An economic evaluation of an on-going IPM program within the Australian Cotton Industry

Ziaul Hoque [1], Bob Farquharson [2], Martin Dillon [3] and Greg Kauter [4]

1 Australian Cotton Cooperative Research Centre and NSW Agriculture, Narrabri, 2 NSW Agriculture, Centre for Crop Improvement, Tamworth, 3 CSIRO Entomology, Narrabri,4 Queensland Department of Primary Industries, Goondiwindi,

Introduction

Cotton production in Australia is a high-value industry with about 90% of fibre produced being exported to Asia, primarily to Indonesia. One aspect of modern cotton production is the heavy usage of insecticide sprays to combat *Helicoverpa* insects. The high cost of sprays and the public view of the industry regarding its perceived impact on the environment have led to the development of integrated pest management (IPM) strategies. The evaluation of insecticide resistance in pest populations has also prompted the development of insecticide resistance management (IRM) strategies. The aim of the work reported here is to improve the understanding and adoption of such strategies by cotton growers. A simple bio-economic assessment of alternative IPM strategies is presented. A farm-level dataset is used to conduct an analysis of alternative spray options.

Data collected over 2 years (1998/99 and 1999/2000 seasons) from a set of contiguous cotton properties in northwest NSW are analysed in the paper. The factors considered include farm inputs (sprays and costs), outputs (cotton yields) and financial returns (Gross Margins (GM)). Cotton properties and paddocks are categorised according to the numbers and types of sprays (termed Hard and Soft spray strategies) used on INGARD® and conventional cotton crops. The analysis is a relatively simple approach that nevertheless provides some useful initial information and comparisons. It is the first stage of a project evaluating the potential economic returns to alternative IPM and IRM strategies for the Australian cotton industry.

Soft versus hard management options

The Cotton CRC IPM Guidelines(Mensah and Wilson 1999) categorises insecticides according to their disruptive effects on beneficial groups such as predatory beetles (ladybeetles etc), predatory bugs (big-eyed bugs etc), spiders, wasps and ants, and thrips. They rated the impact (percentage reduction in beneficials following application) as very low (less than 10%), low (10-20%), moderate (20-40%), high (40-60%) and very high (> 60%) based on extensive testing over several years. This was the basis of defining our 'Soft' and 'Hard' options.

In this analysis 'Soft' option includes insecticide management procedures that aim to maintain beneficial insects while achieving effective control of pests. This includes using selective insecticides which are relatively harmless to beneficial insects compared to the alternatives. The significance of this type of strategy is to preserve the activities of beneficials and reduce the number of insecticide sprays. It is also important in achieving IRM objectives.

'Hard' option chemical controls include spray options where the emphasis is on cost and efficacy rather than impact on beneficials. Deutscher and McKewen (1996) define a 'hard option' spray as one where the spray decision considers standard or lower thresholds and the full range of available chemistry

The data from the farm-level data set included the number and types of sprays used in each fields. To quantify the degree of impact that a given insecticide regime may have had on beneficial insects, a ranked score was allocated to each insecticide application. The total score for each field was tallied according to the number of sprays multiplied by their spray rank score in each case. Scores for each type of insecticide were allocated on the basis of their overall impact on beneficial insects as documented in the IPM Guidelines (see Table 1). The total weighted score for each field was then used to categorise the field as one where hard or soft control options were used

Organising data

All the fields of each season were classified into two major groups - conventional and INGARD®. We ranked all the fields of each group following the scoring procedure mention above, and then arranged them based on their rank in ascending order. The lower half of the ranked fields, we categorised as 'Soft' and rest of the fields were considered as 'Hard'. The same procedure was followed for both seasons. This allocation is shown in Table 2.

A comparison of seasons

Measurements of insect pressure, pest infestation for both years show that 1998/99 was a much heavier than 1999/2000. This has implications for comparing one year with the next. For example, some of the Soft paddocks in 1998/99 would be ranked Hard in 1999/2000. The main factor to consider is whether similar trends between management strategies (Soft and Hard) are consistent between years.

Methodologies evaluated

The question being asked in this paper concerns the economics of various options to control insects (mainly *Helicoverpa*) in cotton production in Australia. From a cotton producer's point of view, the issue is of comparing alternative IPM strategies for insect control. These strategies, involving the use of 'harder' versus 'softer' options with respect to chemistry, are important issues for the industry. Growing resistance to chemical insecticides among *Helicoverpa* populations, especially *H. armigera*, is driving this issue. This has meant increasing numbers of sprays, and total input costs, in commercial cotton production.

