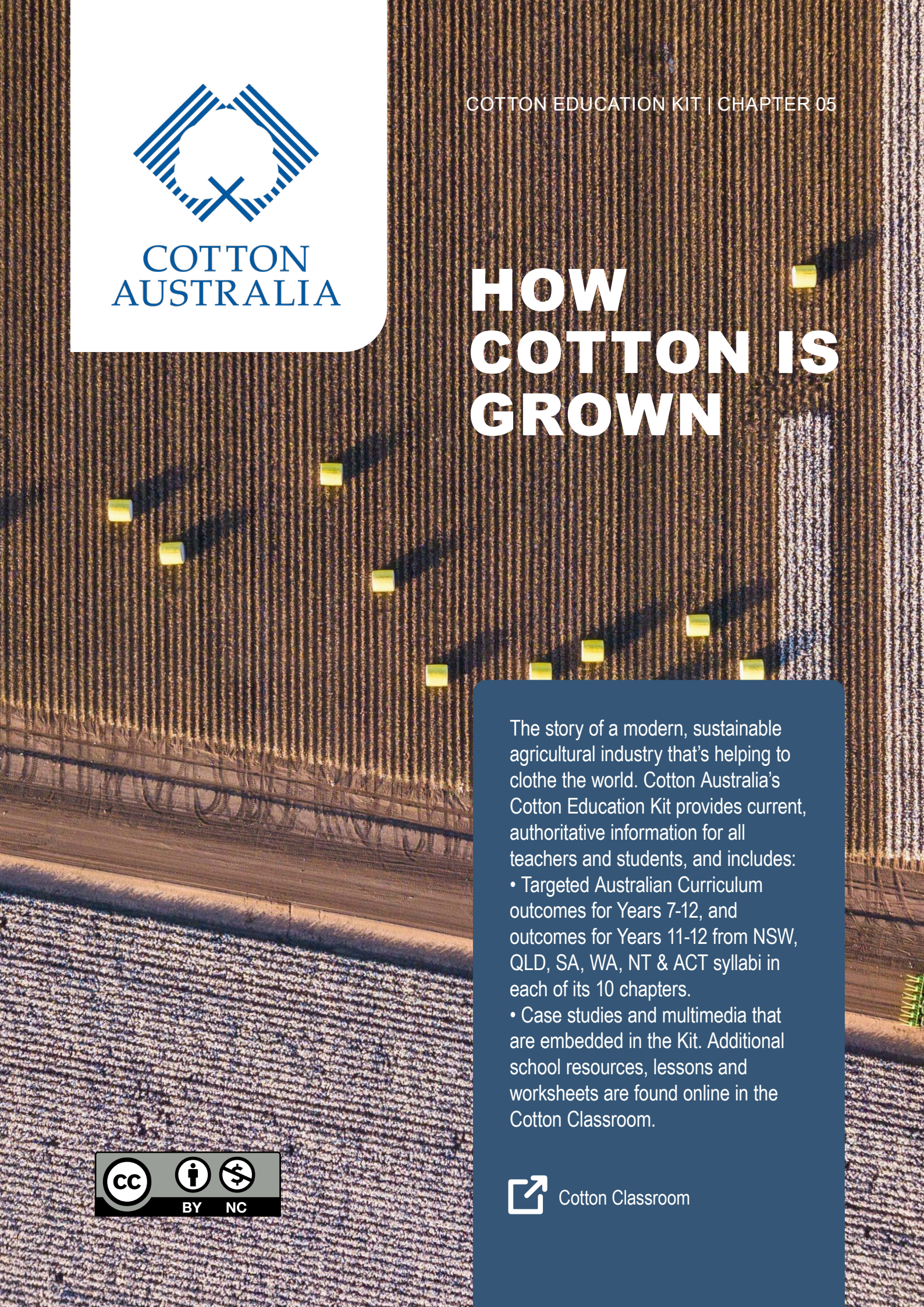


COTTON AUSTRALIA

HOW COTTON IS GROWN

The story of a modern, sustainable agricultural industry that's helping to clothe the world. Cotton Australia's Cotton Education Kit provides current, authoritative information for all teachers and students, and includes:

- Targeted Australian Curriculum outcomes for Years 7-12, and outcomes for Years 11-12 from NSW, QLD, SA, WA, NT & ACT syllabi in each of its 10 chapters.
- Case studies and multimedia that are embedded in the Kit. Additional school resources, lessons and worksheets are found online in the Cotton Classroom.

Cotton Classroom

GROWING CONDITIONS

Water availability and local climate are the most significant contributing factors to the distribution and type of cotton grown in Australia and the rest of the world.

Cotton can be grown either as dryland (rain-grown) or as irrigated cotton (requiring supplemented water supply).

Dryland (rain-grown) cotton requires:

- A full soil moisture profile at the start of the season.
- Rainfall during the summer months.

Irrigated cotton requires:

- A reliable water supply.
- Irrigation water from rivers, dams or underground.

The ideal climate for growing cotton is warm sunny days with temperatures between 27-32 degrees and overnight temperatures between 16-20 degrees C. Temperatures below 11 (cold shock) or above 36 (hot shock) temporarily impede plant development and can delay crop maturity. Extended periods of low solar radiation, (eg cloudy weather) and/or excessively hot weather during the flowering period can reduce yield potential.

Irrigated cotton is better suited to low rainfall environments because the farmer has more control over the level of moisture in the soil. The quality of the cotton is also less likely to be affected by rainfall when the bolls open (rain on open cotton bolls can cause discolouration). Irrigated cotton will significantly out-yield rain-grown cotton.

Dryland (rain-grown) cotton can be grown profitably in some areas. Growers will make the decision about planting a rain-grown cotton crop based on stored sub-soil moisture and the current price being offered for cotton.

Nigel Burnett and Dean Thompson checking out 'baby cotton' at Nigel and Beth Burnett's farm, 'Colorada', at Emerald, Central Queensland.

Cotton is planted directly into wheat stubble to help conserve moisture for healthier soil.

PREPARING THE LAND

The first step in growing any crop is to prepare the land. It takes time to get the soil and the general field characteristics ready for cotton growing.

Soil preparation starts immediately following the last cotton crop. Most farmers now leave their cotton stubble standing in the field and mulch it back into the soil to add valuable nutrients. This also helps the soil retain moisture by reducing evaporation.

On an irrigated cotton farm, fields are levelled and graded so that they have a precise slope or grade. This is done to enable water to flow from the top of the field to the bottom of the field in a controlled way. If the field isn't sloped enough or is uneven, then water can lie around and waterlog the soil; or if too steep, the water will run off too quickly and not soak into the soil profile. It is important that the slope enables the water to flow slowly down the field watering all the plants evenly. A tail drain is constructed at the end of the field to recycle the excess run-off water, this is then reused to irrigate other fields.

