MATCHING COTTON GROWERS' PERCEPTIONS OF THE VALUE OF INGARD™ COTTON WITH ECONOMIC ANALYSIS BASED ON SAME FARM PAIRED COMPARISONS OF PERFORMANCE

Wayne M Hancock
Jennifer L Harrison
Dennis T O'Brien

MATCHING COTTON GROWERS' PERCEPTIONS OF THE VALUE OF INGARD™ COTTON WITH ECONOMIC ANALYSIS BASED ON SAME FARM PAIRED COMPARISONS OF PERFORMANCE[1].

Wayne M Hancock
Jennifer L Harrison
Dennis T O'Brien[2]

Abstract

The genetically modified INGARD™ cotton seed was released in Australia in 1996 and was greeted with high expectations and enthusiasm within the cotton industry. INGARD™ cotton seed contains the Cry1A(c) gene from the soil bacteria *Bacillus thuringiensis var kurstaki* for the biological control of *Helicoverpa armigera* and *H. punctigera* moth larvae in cotton. These are the most serious insect pests of cotton and account for the majority of insecticides applied to cotton in Australia. Significant environmental and economic benefits were claimed by the manufacturer (Monsanto) at the time of release through the reduction in pesticide use and from a less complex production management system.

Grower attitudes and perceptions relating to INGARD™ were followed over two seasons through grower surveys. Partial budgeting of individual growers' insecticide costs, yields and returns for paired varietal (same cotton variety with and without genetic manipulation, that is conventional and INGARD™cotton) comparisons was done to evaluate the economic returns to each grower of the alternative technologies. These results were then compared to growers' perceptions of the value of the INGARD™ technology package relative to the conventional *Helicoverpa* control technology. The economic analysis of INGARD™ versus conventional cotton supports the growers' perceptions of a high price of INGARD™ and their desire for a lower license fee based on the 1997/98 season.

[1] Paper presented at the Forty Third Annual Conference of the Australian Agricultural and Resource Economics Society, and Sixth Annual Conference of the New Zealand Agricultural and Resource Economics Society, Christchurch, New Zealand, 20-22 January 1999.
[2] The authors are members of staff of the School of Business, Southern Cross University, Coffs Harbour, New South Wales, Australia.

INTRODUCTION

The cotton industry was the first large scale user of transgenic plants in Australia, following the release of INGARD™ cotton varieties for the 1996/97 season. INGARD™ varieties contain the Cry1A(C) gene from *Bacillus thuringiensis var kurstaki* and produce an insecticidal crystalline protein toxin in plant tissue that is toxic to the larvae of the main insect pests of cotton (*Helicoverpa armigera and H. puntigera*). The rights to the gene are owned by the Monsanto Corporation and the use of the gene is protected under Australian patent law (Taverner, 1996). The gene has been inserted into locally developed cotton varieties and multiplied for release through the two seed suppliers to the industry - Cotton Seed Distributors (CSD) and Deltapine Ltd. The cotton is generally referred to as Bt Cotton, an abbreviation of the bacterial name used in other products containing the bacterial formulations such as 'Dipel'.

Bt cotton is unique in several ways. It is the first transgenic crop registered for use in Australia and had to pass the scrutiny of the regulatory bodies (The National Registration Authority for Agricultural and Veterinary Chemicals, the Genetic Manipulation Advisory Committee, the Environmental Protection Agency, and the National Food Authority). The registration is provisional for five years and subject to annual review for a gradual increase in area planted to a maximum of 20% of the total area of cotton. Restrictions were placed on areas the Bt cotton could be grown to reduce the risk of transgene escape by Bt cotton interbreeding with native cotton relatives. Research data was to be collected for assessment on the field performance of the crop for regulators to assess. Cultivation has been based on an insect resistance management strategy that is part of the license agreement and part of the registration requirements.

The growers of Bt cotton are required to sign a license agreement to gain access to the Bt varieties. The license is a legally binding document that sets out conditions of use of Bt cotton and rights and obligations of the growers and the owners of the technology. The license is a legal contract under common law and enshrines the protection conferred under patent law for the INGARD™ gene (INGARD™ License Agreement, Monsanto, 1996).

The marketing and distribution of Bt varieties has been different from conventional varieties. Normally, growers would contact the two seed suppliers and place an order. This would be processed and delivery arranged through an existing network of carriers; a system that has worked well. For Bt varieties, growers go to an agent appointed by Monsanto and sign a license agreement which stipulates the area they intend to grow in hectares. A receipt and an authority to purchase is issued, which the grower takes to the seed supplier and places an order for seed; delivery is then arranged. Initially, the restrictive release meant that many growers could not obtain a license, causing some friction within the industry. The delivery of small amounts of seed caused problems for

carriers because they had to repeat deliveries over long distances for small amounts of seed.

Bt varieties have been marketed as the 'new' way to grow cotton, as being a revolutionary change in the approach to insect management by 'in built protection' with implied environmental and management advantages (Peacock and Llewellyn, 1996). Monsanto's promotional material has emphasised the efficacy, and management and financial advantages to growers of the new technology (Monsanto, 1996).

Cotton researchers and extension personel have been aware of increased insect pesticide resistance in the main *Helicoverpa spp* and have encouraged cotton growers to adopt insect resistance management strategies to increase the longevity of existing chemicals' effectiveness (Roush, 1996). Similarly, there has been acute awareness of the poor public perception of the industry for insecticide usage, highly publicised with the Helix problems in cotton straw feed to beef cattle in 1994/95. The voluntary withdrawal of the Helix chemical left a significant gap in the available control measures for *Helicoverpa spp* and meant the industry was again reliant upon older chemicals that were less environmentally friendly and more susceptible to insect resistance problems. Researchers have seen the release of an INGARD™ type technology as the way towards overcoming insect problems and to provide an opportunity to develop further control strategies (Edge, 1996).