The farm level data set must be considered as a case study, because no sampling procedure was followed to ensure industry representativeness - the data were available and deemed very suitable for the present purpose.

This data set was used to compare insect control costs and GM for different chemical control options. A comparison of the averages of paddocks in each option was then used to provide an idea of the costs and benefits in the short term of alternative management strategies. It must be emphasised that both options are still contained within a standard IRM strategy, as recommended to the industry, but the question is about the net benefit of moving from a more traditional to a newer approach, or harder to softer.

Results

The main results and budgetary comparisons are shown in Figures 1, 2 and 3.

The comparison of average spray costs per ha is shown in Figure 1. In 1998/99 spray costs of Soft option were lower than Hard strategies in both INGARD® and conventional crops, by 21% and 17% respectively. A similar trend was found in 1999/00 season, where the Soft option was less expensive than the Hard, by 42% and 44% for INGARD® and conventional crops respectively. Although the selective sprays associated with Soft strategies are generally more expensive per unit, the increased number of Hard sprays has a greater influence on total costs.

The associated cotton yield results are shown in Figure 2. In 1998/99 despite the spray cost trends in Figure 1, average INGARD® cotton yield was higher (7%) for the Soft than the Hard group. For conventional crops the Soft group yields were on average lower (2%) than Hard. The rate of Nitrogen application showed little difference between groups of fields. In

1999/2000 there are no significant yield difference in Soft and Hard groups in both INGARD® and conventional.

After accounting for variable costs according to the information in Scott (1999), the average gross margin (GM) for the Soft group was higher by 25% and 5% for the INGARD® and conventional crops respectively (Figure 3). In 1999/2000 the soft group showed 5% and 6% higher GM than Hard in both INGARD® and conventional respectively. These trends provide a broad indication that spray costs decrease and profits increase under Soft management strategies compared to Hard strategies.

Discussion

The analysis presented here must be considered as partial and preliminary. It has not been possible to incorporate any whole-farm implications of the alternative strategies. Further work is possible here. However, there are some broad trends that appear to be emerging.

A tentative relationship between financial returns and spray rank is shown in Figure 4 (1998/99 season)and Figure5 (season 1999/00). The relationship is derived by a simple linear regression of GM against spray rank. If we take out fields with very high or very low pressure, so that all fields have roughly equal pest pressure, the lines become more steeper and even more significant - especially for INGARD®.

There is a negative relationship between GM and spray rank. This means that as more sprays are applied (increasing rank) financial returns decline. While the actual line is a best fit of all data points used, it does show that as the spray rank increases, say from 75 to 150 in 1998/99 season (Figure 4), the GM declines on average by around $400/ha. Since the GM measure at each rank level includes all spray costs, this is a substantial reduction. In addition average *Helicoverpa* egg pressure didn't show any significant relation with yields (Figure 6 and 7). More details of insect pressure are presented in the paper of Dillon and Hoque (2000) in these proceedings.

These results imply that the extra (or marginal) returns from applying sprays do not appear to cover the extra costs incurred when applying those sprays beyond some level. While acknowledging that the choice is between spray strategies, the economic interpretation of this result is that the cotton yield benefits derived from the last few sprays don't cover the extra costs. This is a standard result from production economics theory, which says that for diminishing returns functions (see France and Thornley 1984) the input level that maximises

profit is less than the level that maximises production (Dillon and Anderson 1990). Depending on the shape of the response (production) function, the difference could be substantial.

Of course this strategy could be used by growers as a means of reducing risk, or as an insurance against crop failure, and this is a valid management strategy for individual growers. However, such a strategy must be recognised as having an associated downside in terms of immediate returns foregone.

There is another downside associated with chemical management strategies, which relates to longer-term effects. This is the risk of increased resistance to insecticides and insecticide groups. The use of larger numbers of sprays influences the selection pressure exerted on the insect population, and the resulting impact on future susceptibility to insecticides. This is an important economic problem that the industry is currently facing. Further work on this issue is planned in the current economic project "Cost/Benefit assessment of IPM in the Australian cotton industry", at the Australian Cotton Cooperative Research Centre.

Acknowledge

We acknowledge the growers and consultants who have provided time and effort in collecting and transmitting the data to us. If there were other management groups who also have such data, we would be interested in similarly analysing the situation for different locations.

References:

Deutscher, Sandra and Lance McKewen, (1996), 'Early season pest management - can it make a difference?', In *Proceedings of the 8th Australian Cotton Conference*, The Australian Cotton Growers' Association, Gold Coast, Queensland, August 14 -16, pp 173-83.