SOIL TYPES AND **ACHIEVING HEALTHY SOILS**

Cotton is predominantly grown on cracking self-mulching clay soils commonly known as Vertosol soil types and represents 60 percent of all cotton grown. These soil types expand and contract depending upon the water content of the clay. A further 30 percent is grown on red/ brown soil and the remaining cotton is grown on river alluvial soil.

Growers test the soil a few months prior to planting to check nutrient levels and how much fertiliser may be required. Nitrogen is the main nutrient needed by cotton plants, and it can be applied in the form of anhydrous ammonia, a liquid that when directly applied to the soil, changes back into a gas and clings to soil particles for the plants to use later. Nitrogen can also be applied in granular form. Nitrogen can be added to the soil up to three months before planting, or during the growing season. Cotton also needs many other nutrients such as phosphorus, potassium, sulphur and zinc. Growers will only apply what is needed by the plant to achieve the best yield.

Growing only one type of crop in a field can lead to a deficiency of nutrients and a build up of disease. To avoid this problem, crop rotations are used.

The choice of crop type used to rotate with cotton is based on a number of factors including suitability of the rotation crop to the growing region climate, water availability, climate forecasts and current market price of the rotation crops.

A common crop rotation scenario is cotton, followed by wheat, followed by a sorghum crop or fallow (crop free) before going back into cotton, however there is a wide range of crops that are grown in rotation with cotton.

60% of cotton is grown on self-mulching, cracking clay soils.

A John Deere MaxEmerge planter in action. Photo by Jamie Condon.

SEED SELECTION AND GM COTTON IN AUSTRTAIA

100 per cent of Australian cotton is currently grown from CSIRO seed varieties. Cotton Seed Distributors produces and tests all seed to internationally accepted protocols with field trials and make comprehensive variety and agronomic trial data and analysis available to growers to choose the best seed variety for their region and circumstances. Today there are two broad classes of cotton biotechnology traits which are approved and available in Australian cotton varieties providing either insect protection, herbicide tolerance or in varieties which are 'stacked' with a combination of both traits.

CASE STUDY: 100 Cotton Varieties and counting

The Cotton Education Kit's Chapter Two gives an overview of Biotechnology and Cotton.

The Plant Biotechnology 101 booklet FROM Crop Life Australia.

Adoption and impact of Genetically Modified (GM) crops in Australia: 20 years' experience.

The official Australian reference guide to Agricultural Biotechnology And gm Crops.

PLANTING

Cotton seed is planted in spring as soon as the soil is warm enough to ensure satisfactory seed germination and crop establishment. The soil is warm enough when the temperature reaches 14 degrees Celsius at a depth of 10 cm for at least three days in a row.

In northern NSW, the right soil temperature is usually reached in late September or early October. In central Queensland, it is likely to occur up to a month earlier, and in southern NSW, planting occurs around mid-October.

On irrigated crops, cotton is sown with six, eight, 10 or 12 row precision planters that place the seed at a uniform depth and interval along rows typically spaced one metre apart (rows planted one metre apart are known as a 'solid' configuration). Seeds are planted about 10 -12 seeds per metre, four centimetres deep, into the soil on top of the rows (mounds).

Another way that Australia's cotton farmers maximise yields and fibre quality and save water and fertiliser is to reduce the number of plants by planting in "skip rows".

This is achieved by leaving a configuration of rows of cotton bare of seed or 'skipped'. Skip row planting is common practice for rainfed planting and when irrigators have limited water as it allows for more available soil per plant to capture rain moisture.

There are three common options for skip row planting, and these have become more common and easier due to the flexibility of modern harvesting equipment;

- Single Skip - every third row is skipped (therefore the field has 66% plant population);
- Double Skip – two adjacent rows are planted and then 2 are skipped (50% plant population);
- Super Single – every third row is planted alone (33% plant population).

A recent variation of solid and skip row planting configurations in irrigated cotton systems is to plant evenly spaced rows 1.5 metres apart (creating a plant population of 66% of a standard solid planting).

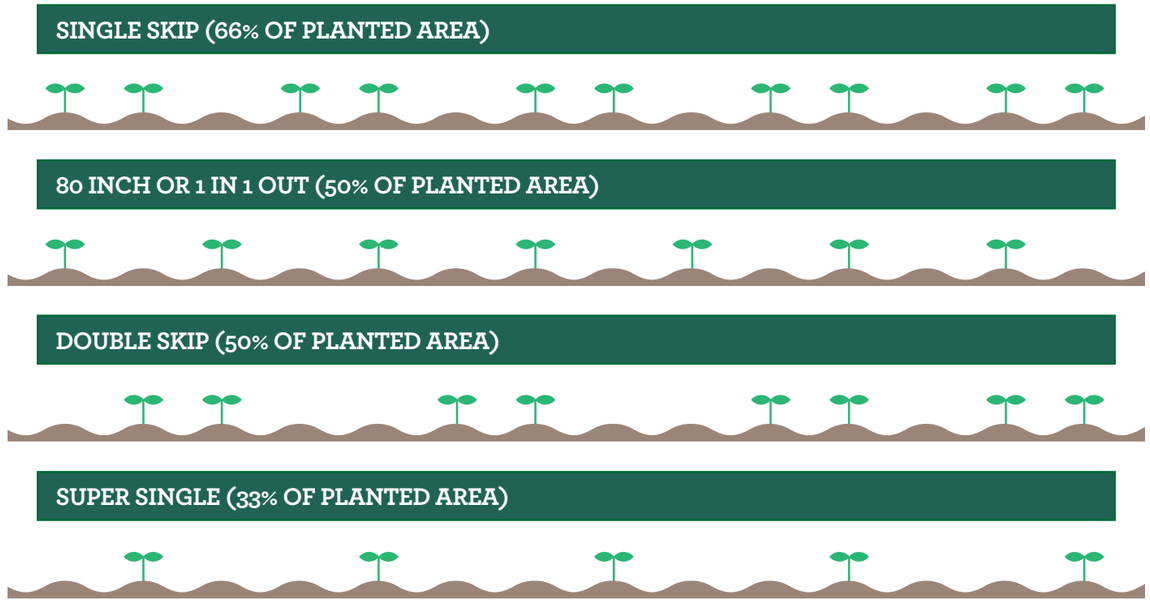
Super single skip row cotton early in the season.

Double skip row cotton early in the season.

Machinery working a double skip row.

ROW CONFIGURATION **GUIDE**

(Source: CSD Getting the most out of skip irrigated cotton)



CottonInfo: Row spacing in rain-grown cotton.

MANAGING **THE CROP**

Producing a high quality, high yielding, water efficient cotton crop requires careful management throughout the season. The following section outlines some of the most important things to manage throughout the growing season.

