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Discover Natural Fibres Initiative

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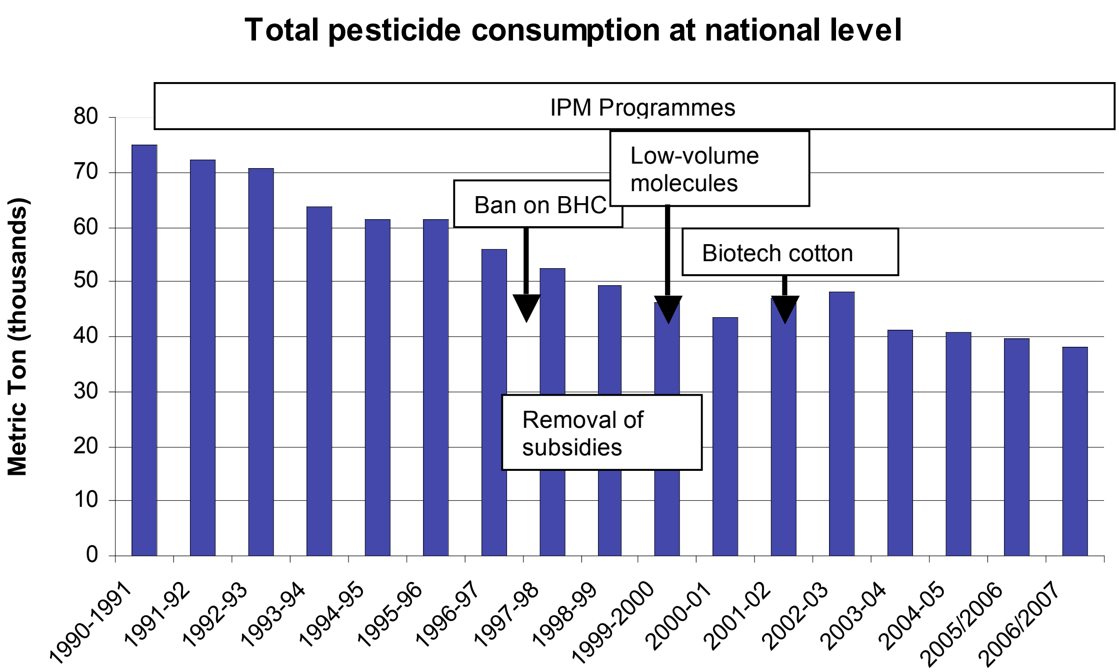
FACTORS INFLUENCING THE USE OF PESTICIDES IN COTTON IN INDIA

1. Pesticide use in cotton

National consumption of pesticides in India peaked in the early 1990s at around 75,000 metric tons of active ingredient and thereafter gradually decreased (Figure 1). Out of the total pesticide use in the country in 2000, insecticides accounted for 80%, followed by herbicides (15%) and fungicides (1.46%) (Gupta, 2006). Organophosphorous compounds are the most used insecticides in the recent decade (Abilash, 2009). Manual weeding is common in most of rural India, in some crops like rice, herbicides have a significant application, however, the overall use is comparatively low.

Figure 1. Total pesticide consumption in India from 1990 to 2007
Source of data: Agricultural Statistics at a Glance 2003, 2006 and 2009



