The impact of biotechnology and other factors on health and safety in the Australian cotton industry

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In submitting this report, the researcher has agreed to CRDC publishing this material in its edited form.

CONTENTS

Abstract

The objectives for this study were:

1. To identify and describe potential factors that have influenced the health and safety of people associated with cotton production in Australia.
2. To establish the health impact that the introduction of new agricultural chemistry technology, integrated pest management and genetically modified cotton has had on the health and safety of people associated with cotton production.
3. Based on these findings, to recommend a more integrated approach to health and safety risk assessment, management and reporting for the cotton industry.

The research was carried out as a desk study using available reports and data. Key informants – growers and agronomists associated with the industry over many years, provided information from their own experience. Lack of a single, long-term dataset with injury and health records for work on Australian cotton farms , severely limited the ability of this study to demonstrate unequivocally changes in rates of injury and poisoning events associated with changes in cotton production. However, taking a hazards-based approach it has been possible to document some key factors associated with improvements to safety in the industry.

Key positive safety impacts have been associated with changes in:

1. Vehicle and on-farm traffic systems
2. Irrigation systems
3. Cultivation technology
4. Pesticides and pesticides application technology
5. Harvest technology
6. GM technology
7. Adoption of OHS management systems
8. Government regulation

Biotechnology has had a major impact on reducing exposure risk to hazardous insecticides and its effects. This has been enhanced by earlier and concurrent technical developments in insecticide chemistry to control secondary pests, changes in ground preparation and cultivation technology.

The high costs of managing safety to farm businesses, industry and government using 'lower-order controls' for on-farm management, have been described for the range of risks confronting the industry during its first three decades. The benefits of 'higher-order' solutions in terms of reduced management input and reduced management stress, has been reported by informants and by research reports.

The following recommendations have been made:

1. Management of safety risk using lower-order control methods is not only less effective in terms of reducing injury, it is also time and resource-intensive. Where possible, higher-order solutions should be sought and implemented. This will often involve modification of a number of interlinked systems, but when the cost of ongoing risk management is included in assessment of cost-benefit, it will often prove to be a valuable investment.

2. A number of hazards of high risk in the industry remain and must be managed. There would be benefit from collective activity by cotton producers for:

   - Benchmarking OHS safety performance and learning from each other
   - Entry level worker safety induction
   - Setting of safety standards for contractors and maintenance of a pool of contractors that meet those standards – cf AAAA accredited aerial operators
   - Examination of hazards of high risk by a technical and safety reference group to identify solutions

3. Work-related injury and illness data is not available, but could be collected by the Cotton Consultants Association during their annual reporting of pesticides and GM cotton use data. This data could be readily collated by the Australian Centre for Agricultural Health and Safety on behalf of all growers.

4. Should insect resistance again become a major problem, there may be a loss of institutional memory about the safety effects of a high dependency on insecticides. Changes in pest management should take into account safety risks and their control, in a formal and planned way. Contingency plans for maintenance of safety should be prepared.

Acknowledgements

Bruce Pyke and Helen Dugdale of the Cotton Research and Develpoment Corporation provided access to valuable documents and data for use in preparation of this report, as well as clarifying information.

The 14 people who became our "key informants" were very generous with their time and sharing their observations and knowledge gained over years of expereince in the industry. That information has been pivotal to the study's findings.

The Australian Centre for Agricultural Health and Safety reecived a grant from the Cotton Research and Development Corportaion to undertake the study.

1. Background

Cotton production in north west New South Wales and central and southwest Queensland has grown to become a significant primary industry for Australia from the late 1970s. Figure 1.1 shows the dramatic growth in area of cotton production from 1960-61 to the late 1990s and the decline during the early 2000s associated with drought and lack of access to water.

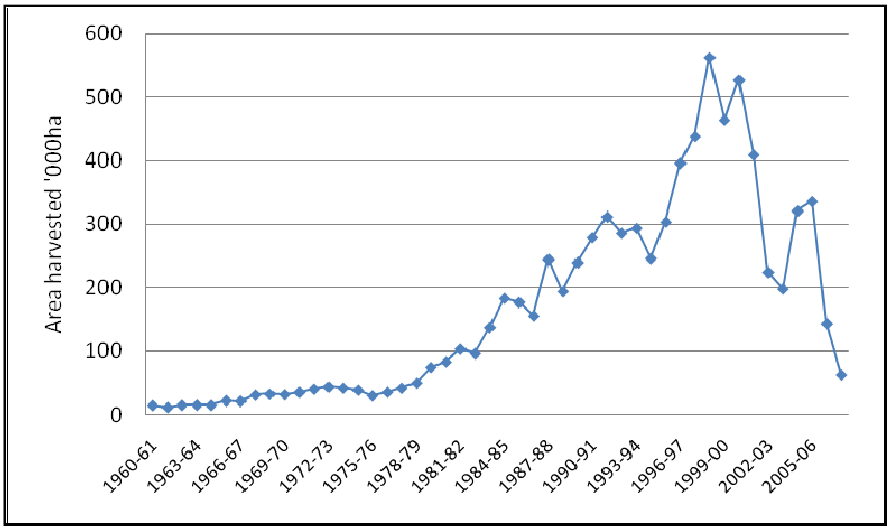


Figure 1.1: Area of cotton harvested by year 1960-67 to 2006-07, Australia.
Source: Australian Bureau of Agricultural and Resource Economics, 2007, 2008

Cotton production has contributed significantly to the value and volume of Australia's primary production and its export earnings. The economic importance of the industry has been marked for local communities, bringing jobs, professional personnel and associated services to communities that would otherwise have faced a greater decline in population and services. Figure 1.2 shows the gross value of Australia's total production and the export value of cotton.

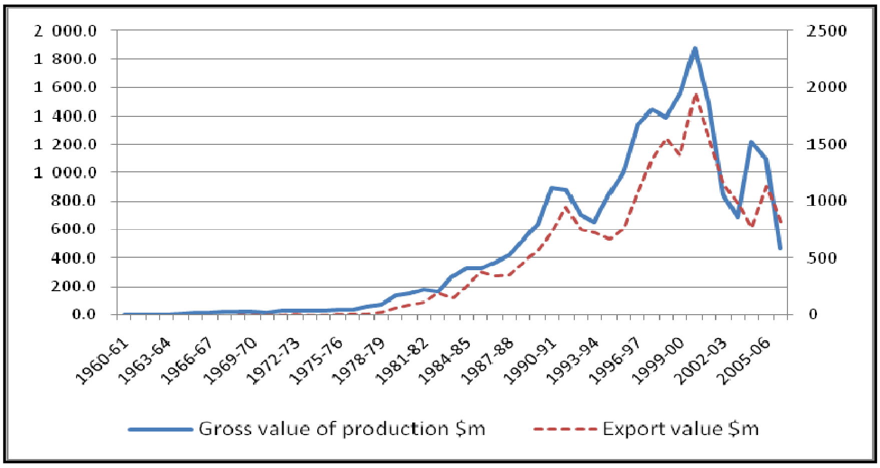


Figure 1.2: Gross value of cotton, and value of cotton exports by year 1960-67 to 2006-07, Australia.
Source: Australian Bureau of Agricultural and Resource Economics, 2007

The cotton industry in Australia had an early interest in pursuing improved safety and has included presentations on cotton production health and safety at most annual cotton conferences since 1990 (Clarke and Churches, 1992b). There has been significant investment in the development of practical resources, incentives and programs to improve health and safety on cotton farms by the industry. Thes have been facilitated through the Cotton Research and Development Corporation and by governments, specifically the NSW and Queensland workplace health and safety authorities.

There has been recent interest in identifying drivers of change to improve safety in the Australian agricultural industries by those wishing to ensure that safety promotion and extension programs have greater impact on achieving adoption of recognised interventions (Fragar, 2008).

At the same time there has been a growing interest by sectors in the cotton industry in examining safety changes and specifically, the impact that introduction of genetically modified cotton may have had on occupational health and safety in cotton production. Studies in China and South Africa have demonstrated a reduction in pesticide poisonings with the adoption of genetically modified (Bt cotton) (Hossain 2004; Pray 2002). While studies have examined the economic and pest control impacts of biotechnology on cotton production in Australia, no research has been reported into the impact that biotechnology, or other changes have had on safety in the industry in this country (Pyke, In press).

The objectives for this study were:

1. To identify and describe potential factors that have influenced the health and safety of people associated with cotton production in Australia.
2 To establish the health impact that the introduction of new agricultural chemistry technology, integrated pest management and genetically modified cotton has had on the health and safety of people associated with cotton production.
3 On the basis of findings, to recommend a more integrated approach to health and safety risk assessment, management and reporting for the cotton industry.

2. Methods

The research was carried out as a desk study using available reports and data. Key sources of published information were from:

- Reports held in the library of the Australian Centre for Agricultural Health and Safety
- Reports held by, or referenced by the Cotton Research and Development Corporation (CRDC)
- Use of the Medline and Web of Science search engines to identify published papers relating to cotton production health and safety

Relevant industry and injury data was accessed by reference to:

- Reports and industry data held by the CRDC
- Workers' compensation claims data accessed through the NOSI database of the Australian Safety and Compensation Commission (ASCC) website.

A number of key informants – growers, agronomists associated with the industry over many years, provided information from their own experience:

- About the type of changes that have impacted on health and safety of those engaged in cotton production
- About the timing of introduction of those changes and
- About interactions of changes that affect impact

A small workshop with informants and industry representatives was held to check assumptions, examine findings and suggest further action.

3. Occupational health and safety associated with cotton production in Austraila

3.1 Reports and surveys pre-1997-98

There is no aggregated dataset available for the period prior to 1997-98 with which to describe the key health and safety risks associated with cotton production in Australia, or to monitor industry performance over time. However, there were a number of one-off surveys and studies undertaken that provided source data for production in 2001. This document detailed the hazards associated with each production phase in cotton production, along with risk assessment ratings for each identified hazard (Franklin et al., 2001).

The earliest report of health and safety of workers associated with cotton production is ***a study carried out by a team of the National Aboriginal and Islander Health Organisation visiting the New South Wales "cotton belt"*** (Kellner et al., 1984). This report noted the importance of the cotton industry to employment of Aboriginal people ; however a number of health complaints of Aboriginal cotton chippers were reported. These included:

- Rashes (56% of chippers) - potentially due to pesticides or plant toxicities – Noogoora Burr, Bathurst Burr *Xanthium spp*)
- Blisters
- Blurred vision and giddiness
- Asthma at greater rates than non-chippers
- Boils (57% of chippers) - presumed to be due to skin trauma while chipping
- Twenty percent of chippers reported being sprayed by a plane and 72% having entered wet fields. At that stage, re-entry periods following pesticide application were stated to be **-** "when dry" or 24 hours as a rule of thumb.

Moree doctors were reportedly concerned about excessive injury associated with machines in gins and harvesters, working long hours and fatigue.

The report also noted that an outbreak of haemorrhagic cystitis in a chlordimeform packing plant in Tennessee in US 1971-1976 (1975) had been reported, and that this chemical had been used on cotton fields where chippers were working (see below). The report made recommendations for a further survey; wider communication of findings; and, that OHS programs monitoring pesticide exposure be extended to cotton chippers.

A ***profile of persons injured while on cotton farms who presented to hospitals*** in Narrabri, Moree and Wee Waa, NSW for a one-year period (November 1990 to October 1991), showed that most injury occurred in the work context of machinery or equipment maintenance (Table 3.1).

Table 3.1: Number of presentations to Emergency Departments of persons injured on cotton farms to three NSW hospitals, by work context, November 1990 to October 1991.

Work context	Number injured	Percent
Cultivating	2	3.5
Irrigating	3	5.3
Chipping	4	7.0
Picking	5	8.8
Carting	3	5.3
Machinery/equipment maintenance	20	35.1
Building maintenance	2	3.5
Fencing	1	1.8
Driving/riding vehicle	4	7.0
Work related- not specified	7	12.3
Leisure	4	7.0
Total	**57**	**100.0**

Source: (Agricultural Health Unit, Moree District Hospital , 1992)

The agents of injury on cotton farms were many and varied (Table 3.2, Agricultural Health Unit, Moree District Hospital, 1992), although workshop equipment were associated with more than 20 percent of injuries.

Table 3.2: Number of presentations to Emergency Departments of persons injured on cotton farms to three NSW hospitals, by agent of injury, November 1990 to October 1991.

Agent of injury	Number	Percent
Farm vehicle	8	14.8
Utility	1	
Car	1	
Truck	1	
Motorcycle (2-,3-,4-wheeled)	3	
Trailer	1	
Vehicle part	1	
Tractor	3	5.6
Cultivator	1	1.9
Slasher	1	1.9
Earth moving equipment	3	5.6
Header	1	1.9
Cotton picker	6	11.1
Module mover	1	1.9
Irrigating equipment	1	1.9
Welder	5	9.3
Grinder	5	9.3
Angle grinder	1	1.9
Hoe	2	3.7
Wire	1	1.9
Animal	2	3.7
Snake	1	
Pig	1	
Fertiliser	1	1.9
Other chemical	1	1.9
Iron sheeting	2	3.7
Timber	1	1.9
Steel bar/peg/post	5	9.3
Vegetation	1	1.9
Glass	2	3.7
Tarpaulin	1	1.9
Total	**54**	**100.0**

Anonymous company records for the period 1992 to 1997 broadly confirm the profile of agents of injury cases presenting to hospital Emergency Departments and the higher risk associated with maintenance activity on cotton farms (Table 3.3).

Table 3.3: Agent of injury by production phase, selection of cotton company injury records 1992-1997.

