

Cotton Outlook

Brisbane 2019



ICAC | 78th Plenary Meeting | Brisbane | Australia

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A sunburnt country

Mike Edwards, Editor, Cotton Outlook

ICAC's Plenary Meeting returns to Australia for the first time since 2000 at a time of frustration for the country's cotton farmers and general gloom in the international market. On current indications, Australia will this season produce the smallest cotton crop since 2007/08 and a fraction of the output attained only two seasons ago. During the past twelve months, world prices have succumbed to the negative effects of Sino-US trade tensions, falling consumption and the prospect of oversupply during the 2019/20 season.

As always, the purpose of our Plenary Special Edition is to shed light on the cotton sector in the host country, as well as touching on some themes of more global relevance. We are indebted to all our Australian authors for their valued contributions, each of which addresses a particular aspect of the industry.

It comes as little surprise that water and climate change are topics common to several articles. They also reflect, even at a time of falling production, a justified pride in the industry's achievements over recent decades and confidence in its future. The foundations for Australian cotton's success were laid at an early stage of the sector's development. Its pioneers had the prescience to initiate, via a levy per bale matched by the government, the strategic approach to research and development that is

without doubt the cornerstone of any successful modern cotton industry. The same research capability facilitated the early identification and adoption of environmentally sound production practices. Australia's pursuit of excellence has produced yields amongst the highest on the planet and fibre quality that commands a consistent premium in the international market.

These articles also sit within a broader context, characterised by the imperative to assert cotton's credentials as a sustainable commodity and thereby recover some of the market share lost to man-made fibres over the past half century or so. We therefore applaud the timely efforts of Cotton Incorporated and the ICAC itself to put cotton on the front foot in discussions of sustainability, debunking myths in favour of a fact-based approach.

The resilience of the Australian cotton farmer through periodic drought and market upheavals is well attested. And the broader cotton community's instinct to gather together, perhaps more than ever in difficult times, has always been strong, whatever the distance that must be travelled. That makes the 'sunburnt country' evoked by Dorothea Mackellar a fitting venue for the global cotton community to address the major challenges of the day in the unique forum of the ICAC Plenary.

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Australian cotton: success in a land of challenges

Michael Murray, General Manager, Cotton Australia

As the acclaimed Australian poet Dorothea Mackellar so vividly wrote in her poem 'My Country', Australia is, "a sunburnt country, A land of sweeping plains, Of ragged mountain ranges, Of droughts and flooding rains."

Those iconic words are woven into Australia's cultural fabric and fittingly describe our landscape and the challenges faced by those living down under.

The Australian cotton industry is largely located on the sorts of sweeping plains Mackellar described, and lives through periods of droughts and flooding rains.

It is often said that Australian farmers are among the toughest in the world. For those who choose to make a living by working the land, it can be both a rewarding and challenging experience. The tyranny of distance, access to services, fluctuating seasonal conditions and competing market forces can test our farmers; but producing high-quality fibre and food that clothes and feeds the world brings enormous satisfaction, and is often enough of an incentive for them to stay on the land.

Australian cotton farmers are also among the most passionate in the world, and this enthusiasm, coupled with an industry-wide spirit of innovation, entrepreneurship and a never-give-up attitude, has seen them survive the high-wire act of running successful businesses off the land and supporting their rural towns and communities. This is all done while receiving the second-lowest levels of subsidy support in the developed world.

When the Australian cotton industry began in earnest in the 1900s, the pioneers of the industry had the perseverance, grit and determination to make a go of it and build an industry that would be viable and successful. Those character traits have been passed down through the generations and remain strong among the nation's modern cotton growers.

When reflecting on the historical timeline of the Australian cotton industry, it is easy to chart the upward trajectory of the industry.

The growing of cotton in Australia began as early as 1857, when a small quantity of dryland cotton was

produced in Queensland. Small amounts of the crop continued to be grown over the following decades before a commercial crop was planted at Wee Waa in New South Wales in 1961, then in the Macquarie Valley in 1966 and Moree in 1976. Since those early days of the modern industry, annual national production has gone from an average in the hundred-thousands of bales to 1.1 million bales in 1985, before doubling to 2.2 million bales in 1992.

The industry has now evolved to comprise up to 1,400 cotton growers, although that number fluctuates depending on the season. Production figures have ebbed and flowed in recent times because of the availability of water, but reached a record 5.3 million bales in the 2011/12 season.

Those days of soaring yields contrast greatly with the current season, when, due to drought and the low availability of water, the industry is staring down the barrel of a sub-million-bale crop. Despite this, as we have seen before, and as Mackellar wrote in her poem, flooding rains will return one day, and the boom and bust cycle of Australia's bush will continue once more. It can be hard to remember that fact during times of drought, when baking heat and swirling dust storms suffocate hope for happier times; but our growers have an ingrained disposition of resilience, innovation and determination that will help see them through this current rough patch.

Given the nature of Australia's climate, where droughts can last for years before rain returns, how does the Australian cotton industry endure?

The modern Australian cotton industry has made considerable progress in recent decades, adapting to the challenges it faces to become one of the most advanced, innovative and efficient agricultural industries in the world.

It may be thought that Australian farmers are heavily subsidised to help keep them afloat in good times and bad. But the reality is the stark opposite. In 2017, the Organisation for Economic Co-operation and Development (OECD) released a report analysing subsidy levels in 52 countries. The study found Australian

farmers were ranked among the lowest in terms of a subsidy safety net, with the second-lowest levels of support in the developed world. Only New Zealand was ranked lower. Without a bevy of subsidies on offer, Australian farmers need to be efficient and resilient in order to keep their businesses alive.

Since water is such a precious resource for all irrigators, significant efforts have been made by Australian cotton growers to improve their water use efficiency and ensure that none of this valuable commodity is wasted. In the decade to 2013, the Australian cotton industry improved its water use efficiency by 40 percent, meaning that growers were producing more crop per drop of water than ever before. This innovation and commitment to improvement ensure our industry remains at the forefront of Australian agriculture and in a better position to cope with seasonal variability.

Public debate in recent times in Australia has raised the question of why cotton is grown in this country, particularly when the nation suffers through long droughts where water becomes scarce. Water regulation in Australia is complex to explain, but in simple terms, Australian irrigators must have a water licence. That licence entitles them to a share of the available water pool in any one year. Governments decide what water allocation is available to irrigators, only after water for critical human needs and the environment has been allocated.

The impact of this regulation means irrigators are the last to receive a water allocation, which therefore influences how much cotton is planted in a given season.

This confounds the inaccurate perception that the Australian cotton industry can take as much water as it likes, whenever it likes. Our industry does the best it can to survive while abiding by the regulatory framework that is in place. In striving to do their best, our growers rely on careful planning, the use of sophisticated forecasting technologies, and careful monitoring of conditions to ensure they grow a viable crop that will return them an income to support their families and communities.

Australia's cotton growers also draw upon the knowledge within the industry to ensure continuing improvement. With millions of dollars invested into research and development each year, the industry affords itself cutting-edge information on best practices and the ways to ensure long-term viability and sustainability. Coupled with this is the open-minded spirit of collaboration that is present in the industry, where growers are more than happy to share advice and information with each other, to see their fellow growers flourish.

Farming in Australia can certainly be a high-wire act. When the season is good, farmers are sky-high on their jet stream of success; but when the season is bad, they scramble to stay afloat.

Droughts will come and go across our big, brown land. While a lack of water is an ever-present concern for Australian cotton growers, the words of Dorothea Mackellar in 'My Country' can provide some comfort and hope, even on the dustiest of days: "But then the grey clouds gather, And we can bless again, The drumming of an army, The steady, soaking rain."





Horizons expanding for Australian cotton

Adam Kay, CEO, Cotton Australia

Australia's cotton industry is growing

For decades, cotton has been grown on the fertile soils and flat plains of central and southern Queensland, northern and central New South Wales, and more recently, southern New South Wales. And while our industry will continue to remain strong in these areas, there have been exciting developments over recent years, indicating Australian cotton's horizons are broadening into new growing regions.

Cotton is a water-efficient crop highly suited to Australia's climate. As a result of our rich vertisol soils, water supply, and warm temperatures, cotton has long been a strong performer and a crop of choice for irrigators in eastern Australia. Moreover, it is only grown when sufficient water is available, meaning it provides growers with flexibility during dry times.

The industry is strongly established across New South Wales and southern and central Queensland, with a network of growers, gins, merchants and other industry personnel working tirelessly to ensure that Australia remains a world-leading producer of high-quality, responsibly grown cotton that sets the standard for the world to follow. Our industry's reputation for innovation and for operating according to best practice has given us a strong launch pad from which to expand into new regions and grow cotton with optimism and determination to continue providing for our farming families and rural communities.

So, where is our industry looking to expand?

Given the conditions needed to grow cotton successfully, northern Australia is a big focus for us. With its flat landscape, plentiful water supply and tendency for days of warm sunshine, the north of the continent has our industry optimistic for a successful expansion.

Over the last year or so, cotton-growing trials have been under way at Katherine in the Northern Territory, Georgetown in Queensland, and Kununurra in Western Australia to assess if the industry could be

viably established in those areas. The initial results were successful and have helped grow our confidence that this could be the start of an exciting new chapter.

This would not be the first time that cotton has been grown in northern Western Australia. In the 1960s and early 1970s, the Ord River Scheme was shaping up as a hotbed for cotton production because of its abundant water supply and warm temperatures, ideal for cotton-growing. However, in 1973, hopes of a booming cotton industry in the region were dashed, mainly due to the development of insect resistance to pesticides. Fast-forward 46 years and cotton is reappearing in northern Western Australia through these exciting new trials, which will guide us in determining the viability of a deeper-rooted industry in the north.

I have had the pleasure of visiting some of the areas into which our industry is looking to expand, and I can report that the mood is buoyant. In April this year I attended a field day at Katherine in the Northern Territory, where I continued to build our industry's important relationship with the Northern Territory's Agriculture Minister, Paul Kirby. I observed the latest cotton trials under way at the Katherine Research Station, and I also heard from the manager of Tipperary Station, David Connolly, who spoke about diversification and the station's 60-hectare trial. In conjunction with the ongoing trials at Kununurra, the crops grown in the north have so far yielded positive results. It was exciting to hear the passion and interest of the growers conducting the trials, and to gain an understanding of the different challenges they face in the north of the continent.

The other aspect of our expansion which is important to discuss is the fact that we have some of our industry's brightest minds working towards ensuring any expansion is a success.

In 2018, Cotton Australia, together with the Cotton Research and Development Corporation, was proud to fund a Nuffield Scholarship for our industry. Luke McKay, from Kununurra, chose to research tropical cotton-

growing systems. He has since produced a valuable piece of research looking into all aspects of the system, including planting and decision processes, biosecurity, and best management practice considerations for northern Australia. As part of Luke's Nuffield Scholarship, he travelled to Brazil, Zambia, China and the USA, which enabled him to gain a strong insight into cotton-growing from those farming in similar conditions. Our industry is proud of Luke's work, and we look forward to continuing to use his findings as part of our careful expansion planning.

While there is a lot of excitement in the industry about potential expansion, we need to proceed carefully if our sector is going to grow successfully in these new areas.

