CASE STUDY ANALYSIS OF THE BENEFITS OF GENETICALLY MODIFIED COTTON

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Abstract

Research in north and south New South Wales (NSW), Australia was conducted to assess the benefits of genetically modified (GM) cotton. Gross margins from 20,263 hectares on two properties for a three to five year period were analysed. A phone survey of cotton growers in the target districts was also used to determine grower opinions on benefits of cotton type. This also allowed for comparison between growing regions. Performance of cotton types is extremely variable, with no cotton type having a clear economic advantage. In years with high weed and/or Heliothis pressure, the financial return of GM cotton should be better than that of conventional cotton. However, findings indicate that GM cotton displays significant environmental and social benefits, due to reduction in chemical use and easier management. Although not as profitable, southern growers have adopted management practices to improve profitability and prefer GM Cotton because it is "easier to grow".

Keywords: genetically modified cotton, environmental benefits, social benefits

Introduction

Transgenic cotton has been available to Australian growers for ten years. Ingard was initially released expressing resistance to Heliothis while Roundup Ready (RR) was later released with resistance to Glyphosate herbicide. This has impacted on the way cotton is grown, but it has raised questions regarding the benefits of genetically modified (GM) cotton. Prior research has lacked conclusiveness on the economic benefits of GM cotton.

This paper investigates the benefits of GM cotton in terms of economic, environmental and social benefits on two irrigated properties in New South Wales – one in the northern growing district and the other in the southern growing district. The properties under examination are privately owned and specific data is confidential. However, generic findings, together with the results of a phone survey of farmer attitudes, will be provided. The properties experience a different climate and growing season, therefore the effect of climate on profitability is examined.

Background

Cotton is an important global crop which has uses ranging from its natural fibre to vegetable oil and animal feed. Currently Monsanto offers two biotech traits commercially in Australian cotton seed varieties, Bollgard II (BII) and Roundup Ready (RR). Cotton varieties incorporating these traits have the same lint and oil quality as conventional cotton lines. However, Monsanto claims they offer significant production and environmental benefits including fewer chemical applications, easier crop management and increased profitability (Monsanto Cotton 2006). RR cotton has a licensing fee of $51 per ha with only approved RR[1] herbicide to be applied - BII currently carries a licensing fee of $300 per hectare while

[1] Active ingredient- Glyphosate

the combined technology of Bollgard II/ Roundup Ready (BR) has a licensing fee of $351per ha (McDonald, J. 2006. pers com).

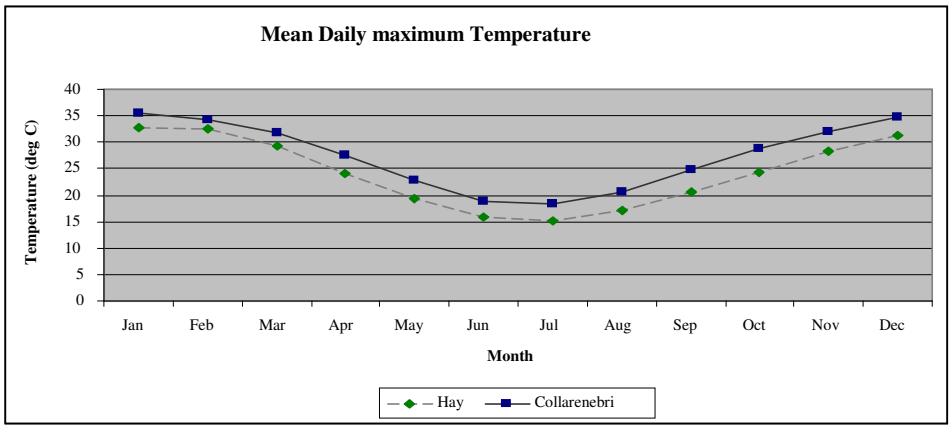
In Australia, conventional cotton can require 10 to 11 insecticide sprays in a season to control Heliothis and other secondary pests. Also, because cotton is a broadleaf plant like many weeds, conventional growers have had to rely on residual herbicides, inter-row cultivation, chipping and careful fallow management to manage broadleaf weeds.

Climate Comparison

The properties in this research are situated in different regions of NSW. One is in the Gwydir region while the second is in the south-west Riverina region. Climatic data for Collarenebri and Hay from the Australian Bureau of Meteorology (BOM) is used to represent the growing areas. Collarenebri is situated on the western edge of the North West Slopes and Plains. Hay is located in the Riverina region of southern NSW.

Collarenebri has a higher maximum temperature (3.2ºC on average) than Hay (Figure 1). It is 3.5 to 4.5ºC hotter during the cooler months.

Figure 4: Mean Daily Maximum Temperature (BOM 2004a&b)



Mean daily minimum temperatures (Figure 2) indicate that Collarenebri has more variability than Hay. Collarenebri experiences minimum temperatures similar to Hay in the winter, but for a shorter period. In summer Collarenebri maintains minimum temperatures approximately 4ºC warmer.

Figure 5: Mean Daily Minimum Temperature (BOM 2004a&b)

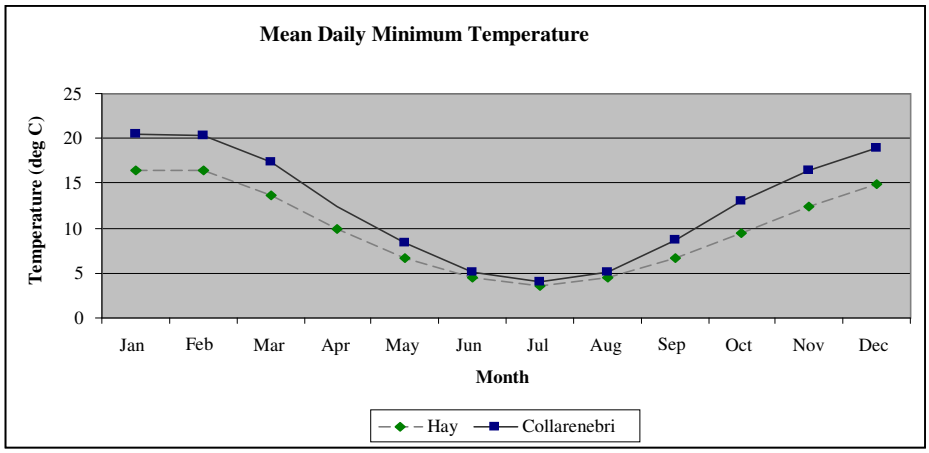
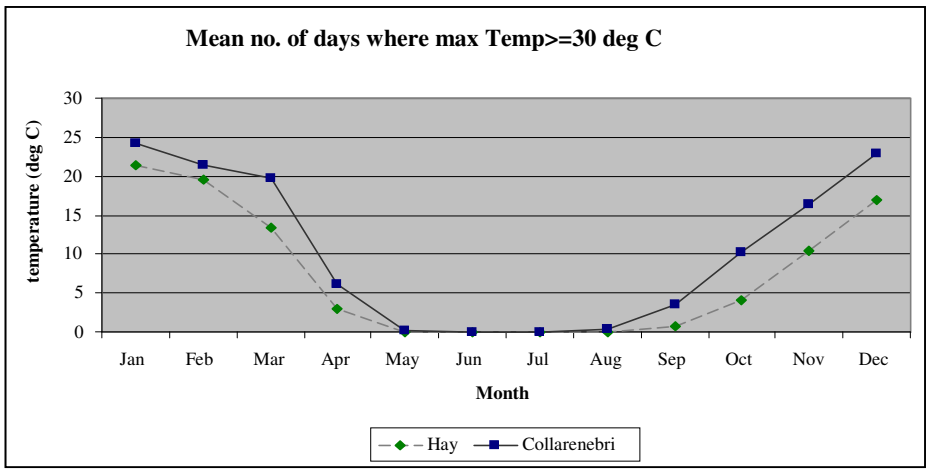


