

An Analysis of pest pressure in an area wide management group.

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Introduction

Interest in Area Wide Management is increasing within the Australian Cotton industry. The increasing costs of chemical control, coupled with increasing levels of resistance to conventional chemistry and an awareness of the potential impacts of sprays on the neighbouring environment have led many growers to consider new approaches to pest management. Area Wide Management (AWM) is an approach that 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).

To assess the benefits of IPM implemented within an AWM group, we undertook an economic evaluation of cotton field productivity and profitability in relation to pest pressure. The work reported here examines the interaction between pest pressure and the associated spray programs. It provides supporting material for the economic evaluation presented in a separate paper in these proceedings by Ziaul Hoque *et al.* (2000).

Methods

Data on pest densities, agronomic inputs, and yield was collected over two seasons from a group of 12 contiguous cotton farms in Northwest NSW. The farms are all members of an AWM group and are implementing a range of management strategies. Details on the estimation of input costs and Gross Margins (GM), and on the ranking of fields into soft and hard categories are provided in Hoque *et al.* (2000). The study encompassed 93 fields in the 1998/99 season and 149 fields in 1999/2000. The pest data represents 9,344 scouting checks - an average of 37 checks per field per season. This substantial dataset of Heliothis, Tipworm and Mirid counts provides a powerful base for analysing the broad range of spray regimes applied to fields within the study. Data was collected directly from scouting checksheets for 98/99 and from CottonLOGIC reports in 99/00.

The predominant pest in both seasons was *Helicoverpa armigera* and to a lesser extent *H. punctigera*. These are not distinguished in the raw data, and so are treated together. Throughout this study we use egg densities as the best measure of heliothis pressure experienced by individual cotton fields. Although a proportion of eggs are likely to die and disappear before they are counted, eggs are a better measure of overall pressure over time than larvae because the eggs have had less exposure to natural and applied mortality factors within the field. For mirids and tipworm we combined all life stages to derive a total density for each species at each check.

Results

In terms of pest pressure, the two seasons were very different, and are well described by Greg Kauter (2000) in his paper "IPM - Sticking to the challenge" presented in these proceedings. The 1998/99 season had very heavy pressure from all pest groups, especially heliothis. In contrast 1999/2000 was a very light season for all pests, and beneficial numbers were high. Figure 1 presents the average density of each pest group over the two seasons. In all cases the dark upper line represents 1998/99 and the lighter lower line is 1999/2000.