	Ground preparation	Planting	Plant growth	Picking and carting	Machinery and equipment maintenance *	Unknow n	Total
Vehicles	0	1	2	1	5	8	17
Mobile plant	11	6	11	14	11	5	58
Fixed plant	0	1	4	4	7	3	19
Workshop equipment	1	0	0	1	31	2	35
Other machinery	1	1	2	0	2	5	11
Hand tools	0	1	1	2	18	4	26
Chemicals	0	0	3	0	2	1	6
Farm structure	0	0	2	1	3	2	8
Materials	0	0	0	2	9	3	14
Motion/posture	0	2	1	0	5	1	9
Environmental	2	2	4	2	3	6	19
Animals	1	0	1	0	1	1	4
Total	**16**	**14**	**31**	**27**	**97**	**41**	**226**

* Includes maintenance of ginning equipment
Source: Franklin 2001

Although pesticides poisoning cases were not commonly reported (in these reports), there was concern expressed about ***exposure of cotton chippers to pesticides*** following the finding of lower than normal blood cholinesterase levels in a small group of Moree cotton chippers in the 1990/91 season. (Blood cholinesterase levels decline with exposure to organophosphate insecticides.) A study was undertaken during the following 1991/92 season by the Australian Agricultural Health Unit at Moree, in association with an environment health specialist of the NSW Department of Health. The study of pesticide exposure in cotton chippers in the Gwydir Valley was undertaken using depression of erythrocyte cholinesterase activity as a proxy measure for exposure to all classes of pesticides used on cotton and as a direct measure of exposure to organophosphate pesticides.

A total of 417 cotton chippers enrolled in the study and had baseline cholinesterase levels established. Sixteen (16) were excluded due to prior exposure. Follow-up samples were collected at fortnightly intervals throughout the growing season for 115 of originally enrolled chippers. A 6% decline from baseline levels was found in this population, that was highly statistically significant. A number of chippers' results dropped by more than 30% considered to be of medical importance, although they did not report symptoms of toxicity.

Other symptoms reported by chippers included: sunburn (43%) skin rashes forearms and lower legs (19.2%) cuts and abrasions from plants and weeds (15.2%). In addition, a smaller study of skin exposure to endosulfan and profenofos was undertaken, with significant levels of endosulfan and profenofos being recovered from clothing worn by chippers.

An over-spray event that occurred during the field work was documented. This occurred as a result of wind change during spraying an adjacent field and the pilot not being aware of chippers in field.

Cotton consultants, whose work included in-field insect and plant checking, were studied in an exposure study that again used depression of plasma and erythrocyte cholinesterase as a proxy measure of exposure to sprayed pesticides during the 1992/93 growing season (Australian Agricultural Health Unit, 1993). Results from January indicated an increase in the proportion of workers who demonstrated cholinesterase levels that were lower than the laboratory reference range – from zero to 36%. In later tests during mid March, the proportion dropped back to 9.5%. However, these numbers were small (n=19 to 25 in each of the 6 sampling periods). Of concern to researchers was the inadequacy of clothing observed being worn during in-field work . Less than half of the workers wore long-sleeve shirts and between 16% and 42% wore long legged pants, leaving legs and arms exposed to chemical residues on plants, solar radiation and hazards causing scratches and abrasions.

The Australian Cotton Foundation reviewed the reports and produced a paper modifying current practice for re-entry of workers to sprayed fields and options for reducing exposure:

- Exclusion from recently sprayed fields until residue levels decayed
- Improved management practices
- Improved standards of protective clothing
- Improved facilities/ amenities for chippers in the field (Australian Cotton Foundation Health and Safety Task Force, 1993)

A management plan was developed and later written information was supplied to employment agencies, growers and contractors that included advice regarding:

- Extension of the re-entry period to 48 hours or when the spray is dry - whichever is longer. The interval may be reduced if crops are short and hoes, not hands, are used
- Provision of washing amenities
- Chipping when crop is high to be discouraged
- Communication systems to be improved
- Dress standards to be advised at recruitment
- Cholinesterase surveillance for chippers

Chlordimeform is a formamide insecticide that was in use under permit in the NSW cotton industry between 1978 and 1986. It can be rapidly absorbed through the skin and by inhalation or ingestion. The major metabolite 4-chloro-o-toluidine was implicated in the development of haemorrhagic cystitis and ***bladder cancer*** in workers exposed to the pesticide during its production. Kenyon (1989), in reviewing its use in NSW, reported that 9/13 workers involved in purification of 4COT developed haemorrhagic cystitis (Britain); 8/335 workers involved in production and processing developed bladder cancer (Germany); and 9/23 workers packaging chlordimeform had urinary symptoms including haemorrhagic cystitis (USA). The pesticide was used in cotton under stringent controls - use was by permit only to approved operators, and regulations required strict adherence to protective measures and monitoring. Despite these controls, surveillance of urinary metabolites indicated that some workers might have undergone significant exposure.

A post-exposure surveillance program was undertaken by the NSW WorkCover Authority, with about 100 of 500 registered users being tested for haematuria and urinary cytology, and more recently with BCLA-8 Mab tests (monoclonal antibody test). Results in 1989 were - 14/80 urine samples had microhaematuria and another study showed 30% to have RBC in urine. A total of 20% of those tested had more than 10% BLCA-8 positive cells in voided urine (against 9.5% of a “control” group - the validity of the control group is at question). The Australian suppliers of chlordimeform undertook a program of surveillance for bladder changes in their previously exposed workers. The 1996 survey resulted in 1 case of bladder cancer being detected and treated, and in 1997, at least one worker is having repeat tests as a result of abnormal cells being found in screening bladder cytology. There are difficulties in assigning cause to individual cases of bladder cancer, as factors such as smoking are also associated with its incidence.

In 1995/ 96 a project to investigate sexually transmissible disease prevention/treatment services in rural NSW was conducted in the Barwon and Dareton health districts. The ***Chippers and Pickers Survey Report*** (Drage and Brett, 1996) found that health professionals reported that the top four issues for which services (advice/ treatment) was required were:

- Injury and poisoning
- Drug and alcohol
- Sunburn/skin conditions
- Methadone service

A high proportion of health workers felt itinerant workers were not aware of health and safety risks associated with their work. They all reported challenges with the provision of health services to this itinerant workforce and that these needs were not being met.

In summary

There were a wide range of safety hazards reported during the first 3-4 decades of cotton production - mostly relating to mechanical hazards and potential chemical hazards.

The ***cost of injury in cotton production*** was estimated and reported for cotton farms in Queensland in 1994 (Ferguson, 1994). In that survey of cotton farmers, the cost of injury/illness was $53,426 per 100 farms. Clearly, these cases do not include ***the high cost of monitoring and controlling risk*** associated with the known hazards, in particular the cost of achieving safe and effective use of pesticides in the industry. Those costs were borne by individual producers, the industry, governments, manufacturers and suppliers, thereby adding cost to key farm inputs.

3.2 Reports and surveys from 1997-98

Information regarding workers’ compensation claims associated with cotton production is available for claims made from 1997-98 to 2005-06 from the Australian Safety and Compensation Council and should be updated, as data is made available from the states. Table 3.4 indicates the total number of workers’ compensation claims in cotton production (excludes cotton ginning) for the years 1997/98 to 2005/06 (preliminary data).

Table 3.4: Total number of workers' compensation claims relating to cotton production, 1997/98 to 2005/06. Australia.

	Fatal Injury	Non-Fatal Injury	Total
1997/98	0	91	91
1998/99	0	81	81
1999/00	0	67	67
2000/01	1	76	77
2001/02	0	118	118
2002/03	3	89	92
2003/04	0	58	58
2004/05	0	72	72
2005/06	0	72	72

Source: The ASCC Online Statistics Interactive National Workers' Compensation Statistics Databases

Note: Excludes cotton ginning, Excludes travel claims

As exposure to risk is associated with the level of on-farm production activity, it would be expected that in those years where production levels were low, there should be fewer claims numbers. Figure 3.1 indicates the number of claims in each year alongside the total area of cotton harvested.

Figure 3.1: Total number of workers compensation claims and total area harvested in the cotton industry, 1997/98-2005/06. Australia.

Source: The ASCC Online Statistics Interactive National Workers' Compensation Statistics Databases . Excludes travel claims

There is no labour force information available to examine claims rates in each year. However, if the area in production is considered as a quasi measure of activity, and hence of the number of people engaged, Figure 3.2 would indicate that claims rates (on a per hectare basis) reduce as area of production increases. This result is preliminary and should be treated with caution; however, the case should be further examined to confirm that increased scale of production on an enterprise basis results in better safety performance.

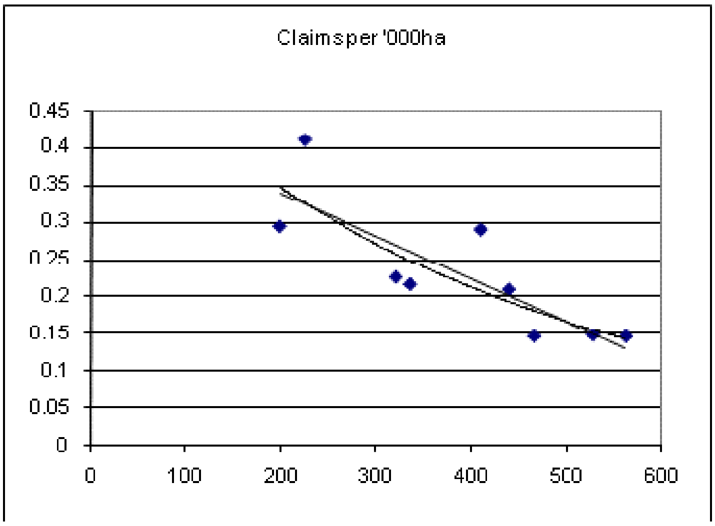


Figure 3.2: Number of workers' compensation claims per 100 ha as a quasi for claims rate, by total area planted. Correlation coefficient - 0.818
Source: The ASCC Online Statistics Interactive National Workers' Compensation. Statistics Databases . Excludes travel claims

Figure 3.3 indicates the age distribution of workers' compensation claims in cotton production for the same period, with injury cases occurring across all age groups.

Again, no information is available to determine whether injury risk is greater in any age group, such as older workers.

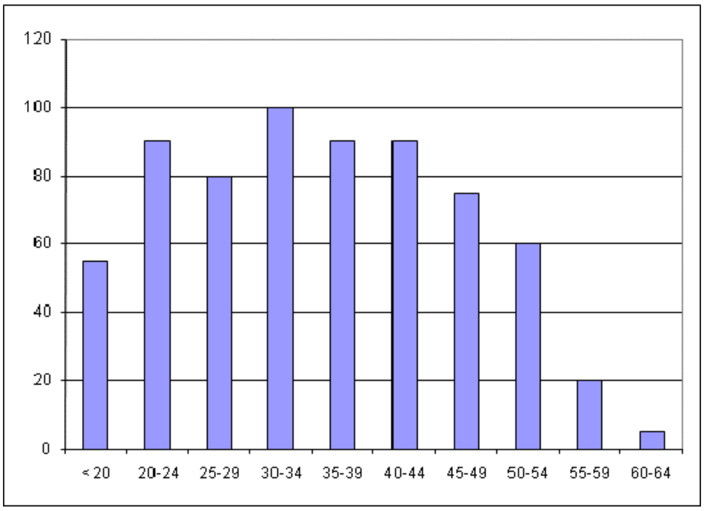


Figure 3.3: Number of workers' compensation claims associated with in cotton production 1997/98 to 1005/06(preliminary data), by age group. Australia.
Source: The ASCC Online Statistics Interactive National Workers' Compensation Statistics Databases Excludes travel claims

The following table (Table 3.5), indicates the more common agents of injury claims in cotton production for the period.

Table 3.5: Agents of injury resulting in workers' compensation claims in cotton production, by broad group, 1997/98 to 2005/06 (preliminary data). Australia

	Machinery and Fixed Plant	Mobile Plant and Transpo rt	Powered Equipment Tools	Non-Powered Hand tools, Equipment	Chemica l Products	Materials Substances	Environ-mental Agencies	Animal, Human Biological Agencies	Other and Unspec-ified	Total
1997/98	5	20	np	20	np	15	15	np	15	90
1998/99	5	15	np	15	np	10	10	np	15	80
199/00	np	20	np	15	np	10	5	np	10	65
2000/01	10	20	np	15	np	10	10	np	10	75
2001/02	10	20	np	20	np	15	25	np	20	120
2002/03	5	25	np	15	np	15	15	np	15	90
2003/04	np	20	np	10	np	10	10	np	5	60
2004/05	10	15	np	5	np	15	10	np	10	70
2005/05	np	20	np	10	np	10	10	np	10	70
Approx Total	**45**	**175**		**125**		**110**	**110**		**110**	**720**

np = less than 3 claims
Source: The ASCC Online Statistics Interactive National Workers' Compensation Statistics Databases
Excludes travel claims
As the number of claims in the industry in each year are small, numbers are rounded to the closest 5 cases.

It is noteworthy that mobile plant and equipment, machinery, non-powered hand tools and equipment were most commonly associated with injury claims in this period. Little information is accessible to determine the number of claims within specific groupings. Of the claims for mobile plant and equipment, tractors were the most common agent associated with an injury claim.

The current cost of compensation for injuries occurring on cotton farms cannot be established. However, the median compensation cost per claim for total claims is approximately $5,400. Table 3.6 indicates the median costs per claims by age group of claimant and demonstrates a higher median cost for claims by older workers.

