More than half of the world’s cotton lint is produced in Asian countries: China contributes 24 percent (6.3 Mt of raw cotton), India 16 percent (4.1 Mt) and Pakistan 10 percent (2.5 Mt) to the total world cotton production (Kooistra, 2006). The cotton-based farming systems differ for management practices and cropping pattern across and within countries, however in common they have the size often smaller than one-half hectare. Cotton is the only crop that gives extra cash for family expenses to millions of smallscale Asian farmers. The cotton chain, including processing and textile industries, provides employment to even a larger population of low-salary factory workers, many of them women. In these countries promoting cotton cultivation is an important part of development strategies to reduce rural poverty.

Environmental and social problems associated with the cotton cultivation

Cotton production also has its drawbacks associated mainly with the massive use of pesticides involved in the cultivation. Pests caused losses estimated around 15% of the world harvest. The pest control strategy largely relies on chemicals: organophosphate, pyrethroid products and some very persistent organochlorines, e.g. endosulfan (WHO, 2005; . At the beginning of the current millennium the world pesticide use exceeded 2.5 million tons and the world pesticide expenditures were around US$ 32.0 billion . In Asia alone, US$ 1.5 billion every year are spent in chemical products. Overall, an estimated 20% of all global insecticides, and 30% of all pesticides used in Asia, are applied to cotton.

Some of the consequences associated with the misuse of pesticides are build up of pest resistance, insurgence of pest outbreaks and decline in populations of natural enemies, resulting in the failure of the chemical crop protection strategy. The increasing cost of inputs - insecticides alone represent around 15-25% of the cotton production cost in China, India, Pakistan and Philippines - not paired with higher yield levels has reduced the profitability of cotton cultivation in many areas in the region (Subrahmanym, 2003; FAO, 2004). Poor farmers often are unable to repay the compound interest on debts contracted with money lenders or input dealers to purchase production inputs. In some cases, farmers have resorted to selling their most important production asset, the land, compromising the livelihood of their families. Even though no systematic study has been conducted yet, media in India describe cotton districts, where farmers live in the most distressful conditions, as suicide hot- spots (NAAS, 2006).

Cotton is also one of the crops known to have a notably severe impact on the environment (Clay, 2004). In many cotton-growing areas detrimental effects on agro-biodiversity along with depletion and contamination of fresh water sources have become major concerns. Pesticide residues – up to hundred times higher than the European Economic Community’s directives permit – have been found in 14 brands of bottled drinking water and soft drinks in India (CSE, 2003).

Pesticide abuse has undermined human health (Kishi et al., 1995). In Asia, agricultural labourers and farmers working in cotton fields are exposed to some of the most toxic pesticides. Every year, an estimate of 1 million to 5 million cases of pesticide poisoning occur in the world, the majority of which are reported in developing countries (WHO, 1999). However, it is well known that the official figures on the incidence of occupational pesticide poisoning are underestimates (Dinham, 1993) and that little is reported about the long-term effects (Kishi, 2005). The socio-economic and climatic conditions of the region make the standard protective measures and equipment for safe handling and spraying of pesticides unsuitable.
Cotton cultivation has several labour-related social implications as well. It is a labour-intensive crop with peaks of demand at weeding and harvesting time for female work. The most common type of contract offered to field workers in India and Pakistan, the piece rate contract, has adverse social consequences on the children who usually accompany the women and participate in the harvesting.

Even more alarming is the case of the bonded young (7-14 years) female labourers employed in the hybrid cottonseed production to manually cross-pollinate cotton flowers in India because of the occupational exposure to pesticides. Children are disproportionately affected by the toxic and long-term effects of pesticides for a number of critical reasons (UNEP, 2004). They absorb pesticides more rapidly than adults, have a less developed ability to detoxify and excrete substances and are also at greater risk for chronic and long-term developmental adverse effects. This is most critical for the reproductive systems of pre-pubescent girls.

**Concept of Integrated Pest Management Farmer Field Schools (IPM FFS)**

Before the introduction of genetically modified crops, Integrated Pest Management (IPM) was designed to contain the need for chemical products. IPM is a complex, knowledge-based approach to plant protection (Hall and Duncan, 1984) that combines biological, cultural and chemical control to keep pests below economically acceptable levels (USDA, 1993).

