Three seasons of IPM in an Areawide Management Group – a comparative analysis of field level profitability

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Introduction

Interest in Integrated Pest management (IPM) and Area Wide Management (AWM) continues to increase within the Australian Cotton industry. The costs of chemical control, coupled with pests developing increasing levels of insecticide resistance and an awareness of the potential impacts of sprays on the neighbouring environment have led many Australian cotton growers to consider new approaches to pest management. AWM is an approach which acknowledges that pest and beneficial insects are mobile, and that the management regimes to control pests imposed on a given field are likely to alter the abundance of beneficial organisms and levels of insecticide resistance in the surrounding locality. By communicating and coordinating strategies, growers within an AWM group have better opportunities to implement IPM strategies like those outlined in the Integrated Pest Management Guidelines for Australian Cotton (Mensah and Wilson 1999).

A key component of IPM is to minimise disruption of predatory and parasitic insects and spiders in and around cotton fields. These arthropods are beneficial because they actively suppress pests that migrate into crops, and thereby reduce pest pressure, reduce crop damage, and reduce the need for intervention with insecticides. Insecticides vary in the degree to which they kill beneficial insects. Where economic pest thresholds are exceeded and chemical intervention is required, the ideal insecticide is one that targets the pest but has minimal impact on beneficials. However the decision on what to spray is not straight forward. The effectiveness and value of many beneficial insects and spiders with regard to different types of pests is not well understood, the cost of different insecticide products varies substantially, and the Insecticide Resistance Management Strategy dictates which insecticide products may be used at any given time.

We undertook a financial evaluation of cotton field productivity and profitability from an AWM group of 12 contiguous cotton farms near Boggabilla NSW over three seasons. Information was obtained from the growers and their consultants for each cotton field in the group. The data included details of insect counts, agronomic details, insecticide sprays and lint yields. We used Scott's (1999) 'Farm Budget Handbook: Northern Irrigated Crops' to standardise variable input costs. In order to compare the relative degree to which individual cotton fields were managed with IPM principles, we analysed the types of sprays applied to each field and related these data to the pest pressure experienced by each field in each of the three seasons.

The Beneficial Disruption Index (BDI)

To compare the insecticide spray regimes applied to each field, we scored each type of insecticide according to its relative impact on beneficial insects and summed these scores (multiplied by the number of sprays) to compute a Beneficial Disruption Index (BDI) for each field. The insecticide spray scores were derived from the information compiled by Wilson *et al* (1999) in Support Document 1 of the Integrated Pest Management Guidelines for Australian Cotton (Mensah and Wilson 1999). They categorised 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. Based on data from extensive field trials over several years, Wilson *et al* (1999) rated the overall impact of insecticides (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%). We applied scores to these overall ratings on the basis of 1 point for every 10 percentage points of impact. The resulting scores for each impact category were as follows: Very low 1, Low 2, Moderate 4, High 6 and Very High 8. The last category is conservatively set at 8 because the range of impact is broad – potentially from 60 to 100%.

BDIPP

In some of our analyses we also normalised the BDI derived for each field relative to the *Helicoverpa* pest pressure experienced by each field. We did this by dividing each field's BDI by the average *Helicoverpa* egg density experienced by that field over the whole season. We called this the Beneficial Disruption Index per unit of Pest Pressure (BDIPP). We used average *Helicoverpa* egg densities as our measure of pest pressure because in most seasons *Helicoverpa* is the predominant pest and, relative to larvae, eggs are subject to less mortality from sprays, natural enemies or Bt toxins. Egg counts therefore give a good indication of the pest pressure that each field is actually subject to. However, it is important to note that in this analysis we have not yet considered other pests like mirids, mites and aphids in our measure of pest pressure. In the 2000/2001 season these secondary pests were often the predominant trigger for insecticide sprays applied to fields in our data set.

Soft versus Hard

To provide an overall comparison between pest management strategies, the spray regimes applied to fields from each season were classified as either 'Hard' or 'Soft' on the basis of their BDI scores. INGARD® and Conventional fields were treated separately for each season, and in each case the 50% of fields with greater than the median BDI value for that season were classified as 'Hard' while the 50% with lower BDI values were classified as 'Soft'.

Results

Table 1 summarises details for the top 20% of fields that had the highest Gross Margins (gross returns less variable costs) (GM) in each season, and compares them with the average values for the remaining fields. The figure of 20% was chosen to allow comparison with the Australian Cotton Comparative Analysis (Boyce Chartered Accountants 2001).

