

IRRIGATED COTTON GUIDE





Cotton is one of Australia's most important summer crops. In an average year, Australia's cotton growers produce enough cotton to clothe 500 million people. It is a major commodity, representing from 30 to 60 percent of the gross value of the total agricultural production in Australian regions where it is grown, helping to underpin more than 50 rural communities.

Australian Grown Cotton Sustainability Report, 2014

Australian cotton growers are some of the best in the world, achieving yields well in excess of world averages and also producing some of the best fibre quality cotton.

This makes Australian cotton attractive to merchants and spinners around the globe.

The modern Australian cotton industry has grown from humble beginnings with its roots in the Namoi valley of north west New South Wales, to a professional, technologically advanced industry spanning from Central Queensland into Victoria.

In recent years, the industry has seen substantial expansion into areas once thought impractical to cotton growing. At present, two thirds of Australian cotton is grown in New South Wales and the majority of the remainder grown in Queensland. Through plant breeding and advances in biotechnology, the Australian cotton industry has been expanding into new

regions, including south of the Victorian border and north into the Flinders River in the Gulf of Carpentaria and the Ord Irrigation Scheme in Western Australia.

Irrigated production makes up the majority of Australian cotton. Currently, irrigated cotton accounts for the majority of annual production, however, in recent seasons the popularity of cotton as a dryland crop has seen an increase in the area planted to dryland cotton.

This booklet is an introductory guide for those who are new to growing cotton or are interested in discovering more about cotton production.

Further information, resources and tools including a gross margin calculator are available at www.acresofopportunity.com.au

CONTENTS

Pre-season – before you plant	4
Planting and establishment	10
Effect of temperature on establishment	11
Pest control	14
Irrigate to minimise plant stress	17
Monitor to manage the crop	18
Flowering to cut-out is a critical time	20
Harvest/picking	21
Post harvest crop control	22
Contact	23



PRE-SEASON – BEFORE YOU PLANT

It's important to complete ground and field preparation early. In surface irrigated systems, beds need to be of sufficient height to allow for good drainage, and furrows need to be of sufficient capacity to move runoff water out of the field after rainfall. Cotton can also be grown successfully under pivots and lateral irrigators.

Completing any cultivations and fertiliser applications early will also enable a smooth transition into the planting operation, and allow the maximum amount of time to accumulate moisture into the soil profile.

Row spacing will vary depending on the farming operation; however most equipment is set up to cater for varying widths. It's important to consider that some cotton equipment, especially pickers, are a standard 2 m wheel spacing, although the heads can be moved to handle a minimum row spacing of 75 cm.

Create a firm, consolidated seed bed. Planting is a critical operation in the cotton farming system and every effort should be made to ensure that the seed is given every opportunity to establish.

A well-consolidated bed is less likely to slump, and will allow for more accurate seed placement and lessen the likelihood of seed sinking when irrigation water is applied.

It's good farming practice to service all machinery, pumps and ring tanks to ensure they are in good condition and to avoid breakdowns. In a cotton-farming system, some operations are time-sensitive, so there is tangible value in having machinery prepared and running before the planting season by having it serviced early.

It is important to investigate cotton-ginning and marketing organisations for the processing and marketing of your cotton crop, prior to planting. There are many options available to market your cotton, including the opportunity to forward sell. Remember that you will produce two commodities with each cotton crop – the lint and the seed – both of which can provide lucrative returns if marketed wisely.

A list of cotton merchants operating in Australia is available at:
www.austcottonshippers.com.au/about-acsa/



Neighbourhood relationships

Cotton is particularly sensitive to phenoxy herbicides (2,4-D, MCPA), suffering growth distortion, fruit loss and delayed maturity from even very small concentrations drifting onto the crop. It is important to talk to your neighbours, particularly those within a couple of kilometres, about your intentions to plant cotton.

CottonMap (www.cottonmap.com.au) allows growers, consultants and spray contractors to plot cotton fields online so you and your neighbours are aware of the location of nearby cotton fields when spraying.

It's also critical to decontaminate any spray rig equipment that has been used for application of phenoxy herbicides before you start the cotton season. A check needs to be made with all spraying contractors to ensure adequate decontamination has been conducted. All rubber hoses, O-rings, gaskets and seals should be replaced as harmful chemicals can be drawn back into solution by some solvents used in other chemical products.

If required, it's important to engage outside assistance to help manage the crop. This can include a crop consultant (agronomist) and contractors for time sensitive farm operations (e.g. planting, picking, spraying). Where possible, these should be organised prior to planting.

A good cotton consultant will assist you with the management of the cotton crop, from planting to picking. Their knowledge is in ensuring that the crop is managed without stresses throughout the season. Cotton consultants help with forecasting crop requirements, variety selection, planting, fertiliser requirements and application, irrigation timing, insect and weed scouting and control, and crop defoliation. Even the most experienced cotton growers utilise the services of cotton consultants.

PRE-SEASON – BEFORE YOU PLANT

Nutritional requirements

Cotton requires a good supply of both macro- and micronutrients to produce high yields. Most soils require the application of nitrogen (N), phosphorus (P) and potassium (K), and some growers will need to apply zinc (Zn) and other micronutrients.

