5. Pesticides Use Pattern among Cotton Cultivators in Gujarat

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I. INTRODUCTION

Cotton is an important commercial crop in India. There are about 40 million farmers cultivating cotton on approximately 9 million hectares in India. 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, P.K., 2004). Innovations in the pesticides have progressed from highly toxic pesticides which are harmful to humans and environment to less toxic pesticides that are still effective on the pests.

The loss due to bollworm is estimated at around 50 to 60 per cent of cotton yield. Shetty (2004) notes that globally about 504 insects and mites, 150 plant pathogens and 273 weeds are known to have developed resistance. Hence, in such cases farmers try to mix different chemicals, even if they are not recommended, to be used in combination and spray. Therefore, the pests become resistant to the whole group of chemicals and farmers end up spraying more doses of pesticides to control the same. It is now well known that constant and continuous exposure to pesticide could result in severe health impacts for the farmers and farm workers. The environmental

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impacts of pesticide including the contamination of ground water and its impact on humans and animals have also been well documented. Current research in agri-biotechnology by both private sector and public sector aims at introducing traits that would provide protection to the plant. It is in this chain of event that the recent times have seen the introduction of genetically modified cotton, which is a major innovation in agri-biotechnology aiming at reducing pests in cotton. Bascillus Thuringencis (Bt) is a naturally occurring bacterium that acts against the bollworm. 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 of its trait – the Cry 1 gene that protects the crop from bollworm, tobacco budworm, pink bollworm, which are the major pests that attack cotton in all the cotton cultivating parts of the world. Hence, it is in this context that the introduction of Bt cotton technology is viewed with appreciation and apprehension. Appreciation for the technological advancement and apprehension for-the unforeseen and unanswered questions, on impact of the technology on humans and environment. Therefore, if the benefits of the much publicized Bt cotton is fully derived, *viz.* reduction in the use of pesticide and thereby reduce the crop loss, the technology could help in saving the cotton crop directly, by reducing the pest attack and reducing the use of pesticide.

Due to this potential pest controlling advantage on cost of cultivation and further on health and environment, farmers in many countries have started adopting Bt cotton. Area under genetically modified crops increased from a mere 1.7 million hectare in 1996 to 81 million hectares in 2004. Invented and patented by the US based Monsanto, this technology was licensed to the Indian company Mahyco, through their collaborative initiative called Mahyco-Monsanto Biotech Ltd. (MMB) and the genetically modified cotton seeds were commercialized in India in June 2002. The area under Bt cotton increased from approximately 100,000 hectares in 2003 to 500,000 hectares in 2004 when approximately 300,000 small farmers in different parts of India adopted cultivation of Bt cotton (James, 2004). This paper focuses on the situation in Gujarat, which was one of the states chosen for approved Bt cotton cultivation and also gained attention because of the cultivation of the unapproved Bt variety. With the steep increase in the area under Bt cotton in India and elsewhere, it would be of interest to find out the varietal preference of farmers in Gujarat and the corresponding pesticide use pattern.

In doing so, Section II presents a list of various diseases and insects that affect the cotton crop. Section III traces the evidences from literature on the impact of Bt cotton on the use of pesticides. Section IV presents the evidence based on the data collected through a survey among cotton cultivators in Gujarat and the last Section V presents the conclusion.

II. DISEASES AND INSECTS AFFECTING COTTON CULTIVATION AND THE IMPACT OF USE OF PESTICIDE

Cotton crop is highly susceptible to diseases and pests. Most of the diseases that affect cotton cultivation occur at all stages of growth of the crop and round the year, which necessitates spraying of pesticides. A few of these diseases are: (1) wilt, where the leaves turn brown and drop off; (2) root-sudden and complete wilting of the plant; (3) anthracnose-reddish brown depression spots on leaves and bolls; (4) bacterial blight- affects the plant at all stages which causes secondary infection; (5) alternaria which causes leaf spots and affects the plant at all stages; (6) areolate or greymildew, and carcospora or leafspot both occur at maturity stage where the leaves become yellowish and fall. Besides these helminthosporium leaf spot and root knot nemotode are also reported to occur in some parts of India. The following table provides information on some of the type of pests affecting cotton crop.

As evident from the *Table 1*, most of the insects that affect the cotton crop are active throughout the plant life. There are varietal differences, however, in terms of susceptibility to pests. Asiatic or old world cottons (*Gossypium arboreum* & *G. herbaceum*) and American cottons (*G. hirsutum* and *G. barbadense*) are the four cultivable cotton species. Asiatic cottons are commonly referred to as *desi* cottons. In India, *G. Arboreum* and *G. hirsutum* are the principal species that are cultivated. Desi varieties and, in particular, G. *Arboreum* are known for their drought tolerance and resistance to sucking pests. On the other hand, American cottons usually have long and extra long staple and better spinning potential (higher counts) than desi cottons. They were introduced in India by the colonial administrators to meet the demands of English textile manufacturers anxious to secure an alternative and cheaper source than from the United States (Guha, 2007).