Table 3.6: Median cost of workers compensation claims 2000/01 to 2004/05 by age group of claimant for claims in cotton production. Australia. ($A)

	2000/01	2001/02	2002/03	2003/04	2004/05
< 20	6,200	1,700	4,400	np	2,500
20-24	1,500	1,900	2,300	np	2,300
25-29	1,800	2,300	3,300	2,400	9,600
30-34	2,600	3,500	6,000	2,400	4,100
35-39	14,000	3,600	16,800	29,700	2,500
40-44	2,000	7,500	6,400	4,500	9,000
45-49	6,300	2,400	4,400	1,200	1,700
50-54	15,400	5,400	5,500	22,300	np
55-59	34,500	20,400	np	np	8,800
60-64	np	np	np	np	7,300
65+	np	np	np	np	np
Median	**2,900**	**3,500**	**5,200**	**5,300**	**5,400**

np = less than 3 claims
Source: The ASCC Online Statistics Interactive National Workers' Compensation Statistics Databases
Excludes travel claims

In summary

The number of workers’ compensation claims made in cotton production in Australia is small, although the cost per claim is significant. This has limited the degree to which further analysis of injuries and their causal factors can be made. However, the limited data does confirm some findings from earlier studies showing the wide range occupational health and safety risks associated with work in cotton production, particularly relation to mechanical hazards.

3.3 A framework for describing hazards of significant health and safety risk

Table 3.7 lists the hazards of moderate to high risk to people associated with cotton production in Australia. This framework provides the basis for considering the impacts on health and safety on changes in technology or management, or in the operating environment for cotton production.

Table 3.7: Hazards of moderate to high risk associated with cotton production in Australia, and persons at risk

Hazard type	Activity posing risk	Persons at risk
Mechanical hazards		
Vehicles		
Trucks	Transport fuel	Drivers, passengers, assistants, bystanders
	Transport chemicals – pesticides, fertilisers	Drivers, passengers, assistants, bystanders
	Transport of machinery	Drivers, passengers, assistants, bystanders
	Transport of other farm supplies	Drivers, passengers, assistants, bystanders
	Transport of seed	Drivers, passengers, assistants, bystanders
	Transport of cotton modules	Drivers, passengers, assistants, bystanders
Utilities, other vehicles	Checking	Agronomists, supervisors, managers
	Scouting	
	Supervising	Supervisors, managers
	Transporting people, tools, equipment	
ATVs	Checking	Operators, passenger
	Scouting	Operators, passenger
	Supervising	Operators, passenger
	Weed spraying	Applicator
	Flagging	Markers
Aircraft	Fertilising	Pilots
	Pesticides application	Pilots
	Crop monitoring	Pilots
Mobile plant		
Tractors	Ground preparation and cultivating	Machinery operators
	Planting	Machinery operators
	Cultivating	Machinery operators
	Harvesting operations	Machinery operators
Tractor implements	Ground preparation and cultivating	Machinery operators
	Planting	Machinery operators
	Cultivating	Machinery operators
Spray rigs	Pesticide application	
Cotton pickers	Harvesting	Machinery operators
Module builders	Harvesting	Machinery operators
Boll buggies	Harvesting	Machinery operators
Mobile water pumps	Irrigation	Irrigators
Fixed plant		
Travelling irrigators	Irrigation	Irrigators
Pumps	Irrigation	Irrigators, mechanics
Drip irrigation systems	Irrigation	Irrigators
Powered tools and equipment		
Air, electrical and fuel driven	Workshop and outdoor maintenance	Mechanics, bystanders
Hand tools		
Workshop tools	Machinery maintenance	
Hoes	Chipping	Chippers
Monitoring devices	Crop checking	Agronomists

Hazard type	Activity posing risk	Persons at risk
Electrical hazards		
Power lines	Fertilising	Pilots
	Pest control	Pilots
	Crop monitoring	Pilots
Power tools	Repairs and maintenance	Mechanics
Power leads	Repairs and maintenance	Mechanics
Chemical hazards		
Pesticides		
Fungicides	Pest control	Pilots, applicators and handlers, bystanders, field workers on re-entry
Insecticides	Pest control	Pilots, applicators and handlers, bystanders, field workers on re-entry
Herbicides	Pest control	Pilots, applicators and handlers, bystanders, field workers on re-entry
Growth regulants	Plant control	Pilots, applicators and handlers, bystanders, field workers on re-entry
Defoliants	Plant control	Pilots, applicators and handlers, bystanders, field workers on re-entry
Fertilisers		
Anhydrous ammonia	Fertilising	Fertiliser applicators, bystanders
Other fertilisers	Fertilising	Fertiliser applicators, bystanders
Fuels		
Aviation fuels	Pest and plant control	Pilots, re-fuellers
Diesel, petrol, gases	Transport	Drivers, workers, bystanders
	Checking and supervising	Agronomists, drivers, bystanders
Oxyacetylene	Machinery maintenance	Mechanics
Oils and lubricants	Machinery maintenance	Mechanics
Environmental hazards		
Particulates		
Dust	Ground preparation and cultivating	Operators and drivers
Fire/smoke	Stubble burning	Operators and drivers
Noise		
Tractors and mobile plant	Field work	Operators
Module builders	Module building	Operators, bystanders
Pumps	Irrigating, maintenance	Irrigators, mechanics
Flying objects		
Trash	Harvest and module building	Operators, bystanders
Insects	Chipping and field work	Chippers, supervisors, field workers
Radiation		
Solar radiation	Chipping, irrigating, checking	Chippers, irrigators, agronomists
Biological		
Vegetation – plant products	Cotton chipping, checking	Chippers, irrigators, agronomists
Traffic ways		
Lanes, banks	Movement of goods and people	Drivers, passengers
Access to public roads	Movement of goods and people	Drivers, passengers
Outdoor surfaces		
Slips., trips and falls	Field work	Chippers, irrigators, agronomists
Confined space hazards		

Hazard type	Activity posing risk	Persons at risk
Irrigation pipes/ culverts	Irrigation	Irrigators, bystanders
Pump wells	Irrigation	Irrigators, maintenance workers
Distribution tanks	Irrigation	Irrigators
Falls from heights hazards		
Structures		
Workshops	Repairs and maintenance	Mechanics
Other buildings	Office work, other	Officer staff, other
Fuel tanks	Fuel storage	Refuellers, bystanders
Gas tanks	Fertiliser and other gas storage	Fertilisers, bystanders
Silos	Fertilising	Fertilisers, bystanders
Windmills	Water access	Maintenance personnel and irrigators
Drowning hazards		
Trenches		
Channels	Water movement	Irrigators, bystanders, visitors
Water storages	Water storage	Irrigators, bystanders, visitors
Ergonomic hazards		
Handling syphons	Irrigation	Irrigators
Handling lay-flat	Irrigation	Irrigation
Using hoes	Chipping	Chippers
Handling bags of seed	Planting	Farm hands, operators
Operating tractors/ plant	Field work	Operators
Stress and anxiety hazards		
Long shifts	Cultivating, spraying, harvesting	Operators
Work at night	Cultivating, spraying	Operators
Insect/pest pressure	Crop management	Farm managers
Financial/ management pressure	Farm management	Farm managers

Sources: Franklin 2001; Personal communications of key informants, 2008

4. Impacts of cotton development on rural communities

4.1 Employment and growth

Socioeconomic factors, including low education levels, low income levels and unemployment have been identified most consistently as the key determinants of the relative health status of populations (Turrell et al., 1999; Smith et al., 2008). There is no doubt that development of the cotton industry in the more remote rural communities has provided employment and economic benefit to these communities at times when other employment opportunities have been declining. The value of employment opportunities in the cotton industry for Aboriginal people in the early 1980s was noted in the study carried out by a team of the National Aboriginal and Islander Health Organisation visiting the New South Wales "cotton belt". This report noted the relationship of Aboriginal people to the cotton industry as "a growing source of seasonal employment for Aboriginal people in north-west NSW" (Kellner et al., 1984).

Indeed, during the 1990s in the Moree community in north west NSW, it became obvious to all that the year-to-year fluctuations in the size of the cotton crop was closely associated with population inflows and outflows. Invariably this had local impacts on the housing market and small business viability (personal observations of authors).

Cotton Australia (http://www.cottonaustralia.com.au/environment/water/communities/, accessed November 2008) estimated that in a typical non-drought year the cotton industry employs about 10,000 people in 50 rural communities, and provides direct support to more than 4,000 businesses. A case study of the effects of drought on businesses in the community of Wee Waa, NSW, illustrated that when comparing 2007to 2001:

- Permanent staff numbers fell 60% between 2004 and 2007
- Casual employment fell 40%
- 2/3 of employees who lost their jobs left the region
- 60% of businesses had downsized as a result of the drought
- 95% of businesses had a 60% or greater reliance on a healthy cotton industry
- Combined Wee Waa Primary and Secondary school numbers declined by a total of 128 students (21%)

4.2 Adverse impacts on communities related to application of pesticides

Communities have an increasing concern about the use and safety of pesticides in **a number of agricultural industries.** The past 20 years or so have seen several communities express concern over potential and/or perceived adverse health effects of pesticides in agricultural production. Table 4.1 provides a summary of a number of instances with which the Australian Centre for Agricultural Health and Safety has been associated from the late 1980s (Fragar, 1998). Health concerns raised by communities have been various:

1. Concerns over a cluster of a particular health condition (e.g. cancer, birth defect, aplastic anaemia) and the linking of that condition to local application of pesticides.

2. Concerns over proximity to, odour of, or actual exposure to pesticides applied in locality. Aerial application of pesticides is a common concern. Health conditions reported are various and include headache, rhinitis, asthma, fatigue, cognitive difficulty and skin irritation.

Health and other government agencies have responded to these expressed concerns with often resource-intensive investigations. For example, the investigation of a cluster of cases of aplastic anaemia in an orchard area of central NSW (Sladden et al., 1997); and, with varying degrees of community consultation. A number of cases have required a mix of surveillance programs to monitor exposure (air, water) and health effects (rate of disease occurrences, case control studies).

Table 4.1: Reported Community Concerns relating to high pesticides useage in various industries Reproduced from (Fragar, 1998)

Time period	Region	Commodity Crop	Health concern	Public Health Response
Late 70's	Wee Waa, NSW	Cotton	Mainly agricultural concerns	North West Pesticide Committee - ongoing interagency committee
Early to late 80's	Moree NSW	Cotton	General Later cluster of neuroblastoma cases in children	Community Liaison Committee NAIHO study of the health problems of Aboriginal Cotton Workers (16) Survey of doctors in cotton area (17,18) Plan for Adverse Impact Register pilot (19) Review cancer rates in cotton area Review birth defects in cotton area
1980 – 1985	Emerald, Qld	Cotton	Childhood leukaemia	Cabinet Enquiry into epidemiology of childhood leukaemia (20,21) Air and water sampling
Early 1990's	North Coast NSW	Old Cattle Tick Dip sites	Various	(22)
1992-1993	Coffs Harbour, NSW	Bananas	Cluster of cleft palate	Community consultation 3x case control studies Air sampling (23)
1994	Central NSW	Horticulture	Cluster of cases of aplastic anaemia	Case control study (27)
1995	Gunnedah, NSW	Cotton	Various symptoms	Consultation with specialists physicians/ immunologists (24). Water sampling (25) Limited air sampling Asthma surveillance Local Chemical Liaison Committee formed, Development of Spray Guidelines
1996	Narromine, NSW	Cotton	Cancer Various other concerns	Public meeting Adoption of Gunnedah Spray Guidelines Investigation of suspected cancer cluster(26)
1996	Far North Queensland	Treatment of tropical fruit for papaya fruit fly	Various	Surveillance during treatment Plan to establish Register of Adverse Health Effects (19)

Recent concerns in northern Western Australia relate to the previous use of DDT and 2,4,5-T contaminated herbicides in unrelated production systems highlight the complexity of the problem and the long-term impacts of effects. (Government of Western Australia, 2004).

The heavy use of pesticides to control insects and other pests in cotton and the aerial application of these in the first four decades of cotton production in NSW, Queensland and the Ord, have been associated with community concern that has often required government intervention in a number of communities. A reasonable overview of the issue from a concerned community perspective is the account by Siobhan M^c^Hugh (1996), who recounted stories from a range of perspectives on many issues of concern, mainly around pesticides.

Early development of the cotton industry in the Namoi Valley and Wee Waa in NSW was associated with some tension between local graziers and cotton growers on issues that included water and pesticides drift. In relation to the pestcides issues, the NSW state government established the *North West Pesticides Committee*, as a state initiave within the Department of Agriculture with representatives from government departments, the cotton and local farming industries.

In the 1980s there was community concern over a cluster of eight leukaemia cases in the Emerald cotton growing area in Queensland that was investigated by the Queensland Department of Health and reported by Donald (1987). The extensive study involved surveying cases and parents in relation to pesticide exposures, infections, vaccinations and family history; air monitoring, noting that minute quantities of chemicals applied by air may drift considerable distances; water testing, finding DDT, dieldrin and endosulfan, but none exceeding MRL levels. The study found that the levels of contamination that were observed were “unlikely to pose health risk”.

In Gunnedah in north west NSW, many complaints were made to the NSW Minister for Health expressing concern over the impact of agricultural pesticide usage (particularly aerial application), on the health of the community and the environment during the 1994-1995 cotton growing season. The industry had expanded upstream from Boggabri/ Gunnedah on the Namoi River in the preceding few seasons. The NSW Health Department responded by undertaking a preliminary study into the health impact of pesticides on affected persons in Gunnedah and collected data on the health status of 61 residents in the region who reported concerns about effects of aerial pesticide spraying on their health. The information was collected in the context of provision of specialist medical consultation to affected persons provided by a team of specialists assembled by the Society of Immunology and Allergy (NSW Branch). The findings were based on clinical examination, blood pathology and a questionnaire on health status, with the aim to provide a descriptive picture of the health of the population affected by spraying (Fragar et al., 1996).