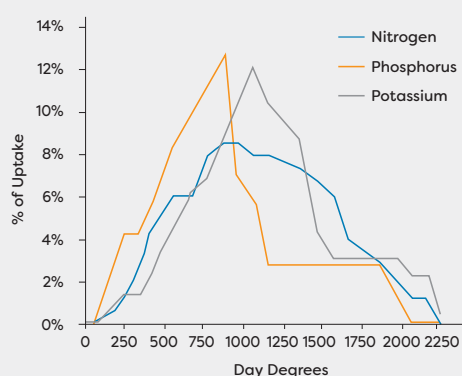
Fertiliser should be applied in a timely manner, to ensure availability for plant uptake before periods of peak nutrient demand. Regular soil testing, with accurate interpretation of the results, is valuable when assessing soil nutrient levels prior to planting.

Samples are best taken from May to August, ideally from varying depths of the soil profile. In-crop measurements should be conducted to reassess crop requirements during the season.

Nutrient requirements should be budgeted on soil and crop tests, and on crop requirements and yield target.

Nutrient use efficiency can be boosted through careful fertiliser application. Your cotton consultant can give you advice on the most appropriate rate, product, timing and application method. A popular nitrogen application technique is to apply 60% up front and then 40% in-crop. There are a number of different application techniques for nutrient application – your cotton consultant can advise you on the most appropriate method for your situation.

Don't let nutrition be a yield limiting factor. Careful monitoring and management of nutrient levels is important to ensure yield potential is reached, without inefficient fertiliser application. Without regular monitoring, nutrition deficiencies may not be identified until symptoms appear – which may be too late. At that point, a reduction in yield is likely, despite remedial fertiliser applications.



Unit	Nutrient	Maximum uptake rate (per day)	Percentage taken up during flowering
kg/ha			
	N	4.5	93
	P	1.3	96
	K	4.0	89
g/ha			
	Zn	2.9	100

Figure 1: Maximum nutrient uptake rate and timing of the nutrient of the whole crop.

Source: Australian Cotton Production Manual

Table 1. Nutrient removal at various yield levels in bale/ha (1 bale = 227 kg). Source: Rochester (2014).

	Nutrient	Yield: bales/ha					
		6	8	10	12	14	16
kg/ha							
	N	65	95	125	155	185.5	216
	P	14	19	24	28	32.5	37
	K	22	29	37	44	51.5	59
	S	6	8	10	12	14.5	17
	Mg	8	11	14	17	20	23
	Ca	3	4	6	7	8	9
g/ha							
	Fe	112	138	164	190.5	216.8	243.1
	Mn	9	12	15	18	21	24
	B	28	42	56	70.5	84.8	99.1
	Zn	72	91	110	129	148	167
	Cu	16	20	24	28	32	36

Placement of fertiliser is very important, as root burn can occur if fertiliser is placed too close to the root system. It's recommended that nitrogen be applied 10 cm to the side of the plant line, and additional nitrogenous fertiliser deposited below the line of the bottom of the furrow, in order to prevent nutrients leaching laterally from the field with irrigation water. Phosphorus and potassium can be placed under the plant line, but should be far enough away to not cause root burn.

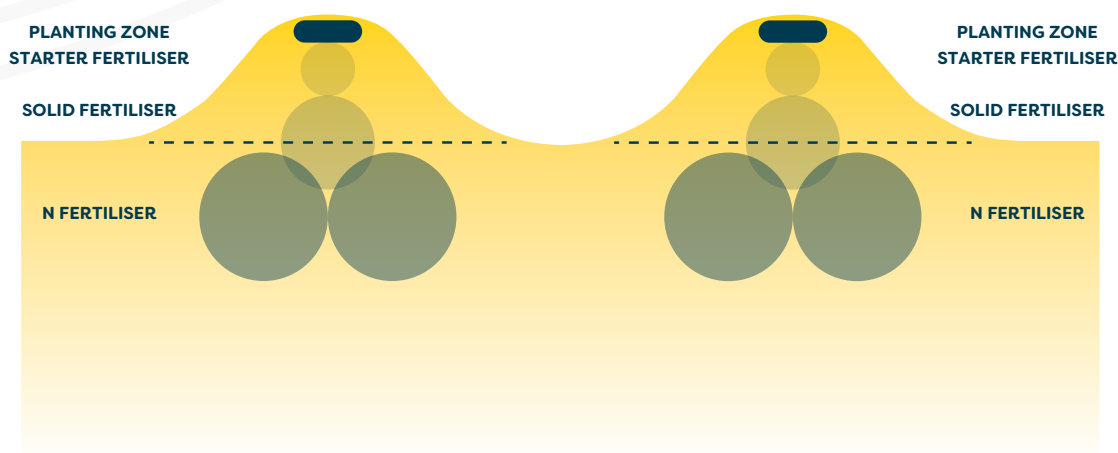


Figure 2: Schematic placement of fertiliser

PRE-SEASON – BEFORE YOU PLANT

Select the right variety and seed treatment

Selecting a cotton variety that has the right regional and production type fit is a very important decision. Cotton Seed Distributors (CSD) has a range of varieties available, which should be selected based on:

1. Yield in your area and production type
2. Disease tolerances
3. Resilience in fibre quality
4. Technology choice
 - a) Conventional: non GM cotton.
 - b) Roundup Ready Flex® can be sprayed over-the-top with Roundup Ready® Herbicide with PLANTSHIELD® and / or Roundup Ready® PL Herbicide with PLANTSHIELD® Technology. The technology has revolutionised cotton production providing an exceptional weed control system offering flexibility to control weeds as and when they appear.
 - c) Bollgard® 3: is the latest generation technology that offers excellent control of helicoverpa, the main cotton pest within Australia. It offers three different protein toxins for control and reduces the need for broad spectrum insecticide sprays.
5. Other crop characteristics such as determinacy, leaf shape and season length should also be considered.