Table 1: A comparison of the top 20% of most profitable fields (highest Gross margins) with the remaining fields.

	Conventional		INGARD®	
	Top 20%	Lowest 80%	Top 20%	Lowest 80%
1998/1999 Season				
Average Helicoverpa (eggs/m)	4.09	4.84	2.42	4.14
BDI	19	125	56	92
BDIPP	32	30	28	24
No. of sprays	12.6	13.4	6.9	9.1
Total Spray Cost ($/Ha)	686	765	372	583
Yield (Bales/Ha)	8.34	7.39	8.91	7.54
GM ($/Ha)	2478	1849	2971	1967
1999/2000 Season				
Average Helicoverpa (eggs/m)	1.14	1.02	0.93	0.70
BDI	19	21	9	6
BDIPP	18	22	8	9
No. of sprays	5.3	6.4	2.1	2.1
Total Spray Cost ($/Ha)	295	334	93	104
Yield (Bales/Ha)	9.73	8.67	10.70	8.86
GM ($/Ha)	3680	3024	4284	3206
2000/2001 Season				
Average Helicoverpa (eggs/m)	0.76	1.41	0.59	0.79
BDI	34	32	10	12
BDIPP	48	40	18	18
Number of spray applications	7.7	7.7	2.3	2.4
Total spray cost ($/Ha)	499	498	118	153
Yield (Bales/Ha)	8.26	6.85	9.42	7.39
Gross Margin ($/Ha)	2620	1808	3522	2309

The relationship between BDI and GM for each season is illustrated in Figures 1, 2 and 3. The 1998/99 season was characterized by intense *Helicoverpa* pressure and had up to three times higher BDI figures compared with subsequent seasons. There is a clear overall trend in 1998/99 for fields with high BDIs to have lower GMs. This trend is even more apparent for INGARD® fields. The 1999/2000 season was relatively light in terms of pest pressure. The overall BDIs are much lower, and there is no obvious trend in profits as BDI increases. The 2000/2001 season was characterized by high densities of sucking pests. INGARD® fields show a downward trend in profits relative to BDI, but Conventional fields had the opposite trend.

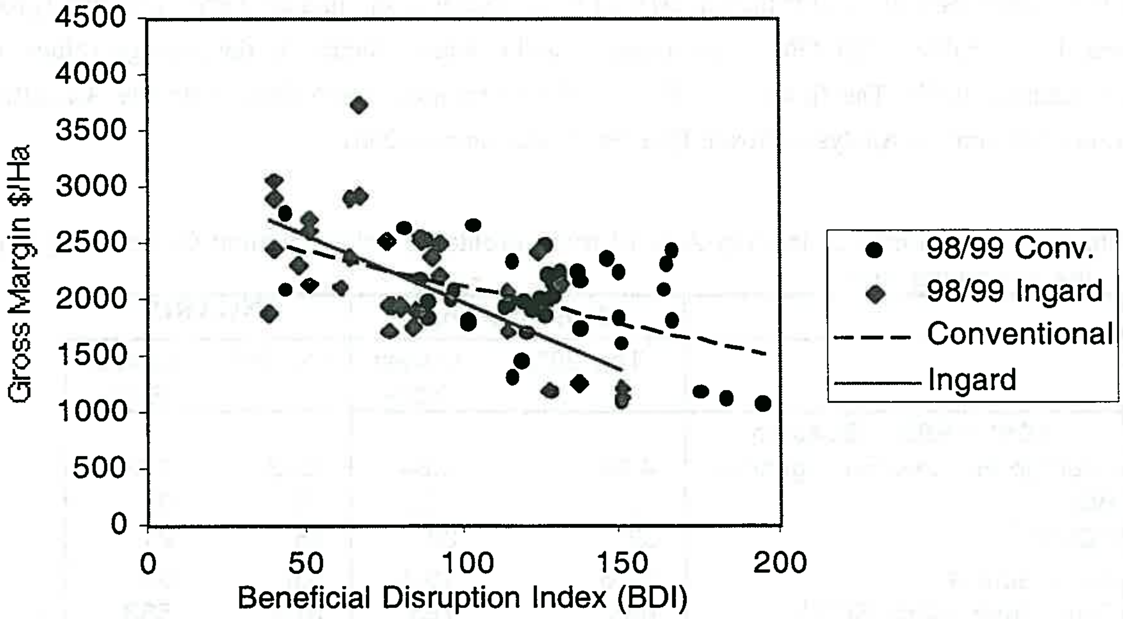

Figure 1. The relationship between GM ($/Ha) and BDI in 1998/99. Dark dots and the dashed line represent Conventional fields, light dots and solid line represent INGARD® fields. INGARD® GM= 3184.9 - 11.95 BDI (R-squared = 0.461)
Conventional GM= 2762.45 - 6.349 BDI (R-squared = 0.242).

