



J. Biosci. Res., 2011. Vol. 2(2):99-111

A comparative assessment of BT and non-BT cotton cultivation on farmers livelihood in Andhra Pradesh

LALITHA MAHARANA, P.P. DASH¹, K.N.KRISHNAKUMAR²

¹Environmental Management & Policy Research Institute (EMPRI)

Department of Forest, Ecology & Environment,

Hasiru Bhavana, Doresanipalya Forest Campus, Bangalore 560 078, India.

²Communication and Extension Management

Indian Institute of Forest Management

Po Box 357, Nehru Nagar

Bhopal, Madhya Pradesh- 462003, India

Abstract

This paper explains a comparative study of genetically modified BT cotton and non BT cotton with respect to the demographic and socio-economic conditions of farmers. For the present analysis a total of 112 samples were selected containing a mixture of small & big cotton growers in the villages. Results show that BT cotton cultivation had a significant positive impact on average yields and on the economic performance of cotton growers rather than non-BT cotton growers. In case of utilizing pesticides about three fourth of the non BT cotton farmers were going for high doses (78.15%) of pesticides as compared to BT cotton farmers (42.5%). The comparative analysis of BT & non BT cotton growers with respect to modern management practices like ploughing by tractors, sprinklers irrigation, use of power sprayers etc. clearly revealed that the non BT cotton growers were following more number of modern practices as compared to BT cotton growers. Based upon the findings of the study, suitable suggestions and recommendations are given to improve the current status of knowledge and socio-economy of the farmers. The study was able to bring to focus the current socio-economic position, perceptions and awareness of the farmers and help for enhancement of the same.

Key words: BT cotton, Socio-economic welfare, cost-effectiveness, Warangal

For correspondence: dash03@gmail.com

Introduction

Cotton touches the lives of ordinary people every day, whether as a product or as a means of employment. Cotton, popularly known as 'white gold', is an important commercial crop not only in India but also in many other countries. India ranks second in area among the cotton-growing countries after

China with around 8.9 mha of land under cotton cultivation (Qayam & Sakkhari, 2003). India not only has one of the largest area allocated to cotton in the world, it also has the largest workforce dependent on cotton in the world. More than one million farmers in India are involved in the cultivation of

cotton that contributes immensely to industrial production and export earnings. India produces about 2.86 million tons of cotton lint every year (Datt, 2005). BT cotton has drawn more attention because of genetic modification using modern biotechnology, such as new insect-resistant and herbicide-tolerant cotton varieties and is proving more productive than traditional varieties of cotton. Bt cotton is a variety of cotton genetically modified to contain a gene (*cry1Ac*) of *Bacillus thuringiensis* (Bt), which is foreign to its genome and is a naturally occurring soil bacterium used to control Lepidopteran insects because of a toxin it produces. Smale et al. (2006) provide a review of methods and findings of 47 peer-reviewed 'Bt cotton' papers published since 1996 which suggest that economic benefits are promising even if evidence for a sustained impact is not yet readily apparent. Some of the key papers showing a statistically significant and economic advantage from growing Bt cotton in developing countries of the world are, South Africa (Ismael et al. 2002a,b; Bennett et al. 2003, 2005a, 2006a, Thirtle et al. 2003, Morse et al. 2004, 2005c, Shankar et al. 2007, Morse and Bennett 2008, Morse 2007), Argentina (Qaim et al. 2003), Mexico (Traxler et al. 2001), Indonesia (Manwan and Subagyo 2002), China (Pray et al. 2002, Huang et al. 2002, 2003, Yang et al. 2005a, 2005b), India (Naik 2001, Qaim 2003, Qaim and Zilberman 2003, Pemsil et al. 2004, Bennett et al. 2004, 2005b, 2006b, Barwale et al. 2004, Morse et al. 2005a, 2005b, 2007a, 2007b, Kambhampati et al. 2005, 2006, Crost et al. 2007).

Andhra Pradesh (A.P.) stands 3rd in cotton area in India with 10.22 lakh hectares, next only Maharashtra (29.80 lakh hectares) and Gujarat (16.87 lakh hectares). In A.P. the area under cotton was increased from 3.54 lakh hectares in 1975-76 to all time high of 12.81 lakh hectares during

1998-99 and thereafter fluctuated between 6.97 to 10.46 lakh hectares. The increase in area is mainly due to extension of cotton area to non-traditional area of Telangana districts. The productivity levels reached highest peak of 608 kg lint/ha during 1983-84 and subsequently has gone down ranging from 202 kg lint/ha to 583 kg/ha (Qayam & Sakkhari, 2003). Since the introduction of these GM crops, there have been controversies surrounding its production and other effects on environment. There are two sections of researchers for and against the Bt cotton. The main idea behind approving genetically engineered BT cotton as a commercial crop was that this would increase farmers' income by reducing expenditure on chemical pesticides, which accounts for 70-80% of the total expenditure on hybrid cotton due to the heavy infestation of pest. The failure of the BT cotton has devastated the farmers since they have spent five to six times to buy seeds of BT than the normal seed. In Maharashtra, the adjoining state of Madhya Pradesh, the same story has been repeated. In Vidarbha, primarily cotton growing area in Maharashtra, BT cotton crop has failed miserably (www.biotech-info.net).