Your consultant or CSD Extension and Development Agronomist (www.csd.net.au/contact) will be able to assist you in making an informed decision on what variety and technology mix will best suit your specific situation.

The relevant CSD Grower Agreement and Bayer (trading as Monsanto Australia Pty Ltd) Technology User Agreement (TUA) need to be completed prior to ordering and receiving seed on farm. Cotton planting seed within Australia cannot be purchased without the appropriate agreements being in place as a requirement of the government regulations. The agreements can be arranged from your local cotton seed supplier, who will have further information on how to order seed. There are some accreditation processes which are required to ensure growers are aware of the crop management plans for the transgenic technologies.

There are many pests and diseases which impact on cotton crops. Seed treatments are available to give some early season protection against diseases and insects. Bion® is an additional choice that can 'turn on' the cotton plant's natural defence mechanisms and provide increased resistance to some pathogens, particularly during the establishment phase of a crop's life. Growers should consult with their cotton consultant to select a suitable seed treatment based on expected disease and early season insect pressure.

Insecticidal technology traits such as Bollgard 3 require a small amount of refuge area to be planted as part of the Australian cotton industry's Resistance Management Plan (RMP). The required area will vary depending on the amount of cotton grown and the technology choice selected. The aim of a refuge crop is to generate significant numbers of helicoverpa moths which haven't been exposed to Bollgard 3 or other Bt products..

The types and requirements for the refuge crop can be found in the table below, and a refuge calculator too can be found at: www.bollgard3.com.au/refuge-calculator/

Table 2. Bollgard 3 refuge options.* Source: Bollgard 3 Resistance Management Plan.

Crop	Condition	% of Bollgard 3 planted area
		Irrigated & Dryland
Cotton	Sprayed cotton refuge an area of irrigated non Bollgard 3 cotton, which can be conventionally managed for <i>Helicoverpa</i> spp. and other pests.	100%
	OR Unsprayed cotton refuge an area of irrigated non Bollgard 3 cotton, which will not be treated for any reason with any product that controls <i>Helicoverpa</i> spp.	5%
		Irrigated & Dryland**
Pigeon Pea	Unsprayed pigeon peas which will not be treated for any reason with any products which control <i>Helicoverpa</i> spp. The pigeon pea crop is managed to ensure several cycles of flowering throughout the cotton season.	2.5%

*Southern QLD, NSW & VIC only. Please refer to Bollgard 3 Resistance Management Plan for Central Queensland refuge options.

**Subject to an approved management plan by Bayer.



PLANTING AND ESTABLISHMENT

Precision planters are the predominant type of planter units used to plant cotton, allowing for accurate and uniform seed placement. While cotton has the ability to compensate for gaps or unevenness in the plant stand, a uniform plant establishment will contribute in easing crop management throughout the season. A successful planting operation is influenced by a number of factors mentioned below.

Planter maintenance

Ensure the planter is well maintained and ready to go well before planting time. Breakdowns in the field can rob time and allow planting moisture to disappear.

Planter depth

Ideal depth depends on the method of establishment and the soil conditions. A simple rule of thumb is to use the “knuckle” method as a quick and easy measurement tool in the field.

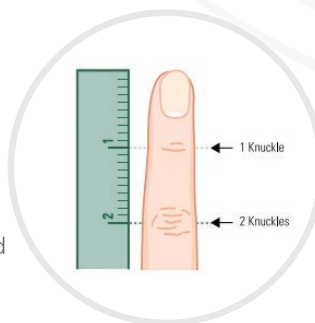


Table 3. Generic recommendation for planting depth based on establishment method

Establishment method	Ideal depth
Planting into moisture (rain or pre-irrigated)	2.5 and 4.5 cm (1 to 1.5 knuckles)
Planting dry and watering up	2.5 cm (1 knuckle)

Planting too shallow (< 2.5 cm) may mean the soil dries out before the seed has time to germinate and does not allow the seed coat to be removed from the cotyledons through soil friction, which can stall crop development. Planting deeper than 5 cm, even under ideal conditions, can also compromise establishment.

Planting speed

One of the keys to achieving a uniform seed placement is planter speed, where the aim is to plant with precision not speed. The ideal speed for planting cotton is between 8-10 km/hr. A desirable outcome of any speed is to eliminate the planter unit from bouncing, ideally having it sitting steady and stable as it moves along.



EFFECT OF TEMPERATURE ON ESTABLISHMENT

Establishing a cotton crop is a critical operation. It sets the standard for the entire season, influencing crop growth, development and management. If establishment is unsuccessful, it is difficult to manage and costly to rectify.