In 1970, India commercialized the world's first cotton hybrid. This was H-4, an intra-*hirsutum* (i.e., both parents *hirsutums*) and was produced by Dr. C. T. Patel

TABLE 1: DETAILS OF INSECTS AFFECTING COTTON CULTIVATION

Insect	Stage of occurrence	Symptom of damage	Period of infection
American bollworm	All stages	The larve feed on leaf. Also bores into square flowers and bolls.	Active throughout the year
Pink bollworm	Crop mid stage to End of the crop	Affected flowers do not grow fully. Show characteristic resetting i.e buds shed	Active in August-November
Spotted bollworm	Boll formation stage	Larvae bore into the terminal shoot of young plant leading to its death. Development of side shoots and branches from damaged parts. Also bore into flower buds and young bolls. Damages buds and flowers. Bolls shed	Active throughout the year
Tobacco caterpillar	Throughout the crop period	Early larvae feed on under surface of leaf leading to skeltanisation of leaves. Also feed on flowers, buds, flowers, calyx and bolls	Throughout the year
Whitefly	Throughout the crop growth	Sucks plant sap by feeding on under surface of leaf-chlorotic spots on leaves. Premature leaf fall.	December-February
Aphids	Early growth stages	Sucks leaf sap. Leaves curl and drop quickly. Sticky honey dew and sooty growth on leaves	May-November
Jassids	Seed mostly at seedling stage or throughout the year	Insect feeds on underside of the leaf causing curling of edges. Leaf turns red and brown, dries up and sheds	Almost throughout the year
Spider mite	Throughout crop growth period	Punctures the leaves, feeds on the sap, it turns red, whitles and falls	Almost throughout the year
Thrips	Vegetative stage	Nymphs and adults lacerate leaf surface and feed on sap. Upper side of older leaf turns brown. Lower side silvery while	May-September

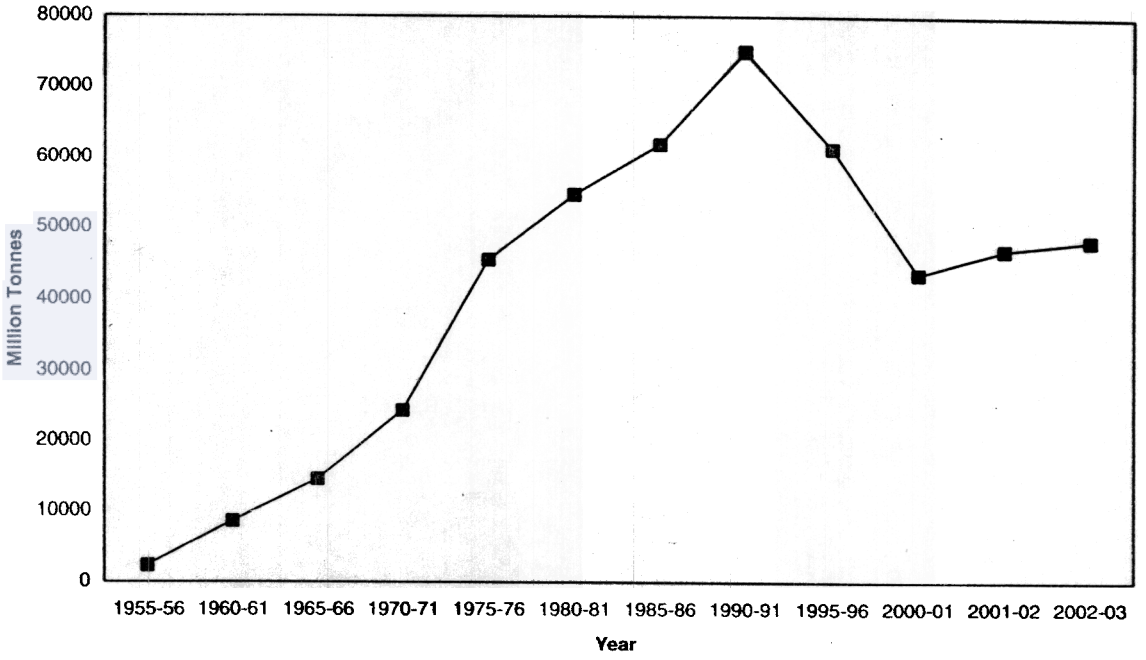
Source: www.Ikisan.com

in 1970 at the Surat agricultural experiment station of the Gujarat Agricultural University. By 2004/05, publicly developed hybrids and proprietary hybrids (all of which are largely intra-hirsutum) account for about two-thirds of the cotton growing area in India (Murugkar, Ramaswami and Shelar, 2006). While hybrids are higher yielding than desi varieties, the flip side of the displacement of desi varieties has been a rapid rise in pesticide consumption. Whether this is due to technology alone or because of other factors (such as price and distribution) needs to be investigated.