According to Sahai (2005, 2007) BT cotton was developed for temperate countries like the US, where pests are limited, chiefly for the tobacco budworm against which the BT toxin is effective. According to Grain 2007, in the first year i.e., in 2002, BT cotton was a disaster, yielding 35 per cent less than the non-BT cotton, even while costing four times more than the non-BT cotton. In the third year, new diseases spread through the soils and the plant. Cattle which grazed BT cotton plants started dying. And in 2006, BT plants started wilting, forcing farmers to harden their hearts and uproot them. Even the bolls formed on these wilted plants did not bear any seeds. According to Gala, 2005 conducted an independent study on BT

cotton on a season-long basis for three years in 87 villages of the major cotton growing districts of AP - Warangal, Nalgonda, Adilabad and Kurnool - and found against BT cotton on all counts. According to Centre for Sustainable Agriculture (CSA) 2004, Warangal has seen hundreds of outraged farmers going on a rampage and demanding just compensation for the failure of BT Cotton that they had sown. A study was conducted in a compact cotton growing area of Khammam district with a fringe of Krishna and Guntur districts in Andhra Pradesh. Farmers had incurred more expenses for growing BT than non-BT cotton. But the result shows a bit good yield in case of non-BT cotton cultivations. (Gmwatch, 2006). There is also a serious concern about the lack of availability of a Package of Practice (PoP) on BT cotton. Plant protection experts feel that even if BT cotton is grown, it needs to have IPM (Integrated Pest Management) technology to reduce other pest infestations. They feel that BT cotton's advantage over non-BT cotton thus needs to be revisited (Centad, 2006). Insect-resistant cotton based on the BT gene has been commercially released in a number of countries, and results suggest that it is having a positive impact on yields, profits, the environment and human health (James, 2002). Analyzed trial data from India which tested BT cotton alongside non-BT (conventional) varieties and concluded that quantities of insecticide can be reduced by about one third relative to non-BT varieties and yield gains can be up to 80% in seasons with bad bollworm attack i.e., typical range may be between 30% and 40% increase (Morse, 2005). Various reports have claimed both successes (e.g., AC Nielsen) and failures (e.g., Shiva and Jafri). The main debate has centred on whether Bt cotton consistently performs better than non-Bt varieties and whether adoption of Bt

varieties results in an economic benefit to producers (Bennett et al. 2006).

In review of all the above situations, this paper will seek to explore some of these issues. The present study primarily analyses the comparative status of Bt and non-Bt cotton cultivating farmers based upon primary and secondary data collection in Warangal. This will also review perceptions of the farmers regarding the socio, cultural, economic & ecological aspects of BT cultivation. And finally some suitable suggestions were provided to improve the socio-economic status of the cotton farmers in the region.

Study area

The study was conducted in Warangal district of Andhra Pradesh, which is one of the leading cotton growing states in India. Warangal district was selected for the study because it was found to be the leading cotton growing districts with in Andhra Pradesh state. The two blocks were selected from Warangal district, Atmakur & Geesukonda. The four villages i.e., Oorugonda, Durgampet, Agrampadu, Akkampet from the block Atmakur, another four villages were Mariyapuram, Ookl, Gollapalli, Gangadevapalli from the block Geesukonda respectively.

The study area lies within 17° 37'.30 and 17° 42'.30' N latitude and 79° 8' 00' to 79° 14' 30' E longitude. It falls under Agro-ecological region 7 of India and Agro-climatic zone V of Andhra Pradesh. It is a part of Musi river basin, a tributary to river Krishna falling under 4D1E3g of the national watershed atlas (Ramdas, 2003). It has a forest cover of 3.70 lakh hectares (tropical dry deciduous and tropical thorny types). The major soil types in the districts are red chalkas (55%), black soils (22%), loamy soils (14%) and sandy loams (9%). The district is generally dry with temperatures ranging between 13° C and 50°

C. The average rainfall has come down to 994mm from 1048 in the past 50 years. About 60% of the total male population is literate while 40% of the total female population is literate. Agriculture is the predominant occupation. Warangal is one of the biggest agricultural markets in Telangana and is known for paddy, cotton and chillies. Cotton has also been a major cash crop since the early 1990's; however the cotton sector has been troubled in recent years, and there was a well-publicized rash of suicides by cotton farmers in 1997-1998. The total area of cotton cultivation is 8, 87,000 ha (hectares) of which approximately 9500 acres were sown by BT cotton in 2002-2003 year (CSA, 2004).