Twenty two percent of 58 symptomatic participants had one or more symptoms that fell into the category of ‘probably related’, while 50% had one or more symptoms that were classified as ‘unrelated’ and 50% as ‘uncertain’. Results for the Short Form-36 item health survey showed that the participants in this study reported a health status poorer than the rest of the Australian population, although the difference between the two was not statistically significant for any of the eight scales in the survey. Following publication of the report, the concerned community, governments at state and local levels, the cotton industry, and environmental conservation groups were engaged for about two years in meetings, mediations and negotiations to try to resolve the tensions that had built up around the issue.

These are the well-documented examples of community concerns over the effects of cotton pesticides application, but other communities have been affected - communities of Moree and Dubbo, NSW (Phillips and Coates, 1996) and more recently the Indigenous communities of the Ord River, Western Australia have all required community meetings and discussions.

In 1996, the NSW Department of Health conducted a survey of water quality in rainwater tanks in the Namoi Valley and found evidence of contamination by a range of pesticides including endosulfan that would have moved a significant distance from any crop sprayed with endosulfan (NSW Department of Health, 1996).

4.3 Impacts on communities of water use by the irrigated cotton industry

More recently, major community concerns have related to ***water use*** by the cotton industry and impacts on environment and water availability downstream from irrigated cotton farms. These concerns have come from a greater recognition of the importance of environmental flows, exacerbated by drought and effects of climate change that will add to dry conditions in much of the inland of Australia. The wider Australian research community also expresses these concerns and response to these issues will play a key part in determining the future of cotton production in local communities.

In summary

Cotton production has played an important role in the growth and maintenance of small communities in inland NSW and Queensland. Although the intensive dependence of the industry on aerial pesticide applications led to community reaction in most areas in early stages of establishment in each new area, concerns over water allocation will play the major role in determining the future of cotton in many rural communities.

5. Key factors that have affected health and safety in cotton production in Australia

Review of reports, data and information provided by the key informants for the study has identified the following areas as providing significant impact on human health and safety associated with production of cotton in Australia from 1960 to 2008:

1. Vehicle and on-farm traffic systems
2. Irrigation systems
3. Cultivation technology
4. Pesticides and pesticides application technology
5. Harvest technology
6. GM technology
7. Adoption of OHS management systems
8. Government regulation

Other factors such as the availability of water for irrigation and the scale of enterprises, have impacts on the exposure of humans to injury or health risk. Figure 5.1 provides a calendar indicating the timing of introduction of some factors that have had significant impact (positive and negative), on health and safety in the industry. Many changes were made over long periods – for example improvements in ergonomic features of tractor cabins and seating.

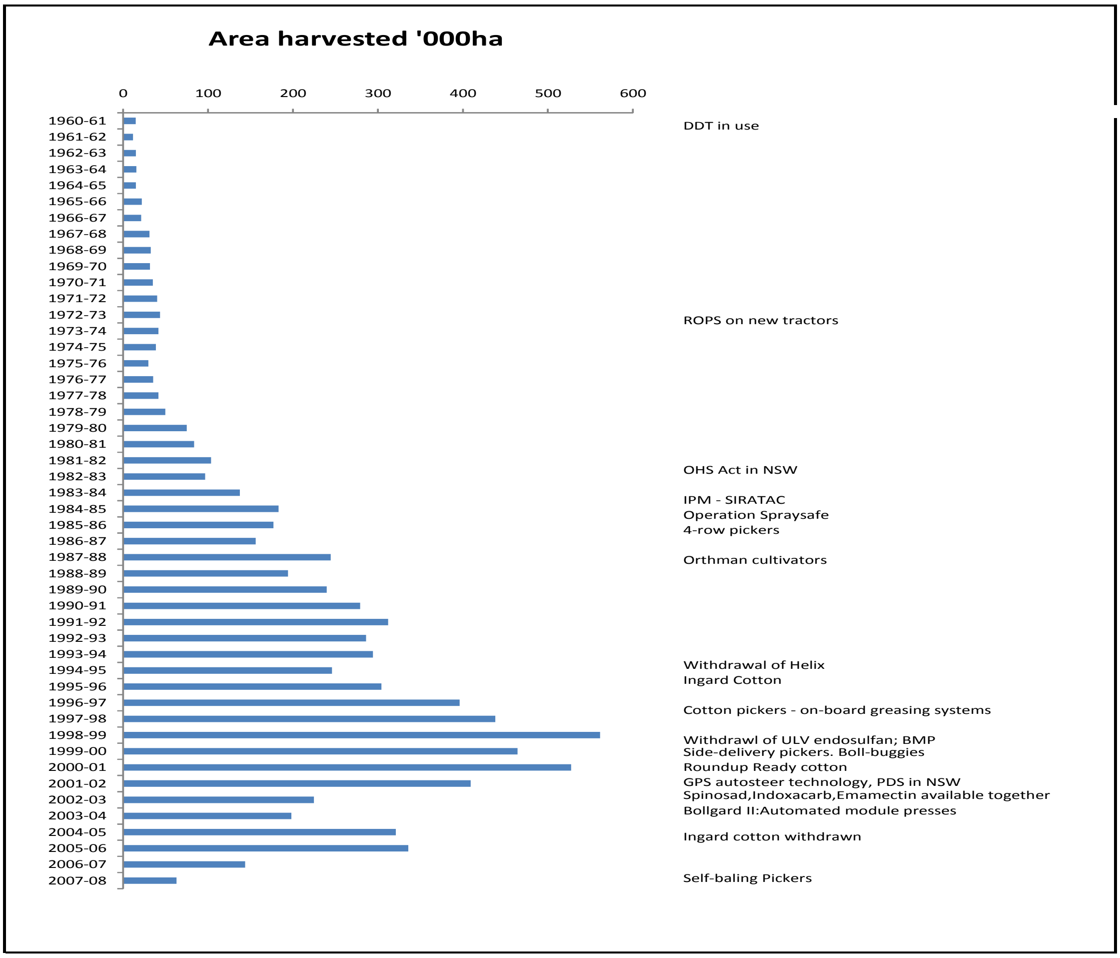


Figure 5.1: Calendar of introduction of some landmark changes impacting on cotton production safety.

5.1 Vehicle and on-farm traffic systems

> *"Vehicle safety is so much better, because of cabs, good tyres, air-conditioning, good maintenance, and better farm roads. We did a risk assessment and identified areas blind spots, marked by flags and signs. We have farm maps, and pay attention to driver safety in induction that was brought in in 2003".*

Vehicles have been used on cotton farms for transporting people who undertake a range of farm work. Informants reported that in earlier times when harvested cotton was transported in tractor-drawn trailers, that traffic levels were intense during harvest, and accidental collision was not uncommon. A number of developments have been important.

The need to move people around a cotton farm was great until recently and several informants reported that people were moved in vehicles that were unsafe. The more recent availability of dual-cab four-wheel drive vehicles fitted with seatbelts, has provided much safer options for all.

These improvements have been complemented by widening and improvement of laneways and traffic systems that occurred with the farm redesigns needed to accommodate 8m and 12m planter and cultivator rigs.

During the late 1970s, cotton module builders and modules began to replace tractor-drawn cotton bins and trailers. This brought semi-trailers onto farms with their associated risks of collision, raised dust on roads and rollover at irrigation channel crossings. They also posed a risk of falls to those engaged in covering the module with a tarpaulin for transport. However, the introduction of 'roll-over tarp' systems has reduced this risk.

Quad bikes were introduced and widely used during the late 1980s and have been demonstrated to pose risk of serious injury and death across Australian farms. This is particularly because they provide no protection for operators in the event of a quad bike rollover. More recently, cotton growers have reported switching to alternative transport for workers involved in field checking, supervision and irrigating.

Most informants reported current implementation of on-farm traffic-safety rules, with increased attention to training, speed limits, signage, wearing helmets and not working under the influence of alcohol.

5.2 Irrigation systems

Irrigation activity in the past has been associated with serious injury and death associated with unguarded irrigation pumps, as well as non-life-threatening manual handling injury associated with picking up, transporting and throwing syphons. Improved OHS management in recent years has seen these risks addressed in a number of ways on cotton farms.

Pump sites are now more routinely caged and guarded on cotton farms, although not universally.

Cotton producers have made differing ***modifications to irrigation systems*** that have improved safety. For example, one informant described their changes in this way:

> *"Now we have permanent layout of syphons, this has reduced ergonomic injury picking up, moving and throwing out syphons.*
>
> *In the 1990s we used heavy 75 mm syphons - in 2008 smaller 63 mm syphons, permanent layout and lighter to start.*
>
> *Now we have ditches with high head/ lead to higher volume/ easier/ quicker to start. All this has resulted in faster irrigation and less fatigue.*
>
> *We also educated the workforce that has resulted in reduced manual handling injury associated with irrigation.*
>
> *We have also installed better tail water pumps with better safety design."*

Another described their systems this way:

> *"Previously we made channel stops with poles, star picket and tarpaulins. What was happening was that people were walking across using them as channel crossing, falling and injuring themselves on the star pickets. Falls from tarps and pickets were identified by the OHS committee as high risk.*
>
> *Now we've put our channels to grade – replacing star pickets and poles with more stable metal purlins or permanent weirs.*
>
> *We used to have a high number of claims from slips from tarps/ stops. Now have reduced falls from stops tarps and crossings."*

The introduction of ***radio telemetry for monitoring*** irrigation pumps, gates, dams, water storages and irrigation channel water height, has significantly reduced the need for in-field activity *and "not putting people at risk of injury - on ATVs, becoming bogged, slipping into channels at night"*

5.3 Cultivation technology

> *"Machinery is now more operator-friendly - better comfort, reduced fatigue, less vibration, less noise, air-conditioned cabins, better ergonomically designed, better comfort, less back strain, less human stress and better productivity."*

Tractors and hitching

One of the most significant improvements in safety for cotton production has been associated with developments in ***tractor design and technology***. Early tractors were small, had no rollover protection for the operator and lacked the comforts associated with modern tractors that have air-conditioned cabins, improved seating and ergonomically designed features for the operator (Figure 5.2).

Figure 5.2: Tractor used for spraying, 1960. Courtesy Cotton Australia website.

It has been mandatory since 1972 in some states for new tractors to be fitted with a rollover protective structure (ROPS). Older tractors have been required to be retrofitted with ROPS since 1981 and 1983 when Occupational Health and Safety Regulations in NSW and most other states required fitment for tractors between 560kg and 15000kg weight. During the 1980s many tractors used for cultivation in the cotton industry were replaced with newer, ROPS-fitted and cabined tractors. However, some older tractors without ROPS were to be found on farms, kept for the other jobs requiring a small tractor.

There have been marked improvements in the ***ergonomic design*** of controls, seats, cabin noise levels and air-conditioning in subsequent designs of new tractors, all resulting in improved operator comfort.

However, some of the greatest improvements have come from the ***increasing horsepower and hydraulic capacity*** of tractors. In 1978, 6-row crop configuration was the most common, by 1982, 8-row configurations were common, and by 2005 12-row configuration were commonplace. With this came increased efficiency. This increased power and hydraulic capacity allowed for more than one operation to be carried out – greater lifting capacity of 3-point linkages, improved depth control and replacing PTO powered spray pumps with hydraulic powered units, has resulted in a reduction in the number of people employed, effectively eliminating a high proportion of hazardous work associated with tractor operation.

The advent of ***Global Positioning Satellites (GPS) and guidance technology*** systems has further enhanced these improvements. Tractor drivers hilling-up using listing rigs had to line up sight pegs on the tractor with a furrow made by a disc marker. This was a constant job, requiring high levels of concentration. *"Now GPS takes over – reduced fatigue, don't get white-line fever from concentrating on rows - also improved first cultivation which was slow and tedious and constant looking behind was required."*

A nice play on words from another experienced producer: *"Good tractor drivers can't necessarily drive straight … I mean - straight tractor drivers couldn't drive straight – they believed they had to use cannabis and drugs to get straight lines".*

A further important development has been the introduction of ***'quick-hitch' systems*** for hooking up trailing cultivation, sowing and spray equipment. This resulted in a reduction of hand and finger injury from crush injury and has changed the job from a 2-person job to a 1-person job safely.

Implements

There have been significant advances for safety in design of a number of key implements used in cotton production. For example, early slashers were without any guarding and are now safer. However, informants have indicated room for improvement in safety during access to undertake maintenance and cleaning. Another major improvement was the development and use of Orthman™ type cultivators. These eliminated clamps and wedges that had been used to secure knives, rolling cultivators, sweeps etc to the tool-bar, eliminating another common cause of hand injury.

Seedbed preparation

Development of improved seedbed preparation has combined with other technical developments to reduce injury risk associated with this phase in the production cycle. Up until the early 1980s following harvest, plants were slashed, the ground disc ploughed, ripped, and rows reformed and cultivated with a variety of implements until a suitable tilth was obtained ready for planting.

Up to the mid 1990s, slashing was replaced by pulling stalks, raking and burning trash, this then was replaced with stalk pulling and mulching. Development of processes of ‘middle busting’ and ‘rip hilling’; combined with GPS auto-steer has seen many properties now planting into permanent rows. The advent of Roundup Ready® cotton has reduced the need for pre-planting, at-planting and lay-by (post-planting) herbicide applications with bed-preparation now being often a ‘single-pass’ cultivation, planting the crop into permanent beds.

Summary

One informant summarised his experience this way:
“In 1978 we used D8 Caterpillar bulldozer for primary tillage. These were uncabined, and operators were subjected to vibration injury, the cold, the heat, dust and noise. The people driving them considered themselves ‘bulletproof and had a macho image’. It’s very different now. We have less hearing damage and claims, less stress, increased sleep.”