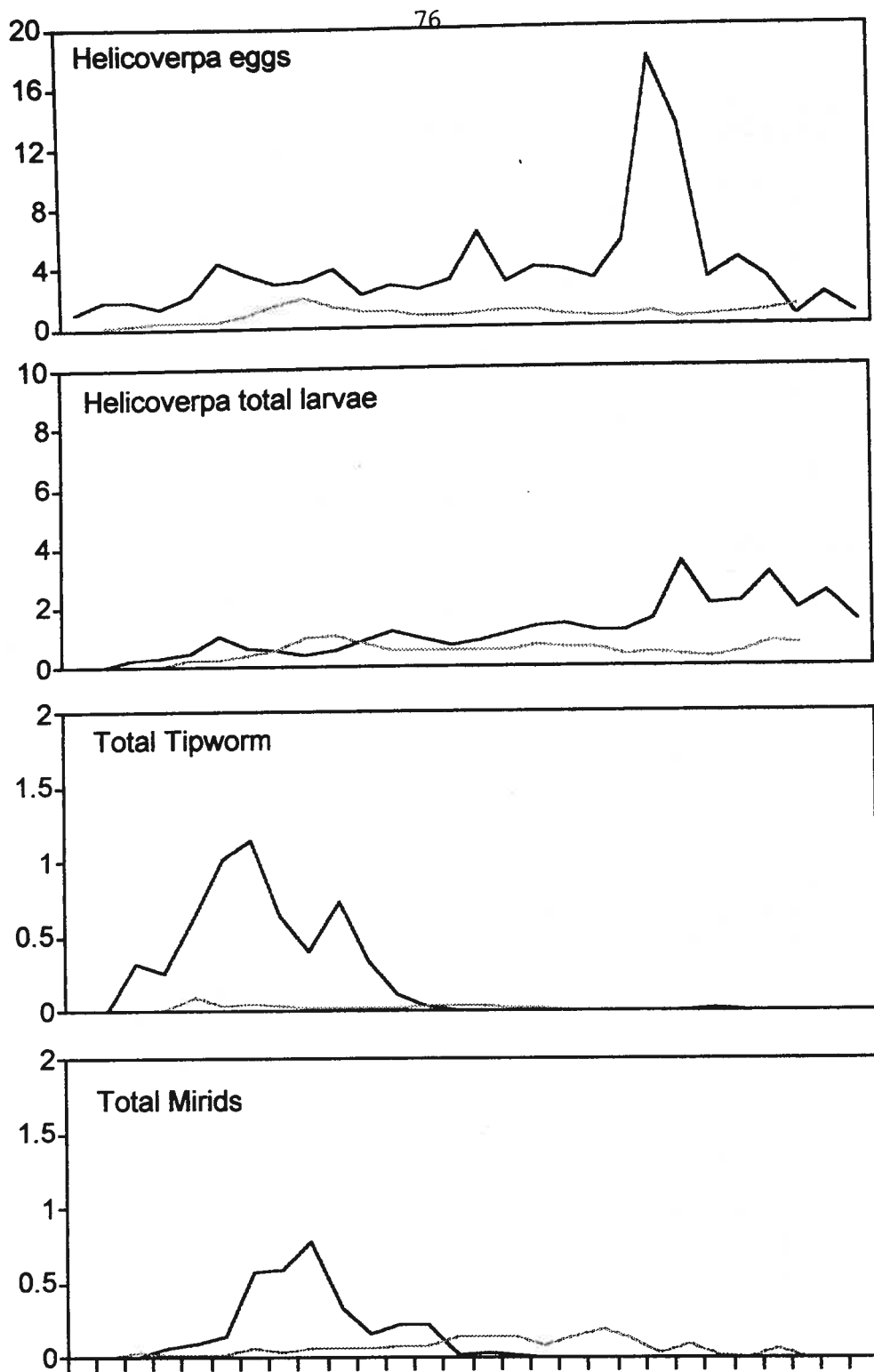


Figure 1. Overall pest pressure averaged across all fields in 1998/99 (n=93 fields) and 1999/2000 (n = 149 fields). Densities were consistently higher in 1998/99, and in each case the upper and darker line represents the 1998/99 season. Note that the scale of the y-axis is different for each graph.

Spray rank categories

The distribution of fields into 4 categories - INGARD Soft, INGARD Hard, Conventional Soft and Conventional Hard is presented in Figure 2. The vertical line in each graph represents the median value at which half the fields have a lower rank (i.e. "soft") and half the fields have a higher rank ("hard"). The words soft and hard are relative, and their classification was very different between the two seasons.