Materials and Methods

Data collection

The data were collected both from primary as well as secondary sources. The primary sources were the sampled BT and non BT cotton growers. Secondary sources were literatures, web sites and other documents. The primary data were collected through personal interview with the selected respondents. Researchers' personal observation of the field situation was also very helpful in making appropriate interpretations of the findings. In order to assess the significant association between the farmer's decision to cultivate BT cotton or not to cultivate BT cotton and other influensary factors, a set of independent variables were selected based on few earlier studies on diffusion of farm innovations, interaction with experts and informal discussion with farmers during pre-survey period. Percentage analysis was done to get the results.

The third stage was the 'Multi stage sampling' scheme which was selection of villages randomly from the selected two blocks. From each selected block four cotton growing villages were selected randomly. Thus the total sample size 112

cotton growers comprising a mixture of small and big cotton growers in the selected villages.

Results

The result shows the analysis of BT cotton and non BT cotton cultivating farmers in order to assess the true conditions and factors related to the choice of species and technology. The major finding and analysis of the study are Comparative analysis of (1) Socio-economic conditions of the farmers. (2) Cultivation details. (3) Adoption of technology (4) Farmers' perceptions with regards to social, economic & environmental issues (5) Awareness about extension service.

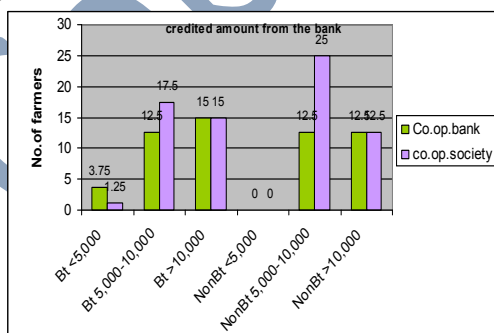
1. Comparative analysis of BT cotton and non BT cotton farmer's socio-economic conditions.

Suitable comparison for various parameters between BT and non BT cotton cultivating farmers was done in order to assess the socio-economic conditions.

A comparative analysis of BT cotton growers and non BT cotton growers with respect to age clearly revealed that most of the BT cotton and non BT cotton respondents were falling in the age class of 40-50 years. It can be inferred that there is not much difference in the ages of the BT cotton and non BT cotton farmers. With respect to family size clearly shows that more BT cotton farmers having small family size (Less than five members) than Non BT cotton farmers. Analysis of various education levels like illiterate, primary level (1-5th), secondary level (5-10th), Senior secondary (12th), college level and higher etc. clearly revealed that the BT cotton farmers were educated where as few non BT cotton farmers were illiterates. But for this, the education level between both categories of farmers seemed to be similar. The educational status was low among the non BT cotton farmers as compared to the BT cotton farmers. Some of the BT cotton

farmers had done their graduation level. Land holding can be classified in the following categories; Less than 1 ha., 1-2.5 ha., 2.5-4 ha. and more than 4 ha. It could be clearly seen that more than half of the farmers were having a land of 2.5-4 ha. It was also assessed whether the farmers were members of various village level institutions (Members in Village panchayats, political party, SHG). BT cotton people are members of all the village level institutions than the non BT cotton farmers. The comparative analysis between BT and non BT cotton farmers with respect to utilization of credit facilities from the co-operative banks was done. It clearly reveals that the BT cotton growers were borrowing more money with respect to non BT cotton growers. Though families are earning good amount of money through farming, they require money as working capital and for other needs. For those needs, the present study found that these people took loan from co-operative banks & co-operative societies and they were no more dependent on money lenders. In the case of BT cotton farmers they were borrowing more money as compared to non BT cotton farmers as the cost of cultivation was high in BT cotton as compared to Non BT cotton (Graph 1).

Graph.1 Comparisons of the BT & non BT cotton farmers with respect to credit facilities



2. Cultivation details about cotton

Cultivation details include the type of varieties used, inputs used, and management practices by the respondent.