Official statistics on crop-disaggregated pesticide consumption are not easily available, however, in several documents published in the 1990s it is reported that around 40% to 50% of the national pesticide use was applied on the cotton crop in those years. Table 1 provides the percentage share of pesticide use per crop and cropped area as presented in Abilash, 2009. Based on the data contained in the GfK Kynetec database used for the SEEP study and the official statistics of the Government of India (GoI) for the years 1994, 2000 and 2006, the share (measured in metric tons) of pesticides used on cotton with respect to the national total use were 17%, 30% and 21% respectively. Consumption patterns are highly uneven within the country and particularly high in the major cotton-producing states, namely Andhra Pradesh, Karnataka, Maharashtra, Punjab and Gujarat. It is plausible that state-level percentages of pesticide use on cotton in these states were higher than the national figures and close to 50%. In support of this assumption, it is worth noting that, while the average national use per hectare was 0.5-1 kg in 2004 (Gupta, 2004), in Punjab it was 5.6 and 8 Kg a.i. per ha in Insecticide Resistant Management (IRM) and non-IRM areas respectively (Peshin, 2005). Overall, the insecticide use in biotech cotton and non-biotech cotton was 2.58 and 6.44 kg a.i./ha, respectively in 2004. The cost of plant protection products gradually increased over time. By the mid 1990s, cotton farmers were spending more than 43% of variable costs of cotton production on insecticides, out of which 80% was for bollworm control (Shetty 2004, Kranthi and Russell, 2009). In 2001, the cost of the 21,500 metric tons (active ingredient) of insecticides used on cotton in India was US$340 million (Karihaloo, 2009).

Table 1. Cropped area-wise pesticide share of major Indian crops in the 1990s

Crop	Pesticide share (%)	Cropped area (%)
Cotton	45	5
Rice	20	24
Chillies/vegetable/fruit	13-24	3
Plantation	7-8	2
Cereals/millets/oil seeds	6-7	58
Sugarcane	2-3	2
Others	1-2	6

Source: Abilash, 2009

1.2 Spectrum of insecticides used

Some of the most common pesticides used on cotton are highly hazardous to human health, like monocrotophos, a chemical with suspected genotoxicity currently banned or severely restricted in many countries, including all EU members, Australia, Brazil, China, and the USA. Its import is illegal in at least 46 countries. Monocrotophos use in India in vegetables was banned in 2006 due to high residue levels, while its use in cotton continues. Table 2 provides the most commonly used pesticides according to a survey carried out in Andhra Pradesh in 2003/2004. Surveys in Punjab have led to comparable results, though alphamethrin and fenvalarate among the pyrethroids and triozophos and ethion among the organophosphates ranked high in farmers' preferences (Peshin, 2009).

Table 2. Pesticides and their chemical family commonly used on cotton in Andhra Pradesh and Punjab

Andhra Pradesh

Pesticide	Chemical Family
Quinalphos 25% EC	Organophosphate
Endosulfan 35 EC	Organochlorine
Monocrotophos 36% SL	Organophosphate
Chlorpyriphos 20% EC	Organophosphate
Cypermethrin 25% EC	Pyrethroid
Imidachloprid 17.8% SL	Nitroguanidine insecticides
Indoxacarb 14.5% SC	Chloronicotinoids
Acetamiprid 70% WP	Chloronicotinoids
Acephate 75% SP	Organophosphate
Profenophos 50% EC	Organophosphate
Phorate 10% G	Organophosphate
Spinosad 45% SC	Spinosyn insecticide I
Phosalone 35 EC	Organophosphate

Source: Mancini, 2005

Pesticide use on cotton in Punjab (technical grade material) kg/ha (2004-2005)

Insecticides use (technical grade material) kg ha^{-1} (2004-2005)	Non-IRM villages	IRM Villages
Synthetic Pyrethroids	0.385	0.166
Organophosphates	7.234	4.951
Organochlorinates	0.187	0.360
Carbamates	0.020	0.011
Chloronicotinoids	0.058	0.037
Oxadiazine	0.062	0.040
Naturalyte	0.086	0.037
Total use of all insecticides	8.032	5.602
Herbicides use (technical grade material)	0.144	0.282

kg/ha

Source: Peshin et.al, (2009)

