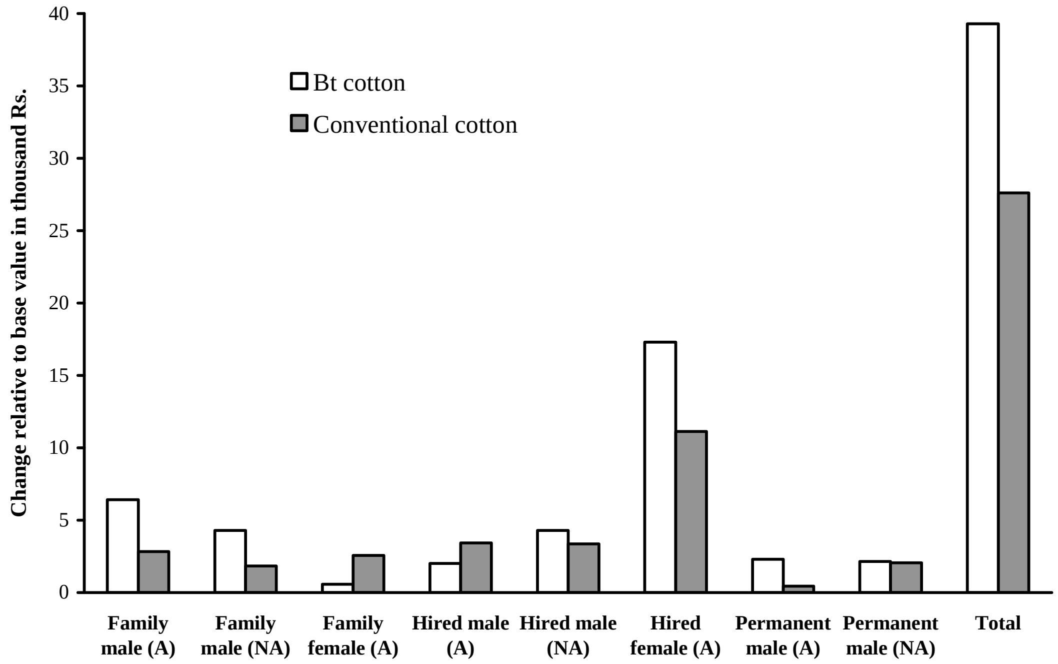

Figure 1. Changes in returns to labour from increased Bt and conventional cotton production

Note. “A” stands for agricultural and “NA” for non-agricultural labourers.

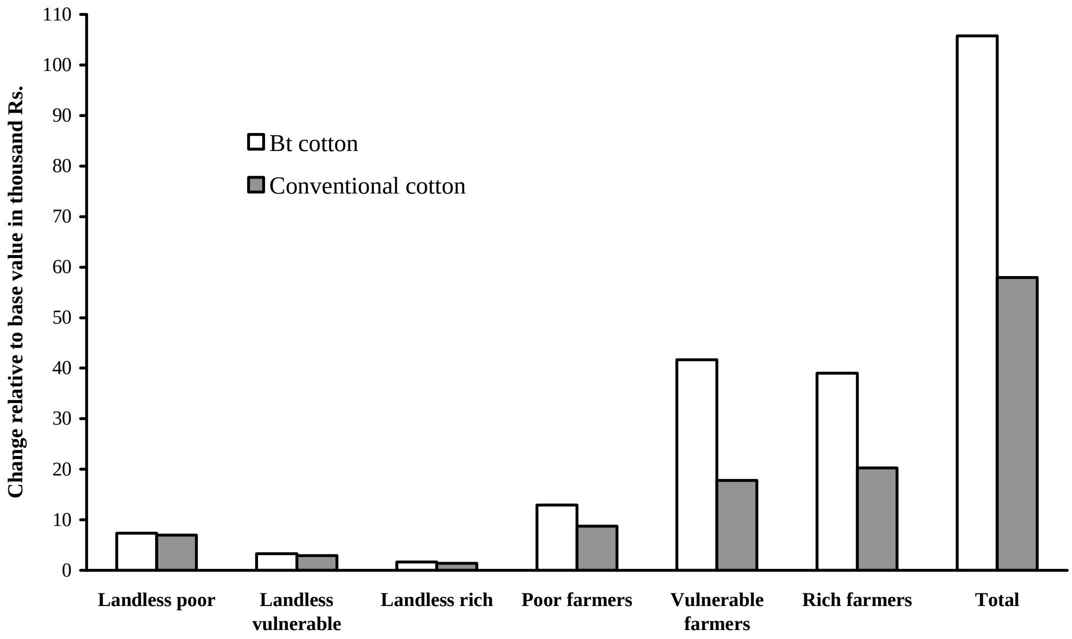

Figure 2. Changes in household incomes from increased Bt and conventional cotton production