Another long-timer put it this way – *“People have pride in farming, we have huge gains in productivity, better machinery, less damage, less downtime, we can retain workers who are better trained and have better job satisfaction, people are important”.*

5.4 Pesticides and pesticides application technology

> *“The OPs are gone- they’re not used as much. There’s less stink, less exposure and less community concern.”*
>
> *“We’ve moved to closed systems to reduce splash and dust exposure. We’ve changed from liquids to granules where possible.”*

The cotton industry has depended on pesticides for control of pests for most of its modern history. However, pesticide use has been associated with health and safety impact on workers and on local communities. This has required significant investment by the industry, by governments, and by farmers and communities to control those risks.

The major production problem of insect resistance to the key insecticides available to the industry required increasing frequency, volume and types of pesticide applications. The loss of non-target beneficial organisms by the early broad-spectrum insecticides compounded the problem. These issues have been the major drivers for development of new chemistry more targeted to the specific pest load, changed pest management regimes and more recently, introduction of biotechnology solutions.

Pest management and chemistry

Tables 5.1 to 5.3 provide summaries of the history of introduction and availability of different pesticides for use to control the range of pests in cotton production. Developments in new chemistry and regulation of pesticides available for use have played key roles in changing not only improvements in pest management, but also the level of human health risk associated with pesticides use in cotton production.

The earliest insecticide in widespread use was DDT (1,1,1-trichloro-2,2-bis(4-chlorophenyl) ethane). However, by around 1973 resistance to DDT was a key problem - most acutely in cotton being grown in the Ord River Irrigation Scheme in northern Western Australia, resulting in cotton production being abandoned in that region. DDT was de-registered for use in about 1977/ 78 with a phase-out period, the last stocks being used until 1982.

DDT is considered to be a safe chemical from an acute poisoning perspective and there are no records of serious acute DDT toxicity associated with its use in the industry. However over the next decade there was recognition of the property of DDT and more specifically, its breakdown products (DDD and DDE) These breakdown products accumulate in the fatty tissues of exposed animals and results in bioaccumulation of animals higher along the food chain, with reproductive effects in some species. This led to a significant reduction in registration for use in agriculture world-wide. Studies have demonstrated residues of DDT in soils associated with cotton production in northern NSW (Sivaramaiah, 2002) and more recently in aquatic animals in waterways downstream of cotton production the Ord River (Fredericks, 2008).

With the withdrawal of DDT there was a dependency on organophosphates for insect control, these being a far more toxic group from a human safety perspective. Endosulfan trials were undertaken in the late 1970s and the product was registered for use in the 1980s. The less toxic pyrethroids were phased in during the 1980s.

Helicoverpa spp resistance remained a key problem for the industry. During the 1980s, researchers turned their attention to ***Integrated Pest Management (IPM)*** and these approaches were introduced to varying degrees into agronomic systems and advice.

Table: 5.1 Summary of insecticides registered for use in cotton production with Poison Schedule, Year of Registration for use, and, where applicable, Year Withdrawn from registration

Insecticide	Poison Schedule	Year IN	Heliothsis	Rough Bollworm/ Pink Spotted Bollworm	Tip Worm	Loopers	Mirids	Thrips	Aphids	Mites	Whitefly	Wireworm/ False Wireworm	Army-worm	Cutworm	Year OUT
Organochlorine															
DDT	9	45													82
endosulfan	7	87	87	87	05	87	92\06	87	87				05\06	05	
Organophosphate															
chlorpyrifos-methyl	6	99	99				02		04						
chlorpyrios-ethyl	6	01	01\03												
dimethoate	6	87					90	87	87	87					
omethoate	7	87					90	87	90						
parathion methyl	7	87	87			87		87	87	87/97					
phorate	7	90					95	90	87	90		95			
profenofos	7	87	87						88\04	87					
sulprophos	7	87	87\98												97
Pyrethroid															
alpha cypermethrin	6	87	87	87			00								
beta cyfluthrin	6	94	94				00								
cypermethrin	6	87	87	87		87									96
deltamethrin	6	87	87				01								
esfenvalerate	6	88	88	95											
bifenthrin	6	96	95				97			96		01			
lambda cyhalothrin	6	88	88	95			98								
zeta cypermethrin + ethion	7	01	01				01\06								
Carbamate															
aldicarb	7	90					92	91	90	90		95			
carbosulfan	7	98					98	98				01			
methomyl	7	87	87												
pirimicarb	6	97							97						
thiodicarb	6	87	87					90							
indoxacarb	6	01	01												
Biological															
bacillus thurengiensis	0	91	91												
nuclear polyhedrosis virus	0	00	00												
Synergist															
piperonyl butoxide (PBO)	0	90	90												
Benzyl phenyl urea															
chlorflurazuron	0	92 (permit)	92												95
Sulfite ester															
propargite	6	94								95					
Avermectin															
abamectin	6	95	99							96					
emamectin benzoate	6	00	00							04					
Triazapentadiene															
amitraz	6	96	96												
Formidimide															
chlordimeform		75	75												77
		79	79												86
Nicotinoid															
imidachloprid	5	98					01	96	01	97\99		01			
acetamiprid	6	04							04						
Spinosyn															
spinosad	5	98	98												
Thiourea															
diafenthiuron	5	97							99	97	05				
Phenyl pyrazole															
fipronil	6	99					99	00							
Pyrrole															
chlorfenapyr	6	99	99							99					
Oxadiazine		02	02												
indoxacarb	6	04	04				04								
Pyrmetrozine															
pymetrozine	5	04							04						
New Chemistry															
parrafinic oil	0 some 5's	05					06		05						
amorphous silica	0	05	05												
etoxazole	0	05								05					
Genetically modified cotton															
Ingard™															
Bollguard II™ Cotton	0	05	05												

Table: 5.2: Summary of herbicides registered for use in cotton production with Poison Schedule, Year of Registration for use, and, where applicable, Year Withdrawn from registration

Herbicide	Poison Schedule	Year IN	Channels	Pre-planting	Post/Pre-planting	Planting	Post - planting	Defoliant	Pre Harvest	Year OUT
Pre-planting										
amitrole	5	87	87							01
amitrole-T	5	87	87							
amitrole + amitrole-T	5	05	05							
atrazine	5	87	87\98							98
diuron	5	87	87		87	02	87			
fluometuron	0 some 5's	87	87\05	87	87	02	88			
fluometuron + prometryn	5	87		87	87	02	88			
prometryn	5	87		87	87		87			
2,2 DPA	5	87	87	87			87			
glyphosate 360	5	87	87	87			87		02	
glyphosate 450	5	88	88	88			88		02	
glyphosate 470	5	02					02			
glyphosate 490	5	98	98	98			02		02	
glyphosate 500	5	02		02			02			
glyphosate 510	5	01	01	01			01		02	
glyphosate 680	5	01	01	01			01			
glyphosate 840	5	05	05	05						
glyphosate trimezium 600	5	02					02			
glyphosate 690	5	05					05			
triclopyr	6	00		00						
imazapyr	5	02	02							
Post-planting										
dicamba	5	88		88						
paraguat	7	88		88						
paraquat + diquat	7	87		87	87	02		92		
metalochlor	5	87		87	95					
pendimethalin	5	87	00	87	87					
trifluralin	5	87		87						
MSMA	7	87					87			
sethoxydim sodium	5	87					87			
fluazifop-p	6	90					90			
haloxyfop-r	6	90					90			
pyrithiobac-sodium	5	97					97			
butroxydim	6	98					98			
norfluazon	0	98		98						
propaquizafop	5	99					99			
s-metalochlor	5	99		99	99	02	02			
clethodim	5	00					00			
halosulfuron-methyl	5	01					01			
carfentrazone-ethyl	6	02		02						
oxyfluorfen	5	02		02						
2,4 D Amine	5	02		02						
chlorthal dimethyl	5	02				02			02	
metachlor		02		02	02	02	02			
fluroxypyr	5	04		04						
triclopyr	6	04		04						
trifloxysulfuron sodium	0	04					04			
glufosinate-ammonium	5	06					06			
bromoxynil	6	07		07						
flumioxazin	7	07		07			07			
Defoliants										
dimethipin	6	87						87		
endothal	6	87						87		
ethepon	6	87						87		
alcohol ethoxylate	0	87						87		02
sodium chlorate	0	87						87		
thidiazuron	0	87						87		
magnesium chlorate	0	96						96\99		99
thidiazuron + diuron	0	98						98		
ethephon + cyclanilide	6	01						01		
diquat	6	01						01		
cetyl-oleyl alcohol	0	02						02		
ethephon+AMADS	6	02						02		

Table: 5.3 Summary of fungicides registered for use in cotton production with Poison Schedule, Year of Registration for use, and, where applicable, Year Withdrawn from registration

Fungicide	Year IN	Alternaria	Rhizoctonia	Pythium	Phytofthora	Fusarium	Year OUT
mancozeb	87	87					
quintozene	89		89				
toloclofos-methyl	96		96				
metalaxly-m	89			89	89		
azoxystrobin + metalaxly-m + fludioxonil	05		05	05			
metalaxyl-m	98					98	

The computer-based cotton IPM modelling program, SIRATAC, was introduced and in use from 1983. This provided information that recommended pest threshold levels and guided chemical use to industry, with feedback to researchers. Use of this system reportedly reduced numbers of pesticide applications. Funding was not available for SIRATAC™ from 1987 and was superseded by a personal computer based program entomoLOGIC™. The industry then relied on growers and consultants keeping spray records and submitting these for analysis. This meant that there was a reduction in feedback to industry regarding integrated pest management and pesticides use. (As an aside, a concern was noted that *"consultants are not there now and not all keeping those type of electronic records"*). Each year since 1998, the Cotton Research and Development Corporation (CRDC) has commissioned Cotton Consultants Australia Inc. (CCA) to survey their members and prepare a report on the performance of Bt cotton in Australia.

Introduction of less toxic and target-specific insecticides in the recent years (Table 5.1), has improved pest control and numbers of sprays, in particular those targeting mirids. Mirids *(Creontiades dilutus)* were considered a minor pest in conventionally grown cotton, but become a major pest in Bt cotton where *Helicoverpa spp* are not sprayed. In 2001/2002 the insecticides spinosad, indoxacarb and emamectin that are target-specific, were available together, making control more effective and reducing the number if spays required for their control.

Figure 5.4 indicates the total insecticide application rates for all target pests for conventional cotton from 1993/94 to 2006/07 seasons derived from CCA collated data. It can be seen that application rates on a total grams of active ingredient per hectare basis was very high in the late 1990's and early 2000's for conventional cotton, associated with high pest loads in those years.

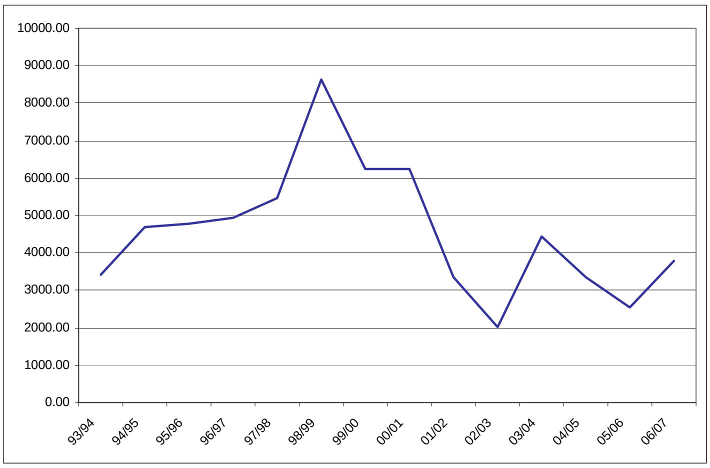


Figure 5.4: Total insecticides application rates conventional crop - . g.ai/ha

Clearly, the reduction in number of pesticide sprays as a result of more effective regimes and use of less toxic chemicals, has contributed to the very low numbers of pesticide-related human poisoning events in the industry since the early 1990s.

Formulation of pesticide products

The formulation of pesticide products has played a role in reducing exposure risk. For example, ***granular formulations of pesticides*** are considered to be much safer in terms of risk of exposure for all informants.

Pesticides handling systems

> *"Improved safety started with AVCARE then ChemCert™ and MFS- Managing Farm Safety™. Chemical handling has improved. We've gone to closed transfer systems – now also better knowledge of spraying technology and systems – still haven't sorted out a good metering systems for mini bulk, have moved a little back to 20 l drums.*
>
> *All filling is now done at ground level - no lifting of drums; and we've reduced ergonomic injury*
>
> *Cotton BMP helped with legal obligations: chemical storage; fuel storage; signage; tank designs"*

There have been significant developments in pesticides handling systems that have improved occupational health and safety associated with pesticides applications.

In the early 1990s, the move from smaller containers to ***shuttles and mini-bulk containers*** associated with ***hoists*** for the backs of utilities, led to improved ease of handling and reduced risk of manual handling injury. ***Closed transfer systems*** such as the Temik™ closed systems; mixing chemicals using metering systems on mixing trailers; and accurate Jen-ell™ type systems and venturi apparatus to mix and transfer liquids; were all cited as major improvements for reducing splash and dust exposure, and safer handling.

Early aerial spraying of pesticides was associated with poorly controlled exposure risk for operators and bystanders. The Aerial Agricultural Association of Australia (AAAA) had been formed in 1958 to "promote a sustainable aerial agricultural industry based on the professionalism of operators, pilots and staff and the pursuit of industry best practice." ***Operation Spraysafe*** was initiated in early 1985 and published a "Pilots and Operators Manual". The manual provides the agricultural pilot with the required guidance necessary for them to avoid off-target contamination and a detailed knowledge of the chemicals in use and their effect on the environment. Operators, pilots and mixers/loaders are accredited through this program. The program has been reviewed and continues to maintain standards of best practice for aerial application of pesticides.