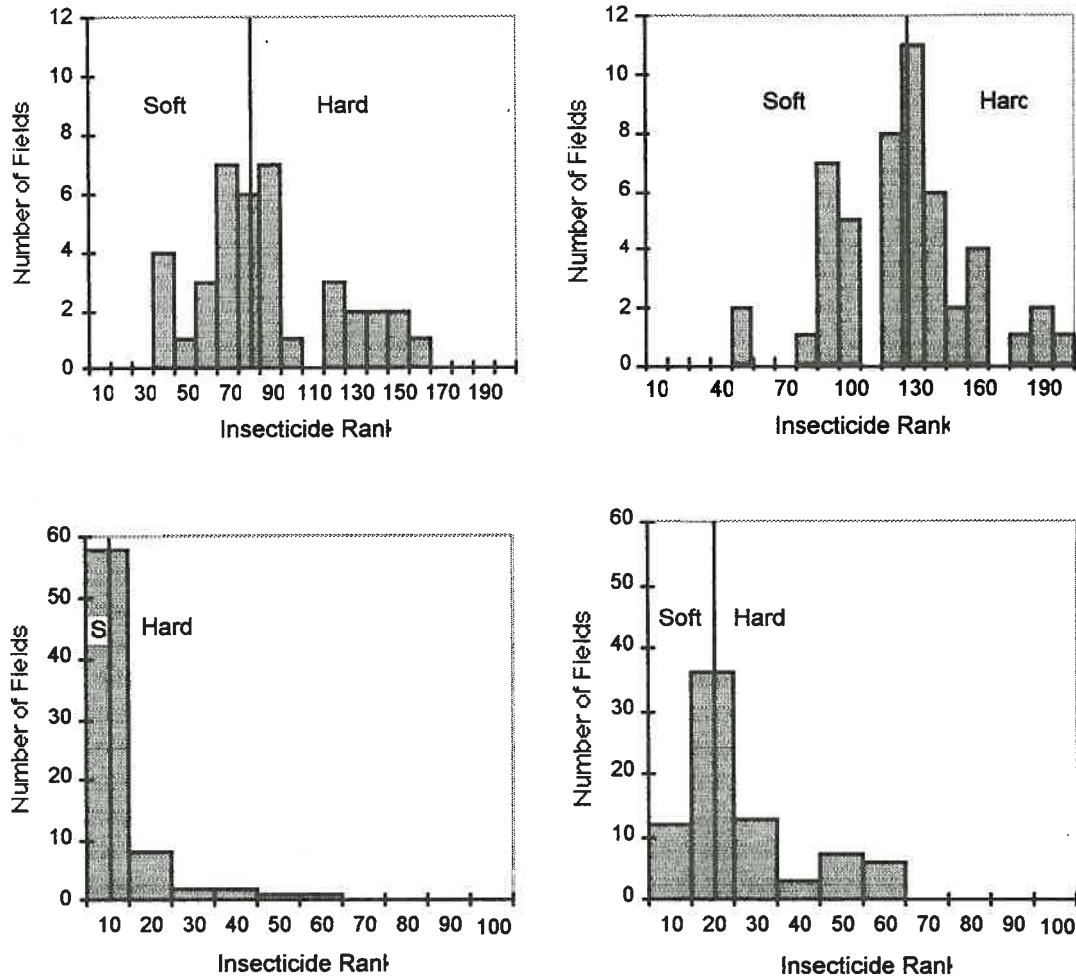


Figure 2. The frequency distribution of fields in spray rank categories. Note that the scale of the Insecticide rank axis in 1999/00 is only half that of 1998/99 and that the count axis have different scales in the two seasons. The vertical line in each graph represents the median spray rank value. Fields to the left of the median were deemed to be 'soft' and fields to the right were deemed 'hard'.

The distribution of the overall average heliothis egg pressure experienced by individual fields within each spray rank category is presented below in Figure 3. The contrast between the two seasons is evident. It is noteworthy that the fields in each category experienced a wide spread of pest pressure within their respective seasons. Only INGARD Soft has a significantly different mean egg density, it is lower than the other categories in both seasons. The other categories have roughly equivalent overall egg pressure within each season.

