Sustainable control of cotton bollworm in small-scale cotton-production systems

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See R6734, R6760, *Perspectives on Pests 1996–2000*, pp. 95–97

Insecticides currently account for around 45% of cotton-growing costs for over 30 million small-scale producers in Asia at a cost of US$811 million each year. In order to reduce the financial and environmental impact of cotton insecticide use, this project built on recent work in India to advance farmers' ability to use insecticides appropriately for control of cotton bollworm in India, Pakistan and China. The project has provided detailed, practical recommendations to empower farmers to adopt insect resistance management, and has developed easy-to-use insecticide quality and resistance detection kits. Direct impact from the village programme in 2004/05 is a net benefit to participating farmers of US$11 million. This project provides UK input into a much larger (US$4 million) CFC project.

ISSUES

Across Asia, approximately 30 million small-scale cotton producers endeavour to support their families on less than two hectares of land, with the cotton crop often being their only source of income. Farmers face devastating attacks from pests, in particular the voracious cotton bollworm caterpillar (*Helicoverpa armigera*), which not only damages cotton but also attacks many food crops. India produces 2.5 million tonnes of cotton each year, sustaining the livelihoods of over 17 million people but, because of the increasing cost of pest control, cotton has become less and less profitable. In total *H. armigera* attacks 181 host plants, including 69 crop species, and causes annual losses worth over US$540 million in India.

Promoting IPM

The threat of cotton bollworm devastation has increased dramatically in recent years. Through over-use of pesticides and poor spraying techniques, the pest has developed resistance to most of the available insecticides. Farmers continue to borrow money to buy more chemicals (both toxic and expensive) and to spray ever more frequently. The net results are decreasing effectiveness against the pest as resistance develops, environmental hazards, and farmers spiralling into debt.

ACHIEVEMENTS

Building on previous CPP projects (R6734, R6760), work was carried out to demonstrate to farmers that, with careful timing of insecticide applications, fewer applications can manage cotton pests better and prevent the development of pest resistance, while natural enemies are maintained. The farmer benefits by purchasing less pesticide and by reduced hazards from pesticide application. The insecticide resistance management (IRM) technology promoted to farmers aims to provide simple, practical principles in a participatory manner. Only materials available off-the-shelf are recommended, and simplified bollworm scouting methods have been introduced.

SELECTED PUBLICATIONS

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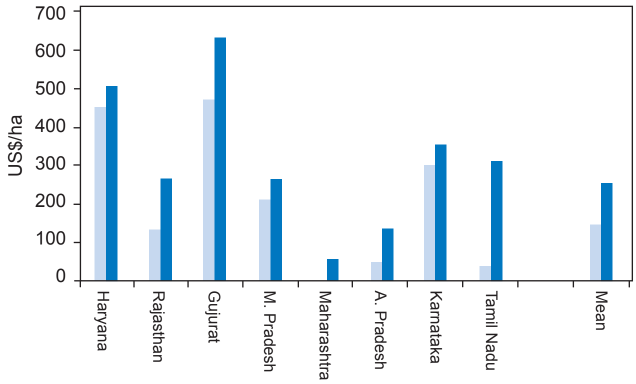
YANG, Y., WU, Y., CHEN, S. *et al.* (2004) The involvement of microsomal oxidases in pyrethroid resistance in *Helicoverpa armigera* from Asia. *Insect Biochemistry and Molecular Biology* 34: 763–773.

The use of resistant varieties reduces the need for scouting of sucking pests. IRM aims to eliminate the application of early insecticide sprays in order to build a good ecosystem necessary for bollworm control. The choice of insecticides used is based on their selectivity and a use-alternation strategy. The aim is to eliminate farmers' dependence on experts (researchers/extension workers) by training them to be managers of pests, predators and parasitoids. This project's specific contributions were as follows.



Net income from cotton (US$ per ha) 2003–04 (light bars, control farmers; dark bars, IRM farmers by Indian State; north on left, south on right)

- Support from UK scientists in the development of rapid 'dip-stick' test kits for insecticide quality of major chemicals. These are now being patented for the benefit of poor farmers who are otherwise at the mercy of pesticide dealers.
- A decision tool aiding the selection of appropriate and effective pesticides that cause minimal environmental damage, summarising all published results for all insecticides used for cotton bollworms globally.
- Collaborative work between UK, Indian, Chinese and Pakistani scientists at Rothamsted Research, which has definitively established the causes and patterns of insecticide resistance to the major pesticide groups (pyrethroids, organophosphates, carbamates and cyclodienes) across Asia. This work has enabled the most effective sequence of non-cross-resisted insecticides to be worked out for individual areas.
- This improved understanding has fed into the national cotton extension programmes in India, China and Pakistan. In India the methods developed under this and the earlier projects have been demonstrated to farmers on an increasing scale. Funding is now entirely from the Government of India. In 2003–04 it covered 10 cotton states, with 27 districts, 331 villages, 5372 core farmers and 18,545 farmer participants in the programme. Average insecticide use declined by 56%, yield increased 24%, and consequently net income by US$107 per ha or 74%. Health and social benefits among participating farmers are also being realised.
- Strategies to mitigate early-season damage while conserving natural enemies include the use of jassid-resistant genotypes, seed treatments, and planting cowpea, African marigold or castor. Some jassid attack discourages *H. armigera* without affecting yields.

In the first bollworm control 'window' (60–90 days after sowing), which aims to suppress the first generation of *H. armigera* while minimising the effect on beneficial practices include: scouting (threshold 0.5 larvae per plant); use of biological controls such as *Trichogramma*, neem and *H. armigera* nucleopolyhedrosis virus; the use of insect growth regulators such as novaluron and lufenuron where available; and use of the insecticide endosulfan, which is less damaging to beneficials.

In the second bollworm control window (90–120 days after sowing), to protect boll formation by controlling the mixed instars of overlapping *H. armigera* generations, practices include: scouting (threshold one larva per plant); use of the insecticides spinosad and indoxacarb where available, or the more widely available quinalphos/chlorpyriphos and profenophos (early use of these chemicals should be avoided as they disrupt beneficials, and use of broad-spectrum insecticides such as monocrotophos and acephate should be avoided). In the third window (110–120 days after sowing), if insecticides are necessary at all, pyrethroids should be used as they retain efficiency against other bollworm species and insect pests present at that time.

Innovative extension methods for these strategies included a national street play contest, with the best play performed all over the country by professional teams; and a short film to be displayed all over the country. Farmer manuals have been printed in local languages, and a more comprehensive handbook of bollworm control is in preparation.

FURTHER APPLICATION

Resistance to insecticides in the pest population is constantly changing. The project has supported the key laboratories in China, Pakistan and India, which provide the national recommendations on pesticide use in cotton pest control. With the inputs of scientists from China, Pakistan and India, work will continue on the biochemical and genetic characterisation of insecticide resistance across the region. Project results are now being applied as a matter of national policy in all three countries. Preventing the development of resistance is an important aspect of the deployment of transgenic, insect-resistant cotton (now being grown in China and India and under trial in Pakistan). The project laboratories are continuing to play a leading role in the development of resistance-management strategies for these important advances.