Plant once and do it right. Emergence is expected to occur within 7-14 days depending on factors such as planting depth, soil

temperature and subsequent weather. A faster rate of emergence is desirable, as the cotton plant emerges and starts to generate its own energy from sunlight. Cool temperatures will diminish root and shoot growth, reduce water and nutrient uptake and make seedlings more susceptible to attack from seedling disease and early season insect pests.

Table 4. The effect of temperature on cotton seedling survival and growth rate.

Source: Constable and Shaw, 1988.

Minimum soil temperature at 10 cm at 8am (AEST)	Seeds emerging and survival	Days to complete emergence
10°C	56%	29
14°C	73%	17
18°C	90%	5

It is important to monitor the soil temperature and air temperature to find an appropriate planting window. It had been an Australian cotton industry guideline that cotton planting should not begin before soil temperatures reach 14°C or above at 10 cm depth, at 8.00 am. In some regions, it can be difficult to obtain such temperatures in early October and therefore a forecast for a rising air temperature

is utilised in conjunction with soil temperatures, in order to time planting to provide seed with the best chance of emergence. There may be a FastStart soil temperature monitor station located near you (www.csd.net.au/soil_temperatures). Always check the soil temperature before you plant.

HAVE YOU GOT THE GREEN LIGHT FOR COTTON PLANTING THIS SEASON?

Planting the cotton crop is one of the most important operations on the farm. It sets the standard for the entire season. There are some key considerations that will help ensure that it is a once-only task.

- ☐ Soil temperature at 10 cm depth above 14°C at 8am (AEST).
- ☐ Forecast average temperatures for the week following planting on a rising plane.



RED LIGHT



STOP!



AMBER LIGHT



STEADY!



GREEN LIGHT



GO!

EFFECT OF TEMPERATURE ON ESTABLISHMENT

High soil temperatures

There has been a lot of research into the effects of cool temperatures on seedling establishment. As the planting window for Bollgard 3 cotton is widened, so too is the possibility of planting into summer temperatures in Central Queensland, west and south west Queensland and north west New South Wales. High temperatures can reduce seedling establishment and in extreme conditions, can kill the seed and seedling.

Seed quality

All CSD seed has a minimum germination test rating of 80% at the point of sale (majority are a lot higher than this). Germination percentages for individual Australian seed lots are available on the CSD website (www.csd.net.au) or by contacting CSD's laboratory operations on (02) 6795 0000.

Seedling survival is rarely 100%, so growers should never rely on seeds planted per hectare and plants established per hectare being the same.

Seed density

Some cotton varieties have lower seed density which means that when conditions are less than ideal, the variety will have lower seedling vigour and in turn, establishment.

When planting varieties with lower seed densities, growers should take extra care and attention to detail with both land preparation and planting operations to ensure adequate establishment is achieved.

Plant populations

The overall aim is to establish a healthy and uniform plant population of 8-12 plants per linear metre. A rule of thumb that CSD recommends is to aim for a plant population of 10 plants established in areas north of Dubbo, NSW and 12 plants established for cooler areas south of Dubbo.

The number of seeds that should be planted is determined by several factors:

1. Soil type and seed bed condition
2. Stated germination percentages of seed
3. Anticipated seedling mortality through disease or insects
4. Establishment method
5. Temperature conditions

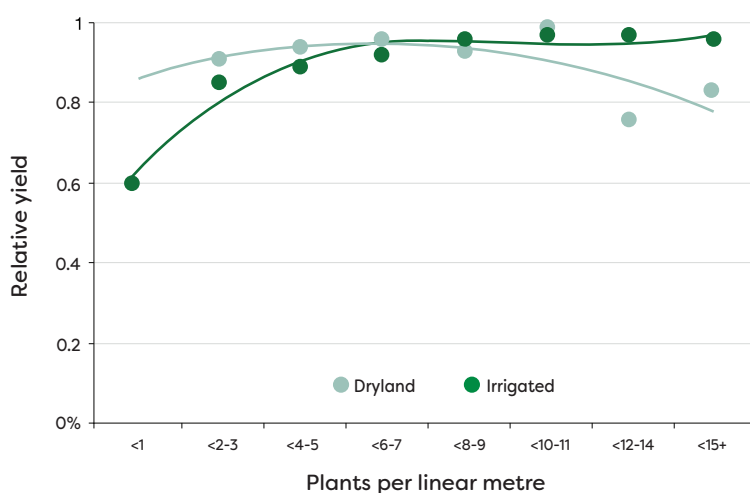


Figure 3
Summary of
CSD plant
population trials
from the past
9 seasons.
(21 irrigated and
9 dryland trials)

Impacts of low and high plant populations on crop management

Table 5. Impacts of low and high plant populations on crop management

Low plant populations (below 8 plants/m)	High plant populations (higher than 15 plants/m)
Plants will be larger as they spread out and grow into gaps.	Plants will be taller, although more compact and with more even fruit distributions.
Plants may start fruiting earlier, but be later in maturing.	Plants will start fruiting later, putting on more vegetative nodes delaying fruiting.
More fruit is concentrated on vegetative branches closer to ground level.	More fruit is concentrated on main stem fruiting branches and in first position.
At very low populations, plant cut-out will be delayed.	No delay or improvement in maturity.
Decreased picking efficiency due to blockages and difficulties in picking large plants.	Picking efficiency will be improved.
More difficulty in controlling plants in post harvest operations (e.g. root cutting).	Easier to control plant in post picking operations.