As a starting point, for any industry's expansion to succeed, there needs to be sufficient demand for the product. Thankfully, cotton is a commodity in demand worldwide and particularly Australian cotton, thanks to its reputation for high quality and responsible and sustainable production.

Cotton's viability in northern Australia will rely upon investment – by growers prepared to venture north, and by gins keen to establish facilities in new regions. Government will play an important role in establishing policy parameters and a framework for the industry, but private business will need to take charge of the growth.

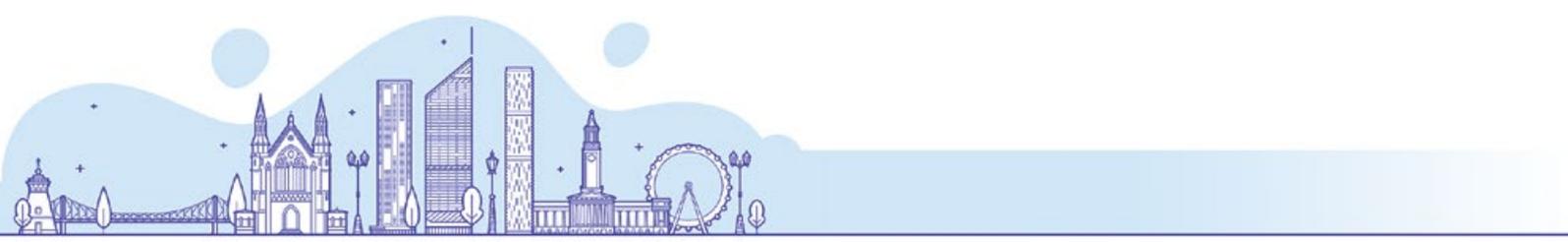
One of the big challenges encountered by the trial operations in northern Australia this season involved ginning. The cotton grown in the trials had to be transported thousands of kilometres to Dalby in Queensland for processing, which added a significant cost for the growers. Finding a solution to the ginning issue is likely to be key to the progression of plans to expand the industry into northern Australia in any serious way.

The other important factor we need to consider is biosecurity. The northern cotton industry crumbled in the 1970s because of issues around pest management and pesticide resistance, and that is not a situation we want to see repeated. Cotton Australia is working closely with a range of stakeholders to ensure the proper biosecurity framework is established before the industry makes a decisive move into new areas. Much of this work will build upon the already strong biosecurity protocols in place across the existing cotton industry, but it will also need to be tailored to suit the unique growing conditions in the tropical climes. Similarly, as in any area of new development, our industry works side-by-side with researchers, and we must strive to foster participation in our best management practices program, myBMP, from the start, to ensure responsible and successful development.

Indeed, supported by CRDC-funded research, Cotton Australia is making sure we implement a tailored, northern-focused version of our best management practices program, myBMP, to assist any developing strands of the industry to maintain the high standards already in place in the country's south. Our brands and retail customers expect these high standards of Australian cotton and we will continue our work in the space.

There is certainly good reason for the Australian cotton industry to be optimistic and excited about future expansion opportunities. Growth in the industry will lead to stronger regional communities and will provide important economic benefits to family farms and rural businesses. We are committed to working with all relevant stakeholders to ensure the potential expansion is managed correctly and thoroughly, and I look forward to reporting back to you in the near future on how the Australian cotton industry has embraced the fresh opportunities we have been afforded.





A very dry argument

David Dowling, Editor, Australian Cottongrower

The state of the Australian cotton industry can easily be summed up in one word – water. Or rather, the lack of it.

In the words of the famous Australian poem, ‘My Country’ by Dorothea Mackellar, Australia is a “Land of drought and flooding rains.” We are certainly well entrenched in the former condition at the time of writing in late October. Given the unpredictable nature of our climate, this could all change by the time of the ICAC meeting in Brisbane in December, but the current indicators are not positive.

It wasn’t that many years ago that Australia was side by side with Brazil as a “middle-ranking” cotton producer, but the trajectories of the two countries have taken vastly different paths in recent years. If you look closely at the chart below, you can make out a rising trend for production in Australia, but it is well masked by huge year-to-year variations which are almost entirely due to water availability.

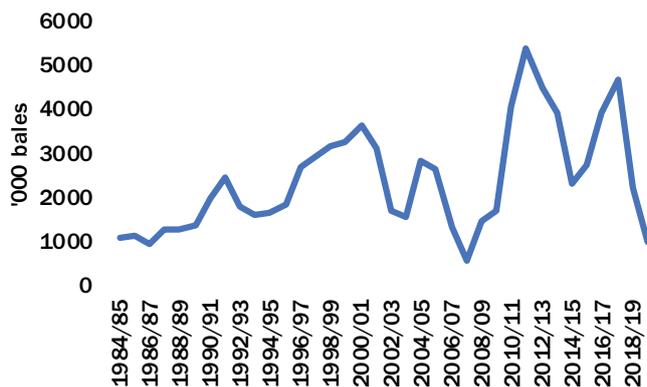
From a peak of nearly 5.4 million bales in the 2011-12 season, Australian production is set to fall to around one million bales in the current season. The availability of Bollgard 3 varieties has extended the available planting window for cotton, but by early December the die will have been cast.

The extended planting window is not the only factor that has helped to underpin cotton production in recent years. There has been a significant shift in cotton plantings to more southern growing areas which also have more reliable irrigation supplies. But these southern valleys have not been spared by the crippling drought, and water availability has been strictly limited, although not to the same extent as in the traditional major production areas of northern New South Wales and southern Queensland. The shortage of irrigation supplies has also produced a rush to secure short-term allocations, especially by growers of the ever-increasing permanent plantings, mainly of almonds and citrus. With “temporary” water now fetching close to \$1,000 per megalitre, it is not surprising that some farmers with irrigation allocations in southern areas are happy to sit this season out and take the lucrative options available in the water trading market.

The drought and resultant low water flows in the Murray-Darling Basin have not escaped the ever-vigilant attention of the metropolitan media, which have received a lot of help and advice from some vocal green-leaning politicians, especially those with constituencies in the lower reaches of the river system. Unfortunately, there is a low level of understanding of simple concepts such as rainfall and evaporation and they seem convinced that the solution is to have a better allocation system for a resource that is virtually non-existent after the past three very dry years.

Not only is the cotton industry faced with a chronic water shortage, but we are also being questioned about our “social licence” to operate and to use water when it is available. Australian irrigators were forced to make concession after concession along the road to a negotiated Murray-Darling Basin Plan about ten years ago, but are now faced with calls for even greater cutbacks in the face of the first drought since then. The solution to all of those problems is rain, and lots of it, which will make the issues go away, until the next drought at least.

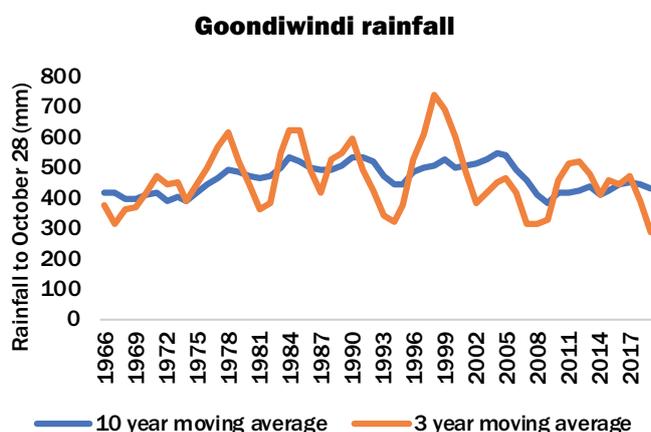
Australian production



Northern development

While the centre of gravity of the cotton industry has swung south in recent years due to better varieties, more reliable water and possibly climate change, there have also been renewed calls to explore development options in the north of the country. Growers who have seen the extraordinary developments in the *Cerrado* regions of Brazil such as Mato Grosso and western Bahia have understandably compared it to some of the savannah country of northern Australia. The rainfall is nowhere near as reliable, but it can be plentiful and there is a new wave of pioneers who are looking to carve out new cropping frontiers in northern Australia, an area where many have tried but few have succeeded in the past.

Better production techniques and planting windows have produced some confidence that this time will be different.



There is already some extensive production on the Gilbert River in the Gulf of Carpentaria and there are also possible production areas on the Mitchell and Flinders Rivers of north Queensland. In the Northern Territory, large-scale trials have produced excellent results on the Douglas-Daly system and also closer to Katherine.

Cotton has also made a comeback in the troubled Ord River irrigation scheme in Western Australia. With a revised production system and strong investor influence, there is a feeling that now may just be the time that cotton becomes the main field crop in the Ord.

So just how bad is the current drought?

In Australian farming lore, the “big daddy” of all droughts was the Federation Drought in the first few years of the 20th Century. The Millennium Drought at the start of the 21st century is right up there too, while the mid-1960s and early 1980s also get a mention. For the old timers, the 1920s and 1940s are also classed as very dry. Of course, in such a large country it often depends on where you are, but it is probably fair to say that drought is the most common state of affairs for most Australian farmers.

To put the current drought into perspective, I looked at some rainfall figures for the past 60 years for the main Australian cotton production areas from January 1 to October 28, when this was written (see the table below).

Eight major cotton areas from north to south are shown. All had a substantial rainfall deficit for 2019 (January 1 to October 28). Some places such as St George and Moree had received only 20 percent of their average rainfall for that period. In five of the eight areas, this has been the driest year for the past 60 years at least. In Moree, the 90 millimetres received was 40 percent below the previous lowest rainfall for that period.

On a three-year moving average basis (also for the same January-October period, so the 2019 figures could be compared), it has been the driest consecutive three-year period for six of the eight regions. At St George, nine of the ten lowest rainfall years out of the past 60 have occurred since 2000.

For Goondiwindi, which is close to the geographic centre of the Australian cotton industry, the ten-year moving average is back to the levels of the 1960s (see the chart to the left) and the record low rainfall of 2019 has already dragged the three-year moving average

Table 1.

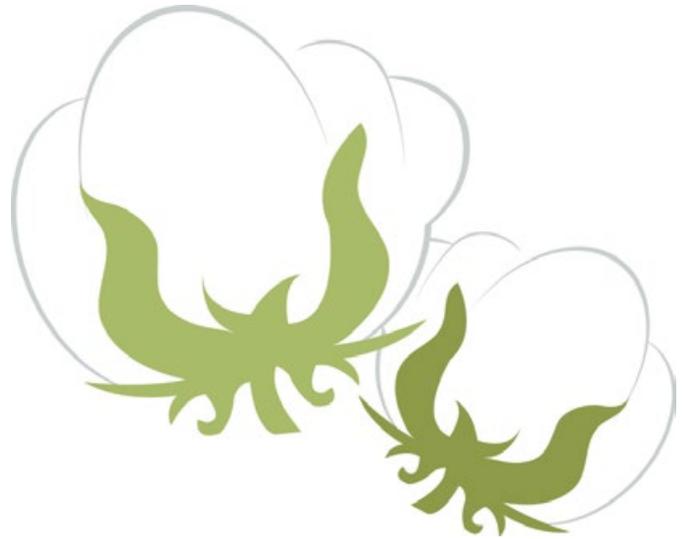
Extent of the drought in Australian cotton growing areas

	Emerald	Dalby	St George	Goondiwindi	Moree	Narrabri	Warren	Hay
Rainfall to Oct 28 2019 (mm)	259.4	154.6	87.8	197.7	90.2	149.1	141.2	164.9
% of average	60.2	34.5	22.1	44	20.2	29.4	36.4	52.7
Ranking	6th	1st	1st	1st	1st	1st	2nd	5th
Three year moving average rank	20th	8th	1st	1st	1st	1st	1st	1st

Ranking refers to the position of the 2019 figures compared with the previous 60 years of record. For example, at Dalby, 2019 is the driest year on record while the 3 year moving average is the 8th lowest.

down to its lowest level since at least 1959. In other words, it is very dry, and this drought is right up there with the worst we have seen.