2.1. Comparative analysis of BT & non BT cotton growers with respect to cotton varieties grown

A comparative analysis of BT cotton & non BT cotton with respect to the variety grown of cotton i.e. hybrid (Brahma) & BT cotton varieties (Mallika, RCH2) was done. The BT cotton farmers in the study sample mostly grew Nuziveedu seeds (Mallika, Bunny BT cotton) Rasi Seeds' RCH2 by the BT cotton growers. Cotton hybrid varieties like Brahma, Bunny were growing by the non BT cotton growers. The numbers of BT cotton varieties were more. On the other hand, the non-BT cotton hybrids in the sampled village reflected a variety of hybrids like Super Bunny, Brahma, etc. While hybrids were sown by 97.5% under non- BT cotton variety Brahma, 2.75% under super Bunny. The average seed cost in the case of the non-BT cotton farmers was only around Rs. 350/- an acre, compared to Rs. 750/- per acre for the BT cotton farmers. The average extent of BT cotton sown per farmer was 1.9 ha. while in the case of the non-BT cotton, it was 0.8 ha. per farmer where the Non BT cotton practices were adopted.

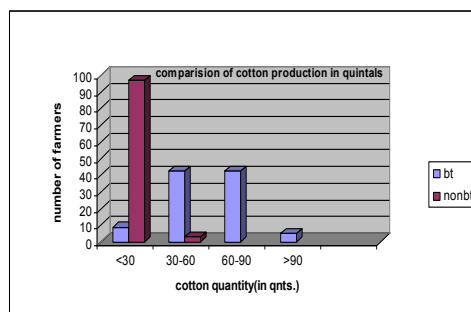
2.2. Comparative analysis of BT & non BT cotton growers with respect to pesticide consumption in agriculture field

The comparative analysis of BT & non BT cotton farmers with respect to pesticide consumption in agriculture fields clearly revealed that the non BT cotton growers were using more pesticides (78.12%) than BT cotton (42.5%) growers. The reason is that BT cotton is meant for act against bollworm. However, it needed pesticide in smaller doses whereas non BT cotton consumes more pesticides.

2.3. Comparative analysis of BT and non BT cotton growers with respect to cotton production in qnts./ha.

The comparative analysis regarding the cotton production clearly revealed that the BT cotton growers were getting more production than non BT cotton growers (Graph 2).

From the above graph, it can be inferred that the production of cotton in case of BT cultivators, mostly in between 30 to 90 q per hectare, whereas for non BT cultivators, the production nearly all cases was less than 30 q/ hac. Thus, it is clearly observable that BT cotton growers were getting more cotton quantity with respect to non BT cotton growers.



2.4. Comparative analysis of BT and non BT cotton growers with respect to overall Economics for cotton cultivation/ha.

A comparative analysis of BT cotton & non BT cotton farmers with respect to total cultivation cost for cultivating cotton like seeds, expenditure on pesticides, average yields, and net returns clearly reveals that BT cotton growers spend more money than non BT cotton farmers as shown in the Table no.1.

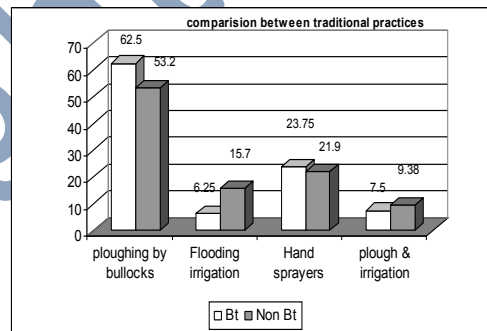
3. Technology adopted

The comparative analysis of BT cotton with non BT cotton farmers with respect to usage of organic inputs like bio fertilizers, compost clearly reveal that the BT cotton growers were using more number of organic fertilizer i.e., composts, bio fertilizers (Table 2.). From the above table no.2, it can be clearly inferred that the number of farmers using compost were much higher in the case with BT cotton as compared to non BT cotton growers with respect to organic

manure. The reason was that the BT cotton farmers are aware about the usage of organic manure which is more useful to crops than chemical fertilizers. In consideration of proper utilization of fertilizers more than half of the respondents growing BT cotton followed recommended doses whereas most of the non BT farmers did not follow any recommended dose.

3.1 Comparative analysis of BT cotton and Non BT cotton growers with respect to traditional management practices

The comparative analysis of BT & non BT cotton growers with respect to traditional management practices like ploughing by bullocks, flood irrigation, use of traditional sprayers etc. clearly reveal that the BT cotton growers were following more number of traditional practices as compared to non BT cotton growers.