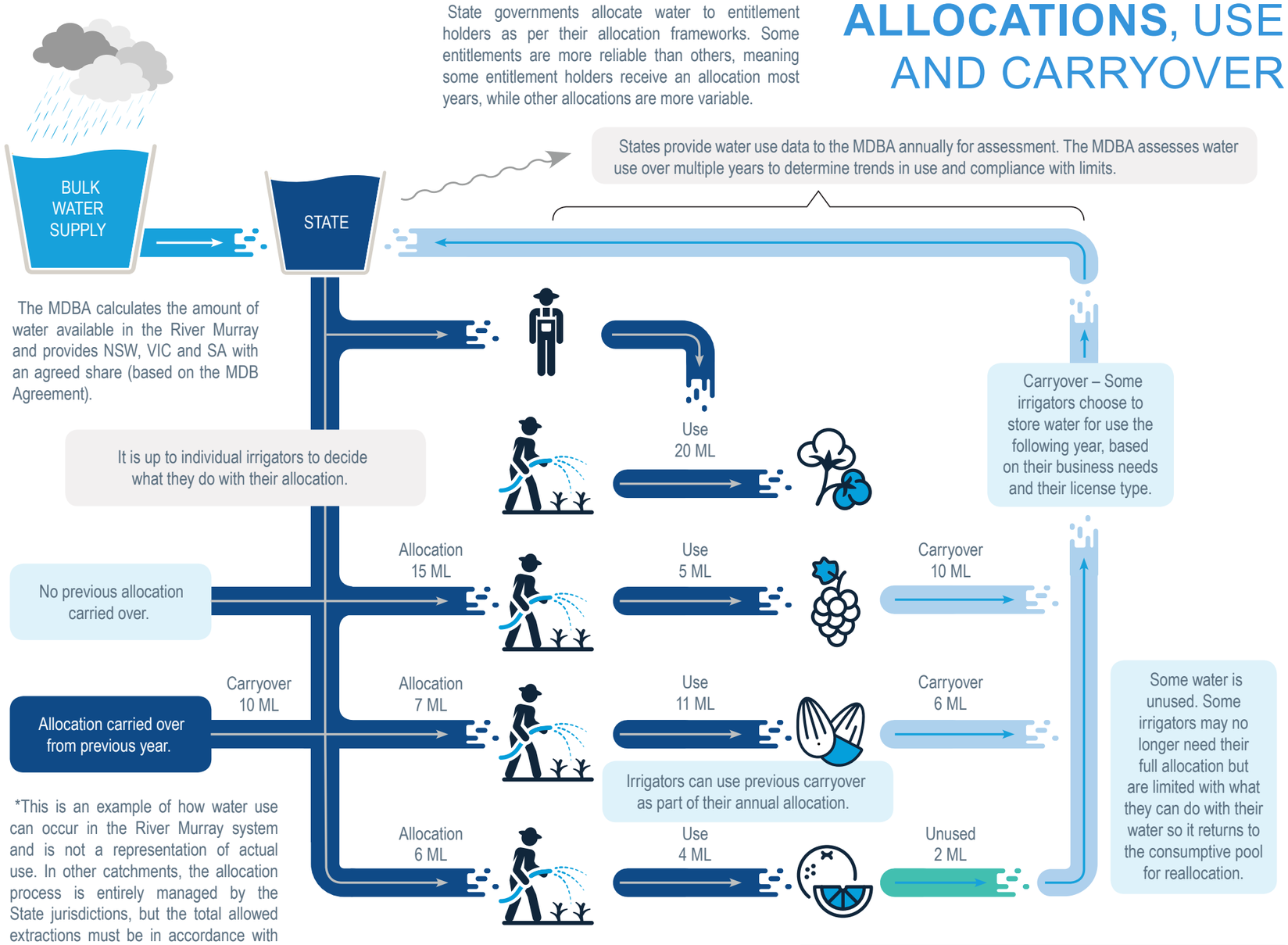
WATERING BY IRRIGATION

While not all cotton crops rely on irrigation water, this is a major component of growing a cotton crop.

Irrigation water trickling down the gently sloping furrow.

ALLOCATIONS, USE AND CARRYOVER

State governments allocate water to entitlement holders as per their allocation frameworks. Some entitlements are more reliable than others, meaning some entitlement holders receive an allocation most years, while other allocations are more variable.



*This is an example of how water use can occur in the River Murray system and is not a representation of actual use. In other catchments, the allocation process is entirely managed by the State jurisdictions, but the total allowed extractions must be in accordance with the Murray-Darling Basin Plan I.

Water for irrigation is a managed resource as shown by the Murray Darling Basin Authority with an example of how water use can occur in the River Murray system.

Know the Facts – Water Allocations.

WHAT IS **IRRIGATION**

Irrigation means moving water mechanically from one place to another for agriculture. Irrigation generally occurs in Australia when rain falls at a different time to when the crops need it. Water for irrigation comes from rivers or underground supplies (huge underground lakes from which water is pumped via bores).

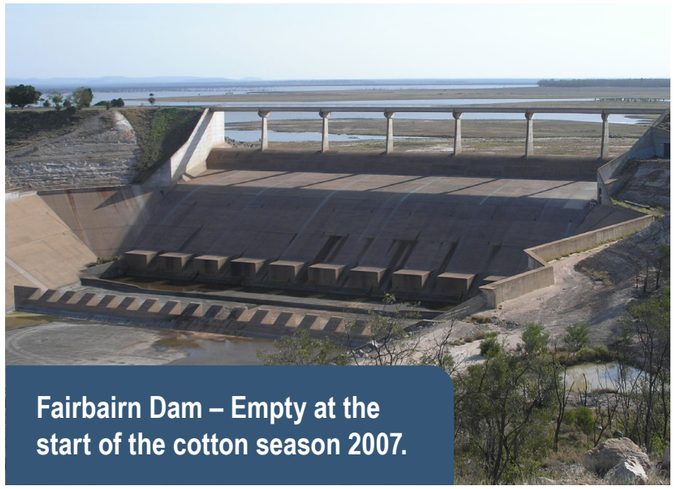
State governments construct dams to hold water and then stringently control the allocation of access to water. Irrigation farmers are issued a licence to access a volume of water, depending on seasonal conditions, at an agreed storage and delivery price each year. They pump the water from rivers or underground water supplies onto their farms where it is usually held in on-farm storages until it's needed.

In the case of cotton growers (who could plant a crop each year), the available water supply for irrigation changes each year depending on how much rain there has been and how much water is in the dams. Water distribution for towns, people and domestic use, livestock, the environment and permanently planted crops (such as fruit trees) always have priority over cotton farms.

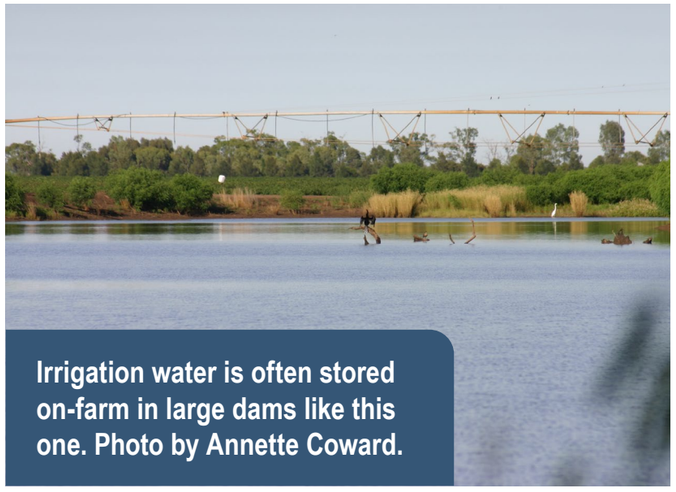
Cotton growing therefore requires careful water management. Well-designed and well-built systems, combined with careful application, ensure that a minimum amount of water is used, and that there are many safeguards against wastage. Usually the land in an area that uses irrigation is naturally flat (often on a flood plain), allowing the water to be easily moved from the natural source to the irrigated area.

