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Pesticide Applications in Bt Cotton Farms: Issues Relating to Environment and Non-Tariff Barriers

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Abstract

Ever since the introduction of Bt cotton in India, the acreage under Bt has been steadily increasing in the country, particularly in Gujarat. This paper was undertaken to examine various aspects of farm level adoption of Bt cotton in Gujarat as well as explore the issues relating to environment and non-tariff barriers affecting the cotton trade of India. The farm level analysis reveals that the Bt cotton adoption is nearly complete with 90 per cent of cotton land under Bt cotton. Except 1 per cent of the land which is under Bollgard II, the rest of the Bt cotton area is under Bollgard 1 variety, which aims at controlling the incidence of bollworms. Hence, a sizeable per cent of pesticide applications has been aimed at sucking pests. Interestingly, farmers growing both approved and unapproved Bt varieties seem to undertake almost equal amount of care for control of pests through increased number of chemical sprays than scientifically recommended. Almost 70 per cent of the farmers use more than one chemical in pesticide applications, which is widely cautioned by entomologists. The latter part of the paper argues that though India's exports of cotton have increased in recent years, the export prospects suffers from two main issues of contamination and non-tariff barriers. The US, Mexico and EC are known for levying a number of non-tariff barriers. EU has even brought out a legislation called 'REACH' which requires the Indian exporters to get their products tested and certified that they do not contain any hazardous chemicals. The paper concludes that since a large number of pesticide application take place especially among the marginal land holdings, appropriate extension services and IPM programs would help in rationalising the use of pesticides in cotton in India, which might help the industry in the emerging context.

Keywords : Bt cotton, pesticide, environment, non-tariff barriers
JEL Codes : Q12, Q56

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Pesticide Applications in Bt cotton Farms: Issues Relating to Environment and Non-Tariff Barriers

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1. Introduction

Livelihood of about 60 million people depends directly and indirectly on cotton cultivation, processing, trade and textiles. Textiles including raw cotton contribute 20.24 per cent of India's exports (Barik and Gautam, 2009). Production of cotton in India which was 142.3 lakh bales in 1996-97 had dropped to 86.24 lakh bales in 2002-03, but increased steeply to reach 258.06 lakh bales in 2007-08 (advance estimates, as on 9 July 2008)[1], thanks to wide scale adoption of genetically modified (GM) cotton in India. The higher yield has been achieved with a relatively higher use of chemical inputs particularly pesticides. Cotton cultivation in India which accounts for about 5 per cent of the total land under cultivation uses nearly 50 per cent of the pesticides produced in India (Shetty, 2004; Barik, 2009). Continuous use of pesticides does irreversible damage to environment, health of human being and livestock besides increasing the cost of cultivation.

An additional impact to be added to this list is the potential of pesticide use affecting the trade prospects due to the pesticide residue causing chemical contamination in agricultural products. This new dimension of pesticide impact on trade comes in the form of non tariff barriers/non tariff measures (NTMs) or sanitary and phytosanitary measures (SPS) that are known as technical barriers to trade (TBT). Non Tariff Measures (NTMs) are all measures other than normal tariffs namely trade related procedures, regulations, standards, licensing systems and even trade defense measures such as anti-dumping duties etc which restrict trade between nations. The recorded use of NTMs in international trade has been on the rise with the lowering of tariffs in the member countries of WTO which accelerated

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[1] Agriculture Statistics Division, GOI, available at http://dacnet.nic.in/eands/Advance_Estimate/4_advance_2007-08.pdf (accessed on 27 September 2008).

since the conclusion of the Uruguay Round in 1994 (Sandrey, *et al.*, 2008). NTMs are used as entry barriers and could be subjective. For instance, banning import of an agri biotech product by a country could be viewed as a trade restricting measure by another[2]. Recently, the American labour department has singled out six products, hybrid cotton seeds, bricks, stones, embroidered textiles, garments and rice, which when exported should have special certification that these products did not use forced or indentured child labour[3].

In the backdrop of the increasing cotton exports from India in recent years, this paper attempts to understand and analyse whether pesticide residue in cotton is becoming a barrier in exports? We also use the farm level data from Gujarat in order to examine whether the GM technology has helped the farmers reduce their pesticide use in cotton which will minimize residue levels on the output with a positive impact on trade. With this focus in mind, in Section 2 we analyse the cotton scenario in India and Gujarat. The third section discusses the pesticide use pattern among the cotton farmers in Gujarat. Section 4 discusses the export scenario and the NTMs. The fifth section presents the conclusion.

2. Cotton Scenario in India and Gujarat

Cotton is an important cash crop, grown in more than 9.5 million hectares spread over 9 states in India. These nine states are Gujarat, Maharashtra and Madhya Pradesh (Central zone), Punjab, Haryana and Rajasthan (North Zone) and Karnataka, Tamil Nadu and Andhra Pradesh (South Zone). Though India's share in world cotton area has stagnated and increased only marginally from 24 per cent in 1961-62 to 28 per cent in 2007-08, production during the same period has increased from 8 to 16 per cent (21 per cent according to the Cotton Advisory Board, Table 1). Increasing production in recent years has resulted in reducing the gap in cotton production between the world and India from 338 KG lint per hectare in 2001-02 to 212 KG lint per hectare in 2007-08. The average yield per hectare for all India in

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2 The case between Canada and European Commission (EC) was based on the measures taken by EC which were affecting the import of agri biotech products from Canada. http://www.wto.org/english/tratop_e/dispu_e/cases_e/ds292_e.htm (accessed on 13 August 2010).

3 http://www.dnaindia.com/india/report_prove-zari-isn-t-made-by-child-labour-us-tells-india_1422226 (accessed on 13 August 2010).

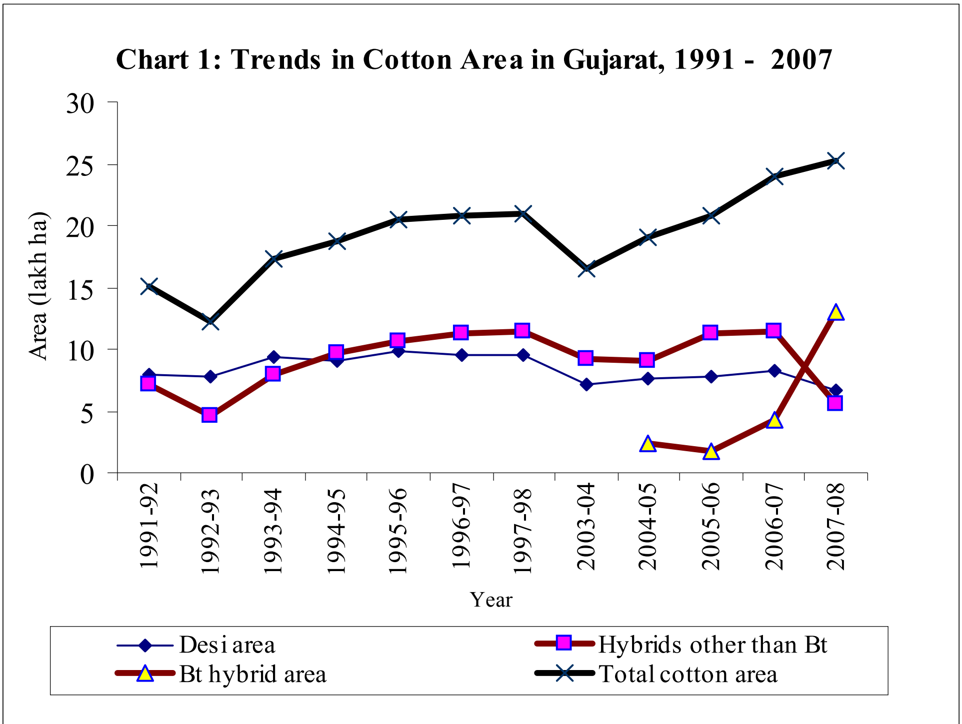
2007-08 has been 563 (KG lint per hectare) with yield levels above the national average reported from Gujarat (743/ ha), Tamil Nadu (691/ha), Andhra Pradesh (667/ha) and Punjab (630/ha).