Determining growers' ex ante and subsequent expectations of the technology and how they matched reality is the topic of this paper. Growers' emerging expectations were followed by grower surveys before release, after the first season in Gwydir Valley of New South Wales and after two seasons across the New South Wales and Queensland cotton growing districts. The surveys covered a number of issues raised by the growers in pre-survey interviews. The expectations were matched with field and economic performance based on actual growers' results. This paper explores how closely growers' perceptions of yield and economic performance of INGARD™ match the actual performance of the technology.

METHOD

This paper reports briefly on elements of a larger study that is investigating farmers' expectations of INGARD™ in the first and second seasons of its introduction against the technology's performance in the field. It also addresses the performance of INGARD™ relative to conventional cotton under the prevailing input and cotton prices scenario, and with hypothetical price levels (sensitivity analysis).

Exploratory interviews were conducted with cotton growers, local produce agents and Monsanto representatives in May and June 1996 prior to the release of INGARD™ in

August of that year. These were conducted in the Gwydir Valley in NSW, the oldest established cotton growing area in Australia. Ten growers who intended to grow INGARD™ and ten growers who did not intend to grow INGARD™, four agents and the local Monsanto representative were interviewed with a common set of questions, slightly altered to take account of the different roles of each group. The answers were recorded and the issues raised formed the basis of the **first survey** of growers in the Gwydir Valley at the end of the first season (April 1997). Thirty out of approximately fifty full time cotton growers in the Valley responded.

With minor changes, the **second survey** was conducted at the end of the second season (April 1998) across all cotton growing areas where INGARD had been released. This allowed for growers' to form opinions over two seasons with the new technology. Two hundred growers were selected from the approximately one thousand full time growers listed by CSD and Delta Pine seed distributors. Growers for the second survey were selected using random sampling based on the seed distributors' sales districts of in Queensland and New South Wales. Growers were telephoned first to explain the purpose of the survey and then survey forms were sent. Ninety growers responded, and respondents included 66 growers who had planted INGARD™ and 24 who had not. The questions included yes/no, numerical scales and written answers.

The **data for the partial budgeting and sensitivity analysis** were supplied by the Cotton Consultants Association from growers' performance records. The data covered the main cotton growing districts of New South Wales and Queensland. One hundred and three growers' responses were used on the basis of having full data sets covering number and costs of sprays for the four growth stages of squaring, flowering, boll filling and opening, yield in bales per hectare and INGARD™ variety and parent variety (e.g. V2 INGARD™ and parent V2) grown on the same farm under the same management regimes in the 1997/98 season. This allowed paired varietal comparisons to be made thus removing the inherent variability across growers due to crop variety differences.

Partial budgeting and statistical analysis was undertaken using MS Excel and SPSS to measure differences between the performances of INGARD™ and Parent lines. Comparisons of the number and costs of sprays per stage and across growing regions, variance in yields and returns and break even points for growers based on different license prices for INGARD™ were calculated.

A number of assumptions that were made including:

- A standard cost of $7.50 per hectare per spray of aerial application for sprays (this does vary slightly depending on distance from the airfield);

- The price of INGARD and conventional seed were taken as equal. INGARD™ seed is slightly more expensive than conventional seed because of the higher production costs caused by quality controls needed for transgenic seed, however, seed cost is a relatively small component of total cost;

- The price per bale was set at $470;

- Standard prices for pesticides were used to simplify analysis. These were the same as used in other industry analyses. However actual prices do vary due to the buying power of individual growers;

- Management costs such as insect scouting (this is mostly undertaken by consultants) of INGARD™ and conventional were assumed to be the same. Consultants generally charged at the same rate despite more intensive checking with INGARD™;

- Licence fee on INGARD™ in 1997/98 was $210 per hectare.

The identity used to estimate farm specific differences in economic returns per hectare to the INGARD™ and conventional technologies was:

$$\prod_{Ii} - \prod_{Ci} = \left[Y_{Ii}P_y - \sum_{j=1}^{n_i} C_{ji} - n_iA - L \right] - \left[Y_{ci}P_y - \sum_{k=1}^{m_i} C_{ki} - m_iA \right]$$

Where:

$\prod_{Ii}$ and $\prod_{Ci}$ are profit or net revenue per hectare for the i^{th} grower (where I = 1,2…103) from INGARD™ and conventional cotton, respectively.

Y_{Ii} and Y_{ci} are yields in bales per hectare for INGARD™ and conventional cotton, respectively for the i^{th} grower with matched varietal pairs.

n_i and m_i are the number of insecticide sprays for INGARD™ and conventional cotton, respectively for the i^{th} grower.

P_y is the price of cotton – set at $470 per bale for all growers.

C_{ji} and C_{ki} are the cost of the j^{th} spray on INGARD™ by the i^{th} grower, and the cost of the k^{th} spray on conventional cotton by the i^{th} grower respectively, where,

$j = 1, 2 \ldots n_i$

$k = 1,2 \ldots m_i$

C_{ji} and C_{ki} are estimated for actual chemicals used but at standard prices that prevailed during the season.

A is the application cost per hectare per spray – set at $7.50 per hectare.

L is the licence fee of $210 per hectare on INGARD™ .

The difference between the net returns for the two technologies on the same cotton varieties for each grower is effectively the difference between those elements of production that differed between the two production methods. That is, in the subtraction the costs of the elements common to each technology cancel out.

RESULTS

GROWER PERCEPTIONS

The Importance of Price, Efficacy, Need for Licensing and Environmental Benefits of INGARD™.