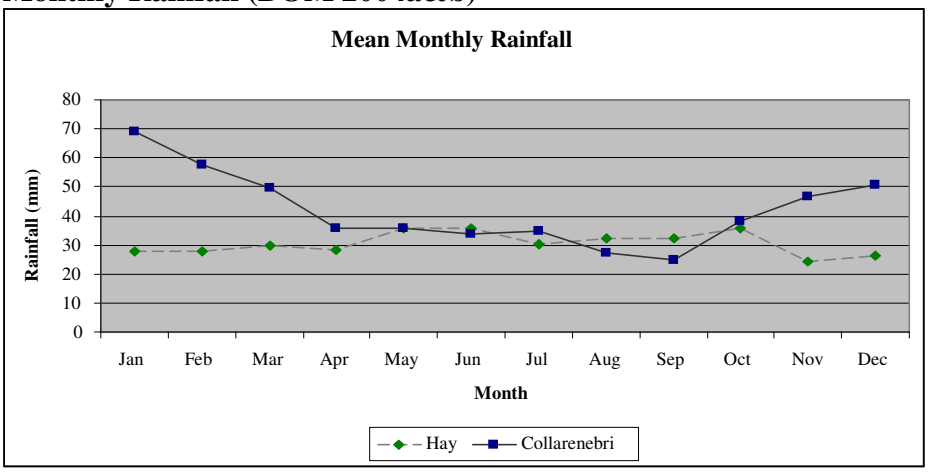
Figure 3 shows that Hay experiences a longer, cooler winter, whilst Collarenebri experiences more days over 30ºC.

Figure 6: Mean No. of Days where Max Temp >=30 deg C (BOM 2004a&b)



Collarenebri experiences more summer dominant rainfall, with the majority falling between the months of November and March (Figure 4). Hay experiences its highest rainfall in the winter months; but its rainfall is more uniform throughout the year.

Figure 7: Mean Monthly Rainfall (BOM 2004a&b)



Methodology

Gross Margins

Gross Margins were calculated for the cotton crops (20,263 hectares) on the 2 properties over 3 year (south) and 5 year (north) periods. A total of 173 gross margins were generated (142 – north, 31 - south). The average paddock size on the northern property was 130 hectare compared to 60 hectare. These gross margins were also compared with industry standards from the 'Australian Cotton Comparative Analysis' for each relevant year.

The aim was to analyse gross margins from the previous five growing seasons for each property across Conventional, Bollgard II, Roundup Ready and stacked gene Bollgard II/Roundup Ready. Gross margins for the northern property were able to be obtained from the years 05/06, 02/03, 01/02, 00/01, and 99/00 making a total of five years data. Three years of data were able to be collated for the southern property. These were, 05/06, 04/05, and 03/04. In addition to the four cotton types, Ingard[2] and Ingard/ Roundup Ready were also present from earlier years.

Telephone Survey

To understand social and environmental benefits of GM cotton, the opinions of farmers in surrounding districts were researched through interviewing using a phone survey. Surveys from within the Riverina region were classed as southern, while all surveys north of the Riverina were classed as northern.

The survey was written to be short, concise; and to be completed in a maximum of five minutes at the very most. It is recognised that the public is increasingly not accepting of unfamiliar phone calls. A short sharp survey was thought to be the best way of securing time from busy growers. This method was used to allow for analysis between northern and southern NSW, in an effort to understand potential differences in the two growing areas. Ethical clearance for the survey was obtained from the School of Natural & Rural Systems Management's Ethics Committee. Participants were asked if they wanted a summary of the results.

Because of time constraints and privacy laws, cotton grower contact details had to be sourced from the Yellow Pages Online. Phone numbers were found by searching for cotton in different regions in NSW. The inclusion of farmer in any searches immediately listed all farmers in that area. There was a very

[2] Predecessor to Bollgard II, carries only one Bt gene.

limited number of cotton grower numbers able to be found, as a small number of growers listed themselves under cotton. Cotton is a new crop in southern NSW which made it very difficult to secure any phone numbers in that region. The Yellow Pages returned no property phone numbers searching for cotton, so general farmers had to be called in order to find cotton growers. This was extremely time-consuming. For this reason only eleven surveys were able to be completed for that region compared to twenty-six in northern NSW. Because of the lack of phone numbers every contact was phoned on the list. The survey was conducted between May and September 2006.

The interviewer contacted growers between 11:30 am and 2:00pm during weekdays to try and reach growers when they were home for lunch. He also contacted growers between 7:30pm and 8:45pm in the evenings, starting just after ABC news and weather. The evening timeslot had the most success, with more growers home at this time, and willing to part with five minutes of their time.

Results

Gross Margins

Northern Property

142 gross margins totalling 18,398 hectares over 5 growing seasons were analysed. Within year comparisons of gross margins found that:

1. in the 99-00 season, Ingard had a significantly higher gross margin than conventional cotton; and
2. in the 00-01 season both Ingard and Ingrad/Roundup Ready had significantly higher gross margins than conventional cotton.

Table 1 shows the significant differences in gross margins in each year reviewed. Figures in brackets are the number of gross margins.

Table 1. Differences between Gross Margins – Northern Property

Year	Significant Difference	No Significant Difference
99-00		I/RR(1), Conv(22) and Ingard (11)
00-01	Ingard (18) > Conv (24)	I/RR (1) and Conv (24) I/RR (1) & Ingard (18)
01-02	Ingard(9) & I/RR(3) > Conv (21)	I/RR (3), Ingard (9) & RR (8) Conv (21) & RR (8)
02-03		BG(1), Conv(3), I/RR(2) & RR(3)
05-06		BG (2), BR (6), Conv (5) & RR(2)

More detailed statistical work using the combined data showed that planting configuration and planting date had no significant effect. A General Linear Model using type, year and area found that gross margins increased by 0.1375% per hectare for each extra ha in field area. Further testing showed however, that area had no significant effect on costs. A mean area was established for all fields of 130 hectare to develop the final model adjusted to take into account all effects. Hence, means for cotton type were adjusted for differences between years and the fact that not all types were grown every year. Bacillus thuringiensis (Bt) gene cotton performed the best with BII, I/RR and Ingard showing the three highest returns, conventional cotton had the second lowest return with BR lowest. However the model only explained 53% of the variance in the data and the only significant finding was that Ingard had a

higher gross margin than conventional cotton. (Ingard is no longer available being replaced by BG and BII.)

Southern Property

31 gross margins totalling 1,865 hectares over 3 growing seasons were analysed. Within year comparisons of gross margins found that in the 03-04 season, Ingard/Roundup Ready had a significantly higher gross margin than Roundup Ready cotton. Table 2 shows the significant differences in gross margins in each year reviewed. Figures in brackets are the number of gross margins.