Plants per metre of row, plants per hectare

Table 6. Plants per metre of row, plants per hectare

Row spacing			
Plants/m	Plants/ha		
	30 inch (75 cm)	40 inch (1 m)	60 Inch (1.5 m)
10	133,333	100,000	66,660
12	160,000	120,000	79,992
14	186,667	140,000	93,326
16	213,333	160,000	106,666
18	239,999	180,000	119,988

Seeding rate calculator example

Table 7. Seedling rate calculator example

Example (75 cm rows)		
Your desired plant stand	10 plants/m 133,333 plants/ha	
Divide by the estimate of survival	80%	$133,333/0.8=166,666$
Divide by germination % of seed	95%	$166,666/0.95=175,438$
Your seeding rate		175,438 seeds/ha 13.2 seeds/m
Divide by the seed/kg for the variety	Sicot 746B3F 11,425	$175,438/11,425=15.36$
Seed/ha required	15.36 kg/ha	

PEST CONTROL

Insect pests

Cotton, like most field crops, can be attacked by a range of insect pests during the season. For this reason, it is very important to employ an experienced crop consultant/agronomist to regularly monitor the crop and help you make pest management decisions.

While there are numerous products registered for the control of various cotton pests; many insecticides, if used at the wrong time, can cause more problems than they solve by disrupting the balance of natural pest enemies ('beneficials'), which can subsequently flare secondary pests, requiring further, harsher control.

Table 8. Common cotton pests

Pest	Crop stage	Where found?	Does Bollgard 3 control?
<i>Helicoverpa</i> spp. (Heliothis)	All season	Attacks fruit and terminal buds	Yes
Soil pests - True wireworm (<i>Agrypnus</i> sp.) False wireworm (<i>Gonocephalum</i> spp.) <i>Pterohelaeus</i> spp.) Black field earwig (<i>Nala lividipes</i>) Symphyla (<i>Hanseniella</i> spp.)	Planting and emergence	Underground feeding on emerging seedlings	No
Thrips (various species)	Emergence until squaring (are also a beneficial insect)	'Rasps' leaves of young seedling	No
Silverleaf whitefly (<i>Bemisia tabacci</i>)	All season but mainly concentrated late season	Underside of leaves, secretes honeydew	No
Green mirid (<i>Creontiades dilutus</i>)	Flowering and boll fill	Attacks fruit and terminal buds	No
Cotton aphid (<i>Aphis gossypii</i>)	All season	Underside of leaves, secretes honeydew	No
Green vegetable bug (<i>Nezara viridula</i>)	Flowering and boll fill	Attacks fruit and terminal buds	No
Two spotted spider mites (<i>Tetranychus urticae</i>)	All season but mainly concentrated in late season	Underside of leaves	No
Solenopsis mealybug (<i>Phenacoccus solenopsis</i>)	All season	Underside of leaves or grouped on stems	No

If you want to know more about pest management in cotton:

- Cotton Pest Management Guide www.cottoninfo.com.au/publications/cotton-pest-management-guide
- Integrated Pest Management Guidelines for Cotton Production in Australia www.cottoninfo.com.au/publications/integrated-pest-management-guidelines-cotton-production-australia

Disease pathogens

A disease occurs when a pathogen is exposed to a susceptible host variety and the environment is favourable for an infection to take place. A disease can be controlled by excluding or eliminating the pathogen, growing a resistant variety or by modifying the environment.

The pathogen

If pathogens are not present in an area – then don't introduce them! Several of the worst diseases of cotton are caused by pathogens that can be carried in dirt and crop residues attached to vehicles and machinery. Always practice good farm hygiene. Insist that vehicles and machinery, and even boots, are cleaned before leaving a farm – so that they are clean when arriving at the next farm.

“COME CLEAN - GO CLEAN”.

Table 9. Common cotton diseases

Disease	Crop stage	Crop symptoms
Seedling diseases	Germination and emergence	Pre-emergent seed rot, post emergent damping off, slow early season growth, lesions on roots
Black root rot	Emergence	Stunted, slow early season growth, blackening of the roots
Verticillium wilt	All season	Yellow mottling of the leaves, stem vascular discoloration, plant death
Fusarium wilt	All season	Yellow mottling of the leaves, stem vascular discoloration, plant death
Alternaria leaf spot	After canopy closure	Brown or grey spots on leaves and bolls with purple margins
Boll rot, seed rot and tight lock	After boll opening	Rotting of the boll or cotton not fluffing once opened
Cotton bunchy top	All season	Pale green angular patches on leaves, small or short leaves, internodes and bolls

The only fungicides registered for use on cotton in Australia are seed treatments for the control of the seedling disease complex that causes pre- and post-emergent 'damping off' of seedlings. All cotton seed in Australia is supplied with a standard fungicide seed treatment.