Table 1 shows the results for questions on the importance of price, efficacy, the need for a licence and environmental benefits from the second survey conducted on ninety cotton growers in 1998. These questions asked farmers to rate the importance of each element in their consideration of whether or not to adopt the INGARD™ technology with one indicating low importance and seven indicating high importance.

Table 1: Indices of importance of INGARD™ technology characteristics - second survey of ninety cotton growers in the main cotton growing areas of New South Wales and Queensland in 1997/98 season.

Question	% Response							Mean	Std dev.
	1	2	3	4	5	6	7		
Price	3.3	1.1	3.3	2.2	14.4	23.3	52.2	6.02	1.45
Efficacy	2.2	1.1	2.2	5.6	6.7	17.8	64.4	6.24	1.35
Need for Licence	5.6	10.1	7.9	21.3	23.6	16.9	14.6	4.56	1.71
Envir Benefit	2.2	0	0	6.7	11.1	25.6	54.4	6.19	1.21

n=90
One indicates low importance and seven indicates high importance

Efficacy, environmental benefits and price in that order all rate as highly important with the need for licensing less important. The mean scores, confirming the relative importance to growers of the need for positive benefits from the technology rather than the need for licensing arrangements. Statistically significant differences between those that did, and did not, grow INGARD™ were not detected.

Growers' comments were consistent with their stated concerns about the cost of the technology (often seen as too high), the efficacy (often seen as too low) and also reinforce the perception of the need for more environmentally friendly practices via reduced spraying of pesticides. Other issues raised were the setting of a price or bench mark cost for new products based on market values, the limited application of the technology in the dryland cotton sector, and the need to keep working with the technology. Positive benefits must flow to the user for technology to be adopted and wanted.

The Importance of Costs Associated with the Use of INGARD™

Table 2: Indices of importance of costs of INGARD™ technology – second survey of ninety cotton growers in the main cotton growing areas of New South Wales and Queensland in 1997/98 season.

Question	% Response							Mean	Std dev.
	1	2	3	4	5	6	7		
Licence	0	0	0	5.6	8.9	21.1	64.4	6.44	0.88
Consultants	4.5	5.6	7.9	27.0	19.1	18.0	18.0	4.76	1.64
Compliance	2.2	4.4	2.2	12.2	11.1	24.4	43.3	5.72	1.57

n=90
One indicates low importance and seven indicates high importance.

The **cost of the license** package for INGARD™ stands out in importance followed by the **cost of compliance** such as refugia while the costs for consultants is less important. This confirms the result from the first survey and supports the result of the question on price in Table 1. The upfront cost of the whole package is a major consideration for growers.

The growers' comments focused mostly on overall price and value for money. The extra costs associated with growing INGARD™ are not seen as limiting and the compliance issues such as refugia are seen as beneficial to the industry in general for future insect control.

Some 56.7% indicated they would use an alternative only after full evaluation, followed by 23.3% at comparable cost and 18.9% at lower cost (42.2% combined). This contrasts with S1 where 52% indicated using an alternative at comparable lower cost and 48% only after full evaluation. It would appear that more caution is seen as desirable whilst cost is still the other major consideration.

Growers were asked to comment on whether or not they should pay more because the technology provides **environmental benefits** and to put a value on any premium. A divergent set of views was received from respondents indicating the sensitive nature of this issue and how differently people see the issue. A total of 84 comments were received with 56% indicating a "No" type of response, 32% indicating a "Yes" type of response and 12% not indicating a Yes/No response. However, those who did indicate a premium could be paid only said a small premium and only for an obvious benefit.

There is the need to be viable as well as environmentally friendly, and cotton growers are not the only people who have environmental problems, and many growers don't feel they are doing such a bad job currently of managing environmental issues and if an evironmentally friendly product was well priced it would be more widely used and the whole community benefits from an improved environment.

This is a serious issue for the cotton industry. Setting a high price on a technology based on perceived environmental benefits will not be sustainable unless the product provides clear financial benefits to the adopters. Any product has to be effective and cost competitive. Many growers felt the benefits of the activities (including pesticide usage) flow to the wider community through the products produced, employment and so on, so growers should not be forced to carry the cost of any damage entirely themselves. However, there was also recognition that the industry needs to keep addressing environmental issues to be economically and socially sustainable.

When asked whether a product such as INGARD™ should have **defined performance and management criteria which allow for compensation** for poor field performance comments were again diverse. Responses on this issue reflect the difficulty in dealing with this type of technology as far as performance and compensation is concerned compared to conventional products. As a product that is dependent upon the plants' physiology for performance and subject to numerous influences in the growing environment, a great deal of information is needed to predict performance under different circumstances. This information is not known at this time. Of the 85 comments received, 76.5 % indicated " yes", 14% indicated "No" and 9.5% did not indicate a yes or no. Price and performance were again the problem with many comments indicating that, at a lower price, the need for compensation would not be so great because "normal commercial risk" would apply. With a lower price and more predictable performance there would be less problems. Compensation for yield loss is more useful than compensation for spray cost in some cases.

Economic Analysis

Figure 1 shows the frequency distribution of yields for the 103 growers' responses used to conduct the economic analysis (partial budget and sensitivity analysis) of the effect of INGARD™ relative to the parent variety of conventional cotton. There is no apparent yield effect from INGARD™ as growers appear to use both methods of insect control to the levels needed to achieve equivalent levels of pest management. This consistency in level of insect management is the result of consultants' monitoring pest levels in both management regimes and recommending treatment at threshold pest levels.