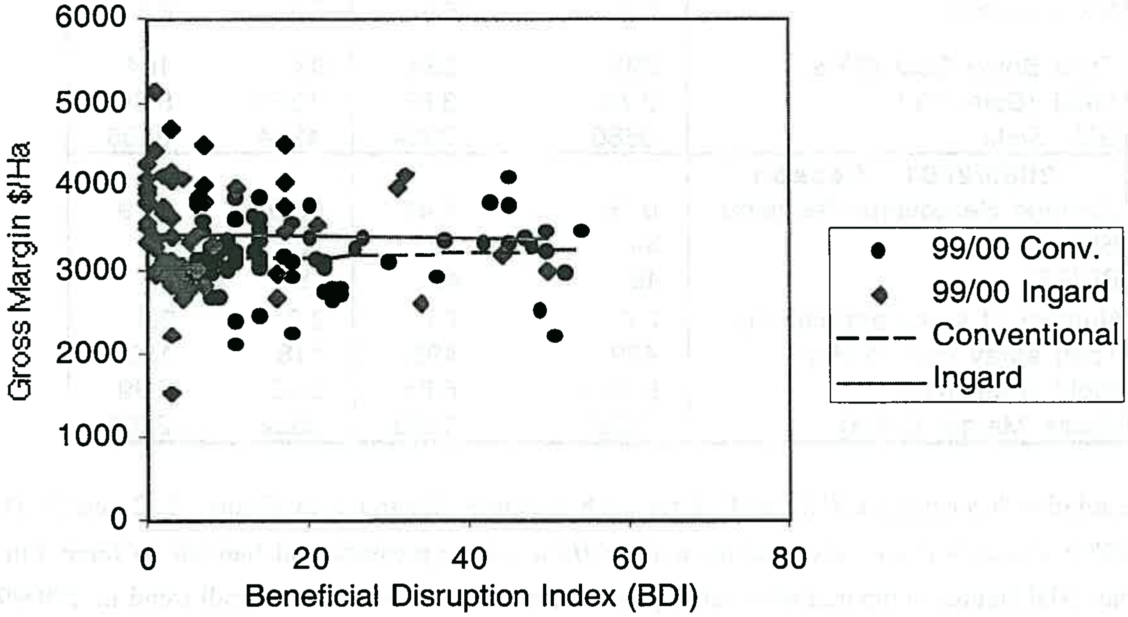

Figure 2. The relationship between GM ($/Ha) and BDI in 1999/00. Dark dots and the dashed line represent Conventional fields, light dots and solid line represent INGARD® fields. INGARD® GM= 3437.15 - 1.3724 BDI (R-squared = 0.0005)
Conventional GM= 3103.85 + 2.3326 BDI (R-squared = 0.007)