Table 1: Share of India in Global Cotton Area and Production

Year	Area (million ha)			Production (Lakh bales)		
	World	India	%	World	India	%
1961-62	32.77	7.98	24	57.75	4.85	8
1971-72	32.98	7.8	24	76.59	6.95	9
1981-82	33.84	8.06	24	88.53	7.88	9
1991-92	33.03	7.66	23	111.84	9.71	9
2001-02	33.38	9.13	27	126.41	10	8
2005-06	34.19	8.68	25	145.64	18.5	13
2007-08	33.6	9.55	28	152.35	24.35	16
				CAB	31.5	21

Note: CAB stands for Cotton Advisory Board.

Source: Barik and Gautam (2009).



Note: Data were compiled from Season and crop report for the years 1991-92-1997-98 and data from 2003-04 were obtained from the Department of Agriculture, Government of Gujarat.

Though Gujarat has the credit of developing the first cotton hybrid (H4, from the Gujarat Agricultural University, Surat) in the 1970s, large scale adoption of hybrids has surpassed the area under the *G.Arboreum* (desi cotton) in the mid 1990s (Chart 1). This scenario further changed with the introduction of GM/ Bt cotton. The *G.Arboreum* variety is known for its drought tolerance and resistance to pests. The *G. Hirsutom*-hybrid varieties which were much sought after by the farmers are long staple varieties and are susceptible to both sucking pests and bollworms. Bacillus Thuringencis (Bt) is a naturally occurring bacterium that acts against the bollworm in cotton plants. Plant biotechnology has enabled that the Bt trait is introduced in the plant itself through the seeds, by which the entire plant acts against the pests. The main advantage of Bt cotton is believed to be its trait –the Cry 1 AC gene (referred to as single gene) that protects the crop from bollworm, tobacco budworm and pink bollworm, which are the major pests that attack cotton in all the cotton growing parts of the world. The remaining important pests include the aphids, jassids, leafhoppers, mirids, mites, stinkbugs, thrips and whiteflies. The importance of these pests in cotton varies regionally (Showalker, *et al.*, 2009). Recognizing the ineffectiveness of the Cry 1 gene on the whole range of sucking pests, scientists have now introduced Bollgard II, which produces two distinct toxins –Cry 1 AC and Cry 2 AB to delay the pest resistance. "This is called pyramid strategy. The pyramid strategy is expected to be most effective when: the majority of susceptible pests are killed by the transgenic crop, resistance to each toxin is recessive, refuge is present and selection with either of the toxins does not cause cross resistance to the other" (Showalker, *et al.*, 2009). Bollgard II (double Bt to use farmers' parlance) referred to as multiple gene which is supposed to provide protection against both bollworms and the sucking pests, has been adopted by farmers in India in recent years (Table 2).

Table 2: Adoption of Single and Multiple Gene Bt Cotton Hybrids in India (million hectares)

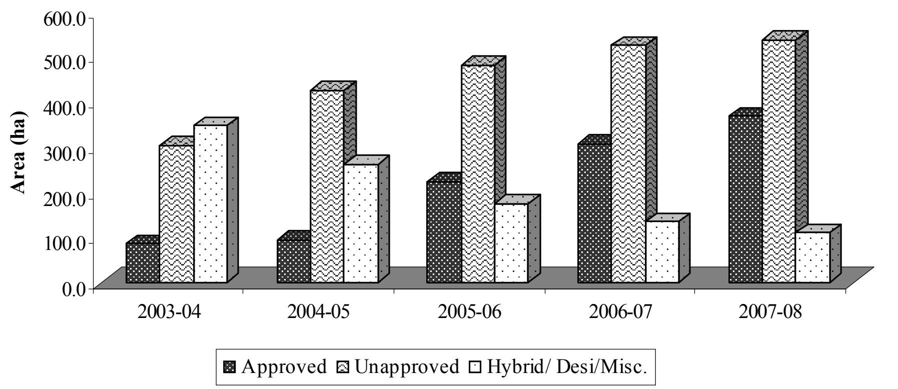
Number of gene	2005	2006	2007	2008	2009
Multiple	-	0.15 (4)	0.46 (8)	2.04 (27)	4.82 (57)
Single	1.3 (100)	3.65 (96)	5.74 (92)	5.56 (73)	3.58 (43)
Total	1.3 (100)	3.8 0(100)	6.20 (100)	7.60 (100)	8.40 (100)

Note: Figures within parentheses indicate the percentages

Source: Chaudhury and Gaur (2010); Table 4.

In 2002, Government of India provided approval for the introduction of three Bt cotton varieties (Cry 1 AC gene) viz, Mech 161, Mech 112 and Mech 184 including in the state of Gujarat. By the time the approved varieties were planted in Gujarat in 2002, it came to limelight that the farmers were also planting on a large scale another Bt variety that was not commercially approved by the Government of India. While the widespread adoption could not be prevented as farmers found the yield difference between the approved and unapproved variety to be negligible (Lalitha *et al.*, 2007), yet it had contributed to bringing in more area under Bt cotton which increased from 2.34 lakh hectares in 2003-04 to 13 lakh hectares in 2007-08 bringing about 453.8 per cent rise in the area under Bt and thereby the area under cotton increased by 67.56 percent from 1991-92 – 2007-08[4]. In 2005, the Government of India approved more Bt varieties for commercial cultivation and thus there were 70 Bt varieties available before farmers in the central region (which includes Gujarat) to choose in 2007. In spite of the fact that more approved varieties are available, the unapproved varieties are still sought after by the farmers in Gujarat as shown by chart 2.

Chart 2. Area under varieties of cotton in Gujarat



Note: Misc. includes those varieties where farmers did not know the name of the hybrid variety.

Source: Farm Household Survey by GIDR, 2007.