PEST CONTROL

The host

All Australian cotton varieties are resistant to bacterial blight and have high tolerances to Fusarium wilt, Verticillium wilt and Alternaria leaf spot. Nematodes and many of the fungal pathogens can also attack cotton. Seed treatments are available that can 'turn on' the cotton plant's natural defence mechanisms and provide increased resistance to some pathogens.

Crop nutrition is also important. Cotton plants that are deficient in potassium are very susceptible to Alternaria leaf spot.

The environment

The environment can be manipulated by adjusting the planting date so that boll opening and cotton picking occur at the driest time of the year and fibre damage and down-grading are minimised. Good crop management to prevent tall rank growth can significantly reduce the incidence of boll rots that thrive in the humid environment of a dense canopy.

Wet weather is usually a significant factor in disease development. There are several leaf pathogens that can infect cotton and cause various leaf spots, and even defoliation, when a maturing crop is exposed to an extended period of wet weather.

Weed control

Summer weeds are aggressive competitors to young cotton seedlings, robbing moisture, nutrients and light. It is therefore important to start the season from a clean fallow and to control early season weeds. Consideration should be given to any herbicide plant back restrictions, as some may require rainfall to assist with the breakdown of these chemicals.

Roundup Ready Flex has revolutionised weed control in the Australian cotton industry, however, the technology is one tool and should be used as part of an overall integrated weed management system. This is particularly the case in high weed density situations. Utilise residual herbicides and inter-row cultivation or manual weeding where required.

Using alternate herbicides modes of action has the additional benefit of minimising the risk of herbicide resistant weed populations developing.

Consult the Roundup Ready Flex Cotton Weed Management Guide for clear recommendations for weed control practices in a Roundup Ready Flex cotton crop. The guide includes a range of herbicides which offer different modes of action throughout the season, reducing the risk of glyphosate resistant weeds developing on your farm and saving you time and money in the future.

The Roundup Ready Flex Cotton Weed Resistance Management Plan details strategies that can be implemented to minimise the risk of glyphosate resistance developing in weeds on-farm.

Both of these guides are available from www.bollgard3.com.au

Ensure cotton plants are fully destroyed post harvest, as they become woody weeds which can host pests and diseases in between seasons. Effective control of volunteer and ratoon cotton will help to achieve resistance management, disease prevention and insect population control objectives. If volunteers are left uncontrolled in fallow areas, they can cause significant drying down of the soil profile reducing the available moisture being carried over for subsequent crops

Your weed management strategy should be an ongoing discussion with your consultant/ agronomist.

For further information visit the WeedSmart website. WeedSmart is an industry-led initiative to enhance on-farm practices and promote long term sustainability of herbicide use. www.weedsmart.org.au

Additional information is also available from Bayer on Volunteer and Ratoon cotton management. Visit www.bollgard3.com.au to download a copy of the Bollgard 3 Resistance Management: Control of Volunteer and Ratoon Cotton

IRRIGATE TO MINIMISE PLANT STRESS

Engage your consultant to help formulate a water budget, and to assist in monitoring soil moisture levels and with scheduling irrigation timing. Correct budgeting of water requirements will ensure irrigation water is available to finish the crop, a potentially critical factor in hot and dry seasons. Additionally, it is important to understand the capacity of your system and the daily amount that can be used to irrigate.