Those delegates who elect to undertake the field trip to the Darling Downs at the end of the conference will see the effects first-hand unless there is some improvement in the meantime. This area is lucky enough to have some areas of underground irrigation water, so there will be some farms with good crop and delegates will get a feel for the real positive aspects of the Australian cotton industry – the excellent farmers, advisors, researchers and support industries which will help the industry recover and reach new heights when the inevitable happens and the “flooding rains” return.





Marketing Australian cotton – poetry in motion

Roger Tomkins, Chairman, Australian Cotton Shippers Association

In 1908, Dorothea Mackellar, a homesick 19-year old Australian, holidaying in England, wrote a poem that has entered the Australian literary canon. ‘My Country’ contains a verse that reads:

*I love a sunburnt country,
A land of sweeping plains,
Of ragged mountains ranges,
Of drought and flooding rains.*

With these few words she managed to distil the quintessential character of rural Australia. Her parents owned country in the upper Namoi Valley around Gunnedah, which was then pastureland but is now an important cotton-growing region. She captured the hours of sunlight and the wide-open plains with rich soils that are so favourable for producing Australia’s world-leading cotton yields. She depicts the mountain ranges that catch the runoff from flooding rains that is so vital to growing our crop. And then, to moderate the euphoria, she very simply reminds us of the inevitability of crippling droughts.

The Australian cotton industry, like all agriculture across the eastern states, is firmly in the grips of a prolonged drought that in many places has now lasted longer than three years. Long-range weather forecasts provide little hope for relief any time soon. The Australian Bureau of Meteorology recently undertook a study on the effects of global warming on the climate

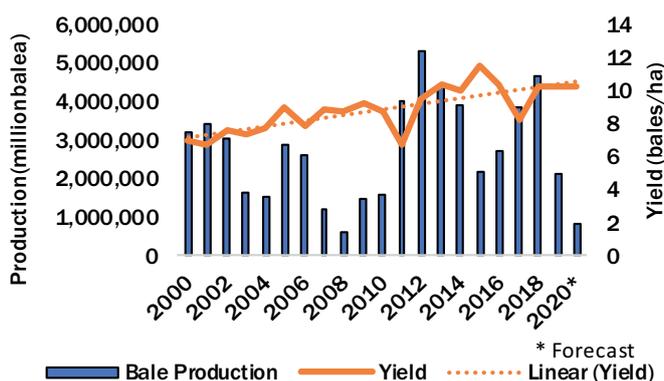
of the Pacific region, including the eastern states of Australia. Their model projected a 90 percent increase in the number of major Pacific rainfall disruptions in the early 21st century, rising to 130 percent by the latter half of the century, so it would seem our climate extremes will become increasingly prevalent. Indeed, it is hard to think of a cotton-producing country with greater variability than Australia.

Readers will note from the chart (below left) that while raw cotton output can swing dramatically within a matter of a few years, Australian yields have maintained an upward trajectory to the point that they are now consistently the highest in the world. Nevertheless, production is forecast to decline further in 2020: current estimates are for 850,000 bales (193,000 tonnes), which would make the coming crop the second smallest Australia has produced this century.

Production may vary on the back of available water supplies, however even in the dry years the research and development of the crop continues unabated. It is the industry-wide focus on sustainable growth and improvement that has been the catalyst for its success. It is also the driver for expansion into new growing regions. The last decade has seen a dramatic advance for the cotton industry in the southern region of New South Wales, while new varieties and production methods are facilitating the development of cotton in the more northerly, tropical regions of Australia. The continued geographic expansion of the crop is seen as a very positive move towards increasing, but also stabilising, Australia’s production base.

Marketing a crop with such production variation has inherent challenges. Very little Australian cotton is ever carried over into a new season, and when that does happen, it is usually for a specific reason. This indicates that whatever the size of the Australian crop there has always been a buyer willing to acquire it. Australian cotton consistently achieves a premium over competing growths, based on its reputation as a very high-quality, contamination-free fibre that can be delivered with a minimal lead time as a result of the relatively short distance to its major Asia-based customers.

Australian Production and Yields



While the heat, sunlight hours and dry conditions may impact production, they are also conducive to the consistent production of the highest quality upland fibre. Classing of the 2019 crop has recently been completed, and the excellent quality achieved further validates the conscientious work of the Australian cotton seed breeding team. As the following charts demonstrate, 88 percent of the crop had strength greater than 30 gpt (compared to 85 percent in 2018 and 87 percent in 2017). The same proportion had a staple length of 37 or longer (compared to 90 percent in the 2018 and 2017 crops). Ninety-eight percent of the crop was classed as Middling (31-3) or better, and the crop had an average Micronaire of 4.3, with 88 percent testing in the 3.8-4.9 range.

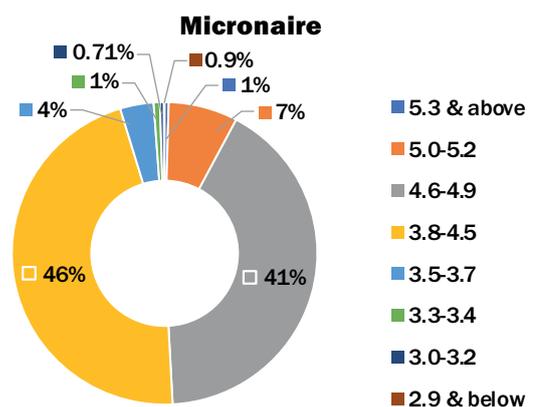
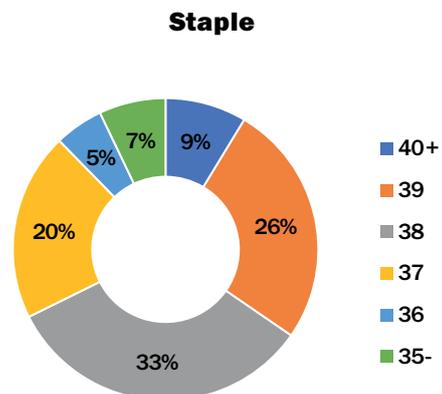
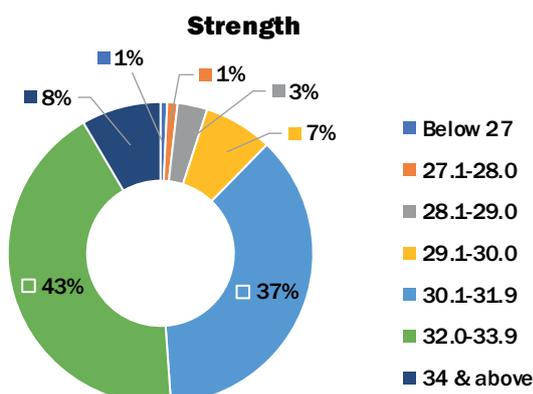
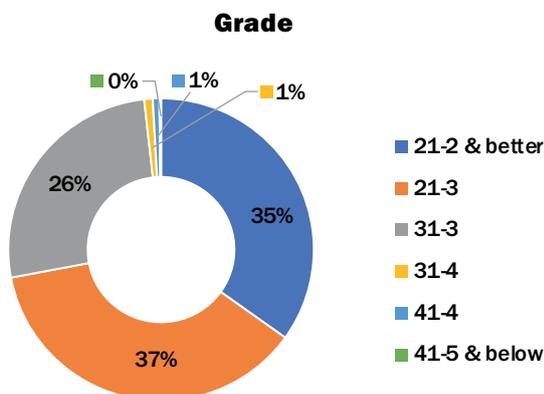
While these fibre measurements provide a valuable demonstration of quality, the performance of a bale of cotton as it is processed further down the textile chain relies on a lot of additional factors that are not easily tested, especially in commercial, high-volume classing operations. These include the prevalence or not of different forms of contamination, as well as dust content, fibre waxiness and dye-uptake performance.

The Australian Cotton Shippers Association (ACSA) is an organisation that brings together 14 major traders that collectively export around 95 percent of the Australian cotton crop. Operating under a mantra of 'Taking Australian Cotton to the World', they are actively involved in, amongst other things, the collective promotion of Australian cotton to the global market. Each year, members of the Association travel to existing or emerging markets to educate current and potential

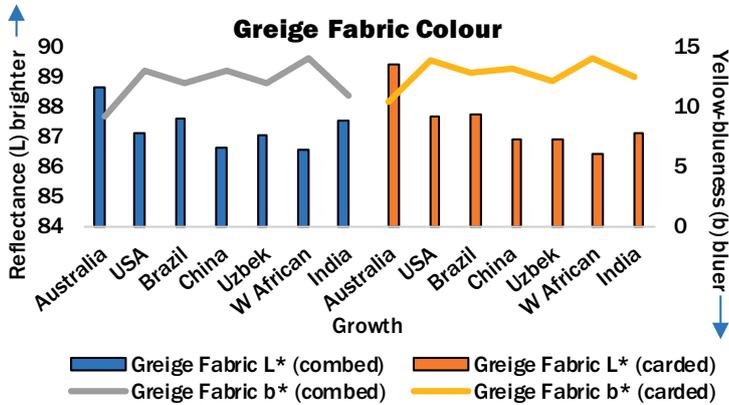
users of Australian cotton and to listen to them as they recount their experiences of spinning our great fibre. The industry strives for continuous improvement, and this feedback is vital in ensuring that Australian cotton continues to meet and even exceed the world's fibre requirements.

On one such market visit, the dye-ability of different growths of cotton was discussed at length. In response, ACSA in partnership with the Cotton Research and Development Corporation (CRDC), commissioned CSIRO Agriculture and Food to conduct a controlled trial to study the dye characteristics of high-quality upland cottons from around the world. The researchers collected one bale of similar quality cotton from seven competing growths (Australia, USA, Brazil, China, Uzbekistan, West Africa and India) at their industrial-scale pilot plant located at Waurn Ponds, Victoria in Australia. The cotton from these bales was then carefully monitored as it proceeded through the manufacturing chain from spinning to knitted fabric.

Bales were spun into carded (Ne 30) and combed (Ne 40) medium-fine count yarns for evaluation. The resulting yarns were then knitted into a continuous length of fine-gauge, single jersey fabric. These knitted fabric lengths were scoured and dyed or bleached in single jet-dye baths at a commercial batch dye house. During this process, the various cottons were assessed on their fibre and yarn properties, spinning performance, dyed and bleached fabric colour and fabric pilling. Principal Researcher and Team Leader Dr Stuart Gordon noted in his report, "The results showed Australian cotton was the best overall in terms of fibre, yarn and



fabric (colour) properties. The Australian cotton was whiter (brighter) and produced relatively cleaner, more even and stronger yarn. These properties translated into a bright, clean fabric with good (bright) dye colour. Bleaching reduced the colour differences between all fabrics. The Australian greige fabric was also one of the best placed in terms of its resistance to pilling.”