Dillon, John L. and Jock R. Anderson (1990), *The Analysis of Response in Crop and Livestock Production* 3rd Edition, Pergamon Press.

Dillon, Martin and Hoque, Ziaul (2000), "An analysis of pest pressure in an area wide management group" In Proceedings of the 10th Australian Cotton Conference, The Australian Cotton Growers' Research Association, Brisbane, Queensland, August 16 - 18.

France, J. and J.H.M. Thornley (1984), *Mathematical Models in Agriculture: A Quantitative Approach to Problems in Agriculture and Related Sciences*, Butterworths.

Mensah, Robert and Wilson, Lewis (1999), *Integrated Pest Management Guidelines for Australian Cotton* , Australian Cotton Cooperative Research Centre, Narrabri, NSW.

Scott, Fiona (1999), 'Farm Budget Handbook: Northern Irrigated Crops', [Online], Available http://www.agric.nsw.gov.au/econ/budget/summer/nthsumir/, [1999, 11 November].

Table 1
Score ranking of insecticides used in cotton production

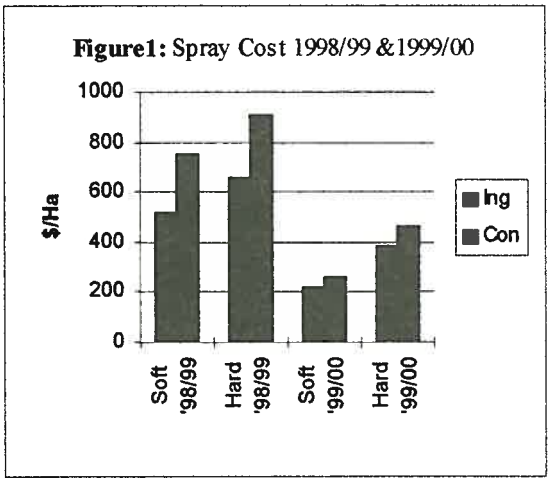
Insecticide	Overall impact	% reduction in beneficials after application	Score
Bt (Bacillus thuringiensis) NPV (Nuclear polyhedra virus) Aldicarb (carbamate) Dicofol (organochlorine) Pirimicarb (carbamate) Propargite (sulfite ester) Spinosad (spinosyn)	very low low	<10% 10-20%	1 2
Diafenthurion (thiourea)	low-moderate	20%	3
Amitraz (formamidine) Chlorfenapyr (pyroll) Endosulfan (organochlorine) Fipronil (phenyl pyrazol) Imadacloprid (chloronicotinyl)	moderate	20-40%	4
Methomyl (carbamate)	moderate-high	40%	5
Organophosphates Thiodicarb (carbamate)	high	40-60%	6
Pyrethroids	very high	>60%	7

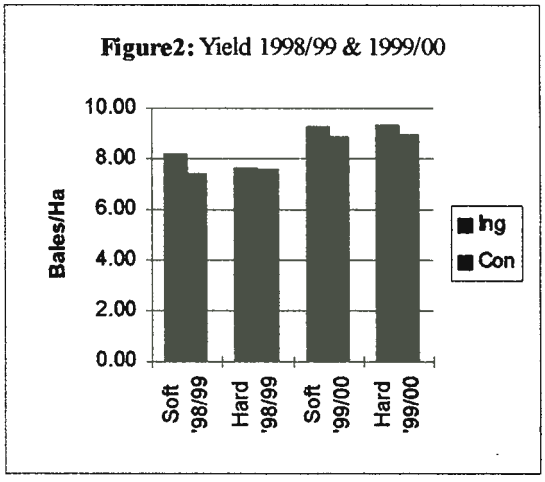
Notes: Some additives to insecticide applications were given a score of zero as they are assumed to have no effect on beneficial insects. These included synergists and UV protectants. Applications of sugar and protein supplements like Predfood and Envirofeast were given a score of -1 because they specifically benefit predatory insects.

Table 2
Classification of case study farms by crop type and chemical option

Cotton crop type	Chemical option	Number of fields		Rank (a) range	
		98-99	99-00	98-99	99-00
Conventional	Soft	27	40	44-120	5-15
	Hard	27	37	121-192	16-54
INGARD®	Soft	20	38	36-76	0-5
	Hard	19	37	79-150	6-51

(a) The ranking for each cotton field is found by multiplying each insecticide chemical score by the number of applications of that chemical.