Table 2. Differences between Gross Margins – Southern Property

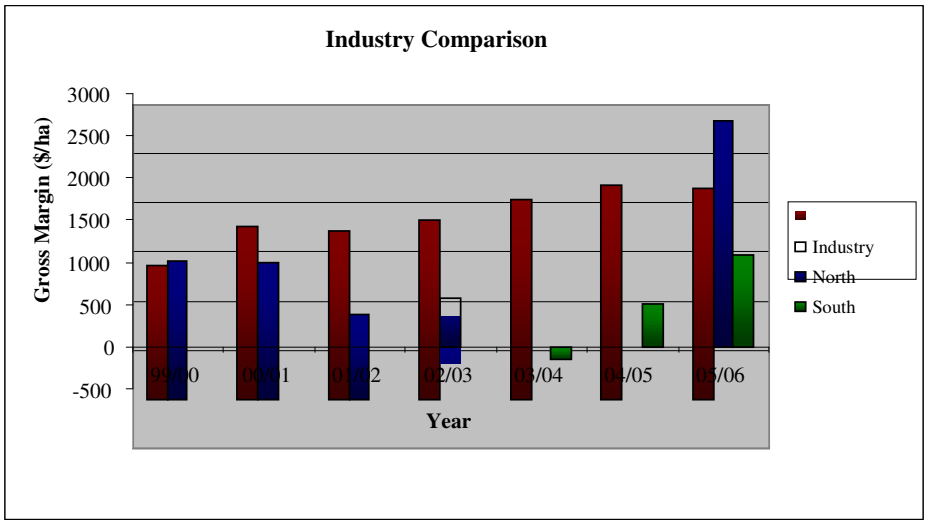
Year	Significant Differences	No Significant Differences
03-04	I/RR (3) > RR (6)	BR (1) & RR (6) BR (1) & I/RR (3)
04-05		BR (6), Conv (4), & RR (4)
05-06		BR (3), Conv (2), & RR (2)

More detailed statistical work using the combined data, found the only significant difference was between the gross margin for IRR and all other cotton types. IRR is no longer available having been superseded by BR.

Industry Comparisons

Gross margins were averaged for each year to compare with industry standards. The industry gross margins steadily increased throughout the seven years of data (Figure 5). Gross margins for the two properties examined were highly variable. Northern property gross margins were on a downward trend, but then produced an excellent return in 05/06. Southern property gross margins are shown to be improving. Industry margins outperformed the northern property in three of the five years and the southern property in all three years.

Figure 5: Gross Margin comparison between Industry and Case Study Properties (Industry data from Doyle et al. 2005a)



Telephone Survey

A total of 37 surveys were completed. In order to achieve this, approximately 148 phone numbers were used and 255 phone calls made. 25 surveys were conducted on growers who grew GM cotton in northern NSW and 10 in southern NSW. Two respondents did not grow GM cotton. One "used to, but because of health problems and no financial benefit I changed to organic". The other grew conventional because "couldn't get hold of any GM cotton in that year".

Cotton Type Comparison

Cotton growers were asked the percentage they grow of each cotton type. For northern NSW it is shown in Figure 6 that the majority of farmers grew only one or two different types of cotton. Stacked gene BR cotton was found to be most predominant, with all but one grower planting a portion of his farm to the cotton type. The graph also shows that 8 out of the 25 respondents grew 100% BR. Ten of the growers planted BII cotton and 11 planted conventional cottons. Ten growers planted RR cotton; but it was less than 20% of the farms' planted area.

Figure 6: Percentage of Cotton Type grown in Northern NSW

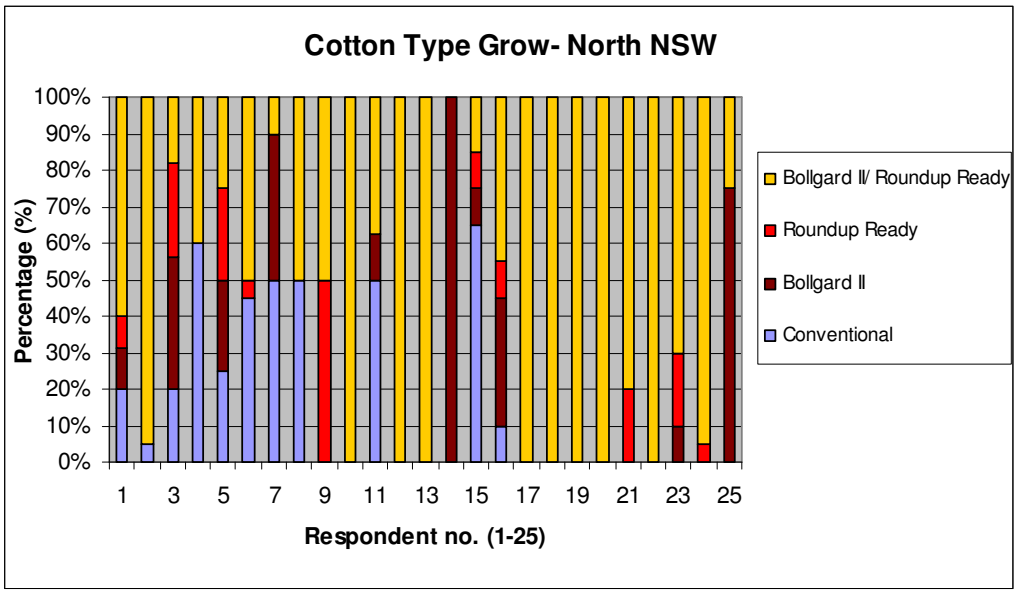
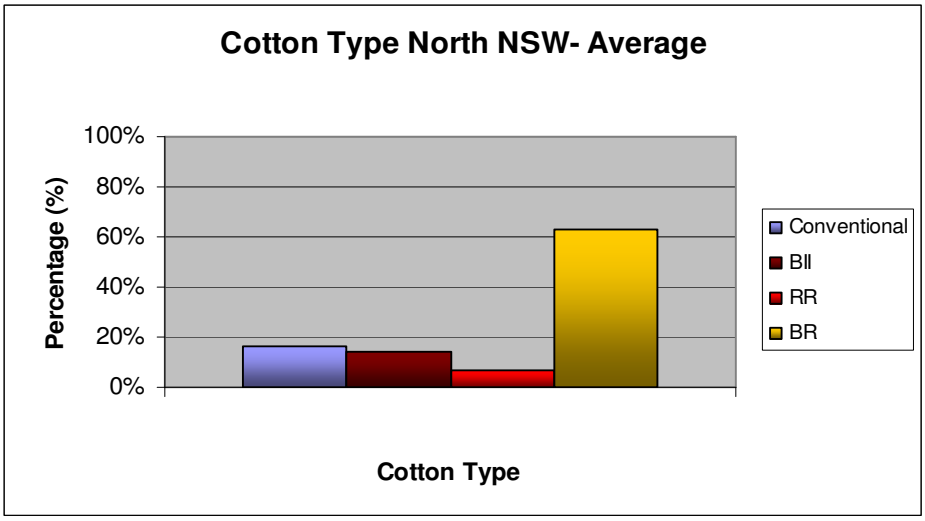