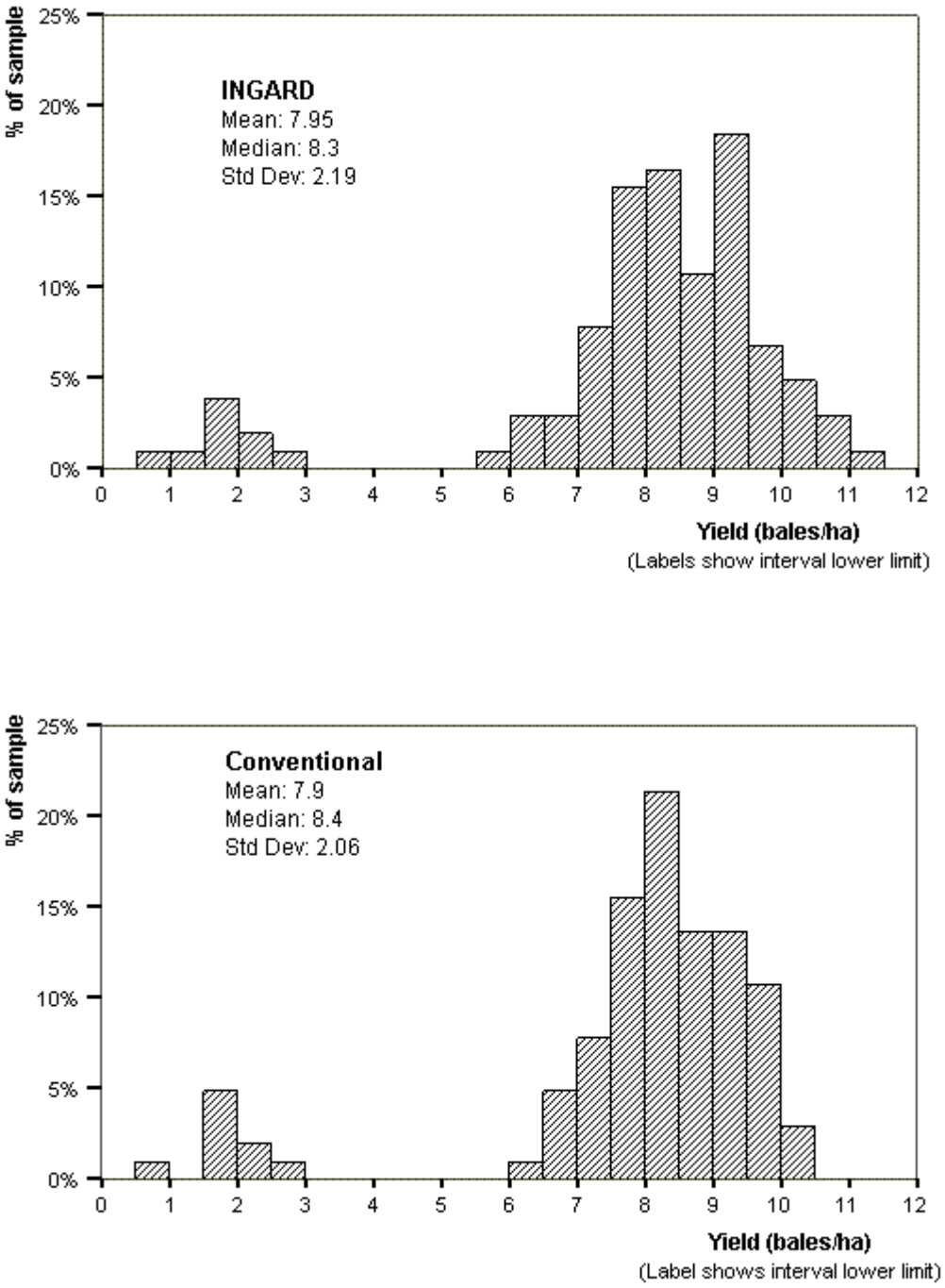

Figure 1: Frequency distribution of Cotton yield for paired varieties of INGARD™ and conventional cotton – survey of 103 cotton growers in New South Wales and Queensland for the 1997/98 season. (Data provided by the

The effect of the technology comes through its role in reducing the number of sprays to achieve the prescribed level of insect control. This effect is shown in Figures 2 and 3.

From these figures it can be seen that the mean reduction in number of sprays is 4.4 sprays, with one grower reducing the number of sprays by ten. All but two growers had some reduction in the number of sprays.