4 "Although many of the details concerning variability in Cry 1 AC expression and toxin content remain unknown, it is clear that the genetic background of a transgenic plant plays a significant role in Bt toxin production and efficacy against insect pests. For this reason, careful plant breeding and testing are necessary to optimize the efficacy of transgenic cotton. Not only should breeders rigorously select the genetic background of their transgenic cotton plants, but these plants also should undergo stringent laboratory and field testing to ensure optimal transgene expression and efficacy under local growing conditions" (Showalker, *et al.*, 2009: 60).

Chart 2 denotes that in 2003-04 when the hybrids and desi varieties were still occupying a larger share of land as compared to unapproved Bt, the area under the approved Bt was very small, which remained the same during 2004-05 as well. However, a policy intervention reducing the price of the seed of the approved variety to Rs.750 per a pack of 450 grams in 2005 from Rs. 1600 that was prevalent from 2002 as well as the availability of more varieties to the farmers have resulted in significant increase in area under approved Bt cotton in Gujarat. Interestingly, the area under unapproved varieties continued to be higher than the area under the approved variety, which makes the Gujarat cotton farmers a distinct group in the Indian context.

3. Bt Technology and its Impact on Pesticide Use

Studies done elsewhere bring out the favorable impact of Bt cotton in reducing the pesticide use. For example, assessing the impact of Bt cotton in China, Pray *et al* (2001) observe that the Bt cultivators could substantially reduce or eliminate the use of pesticides to control bollworm during the middle and late part of the season. Their study carried out during 1999, notes that majority of the farmers could reduce the number of sprays from 12 to 3 or 4 sprays. Hence, assuming that 320,000 hectares were under Bt cotton cultivation, it had resulted in reduction in pesticide use by 15,000 tons. Their study observes that reduction has also occurred in organophosphates some of which have been banned due to their adverse impact on health and environment.

A recent study done in China (Huang *et al.*, 2009) emphasise that introduction of Bt cotton led to significant decrease in the use of bollworm insecticide. However, late in the season some insecticides were required to control which varied in magnitude in different locations. The authors also note that Bt cotton in China has been managed with a fairly stable but sill quite a high level application of insecticides. They note that the insecticide use could be further reduced through education and agri insurance. The authors found that Bt cotton growers' insecticide use ratio at 10 KG/hectare is higher than the optimum as farmers used more than what is recommended in the label.

Edge *et al.*, (2002) observe that the total number of spray reductions per hectare for all arthropod pests ranged from 1.0 to 7.7 sprays and an average reduction of 3.5 sprays per hectare was achieved by Bt cultivators, which had resulted in an estimated loss of $200 to $300 million a year for the pesticide manufacturers. Hence, assuming an average reduction of 2.2 sprays per hectare on the 972,000 hectare cotton produced in 1998 in the US, they conclude that 962 280 KG insecticide active ingredient did not enter the environment and local watersheds thus reducing the potential exposure to non-target animals.

Similarly, Qaim and Janvry (2005) report that in Argentina, Bt farmers on an average used 50 per cent less insecticides on their Bt plots than on plots grown with conventional cotton. Almost all the reductions occurred in a highly toxic chemical, which emphasizes the positive effect of Bt on the environment.

In Columbia, use of Bt cotton is not associated with a significant reduction in insecticide use. As Boll-weewil is the major pest in cotton in Columbia, Bt growers spend more on insecticide than farmers growing conventional varieties (Zambrano *et al*., 2009).

In South Africa, on an average, Bt variety reduced the number of insecticide sprays to three. Though the Bt adaptors still sprayed against pests such as aphids, jassids and thrips, yet the reduction of three sprays for bollworm would reduce the costs, amount of labour and the distance walked carrying the knapsack (Bennett *et al*., 2006).

In the context of India, the scientific research by Kranthi *et al*., (2005) found that the commercial Bt cotton hybrids introduced in India express less than the critical levels of Cry1Ac gene required for full protection against bollworms late in the season and in some plant parts. Hence, they observe that the "Bt cotton hybrids in India may require more supplemental insecticide sprays than being used in Bt cotton varieties elsewhere in the world". However, studies that have been carried out so far tend to analyse the pesticide use on Bt *vs* non Bt and have not focused on the varietal differences within Bt or hybrids.

Qaim (2001) and Indira *et al.,*[5] (2004) clearly bring out the advantages of Bt cotton in pesticide reduction over hybrids and conventional cotton variety.

[5] Qaim's study is based on the field trial data of Mahyco-Monsanto and Indira *et al* (2004) had carried out a survey of farmers who participated in the field trial in 2001.

In Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh, during the 2002 season, Bt cotton required 2.6 times less pesticide sprays than conventional cotton, which had a positive impact on yield due to less crop losses. However, these savings in pesticide reduction did not compensate for the higher seed costs incurred by farmers on Bt seeds (Naik *et al*., 2005).

Narayanamoorthy and Kalamkar (2006) analysed the performance of Bt cotton in two districts of Maharashtra. Their analysis of inputs on Mech 184 and Mech 162 compared to other non-Bt varieties shows that Mech 184 consumed less pesticide as compared to Mech 162 and both the Bt varieties together consumed more pesticides than the non-Bt varieties.

The study carried out by Mahendra Dev *et al*., (2006) in four districts of Andhra Pradesh point out that farmers use insecticides as a precautionary measure or on noticing any pests on the plants without any regard to the threshold limits of the pests. Hence, the cost of insecticide is likely to be more than the benefit it provides. Nevertheless their study proves that the cost of insecticide in Bt cotton reduced by 18.2 per cent over non-Bt cotton and the number of sprays on an average have reduced from 12 in non Bt cotton to 9 in Bt cotton.

Gandhi *et al*.'s study (2007) carried out in Maharashtra, Gujarat, Andhra Pradesh and Tamil Nadu observes that adoption of Bt cotton has resulted in significant reduction in cost of production as pesticide use reduced by as much as 36 per cent in Maharashtra and Andhra Pradesh. In Tamil Nadu it reduced by 50 per cent.

Lalitha and Ramaswami (2007) analyzing the pesticide use among the cotton cultivators in Gujarat during the kharif 2003-04 observe that approved Bt variety required as many as 6.3 number of sprays per hectare, while hybrids and unapproved varieties required an average of 5.9 and 4.6 sprays respectively. Desi cotton required the least of just 0.25 sprays. Of the total of 1926 sprays on the cotton crop, 35, 48 and 17 per cent have been sprayed against bollworm, sucking pests and the other pests respectively. Thus, it emerges that during 2003-04 farmers had to spray an average of 1.8 times on sucking pests as compared to 1.3 times on boll worm.

The study by Lalitha *et al*. (2009) on Gujarat and Maharashtra highlights the differences in pesticide use between both the states. In Gujarat, an average of 7.39 number of sprays was sprayed on the approved Bt, while an average of 6.91 sprays were used in the unapproved variety. However in Maharashtra, Bt cotton required an average of 3.23 number of sprays as against 3.35 sprays on non Bt cotton.

Subsequent to the introduction of Bt cotton in India, cotton consumed only 18 per cent of the total pesticides market in 2006 compared to a much higher share of 30 per cent in 1998. Similarly, the market share of cotton insecticides as percentage of total insecticides declined from 42 per cent in 1998 to 26 per cent in 2006 (Choudhary and Gaur, 2010).