Graph.3 Comparison between BT & non BT cotton with respect to traditional practices

The number of farmers adopting traditional practices was much higher in case of BT cotton growers as compared to the non BT cotton farmers except in irrigation. The reason for this difference could be that the BT cotton growers were usually the small farmers as compared to the non BT cotton growers. Mostly small farmers adopted BT cotton because of less risk in terms of pest incidence & cost of cultivation in case of BT cotton than the non BT cotton. However these small farmers found to be less affordable with respect to modern practices like use of tractors, power tillers,

sprinklers irrigation etc. which were commonly used by big non BT cotton farmers.

4. Farmers regards to perceptions of socio-cultural, economic & ecological aspects:

It is essential to know the perceptions of the farmers related to the socio-cultural, economic and ecological aspects of BT cultivation to get their idea and feedback about by cultivation.

4.1. Comparative analysis between BT & non BT cotton regarding the perceptions with respect to social aspects

Social aspects refer to the perception of the farmers with respect to social issues. The comparative analysis between the BT & non BT cotton farmers with respect to social issues clearly revealed that reduction in bollworm is very high in the case of BT cotton where as it is very less in the case with non BT cotton.

From the table no.3 it can be seen that the pest had been controlled by BT cotton where as it could not be controlled by non BT. Both BT cotton and non BT cotton farmers want to go for BT cotton cultivation. From the above table, it can be seen that BT cotton farmers had low pest infestations with regard to cotton crop, whereas non BT cotton growers were having more problems regarding cotton crop. All the respondents indicated that pest attacks were controlled by BT cotton.

4.2 Economic aspects

Economic aspects include the perceptions of the farmers with respect to economic issues of BT cultivation. The comparative analysis of BT cotton growers & non BT cotton growers with respect to economic aspects like crop yield, market price and credit facilities clearly reveal that regarding crop yield BT cotton variety is as good as non BT cotton variety which is shown in the table no.4.

From the above table, it can be inferred that regarding crop yield BT cotton variety is as good as compared to non BT cotton variety. Regarding market price it is very low than the cost of cultivation. More money is needed in the case of BT cotton cultivation.

4.3 Environmental aspects

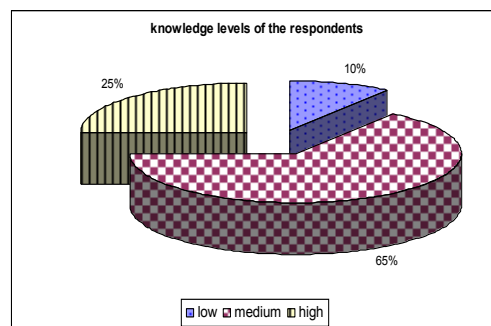
Environmental aspects refer to as the perceptions of the farmers with respect to environment. The comparative analysis of BT & non BT cotton growers with respect to environmental issues can be clearly understood from the furnished table. 5.

The BT & non BT cotton farmers perceptions towards environment was assessed and it can be inferred that both the BT cotton and Non BT cotton farmers do not know about the problems caused by pesticides to the environment. With regards to BT cotton effect on the environment, or any kind of risk to the human beings. Very few BT cotton and most of the non BT cotton farmers have negative effect on soils i.e. soil fertility has been decreased after cultivating BT cotton.

5 Knowledge test of farmers regarding BT cotton:

The comparative analysis between BT cotton and non BT cotton farmers with regards to their knowledge levels towards BT cotton crop is that most of the people are aware up to medium level followed by low awareness & highly awareness (Graph.4).

Graph.4 Comparative analysis between BT & non BT cotton farmers with respect to knowledge



6 Awareness about extension service

This can be referred an individual contact with the extension person regarding information with respect to crop yield and crop protection. The analysis of the cotton growing farmers with respect to awareness towards extension like awareness toward the service clearly reveals that only 36% of the farmers were aware about the service of extension agency (govt.), 3% about other non-government agency and 61% farmers were even not aware about such a service which is operating in their village. The reason may be the extension people were not working properly, and their information is limited to very few people only. The analysis of the cotton growing farmers with respect to trainings conducted by extension service clearly revealed that most of the people did not get any kind of training about the extension service. Very few people only get some kind of training with regards to crop protection, crop improvement. The type of media used by farmers is also important to design suitable extension strategy.

From the above table.6 it can be concluded that newspaper was the major source for getting information related to cultivation among the farmers as 69.6% of the farmers used it. This was followed by radio (59.8%) and T.V (23.21%).

Discussions and Conclusion

The principal reason for the introduction of BT cotton in India in 2002 was its reported ability to make the cotton plant resistant to bollworm the most dreaded cotton pest in India. However, there were lots of controversies surrounding its cultivation. BT cotton technology adoption has been inconsistent in India and most farmers have not maintained the mandated agriculture production regime needed to keep the technology effective.