This program markedly improved protection from pesticide exposure safety for these operators and for field markers and bystanders to cotton fields being sprayed. Additionally, it supported improvements in airstrip, mixing and loading facilities, including quick attachments/ lock on Camlock fittings.

More recently however, introduction of ***improved ground spray rig technology*** is seeing aerial application replaced by ground spraying. Spray rigs with wide boom sprays powered with the current more powerful tractors and stand alone spray coupes with wide boom sprays, have made ground spraying a more economical and safe alternative.

Cotton Best Management Practice (BMP) for Pesticides management

> *"We always had an ethic of respecting the hazards of chemicals in agriculture. We were increasing use of PPE. Prior to BMP we had pre-season meetings with aerial operators. If chippers, irrigators and bug checkers were in fields – then no spraying. We had signs that fields had been sprayed, 48 hr no return period/ no re-entry periods. In time BMP processes formalised the system"*

The BMP program is a program of Cotton Australia that *"provides cotton growers with a farm management system where pesticide use is kept to a minimum, weeds and diseases are well controlled, water use efficiency is maximised, soil health is improved, native plants and animals are protected, and riparian areas are valued"* (Cotton Australia website 2008). It was introduced as a self-help program in the late 1990s and includes "*safe chemical and fuel storage and handling, tail water recycling, stubble retention to improve soil health, reduce erosion and retain soil moisture and nutrients, GPS technology and weather monitoring equipment to apply pesticides accurately and monitor conditions and use of irrigation scheduling and monitoring tools to only apply what the crop needs, to reduce run-off and deep drainage"*.

There is no question that the BMP program, while focussing on positive environmental outcomes, has also played a key role in improving safety of workers and bystanders to spraying operations. In 2004 Cotton Australia reported that *"more than 50% of the cotton crop in Australia was grown on farms practicing BMP. This program has become known to people both within and outside the industry as* *playing a crucial role in improving the way cotton is grown, particularly with regard to the environment".*

Other developments in pesticides safety

Other developments during the years of cotton production in Australia have contributed significantly to pesticides safety for workers and bystanders to spraying activity. Key among these are the ***regulatory arrangements*** that have increasingly focussed attention to exposure risk.

Supply of pesticides into the industry has been governed by the Agricultural and Veterinary Medicines Acts and Regulations at Federal Government level (and previously by states' pesticides laws). The Australian Pesticides and Veterinary Medicines Authority (APVMA) administers these regulations and has increasingly moved to restrict and remove chemicals that were demonstrated to expose users and bystanders to harmful exposure. Significant moves such as establishment of re-entry periods resulted in reduced field exposure for chippers and insect scouts, agronomists, irrigators and farm workers. "Control of Use" legislation in each state sets standards for safe use of pesticides, and in NSW, the Pesticides Act 1999 requires all users of pesticides used in agricultural production to be trained to specified standards to ensure safety of humans and environment.

In summary

Over many years, pesticides use in Australia has been controlled to protect the safety of handlers, bystanders and consumers, by a combination of government regulation and industry self-regulation. The number of pesticide poisoning events has been very small compared to the volumes and frequency of pesticides applications in the cotton industry. More recent moves to effectively control pests have reportedly enhanced the safety performance for many cotton enterprises.

5.5 Cotton harvest technology

The whole process of cotton harvest has been associated with a wide range of risks to human health. In the past, injury was often due to being caught up in machinery, associated with earlier poorly designed mechanical systems, but injury risk was also high as a result of high traffic at the interfaces of picking, module building and carting of harvested cotton.

Cotton picker technology

Before the mid 1980s cotton picking was undertaken using single then 2-row pickers. One informant reported that typically *"operators worked 2 - 3 weeks up to 28 days without a break or a weekend off. One weekend off per month was the norm during picking in the late 1970s. We were working on average 3 hours per day longer than today. We would start at 7.00 am, enter paddock 10.00 am, depending on dew, take no break, eat on the run and finish 10.00 pm or later, depending on dew. We had night service crews for pickers".*

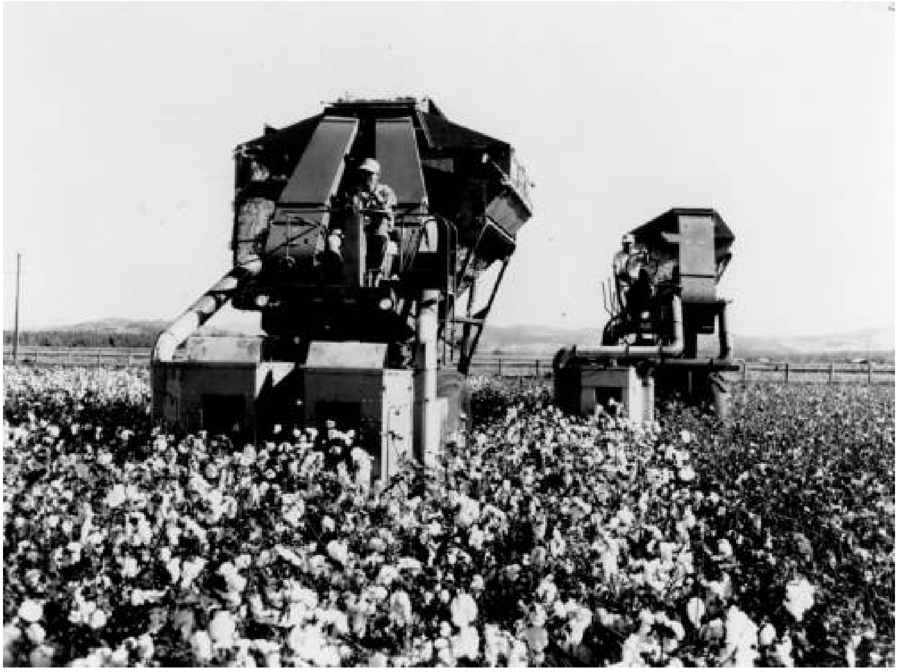


Figure 5.5: 1968 cotton harvest - 2-row and single-row un-cabined cotton pickers. Photo courtesy Cotton Australia website

In 1986-87 cotton pickers developed to ***4-row pickers***. This more than doubled the acres harvested per man per day and resulted in reduced fatigue. "*We went from 10 – 15 ac per picker per day to now 5-60 ac per day per picker".* In 1996, ***on-board greasing systems*** (central and self- greasing heads) in new pickers were introduced, reducing the risks associated with manual in-field maintenance and greasing.

A few years later new pickers were designed, with side-dumping delivery systems into in-field boll-buggies (Figure 5.6).

Figure 5.6: Emptying modern picker. Photo courtesy Cotton Australia website

Modern pickers are described by informants as having the following features:
- *"Comfortable seats*
- *Good monitors, less door blocks, don't have to get under pickers as often*
- *Reversible heads to unblock spindles, no kicking through spindle blocks*
- *Reduced fatigue*
- *Reduced risk of fire and less fires*
- *Reduced injury associated with greasing of heads*
- *Reduced risk of injury from picker basket ram collapse*
- *Reduced entanglement in head drives*
- *Reduced chokes at night, no night-service crews required*
- *Separation of module building from picking"*

The most recent developments have potential to further enhance safety by incorporating module building into the pickers themselves – ***round and square bale pickers***. This process will *"eliminate module builders, boll buggies, chain beds, infield loaders, truck drivers getting bogged, trucks rolling into channels, truck traffic, road dust, will pick up square, round bales with fork lifts, increase picking efficiency, reduced labour and labour costs"*.

Module building technology

> *"It was scary, you would pull up and there would be people crawling all over, under and on top of pickers, where were they?" ("Mind you- people were super-fit from all that stomping"!)*

The introduction of ***module builders*** in around 1979 greatly improved safety at that stage by reducing the number of people who worked in stomping and carting cotton. The stomping crew became the module-building crew and the number of personal injuries was greatly reduced. However, risks in these new systems still included falls and other risks were substituted including crush injury from hydraulic rams, doors and wheels, noise injury and asphyxia within the module. In 1989 introduction of ***boll buggies*** to cope with increased yield and increase picking efficiency, meant that cotton was now not dumped directly into builders, another step that increased safety.

Tarping of modules has been associated with falls and to a lesser extent, spear injury.

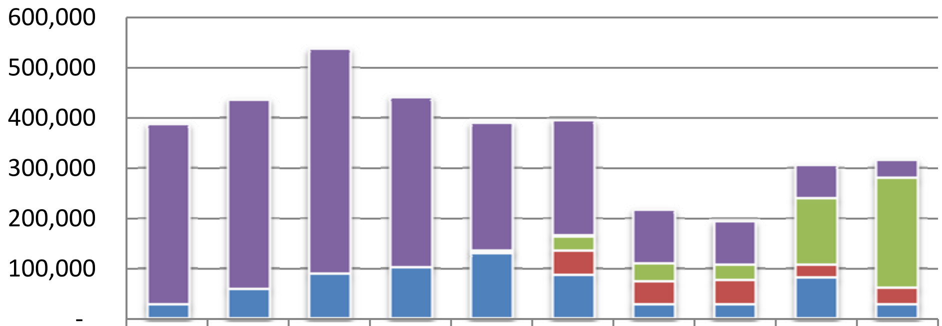
The introduction of ***automated module builders*** in 2002 reduced the number of people in picking crews, with subsequent reduction in total OHS risk. However, as the module driver is now not on the seat, knowing where this worker is located at any time can increase risk. While there are some guard rails to prevent falls, falls risk from module builders is still an issue.

Round bale pickers (John Deere) and ***square bale pickers*** (Case IH), trialled in 2008, "*will remove module builders and constitute the next revolution in removing traffic from picking, increasing picking safety"*.

5.6 GM technology

Background

Bt cotton varieties that carry genes that confer resistance to economically significant pests *Helicoverpa punctigera* and *H. armigera* have been available to cotton growers in New South Wales and Queensland since the introduction of Ingard® cotton, carrying a single Bt-gene in 1995-96 and its replacement in 2003-04 by Bollgard® II that carries two Bt genes. There has been a high degree of adoption of genetically modified cotton. Figure 5.7 indicates the relative proportion of Australian cotton plantings that were conventional varieties or genetically modified varieties, Bt indicating one or both of Ingard®, Bollgard®II, Roundup Ready Flex® varieties, RR indicating cotton with Roundup Ready® genes and Flex indicating the twin Bt genes. In 2006 there was also the release of four Liberty Link® cotton varieties in Australia that are resistant to glufosinate-ammonium herbicide.



	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Conventional (ha)	358,8	376,2	448,2	339,3	255,1	230,2	108,0	86,50	65,94	35,75
Stacked Bt/RR (ha)	-	-	-	-	-	28,28	35,28	29,47	131,8	217,7
RR Alone (ha)	-	-	-	-	4,115	48,48	46,30	49,12	25,12	32,50
Bt Alone (ha)	28,36	60,36	89,46	102,8	130,9	88,14	28,06	28,58	82,78	29,54

Figure 5.7: Total area of the Australian cotton crop planted to conventional, Bt and RR cotton varieties.
Source: Data provided by Bruce Pyke, CRDC, based CRDC, CCA and Monsanto provided data.

Other studies have reported on the effectiveness of introducing Bt cotton varieties in reducing the number of pesticide sprays and volume of pesticides applied.

Each year since 1998 the Cotton Research and Development Corporation (CRDC) has commissioned Cotton Consultants Australia Inc. (CCA) to survey their members and prepare a report on the performance of Bt cotton in Australia. A report by Pyke (In press) demonstrated a reduction in pesticide use in Bt cotton crops compared to conventional cotton crops for the period 2003/ 04 to 2005/06. Figure 5.8 indicates reduction in number of sprays in Bt cotton fields by comparing “frequency distributions (expressed as the percentage of paired fields of conventional and Bollgard®II cotton that received a specified number of sprays) for the seasons 2003/04, 2004/05 and 2005/06 combined”.

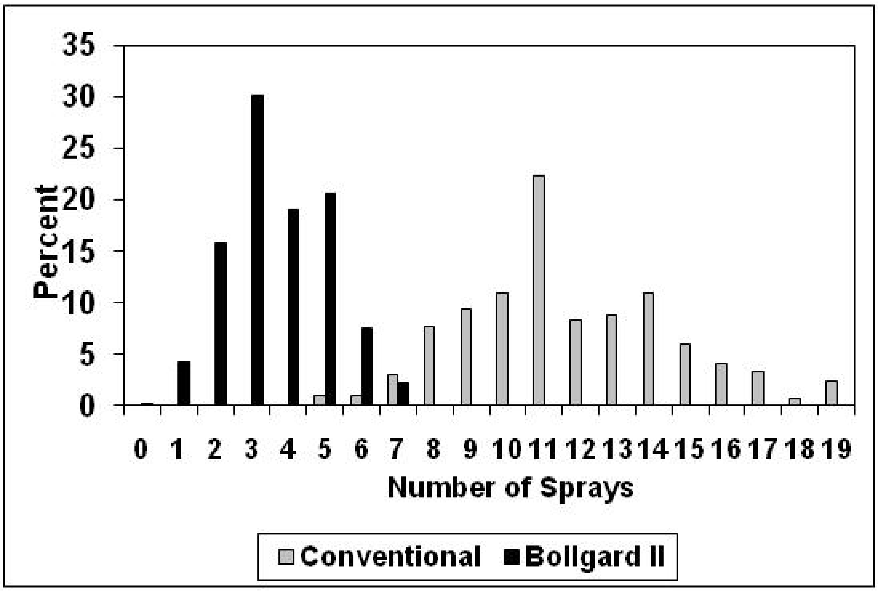


Figure 5.8: Frequency distribution, expressed as the percentage of conventional and Bollgard®II cotton fields that received a specified number of sprays, in Australia for the seasons 2003/04, 2004/05 and 2005/06 combined. Source (Pyke, In press) - used with permission

Knox et al (2006) has demonstrated environmental benefits of Bt cotton over conventional cotton using the environmental impact quotient (EIQ). Results of the EI *evaluation indicate that, due to changes in insecticidal choice and reduction in usage, there was a* reduction of >64% in EI from growing Bt cotton compared with conventional non-GM cotton in Australia.