Graphs 1 and 2 show the pesticide consumption pattern in all India, and in Gujarat from 1974-75-2002-03. Though these graphs show the total consumption of pesti-

cides, they can be taken to reflect the cotton consumption pattern as well since cotton constitutes 50 per cent of the pesticide consumption. We find that for all India, in the late 1980s, pesticide consumption touched 75000 million tones. Shetty (2004) notes that in cotton crop, the bollworm infestation reached a phenomenal peak during 1996 due to which cotton farmers resorted to spraying nearly 30 sprays a season compared to the required 10 to 12 sprays. From the mid 1990s the pesticide consumption had started reducing because, in 1996, the government banned the use of DDT and BHC in agriculture. But after 2000, again the trend suggests an increase in the pesticide consumption.

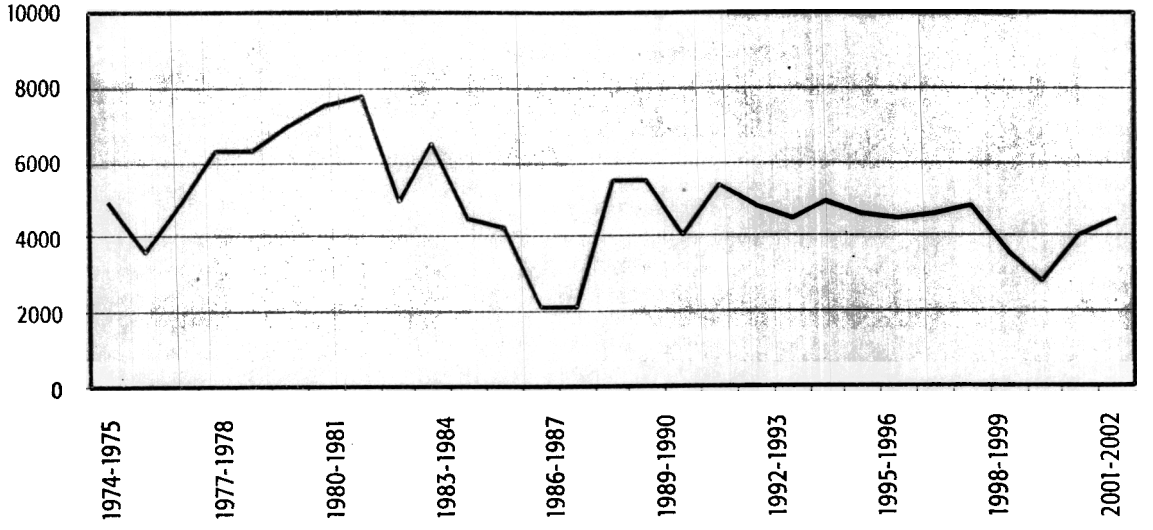
GRAPH 1: TOTAL PESTICIDE CONSUMPTION IN INDIA



Source: National Centre for Integrated Pest Management, available at www.ncipm.org.in

In Gujarat also, there has been an increase in the consumption till the early eighties. Perhaps due to the vagaries of monsoon in mid and late 1980s there has been a sharp decline. After this, pesticide consumption appears to have stabilized around an average of 4500 million tones.

GRAPH 2: PESTICIDE CONSUMPTION IN GUJARAT (MT)



Source: National Centre for Integrated Pest Management, available at www.ncipm.org.in

II. IMPACT OF PESTICIDE USE

Continuous use of pesticides besides increasing the cost of cultivation does irreversible damage on environment as well as on health of human beings and livestock. Further large use of pesticide results in (a) reduction in the natural fertility of the soil; (b) harming the soil structure and soil aeration thus reducing the water holding capacity of the soil, resulting in soil erosion by water and wind; (c) diminishing returns on inputs; (d) indiscriminate killing of useful insects and micro organisms that check crop damage by insects leading to more virulent and resistant species of insects and vectors; (e) reducing the genetic diversity of plant species; (f) producing toxic chemicals which pollute the air, land and water; (g) endangering the health of both the farmers and the workers in agro-chemical factories; (h) poisoning the food and animal feed due to pesticide residue; (i) increasing the outlay on agricultural operations; (j) depleting the fossil fuel resources; and (k) lowering the drought tolerance of the crops (Mukhopadhyay, 2003). Hence, in this background, let us briefly look at the results of a few studies on Bt cotton, specifically on the use of pesticide.