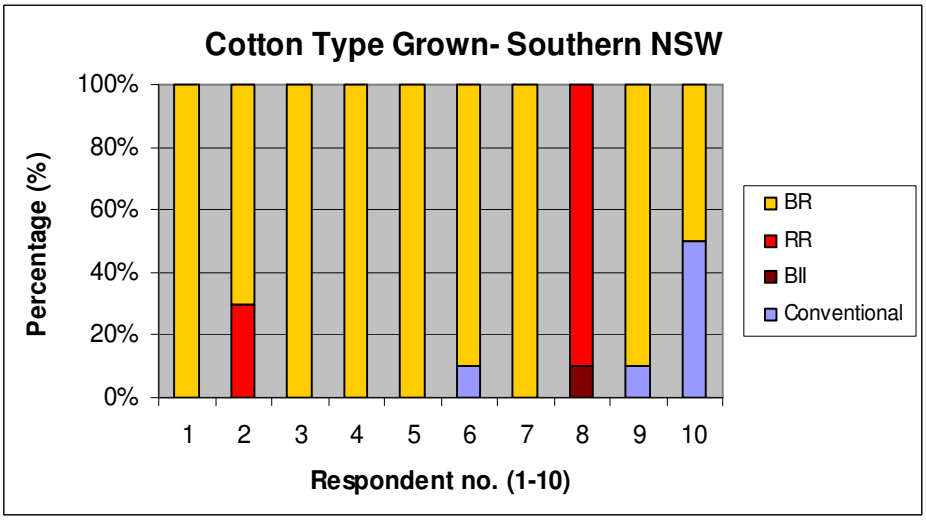
Figure 7 shows the percentage of each cotton type grown through northern NSW. On average BR cotton represents 63% of the cotton planted. This is significantly higher than the remaining three cotton types which make up between 7% and 16% of the cotton planted. On average, 84% of the cotton grown on farms in northern NSW is GM.

Figure 7: Percentage Grown of Cotton Type in Northern NSW- Average



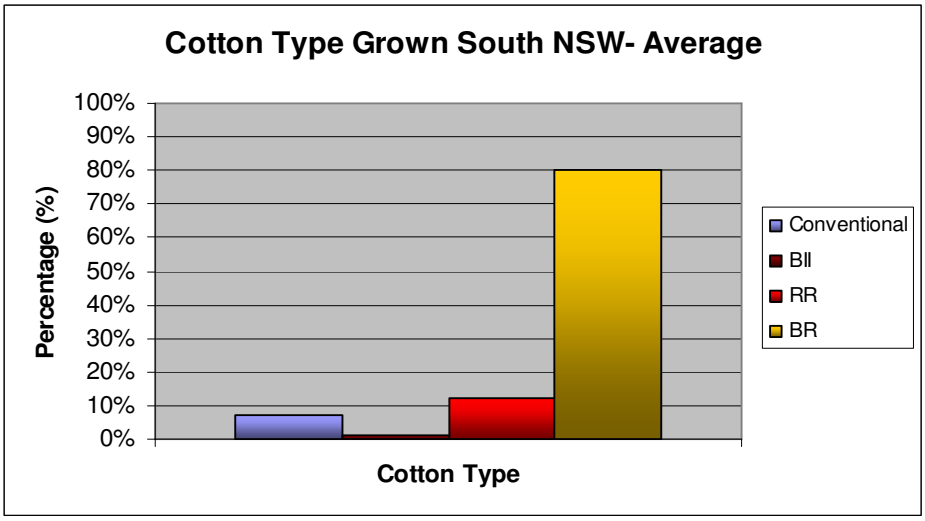
Southern findings followed the same trend as the north, with all but one grower planting BR cotton. BII, RR and conventional cotton are shown in Figure 8 to represent a small minority of the cotton planted. Half the growers interviewed planted their whole farm to BR cotton.

Figure 8: Cotton Types Grown in Southern NSW



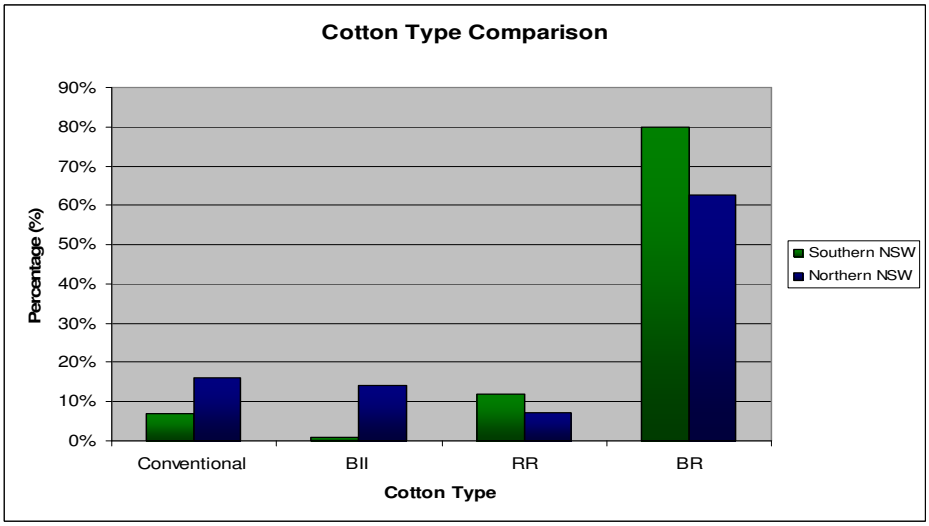
On average 80% of the cotton planted on properties in southern NSW is BR. The remaining three cotton types individually make up 10% or less of the cotton area planted (Figure 9).

Figure 9: Cotton Type Grown in Southern NSW- Average



When the findings for north and south NSW are compared, it is evident (Figure 10) that both are similar. However, southern growers plant nearly 20% more BR cotton.

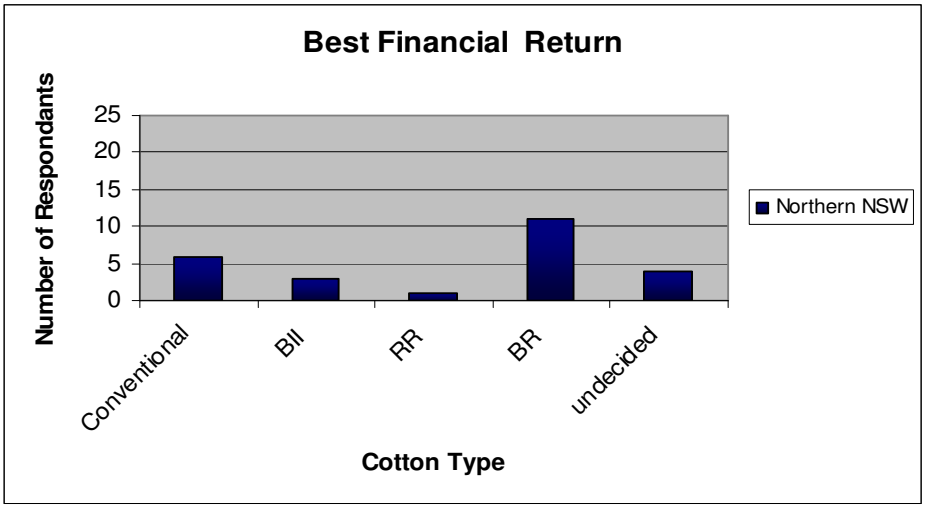
Figure 10: Cotton Type Comparison of North and South NSW