Thus, while a majority of the studies indicate a reduction in the pesticide use on Bt cotton, in the rest of the paper we attempt to probe whether pesticide use pattern differ significantly across different size groups of farmers and what kind of pesticides are being used by the Bt cotton farmers in Gujarat. The farm level information has been collected through a household survey carried out by the GIDR during Kharif 2007-08. The survey was conducted in five districts of Gujarat, namely Rajkot, Bhavnagar, Baroda, Surendranagar and Ahmedabad involving a total sample size of 200 farmers selected at random. The information regarding farm management practices was collected by canvassing a detailed questionnaire from the farm households.

3.1 Pesticide Use Scenario in Gujarat

The survey revealed that of the total 1014.87 hectares of cotton land cultivated by the 200 farmers during 2007-08, almost 53 per cent was planted with unapproved Bt varieties[6], followed by approved Bt with 36.3 per cent and desi variety with 10.7 per cent of the land. Thus, Bt adoption is nearly complete with 89 per cent of the area under Bt cotton (both approved and unapproved). While majority of the Bt cotton adopters have used the Bollgard 1 variety, 1 per cent of the total Bt cotton land is under Bollgard II variety.

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[6] The survey enquired about the source of seed at the time of purchase of the seed and also the name of the variety. The trade names of the approved Bt and desi cotton varieties were collected from the authorized seed sellers and was matched with the names that we obtained from the farmers.

As per the biosafety regulations, companies selling Bt cotton seeds are required to sell a small packet (120grams) of non-Bt seeds referred to as refuge seeds along with the regular Bt cotton seeds (which are packed together). The purpose of growing refuge is to delay the bollworm resistance to Bt. The refuge strategy is based on the principle that the dominance of resistance depends on the dose of transgenic toxin. Resistance is often dominant when the dose of a toxin is low, but recessive when the dose of a toxin high (Showalker, *et al.,*2009). Hence, for effective protection, farmers are supposed to grow these non-Bt seeds as a border to the Bt cotton plot which is indicated in the form of a diagram in the short literature page that accompanies the seed packet. While the approved Bt companies are required to sell this non-Bt seeds as well, the unapproved seed sellers do not sell any refuge seeds. It has been demonstrated that wherever refuge is grown around the Bt plot, resistance to Bt is delayed (Qaim and Janvry, 2005) and the technology. However, we found in our survey that only 27.8 percentage of the approved plots were planted with refuge (non-Bt seeds), while only 3.8 per cent of the unapproved plots were planted with refuge.

3.2. Pests Attack

During the 2007-08 Kharif season, farmers reported more of sucking pests' infestation on cotton than bollworm. In fact, farmers reported names of 12 different sucking pests and six types of bollworm that affected the cotton crop in the entire season. Only 22 per cent of the farmers reported the occurrence of any new pests in cotton. Interestingly, among the new pests that the farmers had seen during 2007-08 season were the ones that they had never seen five years before. Mealy bug was the prominent name as reported by 77 per cent of the farmers. Mealy bug that belongs to the category of sucking pests, is reported to be devastating in effect among all other types of sucking pests.

3.3. Pesticide Spraying Pattern

There were totally 2833 pesticide applications on the total cotton crop (1014.87 hectares) by the chosen farmers which is 2.79 sprays per hectare and 14 sprays per farmer. Of the total 2851 responses received against pesticide application, 2833 responses included pesticide applications ranging from one to 20 times and hardly one per cent were cases of not spraying any type of pesticides.

Among the districts, Rajkot and Bhavnagar together accounted for 52 per cent (27 and 25 % respectively) of the total number of sprays while Surendranagar had the lowest share (15%) of the applications. Notably, in Rajkot, the largest number of pesticide applications (70%) were on approved Bt than on unapproved Bt (30 %), while reverse was the case in Bhavnagar (22 and 78 % respectively). Such differences were not seen in other districts.

Our analysis then tried to look at the pesticide spray pattern across the different size classes of farmers (Table 3).

Table 3: Descriptive Statistics Showing the Pesticide Spray Pattern among Different Landholdings

Landholding	Seed variety	Mean no of sprays	Total reported cases	Std. Deviation	Median (No of sprays)	Maximum (No of sprays)	CV %
Marginal	Approved	4.85	525	2.99	4.0	15	61.6
	Unapproved	4.25	514	2.59	4.0	15	61.1
	Desi	3.57	14	2.03	3.5	7	56.8
	Total	4.54	1053	2.81	4.0	15	61.9
Small	Approved	5.16	388	3.34	5.0	15	64.7
	Unapproved	4.92	552	3.40	4.0	20	69.1
	Desi	2.65	17	1.87	2.0	7	70.6
	Total	4.97	957	3.37	4.0	20	67.7
Medium	Approved	4.44	312	2.77	4.0	14	62.4
	Unapproved	4.74	446	2.94	4.0	15	62.0
	Desi	3.06	18	2.15	2.5	8	70.5
	Total	4.58	776	2.86	4.0	15	62.6
Large	Approved	5.06	18	2.75	5.0	10	54.5
	Unapproved	3.46	28	1.84	3.0	7	53.0
	Desi	1.00	1	0.00	1.0	1	0.0
	Total	4.02	47	2.36	4.0	10	58.8
All classes	Approved	4.85	1243	3.06	4.0	15	63.1
	Unapproved	4.61	1540	3.00	4.0	20	65.1
	Desi	3.02	50	2.02	2.5	8	66.7
	Total	4.69	2833	3.02	4.0	20	64.5

Source: Farm Household Survey by GIDR, 2007.

It is evident that the mean number of sprays is close to five sprays across holdings with differences between approved and unapproved cotton grown plots. Mean number of Sprays are higher for approved plots in the case of marginal, small and larger holdings. Only medium scale farmers show an exception in this pattern. Desi grown plots are important in terms of less number of sprays undertaken and only marginal farmers have shown the highest number of pesticide applications for desi cotton.

The behaviour of marginal farmers with respect to adoption of sprays seems to be quite distinct as compared to rest of the groups. It seems farmers in marginal, small and large categories tend to distinguish between approved and unapproved varieties when it comes to pesticide applications as evident from relatively more number of sprays done in case of approved varieties than unapproved varieties. Notably, though the mean number of sprays shown an overall average within the range of 4 to 5 sprays per approved and unapproved plots, the variations are large as explained by the coefficient of variation in number of sprays. This is also corroborated to an extent by the maximum number of sprays, which has gone to an extent of 15 or 20 as evident from the Table.

It is important to examine how farmers schedule their insecticide applications as the entire cotton season lasts for 6-8 months from sowing to harvesting. Table 4 provides the summary of the schedule of insecticide applications undertaken by the farmers across the three varieties. It is evident that insecticide application rises significantly after the first month of sowing and reaches the peak when the plant is about 90 days old. We find that pesticide application reduces from this point onwards in all the varieties which is different from the experience of the farmers in China where pesticide application is required late in the season also (Huang *et al.*, 2009). This pattern is also different from Non-Bt plots where maximum number of sprays (4.37) takes place during the period of 151-180 days after sowing. In the entire season, insecticide application is higher in approved Bt plots (16.73) as compared to the unapproved Bt plots (14.19).