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 reduced 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 the pesticide use by 15,000 tons. Their study observes that reduction has also occurred in organophosphates some of which are banned due to their adverse impact on health and environment.

Edge, et al. (2001) observe "production of the Bt protein by bollgard cotton reduces and in some cases eliminates, the need to spray for major caterpillar and other lepidopteran pests such as cotton leafperforator, cabbage looper, cotton leafworm, European corn borer and saltmarsh caterpillar. These additional benefits include reduced risk to growers' health, improved environment for beneficial insects and farmland wildlife and a more stable economic outlook for the cotton industry" (p.123).

Their reviews 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 cotton produced on 972,000 hectares 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.

Qaim's study (2003) using the field trial data of Mahyco-Monsanto clearly brings out the cost advantages of Bt cotton particularly in pesticide reduction over hybrids and conventional cotton variety. Indira et al's (2005) study (survey of farmers who had participated in the trials) shows that though the pest load was generally higher in 2001, it was lower in the Bt crop compared to non Bt and the check variety.

Similarly, Qaim and Janvry (2005) report that in Argentina on an average, Bt farmers 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. Qaim et al's (2005) study carried out in Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh for the 2002 season indicates that Bt cotton required only 28% of conventional pesticide sprays on cotton, which has a positive impact on yield

due to less crop losses. However, these savings in pesticide reduction did not compensate the higher seed costs that the farmers spent on Bt seeds.

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 ashids, jassids and thrips, yet the reduction of three sprays for bollworm will reduce the costs, amount of labour and the distance walked carrying the knapsack (Bennett et al, 2006). Narayanamurthy and Kalamkar (2006) analyzed 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

TABLE 2: AREA, PRODUCTION AND YIELD OF COTTON IN GUJARAT 1980-81 - 2004-05

Year	Area in 000 Hectares	Production in 000 tonnes	Yield in 000 Bales of 170 Kg. each	Area under Irrigation in 000 hectares	Area under Cotton as Percentage to total area under crops
1980-81	1566	1738	189	443 (28)	13.45
1985-86	1451	2122	249		13.16
1990-91	1042	1531	250	325 (31)	9.85
1991-92	1135	1181	177		16.08
1992-93	1151	1988	294		15.46
1993-94	1126	1623	245		10.74
1994-95	1313	2522	327		11.72
1995-96	1517	2408	270	529 (35)	13.86
1996-97	1542	2819	311		14.16
1997-98	1598	3417	364	630 (39)	14.55
1998-99	1672	4004	407	652 (39)	15.27
1999-00	1611	2146	226	630 (39)	15.89
2000-01	1675	1283	130	661 (39)	17.43
2001-02	1738	1685	165	714 (41)	17.49
2002-03*	1635	1685	175		
2003-04*	1641	4027	417		
2004-05*	1906@	5440@	485@		
Compound growth rates (percent)					
1990-91-01-02	5.04	2.8	-2.14		
1990-91-2004-05	3.95	4.99	0.987		
2002-03-2004-05	7.96	79.6	66.6		

* based on final forecast, @pre estimated figures, figures in parentheses in column 5 show the percentage of irrigated area under cotton to the total area under cotton.

Source: Socio Economic Review Gujarat State, 2005-06

less pesticide as compared to Mech 162 and both the Bt varieties together consumed more pesticides than the non-bt varieties.

Thus, these studies point towards a reduction in the pesticide use by Bt cultivators as compared to the non-Bt cultivators.

III. COTTON CULTIVATION IN GUJARAT

Gujarat is one of the major cotton cultivating states in India. In 2001-02, 17 per cent of the cultivated area was under cotton cultivation. Of this however, only around 40 per cent of the area is under irrigation. Gujarat farmers have been highly receptive of the hybrids introduced by the Gujarat State Seeds Sales Corporation (GSSSC), which were nevertheless susceptible to pests. However, after the introduction of the genetically modified cotton by the Government of India in a few states including Gujarat, cultivation of unapproved GM seeds were also found to be cultivated in Gujarat, which now has changed the entire cotton cultivation scenario in the state. As shown in *Table* 2, area and production in cotton had increased at the compound growth rate of 5.04 and 2.8 per cent during 1990-91 to 2001-01. During this period, yield declined by 2.14 percent. The period 2002 onwards presents a drastic change where the area, production and yield increased by 7.96, 79.6 and 66.6 per cent respectively, which may be attributed entirely to the cultivation of Bt cotton. Private communication from one of the seed companies based in Gujarat indicates that an estimated 19 lakh hectares are under unapproved variety cultivation in the year 2004-05, which implies that the entire area under cotton is under the cultivation of unapproved variety. According to sources from GSSSC, hybrid cotton seeds which constituted more than 60 per cent of GSSSCs sales and 25 per cent of the turnover has reduced to just 5 per cent of the total turnover during 2003-04 due to the spread of unapproved variety of cotton. This was the cotton cultivation scenario in the state of Gujarat when the survey to understand the performance of Bt cotton was launched. In the following paragraphs, results from the field survey are analysed.