Financial Return

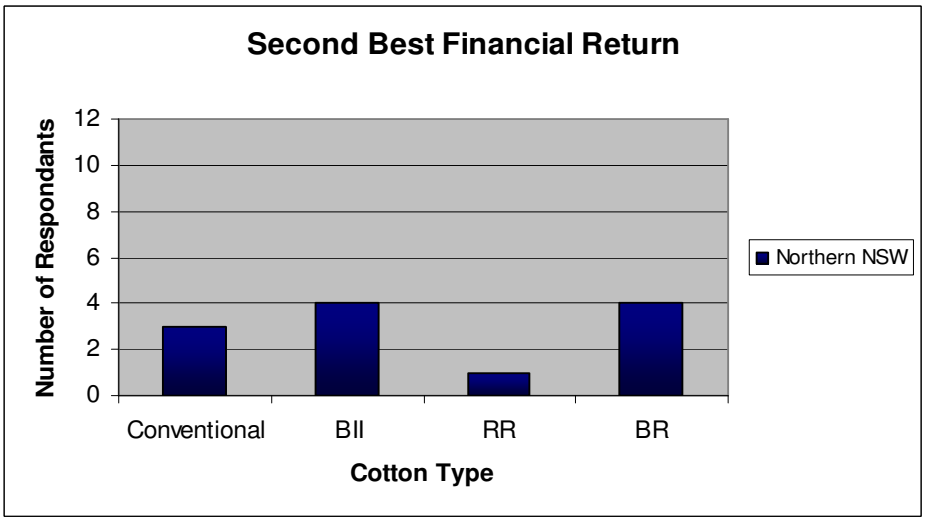
As the majority of growers only grew one or two cotton types, there was not a good indication of the profitability of all four cotton types. As shown in Figure 11, BR was believed to have the best financial return by 11 of the 25 respondents in the northern district. Interestingly, 6 of the respondents believed conventional cotton provided the best financial returns. Four of the 25 interviewed commented that financial performance depended on the field the cotton was grown in and the season.

Figure 11: Cotton Type with Best Financial Return- Northern NSW



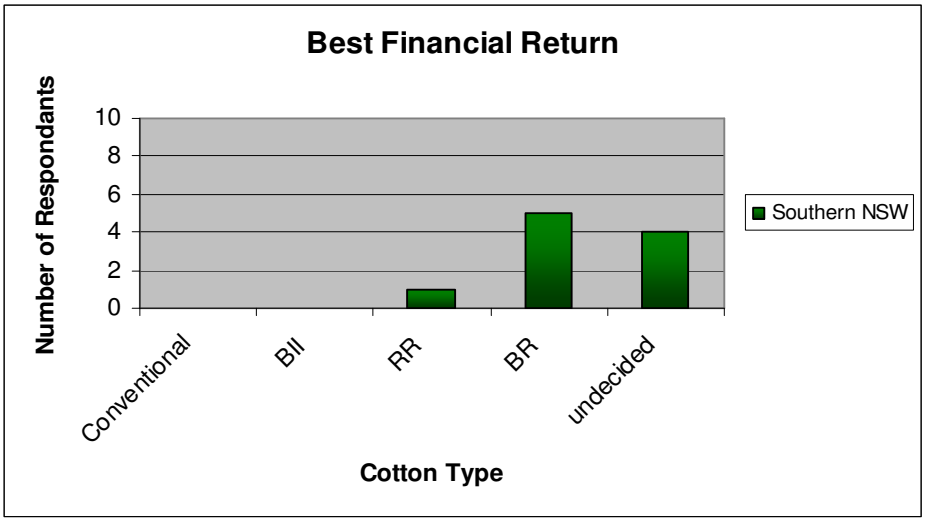
Only half of the cotton farmers interviewed were able to indicate the second best performing cotton type. The second best performing cotton types were believed to be BII and BR (Figure 12).

Figure 12: Cotton Type with Second Best Financial Return- North NSW



Many southern farmers were unable to comment on the most profitable type as they were new to cotton growing. BR was still selected as most profitable by those able to comment (Figure 13).

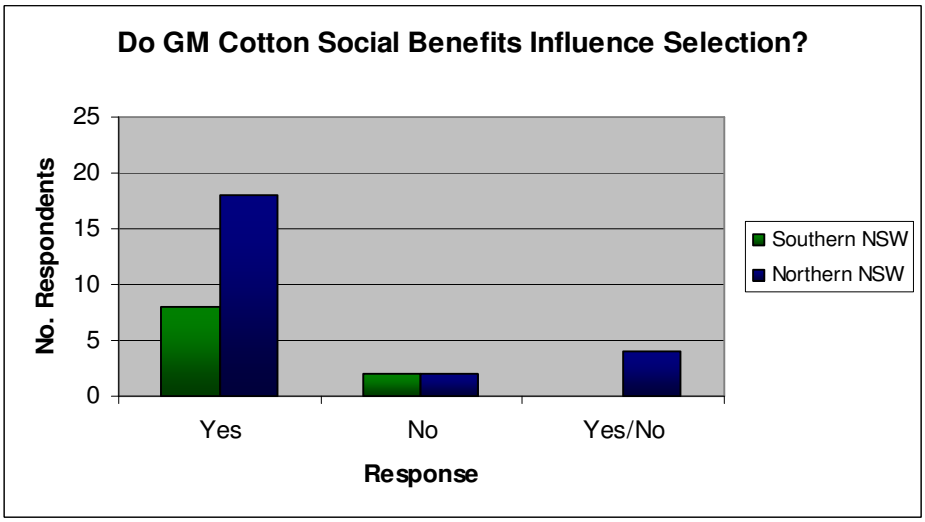
Figure 13: Cotton Type with Best Financial Return- South NSW



Social Benefits

In both the north and south regions, the majority of respondents said social benefits influenced their selection of cotton type (Figure 14).

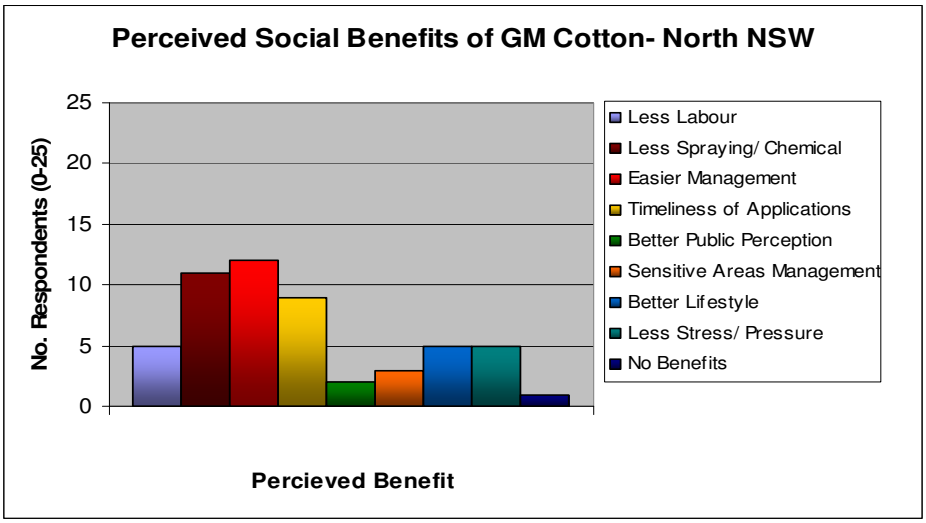
Figure 14: Do GM Social Benefits Influence Cotton Type Selection