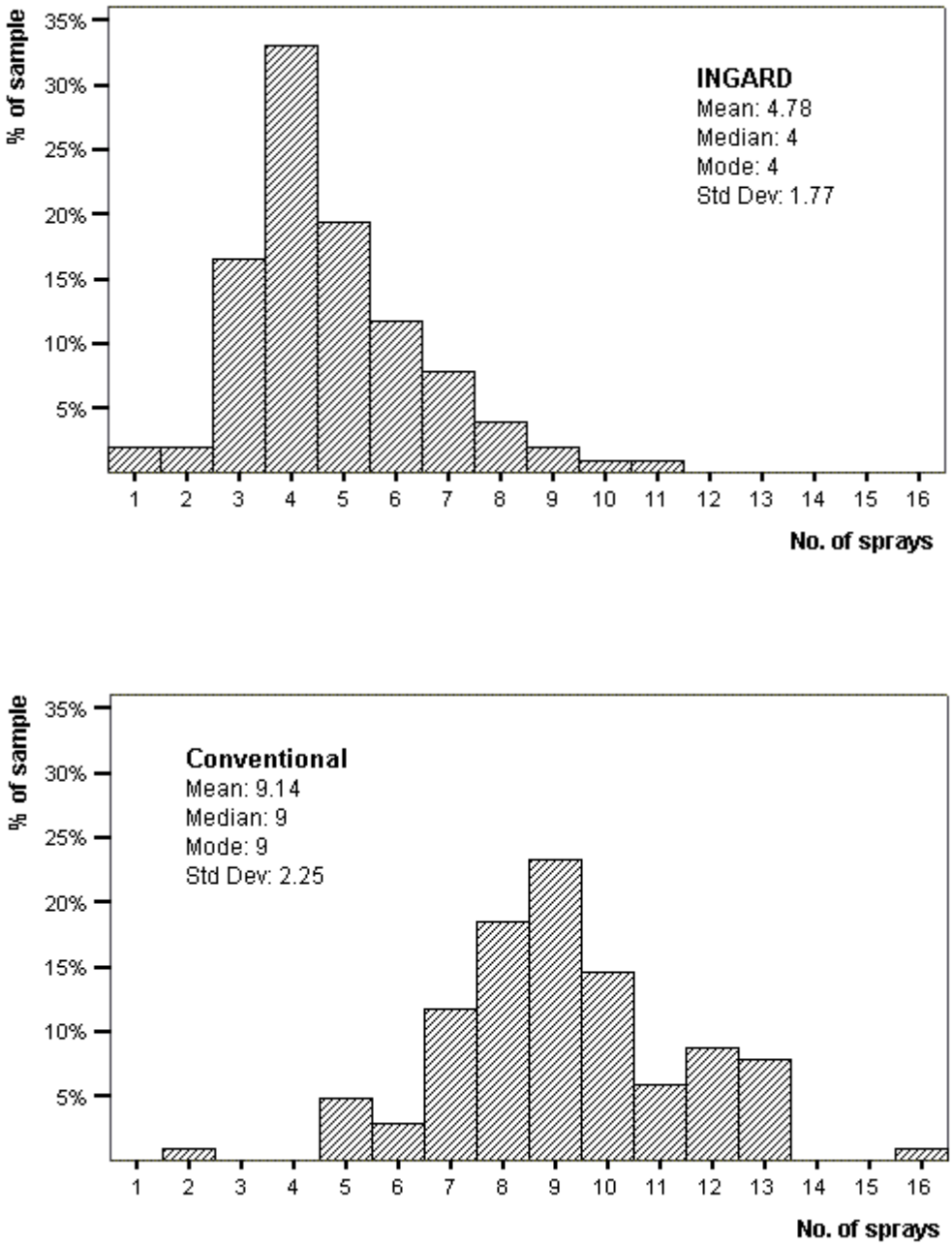

Figure 2: Frequency distribution of **number of sprays** for paired varieties of INGARD™ and conventional cotton – survey of 103 cotton growers in New South Wales and Queensland for the 1997/98 season. (Data provided by the Cotton Consultants Association.)

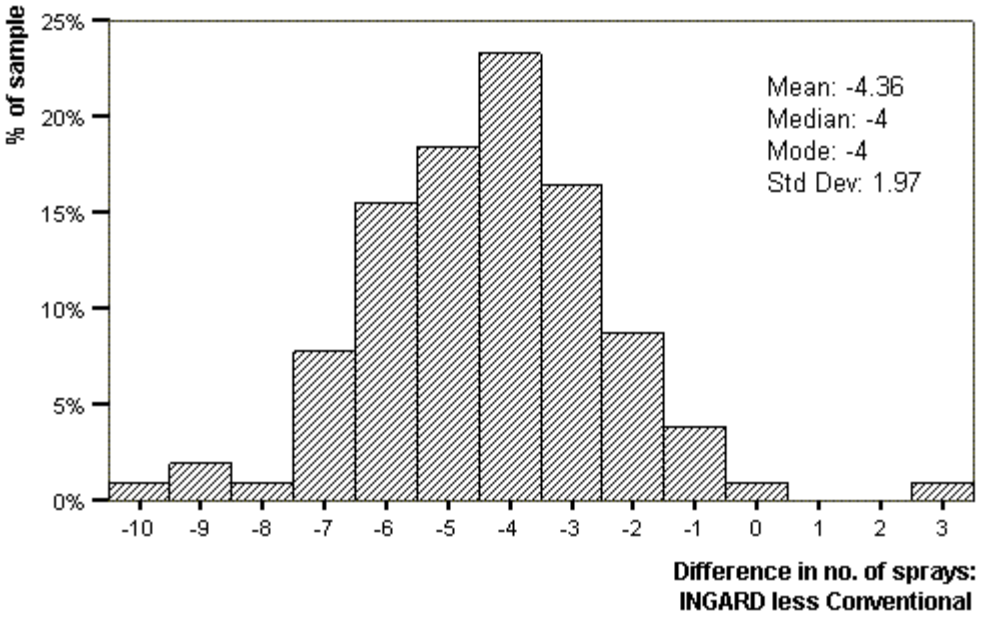

Figure 3: Frequency distribution of **differences in number of sprays** for paired varieties of INGARD™ and conventional cotton – survey of 103 cotton growers in New South Wales and Queensland for the 1997/98 season. (Data provided by the Cotton Consultants Association.)

The saving in number of sprays is, in turn, reflected in the reduction in the cost of pesticide application. Figures 4 and 5 show the differences in the chemical and application costs of insecticide use under the INGARD™ and conventional insect control regimes. An average saving in chemical application costs of $157 per hectare is achieved with the use of INGARD™, with 18% of growers reaching savings in excess of $300 per hectare. Three-quarters of growers achieved chemical application cost savings of $150 per hectare or more.