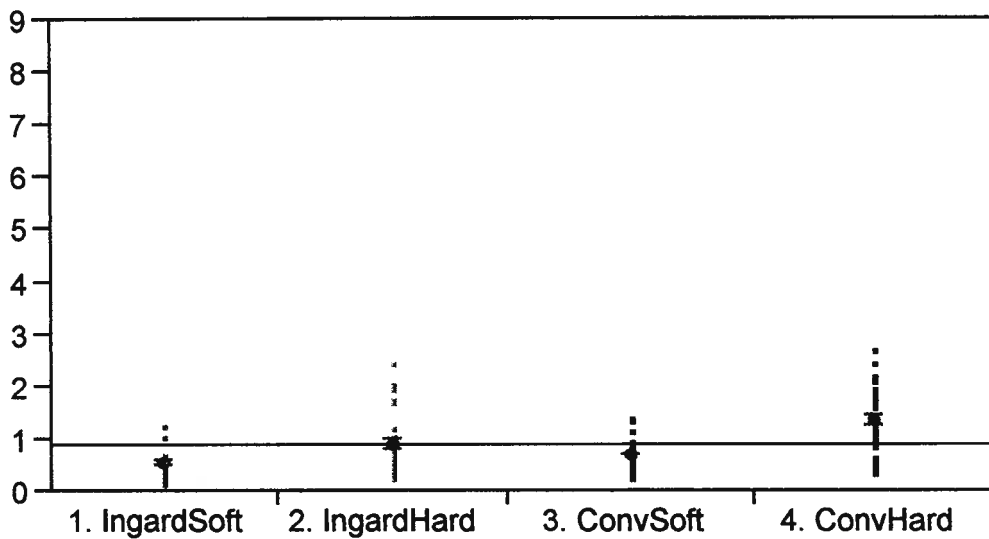
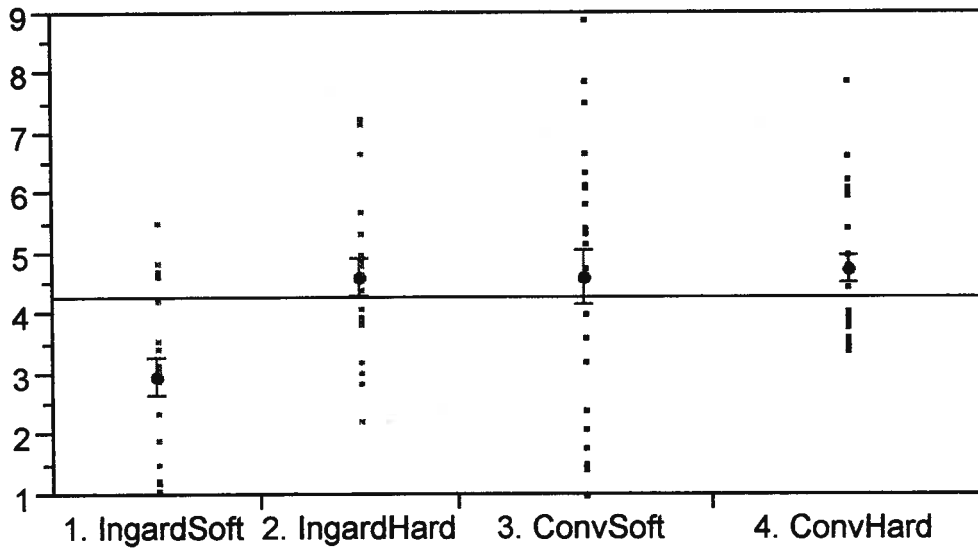


Figure 3. The distribution of overall average egg pressure experienced by each field in each spray rank category. Each data point represents a specific fields egg density averaged over the entire season. The mean egg density of each spray rank category is represented as a large dot with standard error bars.

Average egg pressures within each spray rank category in each stage of the season are presented below in Figure 4. The stages correspond to the stages of the Insecticide Resistance Management Strategy. Once again the difference between the seasons is clear. The 1999/00 season shows similar egg pressure in each stage. However in 1998/99 stage 3 differs with extremely high egg pressure. This peak in pressure is clearly visible in Figure 1. In both seasons the fields that were allocated to the soft categories based on their spray ranks also tended to have slightly lower pressure.