Details of Cotton Cultivation among the Sample Farmers

A survey was undertaken in 2004 in 4 cotton cultivating districts of Gujarat namely Rajkot, Bhavnagar, Bharuch and Vadodara. From each of the districts four talukas were chosen randomly and from each taluka two villages were randomly cho-

sen. From each village five cotton cultivating farmers were chosen. Thus a total of 160 farmers were surveyed. Data regarding the 2003-04 kharif cotton crops were collected (second year of cultivation of approved and perhaps third year of unapproved variety) through a structured questionnaire. The structured questionnaire had detailed questions on (a) farmers' view on the impact of use of chemical insecticide, (b) their perception on use of Bt technology on pesticide use pattern, (c) number of pesticide sprays used on their cotton yields and their details and (d) integrated pest management strategy adopted, if any, by the farmers. Before we discuss these results, some background information on land holding and other details are discussed to understand the farmers' varietal preference, etc.

Totally in the surveyed plots, 504.79 hectares were brought under cotton cultivation (Table 3). Unapproved and desi cotton account for 42 and 27 per cent of the total land under cotton cultivation among the sample farmers. Hybrid occupies 18.3 per cent of the land and the approved variety is cultivated only in 12 per cent of the land under cotton. 70.7 per cent of the cotton is cultivated in irrigated areas of which approved, unapproved and the hybrid cotton have large share while two- thirds of the desi cotton is under un-irrigated land.

TABLE 3: PERCENTAGE DISTRIBUTION OF LAND UNDER COTTON CULTIVATION

Cotton Variety	Irrigated Land %	Un-irrigated Land %	% of Each Variety to Total Land	Total Land Hectares
Approved Bt	94.5	5.4	12.33	62.25
Desi cotton	29.3	70.7	27.15	137.04
Non-Bt Hybrid cotton	92.1	7.8	18.29	92.36
Unapproved	81.1	18.8	42.23	213.13
Total	**70.7**	**29.2**	**100.00**	**504.79**

Source: Field Survey

Tables 4 and 5 present the percentage distribution of farmers and land across different size holdings and the average land holding respectively. We find that among the cotton cultivators in our sample survey in Gujarat, 30 per cent belong to marginal land holdings group which accounts for 7.8 per cent of the total land. The average land holding is only 0.63 hectares per farmer for the marginal farmers. 45 per cent of the farmers belong to the small holdings group with an average of 1.80 hectare with them that accounts for 34 per cent of the total land under cotton cultivation. Medium (17%) and large (8.5%) farmers with an average land

holding of 3.8 and 9 hectares of land account for 26.8 and 31 per cent of the land respectively.

TABLE 4: PERCENTAGE DISTRIBUTION OF FARMERS AND LAND ACROSS DIFFERENT SIZE HOLDINGS

Size of land holding	Details	Approved Bt	Unapproved Bt	Desi	Non-Bt Hybrid	All farmers
1	2	3	4	5	6	7
Marginal	% of farmers	23.8	49.2	6.3	20.6	(29.7) 100
	% of land	25.3	46.0	6.4	22.3	(7.8) 100
Small	% of farmers	15.8	47.4	12.6	24.2	(44.8) 100
	% of land	15.0	46.6	13.7	24.7	(34.4) 100
Medium	% of farmers	11.1	52.8	11.1	25.0	(17.0) 100
	% of land	11.0	51.2	11.5	26.3	(26.8) 100
Large	% of farmers	5.6	38.9	50.0	5.6	(8.5) 100
	% of land	7.3	28.7	60.6	3.4	(31.2) 100

Note: (i) Marginal, small, medium and large land holdings in this paper are defined as holdings with 0.1-1, 1.01-3, 3.01-5 and 5+ hectare respectively. (ii) Figures in parentheses in Column 7 are percentages of total farmers and total land.

Source: Field Survey

TABLE 5: AVERAGE LAND HOLDINGS OF FARMERS UNDER DIFFERENT VARIETIES OF COTTON (IN HA.)