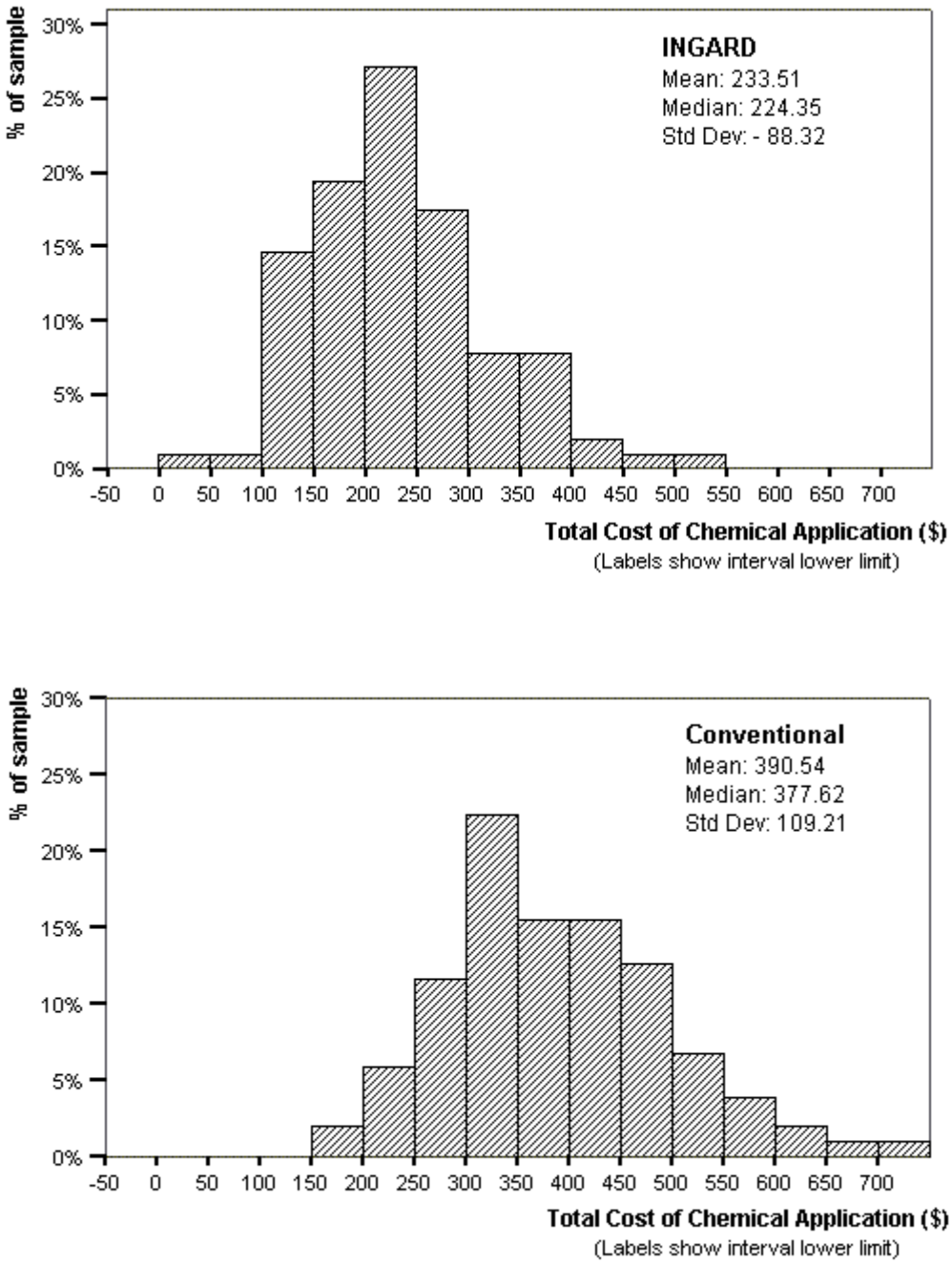

Figure 4: Frequency distribution of **total cost of chemical applications** for paired varieties of INGARD™ and conventional cotton – survey of 103 cotton growers in New South Wales and Queensland for the 1997/98 season. (Data provided by the Cotton Consultants Association.)