Table 4: Insecticide Applications per Plot

Days after sowing	Approved Bt	Unapproved Bt	Non-Bt	All plots
1-30days	0.63	0.68	0.59	0.65
31-60 days	4.33	4.15	1.26	4.04
61-90 days	5.92	4.99	0.96	5.10
91-120 days	3.97	3.12	0.56	3.29
121-150 days	1.45	0.89	0.22	1.07
151-180 days	0.35	0.27	4.37	0.28
Above 181 days	0.08	0.09	1.20	0.08
Entire season	16.73	14.19	9.16	14.51

Source: Lalitha *et al.* (2009)

The status of insecticide applications as described above raises an important question as regards the effectiveness of the Bt technology: Why farmers growing approved and unapproved Bt varieties tend to spray more as against those growing Non-Bt varieties? Our analysis in this regard yielded interesting results, which suggests the new complexities faced by the farmers in internalizing the benefits of the Bt technology. It was found that with bollworm under control (perhaps technology worked well), larger proportions of the insecticide applications (over 73% across varieties) have been targeted towards sucking pests as evident from Table 5.

Table 5: Insecticide Application by Variety and Pest for the Entire Season

Pests	Approved Bt plots	Unapproved Bt plots	Non-Bt Plots	Total
Sucking pests	5.89 (79.7)	5.05 (73.1)	3.64 (83.1)	5.17 (76.0)
Bollworms	0.48 (6.5)	0.55 (8.9)	0.29 (6.6)	0.5 (7.4)
Spodeptora	0.39 (5.3)	0.15 (2.2)	0.11 (2.5)	0.25 (3.7)
Others	0.07 (0.9)	0.2 (2.9)	0 (0.0)	0.12 (1.8)
Unknown	0.56 (7.6)	0.96 (13.9)	0.34 (7.8)	0.76 (11.2)
Total	7.39 (100.0)	6.91 (100.0)	4.38 (100.0)	6.8 (100.0)

Note: Figures in parentheses indicate the respective percentages in total insecticide Applications.

Source: Lalitha *et al.* (2009).

To substantiate this, the survey revealed that only 19 farmers were growing Bollgard II variety which targets sucking pests, spodeptora and bollworm within a total area of 10.9 hectares. It is presumed that wider adoption of this variety (Bollgard II) may reduce the number of sprays in future.

3.4 Pesticide Awareness among the Farmers

In analyzing the use of pesticides, it is also essential to understand, the awareness among the farmers about these products. In this regard, the information we gathered pertained to: the name of the pesticides, active ingredients, against which pest the product is used, why pesticide application is required at a particular point of time, indication on the label, impact of pesticide use on health etc. Precise understanding in these lines would help the farmer in using the pesticides rationally. In the following pages information on some of these aspects is presented.

In all, the farmers have reported 244 names of pesticides which mostly consisted of the trade or brand names. It is a common practice among the farmers to use combinations of chemicals when they apply pesticide, which according to the entomologists will work against the control of pests. This is because, if a pest is resistant to one chemical X, a combination of chemicals that include X would render the entire group of chemical useless and if farmers are not aware of this property of chemicals, they would spray more pesticides, which perhaps is the reality. In our survey, only 20 per cent of the total sprays had used just one ingredient, while 52 per cent of sprays included two chemicals and 21.8 per cent of sprays used cocktail of three chemicals (Table 6).

Table 6: Number of Insecticides Used in each Spraying

Combination	Responses	%
No pesticide	25	0.9
One chemical	569	20.0
Two chemicals	1483	52.0
Three chemicals	622	21.8
Four chemicals	118	4.1
Five chemicals	31	1.1
Seven chemicals	3	0.1
Total	2851	100.0

Source: Farm Household Survey by GIDR, 2007.

Since more than 240 names of pesticides have been reported by the farmers, it may be likely that some of these pesticides would turn out to be harmful to the health of farmers and the environment. While examining this aspect, we could match about 50 per cent of the names reported with the active ingredients as per the WHO classification of pesticides (Table 7).

Table 7: Classification of Pesticides that were Reported to be Used in Bt Cotton Farms

Classification	Number of Pesticides	%
Class 1a(WHO)	6	2.45
Class 1b(WHO)	19	7.78
Class 2(WHO)	66	27.04
Class 3(WHO)	19	7.78
O(WHO)	5	2.04
U(WHO)	15	6.14
Not available	113	46.31
Not classifiable	1	0.4
Total pesticides reported	244	100

Source: Class[7] 1a, 1b, 2, 3, O and U refer to extremely hazardous, highly hazardous, moderately hazardous, slightly hazardous, obsolete as pesticide and unlikely to cause any hazard in normal use.

[7] This is based on the WHO classification (2005).

Interestingly, 37 per cent of the pesticides used by the farmers are coming under the first three categories with majority belonging to the moderately hazardous group (27%). Further a small percentage (2%) of the pesticides fall in the obsolete category, which when used in combination with any other chemical might nullify the chemical effects, thus necessitating more sprays, as observed above.

We have arrived at a short list of pesticides that were found to be common for all the three cotton varieties and which appeared to be popular among the farmers in terms of their frequent application (Table 8). It shows that except for Acepahte which is considered by the WHO to be slightly hazardous for humans and environment, rest of the pesticides either fall in highly hazardous or moderately hazardous category. Particularly Monocrotophos which is the favourite of the farmers comes under the highly hazardous category and is also banned under the UN PIC (prior informed consent). According to the PIC convention, export of a chemicals can take place only with the prior informed consent of the importing country. The PIC procedure is a means of formally obtaining and disseminating decisions of importing countries as to know whether they wish to receive further shipment of a particular chemical and for ensuring compliance to these decisions by the exporting countries. The aim is to promote a shared responsibility between exporting and importing countries in protecting the humans and environment from the harmful effect of the chemicals (WHO 2005: 39).

Table 8: Use of Pesticides in Varieties*

Name of Pesticide	Classification		Approved Bt	Unapproved Bt	Non-Bt	Total
	Pesticide Group	WHO Class				
Monocrotophus	Organophosphate	1b	502	510	21	1033
Acephate	Organophosphate	Class3	330	689	29	1048
Confidor	Neonicotinoids	Class2	245	240	11	496
Acetamapride	Neonicotinoids	NA	183	128	2	313
Imidacrop	Neonicotinoids	Class2	156	165	3	324
Computor	Neonicotinoids	Class2	62	217	0	279
Ektara		Ib	75	82	1	158
Endosulphun	Organochlorin	Class2	124	134	5	263
Starthion	Organophosphate	Class3	101	18	0	119
Prophanophus	Organophosphate	Class2	37	40	0	77

Note: *Compiled from the number of insecticides used per spray; 1b- highly hazardous, class 2 - moderately hazardous and class 3 - slightly hazardous.