In the late 1980s a new participatory approach to IPM training, called Farmer Field Schools (FFS), was implemented to deal with a widespread outbreak of a rice pest in Indonesia. FFS are season-long training courses conducted in the villages for small (25-30) groups of farmers to educate farmers on how to observe and measure in their own fields the ecological relationships underlying IPM. FFS differ from the previous training systems, which were based on short field demonstrations and fixed technical packages, because it provides farmers with continued hands-on opportunities to practice IPM principles and to find locale-specific solutions, coached by expert IPM facilitators. The FFS curriculum goes beyond plant protection to cover all agronomic practices that enhance plant health and resistance to adverse biotic factors. It is structured around a weekly field visit to perform crop ecosystem analysis. Farmers attending the schools learn to sample plants in the field and leaves on the plants according to a randomized design, to record the number of insects visible and to predict insect population dynamics, taking into account the climate conditions and food availability for pests. Farmers are expected to take informed decisions on plant production and protection and to escape from the so-called pesticide treadmill (Bingen, 2004).

**Impacts of IPM FFS on Cotton Growers in Asia**

The FAO-EU IPM Programme for cotton in Asia was implemented from 1999 to 2004 in 5 countries namely Bangladesh, China, India, Pakistan, Philippines and Vietnam to promote an ecological approach to crop protection and production. The Programme aimed to produce a cadre of cotton IPM facilitators from the existing extension and field plant protection staff to train farmers in FFS. A total of 3,661 FFS were conducted and nearly 100,000 cotton growers trained. A number of evaluation studies conducted in India, China and Pakistan attributed impacts in terms of increased farmers’ returns, improved health of farming communities and reduced environmental contamination from heavy pesticide use to the programme. The programme also fostered institutional and policy changes towards a more sustainable cotton farming.

The adoption of better agronomic practices based on farmers’ ecological knowledge generated benefits on the livelihood of cotton growers documented in the following case studies.

**Reduced pesticide use and increased returns**
In Andhra Pradesh, India, the analysis of the agronomic practices in 64 conventional and 73 IPM-converted cotton systems found that farmers trained on IPM, the year after the FFS was conducted, attained a drastic reduction in pesticide use (78%) and in the total number of pesticide applications (from 7.9 to 1.7) without compromising crop yields. The study also showed that IPM farmers changed their practices as a result of improved ecological knowledge and a change in their decision-making process. (Mancini et al., 2006).

In Shandong Province, China an econometric study, comparing the yield, pesticide cost and gross margin of 51 FFS trained farmers with these of 59 conventional farmers, concluded that FFS farmers had higher growth rates for gross margin and yield, and lower costs for pesticide use (Wu et al., 2005).

In Sindh Province, Pakistan 100 FFS farmers were able to back up declining yields by saving on the cost of cultivation. Their improved analytical and decisional skills led to a better input management e.g. reduced seed rate, and less frequency and lower dosage of pesticide applications.

These findings support the idea that a skills-oriented, knowledge-intensive and hands-on educational approach, as FFS, is an efficient system to diffuse the complex principles of IPM among farmers.

**Optimised management of technologies – the case of Bt cotton in China**

The cultivation of genetically modified cotton, known as Bt cotton, was authorised in Asia first in China (1996) and more recently in India (2002) as a response to the aforesaid pesticide problems. Currently, 66% in China and 6% in India of the cotton area is cultivated at Bt cotton. Increased yields and profits, along with reduced pesticide applications have been accredited to the introduction of Bt cotton. However, there are also cases of reported Bt poor performance (Sahai and Rehman, 2004; Kranthi et al., 2005). Generally, lack of effective quality control systems and weak efforts to educate farmers in the two countries have limited the expression of the Bt technology's potential.

A comparative field research carried out in Hubei province of China in 2002 on transgenic Bt cotton managed by farmers with IPM education or by farmers lacking IPM education found that the amount of pesticide used on Bt cotton by non-IPM farmers (9.14 L/ha) was around three times higher than that used by IPM farmers (2.93 L/ha). The resistance of the Bt cotton plants to cotton bollworm larvae declined in late season due to the variation in Bt gene expression and additional sprays were taken to protect the crop (Yang, 2005). Pemsl et al., 2005, after having reached similar conclusions, highlighted the importance to treat Bt cotton as a component of an integrated pest and production management rather than a solution _per sè_ to the pesticide overuse.