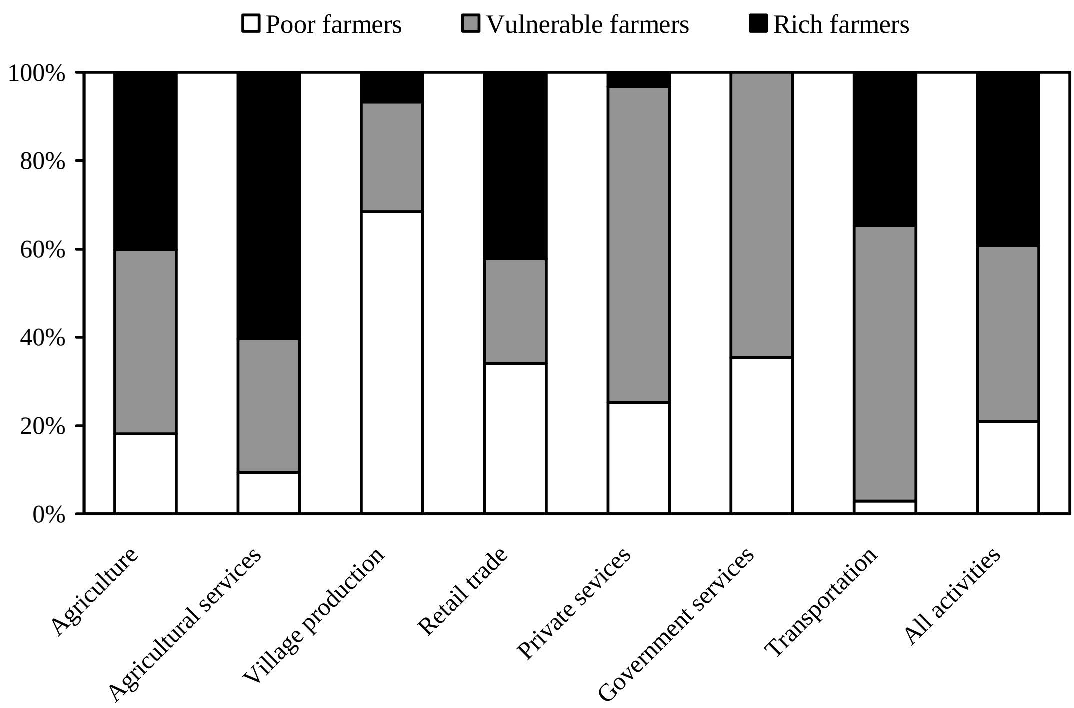

Figure 3. Contribution of farm household categories to different economic activities

Note. The contribution of landless households is not included here.

Appendix

Table A1. Social accounting matrix for Kanzara – activity accounts (in Rs.)

	Activities					
	Bt cotton	Conventional cotton	Food crops	Non-food agriculture	Non-farm	**All**
Bt cotton						
Conventional cotton						
Food crops						
Non-food agriculture						
Non-farm						
All activities						
Food				423279	3179121	3602400
Non-food	124904	1053221	815793	845864	1269439	4109222
Cotton					1655673	1655673
Pesticides	1769	95769	59042			156580
Others	11121	366137	371656	52614	287702	1089229
All commodities	137793	1515127	1246491	1321757	6391935	10613104
Family labour	8813	445629	491967	153381	783425	1883215
Hired labour	42815	859758	508448	320152	2274686	4005858
Permanent labour	6943	73417	75108	71427	30805	257700
Land leased	18067	335595	392005			745667
Capital	38752	953323	630044		395862	2017981
All factors	115390	2667721	2097573	544959	3484778	8910421
Landless poor				49719	98259	147978
Landless vulnerable				45996	48815	94812
Landless rich				13695	140229	153924
Poor farmers	840	165845	405320	100031	153578	825613
Vulnerable farmers	83061	464619	867457	51717	263860	1730715
Rich farmers	100023	535328	645392	216418	206235	1703396
All households	183924	1165792	1918170	477576	910976	4656438
Village temple						
Government					4939	4939
Capital account						
Maintenance	1748	15967	2166	57120	22270	99271
Stock						
ROI	1602	14910	818	30700	584792	632822
Total	440457	5379517	5265217	2432112	11399690	24916994

Table A2. Social accounting matrix for Kanzara – commodity accounts (in Rs.)