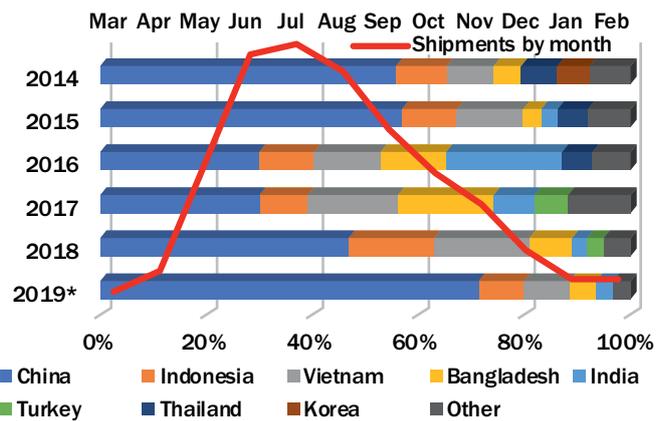


Supply and Demand report for raw cotton has Bangladesh and Vietnam as the second and third largest importers of cotton behind China, and the fourth and fifth largest in terms of total consumption. Australia’s own export data would suggest that while Bangladesh is a consistent buyer, Vietnam has been the territory showing the most dramatic increases in its consumption of Australian cotton. The Vietnamese market now consistently consumes more than 15 percent of our cotton crop. This is likely to be a result of the significant part that Chinese textile groups have played in the recent, rapid expansion of the Vietnamese spinning and textile industry. And, as previously established, Chinese spinners like to use Australian cotton.

Export shipments of cotton from Australia typically commence in March and reach a peak in June and July. Although exports continue year-round, the vast bulk of the crop has typically been shipped by no later than December of each crop year.

At the start of this century, China was buying a little over one percent of the Australian crop. Nineteen years later, they are on track to purchase over 65 percent of this year’s crop. In fact, apart from the two years spanning our 2015/16 and 2017/18 crops, when China was digesting cotton from its huge domestic reserve, they have consistently purchased around 60 percent of the Australian crop for the last decade. This should be of no surprise, given that China produces over 25 percent of the world’s cotton yarn; they are the largest exporter of textiles and clothing (2018 WTO Reports on World Textile and Apparel) and are forecast by Euromonitor to surpass the USA this year as the world’s largest apparel market.

Major markets for Australian cotton

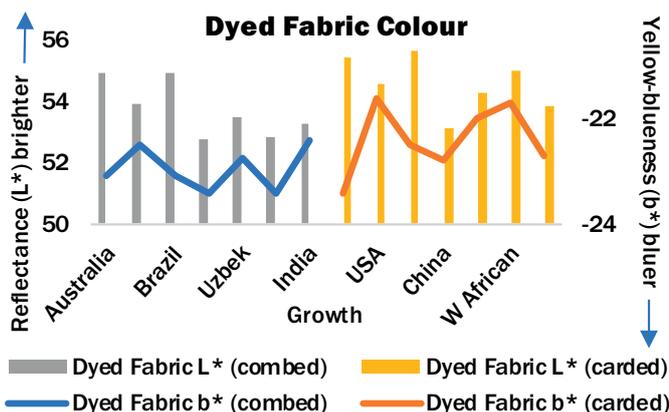


* 2019 year to date (March 1 – August 31, 2019)

As China has grown into the predominant buyer of Australian cotton, Indonesia, Thailand, Japan and Korea have all reduced the volumes they purchase. Indonesia remains a very important market for Australian cotton, consistently buying around ten percent of our crop. Other significant changes to Australia’s cotton trading partners have coincided with the rise of the Bangladesh and Vietnamese textile industries. The latest USDA

The Australian cotton marketplace can be complicated by wild production variations; however, industry-wide investment in seed breeding, best-practice farming methods and world-leading logistic systems have produced a fibre that is highly regarded for its quality, freedom from contamination and reliable, quick lead times for delivery. Investment in research across all areas of the crop, including the likes of the recently completed trial on the spinning performance and dye-ability of Australian cotton, is ongoing. Through collaboration, hard work and ingenuity, the Australian cotton industry has proven it can overcome the challenges of operating in such a harsh and variable climate – one that the Australian Poet Dorothea Mackellar so aptly described as:

*Her beauty and her terror –
The wide brown land for me!*





Australian cotton: forging a brighter, sustainable future

Adam Kay, CEO, Cotton Australia

The worldwide shift requiring industries to become sustainable, responsible global players is an important one, and one the Australian cotton industry has taken very seriously.

Australia's cotton industry has a reputation for being bold, ambitious and innovative; it is an industry that pushes boundaries and leads the world.

I am proud that this approach has allowed the sector to take significant steps in furthering our commitment to sustainability.

For many decades, the Australian cotton industry has been managing on-farm sustainability. Over recent years, this work has been bolstered by significant investment in research and development projects designed to improve our operations, and also through our world-leading best management practices programme, myBMP.

Our leadership in this space stretches back decades: our initial independent environmental performance audit, completed in 1991, was a first for a major Australian agricultural industry. Further environmental assessments were undertaken in 2003 and 2012.

In 2014, our industry produced the Australian-Grown Cotton Sustainability Report, which was a key outcome of the 2012 environmental auditing process. The report revealed the significant achievements of our industry in its journey of improving sustainability, including:

- a 40-percent increase in cotton's water-use efficiency;
- an 89-percent reduction in insecticide use;
- a total of 93 percent of growers using Integrated Pest Management techniques;
- cotton farms dedicating, on average, 42 percent of their land to native vegetation;
- more than 42,000 birds, representing 45 species, found on farm water storages in the Gwydir Valley in New South Wales;
- a total of 153 bird species found in natural vegetation in the Namoi Valley;

- a total of 450 species of invertebrates recorded in one cotton field during the summer;
- an estimated 10,000 people directly employed by the cotton industry in a non-drought year.

When these key findings were released in 2014, they provided our industry with a strong launch pad for planning our next five years of sustainability work.

For the Australian cotton industry to remain sustainable into the future, we need to ensure that all our operations conform to best practice standards. Our industry is proud of its comprehensive best management practices programme, myBMP, which originally began in 1997 before being re-launched in 2010 as an online assessment program.

MyBMP's success is derived in part from its comprehensive nature. The program covers ten key modules of best practice across farm operations, comprising biosecurity, energy and input efficiency, fibre quality, human resources and work health and safety, Integrated Pest Management (IPM), sustainable natural landscape management, pesticide management, petrochemical storage and handling, soil health, and water management.

Full myBMP accreditation can be granted only once a farm has undergone a stringent, independent audit ensuring all relevant Level 1 (legal) and Level 2 (industry best practice) requirements are met. Level 3 practices (where the industry aspires to be in five-to-ten years' time) are not subject to the audit, but growers are encouraged to strive for this level.

Our industry is proud of the fact that 80 percent of all growers are now involved in the myBMP programme, and we will continue our work to ensure that even more become accredited. MyBMP is paving the path towards even greater sustainability for our industry.

Coupled with myBMP's role in boosting our sustainability is the significant investment that has been made in research and development projects. In the 2018/19 funding round, after receiving advice from growers, the Cotton Research and Development Corporation (CRDC) invested \$24.3m in RD&E, with funds

directed to 300 research and development projects in collaboration with more than 100 research partners. This investment will allow our industry to improve its practices still further and will form an important part of our continuing sustainability journey.

Similarly, Australian cotton's extension programme, CottonInfo, in conjunction with Cotton Australia's team of regional managers, has played a valuable role in supporting the industry as regards sustainability. CottonInfo is a joint venture between Cotton Australia, CRDC and Cotton Seed Distributors Ltd. The programme's team of on-ground extension officers facilitate the uptake of myBMP and translate and deliver R&D to growers to ensure the adoption of sustainable practices.

The Australian cotton industry's commitment to sustainability will take a fresh approach later in 2019. Before the year's end, our industry will finalise its second sustainability report – an important document that will reflect the progress the industry has made since the 2014 sustainability report was handed down.

In tandem with the sustainability report, we will officially launch our sustainability targets. The targets are ambitious and set us on a path towards further improvement. They have been developed over time and focus us on the areas that are of greatest importance to our industry and stakeholders right now. These include the priorities that we committed to in our first sustainability report:

- **Environmental:** including increasing water-use efficiency, reducing our carbon footprint and enhancing biodiversity;
- **Economic:** boosting farm productivity;
- **Social:** including reducing work-related injuries and fatalities.

We will be proud to formally launch the targets and promote them more widely in 2020, and then to work together as an industry to achieve the ambitious goals we have set ourselves.

It is important to note that the Australian cotton industry's work in the sustainability space is not limited to what we do on the farm. Our industry has also developed valuable partnerships with a range of stakeholders; these enable us to connect with projects and initiatives that further boost our sustainability efforts.

Our industry's sustainability work continues to be recognised by an increasing number of global sustainability programs. For example:

- Cotton Australia is a strategic partner of the **Better Cotton Initiative (BCI)**. The myBMP standard has been mapped and aligns with the BCI Standard;
- the **CottonLEADS** programme encompasses Cotton Australia's valuable partnership with the US Cotton Foundation;

- myBMP is accredited by the **Partnership for Sustainable Textiles**;
- Australian cotton is included in the **International Trade Centre Sustainability Map**;
- Data from myBMP is included in Preferred Textile reports from **The Textile Exchange**;
- myBMP is included as a sourcing option for sustainable cotton in the **Forum for the Future, CottonUP Guide**.

Many benefits flow through to our growers as a result of their sustainable practices. Not only are their farms becoming more efficient and advanced, but the fibre they produce is increasingly sought after.

Cotton Australia's Cotton to Market program was established to enable our industry to work directly with the supply chain, including brands and retailers, to ensure uptake of Australian cotton remained high. Thanks to the reputation of Australian cotton as a sustainably and responsibly produced commodity, I am pleased to report that our industry is now working with more fashion brands than ever before who are keen to source and use Australian cotton in their products. This has been an exciting step forward for our industry, with an increasing number of consumers becoming aware of Australian cotton's sustainability credentials, and with more Aussie cotton being worn in the community.

As this article has outlined, the Australian cotton industry has a proven track record for taking sustainability seriously, and we will continue to do so into the future. Through the release of our second sustainability report, the launch of our industry's ambitious sustainability targets and engagement with stakeholders, we will continue our work to be the most efficient, environmentally conscious agricultural industry in the world.

I am proud of the work that has been carried out and the achievements we have registered so far; and I thank all those who have devoted themselves to our sustainability journey, for the good of our industry. I am excited about this next chapter, and I look forward to working with everyone in our industry to ensure we meet the sustainability targets we will have in place.





Climate change, water resources and cotton

Michael Murray, General Manager, Cotton Australia

For any farmer, the confluence of weather, water and climatic conditions will be a significant factor in determining the success of a season.

There is no doubt the Australian cotton industry is currently operating in a time of challenging climatic conditions. Drought, brought on by a prolonged period of little rainfall and warm temperatures, is ravaging much of eastern Australia, including cotton-growing regions. This is putting considerable pressure on all affected farmers, and our growers are no exception.