Source: Farm Household Survey by GIDR, 2007.

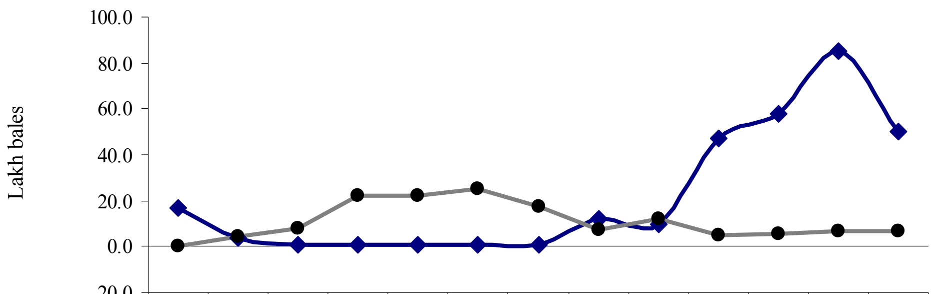
In quantity terms, while the approved Bt cultivators have used 1228 litres and 709 KG of pesticide, unapproved cultivators have used 1299.9 lires and 782 KG of pesticides. We then tried to examine whether farmers are able to differentiate between the different colours indicated on the wrapper of the pesticide. Normally, the red, yellow, blue and green colours as indicated on the cover of the insecticides denote the extreme, high, moderate and slight toxicity of insecticides respectively. In all 50 per cent of the farmers had observed the color label on the pesticide pack which indicates the level of hazardous of the product inside. While most of the farmers responded correctly about the red and green indication, 23 per cent of the farmers thought that yellow label indicates that it is not harmful. In spite of being aware of the hazard indicator on the pack, only 52 percent of the farmers said that they take some precaution while spraying pesticides. These precautions range from wearing gloves to not eating while spraying pesticides. Nevertheless, it should be mentioned that only 50 per cent of the farmers indicated that wearing face masks (covering the mouth and nose with a piece of cloth) appear to be the most used precaution as compared to wearing gloves or wearing goggles while spraying pesticides. However a very small number of farmers (7 out of 200) reported getting sick after spraying pesticides. Skin irritation is the most observed impact (44%) on farmers who spray pesticides. However, none of the symptoms were serious according to the farmers to get medical attention immediately and hence there was no medical expenditure reported or man days lost due to sickness. Similarly none of the farmers reported any adverse impact on the environment due to pesticide use. It is also a limitation of the study as we did not pursue beyond asking the farmers about the 'observed' environmental impact like hardening of the land, reduction in the beneficial insects etc and have not undertaken any scientific testing of the water or land to prove the adverse impact of the pesticides.

Thus, the foregoing analysis of the pesticide use among the cotton cultivators in Gujarat indicate that: (1) though the number of pesticide applications per plot is higher in approved Bt as compared to the unofficial variety, the quantity of pesticide used is less than the unapproved variety; (2) majority of the farmers have used cocktails of two chemicals; (3) a large number of applications were meant for sucking pests and (4) it is likely that a number of chemicals used by the farmers may belong to the hazardous category.

4. Export of Cotton from India and NTBs

With the increase in cotton production in the recent years, India which used to be one of the eight largest importers of cotton, has become an important exporter (Chart 3). Export of cotton from India is regulated by the Ministry of Textiles based on the availability for domestic use and international prices for cotton. The import of cotton takes place under open general license (OGL) with 10 per cent of import duty. While the increase in cotton production contributed by the wider Bt adoption in different states is one of the reasons for increase in exports, favorable monsoon and weather conditions have also helped the farmers to reap better harvests than that they have realized few years back.

Chart 3. Trends in India's Exports and Imports of Cotton



	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
Export	16.8	3.5	1.0	0.7	0.6	0.5	0.8	12.1	10.0	47.0	58.0	85.0	50.0
Import	0.3	4.1	7.9	22.0	22.0	25.2	17.6	7.2	12.0	5.0	5.5	6.5	7.0

Source: Government of India (2006); Barik and Gautham, 2009.

However, India's cotton exports face two problems which could be a serious issue in future affecting the cotton trade. These issues are: (1) contamination in cotton and (2) the NTBs as discussed below.

4.1. Contamination

Though Indian cotton is 100 per cent hand picked, lack of care in handling the cotton at farm, farmyard, ginneries etc result in 20 types of contamination in cotton. Six to eight - per cent of trash is common in Indian cotton bales as pre-cleaning is not a common practice in the ginneries (Barik and Gautam, 2009). Contamination can lead to downgrading of the cotton and the eventual rejection of the consignment. Notably, India, Uzbekistan, Turkey and Mali figure prominently in the list of countries where the most contaminated cotton originates. Some types of contamination are oily substances/chemicals, dust, sand, organic matter like leaves, feather, hair, and plastic. The least contaminated cotton originates from the USA, Israel, Australia and some countries from West Africa.

The international textile manufacturers' federation has compiled the results of the surveys on contamination in cotton from several countries. We provide here a comparison of Shankar 4-6 varieties used by ginneries in 1999 and 2009 (Table 9). It indicates that on an average, percentage of responses which reported that contamination was non-existent has declined from 73 per cent in 1999 to 54 per cent in 2009. While the serious type of contamination has remained the same in both the years, moderate levels of contamination have increased from 15 to 34 per cent.

In the specific case of chemical related contamination, 48 per cent of the responses have said that grease or oil substances were not existent or insignificant. This response has increased to 83 per cent which is encouraging. However, the serious types of contaminations have increased due to presence of rubber particles or stamp colour.

Table 9: Comparison of Contamination in Cotton due to Oily Substances/ Chemicals in 1999 and 2009

Sources of contamination	1999 (54)			2009 (23 samples)		
	Degree of contamination (%)			Degree of contamination (%)		
	Non existent/ insignificant	Moderate	Serious	Non existent/ insignificant	Moderate	Serious
Grease/oil	48	33	19	83	17	0
rubber	86	7	7	74	26	0
Stamp colour	63	20	17	74	26	0
Tar	92	4	4	92	4	4
Average of 1-16 contamination*	73	15	12	54	34	12

Note: *Source of contamination of 1-16 types are: fabrics made of woven plastic, plastic film, jute/Hessian, cotton, strings made of woven plastic, plastic film, jute/Hessian, cotton, organic matter like feather, leaves, leather, paper, inorganic matter like, sand, dust, rust, metal/ wire, oily substances/ chemicals like grease oil, rubber, stamp colour, and tar. Comparison of Shankar 4/6 alone is made here due to the relatively large number of samples as compared to the other varieties considered in the ITMF survey.

Source: Compiled from cotton contamination surveys of ITMF

The level of contamination varies with different varieties that the ginneries have used. We chose to present the Shankar case here as the sample size was relatively larger for this compared to other varieties considered in the survey of ITMF. Unfortunately, since Bt varieties were introduced in the year 2002, we do not have the data on chemical contamination in Bt variety. But in view of the number of pesticide applications with some of the hazardous chemicals, non-tariff barriers due to the use of chemicals could be a potential issue, that needs further scrutiny.