2. Cotton pests and their control

The high use of pesticides on cotton over three decades has resulted in well documented changes in the pest scenario and pressure. Up to 1970, the major pests of cotton were jassid (*Amrasca biguttula*), pink bollworm (*Pectinophora gossypiella*), spotted bollworm (*Earias vitella*) and *Spodoptera litura*. *Spodoptera litura* had started exhibiting resistance to several pesticides when synthetic pyrethroids were introduced in the late 1980s. Towards the end of the decade insects had already developed a significant amount of resistance to pyrethroids too. American bollworm (*Helicoverpa armigera*) and whitefly (*Bemisia tabaci*) emerged as major pests. Evidence of wide-spread American bollworm resistance to pyrethroids and to the most commonly used systemic pesticides (e.g. methomyl, endosulfan and quinalphos) was subsequently proved. In the absence of an adequate ecological understanding of the field problem, farmers resorted to increased pesticide dosages and numbers of applications. Outbreaks of American bollworm notably intensified over time, and were confirmed in 1978, 1983, 1990, 1995, 1997, 1998 and 2001 (Dhawan et al. 2004). Since 2000, the incidence of American bollworm has decreased due to the introduction of new molecules like spinosad, indoxacarb and novaluron to control Lepidoptera, and the release of biotech cotton hybrids for commercial use in 2001/02. These new molecules are used at a dosage per hectare that is 10-35 fold lower than organophosphates. Choloronicotinyl compounds like imidacloprid, acetamiprid and thiomethoxam were released as well in the same period to control sucking pests. However, the efficiency of these molecules to protect seedling cotton has already shown to be short lived. Since 2001-2003, a resurgence of jassid (*Amrasca biguttula*) and mirids, minor pests in the past, has been reported.

The excessive use of pesticide had taken a toll on productivity, too. National cotton yields first decreased and then stagnated at around 190 kg/ha till 2003-2004. From an average of 2-3 insecticide applications per season on cotton in the 1970s, some farmers reported more than 30 insecticide applications in non-biotech cotton during 2003-2004 (Peshin, 2007). From 2003-2004, productivity has been steadily increasing, being 467 kg of lint per ha in 2008.

A comprehensive review of cotton pest control trends in India is provided in the book chapter “Changing Trends in Cotton Pest Management,” written by Kranthi (2009).

2.1 Integrated pest management programmes

The earliest research efforts registered toward the development of IPM was the Operational Research Project (ORP) in cotton and rice crops of the Indian Council of Agricultural Research (ICAR) (Swaminathan, 1975), which led to the development of location-specific IPM technologies for the two crops.

Since 1981, the GoI has adopted IPM as the overriding principle of plant protection to reduce dependency on chemical control. Ever since, many initiatives at the national and state levels have been implemented and a few will be featured here that have had significant impacts. The Directorate of Plant Protection, Quarantine and Storage, GoI, has established 31 Central Integrated Pest Management Centers (CIPMCs) to promote the concept of IPM on rice and cotton across the country.. In 1993, the Commonwealth Agricultural Bureau International (CABI) supported an IPM Regional Programme on cotton.

A significant governmental investment in the cotton sector has also been made through the Technology Mission on Cotton (TMC) launched in 2000 and operative to date. TMC aims to increase cotton production, productivity and improve the quality of cotton, and thus increase the income of cotton growers. Under Mini Mission II of the TMC, activities like cotton crop surveillance, IPM and integrated cotton cultivation (contract farming) are supported.

In 2002, the Central Institute of Cotton Research in Nagpur launched the IRM programme in ten cotton-growing states of India, focusing on 26 districts, which among them, were consuming 80% of insecticides for cotton crops. IRM programmes are implemented by state agricultural universities (Russell 2004, Kranthi et al. 2004).

The Food and Agriculture Organization of the United Nations (FAO) has been committed to support GoI in its effort to develop and promote an ecological approach to crop management in the country since the beginning. FAO, in close collaboration with GoI, implemented a series of IPM regional programmes in three phases. The first phase focused on verification of IPM technology and the development of pilot extension activities with farmers plus “strategic extension campaigns” to promote IPM understanding and application. The second phase emphasized a shift towards human resource development and saw the introduction of season-long training programmes and the now well known “IPM Farmer Field School” approach. This approach was successful in bringing IPM to hundreds of thousands of farmers for the first time. The last phase of the programme focussed on institutionalising the approach in the government structure. It was in this context that the large-scale regional project, the FAO–European Union IPM programme for cotton, operated in the country from 1999 to 2004 , to recover the economic and environmental viability of cotton cultivation (FAO, 2004). The history of IPM in India is well described in Peshin et al. (2009).