Careful design of irrigation systems is important to ensure:

- Water travels down a field at just the right speed to water, but not waterlog, the plants;
- That all run-off water is collected and recycled for re-use in the next irrigation;
- Maximum water savings.



Fairbairn Dam – Empty at the start of the cotton season 2007.



Irrigation water is often stored on-farm in large dams like this one. Photo by Annette Coward.

Fairbairn Dam releasing excess water during a major filling event.

Australia's variable climate sees droughts and flooding rains. That's why governments have built public dams to store water so that there can be a greater security of supply.

TIMING OF IRRIGATIONS

To really get the crop growing well from the early stages, there needs to be adequate moisture in the soil before the crop is even planted. If there isn't enough water in the soil from recent rains, growers can either add a little extra water before cotton seed is planted, or they can add the water just after the seed is planted. This is called 'watering up' the crop. This initial irrigation is usually followed by a further four to five irrigations at two to three-week intervals, from mid-December to late-February.

The time the crop really needs water the most is during January and February in most growing regions. This is when the temperatures are highest and the fruit (bolls) on the plants is starting to mature and fill. The timing of these irrigations is crucial to achieve high yields (quantity) and high-quality cotton fibres.

Blog: Read this blog to hear from cotton farmer Renee Anderson in Emerald, Queensland about how technology such as moisture probs are used on the farm.

MEASURE TO MANAGE: **WATER USE EFFICIENCY**

Water is a cotton grower's most precious resource, and so everything is done to conserve moisture to get the most out of every drop. Australia's cotton industry is now considered the most water-efficient in the world, reporting a 48% improvement in water use efficiency since 1992.

One of the key ways for growers to save water is to only water the cotton plants when they need it with the use of soil and leaf temperature data capturing devices. Fields equipped with soil moisture probes (called capacitance probes) are placed at regular intervals that electronically measure how much moisture is in the soil. This data is sent back to the farmer's computer system or mobile phone/ tablet, where an assessment is made about whether that field needs watering. It's a very measured, scientific approach that has made a huge difference to the way cotton farmers manage their water.

This is a probe to measure soil moisture. It contains a telemetry unit, data logger and solar panel. The moisture probe is in the ground below and generally has sensors at specific intervals in the soil profile, every 10cm for about 120cm.

TYPES OF IRRIGATION

Most of Australia's cotton is grown under furrow irrigation systems, systems that have improved their water saving capacity dramatically over the past 20 years using a range of techniques.

How to start a siphon, and siphon management on a cotton farm.

Furrow irrigation.

Cotton growers are increasingly using other forms of irrigation that offer even greater water savings. In some areas, on some soil types, these methods are not suitable – cotton farmers use the best combination of irrigation tools and techniques that suit their local conditions. Some of the newer forms of irrigation are overhead systems such as pivots and laterals, drip, bankless channels and "through the bank" systems.

Case Study - Drip Irrigation. Rob Tuck from TuckAg shares how Rivulis provided the right irrigation solution for his cotton crop needs, leading to measurable results including water savings and yield increase.

DRIP IRRIGATION

Drip irrigation is an option for use particularly in sandy soils (where water disappears quickly) and extremely hot regions (where evaporation occurs quickly). Drip infrastructure (pipes and dripper mechanisms) is laid beneath the surface, deep enough to not be disturbed by cultivation machinery, but at a level enabling the delivery of water directly to the plant roots. Drip irrigation ensures maximum efficiency of water allocation, although the cost is much greater.

BANKLESS **CHANNELS**

Bankless irrigation is a system of overflowing the head ditch into a paddock with the grade running in the opposite direction to a typical raised bed irrigation and siphon system. The excess water then drains back into the head ditch and on to the next bay.

Case Study: South-west Queensland growers have been worked together to find new ways to save water, and now they are leading the way in water use efficiency using Bankless Channels.

Bullamon Plains in St George QLD has a bankless channel irrigation system to conserve water.

THROUGH **THE BANK**

This is a siphon-less irrigation system, one of a number that's been extensively trialled in the Australian cotton industry. Pipes are inserted through the channel banks, with "gates" to better control water flow into the furrows.

A pilot-automated irrigation system with Padman Box Culverts that are automated using Rubicon FarmConnect BayDrives™ at "Waverley" west of Wee Waa is showing potential for an exciting future, with labour savings and application precision the major benefits.

Drone footage showing automated cotton irrigation systems in Australia. The first solution shown is a permanent siphon system and the second is bankless channel system.

The installation of a solar diesel hybrid irrigation bore pump on a Central West NSW farm has led to big cuts in fuel costs, greater irrigation efficiencies and a massive reduction in greenhouse gas emissions. Attracted by the drop in the price of solar panels in recent years and the prospect of the system paying for itself in less than four years, Andrew Gill and his family decided to install a solar diesel hybrid system at one of the pump sites on their Narromine farm.

Dr Joe Foley (USQ) and his team have been working on refining the current automated irrigation system at “Waverley” west of Wee Waa to a fully autonomous system that makes irrigation decisions based on field sensor data and then controls relevant irrigation gates and pumps.

OVERHEAD PIVOTS OR LATERAL-MOVE IRRIGATORS

Overhead centre-pivots, and lateral-move irrigators are large sprinkler-like irrigation systems that water the cotton plants from above, rather than below. The plants are ‘sprayed’ with water (simulating rain) that is released along the arms of the pivot or lateral-move. In some circumstances they can provide significant efficiencies, primarily by closely managing soil moisture levels to meet all the crop’s water requirement, while maximising the opportunity to store any rainfall in the soil.

Case Study: Variable rate hardware attached to individual sprinklers on centre pivot or lateral-move irrigation machines can be used to apply water more evenly across a field, resulting in improved yield and water use efficiency. USQ researcher Alison McCarthy explains how new software integrates a wider range of data into the decision-making process.

Overhead lateral-move irrigator.

Cotton uses about the same amount of water as other summer crops, is drought and heat tolerant. Cotton's average irrigation requirement is 6-7 megalitres per hectare (ML/ha) (source: Crop and Pasture Science 2013). This compares to the average water use of rice (11.5ML/ha), fruit and nut trees (5.1 ML/ha) and vegetables for human consumption (4 ML/ha) (source: ABARES). The Australian cotton industry experiences seasonal variation in water use but has a long-term trend of reduced water use and increased water efficiency per bale. This is reflected in the Australian Cotton Sustainability Report 2019, which shows from 1992 to 2019, there has been a 97 per cent increase in the bales of cotton grown per megalitre (ML) of water (effective rain and irrigation). This equates to a 48 per cent decrease in the water required per bale of cotton.