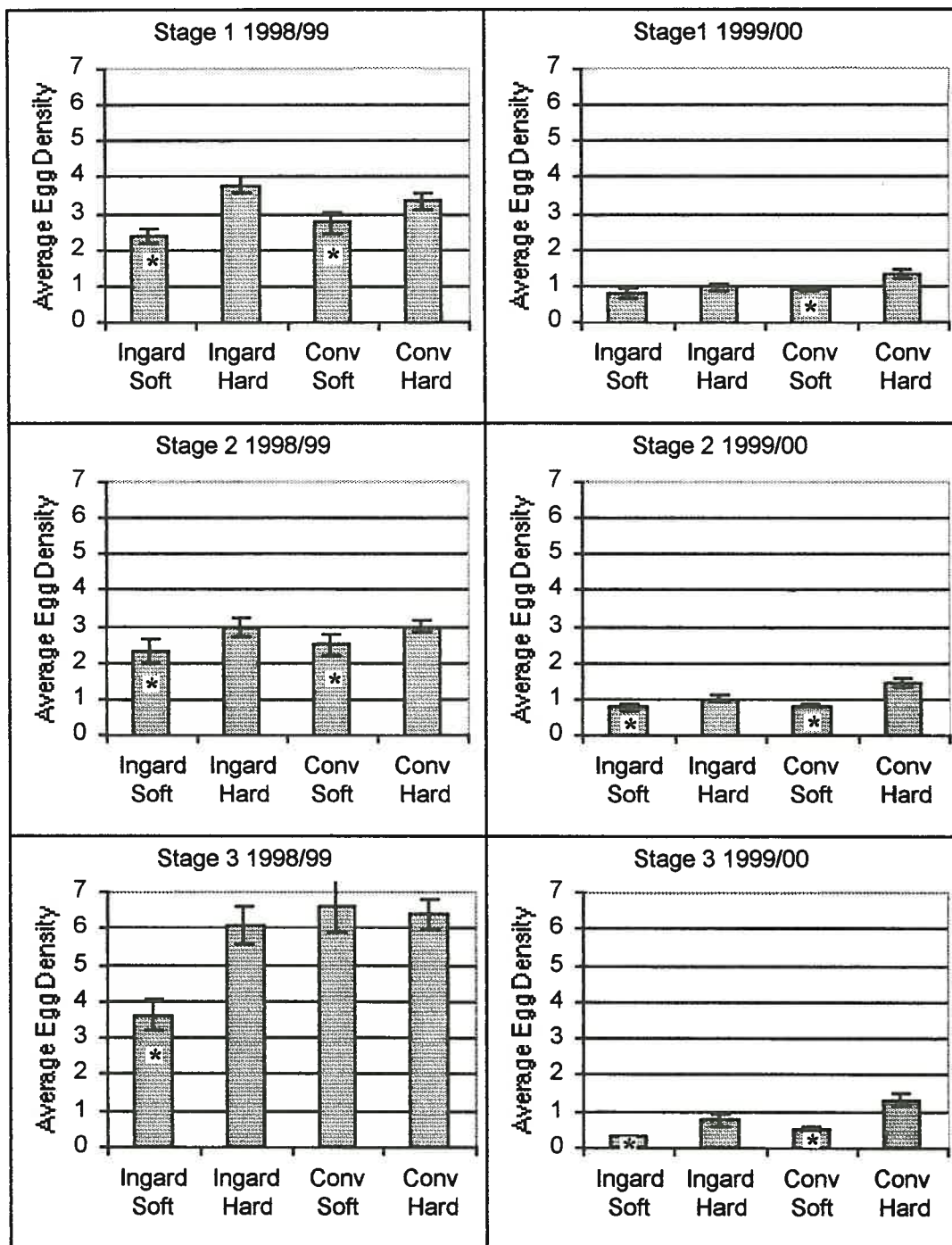


Figure 4. The average egg density of fields in each spray rank category for each stage of each season. Columns with an asterisk * have significantly lower average egg pressure than other spray rank categories in the same graph. The error bars represent the standard error of the mean.