2.2 Biotech cotton

In 2001/02, biotech cotton varieties were introduced for commercial use. Ever since, hundreds of biotech cotton hybrids have been released for commercial cultivation by 35 seed companies in the country. ICAR has also developed the first true breeding variety. In 2008-09, a total of 7.6 million hectares, nearly 81% of the total cotton area, was under biotech hybrids.

2.3 Pesticide Registration Framework

The Insecticides Act, 1968, Ministry of Agriculture, Department of Agriculture & Cooperation (DAC) regulates the import, manufacture, sale, transportation, distribution, and use of insecticides with a view to preventing risks to humans or animals, and for matters connected therewith. A Registration Committee is empowered with the registration of insecticides after verifying that it is efficacious and safe for use by farmers. During 2009-10 (up-to December 2009), 2,497 registrations were granted. The government is currently amending the Pesticides Management Bill, 2008, intended to replace the Insecticides Act, 1968, to provide for a more effective regulatory framework for the introduction and use of pesticides in the country.

A campaign to prevent the manufacture and sale of spurious pesticides has been launched by the DAC in cooperation with all the state governments and the respective CIPMCs. The quality of pesticides is monitored by the central and state insecticide inspectors, who draw samples of insecticides from the market for analysis. The Registration Committee has the right to review the pesticides from time to time and to ban or restrict the use of any pesticide product. Accordingly, the government has banned the use of more than 30 pesticides, restricted the use of seven pesticides including DDT, and refused registration for 18 pesticides. The list of these pesticides is available at http://cibrc.nic.in/list_pest_bann.htm.

2.4 Pesticide policies and regulations

In April 1997, the government of India (GoI) banned the use of hexachlorocyclohexane (BHC), which accounted for about 30% of total pesticide consumption. In the same decade, subsidies for insecticides were abolished.

3. Pesticide risk reduction in India

Intentional and occupational pesticide poisoning is a matter of public concern in India. The likelihood of occupational exposure to pesticides in the Indian scenario is higher than in industrialised countries. Even though proper regulations are in place, shortcomings in their enforcement and inadequate human resources and infrastructure imply that agricultural workers, farmers and in general handlers of toxic chemical substances are at high risk of exposure.

The main risk factors related to pesticide exposure are:

- the use of adequate personal protective equipment is not feasible,
- improper application conditions and practices, such as the lack of suitable washing facilities for workers, routine application of highly toxic pesticides by untrained workers, or prolonged application hours, etc.,
- unsafe storage and disposal facilities at the community level,
- poorly regulated availability of hazardous pesticides,
- untrained pesticide dealers,
- faulty application equipment, poor calibration and maintenance,
- inadequate health centers, medical facilities, and trained health personnel to recognise and treat pesticide poisoning and lack of medicines.

In India, pesticides are largely applied by low-income people, marginal farmers and landless workers. Associated malnutrition and infectious diseases in these populations make them more vulnerable to poisoning. In the extreme hot weather of the tropics, protective gear is not a viable solution to eliminate occupational risks. This is the primary reason why educating farmers about the pesticide hazard alone has not led to significant results (Atkin, 2002).

The most commonly used equipment for application of pesticides is a hand-carried lever-operated knapsack sprayer that is poorly maintained. Pesticide leakages onto the operator and into the environment are unavoidable. The distribution patterns under these conditions are uneven; leaving sections with no pesticide coverage and others receiving overdoses. This reduces pesticide efficacy and increases chances for resistance development.

4. Conclusions

The factors that have influenced pesticide use in India are several and interlinked. A few have been described, such as a ban on BHC, removal of pesticide subsidies, introduction of low-volume molecules, IPM programmes and release of biotech cotton, but others remain to be identified. A clear attribution of change to a single factor is not possible; however, the combined effect has resulted in a significant decrease in pesticide use.

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