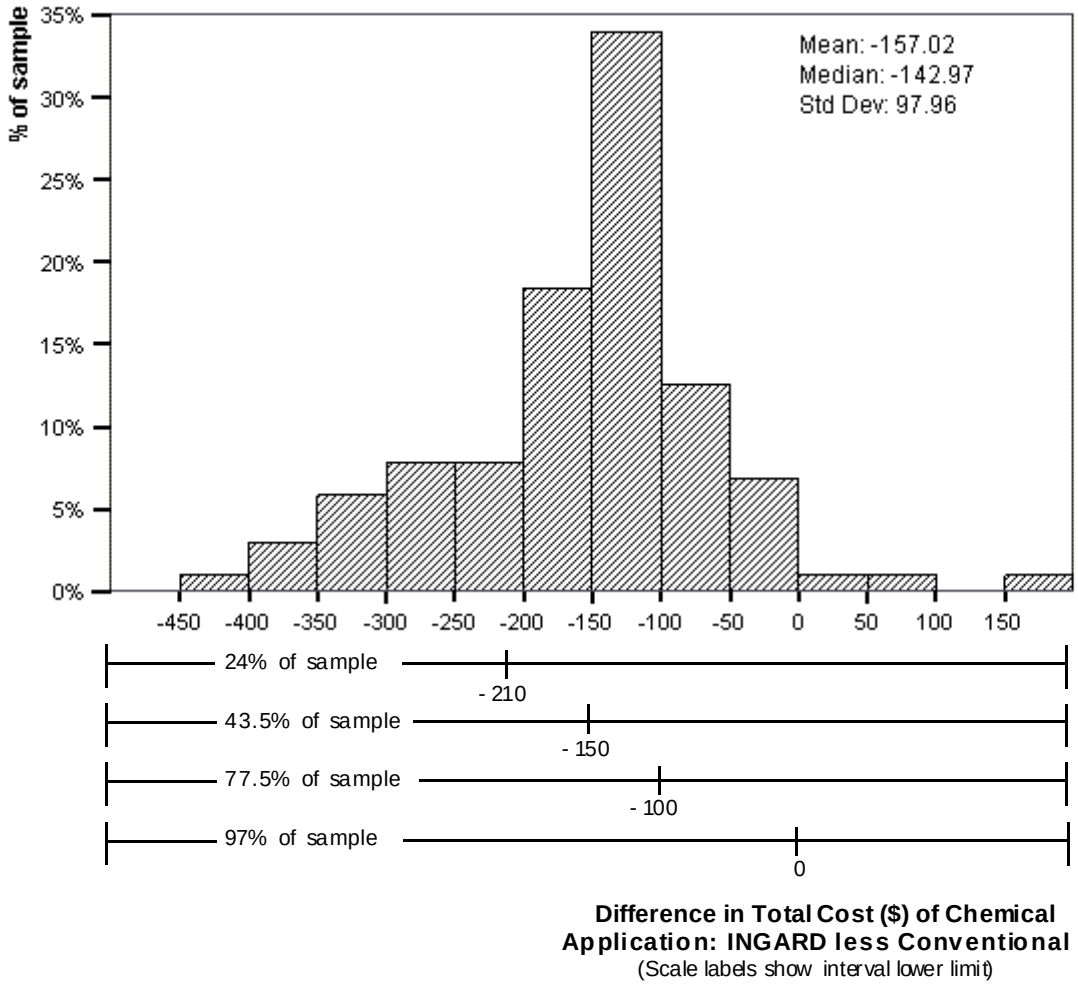

Figure 5: Percent of growers receiving a cost saving from INGARD™ over Conventional cotton with various INGARD™ licence costs – survey of 103 cotton growers in New South Wales and Queensland for the 1997/98 season. (Data provided by the Cotton Consultants Association.)

Ninety-seven percent of growers received some insecticide application cost saving with the INGARD™ technology. When the current INGARD™ licence cost of $210 per hectare is included as part of the insect control cost, only 24 percent of growers had insect control cost savings with INGARD™. With a licence cost of $150 per hectare (as is the case for the 1998/99 season) 44 percent of growers in the 1997/98 survey would have obtained pest control cost savings.

The poor financial returns to most growers is a consequence of the additional licence cost of the INGARD™ technology. Figure 6 shows the differences in returns from

INGARD™ to conventional, estimated using the equation presented earlier. The figure shows a mean difference in returns between the two technologies of $30.35. That is, after accounting for the licence cost on INGARD™ of $210 per hectare and the mean yield gain and consequent mean total revenue gain of $22.65 per hectare against the insecticide application cost saving of $157.02, the INGARD™ technology has a return per hectare that is, on average, $30.35 less than with the conventional technology. Fifty-six percent of growers were worse off with the INGARD™ technology.

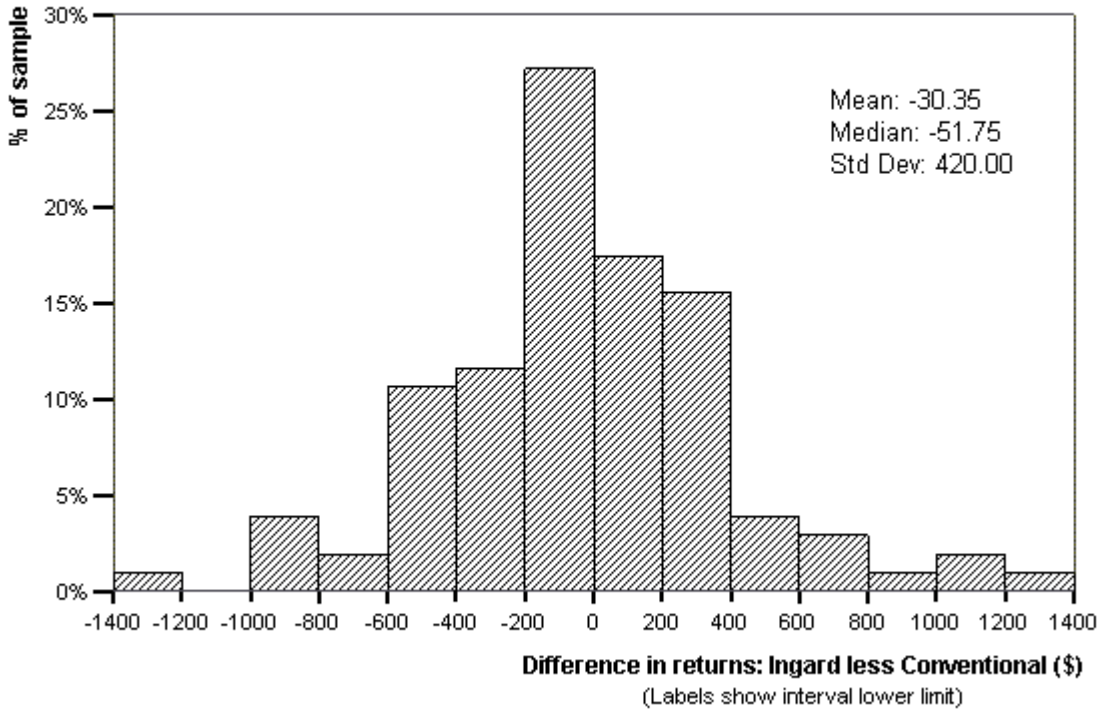

Figure 6: Frequency distribution of differences in returns for paired varieties of INGARD™ and conventional cotton – survey of 103 cotton growers in New South Wales and Queensland for the 1997/98 season. (Data provided by the Cotton Consultants Association.)