Although the production in case of Bt cotton crop was high, the input cost of Bt

cultivation was also substantially high. Developing varieties that require fewer inputs need to be emphasized. Most of the farmers cultivating farmers were belonging to medium land holding. Diversification of agriculture by introduction of suitable intercrops and multicropping need to be emphasized as there was excess dependence on cotton crop. Integrated pest management with emphasis on vermicomposting and other organic fertilizers needs to be introduced, as the present consumption of pesticides was very high in the area. There was also a felt need for planning proper awareness and information dissemination methods on various issues like selection of variety, dosage of fertilizers & pesticides, etc. Extension services were very poor in the sample villages and there was a complete lack of knowledge among the farmers about the extension activities and extension agents in the village. The various Governmental and non- Governmental extension agencies need to increase frequency of visits to the area and make farmers aware. Also, there was lack of knowledge among farmers about whom to contact for BT related queries. The agencies supplying the seeds in the area needs to make sure that the process does not stop only with the seed supply but also involves discussions and feedback of farmers. Distribution of leaflets and pamphlets may be done to increase awareness about BT and agriculture. They may be distributed along with morning newspaper as most of the respondents read newspaper. The study findings are helpful as a baseline study to NGOs and Government bodies working with the BT farmers. State Government can make certain implementation and policy changes in order to improve the status of cotton farmers.

Acknowledgement

The authors are thankful for support provided by panchayats sarpanch, farmers

for the data collection. We also thank IIFM for technical support.

References

- Barwale, R. B., V. R. Gadwal, U. Zehr, and B. Zehr. 2004. Prospects for Bt cotton technology in India. *AgBioForum* 7 (1&2), 23-26
- Bennett, R., T. J. Buthelezi, Y. Ismael, and S. Morse. 2003. Bt cotton, pesticides, labour and health. A case study of small holder farmers in the Makhathini Flats, Republic of South Africa. *Outlook on Agriculture* 32 (2), 123-128.
- Bennett, R. M., Y. Ismael, U. Kambhampati and S. Morse. 2004. Economic impact of genetically-modified cotton in India. *AgBioforum* 7(3), 1-5.
- Bennett, R. N., Y. Ismael, S. Morse, and B. Shankar. 2005a. Reductions in insecticide use from adoption of Bt cotton in South Africa: Impacts on economic performance and toxic load to the environment. *Journal of Agricultural Science* 142, 1-10.
- Bennett, R. M., Y. Ismael and S. Morse. 2005b. Explaining contradictory evidence regarding impacts of genetically modified crops in developing countries. Varietal performance of transgenic cotton in India. *Journal of Agricultural Science* 143, 35-41.
- Bennett, R., S. Morse, and Y. Ismael, 2006a. The economic impact of genetically modified cotton on South African smallholders: yield, profit and health effects. *Journal of Development Studies* 42 (4), 662-677.
- Bennett, R. M., U. Kambhampati, S. Morse, and Y. Ismael. 2006b. Farm-level economic performance of genetically-modified cotton in India. *Review of Agricultural Economics* 28 (1), 59-71.
- Centad. 2006. Centre for trade & development. Indian cotton farming at the cross roads Focus (Feb, 2006). Centad Newsletter
- Centre for Sustainable Agriculture. 2004. BT Cotton Fails Yet Again in India - farmers go on rampage.
- Crost, B., B. Shankar, R. Bennett, and S. Morse. 2007. Bias from farmer selfselection in GM crop productivity estimates: Evidence from Indian Data. *Journal of Agricultural Economics* 58(1) 24-36.
- Datt, Kunal. 2005. Bt Cotton or Better Cotton? *Biotechnology Development Monitor*, 44, 15-19.
- Gala, Rhea. 2005. India's BT cotton fraud, Institute of science & society, Study rejects BT cotton; OUR ECONOMY BUREAU, Friday, March 18, 2005, Financial express.
- Grain. 2004. New studies contradict FAO report and show that genetically engineered BT cotton fails to benefit farmers, www.grain.org
- Gmwatch. 2006. New study exposes Monsanto's BT cotton hype.
- Huang, J. K., R. F.Hu, C. Pray, F. B. Qiao, and S. Rozelle. 2003. Biotechnology as an alternative to chemical pesticides: A case study of Bt cotton in China. *Agricultural Economics* 29 (1), 55-67.
- Huang, J. K., R. F. Hu, S. Rozelle, F. B. Qiao, and C. E. Pray. 2002. Transgenic varieties and productivity for smallholder cotton farmers in China. *Australian Journal of Agriculture and Resource Economics* 46 (3), 367-387.
- Ismael, Y., R. Bennett, and S. Morse. 2002a. Farm-level economic impact of biotechnology: smallholder Bt cotton farmers in South Africa. *Outlook on Agriculture* 31(2), 107-111.
- Ismael, Y., R. Bennett and S. Morse. 2002b. Benefits from Bt cotton use by smallholder farmers in South Africa. *AgBioForum* 5 (1), 1-5.
- James, C. 2002. Global review of commercialized transgenic crops: 2001 (ISAAABrief No.26-2001).