Size of land holdings	Approved	Unapproved	*Desi*	Non-Bt Hybrid	All Varieties
Marginal	0.68	0.58	0.63	0.67	0.63
Small	1.72	1.78	1.96	1.85	1.81
Medium	3.72	3.64	3.89	3.96	3.77
Large	11.53	6.46	10.61	5.30	9.05
All Farmers	**1.77**	**2.08**	**4.73**	**2.01**	**2.41**

Source: Field Survey

Within the different size groups, the farmers with marginal and small size holdings have adopted the new seed varieties be it the hybrid, approved or unapproved seeds (*Table* 4). As compared to this, 50 per cent of the farmers with large size holdings have put larger tracts of land under *desi* cotton cultivation. This is perhaps because *desi* cotton enjoys greater faith of large farmers, or they could be resource por, or they lack irrigation facility on their farm, or the peculiarities of their land like water logging. Any of such reasons could prevent them from going in for new seeds.

TABLE 6: PERCENTAGE OF LAND UNDER COTTON CULTIVATION BY REGION (IN %)

Region	Approved Bt % Land	Unapproved Bt % Land	*Desi* Cotton % Land	Non-Bt Hybrid Cotton % Land	All Varieties % land
Rajkot	38.6	56.4	–	4.9	16.2
Bhavnagar	6.8	58.6	–	34.5	23.3
Bharuch	0.75	25.2	64.2	9.7	31.7
Vadodara	14.7	39.6	23.7	22.04	28.8
Total	12.3				

(Percentages by row total, except the last column which indicate the percentage of land in each region to the total land).

Source: Field Survey

There is a clear statement of preference for certain varieties of cotton that is obvious in *Table 6*. While Rajkot predominantly cultivates Bt variety of cotton (both approved and unapproved), in Bhavnagar, the preference is for both unapproved Bt and hybrid varieties. Bharuch cultivates mainly *desi* varieties and unapproved Bt variety. It has the least preference for approved Bt cotton variety. While the first preference is for unapproved Bt variety for Baroda farmers, they had also cultivated *desi* and hybrid variety on almost equal quantity of land, and approved Bt was cultivated on 14.7 per cent of land.

Results and Discussion

Among the different varieties cultivated, pesticides are used for hybrid (whether genetically modified or not) varieties and not so much for desi varieties. During the survey, we also realized that a couple of farmers had not sprayed pesticide at all either due to lack of resources or because of religious beliefs. 89 farmers sprayed pesticide themselves or by employing their family members.

Farmers reported as many as 89 names of pesticides that were put in use either in liquid or powder form. Though we tried ascertaining each of the names with the pesticide dealer, not all of the farmer-provided names correspond with trade names. Usually the pesticides were mixed with water in certain proportion and sprayed on the crop. *Table 7* provides information on the per hectare expenditure by cotton variety and pests.

The per hectare expenditure on pesticides for all the varieties is Rs.4743. The average expenditure on approved Bt is nearly three times higher than the average expenditure on all the varieties. Both approved Bt and Hybrid cotton grow-

TABLE 7: PER HECTARE EXPENDITURE ON PESTICIDE BY COTTON VARIETIES AND PESTS (IN RS/HA)

Pests	Approved Bt	Unapproved Bt	Desi	Non-Bt Hybrids	All
Bollworm	8032	2096	10	3350	2491
Sucking pests	4597	2195	1	1639	1794
Others	943	401		936	457
Total	**13572**	**4693**	**12**	**5926**	**4743**

Source: Field Survey

ers have identical per hectare expenditure pattern, where the expenditure on bollworm is almost double the amount that is spent on sucking pests. Interestingly, the average pesticide expenditure incurred to control bollworm in unapproved Bt is just 1/4th of the expenditure as compared to approved Bt. This raises a few questions; (a) whether the approved Bt was effective at all in controlling the bollworm? (b) Or did the farmers routinely sprayed pesticides on the Bt crop irrespective of the fact whether the application was required or not? (c) Whether the farmers resorted to repeated applications because they are adopting a very expensive seed? and (d) Would the pesticide use pattern be different if the farmers were given any extension services? These questions lead us to analyse –when do farmers resort to pesticide application?

Table 8 reports that during 2003-04 cotton cultivation per hectare required on an average 3.81 number of sprays. Of the total of 1926 sprays on the cotton crop in our sample, 675 or 35 per cent has been sprayed against bollworm, 48 per cent for sucking pests and the rest 17 per cent for the other pests. Thus during 2003-04, it emerges that farmers had to spray an average of 1.8 times on sucking pests as compared to 1.3 times on bollworm, which is perhaps the positive impact of Bt technology. Maximum numbers of sprays were sprayed between 31-90 days, when the plant attains the stage of flowering and boll formation.