NTMs could be in the form of product standards, process standards, registration and certification and testing, where pesticides could become a major concern for exporters. Among the countries, the US, Mexico, and EC are the countries which impose number of NTMs (Table 10). Though a number of NTBs like minimum import price, import restrictions, anti dumping, customs, labour, rules of origin etc are associated with the textiles and finished products, yet the environmental, SPS and other standards tend to directly focus on the raw material itself. For instance, in terms of product and environmental standards, the insecticides and pesticides that were used at the time of cultivation of cotton and their impact on environment would be scrutinized. Similarly, besides pesticides that are used in the production stage, different solvents, pigments and dyestuffs that are used by the cotton textiles processing and manufacturing industry would be under scrutiny as per the process standards. NTBs in the form of documentation necessitates all the documents regarding the export of a product to be authenticated by the embassy of the importing country in India. Cotton textiles already attract a number of NTBs of which minimum import price, import restriction and certification account for 28, 20 and 15 percent of the different types of NTBs on textiles and clothing (Saini, 2009).

It is in this context that we need to look at the pesticide use pattern in Bt cotton with concern. As shown in the analysis, though the number of sprays against bollworm is less than the sucking pests, the pesticide Monocrotophus which is under the UN PIC and banned in many countries, is being used the most by the farmers. The permissible Maximum Residue Limit (MRL) of monocrotophus in cottonseed and cotton seed oil (raw) is 0.1 and 0.05 respectively (Mukhopadhyay, 2003). With the most number of farmers using monocrotophus, we are not sure of the residue limit of this and the other pesticides that we have listed under the different hazard category on cotton and other products of cotton.

Vietnam and Philippines require the exporters to give report on the chemistry of the product and toxicity of the product in the case of pesticides and fine chemicals. Toxicity tests are conducted over a period of time and may take up to two years. Presently toxicity studies are insisted only by Vietnam and Philippines and exporters from India find it time consuming and unviable to trade with these countries. Similarly process standards concerning yarn are required by Singapore (Mohammad and Taneja, 2005). India has been exporting cotton to Vietnam, which has increased from 0.14 per cent in 1993-94 to 3.52 in 2006-07. Exports to Singapore on the other hand have declined from 1.17 to 0.18 during the same period. China which is another important importer of cotton has brought the same under tariff rate quotas which are imposed on agricultural imports.

European Union already has passed a legislation on the use of chemical substances called 'Registration, Evaluation, Authorization, Restriction of Chemical Substances (REACH) in 2007 which would become a major issue for cotton textile exporters from India. The objective of this regulation is to protect humans from the exposure to hazardous chemicals and to ensure that the product is safe for human beings. REACH is a complex regulation and a variety of infrastructure is required for certifying various products under this regulation. Various suppliers in the cotton value chain will have to ensure that their cotton supplies do not use the 'substances of very high concern' listed by the European Chemical Agency which is regularly updated.

Table 10: Non-tariff Barriers in Cotton and Related Products

Product	Type of NTB	Country	Details
Cotton	Minimum import price	Argentina	If price is below MIP, importer to validate invoice from customs in origin country and submit full set of original documents
Cotton fabrics	Minimum import price	Brazil	MIP in Brazil
Cotton fabrics	Minimum import price	EC	MIP in Czech Republic
Cotton textiles	environmental	EC	Dyes and carcinogenic chemicals to be eco friendly: environmental safeguards under REACH
Cotton textile	Labour	EC	
Cotton textiles	Customs	EC, Mexico, US	
Cotton fabrics	labeling	Japan	Voluntary labeling increases cost, time and efforts
Cotton yarn	Labeling	Korea	Mandatory labeling, composition and composites
Cotton textiles	labeling	Mexico, US	
Cotton textiles	Rules of origin	Mexico, US	
Cotton textiles	Documentation	Mexico, US	
Cotton fabrics	Import restriction	Nigeria	Ban on imported fabrics
Cotton textiles	MFN	Pakistan	Non-extension of MFN status to India

Source: http://commerce.nic.in/trade/NTB productwise.pdf (accessed 15 August, 2010).

An analysis by Mehta (2005) shows that the Index Frequency Ratio of woven apparel, knit apparel and the textile floor coverings in the US alone amounts 19, 7 and 1 per cent respectively where the Index of frequency ratio is defined as the number of products or product lines that are subject to NTBs in the given class to the total of number of commodities in that class. The textile products from India that use Azo dyes and pentachlorophenol have also been banned in a few countries. REACH kind of regulation would be dampening the spirits of exporters of cotton and various cotton value added products from India. As India's exportable surplus increases, more NTBs would be levied by the competitors. Hence, India should take suitable measures to ensure that cotton production and exports from India do not suffer due to lack of standards.

5. Conclusion

This paper shows that in Gujarat, Bt cotton adoption is 90 per cent in the major cotton growing regions in the state. Majority of the farmers use Bollgard 1 which offers protection against bollworm, which shows that the technology has been effective to that extent. However, we did observe that farmers use a larger number of applications for sucking pests. 50 per cent of the farmers use two chemicals and 22 per cent use three chemicals. We doubt the efficacy of such combinations which might have prompted the farmers to use more chemicals. Perhaps due to this, the farmers have not observed any adverse health impact or environmental impact. We found both approved and unapproved cultivators to be using large quantity of pesticides. Nevertheless, the increase in cotton production as reported since introduction of Bt has also increased the exports.

But on the export front, already India has the distinction of being the country with most contaminated cotton. India's textile and clothing attract a number of NTBs. In view of the large number of pesticide sprays and as well as the new regulations like the REACH, this paper raises the concern whether pesticide residue could be a potential NTB.

Though wider adoption of Bollgard II variety promises protection from sucking pests and bollworms, varietal differences and changes in the pest infestation pattern might warrant spraying of some pesticides. While farmers may not be willing to totally stop applying chemical insecticides, yet rational use of pesticides can be promoted along with popularisation of Integrated Pesticide management (IPM) programs in the predominantly cotton growing areas in the country. IPM programs have achieved a significant reduction in the pesticide use (Barik and Gautam, 2009). As pesticide application is highest among the marginal farmers, extension services and IPM programs have to be targeted amongst these farmers. This would ensure that repeated dose of pesticide do not leave the land infertile reducing the productivity.

India has been witnessing a rise in export of cotton in the recent years. With more number of countries adopting NTBs to prevent imports, cotton with intensive use of pesticides could be subject to NTBs in the days to come. Consumers especially in the foreign markets are increasingly aware of the environmental impact of their lifestyle and consumption pattern and are willing to pay a premium price for the eco-friendly products. Hence, if India needs to sustain its exports to other countries, measures need to be introduced to curb pesticide use by inducing more awareness regarding pesticide use and IPM programmes in cotton cultivation. India will also have to create adequate infrastructure for testing the products within the country for instance to comply with the REACH type of regulations. The health and environmental hazards of pesticides are known and only more awareness could lead to reduction in the use and safe application of pesticides that will lead to quality cotton being exported from India.