Northern farmers presented nine common social or managerial benefits:
Less Labour
Less Spraying/ Chemical
Easier Management
Timeliness of Applications
Better Public Perception
Sensitive Areas Management
Better Lifestyle
Less Stress/ Pressure
No Benefits

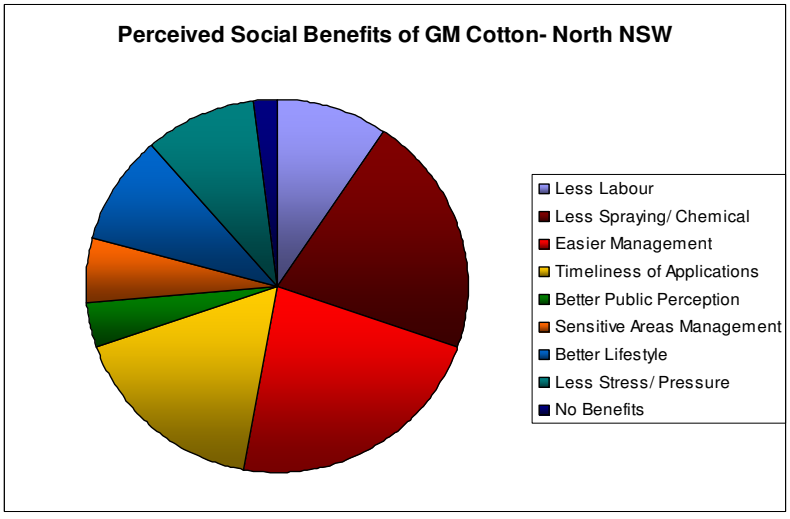
The most common response was that GM cotton did allow for easier management (Figures 15 & 16). Less spraying/chemical use and better timelines in making farming applications were the next most reported benefits. One grower reported that GM cotton 'takes the pressure off for timeliness of applications and the amount of applications'. One fifth of those interviewed believed less labour, a better lifestyle and less stress or pressure were major benefits of the technology. Another grower commented that it is 'time saving, easy to manage and takes out the guesswork'.

Figure 15: Perceived Social Benefits of GM Cotton- North NSW



A small percentage of respondents believed GM cotton provided good sensitive areas management and better public perceptions of cotton. This benefit was best summed up by one grower who remarked 'we are the first farm from town, and can only spray with certain wind directions. There is a better perception from people in town; not so many planes flying around'.

Figure 16: Perceived Social Benefits of GM Cotton- North NSW



Southern growers reported easier management and less spraying or chemical use (Figure 17). Interestingly, one fifth of those interviewed said they wouldn't grow cotton if they didn't have access to the GM traits. One farmer said 'cotton used to be hard to grow but GM has made it easier, hence its adoption down here'.

Figure 17: Perceived Social Benefits of GM Cotton- South NSW

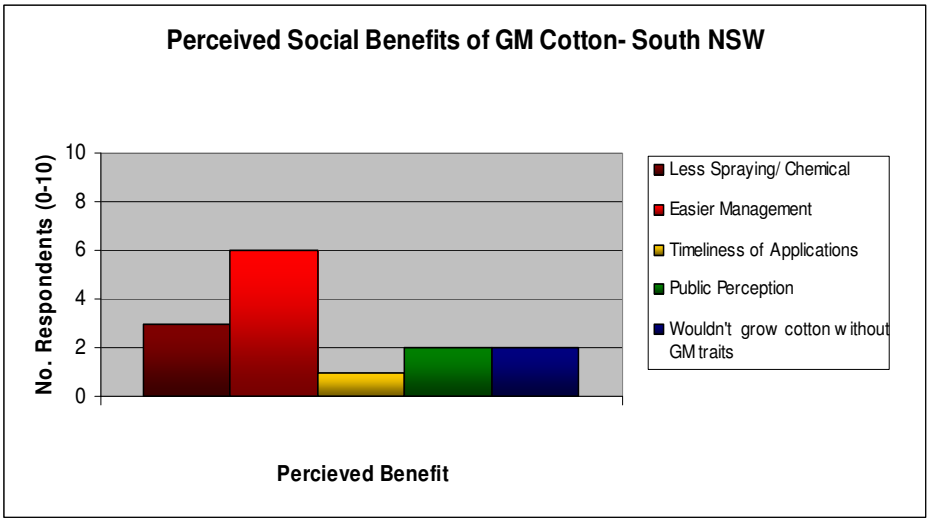
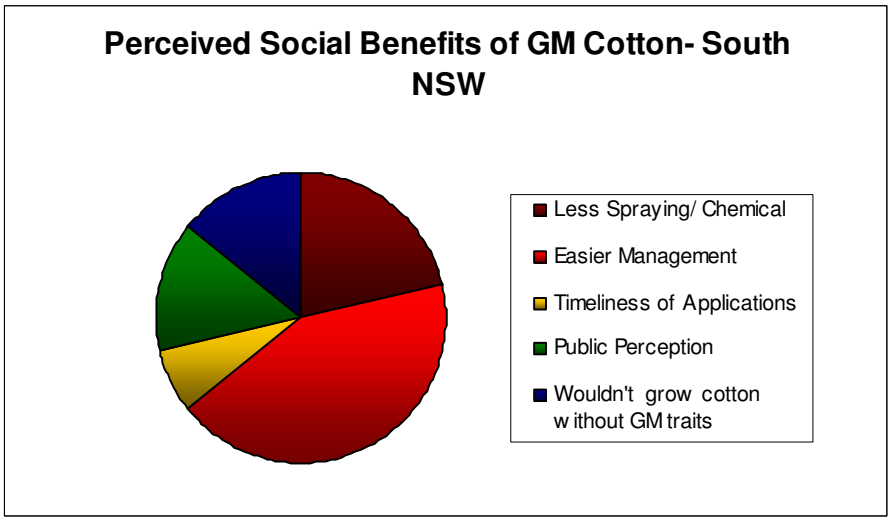


Figure 18 shows that the public perception of GM cotton is a significant benefit perceived by southern growers.

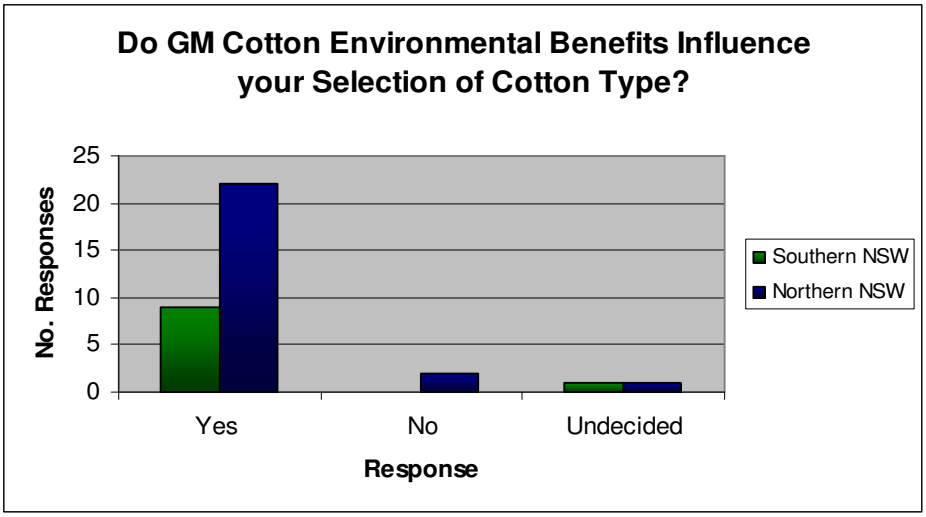
Figure 18: Perceived Social Benefits of GM Cotton- South NSW



Environmental Benefits

When growers were asked if the environmental benefits of GM cotton influenced their selection of cotton types, the responses across both growing regions was predominately yes (Figure 19).