**Improved health of farming communities**

As part of the regular FFS curriculum in Asia, farmers were taught the adverse effects of pesticides on human health. In 2003, a season-long assessment of the acute pesticide poisoning was undertaken in Andhra Pradesh, India by 50 female and 47 male cotton growers. The initiative aimed to measure the health effects of pesticide exposures in real time through direct documentation by farmers. The study documented that a strikingly large majority (84%) of the monitored spray events led to mild to severe poisoning. The neurotoxic/systemic signs and symptoms were typical of poisoning caused by organophosphates, products used in 47% of the applications. The mainstream literature focuses on the people applying the pesticides; whereas the study showed that the handling of pesticides in order to prepare chemical mixtures and refill tanks can be extremely risky. In the studied communities, as in general in south Indian villages, these operations were mainly performed by women, who experienced an extent of poisoning comparable to that of the men. Although 6% of the workers’ spray sessions were associated with serious neurotoxic effects, none sought medical care or were hospitalised. On the contrary, these farmers rarely stopped working for more than a day. This finding confirms the serious underestimation of statistics based on official medical records. Low-income marginal farmers were more often subjected to severe poisoning than landlords.
A second part of the assessment, undertaken in 2004, measured actual changes in the health of the respondents as a result of their participation in the cotton IPM FFS.

In 2004, FFS alumni eliminated their exposure to pesticide belonging to the most hazardous WHO toxicity class (1a) and reduced this to WHO Ib products by a third. Exposure to moderately hazardous pesticides (WHO II) was also significantly lower (-60%) than in 2003. On the contrary, exposure to less toxic products as botanicals and organic compounds was remarkably higher, likely indicating a shift towards the use of more ecological products. A lower degree of acute poisoning was associated with the changed practices, as reported by the respondents. The number of asymptomatic cases rose to 28%, cases of moderate poisoning decreased from 38% to 19% and severe cases were lowered to 3.6% (Mancini, unpublished).

Impact on the environment

To estimate the environmental impact of rain-fed cotton production systems in Central and South India, a Life Cycle Assessment (LCA) of 15 conventional, 10 IPM, and 12 organic cotton-growing farms was carried out. The impact was assessed with reference to five indicators: the Environmental Index Quotient (EIQ), Global Warming potential (GWP), Acidification potential (AP), Eutrophication potential (EP), and Erosion potential. The indicators that contributed the most to the differentiation of the systems were EIQ, accounting for pesticide pollution, and EP. The major reason for this difference can be ascribed to the use of mineral fertilisers and pesticides in conventional and IPM systems. IPM had a comparatively lower environmental impact than conventional systems on the basis of the reduced pesticide use (<75%). The AP of conventional and IPM cotton farms were largely due to the burning of stalks after harvest to destroy weeds and their seeds and clearing the land for the next crop., whereas the GWP was due to the use of artificial fertilisers. Soil erosion was at an acceptably low level for most farms. Even though the organic management systems had by far the lowest potential impact, there were considerable differences in the yields: organic fields produced on an average nearly 50% less than fields in IPM farms and 20% less than those in conventional farms (Kooistra et al., 2006).

Building human and social capital to empower farmers

The impacts of the cotton IPMFFS is expected to go much beyond the change in agronomic practices to include effects on social organisation and human capital. A participatory evaluation of the IPM FFS conducted in 2004 in Karnataka, India confirmed that farmers who had participated in the FFS perceived benefits in terms of increased economic resilience of their households and production systems when faced with adversity. Moreover, farmers, in particularly women, who play an important role in cotton farming, reported that the IPMFFS led to enhanced individual recognition and community social well-being (Mancini et al., 2007).

Conclusions and recommendations

- The current use of pesticides in cotton is unnecessary and determined by issues other than sustaining production. IPM adoption on a large scale would make possible substantial savings of US$ 500-1,000 million annually. Policies to promote the use of environmental control methods, already in place in many countries, continue to be a pertinent way to minimise the risks associated with pesticide use.

- The evidence on the pesticides’ social costs confirms the urgent need for policy interventions that ban the use of hazardous pesticides, viz. products belonging to WHO toxicity class I and II. Developing countries have made some progress in improving the efficiency of their systems for the legislation of pesticides, but further policy support is needed to reduce the millions of poisoning cases occurring yearly worldwide.
- Raising consumers’ awareness, increasing industry’s civil responsibility would catalyze the change towards a better regulation of pesticide use.