Among the different varieties, approved variety required as many as 6.3 number of sprays per hectare, while hybrids and unapproved required an average of 5.9 and 4.6 sprays respectively. Desi cotton required the least of just 0.25 sprays. While reduction in pesticide use is evident in unapproved Bt, this is not so for approved Bt.

Table 8 shows that the average number of sprays to control sucking pests is the highest in approved variety. On approved Bt, growers used 3 sprays per hectare

TABLE 8: PESTICIDE SPRAYS BY DAYS AND TYPE OF COTTON

Type of cotton/days	Pest type	1-30	31-60	61-90	91-120	121+	Total Sprays	Total Sprays perhectare
Desi	Bollworm	3	4	4	1		12	(0.09)
						5		
		4	7					
								(0.25)
Non-Bt Hybrids		11	74	87	38	13	223	(2.4)
								(5.6)
Mahyco		8	42	52	28	14	144	(2.3)
								(6.3)
Unapproved		**15**	**97**	**106**	**52**	**26**	**296**	**(1.4)**
	Others	17	54	60	24	16	171	(0.8)
	All sprays	**79**	330	340(1.6)	142(0.7)	87 (0.4)	**978**	
	All sprays per hectare	**(0.4)**	(1.5)	(1.6)	(0.7)	(0.4)		**(4.59)**
All Varieties	Bollworm	**37(.07)**	**217(0.4)**	**249(0.5)**	**119(0.2)**	**53(0.1)**	**675**	**(1.3)**
	Sucking	86(0.2)	323(0.6)	313(0.6)	132(0.3)	72(0.1)	926	(1.8)
	Others	32(0.06)	95(0.2)	108(0.2)	55(0.1)	35(0.07)	325	(0.6)
	All sprays	155	635	670	306	160	**1926**	
	All sprays per hectare	**(0.3)**	(1.2)	(1.3)	(0.6)	(0.3)		**(3.81)**

Note: Figures in parentheses refer to the per hectare sprays of that particular variety

Source: Field Survey

against sucking pests while it was only 2.4 and 2.3 for unapproved Bt and non-Bt hybrid crops respectively. Equally striking is the fact that number of sprays on approved Bt crops against bollworms is not on average much lower than the number of sprays on non-Bt hybrids. Whether both of these results are peculiarities from our data set or a more robust finding needs to be investigated further. It

percentage of land under cultivation under approved Bt and (2) unapproved Bt and conventional variety. In Vadodara expenditure on hybrid variety is higher than the pesticide expenditure on unapproved and approved variety. These differences could be due to the different pest pressures on the crop. While Bhavnagar and Rajkot appear to be very different from other regions especially considering the expenditure on approved Bt, yet Rajkot may be considered an outlier where the pesticide expenditure is high in each category.

Refuge in Bt Cultivation in Gujarat

The purpose of refuge or non-Bt cotton cultivation around the Bt plots is that the bollworm resistance of the Bt plant is delayed. Though there are questions about whether allocating twenty per cent of the area is adequate, yet the twenty per cent norm has been an accepted practice in many of the Bt cotton growing areas. The simulation exercise carried out by Qaim and Janvry (2005) on the Bt cotton data collected in Argentina points out that rapid resistance build-up and associated pest outbreaks are unlikely if minimum non-Bt refuge areas are observed.

Fakrudin (2003) et al., study also reports that evidences in the "USA and Australia have shown that Cry1Ac protein production decreased over the growing season and that the bio-efficacy of the protein was reduced by interaction with increasing levels of secondary plant metabolites. Differential expression in plant tissues may contribute toward a reduced efficiency of the Bt transgenic crops. If proper resistance management strategies are not implemented the efficacy of pest management through Bt transgenic crops will be seriously diminished due to widespread development of resistance" (p.1306).

In our study out of the 160 farmers, 120 farmers chose to respond to this question on refuge. Only 23 farmers had grown refuge around the approved Bt plot. Of this, only three farmers said that they knew that no pesticides had to be sprayed on the non-Bt plant and others generally sprayed pesticide on the refuge plants also. The unapproved Bt growers neither received any instruction regarding growing of refuge nor did they cultivate on their own. Though it is recognized that in view of the large number of small size of holdings, it may not be possible to strictly implement the refuge schedule, it would be disastrous for the farmers if the neighbouring non-Bt cotton or other plot becomes the host for bollworm. In fact one Bt cotton cultivating farmer in Rajkot did report to us of observing more

bollworms in his neighbouring non Bt field after he started cultivating the Bt cotton.