Fact Sheet: Cotton and Water.

The Doolins at North Star NSW have installed overhead pivots that saw yields improve from seven bales per hectare to 12 bales per hectare.

WATER REQUIREMENTS FOR VARIOUS IRRIGATED CROPS GROWN IN THE MURRAY - DARLING BASIN (MEGALITRES PER HECTARE)

Almonds *	14
Rice **	11.5
Mature citrus ***	10-12
Maize ****	8-9
Lucerne for Hay *****	8.8
Wine grapes ********	8.2
Cotton ******	6-7
Soybeans *****	6
Sorghum *******	5.2
Fruit trees, nut trees, plantation or berry fruits **	5.1
Grapevines **	4.3
Vegetables for human consumption **	4
Sunflowers *****	3.9
Summer Mungbeans *******	3.4

** Australian Almond Board, 2016*

*** Source: Water Use on Australian Farms, 2016-17 (NSW data)*

**** NSW Dept of Primary Industries 2018 (for Sunrasia and Riverland areas)*

***** GRDC Maize Grow Notes 2014*

****** NSW DPI Farm Enterprise Budget Series, Central and Southern Zone 2012*

******* Crop and Pasture Science 2013 (a peer-reviewed, 23 year review of cotton's seasonal water use)*

******** Source: WATERpak - CRDC 2012*

********* Assessing Yield Water Use Efficiency in the Murray Valley and Riverina Wine Regions 2012/13*

CASE STUDY: Webinar discussing late season irrigation management presented by CSIRO & Cotton Seed Distributors.

NUTRITION

Just like any living thing, cotton plants need "food" to grow well. It's important to find the right balance of delivering nutrients to the plant at various stages of its growth, without overdoing it.

To do this, cotton growers need a sound knowledge about plant nutrient requirements and demands, and an understanding of soils. Decisions about application of fertilisers are made with consideration of a large range of other factors including crop rotations, stubble management and irrigation practices.

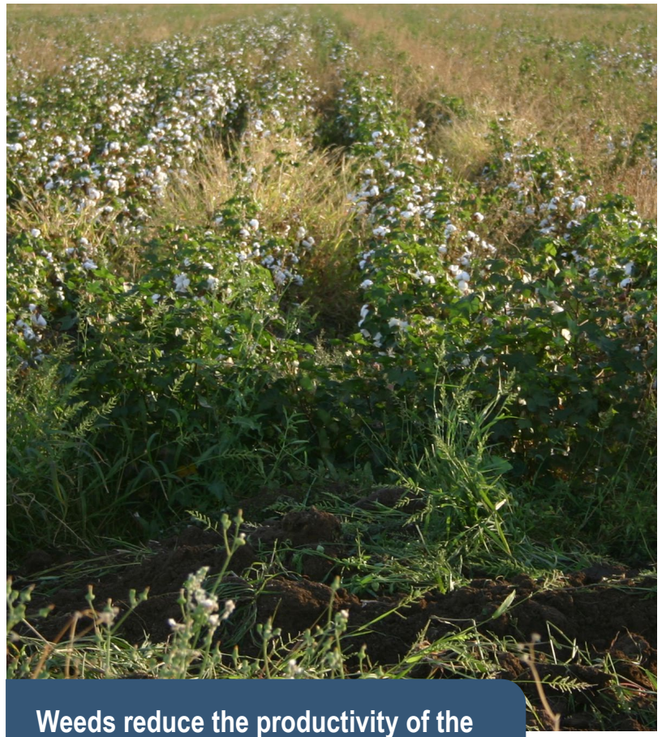
Cotton growers develop a fertiliser program, but before that can happen, a grower needs to:

- Determine soil nutrient status through soil sampling;
- Calculate expected crop nutrient requirement;
- Implement a fertiliser use plan considering – type, rate, application, frequency, timing;
- Monitor crop nutrient status via leaf (and petiole) analysis;
- Develop a long-term crop nutrition and soil health management plan;

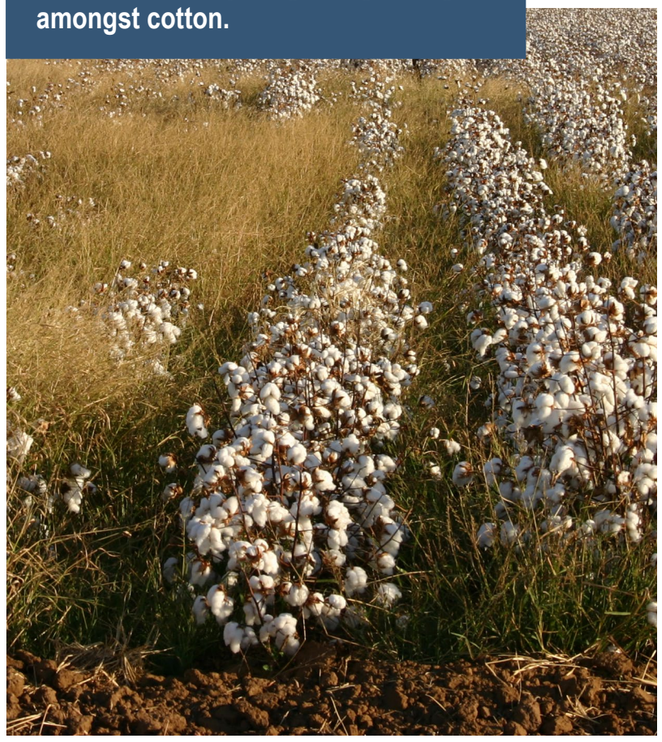
The main nutrients that a cotton crop requires are:

- Nitrogen
- Phosphorous
- Legumes
- Potassium
- Zinc
- Iron

The above information was extracted from the Australian Cotton Production Manual 2020, CRDC.



Weeds reduce the productivity of the cotton crop by competing for food, water and light as shown above and below with Barnyard grass growing amongst cotton.



CONTROLLING **WEEDS**

A cotton farm can be home to a wide range of weed species. Many of these weeds are native and were present before cotton was first grown in these areas. Many more weed species, however, are introduced by a range of methods including the wind, transferred via waterways and wildlife or even farm livestock, and have successfully established on cotton farms.

Some of these weeds are of little importance, but most compete with cotton and are routinely controlled on cotton farms. More than 200 weed species are currently considered to be weeds of significance on cotton farms.

Weeds reduce the productivity of the cotton plants by competing for food (nutrients), water and sometimes light. If the weeds put too much pressure on the cotton plants, the quality and yield of the cotton is reduced.