Pest pressure v Spray rank

There is a significant relationship between pest pressure and field spray ranks both within each season and over the two seasons combined for heliothis (Fig 5) and tipworm (Fig 6).

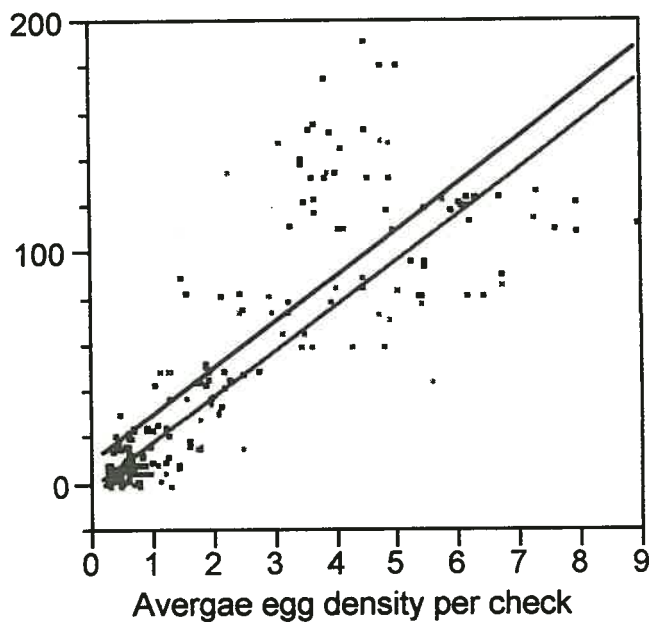


Figure 5. Average heliothis egg pressure per check over the whole season plotted against the spray rank of each field. Both seasons 1998/99 and 1999/00 data are combined. Upper line is conventional fields ($r^2=0.66$), the lower line Ingard fields ($r^2=0.73$) $p < 0.0001$.

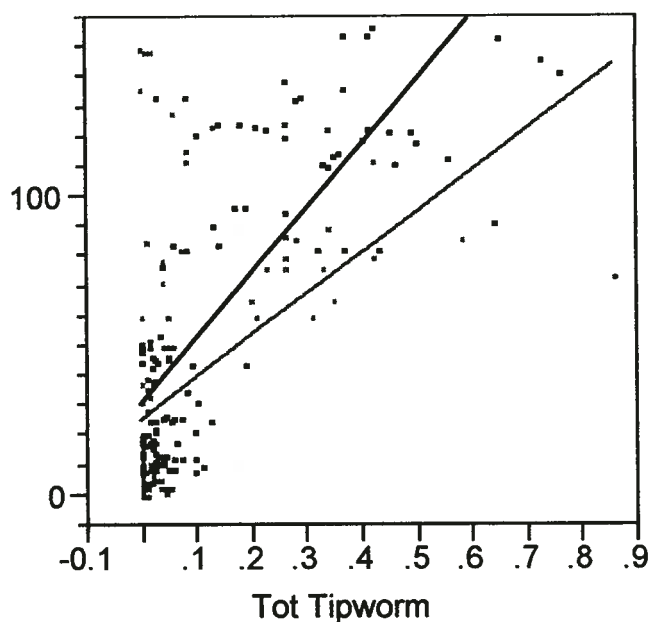


Figure 6. Average tipworm pressure per check over the whole season plotted against the spray rank of each field. Both seasons data are presented. The upper line represents linear regression for conventional fields ($r^2=0.52$), and the lower line represents Ingard fields ($r^2=0.66$). $p < 0.0001$.

The strong correlations in figures 5 and 6 indicate that pesticide applications are predominantly being applied in response to pest pressure. Spray rank was not correlated with mirid density. The dispersion of points in figures 5 and 6 indicate that some fields have substantially higher or lower spray ranks than the pest pressure may have warranted. The dispersion of points away from the line of best fit was not explained by within season variation in egg pressures that may not show up in the overall average egg pressure of each field. Figure 7 shows the lack of a relationship between stage 1 eggs and the residual variation from Figure 5. The residual variation was also not explained by egg densities in stage 2 or 3, even in 1998/99 when stage 3 had extreme egg pressure.