In many cotton-growing valleys, good rain has not fallen since 2016. Since then, our farmers have been forced to survive by rationing such water as has been made available to them, and by making careful business decisions that have allowed them to grow a crop and generate some income for their business.

In Australia, access to water is highly regulated. Irrigators must have a water licence, which entitles them to a share of the overall pool of water available in any one year, with the determination made by state governments along with federal oversight in some instances. The amount of water made available to irrigators is decided only after water for critical human needs and the environment has been allocated first. This means that irrigators are the last to receive a water allocation, the size of which then influences how much cotton is planted in a given season.

This season, irrigators in most cotton-growing valleys have received no new water allocations, because the little water that was available was prioritised for critical human needs and the environment, as stipulated by the various regulations. This means that as a direct result of the prolonged drought and the regulatory framework, very little cotton will be grown this season.

In Australia, the regulation of water is most intense across the Murray-Darling Basin, where the implementation of the 2012 Murray-Darling Basin Plan has greatly reduced the amount of water available for extractive uses, such as agriculture, in favour of greater allocations to the environment.

Despite this significant impact, the Australian cotton industry remains supportive of the Murray-Darling Basin Plan and advocates its full implementation, as it was agreed to in 2012 and re-agreed to in 2018.

Many critics of the cotton industry have looked to use the drought and dwindling water resources as supposed 'evidence' to promote their argument that cotton should not be grown in Australia. However, the fact is, despite the drought and reduced crop forecast for this season, cotton remains an ideal crop from a farmer's point of view because of its flexibility and the healthy returns it provides for their business. Irrigators choose which crops they want to grow using their water licence. Furthermore, cotton is grown as an annual crop in Australia, meaning growers only plant cotton when they have enough water available to sustain a crop. Irrigators do not waste the precious water they own, and they make careful, smart decisions around how to use the resource most efficiently and make a return for their businesses. The reality is, cotton in Australia, whether it be irrigated or dryland, is only grown when a farmer has enough water available to them under their licence, or the forecast of rain to support a dryland crop is healthy.

So, what steps is our industry taking to ensure its survival in the face of challenges posed by climate change and fluctuating water resources?

Our industry is responding to climate change in two principal ways – through the work of our growers and that of our researchers.

Australian cotton growers continue to implement practices to develop landscapes that are more resilient to the impacts of drought and climate variability. They also work to reduce greenhouse gas emissions and improve the land's ability to store carbon through various techniques and innovations, including:

- maximising the efficiency of the major inputs used in cotton growing, such as energy and nitrogen, by optimising irrigation pump performance and using fuel-efficient farm machinery;

- using alternate sources of nitrogen: for example, legume rotation crops that fix nitrogen in the soil;
- improving soil health using controlled traffic and minimum-tillage systems amongst other practices;
- minimising spraying machinery operations, and therefore fuel use, through the industry-wide use of herbicide-tolerant cotton, and during harvest, through the use of machinery that replaces multiple machines with one;
- using renewable and alternative energy sources, such as biofuels and solar panels to power irrigation pumps;
- conserving and managing areas of farm biodiversity, such as native vegetation and riparian areas on farm, which are valuable carbon stores;
- by continuing to build knowledge of climate change, and by having access to improved weather forecasting information, growers can take actions that adapt and reduce the impacts of the changing climate.

Across the broader industry, work to tackle climate change takes many different forms. With water and weather the primary challenges to improving and sustaining cotton farm profitability, our industry is taking positive steps to tackle climate change through:

- continued investment in water-use efficiency research;
- continued investment in improving nitrogen use efficiency;
- the establishment of the climate change facility at the Australian Cotton Research Institute, and support of investigations by Dr Katie Broughton. The facility is also studying the effects of higher CO₂ levels and warmer temperatures on cotton-growing, and exploring how best to develop new cotton varieties that have adapted to hotter, drier conditions;
- support for investigations into alternative energy sources (including bio-diesel from cotton seed, solar-powered irrigation pumps, and ethanol from gin trash);
- support for climate research, and the extension of weather forecasting tools and advice to growers;
- carrying out a life-cycle assessment of an Australian cotton T-shirt, which found the major environmental impact to be in the 'use' component of the garment (wearing, then washing), rather than production and manufacturing.

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- delivering up-to-date knowledge on climate issues to growers through the industry's extension network, CottonInfo, and the myBMP environmental management programme (which includes components on energy and input efficiency, natural resources and soil health).

Of course, our industry alone cannot solve the challenges posed by climate change, which is why we value the strong connections we have formed with the scientific and research communities in order to work together to ensure positive outcomes for both the environment and our farming operations.

The Bureau of Meteorology's current climate projection does not look positive for farmers 'doing it tough' on the land. The Bureau forecasts rainfall is likely to be below average across most of the country for the rest of 2019, and daytime temperatures will probably rule above average across the country during the same period. That is an ominous warning for all farmers already battling the drought.

And while we are doing all we can to ensure the industry is as water-efficient as it can be, and as forward-thinking around climate change solutions as possible, some things remain out of our control. Everyone in our industry is hoping for a reprieve and for rain to fall soon. Without it, that confluence of weather, water and climatic conditions will continue to test us.



Cotton in a changing climate: what the research says

The Australian cotton industry is looking to the future through explicit research focusing on the impact climate change and extreme weather events will have on cotton production, and seeking to understand how we can adapt to environmental changes.

Worldwide cotton production has broadly adapted to the growing conditions in temperate, subtropical and tropical environments, but growth and production systems in Australia may be challenged by future climate change. Changes in climate factors such as warmer air temperatures and extreme fluctuations in precipitation as a result of rising carbon dioxide (CO₂) concentration may significantly impact plant growth and crop productivity.

Previously conducted field studies and research utilising controlled-environment glasshouses in the US have provided an excellent foundation for understanding the potential effects. However, there has been no specific research into the impact of climate change for modern Australian cotton systems, and little research attempted to assess the combined, interactive effects (temperature x CO₂ x water) of climate change on cotton productivity, especially in the field.

Over the past several years, a range of research initiatives led by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Western Sydney University, and supported by the Cotton Research and Development Corporation (CRDC), have been under way: the aim is to better understand the responses of the Australian cotton system to this changing environment. Research has included simulation modelling, and glasshouse and field-based studies, which have revealed some key insights. On-going research requires precisely such a multi-faceted approach in order to further our understanding and knowledge of cotton-system and plant-soil responses to projected environmental conditions for Australian cotton regions.

Climate change will have both positive and negative effects on cotton production. Increased CO₂ may increase yield in well-watered crops, and higher temperatures will extend the length of the growing season. However, warmer temperatures also accelerate the rate of crop

development and could potentially shorten the time to maturity, which may then affect crop management decisions.

Higher temperatures also have the potential to cause significant fruit loss, reduce water-use efficiencies, lower yields and alter fibre quality.

Environmental conditions that encourage excessive shading by the leaves may lead to fruit loss throughout the season. Furthermore, fruit loss may in turn exacerbate excessive vegetative growth and further loss of fruit, due to a lower fruit load to restrict vegetative growth.

The predicted increased frequency of extreme weather events such as droughts, heatwaves and flooding poses significant risks to improvements in cotton productivity. Inter-annual yield variability is likely to be greater, with benefits likely to result from increases in yield potential during favourable seasons, but also large reductions in yield during the seasons affected by extreme weather events.

Research into the integrated effects of climate change (temperature, humidity, CO₂ and water stress) on cotton growth, yield and quality will be important, as will the development of cultivars tolerant to abiotic stresses (especially for more frequent hot, water-challenged – deficit and waterlogged – conditions), and achieving a better understanding of whole-system management strategies to maximise production and minimise losses to cotton grown in variable environments. In a systems context, climate change is a complex issue that is likely to require more than one approach to address the multi-dimensional, integrated impacts on Australian cotton production systems. This overview highlights some of the recent research into legacy effects, climate change across Australian cotton regions, and the impacts of extreme weather events on cotton systems.

Legacy effect

The positive effect of elevated CO₂ on cotton growth and yield is generally consistent across studies; however, single-season experiments do not account for the 'legacy effect' on subsequent crops.

Cotton plants grown in conditions of elevated CO₂ produce nitrogen-poor litter, which decomposes at a reduced rate and can thus reduce the availability of nitrogen in the soil for subsequent crops. As a third of cotton's nitrogen uptake comes from mineralised nitrogen, a reduction in decomposition can strongly limit the yield response to elevated CO₂ in subsequent seasons.

In glasshouse experiments, elevated CO₂ strongly reduced yield in the second year, particularly at ambient temperatures. Conversely, warmer air temperatures had a consistent effect and seemed to nullify the negative effect of elevated CO₂ on yield.

Assessing the strength of this legacy effect in the field will be critical in developing fertiliser recommendations to mitigate the potential negative impact of elevated CO₂ on cotton yield in the future.

Climate change across cotton regions

Since the beginning of the industrial age, atmospheric CO₂ concentrations have increased substantially. During the past 800,000 years, CO₂ levels in the atmosphere have ranged between 170 and 300 μmol mol⁻¹ in response to natural transitions between glacial and inter-glacial periods.

However, atmospheric CO₂ has been rapidly increasing over the past 200 years due to worldwide industrial activity: from a pre-industrial concentration of about 280 μmol mol⁻¹ to 406 μmol mol⁻¹ in 2017 (Tans and Keeling, 2018), with projections for more rapid increases in the future. It is projected that atmospheric CO₂ concentration will rise to 450 μmol mol⁻¹ by 2030.

As a consequence of rising greenhouse gases, including CO₂, in the atmosphere, global air temperatures have also been increasing throughout many regions. Global average air temperature has warmed by more than 1°C since records began in 1850, and each of the last four decades has been warmer than the one that came before (CSIRO and Bureau of Meteorology, 2018). Australia's climate has warmed by 1°C since 1901, with a simultaneous increase in the frequency of extreme heat events (CSIRO and Bureau of Meteorology, 2018).

In a recent study, eight locations across Australia's cotton-growing regions were assessed to explore temperature trends from: (a) 1957 to 2017 (60 years); (b) 1957 to 1996 (39 years); and (c) 1997 to 2017 (20 years). All eight locations exhibited a trend for an increase in the accumulation of the number of day degrees (a measure of heat accumulation throughout a growing season, from September to April) during the period 1957 to 2017. Furthermore, from 1957 to 1996, there was an increase in the number of day degrees at Emerald, and during the period 1997 to 2017 there was an increase in the number of day degrees at Griffith and Moree.

Although the slopes of each regression were mostly positive, suggesting a possible increasing trend in day degree accumulation, the variation in the number of day degrees between years was large over a relatively short timeframe. However, the significant increasing trend in the number of day degrees from 1957 to 2017 for all eight locations indicates an increase in the number of hot days and warmer night-time air temperatures.

Current climate projections indicate Australia will exhibit more heatwaves (air temperatures greater than 35°C). Recent examples were seen during the 2016-17 cotton season, when high temperature records were broken across the country. Moree, in the Gwydir Valley in North West NSW, recorded 54 consecutive days exceeding 35°C. The previous record was 11 days above 35 °C. Mungindi, north of Moree, measured 49 consecutive nights of 20°C or above. The previous record was 27 nights.