- Kambhampati, U., S. Morse, and R. Bennett. 2006. Farm-level performance of genetically-modified cotton: A Frontier Analysis of cotton production in Maharashtra. *Outlook on Agriculture* 35 (4), 291-297.
- Kambhampati, U., S. Morse, R. Bennett, and Y. Ismael. 2005. Perceptions of the impacts of genetically modified cotton varieties: A case study of the cotton industry in Gujarat, India. *AgBioForum*, 8 (2&3), 161-171.
- Manwan, I. and T. Subagyo. 2002. *Transgenic cotton in Indonesia: Challenges and opportunities*. Paper presented at the regional workshop for the South East Asian Biotechnology Information Centers, Philippines.
- Morse, S. and R. M. Bennett. 2008. Impact of Bt cotton on farmer livelihoods in South Africa. *International Journal of Biotechnology*.
- Morse, S., R. Bennett and Y. Ismael. 2004. Bt cotton boosts the gross margin of small-scale cotton producers in South Africa. *Nature Biotechnology* 22(4), 379-380.
- Morse, S., R. M. Bennett and Y. Ismael. 2005a. Comparing the performance of official and unofficial genetically modified cotton in India. *AgBioforum* 8(1), 1-6.
- Morse, S., R. M. Bennett and Y. Ismael. 2005b. Genetically modified insect resistance in cotton: Some economic impacts in India. *Crop Protection* 24(5), 433-440.
- Morse, S., R. Bennett and Y. Ismael. 2005c. Bt-cotton boosts the gross margin of small-scale cotton producers in South Africa. *International Journal of Biotechnology* 17(1/2/3), 72-83.
- Morse, S., R. M. Bennett and Y. Ismael. 2007a. Isolating the 'farmer' effect as a component of the advantage of growing genetically modified varieties in developing countries: A Bt cotton case study from Jalgaon, India. *Journal of Agricultural Science* 145 (5), 491-500.
- Morse, S., R. M. Bennett and Y. Ismael. 2007b. GM crops: Real benefits for resource-poor farmers in developing countries or greater inequality? *AgBioforum* 10 (1), 44-50.
- Naik, G. 2001. *An Analysis of Socio-Economic Impact of Bt Technology on Indian Cotton Farmers*. Ahmedabad, India, Centre for Management in Agriculture, Indian Institute of Management.
- Pemsl, D., H. Waibel and J. Orphal. 2004. A methodology to assess the profitability of Bt cotton: Case study results from the state of Karnataka, India. *Crop Protection* 23 (12), 1249-1257.
- Pray, C. E., J. K. Huang, R. F. Hu and S. Rozelle. 2002. Five years of Bt cotton in China – the benefits continue. *Plant Journal* 31 (4), 423-430.
- Qaim M., E. J. Cap, and A. de Janvry. 2003. Agronomics and sustainability of transgenic cotton in Argentina. *AgBioForum*, 6(1&2), 41-47.
- Qaim, M. 2003. Bt cotton in India: Field trial results and economic projections. *World Development* 31(12), 2115-2127.
- Qaim, M. and D. Zilberman. 2003. Yield effects of genetically modified crops in developing countries. *Science* 299, 900-902.
- Qayam, Abdul and Kiran Sakkhari. 2003. Did BT Cotton Save Farmers in Warangal?, AP Coalition in Defence of Diversity and Deccan Development Society, Hyderabad, June 2003
- Ramdas, R, Sagar. 2003. Strategies for for livestock development in watershed management, anthra report.
- Sahai, Suman. 2005. The science of BT cotton failure in India, Opinion, The Hindu, Aug 29, 2005

Sahai, Suman. 2007. BT cotton: What's the fuss about?_Info Change News & Features, March 2007

Shankar, B., R. M. Bennett and S. Morse. 2007. Output risk aspects of genetically modified crop technology in South Africa. *Economics of Innovation and New Technology* 16(4), 277-291.

Shankar, B., R. M. Bennett, and S. Morse. 2007. Production Risk, Pesticide Use and GM Crop Technology in South Africa. *Applied Economics*.