- There is a need to reduce the impact of agriculture, and particularly of cash crops like cotton, on the environment without compromising on farmers’ economical livelihood.

- Collaboration among the public and private stakeholders and interdisciplinary cross-departmental research programmes are necessary to provide the technical means to achieve an ecologically, economically and socially acceptable production of cotton.
References


Pontius, J., Dilts, D., Bartlett, A., 2002. From farm field schools to community IPM. Ten years of IPM training in Asia. FAO, Regional Office for Asia and the Pacific, Bangkok.


USDA, 1993. USDA Programs related to integrated pest management. USDA Program Aid 1506, Agricultural Research Service, Washington, DC.


Impacts of Farmer Field Schools on Cotton Growers in Asia

Presentation by Francesca Mancini with contributions from FAO-EU IPM Programme for Cotton in Asia staff
Biological Farming Systems, Wageningen University

Presentation content
- Cotton in Asia
- Pesticide use in cotton
- Farmer Field School (FFS) approach
- FFS impacts on human health and the environment

Cotton in Asia
- Around 50% of the world’s cotton is produced in China, India and Pakistan = 13 Mtonnes in 2004/2005
- China and India among the largest consumers
- More than 20 million small-scale producers
- Several millions of workers employed in the cotton industry
- Cotton is a key crop for poverty alleviation

Pesticide use
- Worldwide pesticide use in 2002
  - 3 billion kg pesticides – value 32 billion USD $
  - 25% of insecticides used on cotton, in Asian countries up to 50% (WHO I and II)
  - Most top cotton pesticides are very toxic (WHO I and II)
    - e.g. MONOCROTOPHOS AND ENDOSULFAN

However, pesticide consumption in Asia is declining
- China since late 1990s
- India in 2005/2006 -12/8% pesticide sales
  (Indian Pesticides Manufacturers Association of India)

Exposure
- Short or Long-term: high-level exposure
- Long-term low-level exposure

Acute Poisoning
(According to official records)
- 1-5 000 000 (220 000 deaths)
- 99% in less developed countries
- 735 000 (37 000 deaths)

Sources: FAO/WHO/UNEP, Public Health Impact of Pesticides used in agriculture, 1990
World Health Statistics Quarterly, Vol.43, No.3, 1999
Pimentel et al., 1996
3% of agricultural workers in Asia experience an episode of acute poisoning a year: 25 million cases of occupational poisoning!

Girls employed in Hybrids cottonseed production

Environmental impact

Governments of China, India and Pakistan, in collaboration with the FAO, have been promoting ecological alternatives and investing in farmer education on Integrated Pest Management (IPM)

IPM

Knowledge-based approach to plant protection that combines biological, cultural and chemical control
**Farmer Field Schools**

- Season-long training for 25-30 farmers (6 months)
- Discovery-based: provides farmers with continued hands-on opportunities to practice IPM principles
- Farmers find locale-specific solutions and make informed decisions on pest management

**Ecosystem Analysis**

- Field observation
- Data analysis
- Implementation
- Discussion

**Focus on insect ecology**

Farmers discover functions of arthropods
Collect specimens from the field and keep them insect zoos
Study both pests and their natural enemies and understand how they survive in the field

**Reduced pesticide use...**

(Andhra Pradesh, India, data from 137 farms)

- Before
- After

**Increased Gross Margins...**

Differentials to non-IPM control, average of 7 studies, 1,197 farmers
...as a result of reduced pesticide use
Example: 2003 Impact Assessment Study with 190 farmers Source: NARC, Pakistan

Improved human health
Incidence of acute pesticide poisoning among 97 cotton growers from 3 villages in India

Pesticide effects on female reproductive health
IPM Europe Task Force, Wageningen University, In prep.

Environmental impact of cotton production
15 conventional, 10 IPM, and 12 organic cotton-growing farms in Maharashtra

Bt cotton - Net Profit
Xianiao County, Hubei province, China 2001

Environmental Index Quotient (EIQ)
- AC = Acidification
- GW = Global Warming
- Eutr = Eutrification
- Er = Soil Erosion
- EIQ = Environmental Index Quotient

Exposure was assessed on the basis of Environmental Index Quotient calculation (actual pesticide use)
Health centers’ records were screened for abortion and still birth cases

IPM versus NON IPM households.
Average number of abortions (0.23 on IPM and 0.32 on NON IPM) and still births (0.34 on IPM and 0.54 on NON IPM) was significantly higher among non-IPM households.