Climate projections also indicate that there will be changes in rainfall distribution, including an increase in the intensity of drought and flooding. Drought conditions directly affect dryland crops during the season and reduce water availability for irrigated cotton systems. On the other hand, Australia's cotton is often grown on heavier soil textures (clay soils), so crops may experience yield losses due to waterlogging during heavy rainfall events.

Crop simulation studies

Crop simulation studies assessed the potential impacts on lint yield, water use, and water-use efficiency across nine Australian cotton locations covering diverse irrigated and dryland scenarios at Emerald, Dalby, St George, Goondiwindi, Moree, Bourke, Narrabri, Warren and Hillston.

The results of these simulations are summarised in the table below.

System type	Location	Change in lint yield	Change in water use	Change in crop WUE
Irrigated	Dalby	↑ 6% (at 449 ppm) ↓ 3.6% (at 555 ppm)	↑ 2-4%	
	Bourke		↑ 2-4%	
	Narrabri		↑ 2-4%	
	Hillston		↑ 2-4%	
	Overall	↑ 0-26%	↑ 0-4%	↑ 0-24%
Dryland	Emerald	↑ 15-26%	↑ 2-8%	
		↑ *Only with solid planting config.		
	Dalby		↓ -5 to -2%	
	Moree	↑ 15-26%	↓ -5 to -2%	
	Narrabri	↑ 15-26%	↑ 2-8%	
Overall	↑ 15-26%		↑ 2-22%	
↑ Indicates increase ↓ indicates decrease				
Leaf, plant and crop level effects				

Leaf, plant and crop level effects

The integrated effects of warmer air temperatures and elevated atmospheric CO₂ concentration on cotton

growth, physiology and soil microbiology have been studied in a number of glasshouse and field studies in recent years. In both field and glasshouse studies, elevated atmospheric CO₂ increased vegetative biomass and photosynthetic rates of cotton compared with plants grown at current CO₂ levels. In glasshouse studies, elevated CO₂ improved leaf and plant-level water-use efficiency of cotton, which was associated with improved photosynthesis and biomass production, rather than decreases in water-use. However, these studies also showed that improved water use efficiencies were negated by warmer air temperatures, as more water was required to grow the plants.

The field studies showed similar outcomes, but other crop-level issues emerged. Increased vegetative biomass and reduced water-use efficiency became evident as water consumption also increased. Crops had excessive vegetative growth with large leaf areas significantly increasing transpiration. Further reductions of water-use efficiency were then associated with high temperatures, as well as the excessive shading caused by the leaves, leading to the shedding of fruit throughout the season. In turn, this continued to exacerbate the vegetative growth and the loss of fruit because there was little fruit load to restrict vegetative growth.

Varietal performance

Studies have been conducted to explore differences between cotton cultivars in projected climatic scenarios. As future environments are anticipated to produce larger cotton plants with potentially greater requirements for water, plants with smaller, more compact vegetative growth habits and higher photosynthetic rates (e.g. Sicot 71BRF) may have an advantage over cultivars with substantial plant biomass and leaf area (e.g. DP16). Therefore, there may be variation in plant performance that could be utilised in the selection of breeding lines for future environments; however, implementation in capturing the needs for climate change in breeding programs remains a challenge.

Soil impacts

Studies have indicated that projected climate change may affect nutrient availability and soil microbial communities. This is important to consider given the key role soil microbes play in nutrient cycling and availability, and the importance of nitrogen-use efficiency in cotton systems.

Most climate change effects on soil communities are linked to changes in plant responses, which generate plant-soil feedback.

Low soil nitrogen may reflect greater plant nitrogen uptake and thus may not necessarily mean a low nitrification rate. Additionally, limitations in plant growth may result in greater soil nitrogen levels than when plants are actively growing and utilising nitrogen from the soil.

Recent studies determined that climate responses of soil physicochemical (physical and chemical) properties and nitrification rates were also related to crop growth stage: responses were triggered only when the crop reached the early flowering stage. The studies also found that the changes were related to the abundance of microbial nitrifiers in the soil. Specifically, warmer air temperatures did not significantly change potential nitrification rates, and these alterations were dependent on the growth stage of the crop.

Changes in the rate of nitrification, and to the functional microbial communities that affect nitrification, could potentially lead to alterations in soil nitrogen availability, which may subsequently affect cotton crop productivity and nitrogen-use efficiency.

Impacts of extreme weather events

Climatic projections include far more variable weather conditions in the future, which are likely to have a more severe impact on cotton productivity. Projected climatic conditions are likely to increase inter-annual yield variability because of the high yield potential in seasons where there are no extreme climatic events, but large reductions in yield during seasons that are affected by extreme climatic events.

Simulation models demonstrated an increase in the number of days above 35°C across all locations in the study (ranging from Emerald to Hillston). There was also a reduction or no change in the number of cold shocks ($\leq 11^\circ\text{C}$) throughout the majority of the growing season, except in some NSW growing areas in January and February.

Furthermore, the models indicated increases of two to 16 percent and four to 17 percent in mean rainfall and rainfall variability, respectively, within the cotton-growing season for the period centred on 2030, which would have significant implications for the farming system. For example, nitrate is highly mobile in soil, and thus susceptible to leaching in flooded conditions.

Glasshouse studies have shown that flooding caused a rapid loss of nitrogen from the soil, contributing to a reduction in growth and yield of cotton, particularly at warmer temperatures.

This article is a condensed version of a more comprehensive review of the recent research into effects of climate change and extreme weather events on Australian cotton systems undertaken by Katie Broughton and Michael Bange (CSIRO), David Tissue, Linh Nguyen and Brajesh Singh (Western Sydney University), Yui Osanai (University of New England), Qunying Luo (University of Sydney) and Paxton Payton (USDA), whose efforts are gratefully acknowledged. The full version is available on the CRDC website, www.crdc.com.au.

A global assessment of the impact of climate change and adaptation in modern cotton farming systems has also been published by the International Cotton Advisory Committee in association with CABI, entitled "Climate change and cotton production in modern farming systems".



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Cotton research in Australia: the cornerstone of success

*Dr Ian Taylor, Executive Director, and Allan Williams, General Manager R&D Investment,
Cotton Research & Development Corporation*

The Australian cotton industry is one of the success stories of Australian agriculture. Australian cotton is one of the highest yielding, finest, cleanest and greenest cotton crops in the world.

Cotton is an industry taking responsibility for itself by changing practices to meet its own expectations and those of contemporary society. Australia's best cotton producers now achieve more than two bales of cotton per megalitre of water – almost double the industry average of just a decade ago. The industry is at the forefront of environmental management systems, climate change preparedness and climate change adaptation.

It's an extraordinary story of achievement, thanks primarily to the continued support of the industry and the Australian government for RD&E.

It has been, and continues to be, a combined and collaborative effort. The Cotton Research & Development Corporation (CRDC) invests in RD&E on behalf of cotton growers and the Australian government, with the oversight of industry bodies – originally the Australian Cotton Growers Research Association (ACGRA) and now Cotton Australia – and utilising the research prowess of the many different research partners of the CRDC.

The Australian cotton industry pioneers not only had the vision and determination to grow cotton in Australia, but also to establish an industry supported by its own R&D. Growers established the ACGRA in 1972 with a voluntary R&D levy of \$0.25 per bale. This levy recognised the importance of collective funding for industry R&D. The pioneers were also strong advocates for the Australian government matching growers' financial contributions.

CRDC was set up in 1990 under the Primary Industries Research and Development Act 1989 (PIRD Act), replacing the Cotton Research Council. It was established by the Australian government to work with industry to invest in RD&E for a more profitable, sustainable and dynamic cotton industry – at a time when the industry was facing significant societal pressure around its environmental impacts.

In the almost 30 years since then, CRDC's strategic leadership and collaboration in RD&E investment – in partnership with the industry – have been the driving force behind the industry's continuous improvement and transformation.

Over this time, CRDC has invested more than \$360 million into RD&E on behalf of the industry, delivering billions of dollars in benefit back to Australian cotton growers on their farms. One project alone – CRDC's investment in plant breeding – is estimated to have contributed \$5 billion to the industry and the Australian agricultural economy.

In terms of the impact of R&D, Australia's world-leading cotton yields and quality are easy to see and quantify. Efficiency gains in water use and reductions in pesticide use are also evident.

But arguably, cotton production would not have been possible for the last 25 years in Australia – during which time growers have collectively contributed to producing more than \$32 billion in exports – if it were not for R&D and the industry's commitment to improving its practices for controlling insects and managing diseases such as Fusarium.

CRDC has invested in some 2,800 projects over almost 30 years – moving from a response-oriented

approach in the 1990s, addressing specific industry issues, to a more proactive approach of collaboratively identifying potential future threats and opportunities and strategically investing in them to ensure the industry's continued success.

Some of the major cotton RD&E achievements during this time include:

- Overcoming the industry's greatest threat: pests. Managing pests in a sustainable manner, without building resistance to control measures, has been the greatest challenge for Australian cotton growers and cotton RD&E. Cotton pest management in Australia is vastly different now from the early years of production, with industry-wide adoption of integrated pest management contributing significantly to the industry's success story.
- Breeding success. Investment in plant breeding and biotechnology has positioned Australian cotton as a world-leader. CRDC was the major investor in the CSIRO Plant Breeding Program from 1990 to 2007, with Cotton Breeding Australia formed by Cotton Seed Distributors and CSIRO in 2007 to support future breeding and research. A study has estimated that the industry's breeding programs have produced a return of more than \$5 billion to the Australian cotton industry since they began in 1984.
- Supporting research into the field. Every day, somewhere in a cotton growing valley, extension is under way: be that through a grower talking to a CottonInfo regional extension officer or technical specialist, a researcher presenting to growers and consultants at an event, or an on-farm demonstration trail. The Australian industry recognises that with R&D comes a natural need for 'E' – extension.
- Practising what's best. Australian cotton growers are internationally recognised as leaders in sustainable cotton production and are used domestically as a model for change for other agricultural industries. The industry's flagship best management practice program, myBMP, has driven much of this achievement and since its introduction in 1997 has significantly changed the way cotton is grown in Australia. Today, 81 percent of Australian cotton growers are members of myBMP.
- Tracking sustainability. Assessing, reporting and improving on environmental performance provides assurance that the Australian cotton industry takes sustainability seriously and is committed to continuous improvement. The industry has a strong history of taking ownership of areas where it is having environmental impacts and minimising them through improved management based on sound R&D.
- World-leading BT stewardship. Australia is recognised as having the most rigorous and successful pre-emptive resistance management system for transgenic cotton in the world. A review in the journal *Nature* in 2013 analysed the results of 77 studies from five continents reporting field monitoring data for resistance in *Heliothis* to Bt crops of the genes Cry1Ac and Cry2Ab. It found that after more than a decade of exposure to Bt cotton, the frequency of individuals with alleles conferring resistance to those genes remained at less than one percent.
- Producing a quality product. Australian cotton continues to compete at the premium end of the world market. It has achieved and maintained this market advantage with the aid of R&D and the uptake of Australian-bred varieties that produce cotton fibre with the strength, length, fineness and maturity sought by spinners. This is combined with agronomic practices that produce consistently high-quality cotton, and efficient ginning and shipping systems that deliver cotton on time.
- Measuring and managing our invaluable water assets. Australian cotton growers lead the world in the area of water use efficiency, producing more lint per megalitre than any other nation, at around two bales per megalitre of irrigation water. At the same time, in terms of yield per hectare, Australian growers produce almost three times the world average. Grower innovation and uptake of directed, tangible research has played a major role in this achievement.
- Protecting the crop from foreign threats. While Australia has a natural geographic isolation that provides an advantage in protecting the country from overseas biosecurity threats, ensuring the industry is on the front foot regarding biosecurity is critical. RD&E ensures that the industry is actively managing biosecurity through surveillance, diagnostic protocols and contingency plans, proactive biosecurity campaigns, integrated pest, weed and disease management, and vigilance around identifying, recording and responding to harmful diseases, insects and weeds.
- Collaboration. The Australian cotton industry has long recognised that complex, long-term issues are best resolved through cooperative RD&E and collaboration, both within the industry and with other agricultural sectors. CRDC collaborates within and across cotton, and with its fellow research and development corporations on major cross-sectoral research priorities, including soils, water and diseases. In this, the Australian RD&E system is unique: no other nation has a similar system using a levy base with government co-funding to undertake research that ties together industry, government and research communities.