Smale, M., P. Zambrano, & M. Cartel. 2006. Bales and balance: A review of the methods used to assess the economic impact of Bt cotton on farmers in developing economies. *AgBioForum* 9(3), 195-212.

Thirtle, C., L. Beyers, Y. Ismael, and J. Piesse. 2003. Can GM technologies help the poor? The impact of Bt cotton in Makhathini Flats, KwaZulu-Natal. *World Development* 31(4), 717-732.

Traxler, G., S. Godoy-Avila, J. Falck-Zepeda, and J. Espinoza-Arellan. 2001. *Transgenic cotton in Mexico: Economic and environmental impacts*, Auburn, AL: Auburn University.

Yang, P. Y., M. Iles, S. Yan. and F. Jolliffe. 2005a. Farmers' knowledge, perceptions and practice in transgenic Bt cotton in small producer systems in Northern China. *Crop Protection* 24(3), 229-239.

Yang, P. Y., K. W. Li, S. B. Shi, J. Y. Xia, R. Guo, S. S. Li, and L. B. Wang. 2005b. Impacts of transgenic Bt cotton and integrated pest management education on smallholder cotton farmers. *International Journal of Pest Management* 51 (4), 231- 244. <http://www.biotech-info.net>

Table.1 Comparative analysis of BT and non BT cotton growers with respect to overall economics for cotton cultivation/ha

S. No.	Cultivation details	BT cotton respondents	non BT cotton respondents
1	Total cost of cultivation/hectare (Rs.)	20,000	10,000
2	Cost of seeds/hectare(Rs.)	1,875	775
3	Expenditure on pesticides/Ha (Rs.)	1,000	1,500
4	Average yields/Ha (qnt.)	30-40	15-20
5	Net returns/Ha(Rs.)	80,000	35,000

Table. 2. Comparative analysis between BT & non BT cotton farmer with respect to usage of organic inputs

S.No.	Usage of organic fertilizer	BT cotton respondents		Non BT cotton respondents	
		No.	Percentage	No.	Percentage
1	biofertilizers	0	0.00	0	0.00
2	Compost	48	60.00	12	37.5
3	vermicompost	0	0.00	0	0.00
4	none	32	40.00	20	62.5

Table. 3. Comparative analysis of BT & non BT cotton farmers with respect to their perceptions towards social aspects

S.No.	Social aspects regards to BT cotton	BT cotton respondents		Non BT cotton respondents	
		no	percentage	no	percentage
1	Reduction of Boll worm				
	yes	75	93.75	11	34.37
	no	5	6.25	21	65.6
2	Pest has controlled as compared to hybrid cotton				
	yes	80	100	3	9.37
	no	0	0.00	29	90.6
3	Again want to go for BT cotton				
	yes	77	96.25	5	9.37
	no	3	3.75	27	84.4

Table.4. Comparative analysis of BT & non BT cotton farmers with respect to their perceptions towards economic aspects

S.No.	Economic aspects	BT cotton respondents		Non BT cotton respondents	
		No.	percentage	No.	percentage
1	Regarding crop yield it is good				
	yes	79	98.75	5	15.60
	No	1	1.25	27	84.40
2	Regarding market price for cotton good/bad				
	yes	40	50.00	5	15.60
	No	40	50.00	27	84.40
3	For more credit the respondent to borrow from bank				
	yes	80	100.00	24	75.00
	No	0	0.00	8	25.00

Table.5 Comparative analysis of BT & non BT cotton farmers with respect to their perceptions towards environmental aspects

S.No.	Environmental aspects	BT cotton respondents		Non BT cotton respondents	
		No.	percentage	No.	percentage
1	BT cotton cause harmful effect on environment				
	yes	0	0.00	0	0.00
	no	0	0.00	0	0.00
	Don't know	80	100.00	32	100.00
2	BT cotton cause harmful effect to humans				
	yes	0	0.00	0	0.00
	no	0	0.00	0	0.00
	Don't know	80	100	32	100
3	Pesticides have a negative effect on environment				
	yes	1	1.25	1	3.125
	no	0	0.00	0	0.00
	Don't know	79	98.75	31	96.9
4	Any changes occurred after BT cotton cultivation to the environment				
	yes	16	20.00	31	96.8

	no	23	28.00	0	0.00
	Don't know	41	52.00	1	3.12
5	BT cotton effects on soil				
	yes	16	20.00	28	87.5
	no	6	7.5	0	0.00
	Don't know	58	72.5	4	12.5

Table. 6. Media and awareness

	Radio	T.V	Newspapers	Personal meetings	Demonstrations
frequency	67	26	78	9	5.00
percentage	59.8	23.21	69.6	8.04	4.50