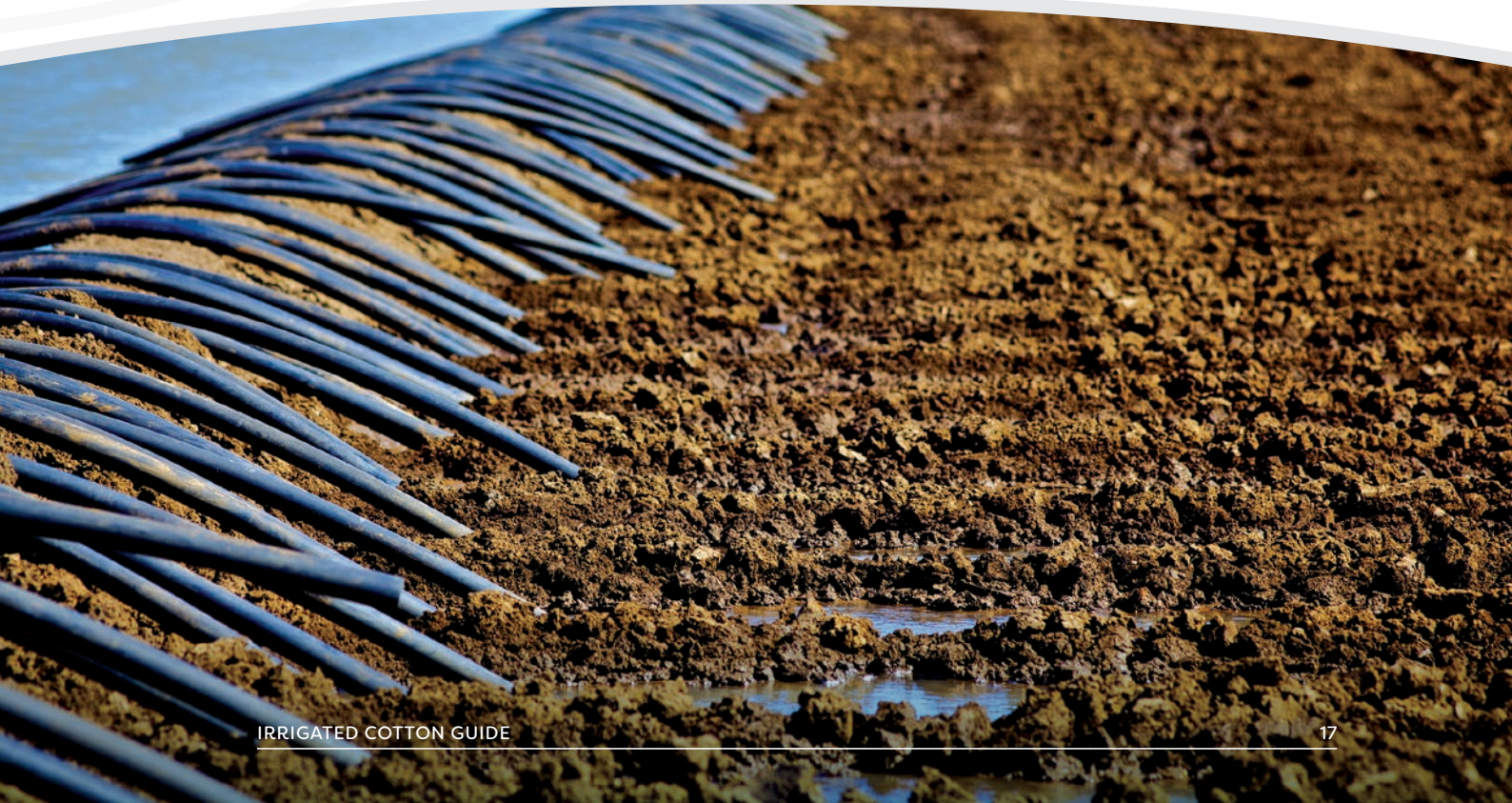
Once in the swing of the season, there is some rhythm to scheduling irrigations based on soil water deficit and climatic conditions. However, both the first and last irrigations can be tricky to time correctly.

First irrigation is timed to maximise root expansion and crop growth at first flower. At first flower, the aim is to have a healthy, actively growing plant which has the desired architecture, framework and leaf area to develop a boll load. The timing of the irrigation is critical and a delicate balancing act in keeping the crop growing healthily, without hindering root expansion and ensuring minimal waterlogging. The irrigation around

first flower is a critical decision not only for the reasons stated above, but also it plays an important role in ensuring the growth targets desired at first flower are met.

In Bollgard 3 crops there is greater impact of miss-timing the early irrigations around squaring and first flower, due to the higher fruit retention levels and fruit load which require careful management and monitoring.

Last irrigation should be timed to ensure that the soil profile is dry at defoliation and boll maturity is complete. At this time of the season, it will take about 45-55 days from last effective flower (cut out) to crop maturity, and sometimes longer in shorter season areas. Given that daily water use is reduced in the later stages of a crop's growth, and presuming there is a full profile, the crop should be able to rely on stored soil water for the last 25-30 days of growth (on most clay soils). Therefore, irrigation water should only be required for the first 20-25 days after last effective flower, although two irrigations may be required if soil moisture conditions are not optimal.



MONITOR TO MANAGE THE CROP

Utilise your consultant/agronomist to monitor crop growth and progress, as well as insect pests and disease, and to prescribe methods of control, if required. A consultant/agronomist can provide a fresh set of eyes and will also have an understanding of where the crop should be up to based on their knowledge of other crops in the district. Critical aspects which your consultant can assist with are growth rates, plant height management and fruit retention.

Cotton is a responsive crop to manage, so growers are able to monitor and manipulate the cotton plant to maximise yield and ease of management. As mentioned earlier, the rate of growth of a cotton crop is determined by temperature and thus depending on the temperature, follows a specific pattern.

Due to this predictability, it allows for management and monitoring to influence crop growth and development. Using the relationship between the rate of development and temperature, a measure of crop progress is described as Day Degrees.

Day Degrees calculation:

$$DD = \frac{(\text{max. temp} - 12) + (\text{min. temp} - 12)}{2}$$

When the temperature is below 12°C, the cotton plant processes cease, and the plant experiences what is termed as cold shock, where the cotton plant's development is retarded. To ensure good early season growth, it is vital to limit the number of cold shock events to which young cotton seedlings are exposed.

Table 10. Day Degrees

Crop phase	Day Degrees	Days
Sowing to emergence	80	7-14
Growth of one node	40	3-4
Sowing to first square	505	30-40
Sowing to first flower	777	60-70
Open boll	1530	110-130
Sowing to 80% open	2050	160-200

Aim to have the crop achieve the following key parameters (developed from CSD's Ambassador Network).