Figure 19: Do GM Cotton Environmental Benefits Influence Selection of Cotton Type?



Less chemical and/or spraying was the biggest environmental benefit perceived as indicated by 23 of the 25 surveyed (Figures 20 & 21). One farmer reported "'Smart Rivers' monitoring has proven it (less chemical)". Sensitive areas management was also a significant benefit to 10 of the respondents. Six people believed less aerial spraying or drift to be a major benefit. Only one person saw no benefit.

Figure 20: Perceived Environmental Benefits of GM Cotton- North NSW

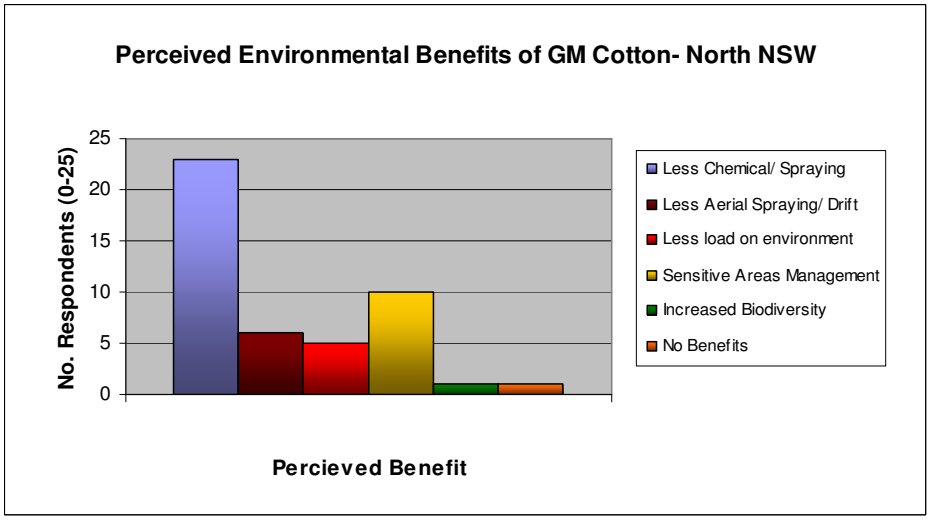
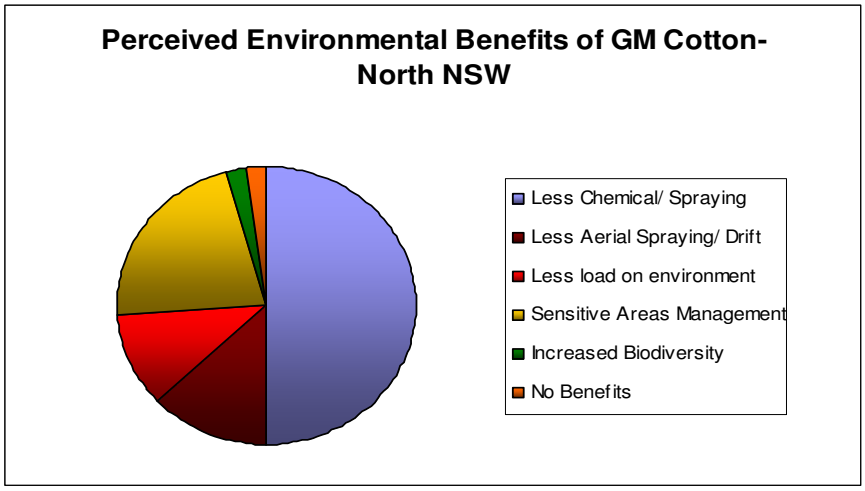


Figure 21: Perceived Environmental Benefits of GM Cotton- North NSW



For southern NSW, the results on environmental benefits were similar, but not the same. Less chemical was the most common response reported by 70% of respondents (Figures 22 & 23). Sensitive areas management was a big benefit, reported by 50% of respondents. One grower said, 'we are near rivers, so you don't have to worry about planes'. Once again, increased biodiversity and no benefit were only reported by one grower each. Less aerial spraying or drift was a significant benefit reported by 30% of growers.

Figure 22: Perceived Environmental Benefits of GM Cotton- South NSW

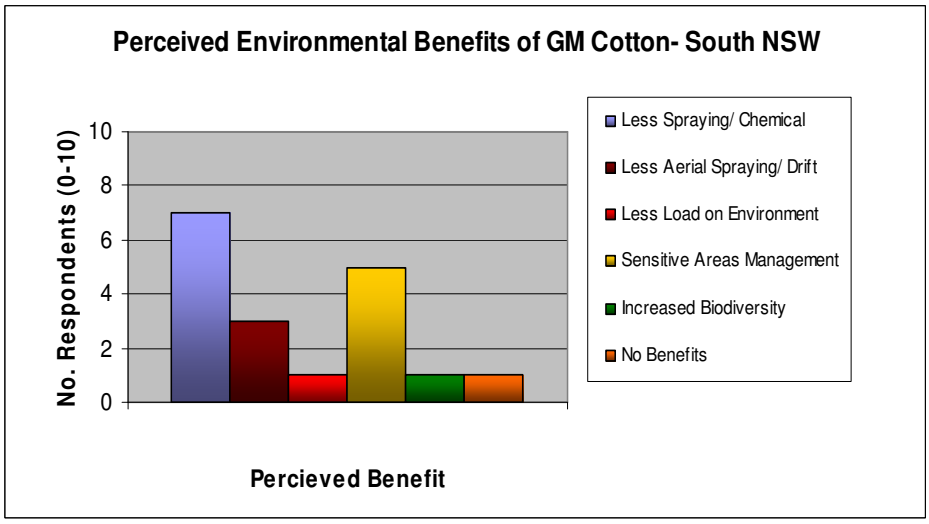
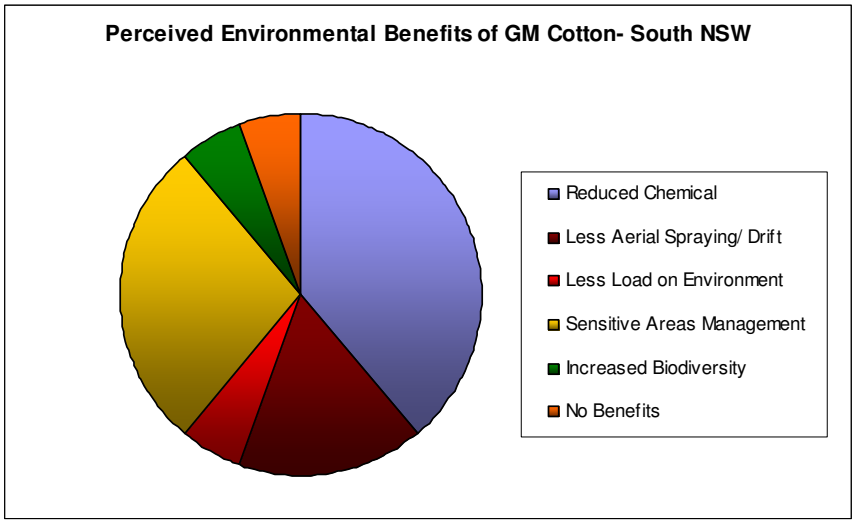


Figure 23: Perceived Environmental Benefits of GM Cotton- South NSW



Discussion

Survey results showed almost 95% of respondents grow GM cotton. Huesing & English (2004) highlighted the significant amount of farming country planted annually to GM crops (more than 67 million hectares (ha) in 18 countries worldwide); growing at 10% per year. Huesing & English (2004) state that "Genetically modified crops are most often associated with high-input industrial economies, but farmers in the developing world are rapidly adopting them. Surprisingly, nearly one third of all GM crop hectares are now grown in developing nations."

