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Report From the
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FACTORS INFLUENCING THE USE OF PESTICIDES IN COTTON IN AUSTRALIA

1. Integrated Pest Management

From the initial development of SIRATAC (a computer-based decision support system for insect management that focused on sampling and thresholds to better time the application of insecticides) in the late 1970s, Australia has had a well-developed and expansive approach to IPM that includes a wide range of tactics that work towards minimizing insecticide use. This expansive approach to IPM has been based on a major research[1] effort focused on reducing dependence on insecticides (Fitt et al., 2009). The research has been codified in a comprehensive guidance document for Australian cotton farmers, "Guidelines for Integrated Pest Management in Australian Cotton", that is based on a seasonal approach to addressing IPM. As noted in Fitt et al. (2009), the guidelines "provide a framework to achieve [the objectives of IPM] by aligning them with phases of the annual crop cycle. To do this, the crop cycle was divided into five key periods: planting to first flower; first flower to first open boll; first open boll to harvest; a post harvest period; and a pre-planting period. The three first periods deal with the growth cycle of the cotton crop. The final two deal with the 'off' season or winter period during which other crops may be grown. Inclusion of the winter period was essential, since many of the actions taken through this period have important implications for the success of IPM in the following growing season".

In addition to the IPM Guidelines, a comprehensive "Cotton Pest Management Guide" (Cotton CRC Extension Team 2009) is updated and published annually. This guide includes information on pests and beneficial insects found in Australian cotton crops, how to sample for them, the recommended treatment thresholds, how to control (or protect) them, managing resistance in conventional and transgenic cotton crops, integrated weed management, integrated disease management, industry biosecurity, lists of pesticides registered for use on cotton, legal responsibilities when applying pesticides and techniques to mitigate pesticide drift.

The Australian cotton industry also recognizes that defining and formalizing an IPM system is just the first step, and that effective implementation requires a consistent and coherent communication and extension effort. This effort is coordinated at the national level by a National Cotton Extension Team resourced from both industry and government funds. It is well supported also by a highly professional core of consultants. The extension team has representatives in all the main cotton regions, and provides a highly coordinated vehicle for consistency and cooperation in providing information (Fitt et al., 2009).

According to Fitt et al. (2009), this coordinated approach to IPM has also fostered the development of regional IPM undertaken via "Area Wide Management" groups, where groups of growers agree on core goals and communicate throughout the season to achieve a local regional approach to pest management. In some instances this participatory research approach has grown to a truly area-wide management system, where pest management efforts are coordinated across a region by using understanding of the pests' ecology and interactions with the farming system to reduce abundance.

The Australian cotton industry has also undertaken a significant capacity-building exercise through formalized education in IPM under the premise that people who understand the IPM system will be able to make better IPM decisions. A tertiary level Cotton Production Course, developed and delivered by the University of New England (NSW, Australia) and the Cotton Cooperative Research Centre (CRC), has produced 180 graduates in 13 years, comprising many of the industry's field agronomists, extension personnel and growers. At a vocational training level, a short-course in IPM was developed specifically for cotton growers and delivered by

[1] Research in the Australian cotton industry is funded by a compulsory levy on cotton growers of A$2.25 per bale, which is matched by the federal government to a maximum of 0.5 % of the gross value of production. This levy also funds Cotton Australia's membership of Plant Health Australia

the Cotton CRCs between 2001 and 2005 with 221 graduates, mainly cotton growers and their immediate staff (Hickman 2006).

2. Biotech cotton

As noted by Pyke (2007), "A decade ago there was a strong reliance on insecticides for effective pest control, particularly for the lepidopterous pests *Helicoverpa punctigera* and *H. armigera* (Fitt 1994). Problems associated with a dependence on insecticide-based pest control practices include high cost, residuals, resurgence and resistance and were the initial driving factors for the early introduction of single Bt insecticidal gene Ingard® [expressing the Cry1Ac protein] varieties in Australia in 1996. Since then, adoption of Bt cotton varieties by Australian cotton growers has been close to the maximum 'capped' areas permitted by regulators. The cap was initially 10 percent of the planted area in 1996/97and was increased to a plateau of 30 percent in 2000/01, a level at which it was maintained until 2003/04, when Ingard varieties were completely replaced with two Bt-gene Bollgard®II varieties [expressing the Cry 1Ac and Cry 2AB proteins]. The removal of this cap led to rapid adoption of Bt varieties by Australian growers with 86 percent of the national crop planted to them in the 2006/07 season".