Establishment

Table 11. Establishment

Soil temperature	Forecast temperature	Established plants
14°C at 8.00 am	Rising	8-12 plants/m

First flower

Table 12. First flower

Total nodes	Nodes above white flower (NAWF)	1st position retention		Vegetative growth rate (per internode)
		North	South	
16	8+	80%	90%	5-6 cm

Cut-out

Table 13. Cut-out

Total nodes	Squaring nodes	Plant height	Bolls/m	Vegetative growth rate (per internode)
25	18	100-105 cm	180+	5-6 cm

End-of-season

Table 14. End-of-season

Total nodes	Squaring nodes	Plant height	Bolls/m	Final retention %
25	18	100-105 cm	150+	65%

Plant growth regulation

Utilise plant growth regulators to manage excessive growth. Excessive rank growth is inefficient, and can lead to boll rots, increase defoliation costs and reduced penetration of insecticides and fungicides.

Generally, there are two times when growth regulators are applied in cotton.

1. In the lead-up to flowering to ensure a balance between the reproductive and vegetative growths. Applications at this time to correct excessive growth have shown improvements in yield.
2. At cut-out to shut down any excessive growth late in the season. The main purpose is to even the crop up and to concentrate the plant resources in filling the later set bolls.

FLOWERING TO CUT-OUT IS A CRITICAL TIME

Critically, the period from flowering to cut out is when up to 90% of the crop yield is set. It is therefore paramount to ensure that the plant/crop grows actively and is healthy through this period. Depending on the regional season length, a major aim throughout this period is to extend the flowering period for as long as possible. Crops approaching cut-out too rapidly are stressed and cannot support the fruit load.

A crop's Nodes Above White Flower (NAWF) will always decrease to a point where it 'cuts out' (four NAWF). This is when there are not enough resources to continue producing additional nodes because the "boll load" is taking most of the plant's photosynthate. The aim is to extend the period till the crop reaches four NAWF for as long as possible within season length constraints. There are limitations; the season length will determine the Day Degrees required in filling later bolls.

The longer the flowering period, the more potential to set more bolls, so the yield potential increases. Studies have shown a positive trend of increased boll numbers as the flowering period is extended.

To extend the flowering period it is important to host a "happy plant" through good crop management. The key is to keep the plant happy through minimisation of:

- Moisture stress, irrigation scheduling and timing
- Nutritional stress
- Weeds, insects and disease

Crop monitoring through this period should include tracking crop water use and irrigation scheduling, monitoring of nutritional requirements through petiole testing, and ensuring fruit retention and accumulated fruit numbers are tracking to the desired target.



HARVEST/PICKING

Do not defoliate too early - time defoliation to ensure the crop and fibre is mature. Defoliating too early can lead to immature cotton fibres, which can cause problems in the dyeing of the fabric later in the processing chain. Your consultant can assist with the timing of the defoliation operation through one of the following methods

1. Four Nodes Above Cracked Boll (NACB). Physiologically, the last harvestable boll is mature when the boll four nodes down have begun to open up (cracked).
2. When the crop reaches 60% open. This is determined through simply counting the number of open bolls compared to the total number of bolls.
3. Cutting bolls and looking for mature seeds. Bolls should be firm to cut even with a sharp knife; the contents of the seed should be fully formed and the seed coat turned from translucent to tan or black.

Nodes Above Cracked Boll (NACB)



Harvest is a good time in the Australian cotton industry, but it is also a time when long hours, tight schedules and heavy machinery mix. Safety is paramount, so it is important to ensure procedures and protocols are put in place to minimise the risk of injury. All staff, including contractors, should be made aware of powerlines, especially with tall and unfolding machinery.

Pick on time and without delay. Cotton has the ability to weather some adverse climatic conditions but can be prone to downgrades in fibre quality. Soil compaction is an issue associated with wet picking, due to the size of the machinery. Impacts can be minimised by timing the last irrigation to assist with drying the soil profile down, as well as not re-entering fields too early post rainfall.

Do not pick if seed cotton moisture is greater than 12%. This can cause ginning fibre quality issues which could lead to discount penalties of your cotton. Some signs that cotton is too wet to pick are:

1. If moisture is evident on your vehicle
2. If you can feel moisture on the bolls
3. Seeds inside the lint do not crack if bitten
4. You are experiencing picker head door blockages or the picker is throwing cotton out the front
5. It is after 9.00 pm – good picking conditions are rare in the late evening

The aim is to have good quality cotton post-ginning, free of downgrades and to have the highest turn out possible. This is achieved through a proper defoliation and picking under the right conditions.

POST HARVEST CROP CONTROL

Ensure all cotton plants are destroyed post picking. As a perennial crop, cotton can regrow into ratoon plants post defoliation/picking, and can:

1. Act as a weed, robbing moisture and nutrients
2. Act as a bridge to host insect pests and diseases
3. Lead to resistance build up
4. Be costly to control

Conduct a pupae-busting operation, if required under your resistance management plan. This pass can be utilised for additional purposes such as planting another crop or remedial action to repair soil constraints such as compaction, or to place immobile nutrients such as potassium and phosphorus deep into the soil profile.

If a pupae-busting activity is not required, growers should undertake additional tactics, such as root cutting, to prevent and control any ratoon cotton growth.

The Resistance management: control of volunteer and ratoon cotton biotech topic is a helpful reference and is available at www.bollgard3.com.au



Please visit www.acresofopportunity.com.au, to find your local CSD Extension and Development Agronomist or your Bayer Territory Business Manager.



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