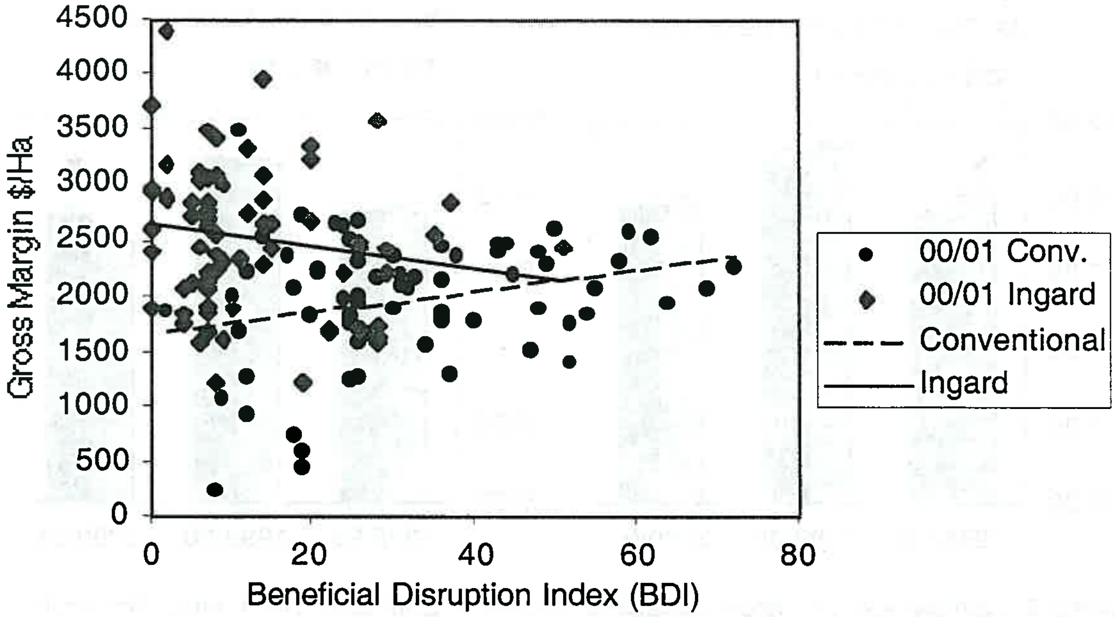

Figure 3. The relationship between GM ($/Ha) and BDI in 2000/01. Dark dots and the dashed line represent Conventional fields, light dots and solid line represent INGARD® fields. INGARD® GM= 2664.05 - 10.1581 BDI (R-squared = 0.024) Conventional GM= 1653 + 9.8402 BDI (R-squared = 0.073)

A comparison of each season's average lint yields for 'Soft' and 'Hard' INGARD® fields is presented in Figure 4a. The light bars represent the 50% of INGARD® fields that had the lowest BDI's, while the dark bars represent the 50% of INGARD® fields with the highest BDI values. In all three seasons there is a trend for the Soft INGARD® fields to have higher Yields than Hard INGARD® fields, but this difference was only statistically significant in 1998/99 as indicated by the arrow. This trend is reversed for Conventional fields (Figure 4b), where the softly managed fields averaged slightly lower yields than the Hard fields. Once again this difference is only statistically significant in one season (2000/01). Figure 5 shows the average GM for the Soft and Hard fields in each season. The variations in profits from season to season are predominantly caused by differences in insect control costs. For INGARD® fields (Figure 5a) the higher yields and lower BDI values translate directly into higher average profits in all three seasons, but only 1998/99 is statistically significant as indicated by the arrow. For conventional fields (Figure 5b) the softly managed fields resulted in higher profits in 1998/99 and 1999/00, but not in 2000/01 when softly managed fields averaged a statistically significant lower GM.

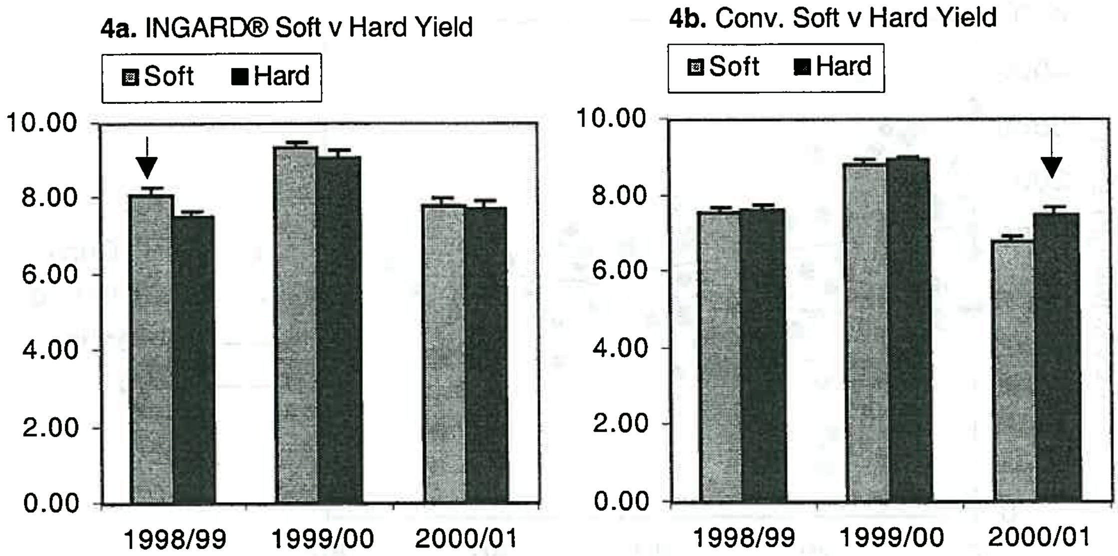

Figure 4. Comparison of Yields (Bales/Ha) between 'Soft' and 'Hard' fields for each season (4a) Ingard, (4b) Conventional. Bars with arrows above are significantly greater (t-test comparing mean yields where $p < 0.05$).