Weeds may also provide a haven for pests and diseases, attracting them to the crop. During harvesting, weeds can choke up the machinery and contaminate the crop, and a contaminated crop means extra time spent cleaning and processing, and additional ginning costs for the growers. Weeds can also cause contamination of the cotton and discolouration of the cotton lint.

There are many different types of weeds found in cotton areas, and they vary between the regions. Some of the common ones are noogoora burr, nutgrass, anoda weed, sesbania and cowvine.

Growers spend a lot of time and effort controlling weeds, using several methods including:

- Cultivation – digging up weeds between the rows of cotton using a machine called a cultivator;
- Herbicides – sprayed to kill weeds before planting and during the season;
- Chipping – weeding by hand using a hoe-like tool, which is time consuming and labour intensive. This is a much less common practice in the modern cotton industry.

WEEDpak covers a number of topics related to improving our knowledge and thus the control of our weeds.

The following YouTube series on weed management in cotton shows some of the key considerations for managing weeds on farm, including sources of weed seeds and managing resistance.

Herbicide Resistance Management Strategy. Herbicide resistance, particularly to glyphosate, is an increasing problem in agriculture. More than 99 per cent of the cotton grown in Australia contains a genetic trait that makes it tolerant to glyphosate. This means glyphosate can be applied over the cotton crop to control weeds, without damaging the cotton plants.
The cotton industry's Herbicide Resistance Management Strategy is designed as a tool to manage the risk of herbicide resistance in irrigated and dryland farming systems that grow cotton containing herbicide tolerance to glyphosate.

MANAGING **DISEASES**

Diseases affect the quality of the cotton lint as well as the productivity of the cotton plant. Different diseases attack different parts of the cotton plant — the leaves, stem, bolls and roots. Disease may even cause the plant to lose its flower buds and bolls, resulting in no cotton being produced at all.

Cotton can be affected by a range of diseases. The most serious ones in Australia are:

- Bacterial Blight, a bacterial disease that causes dark green angular spots on the underside of the leaf. It may also affect young developing bolls.
- Fusarium Wilt, a common fungus that infects plants via the root system. It blocks the plant's ability to take up water.
- Verticillium Wilt, a common fungus that infects plants via the root system. It blocks the plant's ability to take up water.

There are three main ways to combat disease:

1. Rotation and fallow - since diseases can build up in the soil when the same crop is grown year after year, crop rotation is a common method of prevention. Rotating or changing the crops in a field every few years means diseases don't get a chance to settle in, breaking their cycle. Growers may also let a field lay 'fallow'. A fallow field is a field that is being rested, with no crops in it at all.

2. Plant breeding - cotton scientists have also developed resistant or tolerant cotton varieties that are able to fend off certain diseases. By introducing these new, stronger varieties, growers can get rid of diseases without having to use other methods.

3. Fungicides - a fungicide is a chemical that kills fungi. Most planting seed sold in Australia has been coated with a fungicide to protect it during its early days in the soil.

CASE STUDY: CottonInfo webinar: Re-occurring wilt. Join pathology and biosecurity experts as they discuss a possible new disease of cotton. Recorded on 27 August 2020.

Come Clean Go Clean is an industry-wide iniatitive to help stop the spread of pests, weeds and diseases by making sure vehicles and equipment are clean before they come onto or leave your farm. Follow these three simple steps:
1. Wash down your boots and vehicles. Park on a clean wash pad where contaminants can be trapped. Apply high pressure water to all surfaces to remove trash and mud, being sure to get into crevices. Don't forget to clean your boots!
2. Decontaminate. Apply decontaminant to all surfaces.
3. Rinse. Rinse off decontaminant, and clean down the wash pad.

The 2016 Cotton Nutrition Tour was delivered by the industry's extension program, CottonInfo, with support from CottonInfo partner CRDC, researchers and research organisations, and sponsors Yara, Fertcare®, Koch Fertilizer, SST Software and Incitec Pivot. The tour was also supported by funding from the Australian Government.

CONTROLLING INSECTS

Healthy cotton crops are unfortunately very attractive to insects throughout their whole growing period. As cotton is a lush, green and bushy plant, many insects love to attack it.

More than 100 different types of pests attack cotton, which makes crop protection an important part of a cotton grower's job. If these "bad" bugs are left unmanaged, the crop is badly damaged and major yield and quality losses are the result.

The following are the main insects that affect cotton production, requiring control measures in most regions in most seasons:

- Heliothis caterpillar (Helicoverpa punctigera or Helicoverpa armigera)
- Green mirid (Creontiades dilutes)
- Silverleaf whitefly (Bemisia tabaci)
- Two spotted mite (Tetranychus urticae)
- Cotton aphid (Aphis gossypii)

CASE STUDY: Fall Army Worm is one word 'Fall Armyworm'.

The fall armyworm, Spodoptera frugiperda (Lepidoptera: Noctuidae), is one of the most devastating agricultural insect pests in the world. It feeds on a broad range of important food and feed crops including maize (corn), sorghum, rice, millet, sugarcane, cotton, potatoes, etc. It affects the economy and agricultural trade of entire regions and is a threat to food security for millions.

As of December 2020, fall armyworm had spread further south into New South Wales. This highlights the ability of this pest to spread rapidly into new areas.

The Silverleaf Whitefly is one of more than 100 pests that attack cotton.

Fall armyworm is a pest that has recently arrived in Australia and threatens cotton.

The most common and most capable pest of causing significant crop damage is the Heliothis. Heliothis caterpillars can attack the plant at any stage throughout the season. They feed on the tender growing points and can cause squares (flower buds) and young bolls to drop off the plant. They can also bore into large bolls and allow diseases to enter.

Heliothis Caterpillar on cotton boll.

COMBATING **INSECTS**

There are many methods used to control insects to reduce the impact of pests on the crop. Using a combination of these methods is known as Integrated Pest Management (IPM), a widely recognised best practice in agricultural insect control that aims to reduce insecticide use while maintaining profitability, yield and fibre quality. Over-reliance on synthetic (man-made) insecticides create problems such as insecticide resistance, disruption of natural pest enemies, secondary pest outbreaks and environmental consequences.

Some of the methods used to control insect pests include:

- Encouraging beneficial insects into the crop, such as ladybirds, spiders, wasps and ants, to help control the pests;
- Regular monitoring of insect populations and crop damage;
- Use of transgenic cotton such as Bt cotton (Bollgard 3®) that is resistant to heliothis;
- Alternating pesticides to reduce the chance of pesticide resistance;
- Ploughing the field after harvesting to destroy the Heliothis pupae (pupae busting);
- Biological sprays containing viruses or the naturally occurring soil bacterium Bacillus thuringiensis (Bt) that produces proteins toxic to heliothis. Note: growers can't use Bt sprays on Bt cotton, as it is essentially the same toxins, so can't be used for resistance management purposes;
- Growing healthy crops that are capable of recovering from small amounts of pest damage;
- Keeping non-crop areas free from weeds, volunteer cotton and other crops. Weeds can provide a source of habitat for pests to survive on and infest the crop.