WHO Classification of Pesticides

In our survey farmers reported as many as 89 names of pesticides that were in use then. After crosschecking with the pesticide dealers, we could arrive at the exact names of 25 of these pesticides. These names are listed in *Appendix Table 1* at the end with their WHO classification. It should be mentioned that there are lots of pesticides that could not be correctly classified appropriately due to the fact that farmers said the name in the local parlance and not the exact trade or commercial name.

Subject to this caveat, we find (*Table 10*) two entries each that come under class 1a and 1b that are extremely and highly hazardous chemicals category; 10 coming under the category of moderately hazardous, 3 coming under the category of slightly hazardous, 8 coming under Class U that are not hazardous under normal use to human health. Most pesticides in *Table 10* occur in the "moderately hazardous" category.

This is consistent with the responses in Table 11 which indicates that most of the farmers and the farm workers report temporary discomforts such as skin irritation, nausea, vomiting, headache, etc. None reported any sickness that warranted immediate medical help or hospitalization. This could be either due to the fact that some of the pesticides are coming under slightly hazardous category, or the propensity of the chemical is lost because of the proportion in which the different chemicals are mixed.

TALE 10: NUMBER OF SPRAYS BY VARIETY AND PESTICIDE CLASSIFICATION

Classification of pesticide	No. of spray in app. Bt	No. of spray in unap. Bt	No of spray in non-Bt hybrid
Extremely hazardous	6	11	9
Highly hazardous	1	1	
Moderately hazardous	78	133	104
Slightly hazardous	20	47	55
Unlikely to be harmful	5	13	
Total			**168**

Source: Field Survey

TABLE 12: FARMERS PERSPECTIVES ON IMPACT OF INSECTICIDE

Details	Total response %
New weeds	3.5
Notice less numbers of beneficial insects	67.8
New adverse insects	2.1
More bollworm	2.8
Consumes more water	7
Land degradation	13.3
Product quality suffers	3.5
Total responses	**143**

Source: Field Survey

TABLE 13: PERCENTAGE OF FARMERS WILLING TO PAY MORE PRICE FOR PESTICIDES

Details	Total

Source: Field Survey

IV. CONCLUSION

This paper attempted to understand the pesticide use pattern among the cotton cultivators in Gujarat in the context of introduction of genetically modified cotton. It is known that traditionally cotton cultivation accounted for substantial amount of pesticides in the country. Hence, the genetically modified cotton with the trait of saving the crop from the pests, and thereby reducing the pesticide consumption, offers considerable scope for yield improvement and cost reduction in cotton cultivation beside the positive impact on health and environment. In our study it emerged that mostly farmers with small and medium land holdings have opted more for both types of the Bt varieties and the hybrids. Traditional cotton-dominated areas continue to remain so and have not been caught with the Bt cotton cultivation. While land under approved Bt is largest in Rajkot, Bhavnagar tops in unapproved Bt cultivation. Bharuch continues to cultivate

mainly desi variety of cotton. Rajkot accounts for 50 per cent of the total pesticide consumption in the sample as compared to other districts and Bharuch the least. Among the varieties, the approved Bt variety and the non-Bt hybrid variety account for higher number of sprays per hectare and average pesticide expenditure per hectare. More strikingly, and contrary to expectation, the expenditure targeted at bollworms is high in approved Bt.

Future work will be necessary to resolve this puzzle especially to verify that the finding is not due to sampling errors. The study offers two clues that are suggestive. First, the approved Bt growers also use more pesticide against sucking pests. This suggests that approved Bt growers are input-intensive growers while those with lesser resources opt for unapproved Bt or non-Bt hybrids. In other words, the comparison might need to be controlled for other factors especially yield. Second, the paper shows that temporal pattern of pesticide sprays in Bt crops is not very different from the pattern in non-Bt hybrids. More than two-thirds of pesticide sprays still happen in the first 90 days of the plant's life. On the other hand, it might have been expected that with Bt crops, pesticides against bollworm would have been sprayed more in the post 100 day period. This suggests that growers in 2003/04 (in the year of the survey) did not either fully perceive bollworm protection of Bt crops or were not well informed about effective pesticide use.

That failure in information provision could be a serious constraint in optimizing benefits from agricultural technologies is also illustrated by the fact that many of the pesticides used by growers do not have standard trade names. Therefore, very little can be said about the properties of many of the pesticides that are used by growers whether with respect to protection against pests or with respect to their hazards for humans. For those pesticides that could be matched to trade names, we found that most of the pesticides were moderately hazardous to human health as defined by the WHO classification. Future work in this regard would help in understanding the potential hazards of pesticide use.

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