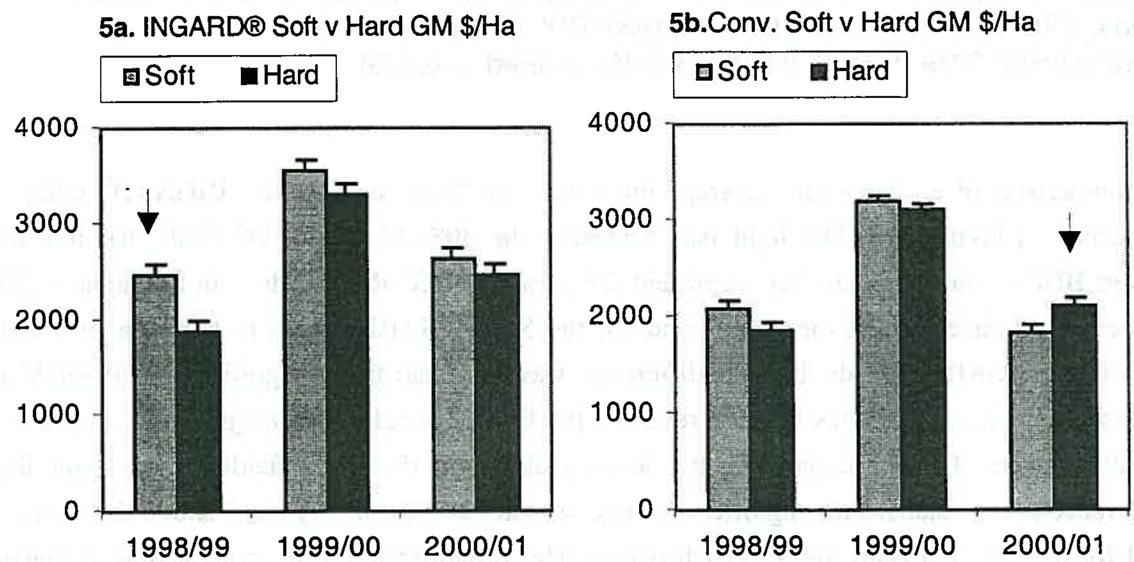

Figure 5. Comparison of Gross Margins ($/Ha) between 'Soft' and 'Hard' fields for each season (5a) Ingard, (5b) Conventional. Bars with arrows above are significantly greater (t-test comparing mean GM where $p < 0.05$).

Discussion

Data and trends from the 1998/99 and 1999/2000 seasons have previously been presented (e.g. Hoque *et al* 2000). Those results showed that in general spray costs decreased and profits increased under Soft management compared to Hard strategies. They also showed that higher yields do not automatically translate into higher profits. The results presented here for INGARD® fields in 2000/2001 also follow this trend (see Figures 3, 5a and Table 1). However, results for Conventional fields in 2000/2001 show that the trend does not always hold true

(Figures 3, 5b and Table 1). Softly managed Conventional fields had lower yields and produced lower profits than Hard fields in that season. The difference is even more apparent in Table 1, which shows that the most profitable top 20% of conventional fields in 2000/2001 had higher BDI and BDIPP values than the average for the rest of the fields.

Compared with the earlier seasons, many of the insecticide sprays in 2000/2001 were targeted at mirids and other sucking pests. In contrast to control options for *Helicoverpa*, there are no completely target-specific insecticides for sucking pests. For example, the main insecticides used against mirids (e.g. Fipronil, Imidacloprid, Endosulfan, Organophosphates) all have a BDI of 4 or higher. The implications of this are that any insecticide spray directly targeting sucking pests will also disrupt beneficial insects, often substantially. Once beneficials are no longer abundant within a cotton field, it is likely that pests will reach economic threshold levels more often, chemical intervention is likely to be required more often, and the relative benefit of softer sprays is likely to be reduced.

There are other down sides associated with chemical management strategies. These include potential environmental contamination, and 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. AWM groups that strive to preserve and nurture beneficial insects and spiders within the landscape are likely to provide their members with a better and less risky platform for implementing IPM. We do not yet have all the answers for managing pests, especially sucking pests, but overall our results show that an IPM approach is generally no less profitable than old fashioned approaches to pest management, with the added benefit of reduced environmental impacts.

Acknowledgments

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