INTEGRATED **PEST MANAGEMENT** (IPM) PRINCIPLES

1. Know your enemy and your friends.
2. Take a year-round approach.
3. Think of the farm and surrounding vegetation as a whole system.
4. Have good on-farm hygiene.
5. Consider options to escape, avoid or reduce pests.
6. Sample crops effectively and regularly.
7. Aim to grow healthy crops.
8. Evaluate pest abundance against established thresholds.
9. Choose insecticides wisely to conserve beneficials.
10. Apply good resistance management principles.

Ladybirds are a beneficial insect in a cotton crop to help control pests.

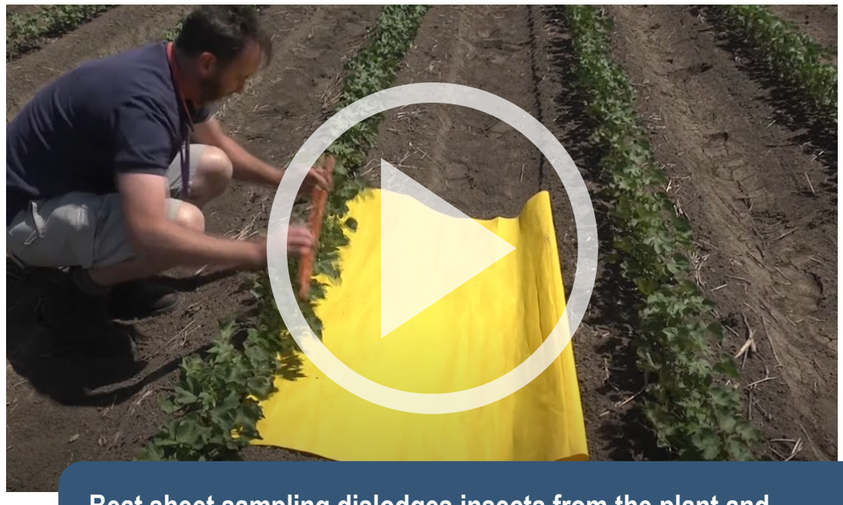
A combination of all of these methods has seen a reduction in insecticide use. Producing a bale of cotton now takes 97% less insecticides since 1992, with some cotton crops not sprayed at all these days.

Integrated Pest Management is a major focus of the cotton industry's environmental program called myBMP, which sets out the latest research and best practice guidelines for controlling insects.

The Cotton Pest Management Guide 2020-21 is the industry's premium resource for insect, mite and weed control, disease prevention, biosecurity and spray application information.

Ever wondered what happens to a caterpillar in a modern cotton crop? This digital booklet will explain it all in a very novel and engaging way! The Very Hungry Helicoverpa by Oliver Knox.

The Very Hungry Helicoverpa



Beat sheet sampling dislodges insects from the plant and is particularly useful in cotton for finding mobile sucking pests and assessing beneficial arthropod populations. This video shows examples of pests and beneficials, their sizes and how they move, to assist you in identification.

SPRAY DRIFT IN AGRICULTURE

To improve farm productivity and address the growing concerns around social accountability, all Australian farmers are increasingly being challenged to manage spray application processes to ensure effective spray application whilst causing no impact to neighbouring communities, crops and the environment. Over the past decade, industry estimates derived from grower reports show the Australian cotton industry has potentially lost $66 million in revenue as a direct impact of off-target spray drift from neighboring farms.

WHAT IS SPRAY DRIFT?

Spray drift is defined by the Australian Pesticide and Veterinary Medicines Authority (APVMA) as the movement of spray droplets of a pesticide outside of the application site during, or shortly after, application. It does not encompass off-target movement of a pesticide caused by runoff, volatilisation, erosion, or any other mechanism that occurs after spray droplets reach their intended target.

One of the main reasons spray drift occurs is applying chemicals at times that are not suitable, such as during a temperature inversion. It is important growers and spray applicators understand the risks around spray inversions, how they are formed, and how to avoid them.

Tools and publications about spray drift.

A handy document produced by Nufarm - the '24 Hour Risk Profile for Summer Spraying'.

WHAT IS A TEMPERATURE INVERSION?

In meteorology, an inversion, also known as a temperature inversion, is a deviation from the normal change of an atmospheric property with altitude. Normally, air temperature decreases with an increase in altitude. During an inversion, warmer air is held above cooler air, the normal temperature profile with altitude is inverted.

WHAT DOES THE COTTON INDUSTRY DO TO PREVENT SPRAY DRIFT?

Training and raising awareness are proven ways of addressing the ongoing problem of spray drift and off-target crop damage. When these training opportunities and workshops have been offered by industry, they have always been oversubscribed, demonstrating the value farmers place on this training. Spray application training workshops help communicate the importance of best practice spray application in a time of great technological change in the industry. While research organisations continue to generate improved knowledge of meteorological conditions and spray application practices, there is an ongoing demand for training of workers whose role it is to practically implement this knowledge on farm.

Each season, Cotton Australia works collaboratively with most cropping industries to devise and implement strategic awareness campaigns around spray drift and best practice for spraying. This entails working closely with cotton growers, spray applicators, chemical producers, resellers, regulators and government organisations like the New South Wales Environment Protection Authority and Biosecurity Queensland to develop and deliver campaigns with the specific aim to reduce spray drift and raise awareness of the issue.

These campaigns include:

- Supporting growers to report spray drift incidents, and keeping an industry log of incidents that have occurred.
- Working collaboratively with stakeholders within the cotton industry and other agricultural sectors to understand, navigate and assist growers through the challenges faced when planning spraying activities.
- Delivering training and workshops on spray application best practice.
- Delivering a targeted media campaign through a range of networks in cropping areas.
- Cotton Australia leading the development and promotion of SataCrop, a mapping tool informing all stakeholders of the location of potentially sensitive crops.

SataCrop is a mapping tool to inform stakeholders before applying spray to crops.

Join Mary O'Brien as she gives a practical demonstration of air movement under inversion conditions using smoke flares.

SATACROP

SataCrop is a tool designed to mitigate the risk of spray drift by allowing operators to understand where sensitive crops and environmentally important areas are located in proximity to their spray operation.

The SataCrop tool is an industry initiative developed by Cotton Australia and Precision Cropping Technologies (PCT).

SataCrop has the ability to map all crop types, including cotton, grains and tree crops. Growers can log in and plot the location of fields they have planted with different crops each season. Other farmers and spray contractors can review the site when planning spray applications to see the location of potentially sensitive neighbouring crops. This, coupled with vigilance around spray conditions, wind directions, and application helps to reduce adverse effects of spray drift.

DEFOLIATION

Once the cotton crop has matured and ripened, it is sometimes treated with a defoliant before it can be picked (or harvested).

When enough bolls have opened naturally, the cotton is tested to see if it is ready to be defoliated and picked by cutting open the bolls and looking to see if the seeds inside are fully formed.