References

Barik, Anupam and H.C. Gautam (2009), 'Revolution in Indian Cotton', Directorate of Cotton Development, Government of India, Mumbai and National Centre of Integrated Pest Management, Indian Council of Agriculture Research, Pusa, New Delhi.

Bennett Richard, Morse Stephen and Ismael Yousouf (2006), 'The Economic Impact of Genetically Modified Cotton on South African Small Holders: Yield, Profit and Health Effects', *Journal of Development Studies*, 42 (4), pp.662-677.

Choudhary B. and K. Gaur (2010), 'Bt Cotton in India-A Country Profile', *ISAAA Series of Biotech Crop Profiles*. Available at www.isaaa.org (accessed on August 20, 2010).

Dev S., Mahendra and N. Chandrasekhara Rao (2007), 'Socio Economic Impact of Bt Cotton', *CESS Monograph No.3*, Centre for Economic and Social Studies, Hyderabad, November.

Edge, Julie, John H. Benedict, John P. Carroll and H. Keith Reding (2001), 'Bollgard Cotton: An Assessment of Global Economic, Environmental and Social Benefits', *The Journal of Cotton Science*, 5 (2), pp.121-136.

Gandhi, Vasant and N.V. Namboodiri (2006), 'The Adoption and Economics of Bt Cotton in India - Preliminary Results from a Study', *WP2006-09-04*, Indian Institute of Management, Ahmedabad.

Guha, Sumit (2007), 'Genetic Change and Colonial Cotton Improvement in 19th and 20th Century India', in Ranjan Chakrabarti (ed.), *Situating Environmental History,* New Delhi: Manohar Publications.

Huang Jikun, Ruijian Chen, Jianwei Mi, Ruifa Hu and Ellie Osir (2009), 'Farmers' Seed and Pest Control Management for Bt Cotton in China', in Robert Tripp (ed.), *Biotechnology and Agricultural Development Transgenic Cotton, Rural Institutions and Resource-poor Farmers*, Oxon/ New York: Routledge.

Indira, A., M. R. Bhagwan and I. Virgin (2005), 'Agricultural Biotechnology and Biosafety in India: Expectations, Outcomes and Lessons', Stockholm Environment Research Institute, Stockholm, April.

International Textile Manufacturers Federation (ITMF), *Cotton Contamination Surveys* (1999, 2001, 2003, 2005, 2007, 2009). Available at http://www.itmf.org/publications/free/datei8.pdf (accessed on 3 August 2010).

Kranthi, K.R., S. Naidu, C.S. Dhawad, A. Tatwawadi, K. Mate, E. Patil, A.A. Bharose, G. T. Behere, R. M. Wadaskar and S. Kranthi (2005), 'Temporal and Intra-plant Variability of Cry1Ac Expression in Bt cotton and its Influence on the Survival of the Cotton Bollworm, Helicoverpa, Armigena (Hubner) (Noctuidae;Lepidoptera)', *Current Science*, 89 (2), July.

Lalitha, N. and Bharat Ramaswami (2007), 'Pesticides Use Pattern among Cotton Cultivators in Gujarat', in Ravindra Dholakia (ed) *Frontiers of Agricultural Development in Gujarat*, Centre for Management in Agriculture, Indian Institute of Management, Ahmedabad.

Lalitha, N., Bharat Ramaswami and P.K. Viswanathan (2009), 'India's Experience with Bt Cotton: Case Studies from Gujarat and Maharashtra', in Robert Tripp (ed.), *Biotechnology and Agricultural Development Transgenic Cotton, Rural Institutions and Resource-poor Farmers*, Oxon/ New York: Routledge.

Mehta, Rajesh (2005), 'Non Tariff Barriers Affecting India's Exports', *RIS Discussion Paper No.97*, Research and Information System for Developing Countries, New Delhi.

Mukhopadhyay, A.N. (2003), 'Pesticide Usage Scenario in India and Viable Alternatives', Voluntary Health Association of India, New Delhi.

Narayanamoorthy, A. and S. Kalamkar (2006), 'Is Bt cotton Cultivation Economically Viable for Indian Farmers?: An Empirical Analysis', *Economic and Political Weekly*, 41 (26), pp. 2716-2724.

Pray, Carl, Danmeng Ma, Jikun Huang and Fangbin Qiao (2001), 'Impact of Bt Cotton in China', *World Development*, 29 (5), pp.813-825.

Qaim, Matin (2001), ' Transgenic Crops and Developing Countries', *Economic and Political Weekly*, 36 (32), pp.3064-3070.

Qaim, Matin and Alain de Janvry (2005), 'Bt Cotton and Pesticide Use in Argentina: Economic and Environmental Effects', *Environment and Development Economics*, 10, pp.179-200.

Qaim, Matin, Naik Gopal, Subramanian Arjunan and Zilberman David (2005), "Bt Cotton Controversy: Some Paradoxes Explained", *Economic and Political Weekly*, 40 (10), pp.1514-1517.

Sahel and West Africa Club Secretariat (SWAC)/OECD (2005), 'Economic and Social Importance of Cotton Production and Trade in West Africa: Role of Cotton in Regional Development, Trade and Livelihoods', SAH/D, 556.

Saini G.K. (2009), 'Non Tariff Measures Affecting India's Textiles and Clothing Exports: Findings from the Survey of Exporters", *Working Paper No.2009-008*, Indira Gandhi Institute of Development Research, Mumbai. Available at http//www.igidr.ac.in/pdf/publication/WP2009-008.pdf, accessed on July 19, 2010.

Sandrey R., L. Smit, T. Fundira and H. Edinger (2008), 'Non-Tariff Measures Inhibiting South African Exports to China and India, *tralac Working Paper non 6/2008*. Available at www.tralac.co.za

Saqib, Mohammad and Nisha Taneja (2005), ' Non-Tariff Barriers and India's Exports: The Case of Asean and Srilanka', *Working Paper no.165*, ICRIER, New Delhi.

Shetty, P. K. (2004), 'Socio-Ecological Implications of Pesticide Use in India', *Economic and Political Weekly*, 39 (39), pp. 261-67.

Showalter, Ann M., Heuberger, Shannon, Tabashnik, Bruce, E. and Carriere, Yves (2009), 'Development, Agronomic Performance and Sustainability of Transgenic Cotton for Insect Control', in Robert Tripp (ed.), *Biotechnology and Agricultural Development Transgenic Cotton, Rural Institutions and Resource-poor Farmers*, Oxon/ New York: Routledge.

World Health Organization (2005), 'The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification 2004', WHO, Geneva.

Zambrano, Patricia, Luz Amparo Fonseca, Ivan Cardona and Eduardo Magalhaes (2009), 'The Socio-Economic Impact of Transgenic Cotton in Colombia', in Robert Tripp (ed.), *Biotechnology and Agricultural Development: Transgenic Cotton, Rural Institutions and Resource-poor Farmers*, Oxon/ New York: Routledge.

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