So much good to report

Kai Hughes, Executive Director, ICAC

Too often, cotton has been vilified in the press. And whether the headlines are blaming cotton for a natural disaster like the draining of the Aral Sea, or making the laughably inaccurate claim that it takes 20,000 litres of water to grow a kilogram of cotton, those types of negative and false headlines nevertheless have an impact on the public. As is often the case with negative news, people remember the sensational (but still erroneous) claims and continue to regurgitate them, compounding the problem.

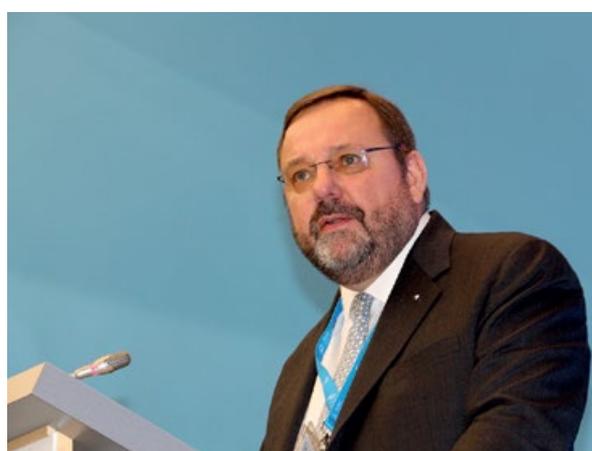
Sadly, the positive aspects of cotton, and the amazing gains it has made towards sustainability in recent years, rarely ever make the news – but the ICAC has made it its mission to correct this situation.

And it couldn't come at a more crucial time, not only for cotton's reputation, but also in order to minimise the environmental and societal damage caused by microfibres, especially from polyester. We are only now learning about the danger these tiny pieces of plastic pose to our water supply, our food chain, and our own bodies.

Here are just a few of the facts causing such rapidly growing concern:

- Washing a fleece jacket sends as many as 81,000 microfibres into the world's waterways.
- Every day, New York City pours as many as 7 billion tiny pieces of plastic into its harbour.
- By 2050 – a mere 31 years from now – there could be as many as 950 million tonnes of plastic in our oceans. To put that into perspective, it's entirely possible that within a generation, the world's oceans will contain more plastic, by weight, than fish.

If all of those things weren't bad enough, research released in August in the peer-reviewed journal *Science Advances* shows that microfibres have been found on remote ice floes in the Arctic Ocean – meaning that they are airborne and pose a threat all over the planet, not just to our waterways.



There is so much good to report!

Unfortunately, bad news doesn't just travel fast; it also travels far and wide. That's why it is the responsibility of everyone in the cotton supply chain not only to point out false statements, but to actively promote cotton by spreading facts and good science. For example, cotton is grown in 75 countries by 100 million family units. That provides direct employment to more than 150 million people, accounting for seven percent of all labour in developing countries.

And whilst many people tend to think of cotton only in terms of the fibre and the clothing that we wear, this is only half of the story. The seeds can be used to grow more cotton, but they can also be used to make cotton seed oil, one of the best and healthiest cooking oils available anywhere. Elsewhere, they are used in seed cake to feed to livestock, and even the stalks can be used to make biomass, which ensures that we put back into the soil the nutrients we have taken out.

In fact, nearly 100 percent of the cotton plant is usable for one application or another, and because it is a xerophyte – a semi-arid plant – cotton requires only 600 millilitres of rainwater annually. That means it can be grown in regions where many other food crops cannot grow, and the fibre and seeds can be stored for future use.



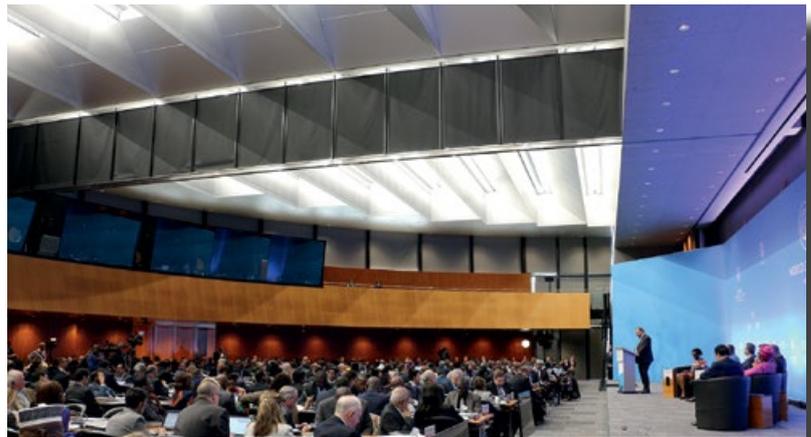
This global celebration of cotton will be held in future years on October 7 – a date that the United Nations is expected to add to its permanent calendar before next year’s event. A number of countries, led by the C4 (Benin, Burkina Faso, Chad and Mali), are strongly urging the UN to officially recognise World Cotton Day because so many of their citizens depend on it to earn a living. Many of them are women who have no other way to generate income for their families.

More than anything else, cotton’s natural properties are what make it unique and worth defending in the media. Consumers already prefer cotton to synthetics. It is because cotton is a comfortable, renewable, natural fibre that consumers will always prefer to sleep in a bed with cotton sheets or wear a cotton shirt or dress, rather than one made from man-made fibres.

And if the public is better educated about the benefits and versatility of cotton, it will make an even more compelling case for choosing natural fibres – a choice that might just help to save the planet from the growing threat of microplastic pollution.

It is for these reasons, and many more, that cotton has come to be known as the ‘poverty-alleviating crop’. Its global importance was highlighted at the October 7 launch of World Cotton Day, an initiative conceived by the ICAC in association with its partners: the World Trade Organisation (WTO), the Food and Agriculture Organisation (FAO), the International Trade Centre (ITC), and the United Nations Conference on Trade and Development (UNCTAD).

Anyone who doubted cotton’s importance had their concerns put to rest when they saw the crowd at WTO headquarters on World Cotton Day – both in terms of the number of attendees and their importance. Initially projections were that 500 people would attend the event in Geneva; in fact, more than 700 people were on-site on October 7, among them a number of senior government officials including more than a dozen Ministers of Agriculture and Trade.





The world cotton market: shifting trade flows and falling prices

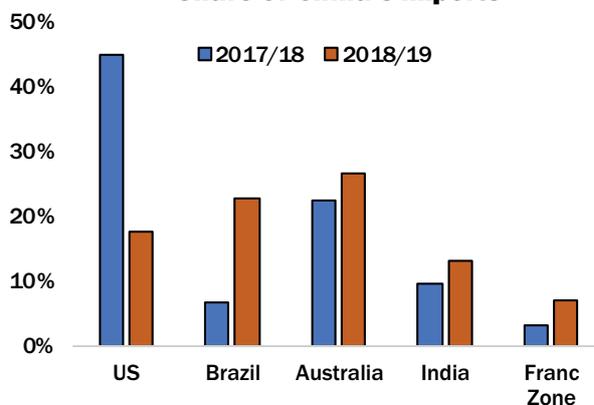
Mike Edwards, Editor, Cotton Outlook

For very many participants in the international cotton market, the period since ICAC met in plenary session in Abidjan in December 2018 has been a difficult one, to say the least. As delegates arrived in Côte d'Ivoire, world prices had already declined sharply from their peak in mid-2018. The Cotlook A Index, the barometer of the global market, had crossed the dollar mark in May/June of that year, a threshold surpassed on only a handful of occasions in its more than half a century of existence. From then until December, the downward trajectory was fairly unrelenting, punctuated only by brief rallies, generally prompted by a statement from a Chinese or US official, or a tweet from the White House.

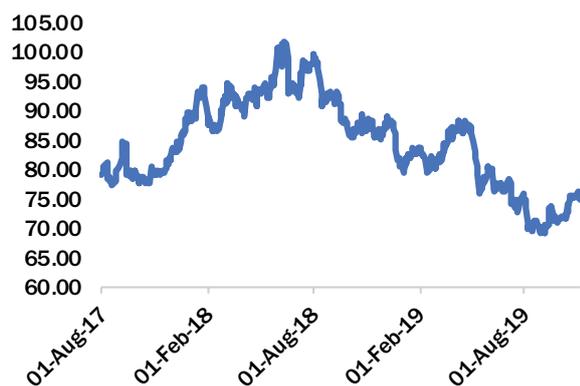
As the last statement indicates, the market's fall was linked closely to the impact, both direct and indirect, of the progressively worsening state of trade relations between the United States and China. Cotton became directly embroiled in the dispute in July 2018, when Beijing introduced an additional tariff of 25 percent on US imports of raw cotton. Market reaction was initially fairly muted. The widespread expectation was that an accommodation between the two sides would shortly be reached. Even if the dispute were to rumble on, it was widely assumed that market disruption would probably be limited to a shift in trade flows. Overall, the threat to the market's price structure was not thought to be too serious.

Trade flows did indeed shift, as is now apparent from Chinese import data. The share of raw cotton imports claimed by the United States fell sharply, from 45 percent during the previous season, to 18 percent in 2018/19. Australia became the single largest supplier with 26 percent (up from 23 percent in 2017/18), while gains were also recorded for India and the African Franc Zone. However, the biggest percentage increase by far was achieved by Brazil, whose share of imports rose from seven to 23 percent.

Share of China's imports



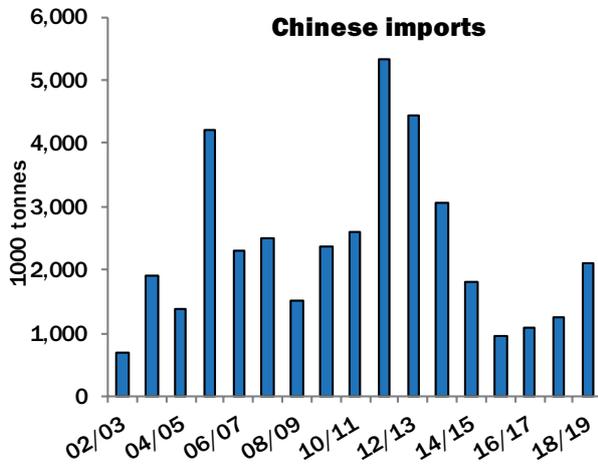
Cotlook A Index



At 2.1 million tonnes, China's cotton imports were the highest since the 2013/14 season. Imports under the Tariff-rated Quota (894,000 tonnes, the volume mandated under the terms of China's accession to the World Trade Organisation) were supplemented by 800,000 tonnes of discretionary Sliding-Scale Quota, as well as (quota-free) purchases by mills in Free Trade Zones and those attributed to China's State Reserve organisation.