Defoliant is applied to the cotton plants to help the green leaves dry and fall off and to help any of the remaining unopened cotton bolls to open. The plant itself is not killed and the cotton can be picked cleanly without the leaves staining the lint. This practice enables the grower to hasten the opening of the cotton bolls which can then be picked in a short period of time. It is essential that the crop is harvested before weather and rain can damage or ruin its quality and reduce yield.

Once defoliated, the cotton crop is ready to be harvested.

PICKING

Cotton picking usually occurs in February to March in Queensland and late March to April in NSW. Cotton picking was once done by hand (and still is in some developing countries) and was therefore a very labour-intensive task. Today, it is carried out by large harvesting machines, but still requires significant labour during this busy time of the season. Cotton farmers sometimes own their own picking machinery but can also use contract harvesters to pick their crop. Additional, casual labour is needed on the farm at this time of year and this is often hard to come by – cotton farmers often use seasonal workers and backpackers to help lighten the load.

Applying defoliant to a cotton crop.

Additional manpower is needed on a cotton farm during picking time. Photo by Georgie Carrigan, Boggabri.

When enough bolls are opened, the crop is ready to be picked. Photo by Noni McCarthy.

Harvesting cotton in Boggabri.

See a cotton picker in action and drop round modules in the paddock. Specialised machinery is featured showing how modules are collected from the paddock and then loaded onto a truck for transport to the local gin.

ROUND BALE **PICKERS**

The newest cotton picking technology is an all-in-one machine designed to provide a cotton picker with the ability to build modules while harvesting the crop. These modules are round rather than rectangular and are built and left at intervals all over the cotton field. The round module picker can pick the cotton, compress it into a round module, wrap it in plastic and sit it on the field in a much shorter timeframe than traditional pickers – and using far less labour. The round module picker costs in excess of A$1 million to buy new, and more than 90% of the Australian cotton crop is now picked with this method.

This two-row cotton picker was some of the first harvesting machinery used in the industry.

How do cotton pickers work? Watch how a cotton picker captures cotton and forms round bales through an animation showing what is happening inside the harvester.

Case Study: cotton is traditionally wrapped in yellow plastic, but the colour change to pink comes as farmers raise money to bring more breast care nurses to the country.

The ins and out of cotton production from planning to in-season agronomy and getting the crop to market is in the 2020 Australian Cotton Production Manual, which is a critical reference tool for cotton growers. The manual is a one-stop-shop for growers, outlining all the various decisions that need to be made on-farm in preparation for, and during, cotton production.

The myBMP website is the cotton industry's portal for best practice information in all aspects of cotton production. There's even an educator's login!

This shows the older technology of module builders that is gradually being replaced across Australia with the more efficient round module technology. One module would contain about 13 tonnes of seed cotton, was 11-12m long and 2.5m wide and 2.5m high.

The new round module technology has cut down the labour required to pick cotton.

THEMES AND AUSTRALIAN CURRICULUM
OUTCOMES FOR SECONDARY SCHOOL

The Cotton Education Kit has been linked to the Australian Curriculum for Years 7-10, and targeted outcomes for Years 11 -12 from all state & territory curriculums across Australia. A list of themes is provided for teachers as a quick guide to assist linking the content to their unit of work or syllabi in their state or territory.

A full list of the individual syllabuses that have been mapped against the Cotton Education Kit can be found in the Cotton Classroom.

Cotton Classroom

CHAPTER FIVE THEMES

- Growing Conditions
- Preparing the Land
- Soil Types and Achieving Healthy Soils
- Planting
- Managing the Crop
- Watering by Irrigation
- Types of Irrigation
- Crop Water Requirements
- Nutrition
- Controlling Weeds
- Managing Diseases
- Controlling Insects
- Defoliation
- Picking

Australian Curriculum	Course	Chapter 5: How Cotton is Grown
Australian Curriculum	Year 7 Geography	ACHGK037 (Forms of water as a resource)
Australian Curriculum	Year 8 Science	ACSSU150 (Multi-cellular organisms) / ACSHE136 (Science influences on agriculture)
Australian Curriculum	Year 9 Science	ACSSU175 (Organisms response to their environment) / ACSSU176 (Ecosystems)
State / Territory	**Senior Secondary Course**	
New South Wales (HSC)	Agriculture (2013)	P1.1 P1.2 P2.1 P2.3 P3.1 P4.1 P5.1 / H1.1 H2.1 H3.1 H3.2 H3.3 H3.4 H4.1 H5.1
	Agriculture Life Skills (2018)	ALS8
	Biology (2017)	BIO12-14 BIO12-15
	Primary Industries (VET) (2020)	AHCPMG202 AHCPMG302 AHCCHM307 AHCCHM201
Victoria (VCE)	Agriculture and Horticulture Studies (2020)	Unit 2: AoS 1 Plant nutrition, growth and reproduction
	Agriculture, Horticulture, Conservation and Land management (VET) (2020)	AHCBAC201 AHCBAC202 AHCPMG202 AHCPMG201 AHCSOL202
	Geography (2016)	Unit 3: AoS 1 Land use change
Queensland (QCE)	Agricultural Practises (Applied) (2019)	C2.3 C2.4 E4.1 E5.3
	Agricultural Science (General) (2019)	Unit 1: Topic 3 / Unit 2: Topic 2 / Unit 3: Topic 2
	Biology (General) (2017)	Unit 1: Topic 2
	Earth and Environmental Science (2019)	Unit 3: Topic 2
Western Australia (WACE)	Biology (ATAR) (2017)	Unit 1: Eco systems / Unit 4: Plant survival
	Plant Production Systems (General) (2017)	Unit 1: Systems ecology / Plant environment / Plant health Unit 2: Systems ecology / Plant environment Unit 3: Plant environment / Plant health
	Plant Production Systems (ATAR) (2017)	Unit 1: Systems ecology / Plant environment / Plant health Unit 2: Systems ecology / Plant environment Unit 3: Plant environment / Plant health
South Australia / Northern Territory (SACE)	Agricultural Production Stage 2 (2021)	Topic 2: Plant production Topic 3: Resource management
	Agricultural Systems Stage 2 (2021)	Topic 2: Plant systems Topic 3: Soil and water systems.
	Geography Stage 1 (2020)	Theme 3: Topic 6 Local Issues/water usage in agriculture
Tasmania (TCE)	Agricultural Systems (2019)	Unit 2: Ecosystems Unit 3: Plant Production Systems
	Agricultural Enterprise (2019)	Unit 1: Managed and Natural Systems Unit 2: Plant and/or Animal Production
ACT (ACT SSC)	Agriculture A/M (2017)	Soil Properties and Plant Production

KEY **LINKS**

- Cotton Australia.
- 360-degree digital film of a cotton farm, the latest addition to Cotton Australia's suite of educational resources informing city and country residents about the Australian cotton industry.
- Google Arts & Culture
- Australian Cotton
- Cotton Research and Development Corporation
- Cotton Seed Distributers
- CottonInfo
- Primezone: Primezone provides teachers and students with access to the latest quality primary industries education resources

COTTON AUSTRALIA