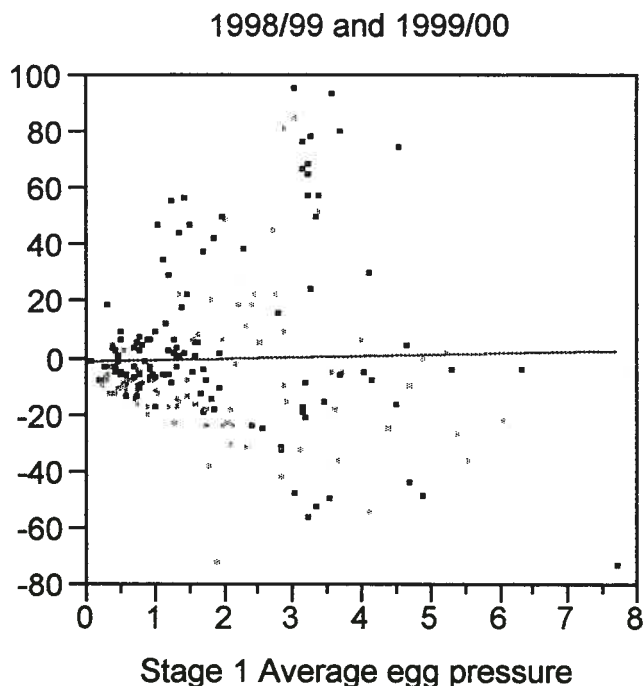


Figure 7. The residual variation from fig 5 plotted against Stage 1 egg pressure. Data from both seasons is presented. There is no statistical correlation. Similar non-relationships were evident with Stage 2 and Stage 3 egg pressures.

Pest pressure v yield

There was no relationship between yield and pest pressure (heliiothis, tipworm or mirids). This is illustrated in figures 6 and 7 in Hoque *et al.* (2000) in these proceedings. This result is expected because farmers strive to protect their potential yield in the face of varying pest pressure.

Pest pressure v Gross Margin

There is a statistically significant decline in gross margin (GM) with increasing spray rank in both seasons. Growers are protecting yield but at a cost of reduced profitability. Hoque *et al.* (2000) presents linear regressions of GM v spray rank for all fields in 1998/99 ($r^2=0.22$, $p<0.0001$) and 1999/00 ($r^2=0.06$, $p<0.0001$). The poor r -square values reflect the wide variation, however the low p values indicate it is a very strong relationship because of the large number of data points. Apart from the fact that spray rank is generally correlated with pest pressure, the decline in gross margin is not explained by pest pressure. Variation away from the line of best fit is not explained by overall heliiothis egg pressure, nor by egg pressure from stage 1, stage 2 or stage 3. Likewise tipworm and mirid pressure are not correlated with the residuals.

The negative correlation between Gross Margin and yield becomes even more pronounced when subsets of fields that experienced roughly equal pressure are examined. Figure 8 plots each fields rank against its gross margin over both seasons. The line represents an analysis with the subset of the data in which fields had egg densities within 1 unit of the mean (3.26 to 5.26 eggs/m in 1998/99) and so had roughly equivalent pest pressure. The decline in gross margin becomes even steeper, and more significant - especially for Ingard fields. The upper and darker line is conventional fields ($r^2=0.13$, $p < 0.05$) and the lower lighter line represents Ingard fields ($r^2=0.38$, $p < 0.0001$).