The shifts in trade between China, the United States and various other suppliers of raw cotton, however, have been eclipsed by the broader impact on world raw cotton consumption of the Sino-US tensions. In September 2018, it seemed probable that during the 2018/19 season world consumption would cross the threshold

of 27 million tonnes for the first time. The figure is of some significance since world production has surpassed that level only once in history – in the aftermath of the record prices attained during the 2010/11 season. Our estimate today suggests that consumption eventually proved close to 25.3 million tonnes.



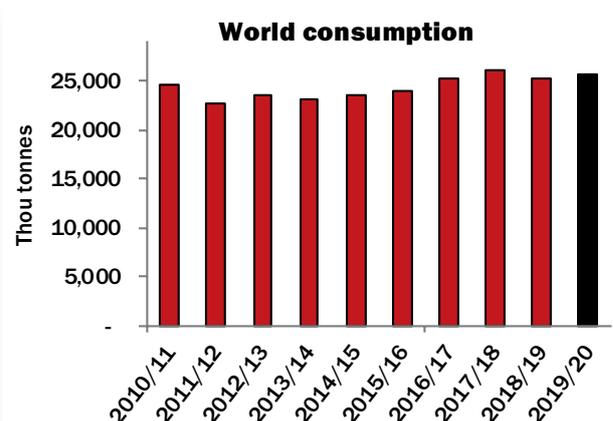
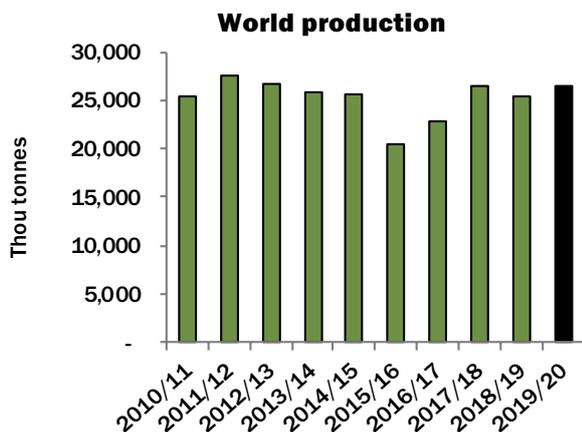
The corrosive effect on trading confidence of the conflict was felt most acutely in China itself but was by no means confined to that market. Poor demand from the downstream sectors of the cotton textile supply chain has placed spinners (many of whom are burdened with outstanding high-priced cotton purchase contracts) in a difficult position. The full impact of collapsing world prices on the international trade, the wellbeing of which depends on the sanctity of the cotton contract, has perhaps yet to become clear. So far at least, the effects have probably been felt less acutely by cotton farmers. Some had already committed their output at prices well above those now in force. Currency factors have partially offset the price decline in certain territories. And in many producing countries (Australia is of course a major exception) the grower is protected from the worst vicissitudes of the world market by government intervention that varies widely both in form and scale.

These factors go some way to explaining the apparent paradox that collapsing world prices have not

resulted in a fall in cotton production during the 2019/20 season. On the contrary, Cotton Outlook’s forecast at the end of October indicated a rise in global output of about four percent, to just below 26.5 million tonnes. Were Australia to have received some respite from the prevailing drought, it is more than likely that global output would this season have once again surpassed the 27-million-tonne mark alluded to above.

Neither has the sharp fall of world prices so far served to stimulate the demand side of the market: the consumption outlook continues to be undermined by the macro-economic and geo-political malaise, which shows little sign of lifting. At the time of writing, Cotton Outlook forecasts a pedestrian increase in world consumption of just over one percent, to 25.6 million tonnes. There are more pessimistic observers who doubt that any growth at all can be relied on during the current season and contend that the Sino-US trade war and its repercussions represent the third major shock to world consumption of the 21st Century (the first two provoked by the global financial crisis of 2008/09 and the period of record world prices and extreme volatility experienced in 2010/11).

Whatever the case may be, the supply and demand numbers do not at present point to a strong recovery of global prices during 2019/20. On current indications, the world will have produced roughly 900,000 tonnes more than it has consumed by the conclusion of the current international season (July 31, 2020). Since a major reduction in cotton supply seems improbable in the short term, the restoration of the market’s health would seem more plausibly to depend on a reinvigoration of the demand side and a restoration of trading confidence throughout the cotton textile supply chain. Sooner or later, the underlying upward trend of world consumption will reassert itself, driven by economic expansion and demographic factors. How soon additional impetus can also be derived from a recognition on the part of the final consumer of cotton’s strong credentials in the areas of sustainability and biodegradability – topics addressed elsewhere in this publication and which also feature on the Brisbane Plenary agenda – remains to be seen.





Cotton: a natural alternative for the microplastic pollution age

Cotton Incorporated

Growing awareness of the persistence of synthetic textile microfibers in the world's waterways may help bolster cotton's position as a natural alternative. Since 2016, there have been more than six million mentions of polyester, microfibers and pollution across English-language media.

Much of the coverage has focused on plastic straws, shopping bags and packaging materials, which find their way into lakes, rivers and oceans through various means. However, there is also a growing awareness of the contribution of synthetic textile fibers to microfiber pollution, as well as shedding of textile microfibers in general.

Numerous studies have confirmed that the machine laundering of textiles generates microfibers that then find their way into the world's oceans, lakes, rivers and wastewater treatment facilities. Most notable among these is a study Patagonia commissioned from the Bren School at the University of California Santa Barbara. That study examined the shedding volumes of synthetic microfibers from specific Patagonia apparel items.

Since the release of the Patagonia study, several organizations have taken up similar research focused on measuring the volumes of microfiber shedding by fiber. Cotton Incorporated, North Carolina State University and the Cotton Research and Development Corporation of Australia took a different approach: measuring the persistence of these microfibers in diverse aquatic environments. While shedding rate research is important to overall understanding, the key environmental issue is how long these fiber accumulations might persist in the various bodies of water.

The two-year study examined degradation rates of 100-percent cotton, cotton/polyester blends, polyester and rayon in sea water, fresh water and waste treatment

plants. The study revealed that cotton microfibers degrade at a markedly faster rate than polyester in the three environments.

"We felt confident that cotton textiles likely shed microfibers in a typical laundry load, just like the synthetics," explains Mary Ankeny, Cotton Incorporated vice president product development & implementation operations. "What we did not know was whether these cotton microfibers were accumulating and persisting in aquatic environments to the same degree as synthetics like polyester," adds Ankeny.

[Research conducted by Cornell University in 2010](#) confirmed that cotton textiles biodegrade more readily on land, as compared to polyester. But no research had been done on how aquatic environments might affect cotton textile degradation.

"Although the Cornell research demonstrated faster degradation rates for cotton than polyester in a land-based disposal scenario, we knew we could not assume that the rates would be comparable across three different water environments," says Ankeny. "We decided to join forces with our Australian cotton counterparts at the [Cotton Research & Development Corporation](#) to fund independent research on the topic." North Carolina State University was identified as having both the capability and expertise to conduct the study.

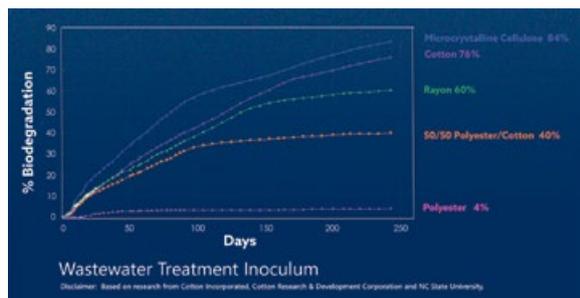
Research methodology

The two-year study set out to determine the degradation rates of cotton, polyester, cotton/polyester blends and rayon in three distinct aquatic environments: wastewater treatment plants, fresh water and sea water. The testing adhered to established test methodologies, which differ for each environment.

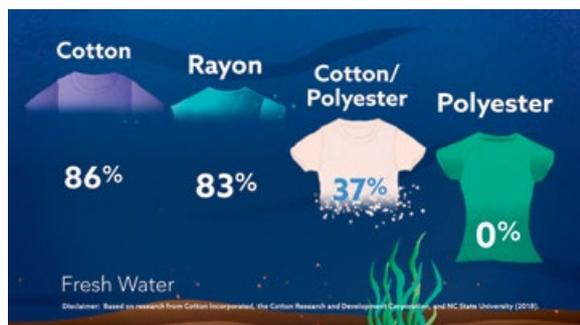
Microfibers of the four fiber types, plus a control of microcrystalline cellulose, were observed in samples from a local (North Carolina) wastewater plant, a freshwater lake in North Carolina, and the Atlantic Ocean off the North Carolina coast.

Research results

In the wastewater treatment environment, the cellulose control achieved 84 percent degradation in 250 days. As per the standardized test method for this environment, the 84-percent milestone marked the completion of the test. The comparative degradation rates over the 250 days are illustrated below:



The fresh water and saltwater tests yielded comparable results after a period of one month:



Synthetic microfiber pollution concerns increase among consumers

According to a 2019 Cotton Incorporated Lifestyle Monitor™ Survey, 27 percent of US consumers are aware

of microplastic pollution. This reflects a 60-percent increase from the 17 percent who made the same claim in 2018. Among those consumers who confirm they are aware, 60 percent say they would avoid purchasing synthetic fabrics in the future.

As the research and promotion company for cotton, Cotton Incorporated is actively sharing the results of the North Carolina State University study to help guide sustainable decision-making among brands, retailers and consumers.

Synthetics and hygiene

The current environmental concerns around synthetic fibers come on the heels of other studies that demonstrate polyester fosters odor-causing bacteria and does not release them as easily as cotton apparel in a standard home laundering process.

In 2014, research from the University of Ghent in Belgium asserted that polyester clothes smell worse than cotton garments following intensive exercise by their wearers, because bacteria that cause odor grow better on polyester. This research was published in the journal [Applied and Environmental Microbiology](#).

Separate research from the University of Alberta, also published in 2014, concluded that polyester is more apt to retain body odors, even after home launderings. In this study, the researchers discovered that laundering was effective in reducing overall odor intensity and bacterial populations in both cotton and polyester fabrics. However, odor was most intense on polyester fabrics following wear and after laundering. The research suggests that the build-up of odor in polyester fabric may be cumulative, and that important odorants such as carboxylic acids are not as effectively removed from polyester by traditional home laundering, when compared with cotton. The results of this study were published in the International Journal of Clothing Science and Technology. It should be noted that Cotton Incorporated was among the sponsors of this research.

Cotton as a natural alternative

The inherent comfort and breathability of cotton have always been points in its favor over synthetics such as polyester. However, the relative inexpensiveness of synthetics and perceptions of their performance, especially in athletic wear, have contributed to the widespread use of synthetics in apparel over several decades. Today, as awareness of synthetics' odor cultivation, odor retention, and the persistence of synthetic microfibers in waterways grows, cotton emerges as a natural alternative.

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