Consistent with the information detailed in the Study, Fitt (2008) reports that during the first 8 years of use of Bt cotton there was an average reduction of 44% in active ingredient (and a 59% reduction in insecticide applications) for *Helicoverpa spp*. Following the introduction of Bollgard II varieties, the reduction in active ingredients averaged 65-75% (with a 80-90% reduction in number of sprays) on a per-hectare basis. Some indication of the magnitude of this reduction is noted in the 1998/99 growing season when 1.75 million fewer liters of insecticide were applied on Bt cotton crops compared to conventional cotton (Fitt 2003).

Total insecticide use on Australian cotton fluctuates widely from season to season, due to a) the area of production changing as a result of water availability, and b) seasonal conditions which directly influence pest abundance. However, as demonstrated by the following figures (courtesy B. Pyke and based on Pyke 2007), there is a significant difference in the total number of sprays between conventional and Bt cotton crops (Figure 1). This difference in frequency is attributable to the reduction in sprays for *Helicoverpa spp*. (Figure 2). Despite the significant reductions in sprays for *Helicoverpa spp*., there has been little change in the total number of sprays for all other pests, i.e. mirids, mites, aphids and thrips (Figure 3).

Figure 1: Frequency of insecticide applications, conventional versus Bollgard II

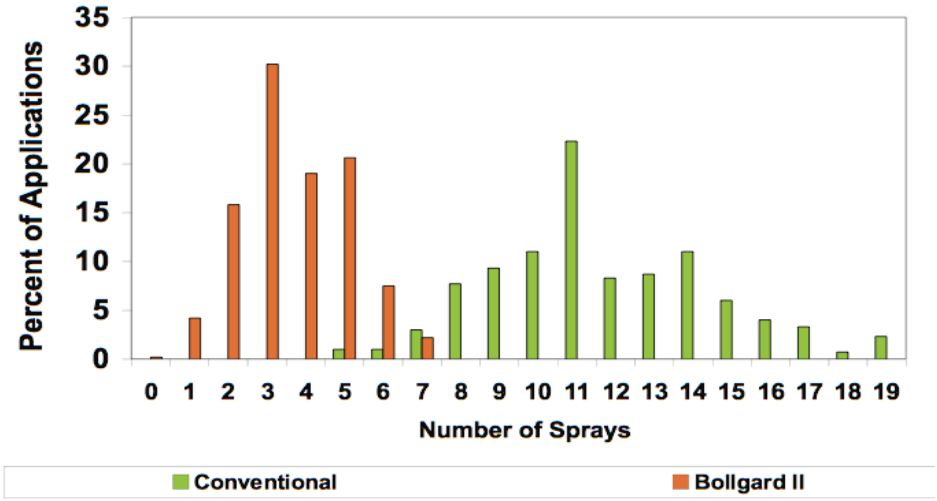


Figure 2 Number of sprays targeting *Helicoverpa spp.*

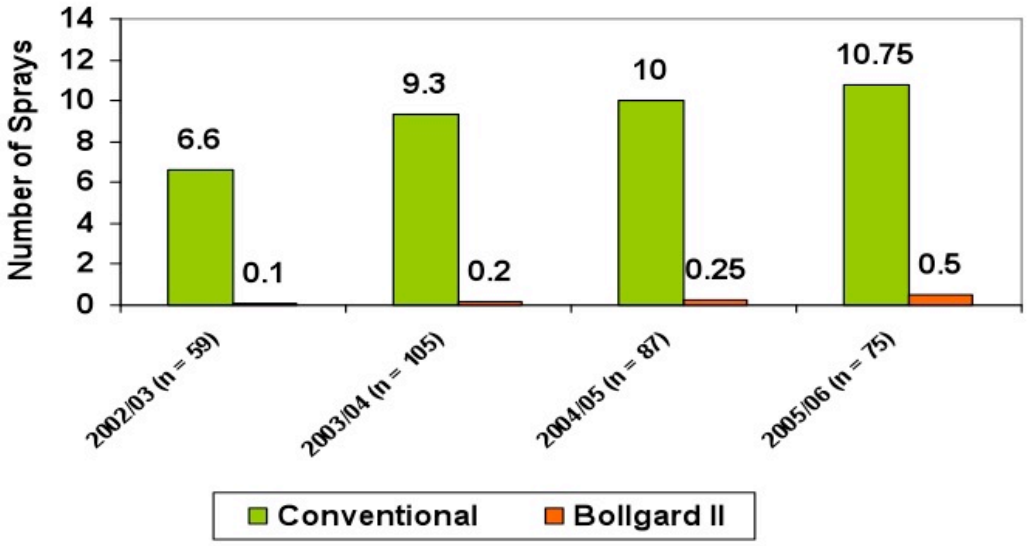
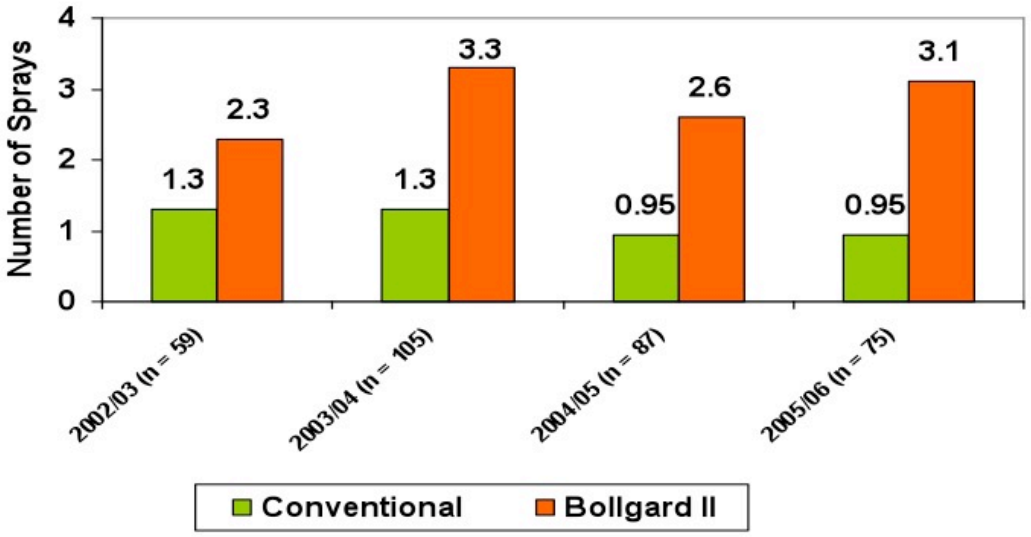


Figure 3 Number of sprays targeting sucking pests



3. Resistance monitoring

As detailed in Forrester et al. (1993), Australia has a long history of problems with the evolution of pesticide resistance in key pest populations, which however has resulted in a world leading approach to effective resistance management. As part of the expansive approach to IPM noted above, all new selective insecticides are incorporated in the cotton industry's Insecticide Resistance Management Strategy (IRMS) that is developed under the auspices of the industry based Transgenic and Insecticide Management Strategies (TIMS) committee. The IRMS is targeted at preventing the development of resistance in the key pests: *Helicoverpa spp.