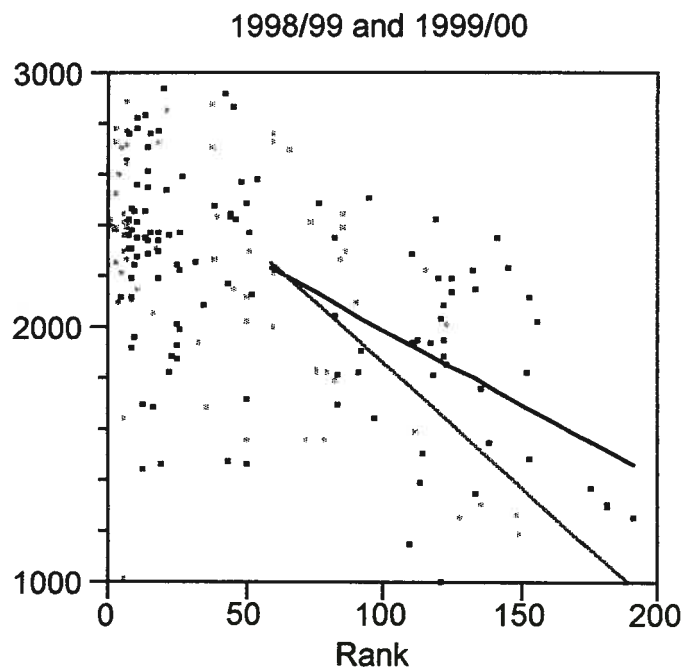


Figure 8. Scatterplot of each fields Spray Rank v Gross Margin for both seasons. The lines represent linear regressions of the subset of fields that had roughly equivalent pest pressure within one unit of the mean in 1998/99. Upper line: Conventional fields, Lower line: Ingard fields.

Discussion

In this paper we only discuss pest pressure and spray regime issues emerging from our analysis. Economic benefits and constraints are discussed in another paper in these proceedings (Hoque *et al.* 2000).

A visual examination of maps of pest pressures during each stage of the 1998/99 season did not show any consistent patterns or spatial trends in pest densities within the group. It is evident that despite the close proximity of the farms in the study group, individual fields experienced a very wide range of pest pressures both within and between seasons. The fields with soft spray ranks had significantly lower pest pressure over at least part and sometimes all of the season. It is not known whether the lower pressure in these fields happened by chance, or whether the beneficials within the soft fields ate more eggs before they could be counted by the scout.

Pest management is an extremely complex process involving an assessment of pest densities, an evaluation of likely impact on yield, and decisions on how best to control pests when warranted.

The analysis presented here indicates that in general cotton growers and consultants within the study group were managing their fields in a responsible manner. The strong relationships between pest pressure and spray rank category of each field (Figures 5 & 6) show that sprays to specific fields were being applied in response to increases in pest densities in those fields. Despite continuous high pressure in 1998/99 fields still exhibited a very broad range of spray rankings, indicating that many growers were generally tolerating sub-threshold pest pressure between times requiring insecticide applications.

However there is a large amount of variation in pest pressures experienced within each spray rank group (Figure 3). In many cases fields in the soft spray rank categories experienced pest pressure equal to or exceeding that experienced by some fields in the hard spray rank groups. Fields with high spray ranks tended to have reduced gross margins. This was particularly evident when subsets of fields with roughly equivalent pest pressure were examined (Figure 8). Fields with low spray rankings had a strong tendency to have better gross margins, however there were a proportion that did not as is evident in the bottom left corner of figure 8.

Overall the results suggest that very substantial gains can potentially be made by spraying only when necessary, and by using pest selective and thus softer chemistry to maintain a low spray rank. There are no data points in the top right section of Figure 8, indicating that there is a limit to yield beyond which fields with high spray ranks result in a net loss of profitability.

The contribution of area wide management to the pest pressures within this data set remains to be evaluated. However perhaps it is noteworthy that the average yield results are higher and the average spray regimes are lower than the valley averages reported in Pyke (1999) for the valley in which the study group resides, despite the very difficult pest season of 1998/9

Acknowledgements

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