Nearly 1,200 women who registered a pregnancy status (2004.4-2005.10) were interviewed
Exposure was assessed on the basis of Environmental Index Quotient calculation (actual pesticide use)
Health centers’ records were screened for abortion and still birth cases

Environmental impact of cotton production
15 conventional, 10 IPM, and 12 organic cotton-growing farms in Maharashtra

Environmental Index Quotient (EIQ)
- AC = Acidification
- GW = Global Warming
- Eutr = Eutrification
- Er = Soil Erosion
- EIQ = Environmental Index Quotient

Exposure was assessed on the basis of Environmental Index Quotient calculation (actual pesticide use)
Health centers’ records were screened for abortion and still birth cases

IPM versus NON IPM households.
Average number of abortions (0.23 on IPM and 0.32 on NON IPM) and still births (0.34 on IPM and 0.54 on NON IPM) was significantly higher among non-IPM households.

Nearly 1,200 women who registered a pregnancy status (2004.4-2005.10) were interviewed
Exposure was assessed on the basis of Environmental Index Quotient calculation (actual pesticide use)
Health centers’ records were screened for abortion and still birth cases

IPM versus NON IPM households.
Average number of abortions (0.23 on IPM and 0.32 on NON IPM) and still births (0.34 on IPM and 0.54 on NON IPM) was significantly higher among non-IPM households.

Nearly 1,200 women who registered a pregnancy status (2004.4-2005.10) were interviewed
Exposure was assessed on the basis of Environmental Index Quotient calculation (actual pesticide use)
Health centers’ records were screened for abortion and still birth cases

IPM versus NON IPM households.
Average number of abortions (0.23 on IPM and 0.32 on NON IPM) and still births (0.34 on IPM and 0.54 on NON IPM) was significantly higher among non-IPM households.

Nearly 1,200 women who registered a pregnancy status (2004.4-2005.10) were interviewed
Exposure was assessed on the basis of Environmental Index Quotient calculation (actual pesticide use)
Health centers’ records were screened for abortion and still birth cases

IPM versus NON IPM households.
Average number of abortions (0.23 on IPM and 0.32 on NON IPM) and still births (0.34 on IPM and 0.54 on NON IPM) was significantly higher among non-IPM households.

Nearly 1,200 women who registered a pregnancy status (2004.4-2005.10) were interviewed
Exposure was assessed on the basis of Environmental Index Quotient calculation (actual pesticide use)
Health centers’ records were screened for abortion and still birth cases
Conclusions

- There is a need to reduce the impact of cotton cultivation on human health and the environment without compromising on farmers’ economical livelihood.
- An effective strategy is re-orienting agricultural and extension policies towards sustainable farming and farmer educational programmes.
- Consumers’ awareness and industry’s civil responsibility play a key role in catalysing the change towards a more sustainable farming.
- Collaboration among the public and private stakeholders, including the scientific community, is necessary to provide the technical means to achieve an ecologically, economically and socially acceptable production of cotton.

The Green-Revolution Scenario

- Lack of National Enforcement of Existing Regulations and of Awareness of Negative Externalities
- Reduced Agricultural Productivity
- Misuse of Insecticides
- Reduced Human Health
- Reduced Environmental Social and Economic Well-Being
- Reduced Agricultural Productivity
- Nutrientically Unbalanced and Biologically Impoverished Soils
- Contaminated WATER
- Damaged Terrestrial Biodiversity
- Reduced Environmental Social and Economic Well-Being
- Misuse of Insecticides
- Reduced Agricultural Productivity
- Nutrientically Unbalanced and Biologically Impoverished Soils
- Contaminated WATER
- Damaged Terrestrial Biodiversity
- Reduced Environmental Social and Economic Well-Being
- Misuse of Insecticides
- Reduced Agricultural Productivity
- Nutrientically Unbalanced and Biologically Impoverished Soils
- Contaminated WATER
- Damaged Terrestrial Biodiversity
- Reduced Environmental Social and Economic Well-Being

Labour pattern

- Improved health - reduction in toxic pesticides use
Area grown to transgenic crops

From: The Economist
FAO-EU IPM Programme for Cotton in Asia

Conservation of Natural Enemies
Post-FFS Year Observations in Yingcheng, Hubei, 2002

Ladybirds, spiders and lacewings in Cotton Fields