*, aphids, mites and whitefly. The TIMS committee includes cotton growers, researchers, state departments of agriculture, and manufacturer representatives. This strategy is reviewed annually, and takes into account the results of the resistance-monitoring programme undertaken by the industry.

Key components of the IRMS include the destruction of overwintering pupae, use of recommended pest thresholds, avoiding early use of broad-spectrum insecticides, a "window-based" approach to when insecticides can be used, rotation of chemical groups, a recommended maximum number of applications of any one insecticide and the control of weeds to minimize alternative hosts for mites, aphids and whitefly (Rossiter 2009).

A rigorous and pre-emptive resistance management strategy is also in place for Bt cotton varieties. Key components of resistance management for *H. armigera* are the destruction of diapausing pupae that are a potential reservoir of resistance genes (Fitt and Daly 1990). This is a core non-insecticidal component of both the IRM and IPM strategies. Growers are advised to sample cotton stubble for overwintering pupae, and by using published guidelines, determine and prioritize which fields require control. Fields which have grown Bt cotton require mandatory cultivation and incorporation of the crop residue to eliminate plant re-growth and destroy pupal stages of potentially resistant pest populations (Fitt 2009).

4. Biosecurity

The Australian cotton industry is a member of Plant Health Australia, an organization with both government and plant industry membership that has the role to coordinate a cooperative whole-of-industry and whole-of-government approach to the development and implementation of plant health policies and management programs, including incursion management. As noted by Fitt (2009), "Australia's next big IPM challenges may well come from incursions of new pests or plant disorders (e.g. viruses) vectored by new or existing insects. Australia's geographic isolation gives it an advantage [but not immunity] from exotic pests and diseases."