Pyke (In press) has further reported that, while *"the changes in pest management in Australian cotton since Bollgard®II replaced Ingard® in 2004 have been significant. Bollgard®II cotton requires less chemical spraying and while many cotton growers choose to plant it because of this benefit, they increasingly consider lifestyle benefits and improvements to worker safety as important reasons to plant it*".

Table 5.4 is reproduced from that report (Pyke, In press) and demonstrates the wider management benefits that cotton growers have experienced with the introduction of the genetically modified cotton varieties. These include perceived occupational health and safety management benefits.

Table 5.4: Percent of Australian cotton growers reporting major benefit and reason for growing Bt cotton

Season	*No. responses*	*Environmental benefits*	*Insect management benefits*	*Lifestyle, OHS benefits*	*Economic & yield benefits*
1998/99	125	80%	10%	10%	0
2001/02	173	27%	28%	17%	28%
2005/06	121	24%	18%	36%	22%

Source Pyke (In press). Used with permission

Of interest is the changing response over the three reporting years, with lifestyle and OHS benefits being the most common benefit reported in the third year of reporting.

Pesticides use related to Bt cotton

Data collected Australia-wide by the CCA has been used to assess pesticide use in conventional and Bt cotton crops. This data was provided by the CRDC. The method of collection was described by Doyle and Coleman (2006) and analysis of insecticide application data is described by Knox et al (2006) as follows:

> "Annual data on area, type of cotton planted, and spray applications are surveyed and compiled by Cotton Consultants Australia Inc. (CCA) for all Australian cotton regions (Doyle et al, 2004).
>
> Between 1998 and 2004 the proportion of the area covered by the CCA survey varied between 52 and 76% of the total Australian cotton-cropping area. The chemical applications from these surveys were weighted for each production area for each season using the official values for the planted area of cotton in each region, compiled by the Australian Cotton Industry Council (Doyle, 2004). After these adjustments, the data for dryland and irrigated cotton for each cotton-growing region and season were pooled to reflect seasonal insecticidal application rates per hectare of conventional, INGARD® and Bollgard® II cotton for the entire Australian crop.
>
> Seasonal insecticide use estimates were then used to calculate the amount of insecticide (kg ai/ha) used for each product and listed in the CCA dataset. The quantity of active ingredient (ai) per L or kg was obtained from either the label information or the manufacturer." (Doyle et al, 2004).

Figure 5.4 (see above Section 5.4) indicated the total insecticide application rates for conventional cotton from 1993/94 to 2006/07 seasons. Figure 5.9 shows the significant difference in rates of insecticide use in Bollgard®II crops on a g ai/ha basis.

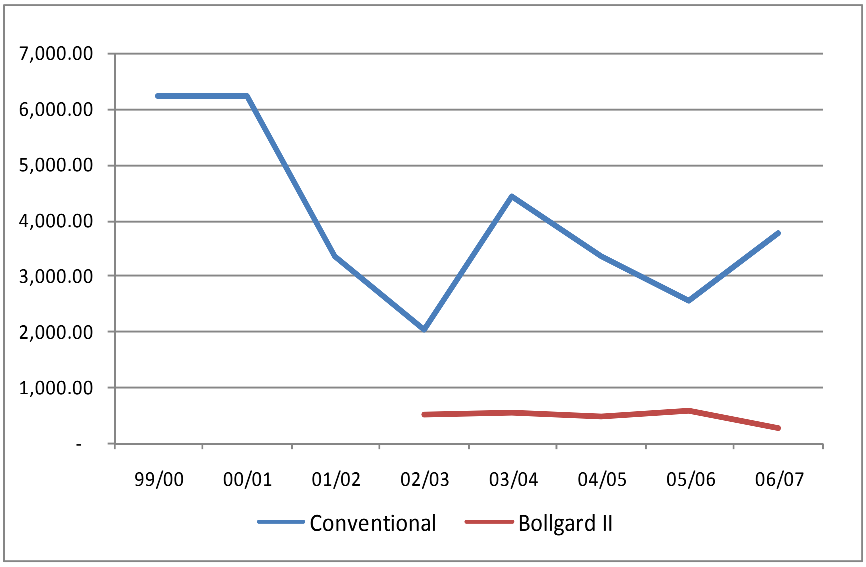


Figure 5.9: Total insecticides application rates conventional crop and Bollgard®II crop (g ai/ha)

Such a reduction in overall insecticide use associated with GM cotton represents a clear health and safety benefit as exposure to pesticides by workers and bystanders would be significantly reduced. However, an important question relates to whether the reduction has changed the profile of pesticides being used in the GM cotton crops. Not all insecticides have equal human safety risk, so it is important that application rates for the more toxic chemicals be examined. Each of the insecticides used in conventional and Bollgard®II crops was assigned to a toxicity category, crudely based on mammalian LD_{50}, and dermal LD_{50}. Figure 5.10 indicates the relative percentage of toxic insecticides used based on application rates (g ai/ha) for conventional and Bt crops.

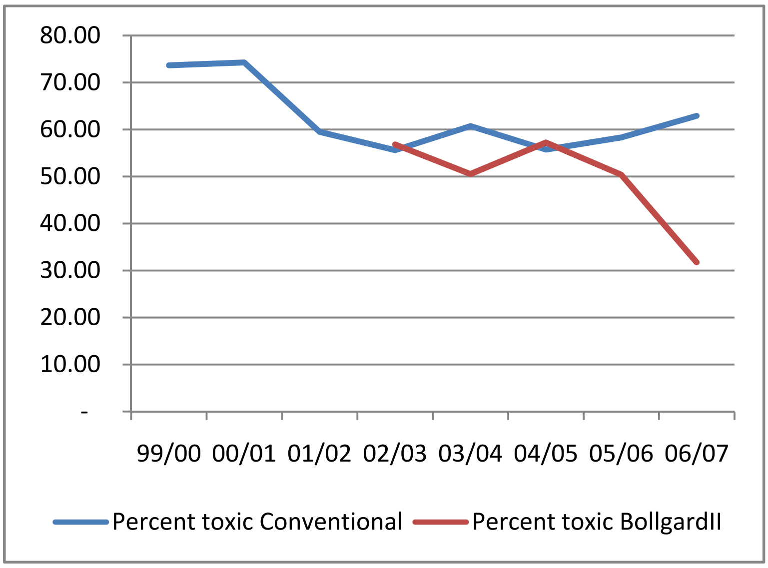


Figure 5.10: Percent of insecticides applied in high toxicity category - conventional and Bollgard®II crops

This preliminary analysis is thus demonstrating that, not only has Bollgard®II resulted in less total insecticide application rates, it may well be that the proportion of more toxic chemicals used is reduced. Data for subsequent seasons should be analysed to determine whether such a pattern is sustained.

Figure 5.11 demonstrates the reduction in number of complaints by community members relating to pesticides made to, and investigated by the NSW Department of Environment. The reduction in 2001/02 and 2002.03 is significant and almost certainly related to the reduction in sprays required in GM cotton.

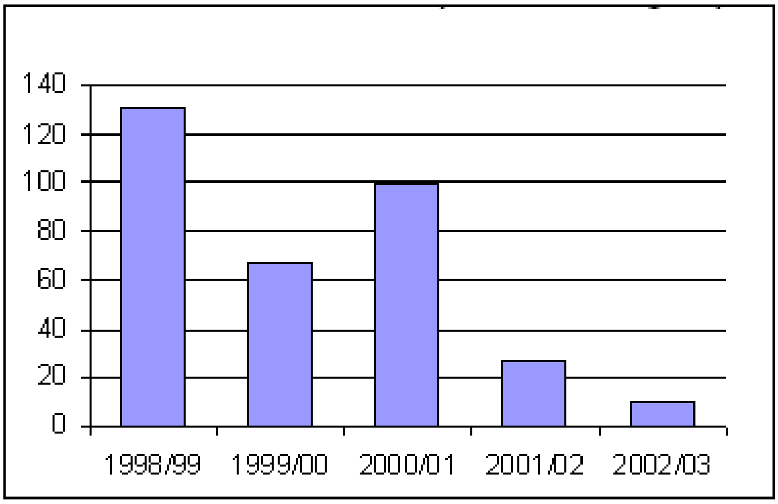


Figure 5.11 : Total number of cotton-related complaints to NSW EPA – North-west NSW Region
Source: B Pyke, used with permission

Other impacts of safety associated with GM cotton

While the effect of GM cotton on potential exposure to pesticides by workers and bystanders is of clear benefit, there are other significant positive impacts on a range of safety hazards that have been reported by key informants. These benefits are substantial, in that they affect the injury risks that have been demonstrated as high risk in workers' compensation claims and companies OHS performance profiles. Positive benefits include:

1. Reduced vehicle movement associated with reduced in-field activity such as crop-checking
2. Reduced vehicle movement in field due to reduced chipper need associated with Roundup Ready® varieties
3. Reduction in use of ATVs and other vehicles for marking associated with reduced need for aerial pesticide application
4. Reduced use of tractor and machinery operation associated with RR cotton and change to minimum till (sometimes a "one pass' operation)
5. Reduced use of spray rigs associated with fewer pesticide sprays
6. Total reduction in aircraft death and injury associated with fewer sprays
7. Reduced chipper injury caused by manual weeding associated with RR cotton
8. Reduced risk of aircraft contact with overhead powerlines associated with fewer sprays
9. Reduced exposure to fuel hazards – aviation, vehicle and machinery, associated with fewer sprays and less vehicle movement
10. Reduced exposure to insect hazards due to reduced in-field work
11. Reduced exposure to solar radiation hazard due to reduced in-field work
12. Reduced exposure to plant hazards – saps etc due to reduced in-field work
13. Reduced exposure to slips, trips and falls associated with less in-field work
14. Reduced stress associated with night work associated with reduced in-field ground preparation, RR cotton
15. Reduced management stress and anxiety about with spray failures, insect resistance associated with Bt cotton

When these benefits are compared with injuries associated with presentation to hospitals and workers' compensation claims, the benefits of such developments are clear.

Potential adverse health effects of GM cotton

Genetically modified cotton has undergone extensive review by the Office of Gene Technology before permitting its commercial introduction into Australia. That review has included review of potential human health impacts. This report has not duplicated those reviews and assumes that the plant or its products, does not pose risk to human health. Since the introduction of GM cotton, there have been no reports of adverse effects of the plants to workers or others associated with farm cotton production.

In summary

The incidence of pesticides poisoning associated with cotton production prior to the introduction of GM cotton was low primarily because of community standards and the regulatory arrangements within which cotton is produced in Australia, along with the attention given to reducing exposure risk by the cotton industry. This was is in contrast to such countries as China, India and South Africa, where introduction of Bt cotton has been demonstrated to reduce the actual incidence of ill health associated with exposure to pesticides (Hossain, 2004; Bennett, Morse and Ismael, 2006).

Notwithstanding this position, the introduction of GM cotton is associated with significant health and safety benefit relating to reduced exposure to pesticides, and reduction in worker exposures to mechanical and traffic hazards of previously high risk.

5.7 Adoption of OHS management systems

An industry strategy for development of industry-specific safety management tools for cotton enterprises was established in the late 1990s funded by the Cotton Research and Development Corporation. Cotton production guidelines for identification of safety hazards, risk assessment and risk control planning, for safety induction of workers and contractors were produced (*Managing Cotton Production Safety)* and made available directly to producers on the Farmsafe Australia website www.farmsafe.org.au, or in hard copy from the Australian Centre for Agricultural Health and Safety.

A 2-day training course – ***Managing Cotton Farm Safety™*** was introduced in 2001 and by 2005, 407 participants from cotton farms in NSW and 72 in Queensland had participated. Other larger cotton production enterprises had contracted **commercial safety services** to guide development of their safety programs.

In NSW, uptake of Managing Cotton Farm Safety™ courses and implementation of safety programs on cotton farms was progressed by 130 cotton farm enterprises through their participation in the Premium Discount Scheme – a 3-year program whereby a discount was provided by WorkCover NSW on Workers' Compensation Insurance premiums to participating small businesses that met certain criteria each year. These included participation in the training program and adoption of safety management systems in their business. The evaluation report demonstrated that significant changes had been made by participating farms. A number of the NSW key informants for this study made comment on the changes brought about that improved safety as a result of these programs. While most producers had been motivated to participate in the program by the availability of a discount, it is interesting to note that the reported motivation for making the safety changes on farm were:

- Because we had identified the high risk hazards (51%)
- Because of concern for not meeting regulatory requirements (24%)
- Because it is good farm safety practice (19%), and
- Because we were provided with practical guidelines to show us how to do it (4%).

5.8 Government regulation

Meeting the requirements of state governments' ***Occupational Health and Safety Acts*** and associated ***Regulations*** has been a significant driver of change for safety for many cotton production enterprises, as farmers and managers have become aware of their obligations. The States' OHS Acts were introduced in the early 1980s and while some amendments have been made more recently, the obligations of employers to maintain a safe workplace and the regulations that provide guidance have remained largely since that period. Unlike some western countries, agricultural businesses in Australian states are not exempt from the provisions of the OHS laws; however, it has not been until the late 1990s that most farmers, including many cotton producers, have understood the obligations that they have to protect the safety of their workforce, including contractors.