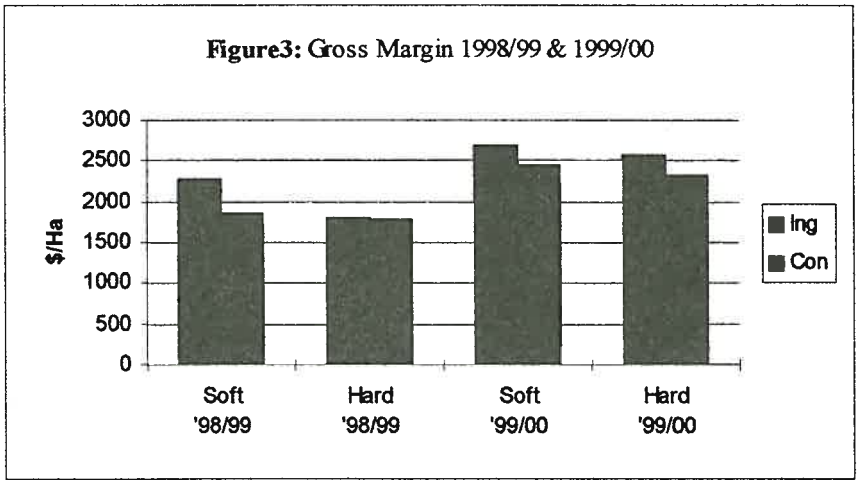


Figure 4: Relation between GM ($/Ha) and rank 1998/99

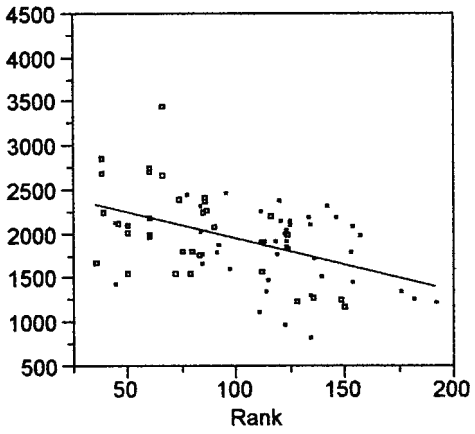


Figure 5: Relation between GM ($/Ha) and rank 1999/00

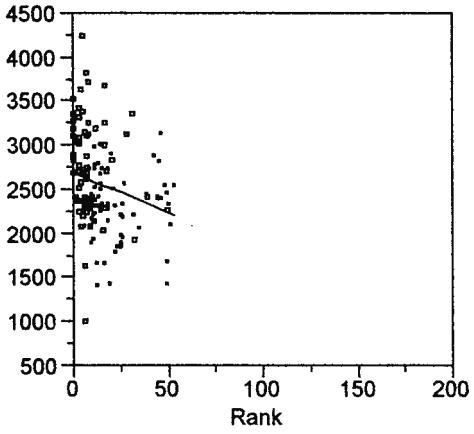


Figure 6: Relation between egg pressure and yield (Bales/Ha) 1998/99

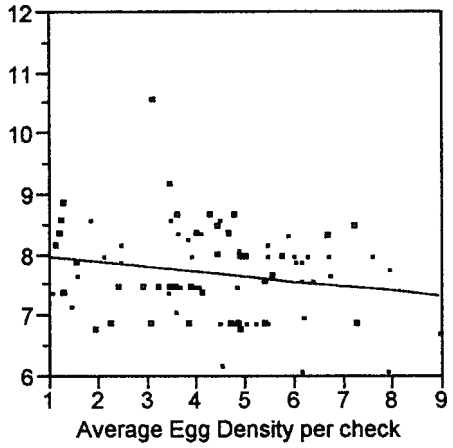
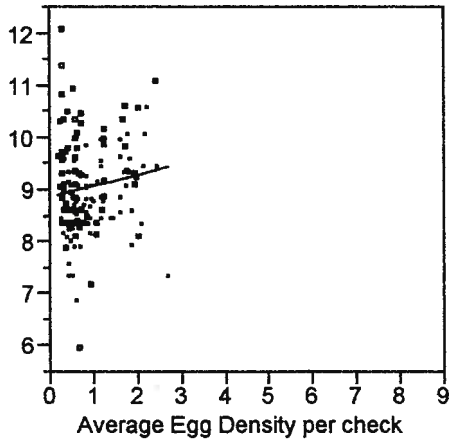


Figure 7: Relation between egg pressure and yield (Bales/Ha) 1999/00



Note: Open squared symbol indicates INGARD® fields and closed circle indicates conventional fields