Thus, to manage this risk, the Australian cotton industry, in association with Plant Health Australia, researchers and federal and state governments, has developed a National Biosecurity Plan for the cotton industry that identifies key threats and situation-specific strategies to rapidly identify and manage incursions should they occur. The plan, which is formally endorsed by the cotton industry, the Australian Government and all state and territory governments, is updated regularly, and is now in its second version (Plant Health

Australia 2009).

A pre-emptive approach to managing the risk of new pests and diseases being introduced to the Australian cotton crop is designed to reduce the risk of pests becoming established, and therefore reduce the potential need for the use of additional pesticides to control new pests and diseases.

5. Best Management Practices

As part of a drive to enhance environmental management of cotton farms, the Australian cotton industry has implemented a Best Management Practice (BMP) approach to environmental management that was originally codified in a BMP Manual (Williams and Williams 2000). As noted by the peak cotton grower representative organization, Cotton Australia, "The Best Management Practices (BMP) program is the Australian cotton industry's commitment to the world's best practice in cotton production. It is a voluntary farm management system that provides self assessment mechanisms, practical tools and auditing processes to ensure that cotton is produced with best practice across a range of focus areas". These focus areas include application of pesticides (to minimize off-farm movement), storage and handling of pesticides (to minimize the risk to users) and IPM (to minimize use).

The BMP program provides a framework for growers to evaluate their management performance against the best standards in the industry, for identifying areas of improvement, and documenting this in an auditable fashion.

6. Pesticide Regulatory Framework

All pesticides sold in Australia must be first registered by the Australian Pesticides and Veterinary Medicines Authority (APVMA), the central national statutory authority, which evaluates all pesticides before they can be legally supplied, sold or used in Australia. This registration process includes the development of the specified use conditions that must be included with the product label when it is sold. Matters addressed on the label include:

- The crops and locations for which the product is registered for use
- Allowable application rates and application methods
- Appropriate weather conditions and drift mitigation strategies
- Safety precautions to be taken (e.g. use of protective equipment)
- Training requirements

The APVMA also reviews older products that have been on the market for a substantial period of time, and products that have had particular concerns raised about their safety and effectiveness. A review may be initiated when new research or evidence has raised concerns about the use or safety of a particular chemical or product. When undertaking a review, the APVMA must be satisfied that continued registration and approval of a chemical:

- would not be an undue hazard to the safety of people exposed to it during its handling or people using anything containing its residues;
- would not be likely to have an effect that is harmful to human beings;
- would not be likely to have an unintended effect that is harmful to animals, plants or things or to the environment; and
- would not unduly prejudice trade or commerce between Australia and other countries.

A review may result in:

- a confirmation that the product is safe and appropriate for registered use;
- the product being restricted in use;
- the product requiring to be reformulated;
- the product requiring a change in labeling to limit the situations in which product/s may be used, or
- the product being suspended, cancelled or withdrawn from the market.

In recent years, a number of pesticides registered for use in cotton have been reviewed. Table 1 below contains selected examples of the types of outcome of reviews by the APVMA:

Table 1. Selected outcomes of the review of registered pesticides in Australia

Product	Outcome

Aldicarb	Considering its presentation in granular form and its application method and use pattern in Australia, there was little likelihood of adverse human health or environmental effects arising from its use. Therefore, there was no reason for the APVMA to discontinue the registration of aldicarb.
Endosulfan	A key concern of the review was to prevent cattle from ingesting endosulfan residues. The APVMA therefore imposed mandatory buffer zones for spraying, restrictions in the total amount of active ingredient that could be applied to a cotton crop per hectare and a need for neighbourhood notification before application. A ban on livestock being fed any pasture, forage or fodder treated with endosulfan was also instituted.
Parathion Ethyl	Registration cancelled February 2000.
Monocrotophos	Registration cancelled December 2000.

Recently the APVMA has also begun specifically reviewing products with a focus on ensuring that the conditions of use include comprehensive instructions for managing spray drift.

Pesticides to be reviewed as part of the “Spray Drift Label Review” include the insecticides chlorpyrifos, endosulfan, dimethoate, parathion-methyl, thiodicarb, pymetrozine, chlorfenapyr, abamectin and emamectin, and the herbicides 2,4-D, bromoxynil, dicamba, diquat, diuron, fluazifop, fluroxypyr, glufosinate-ammonium and glyphosate.

This process of review ensures that the most current information and data available on agricultural products are taken into account when determining whether pesticides should be registered for use in Australia, and if they are registered, the appropriate conditions for their continued use.

Field use of pesticides is regulated by state-legislation, and users of agricultural chemicals are required to abide by all label conditions (which include directions for use). Users are also required to undertake training in the use of agricultural chemicals.

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