Figure 7 shows calculation of the INGARD™ licence value based on mean responses from conventional and INGARD™ technology in the 1997/98 survey of 103 cotton growers. Given mean insecticide and application costs of $233.51 and $390.54 respectively for INGARD™ and conventional pest management approaches, and the mean revenue gain with INGARD™ of $22.65, the value of the licence is almost $180 per hectare. It would appear that Monsanto has priced the technology appropriately to extract from growers the maximum economic rent of the INGARD™ technology.

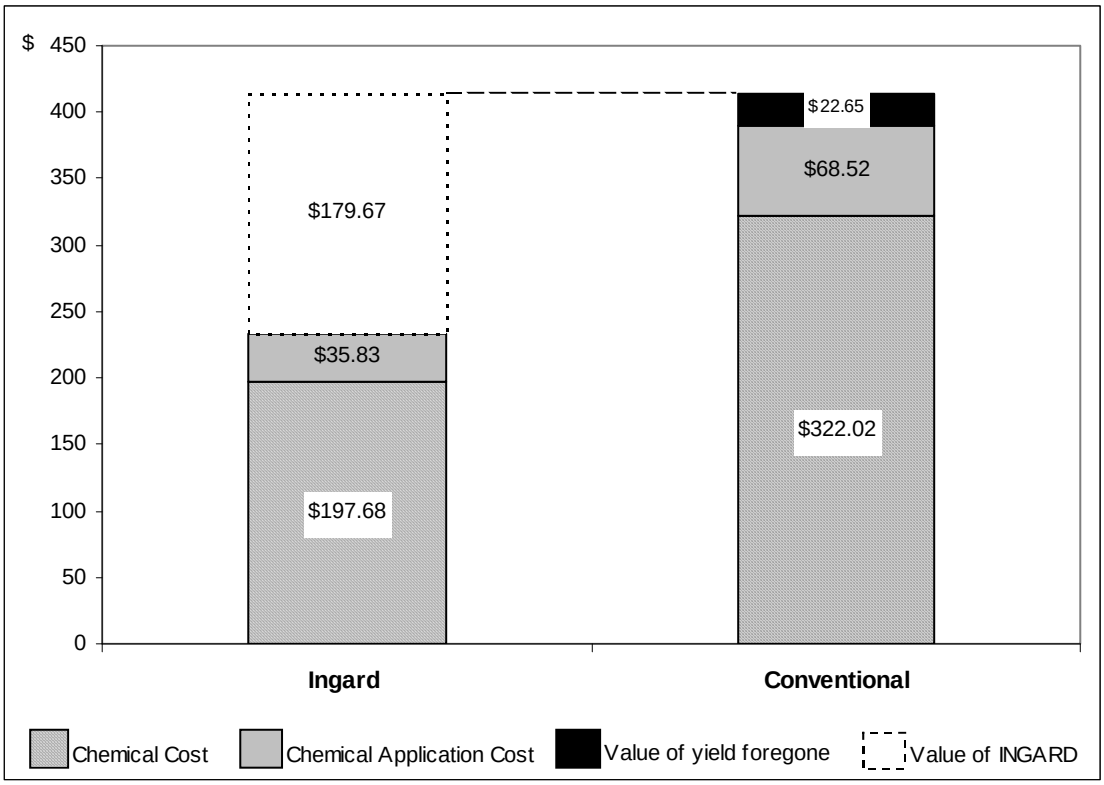

Figure 7: **Value of INGARD™ licence –** estimated from mean response of 103 growers in the 1997/98 season, New south Wales and Queensland. (Data provided by the Cotton Consultants Association.)

Conclusions

The findings of this study are similar to those reported by CRDC (1998) where growers' expectations of initial high performance expectations were not met and growers had subsequently lowered their expectations. The CRDC study found that growers were mostly growing INGARD™ for environmental reasons or to explore the technology. More grower time was required for management, especially insect checking. The average cost of growing INGARD™ estimated by the CRDC study was $35 per hectare higher than conventional and growers in the sample were equally divided between gaining an economic benefit or loss from INGARD™. The varied performance resulted in some satisfied growers, many ambivalent and some disappointed growers.

The initial high expectations generated for the INGARD™ product were not matched by performance achieved by many growers. The perceived high price of the license caused a negative response from many growers. The majority of savings flow from reductions in insecticide use, especially Endosuphan. These are important

environmentally but the economic returns relative to the conventional technology indicate the initial license price exceeded the value of the technology for many growers. The varied performance means that some growers would not gain a benefit if given INGARD™ free of charge. The potential value of INGARD™ to the cotton industry is therefore difficult to assess and growers perceptions vary considerably, depending on their experience with the product. A reduction in license price will encourage more growers to trial the technology and to assess the level and consistency of returns from using INGARD™ . There is a need to assess the environmental benefit of INGARD™ use via reduced insecticide applications and to therefore evaluate the total value of the technology to users and the wider society.

References

CRDC (1998). The Performance of INGARD™ Cotton in Australia in the 1997/98 Season. Cotton Research and Development Corporation - Occasional Paper. CRDC, Narribri, NSW Australia.

Edge,V. (1996) Environmental Issues Facing the Cotton Industry Related to Pesticide Use. Proceedings of the Eighth Australian Cotton Conference, Broadbeach, QLD .

Monsanto (1996) Product Manual and INGARD™ License Agreement. Monsanto Australia Ltd, Melbourne, Australia.

Monsanto (1996) ,The In-Built Cotton Defence System - INGARD™. Monsanto Australia Ltd, Melbourne, Australia.

Peacock,WJ and Llewellyn,DJ (1996) Biotechnology in Cotton - Today and Tomorrow. Proceedings of the Eighth Australian Cotton Conference, Broadbeach, QLD .

Taverner,E. (1996) Evaluation of the New Product- INGARD™ gene by Monsanto - in Cotton. Public Release Summary. National Registration Authority for Agricultural and Veterinary Chemicals. Canberra, Australia.