Survey results indicate that almost all growers believe there is a place in their farming system for GM cotton.

As southern NSW is an emerging cotton growing area, the phone survey was to a degree limited by the availability of growers to interview. Contacting sufficient growers was extremely difficult, compounded by privacy laws preventing the sourcing of contacts. Survey results revealed that GM cotton, specifically BR, has been adopted at an incredible rate. Growers in both districts plant the majority of their country to BR. Only two respondents who grew transgenic cotton were found not to grow BR, with over 37% devoting their entire farm to BR. Growers evidently believe GM cotton offers an alternative with more benefits than conventional cotton.

Economic Benefits

It is difficult to draw conclusions on the economic performance of the cotton types. The return on both properties was shown to be extremely variable. The season experienced had a big impact on the performance of each cotton type. The results indicated the importance of the findings by Marra et al. (1998) and Bryant et al. (1999a) that there is a required level of pest infestation before Bollgard II technology becomes profitable, due to the high licence cost of GM technology which must be paid regardless of insect pressure. Greater yields can be contributed to continual protection from Heliothis by GM cotton, as opposed to spraying when threshold levels are reached in conventional cotton.

Most growers interviewed believed that BR had the best financial return. This was not shown from the case study nor from the literature; however Doyle et al. (2005) found of those surveyed, 66% grew BII for economic benefit in comparison to conventional cotton.

Of the northern growers interviewed, just under a quarter of respondents believed conventional cotton to posses the best return. This is similar to the findings of Bryant (1999b), who found that in years of lower insect pressure, conventional cotton was able to return the highest profit as it did not have to cover licence fee costs.

It is far from definitive which cotton type is most profitable. However, it is evident that there needs to be a level of weed and/or insect pressure before GM cotton will prove profitable in comparison to conventional. Studies by Marra et al. (1998) showed transgenic cotton had no overall benefit as the savings and increased revenues did not outweigh the higher seed and technology costs. Klotz-Ingram et al. (2001) concluded that herbicide tolerant and insecticide-resistant crops do require a certain level of infestation to break- even.

In years of high level infestation, there were several reported benefits of GM cotton which reduce spending. Less labour, easier management, less spraying/ chemical, better timeliness of applications and improved sensitive area management are all factors which contribute to cost savings.

From the literature and survey findings, it could be concluded that the profitability of each cotton type is heavily related to the specific weed and Heliothis pressures faced in the growing season. Financial return is in no way fixed for the type of cotton grown, but dependent on the variables experienced during the growing season.

Social Benefits

Social benefits reported were consistent with the literature. 74% of growers indicated that social benefits offered by GM cotton influenced selection of cotton type.

The best social benefit was simply easier management. Less spraying/ chemical and a better timeliness of applications all indicate that GM cotton is easier to manage. These findings were consistent with those of Fernandez-Cornejo et al. (2000) who reported increased flexibility and a reduction in the number of operations.

Social benefits of GM cotton indicated that RR and BII cotton can be a very effective management tool. RR can be planted in paddocks known to have a heavy weed infestation allowing for greater control of weed problems. This reduces management and can minimise costs like chipping. RR is currently limited by its short application window (Doyle 2005b), but the release of Roundup Ready Flex is expected to further reduce reliance on residual herbicides. Due to its easier management, GM cotton would be expected to reduce the difficulty of growing cotton in remote parts, or small or irregular paddocks.

Perhaps the biggest social benefit of transgenic cotton is its use in managing sensitive areas. This is consistent with literature with Edge et al. (2001) indicating the ability to grow cotton near more heavily populated areas because of a reduction in the reliance on insecticide. GM cotton allows growers to manage areas close to rivers, houses, livestock, neighbours, towns and highways better. One grower indicated that as they were close to town and their neighbours had cattle, there was less time lost waiting for the right wind directions. It meant for one grower they could plant cotton in areas which before were too environmentally sensitive. These benefits reduce the time and frustration required to grow cotton in sensitive areas.

Environmental Benefits

From this project, it became apparent that the perceived environmental benefits of GM cotton are undeniable. The reduction in chemical or sprays is by far the greatest environmental benefit of GM

cotton. Growers are concerned with the amount of chemical required to grow conventional cotton, with nearly 90% saying it influenced their decision when selecting cotton types.

Research indicated that BII has an environmental impact value of 23% of that of conventional cotton (Knox et al. 2006). Survey findings confirmed a significant drop in total volume of residual herbicide and insecticide. Insecticide use on average was shown to be reduced by 50-80%. A considerable number of growers believe GM cotton has reduced the load on the environment.

Climatic Considerations

The most limiting climatic factor of the southern property is the shorter cotton growing season it experiences. Southern NSW has a hot summer, but temperatures reduce considerably after February. Northern growing regions maintain summer temperatures, especially daily minimum temperatures, with a less noticeable cut-out in temperature in early autumn. Collarenebri was shown to receive similar rainfall to Hay in the autumn cotton picking season, however Hay's dominant winter rainfall in a normal season would be expected to have a greater chance of affecting cotton harvest.

Cotton growing techniques in southern areas have adapted to improve production despite the colder climate. However, southern regions such as the Riverina are still not as profitable as northern NSW. Narrow row cotton is shown from the literature to lead to earlier maturity[3] and reduce the chance of rain setting in during picking. BII assists with the drive for early maturity with higher retention rates and less tipping out. Narrow row cotton's higher plant population and increased ability to utilise available sunlight was found to lift yields, and ultimately the profitability of southern farming systems. (Millyard, 2003; McDonald, 2004; Barber, 2005)

The different climate and cropping systems meant southern growers experience different Heliothis pressure. Adapting IPM strategies and making use of available technologies all make management of Heliothis in southern growing areas practicable and viable (Lawrence 2004). By adapting to the different climatic conditions and developing management practices suitable for southern NSW, it was apparent that growers can improve profitability.

Fibre quality issues were reported by Millyard (2003) to have plagued the southern growing area; however changing harvest methods from stripping to picking was reported to have overcome the problem.

Findings by McDonald (2004), that many rice growers are considering growing cotton were reinforced by the survey. Growers reported that they were looking for alternatives to rice that used less water. This, along with the reduced workload of GM cotton and potential for returns similar to rice, is the driving factor behind the adoption of cotton in southern areas.

Conclusions

Neither the case study nor the literature showed consistently superior economic returns from GM cotton. However the survey found that BR was perceived as having the best economic return. As well as the perceived economic benefit, GM cotton provides social and environmental benefits leading to easier management and the ability to successfully grow cotton in more closely settled and environmentally sensitive areas.

For these reasons, GM cotton has been widely adopted especially in the southern district where farms are smaller and more closely settled.

[3] Up to 21 days earlier

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