Pesticides safety on farms is regulated by the Hazardous Substances Regulations under the states' OHS Acts, and by "Control of Use" Acts (in NSW the ***Pesticides Act*** 1999). These generally require that label directions are complied with, including the safety directions. In NSW, training in the use of pesticides has been compulsory for pesticide applicators, including farmers under the Pesticides Regulation of the NSW Pesticides Act 1999. Applicators are required to achieve and maintain a specific level of competency in pesticide use. In most cases the training involves a two-day course, based on the National Rural Production and Amenity Horticulture Training Packages. Compliance by NSW farmers with this requirement is generally regarded to be high, as a high proportion of farmers had completed the ChemCert ™ 2- day training course, or similar, on a voluntary basis before the Regulation came into force.

A survey of participants in a longitudinal study of the Australian Centre for Agricultural Health and Safety found that that the most commonly reported driver for safety changes made on NSW farms in the previous year, including cotton farms, was to meet regulatory requirements (Pollock, 2008).

There is evidence then, that compliance with Government regulations is a key driver for change on cotton farms, certainly in NSW, and most likely in Queensland.

6. Discussion

Lack of a single, long-term dataset with records of cotton farm work-related injury and ill-health has severely limited the ability of this study to demonstrate unequivocally changes in rates of injury and poisoning events associated with modifications in cotton production in Australia. Notwithstanding the lack of injury data, we can be confident that major changes made over the course of time have significantly reduced the risk of work-related injury and poisoning associated with cotton production, and have reduced community anxiety over risks to bystanders and others associated with exposure to pesticides.

Figure 6.1 is a visual representation of the occupational health and safety industry risks associated with key hazards in five decades of cotton production in Australia, with impact of key changes impacting on safety. The picture generally tells a 'good news story" over this extended period - a story told by experienced key informants and by the available data.

This study has taken a hazard-based examination of changes over five decades of cotton production in Australia, and has demonstrated that the following changes have had significant impact on health and safety risk:

1. Vehicle and on-farm traffic systems
2. Irrigation systems
3. Cultivation technology
4. Pesticides and pesticides application technology
5. Harvest technology
6. GM technology
7. Adoption of OHS management systems
8. Government regulation

These changes have had positive effects on mechanical, chemical, ergonomic and environmental safety hazards by **acting at a high level in the *'hierarchy of effectiveness of prevention'*** – i.e. by eliminating hazards altogether, by substituting for hazards of less risk, or by improved design of system to reduce exposure to risk. The 'hierarchy of control' is the well established principle of injury prevention, including prevention of poisoning, and has been incorporated into Australian states' OHS regulations. Regulations require the following for the control of hazards posing safety risks:

1. The hazard posing risk must be ***eliminated*** from the workplace. Only if it is **not possible** or practicable to eliminate the hazard, then:
2. The hazard must be ***substituted for a hazard of lesser risk***;
3. If that is not possible then an ***engineering solution*** must be put in place to reduce risk to workers and bystanders. This will often require guarding to isolate workers from exposed moving parts, or other hazard, but also includes changed designs to systems, rollover protection structures etc .
4. Lower order controls include attention to ***workplace rules*** for undertaking certain jobs, training, allocation of labour, supervision, etc, and use ***of personal protective equipment*** (PPE) to protect from exposure to physical, noise, radiation and chemical risks.

The lower order controls are also much more resource intensive to maintain over time, as they require continuous attention to supervision, training, monitoring and provision of PPE.

EXAMPLE: Consider the risks associated with insecticides application to control key insect and related pests in cotton production. Early and ongoing efforts have been directed to use of *lower-order controls* to reduce risk of exposure to hazardous chemicals for applicators – mixers/loaders/pilots; to infield workers - markers/ chippers/crop-checkers/ agronomists; to bystanders and communities. This has consumed large individual farm resources, industry R&D resources; government resources and local community resources, and resources are still being used to remove unused chemicals. During the 1990s and 2000s, moves mostly by government regulatory action, have removed certain high risk insecticides from use, and newer chemistry has also provided less toxic alternatives to the older chemicals of high risk. These *substitution* alternatives have been ongoing, but have worked only slowly to reduce risk. The introduction of GM cotton, however, has had a much greater impact by *eliminating a high number of insecticide spray applications* needed, and combined with use of newer lower-risk target-specific chemicals has greatly reduced risk as well as the business resources required to manage that risk.

A similar story relates to changes to vehicle and traffic systems, which have not only reduced risk, but have reduced the resources allocated to control of those risks.

The review has also demonstrated the ***interdependency*** between technologies that is producing higher levels of positive impact than would have been effected by each alone. For example, the clear insecticide reduction advantage of Bollgard II® has been greatly enhanced by the developments in chemistry directed to specific pests without adversely affecting beneficial insects. The introduction of Roundup Ready® and Roundup Ready Flex® cotton has had a direct impact on reducing cotton chipping work that is physically risky, but its impact on safety has been enhanced by the changes made in ground preparation and pesticide spray application technology.

There is also a ***convergence of changes*** that are resulting in management of safety and health in the industry becoming much more straightforward and effective. Informants have uniformly reported on the reduced stress associated with production now, compared to just a few years previously.

> *"I was becoming ashamed of being a cotton grower – the ongoing conflict between farmers, especially graziers and cotton growers" (worse than being in conflict with non farmers). I now have a better quality of life. I Used to work 24 hrs per day, poor sleep, even when socialising couldn't escape from work - ground rigs and tractors were working 24 hrs ".*
>
> *"I was on guard all the time, always chasing agronomists. I'm now not working 24 hrs- I can go out and enjoy, not thinking about work."*

A further recent factor relates to improved farm communication systems – *"All workers have a mobile phone – helps safety". "All men have phones – we're always in contact". "This is a great step forward, increased ease managing men, peace of mind, they're OK, better timeliness."*

The innovations have not been without some downside. Most of the changes have resulted in a greatly reduced need for labour. While this has reduced the employment opportunities for local communities, it has also come at a time when actually getting labour has become more difficult. The outcome is this that fewer, more skilled workers are required by the industry, and attention is required to create career paths and skills development for these future workers.

There remains a need to be vigilant about safety as new technology and systems are introduced. The last two decades has seen the introduction of quad bikes - small machines that make getting around the farm easy. However, these machines pose risk of rollover and risk of serious crush injury to the operator in such an event. Controlling for this risk requires engineering controls, training, ongoing supervision and rules for riders. Until a rollover protection system is available, then cotton growers should be considering safer options.

Figure 6.1: Summary of occupational health and safety industry risks associated with key hazards in 5 decades of cotton production in Australia, with impact of key changes impacting on safety

Colour code

- High risk, not effectively managed
- High risk, being managed to some degree
- Hazard of high risk eliminated or well managed
- Innovations will reduce risk to a significant degree

Hazard Type	1960-1970	1970-1980	1980-1990	1990-2000	2000-2008
Mechanical hazards					
Vehicles					
Trucks					Rollover tarps reducing falls
Utilities, other vehicles			4WD station wagons	Dual cabs Improved farm layout	Speed restrictions Driver training Reduced trafiic due to: - Telemetry to check irrigation - Less checking with GM cotton
ATVs			ATVs introduced for checking, marking		Switch to alternative transport Reduction in field use associated with GM cotton Reduction in use due to GPS systems for aerial spraying
Aircraft					? Accident rate higher on hours flown basis
Mobile plant					
Tractors		ROPS	Air conditioned cabins, filter systems	Better seating	RR cotton changing to minimum till, requiring less use of tractors
		Cabined tractors	Increased tractor power Increased hydraulic power Tyre technology Quick-hitch systems	GPS guidance systems Autosteer tractors	
Tractor implements			Reduced draught and improved design - Orthman design cultivators		
Spray rigs			Self-propelled spary coupes		Reduced use associated with GM cotton
Cotton pickers				Increased size, and basket capacity, reduced man hours Improved design picker heads Improved service safety	
Module builders			Introduced 1978		Introduction of automated builders Introduction of self-baling pickers
Fixed plant					
Pumps				Guarding systems	Irrigation telemetry systems
Powered tools and equipment					
Workshop tools				Improved guarding	
Hand tools					
Hoes					Reduced chipping due to RR cotton
Electrical hazards					
Power lines				Look up and live' campaigns Relocation of lines and laneways	
Power tools					Installation of RCDs
Chemical hazards					
Pesticides					
Herbicides	Arsenates	Substituted ureas Paraquat, diquat		Chemcert training	Mostly glyphosate in use Note: Potental increased use of Paraquat?
Insecticides	DDT	DDT Organophosphates Endosulfan	Organophosphates Carbamates	Re-entry periods Improved pesticide Reduced useage due to IPM Chemcert training	GM cotton
Defoliants	OPs mixed with sodium chlorate resulted in fire and	DEF introduced, strong odour		Introduction of new chemistry	
Fertilisers					
Anhydrous ammonia				Cold-flow anhydrous ammonia Better pumps and transfer systems Operator training and accreditation	Better metering systems
Other fertilisers	Bag handling		Bulk handling systems		
Fuels					
Aviation fuels				Introduction gas-trubine aircraft reduced need for on-farm re-fuelling	Reduced useage due to GM cotton
Diesel, petrol, gases				Improvedstorage and handling	Reduced volume used due to GM cotton
Oxyacetylene					
Environmental hazards					
Particulates					
Fire/smoke			Pull, rake and burn stubble	Stalk pullers and mulchers	
Noise					
Tractors and mobile plant			Enclosed cabin systems		
Module builders					Noise remains a risk
Pumps					
Flying objects					
Trash					Introduction of self-baling pickers will phase out module builders
Insects					Reduced chipping and field activity due to GM cotton
Radiation					
Solar radiation					Less in-field activity associated with GM cotton
Biological					
Vegetation – plant products					Reduction in chipping and exposure to plants with GM cotton
Traffic ways					
Lanes, banks			Redevelopment of existing irrigation and farm design Widening roads for 8 & 12m rigs	Road maintenance	Signage and speed restrictions
Access to public roads					
Outdoor surfaces					
Slips, trips and falls				Improved design of access to mobile plant	Reduction in workforce and outdoor activity associatd with GM cotton
Confined space					
Irrigation pipes/culverts				Trash racks	
Pump wells				Uptake OHS management	Remote lubrication systems
Distribution tanks				Uptake OHS management	Remote lubrication systems
Falls from heights hazards					
Structures					
Other buildings				Improved OHS management	
Fuel tanks				Improved OHS management	
Gas tanks				Improved OHS management	
Silos				Improved OHS management	Silo safety systems, improved design
Windmills				Improved OHS management	
Drowning hazards					
Trenches				Improved OHS management	
Channels				Improved OHS management	
Water storages				Improved OHS management	
Ergonomic hazards					
Handling syphons				Less frequent handling	
Using hoes					Reduced chipping associated with RR cotton
Handling bags of seed				Pallets and handling systems	
Operating tractors and plant			Air conditioned cabins, filter systems	Better seating GPS guidance systems	Autosteer tractors
Stress and anxiety hazards					
Long shifts					Shorter shifts, greater productivity Less stress
Work at night					Reduced night work associated with GM cotton
Insect/pest pressure					Less stress associated with spray failures, associated with GM cotton
Financial/ management pressure					

6. Summary of findings and recommendations

Lack of a single, long-term dataset with records of cotton farm work-related injury and ill-health has been noted as severely limiting this study to demonstrate changes in rates of injury and poisoning events associated with any key modifications in cotton production in Australia. However, the study has demonstrated the positive impact of a number of changes in reducing safety risk to those engaged in cotton production and those in close vicinity to areas where cotton is grown. Key positive safety impacts have been associated with:

- Vehicle and on-farm traffic systems
- Irrigation systems
- Cultivation technology
- Pesticides and pesticides application technology
- Harvest technology
- GM technology
- Adoption of OHS management systems
- Government regulation

While GM technology has had a highly significant impact, its effects are not so clearly demonstrated as in other countries where pesticides poisoning events were more common prior to introduction of the GM crops. However, the association of GM introductions with the range of other positive changes have greatly widened the range of safety benefits achieved.

The high costs of managing safety using ‘lower-order controls’ in terms of management, industry and government resources and time, have been well demonstrated for the cotton industry. The great benefits of introducting ‘higher-order’ controls in terms of reduced management input and reduced management stress, have been reported by informants and reports.

There are lessons and recommendations to be made from this review:

1. Management of safety risk using lower-order control methods is not only less effective in terms of reducing injury, it is also time and resource-intensive. Where possible, higher-order solutions should be sought and put in place. This will often involve modification of a number of interlinked systems, but when the cost of risk management is included in assessment of cost-benefit, it will often prove to be a valuable investment.
2. A number of hazards of high risk in the industry remain and must be managed. There would be benefit from collective activity for:
    a. Benchmarking OHS safety performance
    b. Entry level worker safety induction
    c. Setting of safety standards for contractors, and maintenance of a pool of contractors that meet those standards – cf AAAA accredited aerial operators
    d. Examination of hazards of high risk by a technical and safety reference group to identify solutions

3. Work-related injury and illness data is not available, but could be collected by the CCA during their annual reporting of pesticides and GM cotton data. Data could be readily collated by the Australian Centre for Agricultural Health and Safety on behalf of all growers.
5. Should insect resistance again become a major problem, there may be a loss of institutional memory about the safety effects of a high dependency on insecticides. Changes in pest management should take into account safety risks and their control in a formal and planned way. Contingency plans for maintenance of safety should be prepared.

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