	Commodities					
	Food	Non-food	Cotton	Pesticides	Others	**All**
Bt cotton			440457			440457
Conventional cotton			5379517			5379517
Food crops	4777741	487477				5265217
Non-food agriculture	1259284	180356			992472	2432112
Non-farm	4133621	2042294	1736243		3487534	11399691
All activities	10170646	2710126	7556217		4480006	24916995
Food					40241	40241
Non-food						
Cotton						
Pesticides						
Others						
All commodities					40241	40241
Family labour						
Hired labour						
Permanent labour						
Land leased						
Capital						
All factors						
Landless poor						
Landless vulnerable						
Landless rich						
Poor farmers						
Vulnerable farmers						
Rich farmers						
All households						
Village temple						
Government						
Capital account						
Maintenance						
Stock	1394998	376118	58121		40	1829278
ROI	5982094	7207490	498506	156580	1699713	15544382
Total	17547738	10293734	8112844	156580	6220000	42330896

Table A3. Social accounting matrix for Kanzara – factor accounts (in Rs.)

	Factors					
	Family labour	Hired labour	Permanent labour	Land leased	Capital	**All**
Bt cotton						
Conventional cotton						
Food crops						
Non-food agriculture						
Non-farm						
All activities						
Food						
Non-food						
Cotton						
Pesticides						
Others						
All commodities						
Family labour						
Hired labour						
Permanent labour						
Land leased						
Capital						
All factors						
Landless poor	97636	820935	147100	33757		1099428
Landless vulnerable	49345	403726	46900	20660		520631
Landless rich	27190	115037	22800	17892		182919
Poor farmers	583511	1295383	88100	51572	35875	2054441
Vulnerable farmers	788030	885217	143100	107993	266063	2190403
Rich farmers	337603	129162		68042	63870	598677
All households	1883315	3649462	448000	299916	365808	6646500
Village temple				93600	2500	96100
Government						
Capital account						
Maintenance						
Stock						
ROI		1939150	21600	384628	1812544	4157922
Total	1883315	5588612	469600	778144	2180852	10900522

Table A4. Social accounting matrix for Kanzara – household accounts (in Rs.)

	Households						
	Landless poor	Landless vulnerable	Landless rich	Poor farmers	Vulnerable farmers	Rich farmers	**All**
Bt cotton							
Conventional cotton							
Food crops							
Non-food agriculture							
Non-farm							
All activities							
Food	686878	322678	177058	1292751	1603622	984007	5066994
Non-food	142972	83115	37156	386294	584727	392142	1626406
Cotton							
Pesticides							
Others	188715	118234	43264	420963	655673	377352	1804201
All commodities	1018565	524027	257478	2100007	2844023	1753501	8497601
Family labour							
Hired labour							
Permanent labour							
Land leased							
Capital							
All factors							
Landless poor	520	851	800	6711	6976	3378	19236
Landless vulnerable	840	1195	30	1210	3600	12261	19136
Landless rich	10			950	2100	2880	5940
Poor farmers	305	420	40	30175	109405	36135	176480
Vulnerable farmers	1990	2800		55888	94830	58365	213873
Rich farmers	19333	9000	2700	8421	25837	86540	151831
All households	22998	14266	3570	103355	242748	199559	586496
Village temple	3126	2366	3537	11386	6913	8701	36029
Government	2358	1304	1339	4520	7865	5556	22941
Capital account	188432	94772	36470	501833	711001	1003698	2536207
Maintenance	8009	1830	770	14682	181002	30410	236702
Stock							
ROI	117362	112749	109657	398936	666545	262601	1667850
Total	1360850	751314	412821	3134720	4660096	3264026	13583826

Table A5. Social accounting matrix for Kanzara – other accounts (in Rs.)

	Others					
	Village temple	Government	Capital account	Maintenance	Stock	ROI
Bt cotton						
Conventional cotton						
Food crops						
Non-food agriculture						
Non-farm						
All activities						
Food	4545		43215	13145	881910	7895287
Non-food	14000	10041	2253665	308739	84936	1886726
Cotton					858504	5598667
Pesticides						
Others	28841	15225	19645	63734	3928	3195196
All commodities	47386	25266	2316525	385618	1829278	18575875
Family labour						100
Hired labour						1582753
Permanent labour						211900
Land leased						32477
Capital						162871
All factors						1990101
Landless poor						94208
Landless vulnerable						116735
Landless rich						70037
Poor farmers		210				77975
Vulnerable farmers		400				524705
Rich farmers		4580				805542
All households		5190				1689202
Village temple						14492
Government	4656					12568
Capital account	52612	585				
Maintenance	36842	12803				
Stock						
ROI	5125	1260	272878			
Total	146621	45104	2589403	385618	1829278	22282238